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Propagation practices in pomegranate: A review

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Abstract

Pomegranate (*Punica granatum* L.) is mainly propagated by vegetative means. Sexual propagation is not practiced commercially. Stem cutting is one of the most suitable methods for multiplication of planting material which is popular method in major parts of the world, excluding India, where air-layering (*Gootee*) is prevalent. Generally, hardwood and semi-hardwood stem cuttings show high rooting success and survival. In the recent past attempts have been made on micro-propagation, stenting, grafting and budding. However, both sexual and asexual methods of pomegranate propagation are reviewed in this paper
.

Key words: *Propagation, pomegranate, Punica granatum, stenting grafting, budding, micropropagation*

Pomegranate (*Punica granatum* L.) is an ancient edible fruit and its commercial cultivation is mainly confined in tropical and subtropical regions (Levin, 2006; Chandra *et. al.* 2010). It is native to Iran and its domestication started in the Middle East about 5000 years ago. The scientific name *Punica granatum* is derived from the name 'Pomum' (apple) 'granatus' (grainy) or seeded apple. The Romans first called this species "malum punicum" (punic apple or apple of Carthage) that evolved to "Punicum granatum". Punicaceae contains a single genus Punica with two species viz. *Punica granatum* L .and *P. protopunica* Balf. f., (syn Socotria protopunica) of which the latter is endemic to Socotra Island (Yemen). Pomegranate is a large shrub or small tree and has tendency to develop multiple trunks with bushy appearance. Pomegranate is an economically important plant and has been used by mankind since the dawn of civilization. The edible part of the fruit contains considerable amounts of acids, sugars, vitamins, polysaccharides, polyphenols and important minerals. Pomegranate has several health benefits to treat many human diseases like coronary heart diseases, cancer (skin, breast, prostate and colon), inflammation, hyperlipidemia, diabetes, cardiac disorders, hypoxia, ischemia, aging, brain disorders and AIDS with biologically active ingredients isolated from different parts of the plant (Seeram *et. al.* 2006).However, pomegranate is propagated by sexual and asexual means but, latter is most common method of propagation globally.

Sexual propagation

In pomegranate, both sexual and asexual methods are practiced for multiplication of planting material. Still in India, sexual method of propagation is used on limited scale but seedlings raised from seeds show some variability in morphological and fruit characters owing to segregation phenomenon. Thus, seedlings are not used for establishment of commercial orchards. In general, seed germination in pomegranate depends on seed hardiness, variety and sowing season. The germination percentage varied between 7% (in varieties with the hardest seeds) and 98% (in soft - seeded ones). The time taken for germination ranges from 10 days to >100 days depending upon seed hardiness. However, viability of seeds is influenced by the period of seed storage (Levin, 2006). Very early seed germination was noted in 'Ganesh' and 'Bhagawa' cultivars. In both the cultivars germination commenced within 8-10 days after sowing and continued up to 28 days in Solapur condition during May (NRCP, 2007) and their germination percentage was higher (61.5-79.0%). In dwarf pomegranate (*P. granatum* L. Cv. 'Nana), seed germination was very low (Jalikop, 2007). Earlier, Cervelli and Belletti (1994) reported that a water soluble inhibitor was present in dwarf pomegranate seeds and they found that removal of the fleshy seed coat enhanced emergence of seedlings by 5% and a subsequent wash in water for 48 hr by a further 26-62.3%.

Asexual Propagation

(1) Stem cutting - Stem cutting is very common method for production of elite planting material in the

world. In this method, the maturity of wood plays vital role in the rooting. Hardwood (Reddy and Reddy, 1989, 1990; Sandhu *et. al.* 1991; Panwar *et. al.* 2001), semi-hardwood (Deol and Uppal, 1990 ; Panda and Das, 1990) and softwood (Ghosh *et. al.* 1988; Patil *et. al.* 2002) stem cuttings were evaluated for propagation in pomegranate. Hardwood cutting method proved to be the most successful. Interestingly, stem cuttings lack root promoting cofactors i.e. low sugar content, phenolic compounds and C/N ratio. Pre-conditioning of its shoots during June-July by girdling and etiolation increases the level of root promoting cofactors considerably. Some reports are available that girdling increased the length and number of lateral roots in stem cuttings with improved shoot growth (Yesiloglu *et. al.* 1997). Although the maturity of wood used in making cuttings had a significant role in rhizogenesis (Chadha, 2001). Hard wood cuttings respond better to the hormonal treatment as compared to semi hard-wood cuttings (Sharma *et. al.* 2009). The wood younger than 6 months and older of 18 months found unsuitable for the stem cuttings. Similarly, hardwood lateral shoots , which usually flower and fruit , are also unsuitable for propagation and such cuttings should be avoided. Usually, semi-hardwood cuttings give high sprouting but fail to root and establish subsequently (Rajan and Markose, 2007).

Generally, the length and diameter of stem cuttings have a impact on rooting rate and subsequent survival in the field after transplanting. As per reports, 6-12mm thick pomegranate stem cuttings have been found to be suitable for propagation (Reddy and Reddy, 1990; Dhillon and Sharma, 1992; Chadha, 2001; Rajan and Markose, 2007).Usually, use of plant growth regulators (PGRs) especially auxins improve rooting in stem cuttings of pomegranate. Basal cuttings with a diameter of 10-12.5mm when treated with 5000 ppm IBA showed the highest survival percentage, number and length of roots and number of shoots followed by sub-apical cuttings. A high C/N ratio and carbohydrate reserves was found to be responsible for the high success of rooting in basal cuttings (Purohit and Shekharappa, 1985). The quick dip method (Ghosh *et. al.* 1988; Hore and Sen, 1993) is mostly preferred over the prolonged dip method (Panda and Das 1990; Sandhu *et. al.* 1991; Dhillon and Sharma, 2002) for the treatment of stem cuttings. In the quick deep method, 30 second to 5 minute treatment was beneficial for inducing roots in the stem cuttings (Panwar *et. al.* 2001; Tripathi and Shukla, 2004; Saroj *et. al.* 2008). In cv. Ganesh, Indole - Butyric acid (IBA) at 5000ppm with the quick dip method (1 min dip)was optimum for getting higher rooting (73.3%) and field survival (Panwar *et. al.* 2001). Even, IBA at 3000ppm in talc under mist gave 80-100% rooting and survival rate in pomegranate (Rajan and Markose, 2007). Earlier, Ghosh *et. al.* (1988) tested the efficacy of IBA and NAA in pomegranate and found that IBA at 5000ppm effectively induced rooting (83.33%) in stem cuttings. Treating hardwood cuttings with IBA (2500 ppm) + paclobutrazol (2500 ppm) or IBA (2500 ppm) and NAA (2500 ppm) also increased rooting success in pomegranate (Reddy and Reddy, 1989, 1990). The use of p-hydroxybenzoic acid (PHB) + NAA (Hore and Sen, 1993) or PHB + IBA (Tripathi and Shukla, 2004) had also been reported effective for inducing roots in the stem cuttings. Very high sprouting (90.5-96%) in semi-hardwood cuttings with 2500ppm IBA was noted by Saroj *et. al.* (2008) under controlled environmental conditions. They reported that in general, phenol, protein and carbohydrates and the C/N ratio were higher in hardwood cuttings, but N content was higher in semi-hardwood cuttings. Even basal wounding along with use of IBA+NAA , each at 2500 ppm , in hardwood cuttings resulted in higher rooting with better root growth (Reddy and Reddy, 1989). Though, a lower concentration of IBA (100 ppm) in the prolonged dip method (24 hrs) with hardwood cuttings was also found beneficial for more rooting success (Sandhu *et. al.* 1991).

There are reports that rooting media play important role in the root proliferation and subsequently affecting growth of plants raised by stem cuttings. River silt medium showed quite encouraging result in response of rooting success, especially in hardwood cuttings (Baghel and Saraswat 1989; Deol and Uppal, 1990). Bahadur *et. al.* (2009) found that IBA at 750 ppm and rooting medium consisting of soil, sand and FYM in 2: 1: 2 ratio was the most suitable combination to raise pomegranate cuttings. Very high rooting (98%) in stem cuttings with ash medium was also reported (Hu *et. al.* 1993). The time of planting of stem cuttings in nursery and field conditions affect rooting and subsequent survival. Recently, different rooting media and planting time were tested for rooting in stem cutting of pomegranate. Vermiculite and sand media gave more than 85% rooting in pomegranate when planting was done in February under mist and bottom heat system (Khalil, 2013). High rooting success was recorded when cuttings were planted in November (Dhillon and Sharma, 2002). Saroj *et. al.* (2008) noted July-August and January-March as the most congenial period for multiplication through stem cutting in pomegranate.

(2) Air Layering- Air layering is very common in Deccan Plateau of India, especially in Maharashtra and Karnataka. Use of PGRs has been reported to induce

rooting in air-layers similar to stem cuttings. Hore and Sen (1995) found the highest rooting (99.35%) in air layers using PHB (1000 ppm) + IBA (5000 ppm). Bhosale *et. al.* (2009) indicated that sphagnum moss with IBA 5000 ppm could induce early rooting (17 days after layering) with 100% survival of air-layers. Similarly, Tomar (2011) recorded highest rooting (90%) in air layers with IBA 2000 ppm. However, the type of media used for layering also played role in rooting and survival of layers. In general, sphagnum moss is used as a substrate for air-layering (NRCP 2009), but soil, sand and cow dung manure in a 2: 1: 1 proportion was also reported as a suitable media for preparation of air-layers (Hore and Sen 1994).Under open condition June-August is optimum time for air-layering (Hegde and Sulikeri 1989; Hore and Sen 1995).However, in greenhouse with mist facilities planting can be done throughout the year. Ground layering is used for multiplication of pomegranate planting material as reported in other fruit crops.

(3) Stool layering- This technique has commercial implication in guava. Similar effort was made to propagate pomegranate and stool layering in cv. Bhagawa proved beneficial. A spacing of 0.5x0.5m or 0.75x0.5m was found to be optimum for stool layering under Solapur condition of Maharashtra (NRCP 2009). This could be one of the options for multiplication of planting material in pomegranate especially for small and marginal farmers in semiarid regions.

(4) Grafting - Grafting is not a common method of propagation in pomegranate although it had been reported earlier (Asadov 1987; Levin 2006). Though, systematic work on this aspect is very much lacking. Kar *et. al.* (1989) explored the possibility for top working in wild pomegranate by budding and grafting methods. They reported that May, June and July were optimum time for top working. Side veneer grafting gave 100% success. Hamid and Homayoun (2011) found bench grafting a suitable grafting method in pomegranate. They reported 85.83% graft success in wedge grafting. In the recent past, Chandra and Jadhav (2012) standardized grafting methods and time in pomegranate. They noted higher scion sprouting (96.67%) when wedge grafting done on 30th January at 21 days after grafting (DAG). Though, maximum graft success (85.83%) was recorded at 90 DAG with wedge grafting done on 30 January. The growth performance of wedge grafted plants was better with 15 December grafting. In general, the wedge grafted plants had better scion-rootstock compatibility than tongue grafting. Wedge grafting done on 30 January produced more shoot and root biomass owing to its better shoot and root development Rootstock concept has not yet been fully developed in pomegranate and information on rootstock is very meager. Hamid and Homayoun (2011) tested 3 rootstocks for grafting in pomegranate with Gorj-e-Dadashi and Gorj-e-Shahvar as scion varieties. The rootstocks influenced bud take, shoot fresh and dry weight with better scion and rootstock compatibility. However, looking into soil salinity, alkalinity, drought, high density planting, wilt and other biotic and abiotic problems, the significance of rootstock is the need of hour. National Research Centre on Pomegranate, Solapur has already initiated some work on rootstock but it is in preliminary stage. Wild pomegranate accessions collected from Western Himalayas are thriving very well under Solapur condition with good bearing capability. These germplasm could be of great value for rootstock in years to come.

(5) Budding- The method of budding is the most common technique for plant propagation in commercial nurseries in different fruit crops but, little work has been done in pomegranate. Recently, Chandra *et. al.* (2013) reported patch budding a successful technique for budding on wild pomegranate rootstock. They reported more than 90% success by this method. However, the performance of budded plants is yet to be evaluated.

(6) Stenting- Recently, stenting technique of propagation has been standardized in pomegranate. In this method, cutting and grafting is performed simultaneously (Hamid**,** 2011). The scion is grafted onto a nonrooted rootstock. The formation of the union and adventitious roots on the rootstock occurs simultaneously. With this method time can be minimized for grafting and such plants established well when planted into the field. In fact stenting is now being used worldwide by rose growers (Nazari *et. al.* 2009) and is also a valuable technique in propagating species of conifers and also rhododendron, apple, plum and pear (Hartman *et al.*, 2002). Hamid (2011) found that the scion length was reduced by grafting on Gorj-e-Dadashi, Gorj-e-Shahvar and Gool Safid-e-Ashk-e-Zar.

(7) Tissue culture- The demand of disease free healthy planting material is growing very fast in India as well as in the world. Conventional method of propagation may not be sufficient to satisfy the ever growing demand of healthy planting materials. Thus, mass multiplication of pomegranate through tissue culture is very much required to bridge the gap between demand and supply of planting material. For *in vitro* propagation, apparently healthy plants with proven horticultural traits are used for excising the explants (Debergh and Maene 1981). Selection of ideal explants with proper pretreatments and surface sterilization prior to inoculations are key to successful culture establishment Damiano *et.al.* (2008) could successfully able to sterilize auxillary bud segments using NaOCl and Na methiolate with 65 per cent culture establishment.

Browning of cultures is a major obstacle in establishment of explants of pomegranate owing to high phenolic contents and frequent subculturing, use of adsorbants and antioxidants are very effective in lacking browning (Murkute *et. al.* 2003). Mahishni *et. al.* (1991) cultured shoot tip explants on MS medium and subsequently transferred them to Lloyd and McCrown woody plant medium for rapid growth and elongation of shoots. They achieved 80% success in establishment of plantlets in 1: 1: 1 (v/v) peat, perlite and sand mixture. Fougat *et. al.* (1997) achieved axillary branching of nodal segments and proliferation of shoot tip meristems was best on MS medium supplemented with 0.5 mg/l kinetin, 1.0 mg/l BA and 500 mg/l CH (cycloheximide) ,although rooting was the best on MS medium supplemented with 4.0 mg/l NAA, 2.0 mg/l kinetin and 15% CW (coconut water). Kantharajah *et. al.* (1998) found lower salt concentration in culture medium had beneficial effect on *in vitro* rooting. They obtained highest rooting higher number of roots per micro shoot on WPM medium supplemented with 2 mg/l NAA. Naik *et. al.* (1999) described an efficient procedure for *in vitro* clonal propagation in 'Ganesh' using nodal stem segments. Patil *et. al.* (2011) found nodal segments of Bhagawa on MS medium supplemented with 0.2-2mg/l BA, 0.1-1.0mg/l NAA and 0.5-0.25 mg/l $AgNO_3$. Again, Naik *et. al.* (2003) observed that the addition of ethylene inhibitors like $AgNO_3$ (10-40 ìM) and amino ethoxy vinylglycine (AVG) (5-15 ìM) to MS medium containing BA and NAA markedly enhanced the regeneration frequency as well as the number of shoots per explant of pomegranate. Among different strategies adopted for enhancing hardening of *in vitro* raised plantlets, maximum success (89%) was achieved by the use of glass jars with polypropylene caps (Singh *et. al.* 2007). In the recent past, attempts were made to produce synthetic seeds in pomegranate (Naik and Chand, 2006). However, they were successful in encapsulating nodal segments from *in vitro* proliferated shoot cultures or axenic cotyledonary nodes. Protocols for regeneration of pomegranate have been developed and its commercialization has already been started in Maharashtra. Recently, NRC on Pomegranate, Solapur also developed protocol and multiplication of tissue cultured plant on public private partnership has been started through private firm.

Reference

Asadov, K. S. 1987. Forest orchards in Azerbaidzhan. *Lesnoe Khozyaistvo,* 9: 59-60.

Baghel, B. S. and Saraswat, B. K. 1989. Effect of different rooting media on rooting and growth of hardwood and semi-hardwood cuttings of pomegranate (*Punica granatum* L.). *Indian J. Hort.,* 46: 458-62.

Bahadur, V., Hota, R. K., Singh, D. and Singh, D. B. 2009. Effect of rooting media and indole butyric acid on rooting and survival of cuttings in pomegranate (*Punica granatum* L.). In: *Proceedings of the 2nd International Symposium on Pomegranate and Minor Including Mediterranean Fruits*, University of Agricultural Sciences, 23-27, June 2009, Dharwad. pp. 73.

Bhosale, V. P., Jadhav, R. G., Masu, M. M., Sitapara, H. H. and Patel, H. C. 2009. Response of different media and plant growth regulators on rooting and survival of air-layers in pomegranate (*Punica granatum* L.) cv. Sinduri. In: *Proceedings of the 2nd International Symposium on Pomegranate and Minor Including Mediterranean Fruits*, University of Agricultural Sciences, 23-27 June 2009, Dharwad. pp. 72-73.

Cervelli, C. and Belletti, P. 1994. Effect of thermic treatments and seed manipulation on emergence of dwarf pomegranate *(Punica granatum* L. 'Nana'). *Acta Hort.,* 362: 189-95.

Chadha, K. L. 2001. *Handbook of Horticulture* (1st edn.), Indian Council of Agricultural Research, New Delhi, pp. 299.

Chandra, R. and Jadhav, V.T. 2012. Grafting methods and time in pomegranate (*Punica granatum*) under semi-arid agro-climatic condition of Maharashtra. *Ind. J. Agr. Sci.*, 82(11):990-992.

Chandra, R., Babu, K. D., Jadhav, V. T. and Silva, J. T. 2010. Origin, history and domestication of pomegranate. *J. Fruit Veg. Cereal Sci. Biotech.,* 4: 1-6.

Chandra, R., Singh, N.V. and Pal, R.K. 2013. Patch-budding in pomegranate- an easy in-situ budding technique. *ICAR News.,*19 (2):1-2.

Damiano, C, Padro, MDA and Frattarelli, A. 2008. Propagation and establishment *in vitro*of myrtle (*Myrtus communis* L.) pomegranate (*Punica granatum* L.) and mulberry (*Moras alba* L.). *Prop. Orn. Pts.,* 8(1): 3-8.

Debergh, P.C. and Maene, L. 1981. A scheme for commercial propagation of ornamental plants by tissue culture. *Sci. Hort*., 14:335-345.

Deol, I. S. and Uppal, D. K. 1990. Effect of different rooting media on rooting and growth of hardwood and semi hardwood cuttings of pomegranate (*Punica granatum* L.). *Punjab Hort. J.* ,30: 141-4.

Dhillon, W. S. and Sharma, K. K. 1992. Effect of indole butyric acid (IBA) on rooting of cuttings in pomegranate (*Punica granatum* L.). *J. Res. Punjab Agri.,* 29:350-53.

Dhillon, W. S. and Sharma, K. K. 2002. Rhizogenesis

of pomegranate in relation to planting time and cutting thickness. *Indian J. Hort.*, 59: 150-52.

Fougat, R. S., Panday, S. B., Ahmad, T. and Godhani, P. R. 1997. *In vitro* studies in pomegranate (*Punica granatum* L.). *J. Applied Hort.*, 3**:** 23-9.

Ghosh, D., Bandyopadhyay, A. and Sen, S. K. 1988. Effect of NAA and IBA on adventitious root formation in stem cuttings of pomegranate (*Punica granatum* L.) under intermittent mist. *Indian Agri.*, 32: 239-43.

Hamid, R.K. 2011. Stenting (cutting and grafting) - A technique for propagating pomegranate. *J. Fruit Ornam. Plant Res.*, 19(2):73-79.

Hamid, R.K. and Homayoun, F. 2011. Study of pomegranate (*Punica granatum* L.) propagation using bench grafting. *J. Fruit Ornam. Plant Res.* ,19(2):67-72.

Hartman H.T., Kester D.E., Davies Jr. F.T., Geneve R.L. 2002. Plant Propagation: Principles and Practices. 5th Ed, Prentice-Hall Inc. Englewood, Cliffs, NJ., USA, 647 p.

Hegde, N. K. and Sulikeri, G. S. 1989. Effect of indole butyric acid (IBA) on the rooting of air-layers of pomegranate. *Current Res. Univ. Agri. Sci.*, 18: 161-2.

Hore, J. K. and Sen, S. K. 1993. Root formation in pomegranate (*Punica granatum* L.) stem cuttings with NAA and auxin synergists under intermittent mist. *Crop Res.*, 6: 252-7.

Hore, J. K. and Sen, S. K. 1994. Root formation in air-layers of pomegranate with NAA and auxin synergists. *Ann. Agri. Res.*, 15: 310-4.

Hore, J. K. and Sen, S. K. 1995. Role of non-auxinic compounds and IBA on root regeneration in air-layers of pomegranate. *Current Res. Univ. Agri. Sci.*, 24: 83-5.

Hu, X. B., Deng, H. N. and abd Shao, C. 1993. Study on propagation of fruit crops by cuttings with full illumination and intermittent misting. *J. Fruit Sci.*, 10: 92-4.

Jalikop, S. H. 2007. Linked dominant alleles or inter-locus interaction results in a major shift in pomegranate fruit acidity of Ganesh x Kabul Yellow. *Euphytica*, 158: 201-7.

Kantharajah, A. S., Dewitz, I. and Jabbari, S. 1998. The effect of media, plant growth regulators and source of explants on *in vitro* culture of pomegranate (*Punica granatum* L.). *Erwerbsobstbau*, 40: 66-8.

Kar, P. L., Singh, R. P. and Chadha, T. R. 1989. Studies on the standardization of top working technique in wild pomegranate trees. *Hort. J*,. 2: 68-70.

Khalil, A. 2013. Effects of Different Collecting time and Different Medium on Rooting of Pomegranate " Malas torsh cv." Cuttings. *Bulletin of Environment, Pharmacology and Life Sciences*, 2(12):164-168.

Levin, G. M. 2006. *Pomegranate* (I[st] Edn.). Third Millennium Publishing, East Libra Drive Tempe, AZ, pp. 13-120.

Mahishni, D. M., Muralikrishna, A., Shivashankar, G. and Kulkarni, R. S. 1991. Shoot-tip culture method for rapid clonal propagation of pomegranate (*Punica granatum* L.). In: *Horticulture New Technologies and Application*, Prakash, J. and Pierik , R. L. M. (Eds.). Kluwar Academic Publisher Dordrecht, Netheralnds. pp. 215-217.

Murkute, A. A., Patil, S. and Mayakumari 2003. Exudation and browning in tissue culture of pomegranate. *Agri. Sci. Dig.*, 23: 29-31.

Naik, S. K. and Chand, P. K. 2006. Nutrient-alginate encapsulation of *in vitro* nodal segments of pomegranate (*Punica granatum* L.) for germplasm distribution and exchange. *Sci. Hort.*, 108*:* 247-52.

Naik, S. K. and Chand, R. 2003. Silver nitrate and aminoethoxy-vinylglycine promote *in vitro* adventitious shoot regeneration of pomegranate (*Punica granatum* L.). *J. Plant Physio.*, 160: 428-30.

Naik, S. K., Pattnaik, S. and Chand, P. K. 1999. *In vitro* propagation of pomegranate (*Punica granatum* L. cv. Ganesh) through axillary shoot proliferation from nodal segments of mature tree. *Sci. Hort,*. 79: 175- 83.

Nazari F., Khosh-Khui M., Salehi H. 2009. Growth and flower quality offour *Rosa hybrida* L. cultivars in response to propagation by stenting or cutting in soilless culture. *Sci. Hort.*, 119: 302-305.

NRCP, 2007. *Annual Report.* National Research Centre on Pomegranate, Solapur, Maharashtra. pp. 5.

NRCP, 2009. *Annual Report 2008-2009.* National Research Centre on Pomegranate, Solapur, Maharashtra, India, pp. 1-15.

Panda, J. M. and Das, R. C. 1990. Regeneration of pomegranate stem cuttings treated with IAA and IBA under intermittent mist. *Orissa J. Hort.*, 18: 32-7.

Panwar, R. D., Kaushik, R. A., Surinder Singh, Gupta, R. B. and Singh, S. 2001. Effect of indole butyric acid (IBA) on rooting of hard-wood cuttings in pomegranate (*Punica granatum* L.). *Haryana J. Hort. Sci.*, 30: 72.

Patil, A. V., Karale, A. R., Bose, T. K. 2002. Pomegranate. In: Fruits: Tropical and Subtropical (Vol 2). T. K. Bose, S. K. Mitra

and D. Sanyal (Eds.). Naya Udyog, Bidhan Sarani, Calcutta, India. pp. 125-162.

Patil, V.M., Dhande, G.A., Thigale, D.M., Rajput, J.C., 2011. Micropropagation ofpomegranate (Punica granatum L.) 'Bhagava' cultivar from nodal explant. *Afr. J. Biotechnol*., 10, 18130-18136

Purohit, A. G. and Shekharappa, K. E. 1985. Effect of type of cutting and indole butyric acid on rooting of hardwood cuttings of pomegranate (*Punica granatum* L.). *Indian J. Hort.,* 42: 30-6.

Rajan, S. and Markose, B. L. 2007. Propagation of horticultural crops. In: *Horticulture Science Series* (6). K. V. Peter (Ed.). New India Publishing Agency, New Delhi. pp. 81-84.

Reddy, Y. T. N. and Reddy, Y. N. 1989. Rooting of pomegranate cuttings as influenced by paclobutrazol, polythene covering and basal wounding. *Indian Farm.,* 39: 27- 8.

Reddy, Y. T. N. and Reddy, Y. N. 1990. Effects of basal wounding, growth regulator and polythene covering on rooting of pomegranate cutting. *J. Maharashtra Agri. Univ.,* 15: 153-5.

Sandhu, A. S., Minhas, P. P. S., Singh, S. N. and Kambhoj, J. S. 1991. Studies on rhizogenisis in hard wood cuttings of pomegranate. *Indian J. Hort.,* 48: 302-4.

Saroj, P. L., Awasthi, O. P., Bhargava, R. and Singh, U. V. 2008. Standardization of pomegranate propagation by cutting under mist system in hot arid region. *Indian J. Hort.,* 65: 25-30.

Seeram, N. P., Zhang, Y., Reed, J. D., Krueger, C. G. and Vaya, J. 2006. Pomegranate phytochemicals. In: *Pomegranates: Ancient Roots to Modern Medicine.* N. P. Seeram, R. N. Schullman and D. Heber (Eds.). CRC Press Taylor and Francis Group, Boca Raton, Florida. pp. 3-29.

Sharma, N., Anand, R. and Kumar, D. 2009. Standardization of pomegranate (*Punica garanatum* L.) propagation through cuttings. *Biological Forum Int. J.*, **1**(1): 75-80.

Singh, N. V., Singh, S. K. and Patel, V. B. 2007. *In vitro* axillary shoot proliferation and clonal propagation of 'G-137' pomegranate (*Punica granatum* L.). *Indian J. Agri. Sci.,* 77: 509-11.

Tomar, K.S. 2011. Effect of different concentrations of growth regulators on rooting and survival percentage of pomegranate air layers. *Progressive Agriculture.,* 11:431-433.

Tripathi, S. N. and Shukla, H. S. 2004. Propagation of pomegranate (*Punica granatum* L.) cultivars by stem cuttings with indole butyric acid and p-hydroxybenzoic acid. *Indian J. Hort*., 61: 362-5.

Yesiloglu, T., Gubbuk, H., Polat, E. and Erkan, M. 1997. The effects of girdling and scoring of cuttings on the rooting rate and quality of nursery plants of pomegranate. *Acta Hort.,* 441: 407-10

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Isabgol (*Plantago ovata* Forsk) improvement through induced mutagenesis -A review

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Abstract

Isabgol (*Plantago ovata* Forsk) is a wonder medicinal plant in the Unani and Ayurvedic system of medicines. In this crop the major limiting factors for yield are narrow genetic base, and lack of variability on account of low chromosome number, small chromosome size, presence of high heterochromatin in the chromosomes, low chiasmata frequency, low recombination index and shattering. It is known only under cultivation and no wild plants have been reported so far. Several efforts have been made in the part of genetic improvement of this economically important plant. Keeping in view limited success of these experiments, fresh breeding efforts for improvement in several quantitative and qualitative traits need to be undertaken. Some of the traits need to be improved are increase in the seed size and yield, development of compact and non-shattering spike and production of seeds with higher swelling factors and resistance to biotic and a biotic stresses. In recent time, mutagens have been important tools in crop improvement. These mutagens have been used to produce high yielding varieties like Niharika and RI-1. The over all review on mutation breeding of isabgol suggest to focus in future for developing shattering resistant varieties.

Key words: *Isabgol, mutation, gamma rays, radiation, EMS*

Introduction

Isabgol is also known as Blond psyllium (Trease and Evans, 1978). It belongs to the family Plantaginaceae with chromosome number 2n=8. Isabgol is a plant of West Asian origin and was introduced in India during Muslim settlement in middle age. It is a cross pollinated crop (Husain *et a*l, 1984). About 260 *Plantago* species have been found in temperate regions and tropical zones(Vander Aart andVulto,1992). Among them 10 are found in India out of which only two are economically important, they are *Plantago ovata* Forsk. (Blond psyllium) and *P. psyllium* L. (French psyllium).

Isabgol is a short-stemmed annual herb of 10-45cm tall and number of tillers vary from 3 to75.A large number of flowering shoots arises from the base of the plant. Flowers are numerous, small and white (Dhar et al.,2005).The flowers are bisexual, tetramerous and protogynous with flowers maturing occurring in acropetal succession. Thus,the gynoecium of the most flowers matures first, protruding its stigma through the tip of the unopened flower and androcium mature later (Dalal and Sriram,1995).

Isabgol is the first ranking export commodity among medicinal plants in India. About 13,000 tonnes of seeds and 3,200 tonnes of seed husk are produced annually, 90 per cent of which is exported to Europe (Lal *et al*., (1999). India continues to rank first in its production and trade in the world market. About 17508 tones of isabgol husk (worth Rs.171 crores) and 1067 tones of isabgol seed (worth Rs.6 crores) was exported during(2002 (Anonymous, (2003). In Rajasthan it is grown in 214188 hectares area with the production of the 113344 tonnes and a productivity of 529 kg. /ha (Anonymous,(2011). The state of Rajasthan in India provides 60% of the world's production, while the jalore district alone accounts for 90% of Isabgol production in Rajasthan.

Isabgol has been proved beneficial in habitual constipation, chronic diarrhea and dysentery and irritation of digestive tract (Viqar *et al*., 2002). The husk or mucilaginous seed coat has the property of absorbing and retaining water and therefore, it has numerous pharmaceutical uses principally as a swelling dietary and potentially for lowering blood cholersterol level (Goswami, 1988). After removing husk the seeds are used as cattle and poultry feed containing about 17 to 19 per cent protein (Dalal and Sriram, 1995).

Mutagenesis and Mutation

Physical mutagens are also known as radiation. Radiation was the mutagenic agent known for its effect on genes and first reported in 1920. Radiation itself was discovered in 1890. Roentgen discovered X-rays in 1895. Becquerel invented radioactivity in 1896 and Marie and Pierre Curie

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discovered radioactive element in 1898. The physical mutagen includes, ionizing and non ionizing radiations. Chemical mutagens bring about changes in the hereditary after treatments and detail of such interaction between mutagens and DNA was invented by Freese and Freese (1966); Hollender (1971); and Auerbach (1976).

In isabgol, hybridization is cumbersome due to very small size of flower .Therefore, mutation breeding is the ultimate source of genetic variation (Stebbins 1950) .It provides raw material upon which other factors of evolution act and therefore all new species ultimately arises from mutation. After Muller (1927) and Stadler (1928), several pioneer workers demonstrated the potential significance of inducing useful mutations *viz.,* Nilson-Ehle (1948), Muller (1957) and Swaminathan (1969). Mutation induction through the application of irradiation was most frequently used for developing mutant varieties (89%) in seed propagated crops whereas use of chemical mutagens was relatively infrequent. Sixty four percent mutant varieties have been developed through gamma rays and 22% by X rays. The majority of the accessions (75%) is of crop plants and 25% ornamentals and decorative plants. There have been more than 2700 official released mutant varieties from 170 different plant species in more than 60 countries out of the world that not only increased biodiversity but also provide breeding materials for conventional plant breeders, thus it directly contribute to the conservation and use of plant genetic resources. In India, so far 259 varieties are developed through induced mutagenesis out of which 3 varieties have been developed in isabgol. Close to 90% of these officially released mutant varieties were produced using radiation and contribute billions of dollars of additional income to farmers annually (Ahoowalia *et al.*,2004).

A very scanty work has been initiated in the field of mutation breeding in isabgol. However, this review will focuses on the few developments made on these aspects to emphasize the need to do more research in the days ahead.

Polyploids were obtained by treating the diploid seeds with 1.0% colchicine solution for 16 to 18 hr .(Chandler, 1954). These polyploids were more robust than the diploids. Pollen grain size, seed size (36%) and quality of mucilage (22%) were greater in polyploids but fertility reduced (9.26%). Yet Chandler suggested that increase in seed size and the amount of mucilage as well as vegetative vigour in tetraploids compared with diploids is of decided commercial interest and this more than compensate for the reduction in fertility. However, Mital *et al.*,(1975) found that low spike bearing capacity and small spikes were responsible for low yield and suggested that intensifying selection in polyploid population to improve upon their economic and agronomic base has a promise. Bhagat and Hardas (1980) examined the effect of induced chemical mutagens on accession IC7739. They observed that mutagenic progenies were early and showed pronounced improvement in tiller number, spike number and spike length as well as seed yield which was 40.4% higher than that IC 7739.(EMS) and(NMU) were found effective in broadening the spectrum of polygenic variation. Gamma rays induced genetic variability was studied by irradiating the seed under nitrogen atmosphere and found that dose of 40 and 80 Kr is suitable for efficiently inducing variability for maturity and synchronization of flowering (Patel *et al*., 1981).A decrease in swelling factor and zylose content, after irradiation at 25 Kr has been reported by Sodhi *et al.,* (1989).Further, they observed no significant change at a dose of 10Kr. In M_1 generation plant height stimulated at lower doses, but inhibited at higher doses whereas in M_2 increased dose gave significant reduction in plant height, unlike tillers and spike number were more at 40Kr but in M_2 these were progressively reduced at higher doses. Seed weight was more than twice in M_1 and M_2 than that of control. In another study they reported that 60 and 120 Kr dose had promotry effect. Still higher doses than that of 140kr dose reduced the germination rate to 29.68% of the control. Germination %, seedling height and seedling dry weight declined with increasing dose of gamma rays as well as EMS. Sareen and Koul (1991 and Sareen et al.,(1999) concluded that LD_{50} was between 120 and 140Kr of gamma rays and in between 0.5 to1.0% of EMS. They further reported substantial increase in reproductive output of variants induced by gamma rays in isabgol. The treated seeds allocated more resources to reproductive functions at both flowering and fruiting stages. Comparatively more resources were mobilized for female function which resulted in increased reproductive output of treated seeds. Mutagenesis induced changes in mean values for different agronomic and yield-related traits in both positive and negative directions. A new variety Niharika which is a gamma rays induced mutant was developed by CIMAP, Lucknow(U.P) for commercial cultivation in northern plains of India (Lal *et al*., 1998).Simultaneously a promising genotype, M 20-22, was also identified which gives a better seed yield than Gujarat Isabgol-1 under the north Indian plain conditions (Lal *et al.*, 1999).It has been found that morphological deformities were more frequent with physical mutagen than the chemical mutagen or in combination. The effectiveness of mutagens, in general decreased with increasing dose or concentration. The maximum effectiveness and efficiency has been found between 40 Kr treatment of gamma rays on the basis of M_1 lethality, pollen sterility and M_2 seedlings. The apparent physiological damage

and various miotic and meotic abnormalities due to mutagenic treatments adversely affected mutagenesis and therefore, impeded the recovery of mutation in isabgol (Singh and Rathore, 2000). A wide range of viable morphological mutants were isolated and the spectrum of viable mutations was wider. Pollen fertility declines with increased doses of gamma rays irradiation and at more than 50 Kr doses also reduces seed germination. According to Lal and Sharma (2002) LD_{50} was found to be between 40-50 Kr doses**.** Jain *et al*., (2005) reported that frequency of morphological and chlorophyll mutations increased with increasing doses of gamma rays, with the highest (1.92%) being observed with 135 Kr. Occurrence of chlorophyll mutants were rare than morphological mutants. Xantha-type chlorophyll mutants and sterile spikes were produced at higher doses of radiation while other mutants were present at almost all the doses of radiation. Mutagenic effectiveness and efficiency were high at low to moderately high doses of gamma rays (15 KR to 90Kr). The 15 Kr dose was the most effective treatment, while the efficiency measured on per cent seedling height reduction and reduction in pollen fertility was maximum at 75 and 45Kr, respectively. At 75 Kr the on per cent reduction was maximum in both seedling height and pollen fertility. Thus, for obtaining highest efficiency in mutation breeding experiments, gamma rays doses ranging between 45 to 90Kr may be used in this crop. Sivaneson and Ranwah (2009) evaluated 33 M_6 progenies and found that *per se* performance of DR 2 and PN 87 were superior for most of the traits. Higher magnitude of genotypic and phenotypic coefficient of variance(GVC) and(PCV), heritability value along with high genetic gain was observed in percent disease index at 90 days after sowing and total phenolic compounds in leaves .A high yielding genotype for arid western plain of Rajasthan RI-1 was developed through mutation breeding and recorded more than 10% higher seed yield of their various checks (RI-89 and GI-2) **(** Kumar et al., 2009). Sharma and Gahlot (2010) reported concomitant decrease in germination percentage as the dose of gamma irradiation increased from 400 to 600 Gy with 50 per cent reduction in germination at 600 Gy. Pollen fertility declined with increased dose of irradiation as compared to control. M_1 damage was observed in the form of deformed leaf morphology *viz.*, broad leaves, thin and narrow leaves, different types of inflorescence mutants, blunt end leaf, small leaves etc. Occurrence of chlorophyll mutants were rare than morphological mutants. Xantha type chlorophyll mutants and sterile spikes were produced at higher doses of radiation as where other mutants were also present at almost all the doses. Mali and Sharma (2012) found that mutant lines viz,. RBIM-2-12, RBIM-6-13, RBIM-7-10, RBIM-7-16, RBIM-1-11 and RBIM-8-14 exhibited high mean performance for seed yield along with other traits . These mutants could be utilized in future programme in order to get superior varieties. The high GCV and PCV was recorded for biological yield per plant**,** seed yield per plant and leaf area. The high estimates of heritability coupled with high genetic advance were recorded for number of effective tillers per plant, biological yield per plant, seed yield per plant and leaf area. Therefore, these characters can aid in selection programme.

Conclusion and further prospects

Isabgol is important for its seeds and husk which have been used as a laxative for centuries both in India and abroad. Since the existing variability in this crop is limited, induced mutation breeding may be initiated to increase its variability. The most potential application of mutation breeding in crop improvement is the creation of genetic variability for qualitative and quantitative traits which can in turn be utilized by plant breeders. Many workers have reported that yield potential has been increased by many folds in this crop through mutation breeding. Nevertheless, major constraints in realizing the full potential of already poor yielding varieties is a problem of seed shattering, which need immediate attention as the seed is correlated with husk production. It is a very sensitive crop and even moderate dew causes considerable damage by allowing the formation of abscission layer on the ovary wall where it cracks and the seeds fall off. However, being sensitive to shattering, its wider spread adoption by the farmers is not gaining ground. Therefore, there is an immediate need for identification of donors having genes for tolerance to shattering. To overcome this problem the indehiscent capsules in *Plantago macrocarpa* species presents ample scope for breeding tolerant to the formation of the abscission layer by mutation breeding or wide hybridization.

References

Anonymous 2003. Area and Production of Isabgol in each district of Rajasthan. Directorate of Econ. and Stat. Raj., Jaipur.

Anonymous 2011. Sustainable production technology in Rajasthan. Raj. Agric. Univ. Mandore, Jodhpur.

Bassett, I.J. and Baum, B. R. 1969. Co specificity of *Plantago fastigiata* of North America with *P.ovata* of the old world. *Can. J. Bot*., 47: 1865-68.

Bhagat, N.R. and Hardas, M. W. 1980. Studied on induced and natural polygenic variation in *Plantago ovata* Forsk. *Indian Drugs,* 17 : 376-381.

Chandler, C. 1954. Improvement of Plantago for mucilage production and growth in the United States. Contribution from Boyce

Thompson Inst., 17: 249-59.

Dalal, K. C. and Sriram, S. 1995. Advances in horticulture - Vol II medicinal and aromatic plants, (Eds. K.L. Chadha and Rajendra Gupta). Malhotra Publishing House, New Delhi.

Dhar, M. K., Kaul, S., Sareen, S. and Koul, M. K. 2005. *Plantago ovata* : Genetic diversity, cultivation, utilization and Chemistry. *Plant Genetic Resources :Characterization and Utilization*, 3(2) : 252-263.

Goswami, S. 1988. Effect of isabgol on serum lipids. *Ancient Science of Life*, 7: 321-331.

Hollaender, A. 1971. Chemical mutagens . 1 and 2 Plenum press, New York London.

Husain, A., Sharma, J. R., Puri, H. S. and Tyagi, B. R. 1984. Genetic Resources of important Medicinal and Aromatic plants in South Asia. CIMAP, Lucknow (India). pp. 52-72.

Hyde, B. 1953. Differential chromosomes in *Plantago ovata. Amar J. Bot.*, 40 : 809-815.

Jain, D. K., Ranwah, B. R., Bordia, P. C. 2005. Mutagenic effectiveness and efficiency of gamma rays in isabgol (*Plantago ovata* Forsk). *Crop Improvement*, 32: 71-77.

Kumar, S. R., Beniwal, B. R. and Choudary, B. R. 2009. A highflying genotype of isabgol for arid western plain of Rajasthan. *Ann. Arid Zone*, 48(2): 169-170.

Lal, R. K., Sharma, J. R. and Mishra, H. O. 1999. Induced variability and varietal selection in isabgol *(Plantago ovata). J. Medi. and Arom. Pt. Sci.*, 21: 34-37.

Lal, R. K., Sharma, J. R. and Misra, H. O. 1998. Register of new genotypes and development of new variety 'Niharika' of isabgol (*Plantago ovata*). *J. Med. and Arom. Pl. Sci*., 20: 421-422.

Lal, R. K. and Sharma, J. R. 2000. Effects of gamma irradiation (Co60) on economic traits in isabgol (*Plantago ovata*). *Journal of Medicinal and Aromatic Plant Sciences,* 22: 251-255.

Lal, R. K. and Sharma, J. R. 2002. Induction by gamma irradiation (^{60}Co), characterization and utilization of mutants for economic traits in isabgol (*Plantago ovata*). *Journal Medicinal and Aromatic Plant Sciences*, 24: 3, 689-694.

Mali and Sharma, A. K. 2012. Studies on genetic variability, character association and genetic divergence in M_5 generation in isabgol (*Plantago ovata* Forsk). M.Sc. Thesis, SKRAU, Bikaner.

Mital, S. P., Bhagat, N. R. and Maheswari, M. L. 1975. Improvement of *Plantago ovata (*Forsk) through tetraploid and mutation breeding. *Indian J. Agric. Sci.*, 45:426-429.

Mullar, H. 1927. Artificial transmutation of gene. *Science*, 66: 84-87.

Patel, D.R., Sriramand, S. and Dalal, K. C. 1981. Gamma rays induced genetic variability in isabgol (*Plantago ovata*).Paper presented in the VI All India Workshop on medicinal and aromatic plants, held at Madurai.

Sareen, S. and Koul, A. K. 1991. Gamma rays induced variation in *Plantago ovata*. *Crop Improvement*, 18(2): 144-147.

Sareen, S., Koul, V. and Koul, A. K. 1999. Resources allocation in induced variants of *Plantago ovate* Forsk. *Crop Improvement*, 26(1): 38-45.

Sharma, A. K. and Gahlot, M. K. 2010. A bulletin on: Research and Development in isabgol. Published by COA, Bikaner.

Singh, R. K. and Rathore, R. K. S. 2000. Mutagenic efficiency and effectiveness of gamma rays, EMS and sodium azide individual and in combination on *Plantago ovata* Forsk. *J. Agril. Sci. Res., 36(1&2): 88-91.*

Sivaneson, S. and Ranwah, B. R. 2009. Induced genetic variability and character association in isabgol (*Plantago ovata* Forsk.). *Journal Medicinal and Aromatic Plant Sciences*, 31: 344-347.

Stadler, L. J. 1928. Mutation in barley induced by X rays and radium. *Science*, 141: 163-166.

Trease, G. E. and Ewans, W. C. 1978. Pharmacognosy. 11th Edition Bailliere Tindail, a division of Cassell and Collier, Macmillan publishers Ltd., London.

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Comparative performance of rainy and winter season guava cultivars under arid irrigated conditions of Punjab

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Abstract

Guava (*Psidium guajava* L.) is one of the most important tropical and subtropical fruits as it has a high nutritive value and can be grown under different soil and climatic conditions. It bears twice in a year but the best quality fruit is obtained in winter. A study was conducted to evaluate the performance of seven guava cultivars viz. Allahabad safeda, Apple colour, Behat coconut, Lalit, Lucknow 49, Pear shaped and Red fleshed at Regional Research Station, Abohar during the years 2010- 2012. Ripened fruits of all the varieties were collected from the orchard during winter as well as rainy season and analyzed for fruit weight, fruit yield, total soluble solids (TSS), acidity, Vitamin C and total sugars. The highest fruit yield was recorded in Lucknow -49 during rainy season (85 Kg/tree) followed by Lalit (79.0 kg) as well as during winter season (52.7 Kg/tree). The maximum content of Vitamin C (283.3 mg/100g pulp) was also recorded in Lucknow -49 during winter season harvest.

Key words : *Guava cultivars, fruit yield, Vitamin C, rainy season, winter season*

Introduction

Guava (*Pisidium guajava* L.) belongs to the family Myrtaceae. It is one of the important tropical and subtropical fruits because it has high nutritive value and can be grown under different soil and climatic conditions. Besides India, it is grown widely throughout the tropics of the world. It bears twice in a year but the best quality fruit is obtained during winter season. In India, guava ranks fourth after mango, banana and citrus fruits. It occupies 2.19 lac hec. of land with an annual production of 25.7 lac MT. It is a hardy fruit crop thriving well under a wide range of soil types varying from sandy loam to clay loam with a pH range of 4.5 to 8.2. Guava fruit is rich in 'Vitamin-C', minerals like calcium, iron and phosphorous with pleasant aroma and flavour (Dhaliwal and Dhillon, 2003). It has a great demand as a table fruit as well as in processing industry. Guava is a hundred percent edible fruit and is considered as “apple of the poor” due to its lower cost, easy availability and high nutritive value. It plays an important role in reducing nutritive disorders caused by the deficiency of Vitamin C in human health. Studies on evaluation of guava cultivars have been reported from different locations in India (Aulakh, 2005, Deshmukh et al., 2013, Ghosh et al., 2013). To evaluate the performance of different guava cultivars under arid irrigated region of Punjab, seven cultivars of guava were introduced in the year 2001 at Regional Research Station, Abohar. These cultivars were evaluated during rainy and winter season in the years 2010-2012 with the objectives to check the performance with respect to their quality and quantity attributes

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Materials and Methods

Seven cultivars of guava namely Allahabad safeda, Apple colour, Behat coconut, Lalit, Lucknow -49, Pear shaped and Red fleshed planted at a distance of 25'x25' were evaluated with respect to growth, yield and quality traits of fruit at PAU, Regional Research Station, Abohar during 2010-2012. The trial was replicated thrice. Three trees per replication were selected from established bearing orchard (Year of plantation: 2001) for each cultivar and data were taken from selected plants with respect to growth, fruit yield and quality attributes. Ten fruits of each variety were harvested randomly from each replication. The plants were irrigated at weekly interval in summer and at monthly interval during winter and the fertilizers were applied as per recommendation of Punjab Agricultural university, Ludhiana -FYM-50Kg, Urea- 1000g, SSP-2.5kg and MOP -1.5kg . FYM and half inorganic fertilizers are applied in May June and the remaining half were applied in September - October. The tree volume, fruit yield, fruit weight and physico-chemical analysis viz., TSS (%), acidity (%), Vitamin C (mg

/100g pulp) and total sugars (%) were assessed. The observations on tree volume were recorded in June-July. The total soluble solids (TSS) were determined with the help of digital refractometer. Acidity was quantified by titrating the juice against N/10 NaOH and expressed as per cent citric acid. Vitamin C of fruit was determined with the help of the method given in A.O.A.C. (1995) and total sugars were analyzed as per the method given by Dubois et al., (1956). The fruit characters of different guava cultivars were recorded at the time of harvesting of the crop during winter and rainy season. The data recorded during 2010, 2011 and 2012 was pooled before analysis.

Results and Discussion

Physical attributes

A perusal of the data presented in the present study reveals significant variation in the seven guava cultivars during the two harvesting seasons (Table 1). The highest tree volume (124.6 m3) was recorded for Allahabad safeda followed by Lalit (112.5 m3), Red fleshed (102.23 m3). During the rainy season highest fruit weight (165 g) was recorded for Lalit followed by Lucknow-49 (108 g), all other varieties bore fruits of less than 100 g. During the winter season Lucknow-49 out performed all other varieties in terms of fruit weight (271.6 g) followed by Lalit (219 g), Behat coconut (181.3 g) and Allahabad safeda (165 g). In general higher fruit weight was recorded during the winter season as compared to the rainy season for all the cultivars. The highest values for mean fruit yield (69.25 Kg/tree) and mean fruit weight (192 g) was recorded for cultivar Lalit, closely followed by Lucknow-49 having mean fruit yield (68.85 Kg/tree) and mean fruit weight (189.8 g). Variation shown in tree volume among different cultivars is a genetic character. The variation amongst cultivars with regard to fruit weight and yield / plant might be due to genetic make up, inherent characters and climatic adaptability which might be used as a diagnostic characteristic for selection of a cultivar for local conditions (Aulakh 2005, Patel et al., 2011). Varietal variations in guava for physical characters have also been reported by Sharma et al. (1998) and Singh et al. (2008)

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Quality attributes :

The results on fruit quality in terms of TSS, acidity and TSS: acid ratio are presented in Table 2. The maximum mean TSS content (13.2%) was recorded in Lucknow-49 followed by Lalit (11.6%) and Allahabad safeda (11.3%). All the cultivars showed higher TSS content during winter season as compared to the rainy season. The higher TSS content in winter might be due to enhanced utilization of nutrients and accumulation of carbohydrates into fruits of these cultivars during low temperature conditions. The cultivar Allahabad safeda showed minimum mean acidity per cent (0.32) followed by Lucknow-49 (0.38) and Apple colour (0.39). All the cultivars showed lower acidity during the winter season as compared to the rainy season. However, Allahabad safeda recorded 36% lower acidity in winter season (0.25%) against rainy season (0.39 %). Maximum mean TSS:acid ratio (37.57) was recorded in Allahabad safeda, closely followed by Lucknow-49 (34.52) owing to lower acidity in these cultivars.

The results with respect to Vitamin C and total sugars contents are depicted in Table 3. The Vitamin C and total sugar content varied significantly among different guava cultivars. Guava cultivar, Lucknow 49 showed highest Vitamin C content during winter (283.3 mg/100 g pulp) as well as in rainy season (185.7 mg/100 g pulp). The variation in Vitamin C content may be due to varietal variability and seasonal conditions (Deshmukh et al., 2013). The sugar is one of the important gradients for preparation of value added products from guava and high concentration of sugars is desirable for enhancement of taste of the fruit. The highest total sugar was recorded in Allahabad safeda during both the seasons (2.85 & 4.73 in rainy and winter seasons, respectively). The results obtained by us are in accordance with those of Babu et al. (2002) who reported that the cultivars Allahabad safeda and Lucknow 49 produced better quality fruits.

The winter season guava has a better market price as compared to the rainy season crop. The quality attributes, viz., fruit weight, TSS : acid ratio, Vitamin C and total sugars of the winter harvest scored an edge over the rainy season harvest crop with maximum fruit weight (271.6 g) and Vitamin C (283.3 mg/100 g pulp) in Lucknow-49 and maximum TSS: acid ratio (37.57) in Allahabad safeda. Nevertheless, the rainy season produce in terms of fruit yield is more in four (Allahabad safeda, Lucknow -49, Pear shaped and Lalit) amongst seven cultivars evaluated. It is suggested that the improvement of quality attributes of rainy season crop can enhance the marketing of rainy season crop as well.

Table 1.Tree volume, fruit yield and fruit weight of guava cultivars during rainy and winter seasons(2010-12)

Cultivars	Tree volume (m3)	Fruit Yield (Kg/Tree)			Fruit Weight (g)		
		Rainy Season	Winter Season	Mean	Rainy Season	Winter Season	Mean
Allahabad safeda	124.6	76.0	39.7	57.85	88.3	165.0	126.65
Apple Colour	95.73	28.0	28.3	28.15	81.0	115.0	98.00
Behat coconut	92.37	21.0	29.0	25.00	80.3	181.3	131.80
Lucknow-49	96.33	85.0	52.7	68.85	108.0	271.6	189.80
Pear shaped	94.33	27.3	18.7	23.00	65.7	117.7	91.70
Lalit	112.50	79.0	59.5	69.25	165.0	219.0	192.0
Red fleshed	102.23	19.7	26.0	22.85	79.0	130.0	104.5
CD (5 %)		6.0	6.9	--	7.63	17.9	--

Table 2. Total soluble solids and acidity content of guava cultivars during rainy and winter seasons(2010-12)

Cultivars	Total Soluble Solids (%)			Acidity (%)			TSS : Acidity ratio		
	Rainy	Winter	Mean	Rainy	Winter	Mean	Rainy	Winter	Mean
Allahabad safeda	10.9	11.8	11.3	0.39	0.25	0.32	27.95	47.20	37.57
Apple Colour	9.4	10.2	9.8	0.40	0.39	0.39	23.50	26.15	24.82
Behat coconut	9.9	10.3	10.1	0.50	0.37	0.43	19.80	27.84	23.82
Lucknow-49	12.7	13.8	13.2	0.40	0.37	0.38	31.75	37.29	34.52
Pear shaped	9.3	9.8	9.5	0.44	0.37	0.40	21.14	26.48	23.81
Lalit	10.6	12.6	11.6	0.50	0.35	0.42	21.20	36.00	28.60
Red fleshed	9.0	10.6	9.8	0.52	0.36	0.44	17.30	29.44	23.37
CD (5%)	0.26	0.35	--	0.11	0.008	--	--	--	--

Table 3. Vitamin C and total sugar content of guava cultivars during rainy and winter seasons (2010-12)

Cultivars	Vitamin C (mg/100 g pulp)			Total sugars (%)		
	Rainy	Winter	Mean	Rainy	Winter	Mean
Allahabad safeda	160.0	235.0	197.5	2.85	4.73	3.79
Apple Colour	174.3	211.7	193.0	2.76	4.66	3.71
Behat coconut	160.0	186.7	173.3	2.60	4.45	3.52
Lucknow-49	185.7	283.3	234.5	2.70	4.46	3.58
Pear shaped	164.3	210.0	187.1	2.61	4.43	3.52
Lalit	181.0	193.0	187.0	2.38	4.50	3.44
Red fleshed	18.00	205.0	192.5	2.45	4.16	3.30
CD (5 %)	5.01	16.10	--	0.041	0.093	--

References

A.O.A.C. 1995. Official methods of analysis. Association of Official Analytical Chemists. 16th ed. Washington DC.

Aulakh, P. S. 2005. Performance of different guava cultivars under arid irrigated conditions of Punjab. *Prog. Hort.*, 37: 328-30.

Babu, K. D., Dubey, A. K. and Yadav, D. S. 2002. Evaluation of guava cultivars for their performance under mid hill altitude of Meghalaya. *Indian J of Hill Farming*, 15 : 119-21.

Deshmukh, N. A., Lyngdoh, P., Jha, A. K., Patel, R. K and Bidyut, C. D. 2013. Comparative study on newly developed guava hybrids with commercial cultivars under mid hills of NE India. *The Bioscan*, 8(4) : 1467-70.

Dhaliwa,l G. S. and Dhillon, S. K. 2003. Effect of tree size on Physico-chemical characteristics of fruits of guava cv. Sardar. *Indian Journal of Horticulture*, 60: 312-17.

Dubois M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. and Smith, F. 1956. Colorimetric methods for determination of sugars and related substances. *Ann. of Chemistry*, 28: 350-56.

Ghosh, S.N., Roy, S. and Bera, B. 2013. Study on performance of twenty one guava cultivars in red and laterite soil of west Bengal under irrigated conditions. *J of Crop and Weed*, 9(2) : 81-83.

Patel, R. K., Deka, B. C., Babu, K. D., Singh, A., Deshmukh, N. A., Nath, A., Chandra, R., Patel, R. S. and Ngachan, S.V. 2011. Guava production technology. Technical Bulletin. Published by ICAR Research Complex for NEH region, Meghalaya, p 73.

Sharma, A. B., Patel, M. P., Pandey, K. K.and Pandey, A. 1998. Assessment of some commercial varieties of guava (*Psidium guajava* L.). *Adv. Plant Sci.*, 11: 187-91.

Singh, A. K., Mishra, S. K. and Singh, A. 2008. Studies on physico-chemical characters of different guava (*Psidium guajava* L.) cultivars. *Plant Arch.*, 8: 453-55.

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Effect of biofertilizers and micronutrients on growth and yield of garlic (*Allium sativum* L.) var. 'G-282'

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Abstract

A field experiment was conducted to study the "Effect of biofertilizes and micronutrients on growth and yield of Garlic (*Alium sativum* L.) var G-282" during *rabi* season 2012-13 at the Department of Vegetable science, College of Horticulture and Forestry, Jhalawar. The experiment consist of 12 treatment *viz.*, three biofertilizers (control, PSB, *Azotobacter*) in combination with four micronutrients (control, ZnSO4 @ 0.4%, Boric acid @ 0.2% and CuSO4 @ 0.05%) was laid out in simple RBD with three replications. The treatment T5 (PSB + ZnSO4 @0.4%) was recorded maximum plant height at 60 days and 130 days after sowing (48.83 cm and 77.30 cm), number of leaves/plant at 60 days and 130 days after sowing (7.5 and 14.80), leaf length (39.27 cm) and neck thickness (0.92 cm), total chlorophyll both at 60 and 90 DAS (0.43 and 0.78 mg/g) then over control. The yield characters of bulb like maximum fresh weight of bulb (34.37 g), diameter of bulb (5.49 cm), number of cloves per bulb (30.67), fresh weight of 50 cloves (86.67 g), dry weight of 50 cloves (42.50 g), yield per plot (5.15 kg plot-1) and yield of bulb per hectare (229.03 q ha-1) other then rest treatments.

Key words: *Growth, Yield, Biofertilizers, Micronutrients, Garlic.*

Introduction

Garlic is the second most important bulb crop after onion. It is an important spice crop belonging to family alliaceae and botanically known as *Allium sativum* L. The economic yield is obtained from its underground bulb, which consists of bulblets, popularly called as cloves. A fresh bulb contains about (62.8%) moisture, (6.3%) fat, (0.8%) fiber and is a good source of carbohydrates, vita.- C, Selenium, Phosphorous and Manganese. It is specially rich in protein, carbohydrate and ascorbic acid. About 142 calories of energy is obtained from 100 gm of garlic.

Biofertilizers are live carrier based microbial preparation used in agriculture as low input resources to enhance the availability of plant nutrients or promote the growth by way of synthesizing growth factors. They are low cost effective, inexpensive and eco-friendly sources of nutrient. Micronutrient i.e. zinc play a vital role in the metabolic activities of plant. The principle functions of zinc in plant are as metal activator of enzymes like dehydrogenase (pyridine nucleotide, glucose-6 phosphodiesterase, carbonic anhydrase etc.). It is involved in the synthesis of tryptophane, a precursor of IAA, it is associated with water uptake and water retention in plant bodies (Noggle and Fritz, 1980). PSB might have increased the amount of available phosphorus in the root zone for the growth and development of plants. In addition to phosphate solubilization these microbes can mineralize organic phosphorus into a soluble form. These reactions take place in the rhizosphere and the microorganism render more phosphorus into soil solubilization required for their smooth growth and metabolism. The surplus is available for plants to be absorbed. It also produce fungistatic and growth promoting substances, like auxins, gibberlines, cytokines etc. which influence the plant growth parameters by enhancing cell division, cell elongation and thus increasing the metabolic activity (Bhattacharya and Jain 2000 and Gurmani *et al.*, 2012).

Material and Methods

An experiment was conducted at the Department of Vegetable Science, College of Horticulture and Forestry, Jhalawar. Jhalawar is situated between 23045' 20" and 24052' 17" North latitudes and 75027' 35" and 76056'46" East longitudes covering an area of 6322.35

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Km2. Jhalawar district falls under sub-humid South Eastern Plains under agro-climatic zone V. The climate of Jhalawar is typically sub-humid and characterized by extremes of temperature both in summer and winter with high rainfall and moderate relative humidity. the soil of the experimental field was black cotton, pH 6.9, clay, and loam in texture, normal in reaction with medium in respect to nitrogen, phosphorus and potassium.

The experiment consist of 12 treatment viz., three biofertilizers (control, PSB, *Azotobacter*) in combination with four level of micronutrients (control, ZnSO4 @ 0.4%, Boric acid @ 0.2% and CuSO4 @ 0.05%) was laid out in simple RBD with three replications. The treatments were T0- control (applied RDF NP &K), T1- control + ZnSO4, T2- control + Boric acid, T3- control + CuSO4, T4- control + PSB, T5- PSB + ZnSO4, T6- PSB + Boric acid, T7- PSB + CuSO4, T8- Control + *Azotobacte*r, T9- *Azotobacter* + ZnSO4, T10- *Azotobacter* + Boric acid, T11- *Azotobacter* + CuSO4. Plot of 1.5 × 1.5 m size were prepared. The distance between plant to plant as well as row to row was kept at 15 × 10 cm. Thus 150 plants were accommodated in each plot. Ten plants were randomly selected from each plot and tagged. The following observations were recorded on these plants. Plant height (cm), number of leaves per plant, leaf length (cm), neck thickness (cm), chlorophyll content (mg/g leaves), fresh weight of bulb (g), diameter of bulb (cm), number of cloves per bulb, fresh weight of 50 cloves (g), dry weight of 50 cloves (g), bulb yield per plot (kg plot-1) and bulb yield per hectors (q ha-1).

Results and Discussion

Plant growth characteristics

The results of present *investigation* showed that inoculation of biofertilizers and foliar application of micronutrients significantly increased *the plant height, number of leaves per plant,* leaf length and neck thickness compared to control.*(Table-1). The maximum value of growth parameters i.e.* plant height at 60 DAS (48.83 cm) and 130 DAS (77.30 cm), number of leaves per plant both at 60 DAS and 130 DAS (7.5 and 14.80), leaf length at 130 DAS (39.27 cm), neck thickness (0.92 cm) and total *chlorophyll content both at 60 and 90 DAS (0.43 and 0.78 mg/g in leaves), was recorded under treatment T5 (PSB +* ZnSO4*) as compared to control. These results are in conformity with the findings of* Sharangi *et al*. (2003) in garlic, Singh and Singh (2004) in cauliflower, Abd-El-Moneem *et al.* (2005) in garlic, Rohidas *et al*. (2010) in garlic, Abd-El-Samad *et al.* (2011) in tomato, Verma and Yadav (2011) in cauliflower and Gurmani *et al*. (2012) in tomato.

The increase in plant growth parameters may be due to inoculation of biofertilizers and foliar spray of micronutrients. PSB might have increased the amount of available phosphorus in the root zone for the growth and development of plants. In addition to phosphate solubilization these microbes can mineralize organic phosphorus into a soluble form. These reactions take place in the rhizosphere and the microorganism render more phosphorus into soil solubilization required for their smooth growth and metabolism. The surplus is available for plants to be absorbed. It also produce growth promoting substances, like auxins, gibberlines, cytokines etc. which influence the plant growth parameters by enhancing cell division, cell elongation and thus increasing the metabolic activity (Bhattacharya and Jain 2000 and Vivek *et al*., 2001). In addition to biofertilizers, the micronutrients resulted in the highest value of vegetative growth because micronutrients (Zn) play an important role in many physiological process and cellular formation within the plants. It also play an essential role in improving plant growth through the biosynthesis of endogenous hormones which is responsible for promoting of plant growth, strengthening plant cell wall and translocation of carbohydrates from leaves to other plant parts (Battal, 2004 and Hansch and Mendel, 2009). The same trends were also recorded by various scientists El-Gamelli, (2000), El-Shafee and El-Gamaily (2002), El-Tohamy *et al*., (2009) in onion, Alam *et al*. (2010) and Rohidas *et al.* (2010) in garlic.

Yield Attributing Characters

The average fresh weight of bulb, diameter of bulb, number of cloves per bulb, fresh weight of 50 cloves, dry weight of 50 cloves, yield of bulb per plot and yield of bulb per hectare increased *significantly with application of biofertilizers and micronutrients over control (Table-2). the maximum values of yield and yield attributes* i.e. fresh weight of bulb (34.37 g), diameter of bulb (5.49 cm), number of cloves per bulb (30.67 clove), fresh weight of 50 cloves (86.67 g), dry weight of 50 cloves (42.50 g), yield of bulb per plot (5.15 kg) and yield of bulb per hectare (229.03 q ha-1) was *recorded with the inoculation of PSB and foliar application of ZnSO4 @ 0.4% (T5) and minimum under* control (T0) *respectively. These results are in conformity with the findings of* Nagar and Meena (2004) in cluster bean, Srivastava *et al*., (2005) in

garlic, Kadlag *et al*. (2007) in tomato, Kachari and Korla (2009) in cauliflower, Rohidas *et al*., (2010) in garlic, Abedin *et al*., (2012) in onion and Darzi and Seyedhadi (2012) in dill. The increase in yield and yield attributes by the application of biofertilizer and micronutrient might be due to availability of sufficient amount of nitrogen, phosphorus by solubilization of natural status of nutrient present in soil and increase uptake of nutrients and effective utilization of nutrients for increased metabolism and synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head (sink) and also release of energy rich organic compounds by the biofertilizers which ultimately increased auxin activities, growth and activity of microbial saprophytes and phosphates activity which ultimately influenced the yield and yield attributes. In addition with biofertilizers the micronutrient (Zn) might have influenced the formation of some growth horomens in the plant as it is

Table 1. Effect of biofertilizers and micronutrients on growth attributes of garlic var. 'G-282'

Treatment No.	Plant height (cm)		Number of leaves		Leaf length (cm)	Neck thickness (cm)	Total chlorophyll (mg/g)	
	60 DAS	130 DAS	60 DAS	130 DAS			60 DAS	90 DAS
T0	37.73	64.33	6.10	12.70	31.74	0.60	0.20	0.53
T1	45.77	72.63	7.10	14.18	37.10	0.78	0.39	0.62
T2	44.73	71.27	6.67	14.10	36.50	0.70	0.30	0.71
T3	42.87	69.93	6.60	13.97	35.28	0.65	0.27	0.61
T4	46.03	72.40	6.57	13.90	36.04	0.68	0.32	0.68
T5	48.83	77.30	7.50	14.80	39.27	0.92	0.43	0.78
T6	47.30	74.50	7.12	14.23	37.99	0.84	0.41	0.72
T7	45.47	73.93	6.73	14.20	36.57	0.74	0.31	0.69
T8	44.03	69.97	6.83	13.93	35.72	0.65	0.30	0.68
T9	47.77	73.78	7.13	14.30	37.20	0.85	0.42	0.73
T10	45.37	72.01	6.57	14.17	36.95	0.76	0.38	0.70
T11	44.60	70.77	6.67	14.03	36.59	0.72	0.35	0.63
S.Em±	2.09	2.38	0.26	0.38	1.61	0.04	0.03	0.09
CD at 5 %	4.35	4.93	0.54	0.79	3.34	0.08	0.07	0.08

Table 2. Effect of biofertilizers and micronutrients on yield attributes of garlic var. 'G-282'

Treatments			Number of cloves par bulb	Fresh weight of 50 cloves (g)	Dry weight of 50 cloves (g)	Bulb yield Kg plot-1	Total bulb yield ha-1 (q)
	Fresh weight of bulb (g)	Bulb diameter (cm)					
T0	26.67	3.67	24.33	71.00	31.53	4.00	177.77
T1	32.58	4.96	27.67	81.33	38.58	4.79	217.18
T2	31.25	4.63	26.00	78.67	36.28	4.69	208.59
T3	29.67	4.58	26.00	79.00	36.11	4.40	195.40
T4	32.17	4.93	27.00	79.33	37.03	4.73	214.51
T5	34.37	5.49	30.67	86.67	42.50	5.15	229.03
T6	32.73	5.13	28.67	82.67	39.28	4.86	216.00
T7	29.83	4.78	27.00	80.67	36.80	4.48	198.96
T8	27.41	4.77	26.67	77.67	35.66	4.11	182.66
T9	30.17	4.92	28.83	81.67	38.63	4.52	201.03
T10	29.51	4.79	28.00	78.00	36.93	4.41	196.59
T11	29.36	4.64	27.33	79.33	36.37	4.39	195.70
S.Em ±	1.39	0.31	1.36	2.89	1.25	0.31	9.71
C.D. at 5%	2.87	0.64	2.82	6.01	3.97	0.64	28.66

T0-control, T1- ZnSO4 @ 0.4%, T2 Boric acid @ 0.2%, T3 CuSO4 @ 0.05%, T4 PSB, T5 PSB + ZnSO4, T6 PSB + Boric acid, T7 PSB + CuSO4, T8 *Azotobacter*, T9 *Azotobacter* + ZnSO4, T10 *Azotobacter* + Boric acid, T11 *Azotobacte*r + CuSO4, PSB & *Azotobacter* @ 2 kg ha-1 seed treatment.

associated with water relation in the plants and also involved in auxins metabolism like tryptophane synthetase, tryptomine metabolism, influence the activity of dehydrogenase enzymes eg. Pyridine nucleotide, glucose-6 phosphate and triose phosphate and also synthesis of tryptophane, a compound of proteins and needed for the production of growth hormones such as IAA and GA. Similar finding were recorded by Sharangi et al. (2003), Abd-El-Moneem et al. (2005) in garlic, Kumar and Sen (2005) in okra, Mahfouz and Sharaf-Eldin (2007) in fennel, Upadhyay et al. (2012) in cabbage.

Reference

Abd El-Samad, E.H., .Khalifa, R. Kh. M., Lashine, Z. A. and Shafeek, M. R. 2011. Influence of Urea Fertilization and Foliar Application of Some Micronutrients on Growth, Yield and Bulb Quality of Onion. *Australian Journal of Basic and Applied Sciences*, 5(5): 96-103

Abd-El-Moneem, K. M. H., Fawaz, S. B. M., Saeed, F. A. and El-Shehaby, A. I. 2005. Effect of clove size and certain micronutrients on fusarium basal rot of garlic. *Assiut Journal of Agricultural Sciences, 36(4): 163-175*.

Abedin, Md. J., Md. Nurul, A., Hossain, Md. J., Nure Anjuman Ara, Md. J. Haque, Md. F. 2012. Effect of micronutrients on growth and yield of onion under calcareous soil environment, *Int. J. Bio. Sci.*

Alam, M. N., Abedin, M. J. and Azad, M. A. K. 2010. Effect of micronutrients on growth and yield of onion under calcareous soil environment, *Int. Research J. of Plant Science*, 1(3): 56-61.

Battal, P. 2004. Effect of some mineral nutrients on gibbrellic acid levels in maize plants, *Economic Botany*, 58(2):195-203.

Bhattacharya, O. and Jain, K. K. 2000. Phosphorus solubilizing biofertilizers in the whirlpool of rock phosphate challenges and opportunities, *Fertilizer News*, 459(10): 45-49.

Darzi, M. T. and Seyedhadi, M. H. 2012. Effect of organic manure and biofertilizers on the fruit yield and yield components in Dill (*Anethum graveolens). J. of Medicinal Plants Research*, 6(16): 3266-3271.

Dubey, A. K. and Singh, S. K. 2008. Effect of biofertilizer with nitrogen on growth and yield of onion (*Allium sativum* L). *Journal of Farming System Research and Development*, 14(1): 109-110.

El-Gamelli, El-Hadi, H. 2000. Effect of some foliar fertilizers application on growth, bulb yield, quality and storage ability of Giza 20 onion cultivar (*Allium cepa* L.). *Annals of Agricultural Science*, Moshtohor, 38(3): 1727-1737.

El-Shafie, F. and El-Gamaily, E.E. 2002. Effect of organic manures, sulphur and micro-elements on growth, bulb yield, storability and chemical composition of onion plants, *Minufiya J. Agricultural Research*, 27(2): 407-424.

El-Tohamy, W.A., Khalid, A. Kh., El-Abagy, H. M.and Abou-Hussein, S. D. 2009. Essential oil, growth and yield of Onion (*Allium Cepa* L.) in response to foliar application of some micronutrients, *Australian Journal of Basic and Applied Sciences*, 3(1): 201-205.

Gurmani, A. R., Din, J. U., Khan, S. U. Andaleep, R., Waseem, K., Khan, A. and Hadyat-Ullah, 2012. Soil Application of zinc improves growth and yield of tomato, *Int. J. Agric. Biol*., 14: 9196.

Hans, R. and Mendel, R. R. 2009. Physiological function of mineral micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl). *Current Opinion in Plant Biology*, 12: 259-266.

Kachari, M. and Korla, B. N. 2009. Effect of biofertilizers on *growth and yield of cauliflower* cv. K-1. *Indian Journal of horticulture*, 66(4): 496-501.

Kadlag, A. D., Jadhav, A. B. and Bharti, R. 2007. Yield and quality of tomato fruit as influenced by biofertilizers. *Asian Journal of Soil Science*, 2 (2): 95-99.

Kumar, M. and Sen, N. L. 2005. Effect of zinc, boron and GA3 on yield of okra (Abelmoschus esculentus L.). Indian Journal of Horticulture, 62 (3): 308-309.

Mahfouz, S. A., Sharaf Eldin M. A. 2007. Effect of mineral vs. biofertilizer on growth, yield and essential oil content of fennel (*Foeniculum vulgare* Mill). *Int. Agrophisics.*, 21(4): 361-366.

Nagar, K. C. and Meena, N. L. 2004. effect of phosphorus solubilizing bacteria on yield components, yield and quality of cluster bean. *Legume research*, 27 (1): 27-31.

Noggle, G. R. and Fritz, G. T. 1980. *Introductory Plant Physiology*, Prentice Hall of India Pvt. Ltd. Publication New Delhi.

Rohidas, S. B., Bharadia, P. S., Jature, S. D. and Ghate, K. B. 2010. Effect of micronutrient on growth and yield of garlic (*Allium sativum* L.*)* var.G-41. *Asian J. of Hort.; 5(2): 517-519.*

Sharangi, A. B., Pariari, A., Datta, S. and Chatterjee, R. 2003. Effect of boron and zinc on growth and yield of garlic in New Alluvial Zone of West Bengal. *Crop Research Hisar; 25(1): 83-85.*

Singh, V. N. and Singh S. S. 2005. Effect of inorganic and biofertilizers on production of cauliflower (*Brassica oleracea l. var. botrytis*). *Vegetable Science*, 32(2): 146-149.

Srivastava, R., Agarwal, A., Tiwari, R. S. and Kumar, S. 2005. Effect of micronutrients, zinc and boron on yield, quality and storability of garlic (*Allium sativum L*). *Indian Journal of Agricultural Sciences, 75(3): 157-159.*

Subba Rao, N. S., Sen, A. N. and Dadawal, K. K. 1982. Rhizobium Research in India Review of Soil Research in India Part ² 12th International Congress of Soil Science, New Delhi, 211-224.

Upadhyay, A. K., Bahadur, A. and Singh, J. 2012. Effect of organic manures and biofertilizers on yield, dry matter partitioning and quality traits of cabbage (*Brassica oleracea* var. *capitata*). *Indian Journal of Agricultural Sciences*, 82 (1): 31-34.

Verma, M. K. and Yadav, Y. C. 2011. Studies on effect of biofertilizer with chemical fertilizers on growth and yield of cauliflower *(Brassica olerasia* var. botrytis) cv. Pusa Snowball K-1. *Annals of Horticulture*, 4(2): 202-205.

Vivek, K. Jaiswal, R. C. S., Singh, A. P., Kumar, V., Khuranas, M. P. and Panday, S. K. 2001. Effect of biofertilizers on growth and yield of potato, In: National Symposium on Sustainability of potato Revolution in India, Shimla, India. *J. Indian Potato Assoc.* 28:60-61.

Yadav, P. V. S., Singh, N. K. and Tikkoo, A. 1999. Effect of zinc and boron application on yield of tomato (*Lycopersicon esculantum* L.). *Haryana Journal of Horticulture Science*, 28(3&4): 241-243.

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Influence of soil and leaf nutrients on quality of kinnow mandarin grown in aridisol of Punjab, India

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Abstract

The present study was conducted to determine the relationship between soil and foliar nutrient status with fruit quality of Kinnow orchards in aridisol of Punjab. All Kinnow orchards soils were found alkaline to saline in nature with pH value ranging from 8.4 to 9.5 and deficient of macronutrients while sufficient in most of micronutrients. Foliar analysis suggested that percent samples of different locations were nearly sufficient in Mn, Cu, Fe and Zn and deficient of K and N. Soil properties viz; pH, EC and $CaCO_3$ showed an adverse relationship with available major and micro-nutrients. Correlation studies suggested that soil properties showed a significant and negative relationships with soil and foliar N, P and K, while non-significant but negative with Mn, Cu, Fe and Zn. The results show pronounced effect of the soil and leaf nutrient conditions on physico-chemical quality characteristics of 'Kinnow' mandarin fruit besides other un-foreseen factors at different locations.

Key words: *Aridisol, Kinnow orchards, Macronutrients, Micronutrients, Punjab*

Introduction

Kinnow, is a hybrid between King Sweet orange and Willow Leaf mandarin, it is one of the most promising hybrid not only for the plains of northern India but also in the valleys and hilly tracts of medium altitude. Local over fertilization may decrease ground water quality, reduce profit margins, induce deficiency of other elements and interfere with metabolic processes. Soil and leaf analysis can be used to evaluate the nutritional status of the trees and nutrient availability in the soil to supply the trees with nutrients requirement (Embleton *et al.* 1996). Among them adequate supply of plant nutrients is a very important factor to produce the good quality fruits (Ioannis *et al.* 2004). The application of macro-nutrients particularly nitrogen (N), phosphorus (P) and potassium (K) plays important role in yield, as well as fruit quality (Liu *et al.* 2010), especially N is necessarily needed for optimum vegetative, as well as reproductive growth (Alva *et al.* 2006). The level of N fertility has more influence on the growth, yield and quality of citrus than any other single plant nutrient (Thompson *et al.* 2002) Hence, a balanced supply of N, P and K gives high yield with better citrus fruit quality (Albrigo 2002). In advanced countries, leaf tissue testing is a valuable tool to examine the tree nutritional status (Obreza *et al.* 1999), while soil analysis is common practice for evaluation of soil nutrients and planning for nutrient application to maintain high yield and good quality of citrus fruit (Lester *et al.* 2010), which is rarely practiced in aridisol. Although old information is available on leaf and soil analysis in citrus producing areas of aridisol, but it could not be adopted as a regular practice for designing a fertilizer application program. The present study was conducted to investigate the relationship of soil and foliage nutrient status with fruit quality of 'Kinnow' mandarin at different locations in the aridisol.

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Material and Methods

A survey from 2012-14 was carried out to investigate the causes of Kinnow orchards deterioration in aridisol and entisol of Punjab. Thirty six Kinnow orchards were selected and 108 soil samples were collected from them. Nine Kinnow orchards selected each for high yielding and low yielding orchards on the basis of yield. HYO = High yielding orchards (138-145kg/tree) and LYO = Low yielding orchards (75-104 kg/tree) on the basis of yield as per recommended. Four sites were selected in each Kinnow orchard; each site was a crossing point of four plants. Four samples were taken from each garden upto 15 cm. These soil samples were brought to laboratory, air dried, ground and passed through a 2 mm sieve and analyzed for physical, chemical characteristics and various nutrient levels were determined. One hundered and eight Kinnow leaf samples were collected from 5-7 months old spring flush immediately above the node, from the same orchards from where soil sampls were collected. Each plant sample was a composite of three sub-samples. Leaves were collected from 8-10 plants haphazadarly

from an orchard and a total of 100 leaves were taken from each sample. All the leaves were sampled non-fruiting twigs 3-6 feet above the ground level. No Kinnow plant was sampled from the borderlines. Leaf samples were washed with distilled water and oven dried at 60-70°C to a constant weight. The oven dried plant samples were ground and analyzed for varoius nutrients.

Analysis of soil, plants and fruit samples:

Soil and plant samples were analyzed using the following methodology. Soils were analyzed for their physico-chemical properties such as soil texture (Koehler *et al.* 1984), soil pH (1:2) (Mclean 1982) using 105 Ion Analyzer pH meter, Soil EC(1:2) and calcium carbonate content (Nelson and Sommers 1982). AB-DTPA extracts of soils (Soltanpour and Schwab, 1977) and plant digest (using HNO_3 and $HClO_4$ mixture for digestion) were prepared and analyzed for Cu, Fe, Mn and Zn using Atomic Absorption Spectrophotometer "Perkin Elmer" model No.2380 while K using' Perkin Elmer' Flame Photometer model No.2380 and P by Spectrophotometer "Spectronic Lmbda (ë) 35" using required standard solutions. Available nitrogen in soils and plants were determined using Kjeldahl distillation procedure as described by Subbiah and Asija (1956). The data were subjected to linear and multiple correlation analyses in order to diagnose the optimum leaf and available soil nutrients in relation to soil properties. Fruit quality parameters viz; SSC (soluble solids content), acidity and Vitamin-C were estimated as per recommended method.

Results and Discussions

The mean EC (Electrical conductivity) observed higher in low yielding orchards (0.39± 0.3dS m^{-1}) (Table 1). The results suggested that these soils were low (< 2-4 dS m^{-1} at 25°C) in electrolyte concentration due to leaching induced by heavy rainfall. Similar trend was found in $CaCO_3$ content. Soil texture of high and low yielding Kinnow orchards was loamy sand (Table 1). However, being well drained in nature, the chances of nutrient leaching are always more if the level of organic matter is not maintained. Thus, it is very important to add organic and chemical fertilizer to maintain adequate fertility status of these soils. Soil pH of high and low yielding orchards ranged from 8.4-9.2 and 8.5-9.5 (Table 1). Available N, P and K concentrations in Kinnow orchard grown in aridisol of Punjab was found sub-optimum in different Kinnow orchards (Table 2). P varied from1.21-5.47 and 1.21-1.46 kg/ha in two different productive orchards. Exchangeable K ranged from 103.2-121.4 and 51.0-103.2 kg/ha in high and low yielding Kinnow orchards in aridisol (Table 2). Similarly, Mn content varied from 1.78-3.80 and 1.89-2.94 in high and low yielding orchards. Values for Fe and Zn varied from 1.46-5.68 and 0.31-2.56 in high and low productive Kinnow orchards grown in aridisol (Table 2). The data showed that all samples contained low N, P and K (Table 4). The data showed that nearly all soil samples were deficient of Zn and Fe while for Cu and Mn sufficient. N concentration in the leaves ranged between 2.18-2.89 with the mean value of 2.32±0.1%**,** on dry matter basis, which tends to be low in high yielding Kinnow orchards (Table3). P-concentration in the mature leaves of high and low yielding orchards ranged between 0.09-0.13%, and 0.10-0.17 with respective means 0.09±0.01 and 0.15±0.20, which ranged between low and sufficient levels and with medium level mean. P & K concentration in the leaves ranged between low yielding and high yielding orchards (0.46-1.78%) and the mean is medium. Fe and Cu concentrations can be higher than, equal to, those in normal trees. The mean Fe-concentration was high and ranged from (249.5-492.0 ppm) in high yielding orchards (369.7±77.7) than mean value of (242.3±48.5) low yielding orchards. Mn ranged from 16.78-36.78 ppm and 191.3-362.4 ppm in high and low yielding orchards evaluated between low and medium. Zn concentration was low in most cases ranging between 13.61-41.0 and12.9-39.1 ppm in high and low yielding Kinnow orchards, respectively. Zn deficiency is widespread in citrus trees in India (Srivastava and Singh 2004) and in soils with very high pH, availability of Zn to plant roots is extremely low. In addition, Srivastava and Singh (2009) found that when severe Zn deficiency symptoms appear, early spring foliar sprays could increase the micronutrient concentration in the targeted organs.

Correlation between soil/foliar nutrients with soil physico-chemical properties and quality of fruits:

Data presented in Table 5 revealed that fruit yield was significantly and positively correlated with available N, P, K and Mn but, negatively and significantly with soil pH, EC and $CaCO_3$ content. Table 5 and 6 revealed that available/ foliar N showed a significant but negative relationship with soil pH (r = -0.469*/r = -0.532**). Similar, results were reported by Srivastava and Singh, (2004). A highly significant and negative relation was observed with EC (r = -0.522**/r =-0.573**) from this it may be concluded that increase of pH and EC resulted decrease in N availability. Data presented in Table 5 revealed that available P was significantly and negatively correlated with soil pH but non-significantly with EC and $CaCO_3$ content. From this it might be concluded that increase in the soil pH, EC and $CaCO_3$ would decrease the availability of foliar P. Exchangeable K like other macro-nutrients decreased with increase in soil pH and EC (Table 5) (r =

-0.633**, r = -0.589**). Similar, results were reported by Chinchmalatpure *et al.* (2000). However, foliar K significantly and positively correlated with EC (r = 0.416*). Available Mn showed non-significant but negative relationship with soil properties viz; pH and $CaCO_3$ but significant and negative relationship with EC (Table 5). Table 5 found that foliar Mn significantly and negatively related with soil pH (r = -0.477*). Foliar Cu showed negative and significant relationship with $CaCO_3$ content (Table 6). Available soil and foliar Fe showed negative and non-significant relationships with soil properties viz; soil pH, EC and $CaCO_3$ content (Table 5 & 6). Foliar zinc showed significant and negative relationship with soil pH (r = -0.456*) and EC (r = -0.451*) as shown in Table 6. Table 5 it has been shown that available N showed a significant and positive correlation with P (r = 0.533**), K(r = 0.622**) and Cu (r = 0.437*). Soluble solids content exhibited positive and significant correlation with vitamin C content (Table 7). Soluble solids content was positively correlated with soil (r = 0.591*)/ foliar N (r = 0.671*). Table 7 and 8 revealed that soluble solids content showed the significant and positive relation with soil K (r = 0.622**)/foliar (r = 0.742**). Fruit juice content exhibit the positive and significant correlation with available N (r = 0.577*) and exchangeable K (r = 0.685*) as shown in Table 7. Whereas, fruit juice related positively and significantly with foliar N (r = 0.566*) and foliar K (r = 0.561*) as shown in Table 8. Vitamin C content positively and significantly correlated with available P, Mn and Fe (Table 7). Foliar Mn correlated significantly with vitamin C content (Table 8).

Table1. Soil physico-chemical properties of Kinnow orchards growing aridisol.

	HYO		LYO	
	Range	Mean +SD	Range	Mean +SD
pH	8.4-9.2	8.8 ± 0.3	8.5-9.5	9.2 ± 0.3
EC(dS m^{-1})	0.06-0.32	0.14±0.1	0.13-0.84	0.39±0.3
$CaCO_3$ (%)	2.7-5.2	4.1±0.8	3.6-7.6	5.9±1.4
Sand (%)	46.8-72.4	57.7±2.9	47.2-55.1	62.4 ± 1.1
Silt (%)	20.4-39.2	31.0 ± 2.2	28.0-37.8	34.8 ± 1.0
Clay (%)	9.5-15.0	12.6 ± 0.5	11.6-17.7	14.4 ± 0.6

Table 2. Soil available N and AB-DTPA- P, K, Cu, Fe, Mn and Zn in Kinnow orchards growing aridisol.

	HYO		LYO		
	Range	Mean +SD	Range	Mean +SD	Evaluation
N (Kg/ha)	120-202	148.2±32.4	69-89	80.89±7.4	Low
P (Kg/ha)	1.21-5.47	2.69±1.5	1.21-1.46	1.26±0.1	Low
K (Kg/ha)	103.2-12	1.4114.5±8.3	51.0-103.2	73.52±26.7	Low
Mn (Kg/ha)	1.78-3.80	3.03±0.5 5	1.0-103.2	73.52±26.7	Medium
Cu (ppm)	0.52-2.36	1.75±0.7	1.07-1.56	1.20±0.1	High
Fe (ppm)	1.79-5.68	3.50±1.5	1.76-2.20	2.04±0.1	Low
Zn (ppm)	0.86-2.56	1.39±0.3	0.80-1.60	1.17±0.1	Low

Table 3. Foliar macro and micro-nutrients of Kinnow orchards grown in aridisol

	HYO		LYO		
	Range	Mean ± SD	Range	Mean ± SD	Evaluation
N(%)	2.18-2.89	2.32 ±0.1	2.11-2.53	2.28±0.20	Low
P(%)	0.06-0.13	0.09±0.01	0.10-0.17	0.15±0.20	Medium
K(%)	0.46-1.43	1.04±0.30	0.58-1.78	1.09±0.50	Medium
Mn(ppm)	16.78-36.78	23.34±7.6	17.14-32.42	24.94 ±5.30	Medium
Cu(ppm)	42.00-118.7	73.64±29.3	14.70-57.80	35.30 ±16.5	High
Fe(ppm)	249.5-492.0	369.7±77.7	191.3-362.4	242.3±48.5	High
Zn(ppm)	13.61-41.6	18.90± 3.7	12.9-39.1	16.12±2.1	Low

HYO = high yielding orchards
LYO = low yielding orchards

Table 4. Index values for available N and AB-DTPA- P, K, Cu, Fe, Mn and Zn in soils reported by various sources.

Soil Nutrient elements	Soil fertility class			References
	High	Medium	Low	
N (kg/acre)	> 543	271-543	< 271.0	Subbiah and Asiza (1956)
P(kg/acre)	> 9.0	5-9	< 5.0	Olsen *et al.* (1954)
K (kg/acre)	> 138.7	54.8-138.7	< 54.8	Jackson (1967)
Mn (ppm)	> 7.0	3.5-7.0	< 3.5	Foliet and Lindsey (1970)
Cu (ppm)	> 0.4	0.2-0.4	< 0.2	Jones (1972)
Fe (ppm)	> 9.0	4.5	< 4.5	Lindsey (1979)
Zn (ppm)	> 1.2	0.6-1.2	0.6	Peryea (2000)

Table 5. Relationship among macro and micronutrients of soils with soil properties of the tested soil samples of aridisol.

	Soil pH	EC	$CaCO_3$	N	P	K	Mn	Cu	Fe	Zn
Yield	0.548**	0.491**	0.448*	0.460*	0.830**	0.615**	0.549**	0.313	0.375	0.223
Soil pH		0.435*	0.212	-0.469*	-0.567**	-0.633**	-0.046	-0.138	-0.276	-0.151
EC			0.213	-0.522**	-0.241	-0.589**	-0.446*	-0.323	-0.156	-0.274
CaCO3				-0.273	0.036	-0.109	-0.320	0.318	-0.288	0.140
N					0.533**	0.622**	0.365	0.437*	0.088	0.253
P						0.457*	-0.110	0.184	0.221	0.165
K							0.205	0.265	0.101	0.365
Mn								0.171	0.187	-0.092
Cu									0.226	0.400*
Fe										0.507**
Zn										1

* = Significant at 5% level
** = Significant at 1% level

Table 6. Relationship among macro and micronutrients foliar with soil properties of the tested soil samples of aridisol.

	N	P	K	Mn	Cu	Fe	Zn
Yield	0.855**	0.581**	0.079	0.134	0.649**	0.627**	0.588**
Soil pH	-0.532**	-0.392*	0.202	-0.477*	-0.272	-0.265	-0.456*
EC	-0.573**	-0.583**	0.416*	-0.061	-0.334	-0.275	-0.451*
CaCo3	-0.471*	-0.394*	0.096	-0.038	-0.387*	-0.360	-0.214
N		0.605**	-0.057	-0.096	0.328	0.356	0.688**
P			0.004	0.196	0.574**	0.398*	0.453*
K				0.168	0.224	0.304	-0.055
Mn					-0.087	-0.011	0.042
Cu						0.432	0.481*
Fe							0.491**
Zn							1

* = Significant at 5% level
** = Significant at 1% level

Table 7. Relationship among soil macro and micronutrients with quality of fruits.

	Acidity	Juice	VitaminC	N	P	K	Mn	Cu	Fe	Zn
SSC	-0.335	0.205	0.516*	0.591*	-0.135	0.622**	0.160	-.389	0.160	0.404
Acidity		-0.401	0.406*	0.210	0.077	-0.211	-0.020	0.109	-0.097	0.003
Juice			0.380	0.577*	-0.219	0.685*	-0.331	-0.123	-0.364	-0.349
Vitamin C				0.272	0.668*	0.003	0.628*	-0.089	0.511*	0.142

* = Significant at 5% level
** = Significant at 1% level

Table 8. Relationship among foliar macro and micro -nutrients with quality parameters of the tested samples of aridisol.

	Acidity	Juice	Vitamin C	N	P	K	Mn	Cu	Fe	Zn
SSC	-0.335	0.205	0.516*	0.671*	-0.175	0.742**	0.260	-0.281	0.100	0.346
Acidity		-0.401	0.406*	0.314	0.171	-0.321	-0.120	0.209	-0.162	0.102
Juice			0.380	0.556*	-0.316	0.561*	-0.232	-0.423*	-0.234	-0.109
Vitamin C				0.128	0.162	0.012	0.527*	-0.091	0.233	0.091

* = Significant at 5% level
** = Significant at 1% level

Reference

Albrigo, L. G. 2002. Foliar uptake of N-P-K sources and urea biuret tolerance in citrus. *Acta Hort.*, 594: 627-633.

Alva, A. K., Paramasivam, S., Fares, A., Obreza, T.A. and Schumann, A.W. 2006. Nitrogen best management practice for citrus trees: II. Nitrogen fate, transport and components of N budget. *Scientia Hort.* 109: 223-233.

Chinchmalatpure, A. R., Lal, B., Challa, O and Sehgal, J. 2000. Available micronutrient status of soils on different parent materials and landforms in a micro-watershed of Wunna catchment near Nagpur (Maharashtra). *Agropedol*., 10: 53-58.

Embleton, T. W., Coggins, C. W. and Witney, G. W. 1996. What is the most profitable use of citrus leaf analysis? pp. 2: 1261-1264. *In*: 8th Inter. Citrus Cong., Sun City, South Africa.

Ioannis, E. P., Protopapadakis, E., Dimassi, K. N. and Therios, I. N. 2004. Nutritional status, yield and fruit quality of "Encore" Mandarin trees grown in two sites of an orchard with different soil properties. *J.Plant Nutr.*, 27: 15051515.

Jackson, M. L .1967. Soil Chemical analysis. Prentice Hall of India, Pvt. Ltd., New Delhi. pp. 452-485.

Koehler, F. E., Moodie, C. D. and Mcneal, B. L.1984. Laboratory Manual for Soil Fertility Washington State Univ., Deptt. Agron. & Soil Pullman, Washington D.C. 43-45 pp.

Lester, G. E., Jifon, J. L. and Makus, D. J. 2010. Impact of potassium nutrition on food quality of fruits and vegetables: a condensed and concise review of the literature. *Better Crop.* 94: 18-21.

Liu, G., Jiang, C., Wang, Y., Peng, S. and Lu, J. 2010. A review on effects of mineral nutrients on citrus. *China J. Soil Sci.*, 41:doi: cnki: sun: trtb. 0.2010-2006-2045

Mc Lean, E.O. 1982. Soil pH and lime requirement. *In:* Methods of soil analysis, Part 2: 2nd edition. Page AL, Miller RH and Keeney DR (Eds), pp. 199-208. *Amer. Soc. Agron*., Madison, WI. USA.

Nelson., D. W. and Sommers, L. E. 1982. Total carbon, organic carbon and organic matter. *In*: Methods of soil analysis, Part 2: 2nd edition. Page AL, Miller RH and Keeney DR (Eds), pp. 574-577. *Amer. Soc. Agron*., Madison, WI. USA.

Obreza, T. A., Alva, A. K., Hanlon, E. A. and Rouse, R. E. 1999. *Citrus Grove Leaf Tissue and Soil Testing: Sampling, Analysis and Interpretation*. Coop. Ext. Serv. Institution Food Agriculture Science, University Fl.http://edis.ifas.ufl.edu/CH046.

Soltanpur, P. N. and Schwab, A. P. 1977. A new soil test for simultaneous extraction of macro-micronutrients in soil. *Comm. Soil Sci. Plant Anal*, 8: 195-207.

Srivastava, A. K. and Singh, S. 2004. Soil and plant nutritional constraints contributing to citrus decline in Marathawada region, India. *Comm. Soil Sci. & Pl. Anal*, 35(17/18): 2537-550.

Srivastava, A. K. and Singh, S. 2009. Zinc nutrition in 'Nagpur' mandarin on Haplustert. *Plant Nutrition*, 32(7): 1065-1081.

Thompson, T. L., White, S. A., Walworth, J. and Sower, G. 2002. Development of Best Management Practices for Fertigation of Young Citrus Trees. Citrus and Deciduous Fruit and Nut Research Report, University of Arizona, CALS. Http://ag.arizona.edu/pubs/crops/az1303.

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Stability analysis of fruit yield and related traits in Ridge Gourd

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Abstract

The investigation was carried out to study stability parameters on eight quantitative traits of ridge gourd. The result showed significant genotypic mean square for most of the characters *viz.*, days to opening of first female flower, number of node at which first female flower appeared, days to first fruit harvest, number of fruits per vine and total fruit yield per vine indicating enough variability among the 8 parents and their 28 F_1's. The mean square due to environments were highly significant for all the characters (except fruit length), suggesting the existence of considerable variation among genotypes, as well as environments. The G x E interaction when tested against polled error was found significant for number of secondary branches per vine. The mean square due to environment (E) + genotype (G) interaction was obtained significant for days to opening of first female flower, number of fruits per vine and fruit yield per vine. Joint consideration of means performance and stability parameters revealed that cross AHRG-1 x Salumber Long had exhibiting below average stability hence, that cross was suited for better environment.

Key words: *Fruit yield, ridge gourd, stability and genotypes x environments*

Introduction

Ridge gourd [*Luffa acutangula* (Roxb.) L.] commonly known as '*kalitori'*, angled gourd, angled *loofah* or ribbed gourd is an important cucxurbitacious crop, which is consumed as vegetable. Ridge gourd well known for preparations of chutneys and curries in India, which is easily digestible and prevent constipation with good nutritive value and high yield potential. It is beneficial for jaundice patients and cure for tetanus (Pal and Jain, 1998). The farmers of different states grow the landraces available with them. Since, there are few varieties and majority of them were developed from available germplasm, the performance of ridge gourd germplasm / genotype is of great importance in respect of screening them for their stability, sustainability as well as for possibility of cultivation in non-conventional areas including unfavorable environments. G x E interaction study is important not only from the genetically and evolutionary point of view but is also related to agricultural production problem in general and to plant breeding, in particular (Breese, 1969). Phenotype is the product of interaction between genotype and environment. A particular genotype can express its full genetic potential only under the optimum environmental conditions. Even then stable genotypes are the ones giving consistent performance over a series of environmental conditions.

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Materials and Methods

The experiment was conducted at the Horticulture farm, College of Agriculture, Bikaner and KVK Research farm, Bhartiya Krishi Vigyan Kendra, Fatehpur Shekhawati, Sikar during rainy season, 2011. The experimental material consisted eight genetically diverse parents namely, Pusa Nasdar, Swarna Uphar, AHRG-1, Salumber Long, Jaipuri Long, Swarna Manjari, Arka Sujath and Arka Sumeet were crossed in diallel fashion excluding reciprocals during summer season, 2011. All the eight parents and their 28 F_1's were evaluated in randomized block design with three replications under four different environments created by two different sowing time and locations *viz*., location Bikaner during *Kharif* 5th July, 2011 (E_1) and 25th July, 2011 (E_3), and Fatehpur-Shekhawati during *Kharif* 5th July, 2011 (E_2) and 25th July, 2011 (E_4). All the recommended package of practices were followed for raising the crop. The observations were recorded on days to opening of first female flower, number of node at which first female flower appeared, days to first fruit harvest, number of fruits per vine, fruit length, fruit girth, fruit weight and fruit yield per vine from five

randomly selected plants in each replication. Stability analysis was done using Eberhart and Russell (1966) model.

Results and Discussion

The stability analysis of variance mean square data (Table 1) exhibited significant differences attributable to genotype and environment in ridge gourd . The results are in close conformity of Soni (2009) and Samadia (2007) in bottle gourd and Yadav and Ram (2010) in muskmelon. G x E interaction variance was non-significant for almost all the characters. Mean squares due to environment linear were significant for almost all the characters except fruit length, indicating that environments differed significantly. Similarly results were reported by Soni (2009), Samadia (2007) and Shaikh *et al*.(2012) in bottle gourd and Yadav and Ram (2010) in muskmelon. An ideal stable genotype would be that, which possessed unit regression coefficient (b_i=1) and deviation from regression not significant from zero (S^2d_i=0) as well as higher mean performance over population mean (Eberhart and Russell, 1966). The stability parameters, such as regression coefficient (b_i) and deviation from regression (S^2d_i) along with mean performance of genotypes for various characters were computed to assess the stability and suitability of performance over the location parameters are presented in Table 1 to 4.

Out of eight parents six parents *viz.*, Pusa Nasdar, Swarna Uphar, AHRG-1, Salumber Long, Jaipuri Long and Arka Sujath showed early opening of first female flower, lower number of node at which first female flower appeared and early in first fruit harvest. Arka Sumeet was also showed lower number of node at which first female flower appeared as it had lower mean than the general mean (Table 2). Parent Swarna Uphar showed average stability for opening of first female flower and first fruit harvest and parent Pusa Nasdar for number of node at which first female flower appeared as they had lower mean than the general mean and regression coefficient equal to unity (b_i=1) and non-significant deviation (S^2d_i) from the regression. Out of twenty eight F_1's nine F_1's, viz. Pusa Nasdar x Swarna Uphar, Pusa Nasdar x AHRG-1, Pusa Nasdar x Arka Sumeet, Swarna Uphar x AHRG-1, Swarna Uphar x Arka Sumeet, AHRG-1 x Salumber Long, AHRG-1 x Jaipuri Long, AHRG-1 x Swarna Manjari and AHRG-1 x Arka Sumeet had lower mean than the general mean for all these traits (Table 2). Crosses *viz.*, Pusa Nasdar x Salumber Long, Pusa Nasdar x Jaipuri Long, Jaipuri Long x Swarna Manjari and Swarna Manjari x Arka Sujath for days to opening of first female flower and days to first fruit harvest, Swarna Uphar x Salumber Long for number of node at which first female flower appeared and days to first fruit harvest, Salumber Long x Arka Sujath for days to opening of first female flower, Salumber Long x Swarna Manjari for number of node at which first female flower appeared and five crosses Pusa Nasdar x Swarna Manjari, Pusa Nasdar x Arka Sujath, Pusa Nasdar x Arka Sujath, Salumber Long x Jaipuri Long and Salumber Long x Arka Sumeet for days to first fruit harvest showed as they had lower mean than the general mean (Table 2). Crosses *viz.*, Pusa Nasdar x Jaipuri Long, Pusa Nasdar x Arka Sumeet and Swarna Uphar x Arka Sumeet for days to opening of first female flower and days to first fruit harvest and Pusa Nasdar x AHRG-1, Swarna Uphar x Salumber Long, Swarna Uphar x Swarna Manjari and Salumber Long x Arka Sumeet for days to first fruit harvest showed average stability as they had lower mean than the general mean and regression coefficient equal to unity (b_i=1) and non-significant deviation (S^2d_i) from the regression while none of the crosses were not average stability.

Parent Pusa Nasdar for number of fruits per vine, fruit girth, fruit weight, fruit yield per vine, Jaipuri Long for number of fruits per vine, fruit girth and fruit yield per vine, AHRG-1 for number of fruits per vine, fruit girth and fruit yield per vine, Salumber Long for number of fruits per vine, fruit length, fruit girth and fruit yield per vine, Swarna Manjari for number of fruits per vine, fruit girth and total fruit yield per vine, Swarna Uphar for number of fruits per vine and fruit length, Arka Sumeet for fruit length and fruit girth showed higher for these traits as they had higher mean than the general mean (Table 3 and 4). Jaipuri Long and Swarna Manjari for total fruit yield per vine showed average stability as they had lower mean than the general mean and regression coefficient equal to unity (b_i=1) and non-significant deviation (S^2d_i) from the regression while none of these parents not showed average stability for all these traits. Out of twenty eight F_1's crosses AHRG-1 x Swarna Manjari, Jaipuri Long x Swarna Manjari and Jaipuri Long x Arka Sumeet for number of fruits per vine, fruit length, fruit girth, fruit weight, total fruit yield per vine, Pusa Nasdar x Arka Sujata and Swarna Uphar x Jaipuri Long and Jaipuri Long x Arka Sujata for number of fruits per vine, fruit length, fruit weight, total fruit yield per vine, Pusa Nasdar x Swarna Manjari, Swarna Uphar x AHRG-1, AHRG-1 x Jaipuri Long for number of fruits per vine, fruit girth, fruit weight and total fruit yield per vine, Swarna Uphar x Jaipuri Long for number of fruits per vine, fruit length, fruit weight and fruit yield per vine, Salumber Long x Jaipuri Long for number of fruits per vine, fruit length and fruit yield per vine, Salumber Long x Swarna Manjari for number of fruits per vine, fruit weight and fruit yield per vine, Pusa Nasdar x Swarna Uphar for number of fruits per vine and fruit girth, Pusa Nasdar x Salumber Long for fruit length and fruit weight, Pusa

Nasdar x AHRG-1 for fruit girth and fruit yield per vine, Swarna Uphar x Swarna Manjari for fruit length and fruit weight, Swarna Uphar x Jaipuri Long for fruit weight and fruit yield per vine, Swarna Uphar x Arka Sumeet for fruit length and fruit weight, AHRG-1 x Salumber Long for number of fruits per vine and fruit yield per vine, Salumber Long x Arka Sumeet and Swarna Manjari x Arka Sumeet for fruit girth and fruit weight, Pusa Nasdar x Arka Sumeet for fruit girth, Pusa Nasdar x Jaipuri Long for fruit weight, Swarna Uphar x Arka Sujath and Salumber Long x Arka Sujata for fruit length showed higher these traits as they had higher mean than the general mean (Table 3 and 4). Pusa Nasdar x Swarna Uphar and AHRG-1 x Jaipuri Long for number of fruits per vine and AHRG-1 x Salumber Long for total fruit yield per vine showed average stability as they had higher mean than the general mean and regression coefficient equal to unity (b_i=1) and non-significant deviation (S^2d_i) from the regression. These findings are in agreement with the findings of Dubey *et al.* (2005) and Soni (2009) in cucurbits.

Table 1. Analysis of variance for stability parameters of various characters over the environments in Ridge gourd

Source of Variance	d.f.	Days to opening of first female flower	No. of node at which first female flower appeared	Days to first fruit harvest	No. of fruits per vine	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Total fruit yield /vine (kg)
Genotypes (G)	35	72.66**	12.13**	494.25	14.52**	10.21	1.61	168.97	0.27**
Environment (E)	3	1813.70**	56.41**	1449.17*	53.90**	5.74	4.04*	396.06*	0.97**
G x E	105	19.21	6.77	321.38	1.935	7.41	1.12	133.28	0.04
E + G x E	108	69.06**	8.15	352.71	3.38**	7.36	1.20	140.58	0.07**
E (Linear)	1	5441.10**	169.22**	4347.52**	161.71**	17.22	12.14**	1188.17**	2.93**
G x E (Linear)	35	23.40	8.18	43.05	2.59*	8.89	0.65	143.06	0.05
Pooled Deviation	72	16.64*	5.90**	447.76*	1.56**	6.48**	1.32**	124.82**	0.03**
Pooled Error	280	2.49	2.20	315.79	0.31	2.38	0.86	67.47	0.01

* and ** significant at 5 and 1 per cent levels, respectively.

Table 2. Estimates of stability parameters for days to opening of first female flower, number of node at which first female flower appears and days to first fruit harvest

Characters	Days to opening of first female flower			No. of node at which first female flower appeared			Days to first fruit harvest		
	X	b_i	S^2d_i	*X*	b_i	S^2d_i	*X*	b_i	S^2d_i
Crosses									
P_1 x P_2	55.233	0.85	9.26**	20.08	1.58	23.22**	60.72	0.74	-290.36
P_1 x P_3	56.758	1.00	6.99*	20.35	0.83	-1.71	61.99	0.93	-285.40
P_1 x P_4	56.633	1.17	5.98*	22.49	0.14	3.23	61.98	1.25	-297.99
P_1 x P_5	54.2	0.92	-0.97	22.83	-0.3	4.22	59.73	0.91	-302.64
P_1 x P_6	59.367	1.07	17.43**	23.43	1.58	-1.13	65.38	0.80	-228.84
P_1 x P_7	58.592	1.63	2.68	22.55	3.89*	-0.48	63.98	1.71	-283.83
P_1 x P_8	56.725	1.02	2.49	22.08	3.22	-0.38	62.35	0.98	-292.12
P_2 x P_3	53.467	0.72	0.74	20.08	1.91	21.62**	59.55	0.70	-306.79
P_2 x P_4	59.058	0.83*	-2.24	20.84	-2.56	2.73	63.63	0.94	-299.52
P_2 x P_5	58.725	0.76	11.16**	27.15	4.44	10.21**	64.76	0.61	-260.00
P_2 x P_6	60.8	1.01	13.48**	23.88	1.75	-1.35	66.09	1.21	-307.74
P_2 x P_7	65.4	0.87	85.54**	25.46	1.09	3.41	70.68	1.02	-244.28
P_2 x P_8	53.875	0.91	3.03	21.53	0.83	1.60	59.01	0.92	-300.51

P_3 x P_4	57.267	0.39	33.34**	20.22	1.13	1.07	64.33	0.70	-261.29
P_3 x P_5	58.192	0.58	53.46**	20.97	0.70	-1.98	63.57	0.52	-253.26
P_3 x P_6	54.717	0.81	2.99	20.80	0.75	8.82**	62.42	1.47	-306.71
P_3 x P_7	58.667	0.80	17.65**	23.90	1.12	6.79*	65.54	1.29	-273.00
P_3 x P_8	57.283	0.80	1.74	20.83	1.14	-0.84	62.30	0.79	-299.80
P_4 x P_5	59.142	1.30	5.12*	23.84	1.02	0.42	64.40	1.52	-306.56
P_4 x P_6	61.167	1.05	15.04**	20.50	-0.34	-0.85	66.14	1.08	-291.52
P_4 x P_7	59.767	1.68*	-1.31	23.31	0.82	-2.04	65.58	1.73	-294.51
P_4 x P_8	57.742	0.83	14.09**	23.34	0.69	3.10	63.03	0.95	-298.87
P_5 x P_6	57.117	1.54	3.59	23.23	2.32	-1.79	62.62	1.59	-291.08
P_5 x P_7	61.558	1.39	24.52**	24.65	-0.68	2.14	67.00	1.59	-302.25
P_5 x P_8	61.333	1.66	29.75**	23.18	1.95	4.49	66.63	1.72	-250.18
P_6 x P_7	51.675	0.21	25.91**	24.49	0.46	2.77	56.91	0.29	-293.29
P_6 x P_8	66.292	1.30*	-2.29	24.70	2.66	10.86**	71.29	1.27	-290.50
P_7 x P_8	68.6	1.30*	-2.08	24.13	1.00	0.86	126.41	-1.62	1477.60**
Parents									
Pusa Nasdar (P_1)	55.642	0.92	5.42*	21.05	0.95	-1.92	61.50	0.71	-279.16
Swarna Uphar (P_2)	57.833	0.96	-1.52	21.83	0.81	6.55*	62.69	1.08	-306.05
AHRG-1 (P_3)	52.233	1.11	1.57	20.57	-0.35*	-1.95	57.58	1.30	-310.51
Salumber Long (P_4)	57.125	0.61	78.04**	23.48	0.92	8.63**	62.40	0.47	-231.31
Jaipuri Long (P_5)	55.992	1.59	12.19**	21.00	-0.73	20.47**	61.52	1.62	-262.04
Swarna Manjari (P_6)	61.5	1.54	11.96**	21.03	-0.2	-1.58	66.38	1.64	-312.54
Arka Sujath (P_7)	57.758	0.86	5.66*	21.54	1.57	1.84	62.93	0.86	-304.00
Arka Sumeet (P_8)	71.73	0.00	19.55**	21.47	-0.10	0.07	77.42	0.70	-296.43
General Mean	58.59	1.00		22.41	1.00		65.57	1.00	
S.E. (b_i) $\pm$	2.355	0.33		1.402	1.121		12.22	1.93	

* and ** significant at 5 and 1 per cent levels, respectively

Table 3. Estimates of stability parameters for number of fruits per vine, fruit length and fruit girth

Characters	No. of fruits per vine			Fruit length (cm)			Fruit girth (cm)		
	X	bi	S^2di	*X*	bi	S^2di	*X*	bi	S^2di
Crosses									
P_1 x P_2	6.82	1.07	1.15**	19.91	-0.20	3.18	9.45	0.93	-0.87
P_1 x P_3	6.28	0.92	3.40**	19.55	-1.67	-1.10	9.90	2.14	-0.06
P_1 x P_4	5.19	-0.13	0.56	21.76	-0.97	1.76	8.84	-0.88	-0.35
P_1 x P_5	6.18	-0.52	0.63*	19.07	1.71	6.05	8.99	-0.50	0.75
P_1 x P_6	7.66	0.88	0.62	19.21	-1.90	2.23	9.54	1.89	0.13
P_1 x P_7	6.95	0.28	0.82*	21.76	-0.35	11.99**	9.14	2.67	-0.64
P_1 x P_8	6.39	0.63	0.19	20.54	2.45	2.46	9.24	-1.38	1.25
P_2 x P_3	8.11	1.19	0.44	20.29	0.66	4.38	9.25	2.46	-0.70
P_2 x P_4	7.43	1.25	-0.28	21.35	0.31	2.33	8.73	1.39	-0.47
P_2 x P_5	6.70	1.38	0.02	19.61	-2.64	0.07	8.54	-1.52	0.24
P_2 x P_6	6.32	0.70	0.01	21.02	0.34	1.75	9.07	0.41	-0.16
P_2 x P_7	4.63	0.70	0.12	21.56	-1.42	0.10	8.15	0.03	1.22
P_2 x P_8	5.21	0.86	0.96*	23.02	-6.16	2.78	9.39	1.90	0.33
P_3 x P_4	8.72	1.18	1.51**	20.88	2.37	0.02	8.45	1.06	-0.08
P_3 x P_5	9.46	1.10	1.79**	20.32	3.82	-1.75	9.73	0.34	-0.71
P_3 x P_6	7.66	0.51	9.33**	17.95	-1.01	-1.15	9.30	2.23	-0.67

P_3 x P_7	3.93	0.67	0.17	20.73	2.48	-1.87	8.92	1.53	-0.77
P_3 x P_8	5.63	0.16	3.97**	21.92	1.96	8.29*	8.99	0.28	-0.21
P_4 x P_5	7.86	0.41	1.72**	23.67	6.07	12.63**	8.47	1.95	0.11
P_4 x P_6	7.80	1.92	3.26**	17.51	-2.09	2.91	8.70	0.97	0.00
P_4 x P_7	6.36	0.83	-0.12	21.88	4.10	-0.20	8.17	-0.72	-0.72
P_4 x P_8	4.56	-0.33	0.17	22.35	-0.27	4.43	9.06	0.96	-0.84
P_5 x P_6	9.11	0.73	3.43**	22.41	17.85	36.83**	9.90	2.10	0.14
P_5 x P_7	7.67	1.21	0.21	21.22	3.05	3.70	8.82	0.26	-0.72
P_5 x P_8	6.48	1.79	0.68*	24.55	9.67	7.84*	9.59	1.04	0.82
P_6 x P_7	4.12	1.32	2.64**	19.95	1.81	-1.82	8.30	2.13	-0.51
P_6 x P_8	3.31	0.75	1.34**	21.08	2.26	1.70	9.16	-0.23	-0.73
P_7 x P_8	2.35	0.00*	-0.29	19.99	3.57	4.32	8.63	0.60	-0.61
Parents									
Pusa Nasdar (P_1)	9.48	2.84	2.67**	18.78	-0.40	-2.26	9.86	-0.19	0.68
Swarna Uphar (P_2)	6.64	2.12*	-0.30	21.22	0.78	11.68**	8.85	4.33	-0.04
AHRG-1 (P_3)	9.23	2.41	1.13*	19.03	-0.26	-0.38	10.78	2.68	13.88**
Salumber Long (P_4)	9.33	1.91	0.65*	24.05	4.33	-2.00	8.91	2.93	0.24
Jaipuri Long (P_5)	7.27	1.80	2.08**	22.19	-6.35	4.02	10.44	-0.27	7.28**
Swarna Manjari (P_6)	7.83	2.09	0.09	20.11	-0.56	0.39	9.89	1.20	-0.35
Arka Sujatah (P_7)	3.56	0.72	0.47	19.90	-4.93	5.47*	10.20	2.67	-0.24
Arka Sumeet (P_8)	3.57	0.66	-0.06	21.55	-2.43	16.25**	8.47	-1.40	-0.59
General Mean	6.55	1.00		20.89	1.00		9.16	1.00	
S.E. (b_i) $\pm$	0.72	0.59		1.47	3.68		0.66	1.98	

* and ** significant at 5 and 1 per cent levels, respectively

Table 4. Estimates of stability parameters for fruit weight and total fruit yield per vine

Characters	Fruit weight (g)			Fruit yield per vine (kg)		
	X	bi	S^2di	*X*	bi	S^2di
Crosses						
P_1 x P_2	128.95	4.08	39.16	0.92	1.23	0.05**
P_1 x P_3	128.68	2.42	24.76	1.09	0.99	0.13**
P_1 x P_4	133.20	1.92	302.31**	0.71	0.24	0.00
P_1 x P_5	138.52	4.52	113.48	0.92	-0.38	0.09**
P_1 x P_6	130.52	3.33	138.56	1.06	0.59	-0.01
P_1 x P_7	131.97	-1.92	-57.69	0.94	0.41	0.01
P_1 x P_8	119.83	0.91	47.02	0.79	0.39	-0.01
P_2 x P_3	126.20	1.47	7.01	1.04	1.23	0.00
P_2 x P_4	131.20	3.17	67.35	1.09	1.58	0.01
P_2 x P_5	140.58	-1.90	77.94	1.12	1.86	0.02
P_2 x P_6	132.85	-0.52	-31.70	0.88	0.62*	-0.01
P_2 x P_7	128.77	2.56	108.85	0.66	-0.17	-0.01
P_2 x P_8	121.15	2.16	-31.06	0.66	0.57	0.00
P_3 x P_4	123.10	1.89	-68.16	1.09	0.98	0.01
P_3 x P_5	133.83	-0.76	-68.42	1.32	1.13	0.06**
P_3 x P_6	134.68	-3.35	-11.90	1.05	0.95	0.10**
P_3 x P_7	130.37	-0.24*	-76.24	0.79	1.52	0.15**

P_3 x P_8	126.48	-0.05	9.61	0.76	0.54	0.10**
P_4 x P_5	147.77	1.65	203.81*	1.19	0.13	0.00
P_4 x P_6	133.33	0.60	225.82*	1.06	2.70	0.03*
P_4 x P_7	129.17	3.34	-7.24	0.85	0.40	-0.01
P_4 x P_8	132.77	-0.78	417.81**	0.63	-0.10	0.00
P_5 x P_6	134.32	1.89	-20.68	1.25	0.41	0.05**
P_5 x P_7	138.28	-1.71	-30.28	1.09	1.31	-0.01
P_5 x P_8	136.13	-0.13	-10.58	0.93	1.90	0.00
P_6 x P_7	128.07	-0.62	-19.41	0.63	1.60	0.00
P_6 x P_8	140.07	-0.78	197.30*	0.52	1.10	0.04*
P_7 x P_8	119.64	1.67	-61.43	0.29	-0.18*	-0.01
Parents						
Pusa Nasdar (P_1)	135.42	5.75	-34.03	1.28	2.72	0.00
Swarna Uphar (P_2)	128.48	0.59	-62.24	0.87	1.84*	-0.01
AHRG-1 (P_3)	126.98	2.34	182.30*	1.20	1.94	-0.01
Salumber Long (P_4)	139.88	-1.08	-64.76	1.39	2.01	0.01
Jaipuri Long (P_5)	126.43	1.85	35.71	0.97	1.09	0.02
Swarna Manjari (P_6)	129.02	3.50	-21.88	1.02	1.65	0.00
Arka Sujath (P_7)	123.97	-0.44	153.77	0.49	0.76	0.02
Arka Sumeet (P_8)	118.37	-1.33	-7.54	0.47	0.41	-0.01
General Mean	130.8	1.00		0.92	1.00	
S.E. (b_i) $\pm$	6.50	1.90		0.11	0.65	

* and ** significant at 5 and 1 per cent levels, respectively

Reference

Breese, E. L. 1969. The measurement and significance of genotype x environment interaction in grasses. *Heredity*, 24: 27-44.

Dubey, A. K., Srivastava, J. P. and Singh, S. K. 2005. Studies on stability and genotypes x environment interaction in pointed gourd (*Trichosanthes dioica* Roxb.). In: Proceedings of National Seminar on Cucurbits held on 22nd- 23nd Sept., 2005 at Pantnagar. : 307-311.

Eberhart, S. A. and Russell, W. A. 1966. Stability parameters for comparing varieties. *Crop Science*, 6 : 36 40.

Pal, D. C. and Jain, S. K. 1998. Tribal Medicine, Naya Prakash, Calcutta, India.

Samadia, D. K. 2007. Stability parameters in bottle gourd. *Indian Journal of Arid Horticulture*, 2(2): 20-23.

Shaikh, J. A., Kathiria, K. B. and Acharya, R. R. 2012. Stabilty analysis for fruit yield and its component traits in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). *Vegetable Science*, 39 (1): 89-91.

Yadav, R. K. and Ram, H. H. 2010. Genotype-environment interaction and stability analysis for yield and yield attributing characters in muskmelon. *Indian Journal of Horticulture*, 67 (Special Issue): 179-184.

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Stability analysis for yield and yield attributes in fenugreek

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Abstract

Stability analysis was carried out in twenty-five fenugreek (*Trigonella foenum-graecum* L.) genotypes over three environments created by three dates of sowing with the interval of fifteen days to identify phenotypically stable genotypes for yield and yield traits. A joint regression analysis of variance revealed that variances due to genotypes were found significant for seed yield per plant and number of seeds per pod. Mean squares due to environment were found significant for almost all the characters except number of pods per plant. Mean square due to environment (E) + Genotype (G) x environment (G X E) was found significant for plant height, number of primary branches per plant and number of seeds per pod. Mean squares due to G x E interaction were found significant for number of primary branches per plant and number of seeds per pod. Mean squares due to linear components of G X E were found significant for number of primary branches per plant and number of seeds per pod. Thus, role of environment and G x E interactions must be taken into account while devising and implementing selection or breeding programmes in fenugreek.

Key words: *Fenugreek, G X E interaction, Stability, Yield*

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spices crop widely grown in north-western India. It is originated between South East Europe and West Asia (Smith, 1982). It is native to the countries bordering the Eastern shores of Mediterranean region, extending to Central Asia. Fenugreek is self- pollinated crop with chromosome no. 2n=16 (Frayer, 1930). It is an important condiment crop grown for both seed as well as leaves purpose. It can be grown under a wide range of climatic conditions and extensively used as fresh leaves (green leafy vegetable), chopped leaves (flavouring agent), sprouts (salad), micro greens (salad), pot herbs (decoration), seeds (spice, condiments or medicines), extracts and powders (medicines). Fenugreek seed contains carbohydrate (48%), protein (25.5%), mucilaginous matter (20.0%), fat (7.9%) and saponin (4.8%). The seed also contains major nutrients and minor nutrients with amino acid *viz.*, leucine, valine, lysine and phenylalanine. The fenugreek seeds are bitter in taste due to presence of alkaloids known as "*Trigonellin*". A potential use of fenugreek is for extraction of diosgenin. Diosgenin is a steroid precursor, which is used as a basic material in the synthesis of sex hormones and contraceptives. Fenugreek also has a high degree of medicinal value as it is used in certain Ayurvedic medicines for curing colic flatulence, dysentery, diabetes, diarrhoea and dyspepsia with loss of appetite.

More than 80 per cent area and production of the country is contributed by Rajasthan state alone. In Rajasthan the area under fenugreek is 82.35 thousand ha with production of 87.38 thousand tonnes (Anonymous, 2012-13). Fenugreek can be grown under wide range of climatic conditions. It requires cool climate and dry weather at the time of maturity. It can be grown on all types of soil, which is well drained. Unlike other legumes, fenugreek is fairly tolerant to salinity (Habib *et al*., 1971). Cloudy weather particularly during the time of grain feeling stage increases the incidence of diseases and pests, which adversely affect the yield as well as quality of the produce. A successful evaluation of stable genotypes, which could be used in a breeding programme to develop promising genotypes, can be done through the study of stability of different genotypes under different environmental conditions. A specified genotype does not exhibit same phenotypic characteristics under all the environments and different genotypes respond differently to a specified environment. This variation arising from the lack of correspondence between genetic and non-genetic

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factors is known as G x E interaction. Keeping in view, the study has been under taken to find out stable genotype of fenugreek under and conditions of Rajasthan.

Materials and Methods

Twenty five elite genotypes of fenugreek were received from the germplasm collection of AICRP on Spices located at S.K.N. College of Agriculture, Jobner (Rajasthan). These genotypes were tested in randomized block design with three replications under three environments created by three dates of sowing (25 Oct., 10 Nov. and 25 Nov, 2011) with the interval of fifteen days at Research Farm, College of Agriculture, Bikaner (Rajasthan) during *Rabi* 2011-12. The data were collected on ten randomly selected plants from each replication and environment for plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod and seed yield per plant. For statistical analysis, mean values were used. The data were analyzed for stability parameters according to Eberhart and Russell (1966).

Results and Discussion

Mean squares due to genotype were significant for number of seeds per pod and seed yield per plant (Table1). Mean squares due to environment were significant for almost all the characters except number of pods per plant. G x E interaction variance was significant for number of primary branches per plant and number of seeds per pod. Mean squares due to environment linear were significant for almost all the characters except number of pods per plant so indicating that environments differed significantly. Significant differences attributable to genotype, environment and G x E interaction were also reported by Singh and Singh (1990) and Sood *et al*. (2001).

Mean squares due to (E) +G X E was found significant for plant height, number of primary branches per plant and number of seeds per pod. Significant difference in E+G X E were also reported by Manikannan *et al.* (2002) in urd bean. Linear components of G x E were significant for number of primary branches per plant and number of seeds per pod. Significant linear components of G x E were also reported by Solanki and Choudhary (1996). Pooled deviation (non linear) was found non-significant for almost all the characters except number of primary branches per plant. Non-Significant Pooled deviation (non linear) were also reported by Rao and Rao (2004) and Datke and Gandhi Prasad (2000).

Plant height

Genotypes with short mean plant height than population mean are more suitable for this character (Table 2). Out of twenty five genotypes, thirteen genotypes viz., Rmt-143, Rmt-35, Rmt-305, UM-117, UM-120, UM-122, UM-131, UM-133, UM-171, UM-190, UM-201, UM-205 and UM-207 exhibited short mean plant height than population mean (38.14 cm). On the basis of mean and regression coefficient, genotypes Rmt-305, UM-117 and UM-190 showed above average stability as they had lower mean than general mean along with regression coefficient higher than unity (b_i >1) and non-significant deviation (S^2d_i) from regression. Genotypes UM-120, UM-122, UM-133, UM-201, UM-205 and UM-207 had lower mean than general mean and regression coefficient lower than unity (b_i<1) showed below average stability. Genotypes Rmt-351, UM-131 and UM-171 showed average stability as they had lower mean than general mean and regression coefficient equal to unity (b_i=1). Therefore, these genotypes were stable and desirable.

Table 1. Analysis of variance for stability in fenugreek genotypes over three environments.

Source of Variation	D F	Plant height (cm)	No. of primary branches per plant	Number of pods per plant	Number of seed per pod	Seed yield per plant (g)
Genotypes (G)	24	6.856	0.373	17.383	1.548##	0.877#
Environment (E)	2	535.439##	1.405##	17.474	105.812##	3.866##
Gen. x Env. (G x E)	48	8.996	0.514*	27.078	0.208**	0.528
(E + G x E)	50	30.058**++	0.550**	26.694	4.432**++	0.662
E (Linear)	1	1070.879**++	2.810*++	34.949	211.63**++	7.732**++
G x E (Linear)	24	10.445	0.511**	22.840	0.405**++	0.387
Pooled Deviation	25	7.244	0.497**	30.064	0.011	0.642
Pooled Error	150	8.112	0.285	23.813	0.074	0.466

#, ## significant at 5% and 1% level against G x E, respectively

*, ** significant at 5% and 1% level against pooled error, respectively

+, ++ significant at 5% and 1% level against pooled deviation, respectively

Table 2. Stability parameters for plant height, number o f primary branches per plant and number of pod s per plant in fenugreek genotypes.

Genotypes	Plant height (cm)			Number of primary branches per plant			Number of pods per plant		
	x	b_i	S^2d_i	x	b_i	S^2d_i	x	b_i	S^2d_i
Rmt-143	34.67	1.47	24.72*	3.06	-3.42	0.35	17.62	-5.83	19.56
Rmt-305	34.96	1.18**	3.73	3.73	-1.21	0.09	21.58	-1.04	50.95
Rmt-351	37.16	1.01**	-7.11	3.93	-0.98	-0.27	20.58	3.13	-1.76
UM-114	38.69	0.93**	-6.56	3.51	-0.05	2.60**	20.74	-4.28	57.23
UM-117	36.44	1.32**	-8.08	3.21	2.60**	-0.28	14.64	5.28*	-17.25
UM-120	36.96	0.50**	6.81	2.87	0.00	-0.21	17.64	-1.07	14.41
UM-122	37.82	0.88	1.47	3.50	-1.21	-0.14	18.11	-2.34	-21.99
UM-125	39.49	2.11**	0.81	2.99	4.10**	-0.27	19.43	8.67**	-14.47
UM-128	38.84	1.33**	-7.28	3.19	-0.27	-0.12	21.57	4.09	18.60
UM-131	37.48	1.09**	-3.72	3.45	-0.41	-0.14	23.77	0.46	21.77
UM-133	36.44	0.82**	-4.75	3.78	3.59**	1.2	20.99	1.25	8.84
UM-138	41.20	1.21**	-8.11	3.12	2.51	-0.25	22.76	-0.00	-15.33
UM-165	38.48	1.46**	-6.05	2.87	3.03**	0.13	22.94	2.52	-4.41
UM-166	40.44	1.44*	14.84	3.17	5.59**	0.45	19.71	9.69	41.81
UM-169	39.17	1.87**	-2.41	3.21	2.93	-0.15	22.19	6.80	-19.42
UM-171	38.12	0.92**	-7.96	3.28	0.53	-0.16	22.36	-5.54	1.60
UM-190	38.07	1.24**	4.15	3.13	-0.51	3.27	16.99	0.91**	95.85
UM-196	38.36	1.19**	-7.79*	3.68	-1.42	-0.27	21.62	-2.55	-17.80
UM-201	37.92	0.57*	-5.32	3.86	0.43	-0.04	20.93	1.01	9.09
UM-202	39.13	0.37*	-7.30	3.73	0.24	-0.28	21.33	3.33	-20.08
UM-205	38.11	0.62	11.92	3.38	1.37	-0.01	17.62	-0.42	-21.50
UM-206	38.23	0.21	-6.13	3.31	3.78	.011	19.62	2.25	32.18
UM-207	38.07	0.11	-7.05	3.23	1.21	-0.01	20.57	-4.19	-15.85
UM-209	39.61	0.55*	-6.40	2.84	2.48	-0.04	16.28	2.36**	-23.78
UM-211	39.66	0.58	25.52	2.56	0.08	-0.23	16.36	0.49	-21.89
Population mean	38.14	1.00		3.31	1.00		19.92	1.00	
$SE(b_i) \pm$		0.31			1.27			3.42	

Number of primary branches per plant

Genotypes Rmt-305, Rmt-351, UM-114, UM-122, UM-131, UM-133, UM-196, UM-201, UM-202, UM-205 and UM-206 showed higher number of primary branches per plant (Table 2) as they had higher mean than population mean (3.31). Genotypes UM-133, UM-205 and UM-206 had greater mean than general mean and regression coefficient higher than unity (b_i >1) and non-significant deviation (S^2d_i) from regression exhibited above average stability. Genotypes Rmt-305, Rmt-351, UM-122, UM-131, UM-196, UM-201 and UM-202 had higher mean than general mean and regression coefficient lower than unity (b_i <1) exhibited below average stability.

Number of pods per plant

A close perusal of (Table 2) showed that fourteen genotypes viz., Rmt-305, Rmt-351, UM-114, UM-128, UM-131, UM-133, UM-138, UM-165, UM-169, UM-171, UM-196, UM-201, UM-202 and UM-207 showed higher number of pods per plant as they had high mean than general mean (19.92). Six genotype Rmt-351, UM-128, UM-133, UM-165, UM-169 and UM-202 exhibited above average response as they had higher mean than general mean and regression coefficient higher than unity (b_i >1) and non-significant deviation (S^2d_i) from regression. Seven genotypes Rmt-305, UM-114, UM-131, UM-138, UM-171, UM-196 and UM-207 had greater mean than general mean and regression coefficient lower than unity (b_i <1) exhibited below average stability while only one genotypes UM-201 had greater mean than general mean and regression coefficient equal to unity (b_i =1) exhibited average stability.

Number of seeds per pod

Genotypes Rmt-143, Rmt-305, Rmt-351, UM-122, UM-131, UM-166, UM-169, UM-202, UM-

Table 3. Stability parameters for number of seeds per pods and seed yield per plant in fenugreek genotypes.

Genotypes	Number of seeds per pod			Seed yield per plant (g)		
	x	b_i	S^2d_i	X	b_i	S^2d_i
Rmt-143	13.50	0.99**	-0.06	2.54	2.82	2.46**
Rmt-305	13.00	0.79**	-0.07	3.28	1.73	-0.14
Rmt-351	13.70	0.70**	-0.07	2.14	1.22**	-0.42
UM-114	11.72	0.72**	-0.06	2.48	2.83	0.13
UM-117	12.31	0.98**	-0.07	3.12	-0.15	-0.28
UM-120	11.63	0.92**	-0.07	3.08	0.23	-0.45
UM-122	12.86	0.94**	-0.06	3.45	-0.64	-0.43
UM-125	12.32	0.83**	-0.05	3.78	1.89*	-0.29
UM-128	12.54	1.34**	-0.07	2.92	0.06	-0.40
UM-131	14.05	0.93**	-0.07	3.72	-0.29	-0.40
UM-133	12.00	0.72**	-0.05	2.82	2.91	0.56
UM-138	12.41	0.81**	-0.07	2.61	1.44	0.92
UM-165	12.51	1.02**	-0.07	3.08	-0.50	-0.38
UM-166	13.08	0.96**	-0.06	3.92	1.23*	5.15
UM-169	12.64	1.02**	-0.06	3.36	1.95	-0.46
UM-171	11.61	1.25**	-0.07	4.04	2.69**	0.61
UM-190	11.57	1.26**	-0.04	2.45	0.31	-0.33
UM-196	12.30	1.26**	-0.05	3.11	1.21	0.13
UM-201	12.17	1.53**	-0.07	3.88	-0.39	-0.13
UM-202	12.80	1.33**	-0.07	2.53	0.63	-0.14
UM-205	14.02	0.90**	-0.06	2.83	2.08**	-0.39
UM-206	12.91	0.95**	-0.03	2.15	0.98	-0.17
UM-207	11.80	0.87**	-0.02	2.68	-0.45	-0.25
UM-209	12.22	0.85**	-0.05	2.81	0.51	-0.22
UM-211	13.12	0.96**	-0.06	2.71	1.01	-0.24
Population mean	12.59	1.00		3.02	1.00	
SE (b_i)±		0.04			0.92	

205, UM-206 and UM-211 showed greater number of seeds per pod (Table 3) as they depicted higher mean than population mean (12.59)**.** Genotypes UM-202 had higher mean than general mean and regression coefficient higher than unity (b_i >1) and non-significant deviation (S^2d_i) from regression exhibited above average stability. Genotypes Rmt-305, Rmt-351 had greater mean than general mean and regression coefficient lower than unity (b_i <1) exhibited below average stability while genotypes Rmt-143, UM-122, UM-131, UM-166, UM-169, UM-205, UM-206 and UM-211 had greater mean than general mean and regression coefficient equal to unity (b_i =1) exhibited average stability.

Seed yield per plant

Data presented (Table 3) showed that twelve genotypes namely Rmt-305, UM-117, UM-120, UM-122, UM-125, UM-131, UM-165, UM-166, UM-169, UM-171, UM-196 and UM-201 showed higher seed yield per plant as they depicted higher mean than population mean (3.03g). Joint consideration of mean performance and stability parameters revealed that genotypes Rmt-305, UM-125, UM-166, UM-169, UM-171 and UM-196 had higher mean than general mean and regression coefficient higher than unity (b_i >1) and non-significant deviation (S^2d_i) from regression exhibited above average stability. Genotypes UM-117, UM-120, UM-122, UM-131, UM-165 and UM-201 exhibited below average stability as they had greater mean than general mean and regression coefficient lower than unity (b_i <1).

On the basis of present study, genotype UM-205 was identified as a stable genotype for number of seeds per pod over varied environments as it had regression coefficient equal to unity with non-significant deviation (S^2d_i) from regression. Genotype UM-171 was stable for seed yield per plant, Rmt-305 was stable for seed yield per plant and plant height, genotype UM-165 was also stable for plant height, and number of pods per plant. These genotypes perform better under favorable environment. All above

genotypes showed regression coefficient higher than unity with non significant deviation (S^2d_i) from regression. Superior genotypes were identified for poor environment. Genotype UM-131 was stable for seed yield per plant, number of primary branches per plant, number of pods per plant, genotype UM-122 was stable for seed yield per plant, plant height and number of primary branches per plant, genotype UM-120 was also stable for seed yield per plant, plant height. All above genotype showed regression coefficient less than unity with non-significant deviation (S^2d_i) from regression and this identified for poor environment.

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References

Anonymous, 2013. Horticultural database 2012-13. National Horticultural Board, Gurgaon, India.

Datke, S. B. and Gandhi Prasad, N. S. 2000. Genotype x environment interaction in pigeon pea. *PKV Res. Journal*, 24 (1): 19-22.

Eberhart, S. A. and Russell, W. L. 1966. Stability parameters for comparing varieties. *Crop Sci*., 6: 36-40.

Frayer, J. K. 1930. Chromosome atlas of flowering plant. Georg Allen and Urwin London*;* pp. 519.

Habib, A. F., Swamy, R. J. and Mensinkai, S. N. 1971. Salt tolerance in methi at germination stage. *Current Sci.*, 40 : 67.

Manikannan, C., Jabaraj, S. and Ashok, S. 2002. Stability analysis for seed yield and its components in urd bean. *Madras Agric. J*., 89(10-12): 706-708.

Rao, C. M. and Rao, Y. K. 2004. Stability analysis in chickpea (*Cicer arietinum* L.). *Legume Res.*, 27 (4): 235-242.

Singh, V. and Singh, F. 1990. Stability of yield and harvest index in chick pea. *Indian J. Agric. Sci*., 60 (7): 443-447.

Smith, A. 1982. Selected materials for turmeric, coriander seed, cumin seed, fenugreek seed and curry powder. Tropical Product Institute, London Co.,165: 7-45.

Solanki, Z. S., and Choudhary, B. R. 1996. Stability in clsuterbean (*Cyamopsis tetrgonoloba* (L.) Taub.). *Indian Agric. Sci.*, 66 (8): 470-473.

Sood, B. C., Bhambota, S. K. and Gartan, S. L. 2001. Studies on genotype x environment interaction and stability in chickpea (*Cicer arietinum* L.). *Indian Pulses Res.*, 14 (1): 31-33.

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Effect of drip irrigation and bioregulators on water use efficiency and fruit yield of round gourd (*Praecitrullus fistulosus*)

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Abstract

A field experiment was conducted during 2011 and 2012 at Niche Area Excellence Farm, Bikaner to study the effect of drip irrigation and bio-regulators on water use efficiency and fruit yield of round gourd (*Praecitrullus fistulosus*). The treatments consists of three drip irrigation schedules viz. 60, 80 and 100% ETc and four levels of bioregulators viz. control (water spray), thiourea (500 ppm), N-acetyl cysteine (20ppm) and TGA (100 ppm) foliar spray twice at vegetative and flowering stage. One absolute control was taken and the crop was grown with surface irrigation using recommended package of practices. The experiment was conducted in randomized block design and replicated thrice. Results indicated that there was increase in fruit yield with increase in irrigation levels from 60% to 100% ETc and the highest fruit yield of 328.8 q/ha was recorded with 100% ETc.. The study further revealed that number of fruit per plant increase with increasing level of irrigation upto 100% ETc. Among the bioregulators fruit yield was maximum in N-acetyl cysteine @ 20ppm (319.5 q/ha) spray as compared to thiourea (500ppm) and TGA (100ppm) spray where yields were 314.5 and 319.5 q/ha, respectively. The study also indicated that number of fruits per plant, fruit weight and water use efficiency (WUE) were higher in bioregulators spray as compared to water spray (control).

Key words: *Bioregulators- thiourea, N-acetyl cysteine, TGA, drip irrigation level, round gourd, fruit yield, water use efficiency.*

Introduction

Rajasthan, particularly western region comes under hyper arid zone with very scarce water resource. Thus, more crop per drop of water is main motto of any agricultural production system in these region of the state. Round gourd (*Praecitrullus fistulosus*) the major cucurbitaceous vegetable of the region is grown extensively in this area. However, the yield level is very poor even with higher amount of water use. Drip irrigation maintains moisture content at near about field capacity in one hand and eliminates water losses on other hand. Devaranavadgi *et al*, 2011 reported that drip irrigation (100% ET) produced superior values for plant height, average fruit length, fruit weight, fruit girth and fruit yield/ha in bitter gourd. Sulphydryl (-SH-) compounds improve phloem translocation of photosynthate and thus enhance crop productivity. So, they act as bioregulators and play an important role in improving water use efficiency through enhanced phloem translocation and yield formation in arid regions. Thiourea (500 ppm) significantly increased yield and quality of tubers in potato (Mani *et al*, 2013). Beside thiourea, N-acetyl cysteine and thioglycolic acid (TGA) also may enhance fruit yield and water use efficiency of round gourd. The information on bioregulators, and drip irrigation on round gourd growth and yield are meager. Hence, there is a felt need to generate precise information on irrigation requirement of round gourd through drip and effect of bio-regulators on round gourd in summer season.

Materials and Methods

A field experiment was conducted on round gourd during summer season of 2011 and 2012 at Niche Area Excellence Farm, S K Rajasthan Agricultural University, Bikaner situated in western hyper arid zone of Rajasthan. The soil was sandy loam in nature, having field capacity 6.50%, PWP 1.8%, bulk density 1.51 g /cc, pH (1:2) 8.4, electrical conductivity (1:2) 0.2 dS/m. The soil is very low in organic matter (0.11%) and medium in available P (32.4 kg/ ha) and high in available K (336 kg/ ha). The experiment was laid out in randomized block design with three replications. The treatments consist of three irrigation levels (60%, 80% and 100% ETc) and four bio-regulators levels (conrol-water spray, thiourea @ 500ppm, N- acetyl cysteine @

20ppm and TGA @ 100 ppm) foliar spray at vegetative and flowering stage. The irrigation treatments were compared with control i.e., crop grown with surface irrigation.. The total irrigation water provided were 326.26, 426.26 and 526.3 mm at 60%, 80% and 100% ETc, respectively including the rainfall of 26.2 mm (Table 1). Where as, in control 10 irrigation each of 60 mm was applied and thus total 626.2 mm water was applied including rainfall. Ground water was beyond 10 m throughout the growth period. Round gourd variety Tinda Ludhiana was sown on 14th March using seed rate of 12 kg/ha in crop geometry of 120 cm x 60 cm and finalally harvested on 30th June in both the years. In total plucking of fruits were done for 5 to 6 times in both the years. All the cultural operations were carried out as per recommendations.

Table 1. Monthwise irrigation events and irrigation water applied mean of two years

Month	Irrigation events	Irrigation water applied through drip (mm)	
	60% ETc	80% ETc	100% ETc
March (14 to 31)	22.15	29.53	36.91
April	84.5	112.67	140.84
May	130	173.33	216.66
June (1-21)	63.41	84.53	105.69
Total	300.06	400.06	500.1
Rainfal	26.2	26.2	26.2
Total (Including rainfall)	326.26	426.26	526.3

Water used in control (surface irrigation): 626.2 mm

Results and Discussions

Irrigation levels

Increasing irrigation levels from 60% to 100% ETc under drip increased fruit yield (Table 2). The highest fruit yield of 328.8 q/ha was recorded at 100% ETc against 320.8 and 293.3 q/ha with 80% and 60% ETc irrigation through drip, respectively. However 60% and 80% ETc and 80% and 100% ETc gave at par fruit yield. All the drip irrigation levels gave significantly higher yield than surface irrigation which recorded 112.6 q/ha fruit yield.

Drip irrigation levels of 60%, 80% and 100% ETc saved water by 299.94, 199.94 and 99.96 mm, respectively over surface irrigation which used 626.2 mm water. Hence, increased yield coupled with less water use in drip irrigation recorded higher water use efficiency (WUE) of 89.88, 75.24 and 62.47 kg/ ha-mm at 60%, 80% and 100% ETc, respectively against 17.96 kg/ ha- mm under surface irrigation (Table 2). Lower water use efficiency in surface irrigation (absolute control) may be due to loss of irrigation water from sandy loam soil through deep percolation resulted in higher water use but lowered fruit yield. Drip irrigation system saved quite a large amount of water, which can be useful in horizontal expansion of crop area in summer season when mostly irrigated crops are raised

Table 2. Effect of irrigation and bioregulators on yield, yield attributes, water use and water use efficiency of round gourd (pooled of two years)

Treatment	Fruit yield (q/ha)	No. of fruits/ plant	Fruit Weight (g)	Water use (mm)	WUE (kg/ha-mm)
Drip irrigation level					
60%	293.3	12.5	189.4	326.26	89.88
80%	320.8	14.4	201.7	426.26	75.24
100%	328.8	14.7	205.5	526.30	62.47
Surface irrigation	112.5	9.5	115.6	626.2	17.96
CD at 5%	8.6	1.1	2.5	-	-
Bioregulator spray					
Control	305.5	13.3	195.6	426.28	71.67
Thiourea (500 ppm	314.5	13.9	198.8	426.28	73.79
N-acetyl cysteine (20 ppm)	319.5	14.3	201.9	426.28	74.96
TGA (100 ppm)	317.4	14.0	199.1	426.28	74.47
CD at 5%	9.9	NS	2.8	-	-

in Rajasthan.

Bio-regulator

Highest fruit weight of round gourd was recorded with N-acetyl cysteine (20 ppm) foliar spray (201.9 g) as compared to control (195.6 g) , thiourea spray @ 500 ppm (198.8 gm), TGA @ 100 ppm (199.1 g). Similarly, though not significant N-acetyl cysteine @ 20 ppm foliar spray also gave the highest number of fruit per plant than all other bioregulators spray. Thus, increased yield attributes with foliar spray of N-acetyl cysteine (20 ppm) recorded higher fruit yield (319.5 q/ha) over thiourea spray @ 500 ppm (314.5 q/ha), TGA @ 100 ppm (317.4 q/ha) and control (305.5 q/ha)). However, fruit yield in control and thiourea, thiourea and N-acetyl cysteine and N-acetyl cysteine and TGA were at par (Table 2).

Interaction effect

Highest fruit yield (300.6 q/ha) with the bioregulator spray of N-acetyl cysteine compare to all other bioregulator treatments at drip irrigation level of 60% ETc which was at par with 80% ETc in control (315.6 q/ha) (Table 3). Similarly, fruit yield in 80% ETc at N-acetyl cysteine @ 20 ppm (324.5 q/ha) was at par with 100% ETc with or without bioregulator spray. Thus, application of N-acetyl cysteine @ 20 ppm can save 20% irrigation water. It is further observed that at 80 and 100% ETc bioregulators gave at par yield with no spray treatment. However, at 60% ETc N-acetyl cysteine gave significantly higher yield than control.

Table 3. Inter action effect of irrigation and bioregulator on fruit yield and water use efficiency

Tratment	Fruit yield (q/ha)			Water use efficiency (kg/ha-mm)		
	60% ETc	80% ETc	100% ETc	60% ETc	80% ETc	100% ETc
Control	280.5	315.6	320.5	85.97	74.03	60.89
Thiourea (500 ppm	294.5	320.5	328.6	90.26	75.18	62.43
N-acetyl cysteine (20 ppm)	300.6	324.5	333.5	92.13	76.12	63.36
TGA (100 ppm)	297.5	322.4	332.5	91.18	75.63	63.17
CD at 5%	17.1			-		

References

Devaranavadgi,V. S., Shirahatti, S.S. and Patil, M.G. 2011.Effect of different drip irrigation level on growth and yield of bitter gourd (*Momordica chanrantia* L.) in semi arid conditions of Karnataka. *International Journal of Agricultural Engineering*, 4(2):179-182.

Mani, F. , Bettaieb, T. , Zheni, K., Doudech, N and Hannachi, C. 2013. Effect of thiourea on yield and quality of potato (*Solanum tuberosum* L.). *Journal of Stress Physiology & Biochemistry*, 9(1):87-95.

Manjunatha, M.V. and Manjunatha, Hebbara. 2003. Response of ridge gourd to various levels of drip and surface irrigation in saline vertisols of canal command, Karnataka. *Asian Journal of Soil Science*, 5(2):257-260.

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Effect of drip irrigation levels and fertigation on cucumber (*Cucumis sativus*) cultivars under protected cultivation

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Abstract

An experiment was conducted during 2010-11 and 2011-12 in poly-house at Niche area excellence farm, Bikaner to study the effect of drip irrigation levels and fertigation levels on plant height, fruit yield and water use of cucumber (*Cucumis sativus*). The treatments consists of three drip irrigation schedules viz. 40, 60 and 80% ETc and three fertigation levels viz. 75%, 100% and 125% recommended dose of fertilizers. The experiment was conducted in randomized block design and replicated thrice. The study indicated that there was increase in plant height, fruit /plant and fruit yield with increase in irrigation levels from 40% to 80% ETc but the water use efficiency decreases from increasing the irrigation levels. Highest fruit yield of 625 q/ha was recorded with 80% ETc, which was at par with 60% ETc (614 q/ha). Similarly, nutrients uptake increases with higher levels of irrigation and highest N, P and K uptake of 112.5, 34.3 and 140.0 kg/ha, respectively was recorded at 80% ETc. However, nutrient use efficiency was higher in 40% ETc and control i.e., surface irrigation. The study further indicated that plant height, fruit /plant, fruit yield and water use efficiency was also increase with increasing the fertigation levels from 75% to 125% recommended dose (RD) of fertilizer. Fertigation with 125% recommended level of fertilizer gave highest N, P, K uptake of 116.8, 35.8 and 148.6 kg/ha, respectively. However, 75% RD recorded the highest nutrient use efficiency.

Key words: *Fertigation, drip irrigation level, cucumber, plant height, fruit yield, water use efficiency*

Introduction

Rajasthan, particularly western region comes under hyper arid zone with very scarce water resource and scanty and erratic rainfall. The arid climate is quite extreme with temperature as high as near about 49^0C and lowest as low as 0^0 C. Cucumber being very sensitive to changing environmental conditions adoption of protected cultivation may prove useful for improving farm income and it is an effective tool for higher and quality production of crops. Summer season vegetables like cucumber could be grown profitably inside the poly house as off-season crop during winter months (Saikia *et al.,* 2001). Drip irrigation maintains moisture content at near about field capacity in one hand and eliminates water losses on other hand. Fertigation with drip irrigation also enhance the water use efficiency as compare to sole application of fertilizers. Choudhary and More (2002), reported that application of fertilizers through drip (fertigation) was superior to sole solid fertilizer application under furrow and drip fertilizer application. Overall growth in terms of height of plant, numbers of leaves per plant inside the green house was more compared to open field in capsicum (Ghosal and Das, 2012). Production of vegetables under protected cultivation system results in effective use of the land resources, beside being able to increase the production of quality vegetables for both the export and domestic markets by offsetting biotic and abiotic stresses to a great extent that otherwise prevalent in open. Cultivation of capsicum in a polyhouse was found to be highly feasible as reflected in higher values of net present value (NPV), B:C ratio and internal rate of return with payback period of less than two year (Murthy *et al*, 2009).

Materials and Methods

An experiment was conducted during 2010-11 and 2011-12 in poly-house at Niche Area Excellence Farm, S K Rajasthan Agricultural University, Bikaner situated in arid western hyper arid zone of Rajasthan. The soil was sandy loam in nature, having field capacity 6.7%, PWP 2%, bulk density 1.52 g /cc, pH (1:2) 8.2, electrical conductivity (1:2) 0.2 dS/m. The soil is very low in organic matter (0.11%) and medium in available P (34 kg/ ha) and high in available K (351 kg/ ha). The experiment was laid out in randomized block design with three replications. The treatments consist of three irrigation levels (40%, 60% and 80% ETc) and three

fertigation levels (75%, 100% and 125%). The total irrigation water provided was 339.71, 509.59 and 679.42 mm at 40%, 60% and 80% ETc, respectively (Table 1). Ground water was below 10 m throughout the growth period. Cucumber variety "Hasan" was sown at 30 cm plant to plant and 60 cm row to row spacing on July 15, and tomato fruits were harvested 13 times started from September 10, to February 28, under protected cultivation in both the years. Under ambient condition fruits were harvested 5 times at 15 days interval during September 10, to February 28, also in both the years. All the cultural operations were carried out as per recommendations.

Results and Discussions

Irrigation levels

Increasing irrigation levels from 40% to 80% ETc under drip increased plant height, fruit/ plant and fruit yield (Table 2). Increased plant height and yield attributes with increasing irrigation levels through drip irrigation thus, enhanced fruit yield of cucumber and highest fruit yield of 625 q /ha was recorded at 80% ETc against 614, 502 and 176 q /ha with irrigation at 60%, 40% ETc through drip and surface irrigation, respectively. However fruit yield obtained with 60% ETc was at par with 80% ETc. It was further revealed that all drip irrigation levels under protected cultivation gave significantly higher fruit yield of cucumber than surface irrigation at open field condition (176 q/ha). This is in confirmation with Nagalakshami *et al*, 2001, who reported that capsicum grown in naturally ventilated poly house gave four times more yield and yield componenst compared to those grown in the field.

Cucumber being a long duration crop and very sensitive to environmental condition, under protected cultivation used more water than the crop grown in open field condition. Highest amount of water use of 679.42 mm was recorded with 80% ETc followed by 509.59, 339.71 and 441.23 mm with 60% and 40% ETc under protected cultivation and surface irrigation under open field condition, respectively. Increased water use in protected cultivation decreased water use efficiency. Thus, crop grown with 40% ETc gave the highest water

Table 1. Monthwise irrigation events and irrigation water applied (means of two years)

Month	Irrigation events	Drip irrigation (mm)		
		40% ETc	60% ETc	80% ETc
July (15-30)	8	20.19	30.29	40.39
August	15	58.23	87.35	116.46
September	16	56.42	84.63	112.83
October	15	66.83	100.24	133.65
November	15	51.92	77.88	103.84
December	16	36.57	54.86	73.15
January	15	36.63	54.96	73.26
February	14	12.92	19.38	25.84
Total	114	339.71	509.59	679.42

Table 2. Effect of drip irrigation and fertigation levels on height, yield, yield attributes, water use and water use efficiency of cucumber (pooled of two years)

Treatment	Plant height at harvest (m)	Fruit/ plant	Fruit yield (q/ha)	Water use (mm)	WUE (kg/ha-mm)
Irrigation level					
40% ETc	3.75	9.1	502	339.71	147.77
60% ETc	4.15	12.3	614	509.59	120.48
80% ETc	4.20	13.8	625	679.42	91.99
Control (Surface irrigation)	2.95	4.2	176	441.23	39.88
SE±	0.2	0.7	6		
CD at 5%	0.6	2.1	19		
Fertigation					
75% RD	3.68	10.5	510	509.57	100.08
100% RD	4.15	11.8	590	509.57	115.78
125% RD	4.27	12.9	641	509.57	125.79
SE±	0.2	0.7	6	-	-
CD at 5%	0.6	2.1	19	-	-

use efficiency (147.77 kg/ ha-mm) against 120.48 and 91.99 kg/ ha-mm with 60 and 80% ETc, respectively under protected cultivation. Lowest water use efficiency of 39.88 kg/ha-mm was recorded with surface irrigation under open field condition. Lower water use efficiency in surface irrigation (absolute control) may be due to loss of irrigation water from sandy loam soil through deep percolation, which resulted in higher water use but lowered fruit yield.

Increase in irrigation level increased N, P and K uptake and highest N, P and K uptake of 112.5, 34.3 and 140.0 kg/ha, respectively was recorded at 80% ETc (Table 3). However, 80% ETc gave lower nutrient use efficiency. All the drip irrigation levels gave higher nutrient uptake than control, i.e., with surface irrigation.

Fertigation

The study of three fertigation levels indicated that plant height, fruit per plant, fruit yield and water use efficiency increased with increasing the fertigation level from 75% to 125% recommended dose of fertilizer. However fruit per plant was not influenced by higher dose of fertilizers and it was at par between 100% and 125% recommended dose of fertilizer. The highest fruit yield 641 q/ha was recorded at 125% recommended dose against 590 and 510 q/ha at 100% and 75% recommended dose, respectively (Table 2). The water use in 75% to 125% recommended dose of fertilizers was same but the water use efficiency increased with increasing the fertigation level from 75% to 125% of recommended dose of fertilizer. The highest water use efficiency of 125.79 kg/ha-mm was recorded at 125% recommended dose against 115.78 and 100.08 kg/ha-mm at 100% and 75% recommended dose, respectively.

Highest N, P and K uptake of 116.8, 35.8 and 148.6 kg/ha, respectively was recorded with 125% of recommended dose (RD) of fertilizer (Table 3).

Table 3. Effect of drip irrigation and fertigation levels on N, P and K uptake and nutrient use efficiency of cucumber (pooled of two years)

Treatment	Nutrient up take (Kg/ha)			Nutrient use efficiency (q/ kg nutrient)		
	N	P	K	N	P	K
Irrigation level						
40% ETc	85.3	25.4	110.4	5.9	19.8	4.5
60% ETc	107.5	33.0	135.1	5.7	18.6	4.4
80% ETc	112.5	34.3	140.0	5.6	18.2	4.2
Control (Surface irrigation)	30.8	9.5	38.7	5.9	18.6	4.2
SE±	1.1	0.3	1.4	-	-	-
CD at 5%	3.3	1.0	4.6	-	-	-
Fertigation						
75% RD	82.3	25.2	107.1	6.2	20.2	4.8
100% RD	106.2	31.7	129.8	5.6	18.6	4.5
125% RD	116.8	35.8	148.6	5.5	17.9	4.3
SE±	1.1	0.3	1.4	-	-	-
CD at 5%	3.3	1.0	4.6	-	-	-

However, higher nutrient use efficiency was recorded with 75% RD.

References

Choudhary, S.M and More, T.A. 2002. Fertigation, fertilizer and spacing requirement of tropical gynoecious cucumber hybrids. *Acta Horticulturae*, 588: 233-240.

Ghosal, M.K. and Das, R.K. 2012. A study on the cultivation of capsicum in a greenhouse during offseason in warm and humid climate of India. *International Journal of Agricultural Sciences*, 8(1):220-223.

Murthy, D.S., Prabhakar, B.S., Hebbar, S.S., Srinivas,V. and Prabhakar.M. 2009. Economic feasibility of vegetable production under polyhouse: a case study of capsicum and tomato. *Journal of Horticulture Science*, 4(2):148-152.

Nagalakshmi,S., Aandakumar, N., Palanisamy, D. and Sreenarayanan, V. 2001.Naturally ventilated polyhouse for vegetable production. *South Indian Horticulture*, 49(Special):345-346.

Saikia, J., Baruah, H. K. and Phookan, D. B.2001.Offseason cultivation of cucumber in low cost polyhouse. *Annals of Biology*, 17(1): 61-64.

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Estimation of genetic components through biparental progenies in muskmelon (*Cucumis melo* L.)

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Abstract

Sixteen biparental progenies (BIPs) involving two crosses, IC- 274014 × Punjab Sunehri and IC-274014 × MM-28 developed by North Carolina Design III were evaluated in a Randomized Complete Block Design during 2009. The observations were recorded on days taken to first pistillate flower opening, total fruit yield per vine, number of fruits per vine, fruit weight, rind thickness, flesh thickness, and total soluble solids (TSS) content. Additive genetic variance was greater for days taken to first pistillate flower opening, total fruit yield per vine, number of fruits per vine and flesh thicknes in IC- 274014 × Punjab Sunehri and for number of fruits per vine, fruit weight, rind thickness and TSS content in IC-274014 × MM-28. Dominance variance was higher than additive genetic variance for total fruit yield per vine, fruit number per vine, fruit weight and rind thickness in cross IC-274014 × Punjab Sunehri, whereas dominance variance was higher for days to first female flower opening, total fruit yield per vine, fruit weight, rind thickness and flesh thicnkess in IC-274014 × MM-28. In cross IC- 274014 × Punjab Sunehri, for total fruit yield per vine, fruit weight, rind thickness and TSS content, degree of dominance was more than one along with low heritability and genetic advance. However, in the cross IC-274014 × MM-28, for days taken to first pistillate flower opening, total fruit yield per vine fruit weight, , rind thickness and TSS, degree of dominance was more than one along with low heritability and genetic advance.

Key words**:** *Biparental progenies, gene action, genetic advance, heritability, muskmelon*

Introduction

Muskmelon (*Cucumis melo* L.) is an important cucurbitaceous crop relished for its sweet taste and mainly consumed as a dessert fruit. In the world, total production of muskmelon is 31.25 million tonnes from an area of 12.90 lakh ha. The leading muskmelon producing countries are China, Iran, Turkey, Egypt, India, U.S.A and Spain. In India, it is cultivated on an area of about 39.72 thousand ha with a production of 8.13 lakh tonnes. In India, muskmelon is widely cultivated in Rajasthan, Punjab, West Bengal, Uttar Pradesh, Madhya Pradesh and Maharashtra (Anon 2011). However, in Punjab, area under this crop is 4.83 thousand ha and production 83.90 thousand tonnes with an average productivity of 17.37 tonnes ha^{-1} (Anon 2013).

The economic importance of the crop has stimulated the breeding work which is aimed at the improvement of qualitative and quantitative characteristics. In the past, nature and the mode of inheritance of horticultural traits had been studied by applying different biometrical techniques such as line × tester analysis (Dhaliwal and Lal 1996), diallel analysis (Choudhary 2006) and generation means analysis Zalapa *et al.* (2006) but the accurate information was lacking. Biparental mating design is one of the simplest random mating design available to effect forced recombination and breaking down undesirable linkages as pointed out by Comstock and Robinson (1952). Before starting any breeding programme it is right to know the inheritance of important economic characteristics. By studying the genetics of economic traits and the precise estimation of components of genetic variation, the appropriate breeding strategy can be formulated for their improvement. It is, therefore, important in choosing an appropriate breeding programme for improving yield in any crop.

Heritability provides an idea to the extent of genetic control for expression of a particular trait and the reliability of phenotype in predicting its breeding value (Tazeen *et al*, 2009). High heritability indicates less environmental influence in the observed variation (Songsri *et al*, 2008). It also gives an estimate of genetic advance a breeder can expect from selection applied to a population and help in deciding on what breeding method to choose (Hamdi *et al*, 2003). Genetic advance which estimates the degree of gain in a trait obtained under a given selection pressure is another important parameter that guides the breeder in choosing a selection programme (Shukla *et al*, 2004). High heritability and high genetic advance for a given trait

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indicates that it is governed by additive gene action and, therefore, provides the most effective condition for selection (Tazeen *et al*, 2009). The objectives of this study were to investigate components of genetic variation such as additive genetic variance and dominance variance which help in estimation of degree of dominance and heritability and genetic advance of different characteristics which is pre-requisite for suggesting an appropriate breeding strategy in this crop.

Material and Methods

The present investigation was undertaken at Vegetable Research Farm, Punjab Agricultural University, Ludhiana during the spring-summer seasons of 2008 and 2009. The biparental progenies (BIPs) were developed in year 2008 by backcrossing the randomly sampled F_2 plants with parents which were designated as P_1 and P_2 (Parents). For crossing, the F_2 plants were used as males and parents as females. The biparental progenies (BIPs) of the crosses thus raised were evaluated in spring-summer season of 2009. The experiment was laid out in a Randomized Complete Block Design (RBD). The standard packages of practices were followed for raising the crop (Anonymous, 2009). Seedlings of BIPs were raised in polythene bags during February, 2009 and transplanting was done in first week of March, 2009. In this study, biparental progenies of two crosses, IC-274014 × Punjab Sunehri and IC-274014 × MM-28 were produced. The data of individual plants of each progeny were recorded for days taken to first pistillate flower opening, number of fruits per vine, fruit weight (kg), total fruit yield per vine (kg), rind thickness (mm), flesh thickness (cm) and total soluble solids content (%). The statistical analysis was done as suggested by Kearsey and Pooni (1996). Expected genetic advance (%) of full sib families was calculated to further elaborate the results.

Results and Discussion

Analysis of variance (ANOVA) for North Carolina Design III is presented in Table 1 for crosses IC- 274014 × Punjab Sunehri and IC-274014 × MM-28, respectively. For days taken to first pistillate flower opening, analysis of variance for cross IC-274014 × Punjab Sunehri indicated that variance due to sums (additive) was highly significant whereas variance due to differences (difference) was non-significant. However, in case of cross IC-274014 × MM-28 variance due to sums was non-significant while variance due to differences was significant. For the character number of fruits per vine in cross IC- 274014 × Punjab Sunehri analysis of variance showed that variances due to sums and differences were highly significant for this character. Contrary to the above, with respect to cross IC-274014 × MM-28 analysis of variance due to sums was significant but variance due to differences was non-significant. For fruit weight, analysis of variance in cross IC-274014 × Punjab Sunehri, variance due to sums was non-significant but variance due to differences was highly significant. However, in case of cross IC-274014 × MM-28, variance due to sums was highly significant and variance due to differences was significant for this character. For the character total fruit yield per vine, analysis of variance for cross IC-274014 × Punjab Sunehri analysis of variance indicated that both variances due to sums and differences were highly significant. Analysis of variance in cross IC-274014 × MM-28 revealed that variance due to sums was non-significant whereas variance due to differences was significant. For under rind thickness, analysis of variance for cross IC-274014 × Punjab Sunehri showed that variance of sums was non-significant but variance due to differences was significant. However, analysis of variance of cross IC-274014 × MM-28, indicated that variance due to sums was significant and variance due to differences was highly significant for rind thickness. In case of flesh thickness, the analysis of variance revealed that biparental progenies (BIP_s) of cross IC-274014 × Punjab Sunehri were significant for variance due to sums but non-significant for variance due to differences. Again, opposite to the above, BIP_s of cross IC-274014 × MM-28 showed that variance due to sums was non-significant but variance due to differences was significant. For TSS content in cross IC- 274014 × Punjab Sunehri, recorded non-significant variance due to sums but variance due to differences was highly significant. However in the cross IC-274014 × MM-28, both variances due to sums and differences were significant.

The genetic variation generated by Biparental progenies helps to estimate additive and non- additive components (Table 2). Regarding estimates of additive and dominance values, days taken to first pistillate flower opening which is an indication of earliness, the results of cross IC-274014 × Punjab Sunehri revealed that additive genetic variance was highly significant but dominance variance was non-significant. The average degree of dominance was less than one (0.40), heritability was high (87%) and genetic advance was 1.29 %. For same cross, inbred lines may be developed by selecting early types. Contrary to above, in case of cross IC-274014 × MM-28, dominance variance was found significant but additive genetic variance was non-significant. The average degree of dominance was more than one (1.81). The heritability (24.01%) and genetic advance was 0.54%. In this case, heterosis is present due to non-additive gene effects. These findings are in agreement with findings of Moon *et al*. 2004.

Cross IC- 274014 × Punjab Sunehri displayed

that both additive genetic variance and dominance variance were highly significant but the value of additive genetic variance (0.103) was higher than the dominance variance (0.072) for the character total fruit yield per vine. The average degree of dominance was more than one (1.18). The heritability and genetic advance were 56.73% and 16.33%, respectively. In case of cross IC-274014 × MM-28, variance due to non-additive effects was found significant but variance due to additive effects was non-significant. The average degree of dominance was more than one (1.61). The heritability and genetic advance were 29.47% and 9.23%, respectively. In earlier studies, Singh *et al.* (1976) reported the evidence of dominance variance for this character in cross Hara Madhu × Early Gold. The results also corroborated the findings of Munshi and Verma (1998) and Moon *et al.* (2004). The component s of genetic variance in both crosses indicated presence of over dominance which exhibited the scope of heterosis breeding for increasing total fruit yield in muskmelon.

In case number of fruits per vine with respect to cross IC-274014 × Punjab Sunehri, both additive genetic variance and dominance variance were highly significant but the value of additive genetic variance was higher (0.251) than the value of dominance variance (0.080). The average degree of dominance was less than one (0.80). The heritability and genetic advance were 68.30%and 14.67%, respectively. However, in case of cross IC-274014 × MM-28, additive genetic variance was significant but dominance variance was non-significant. The average degree of dominance was less than one (0.25). The heritability and genetic advance were 67.22% and 16.60 %, respectively. Singh *et al.* (1976) and Zalapa *et al.* (2006) reported that additive component of variance was higher than dominance variance for number of fruits per vine.

In cross IC-274014 × Punjab Sunehri, dominance variance was found highly significant but additive genetic variance was non-significant for fruit weight. The average degree of dominance was more than one (1.73). The heritability and genetic advance were 29.95% and 6.45 %, respectively. In respect of cross IC-274014 × MM-28, additive genetic variance was highly significant while dominance variance was significant. The average degree of dominance was less than one (0.94). The heritability and genetic advance were 61.43% and 11.67%, respectively.

In respect of rind thickness, information obtained from BIPs of cross IC- 274014 × Punjab Sunehri revealed that dominance variance was found significant but additive genetic variance was non-significant. The average degree of dominance was more than one (2.63). The heritability (10.93 %) and genetic advance (2.02%) were very small. In case of cross IC-274014 × MM-28, additive genetic variance was significant and dominance variance was highly significant but the value of additive genetic variance (0.171) was more than the dominance variance (0.149). The average degree of dominance was more than one (1.32). The heritability and genetic advance were 45.29% and 10.36%, respectively. Over-dominance has been reported for this character in the past studies (Singh *et al.* 1990). Many studies in the past emphasised the heterosis breeding in muskmelon by exploiting non-additive genetic variance.

With respect to the flesh thickness in case of cross IC-274014 × Punjab Sunehri, it was revealed that additive genetic variance was significant but dominance variance was non-significant. The average degree of dominance was less than one (0.70). The heritability and genetic advance were 58.84% and 5.39%, respectively. Similar findings were reported by Chadha *et al.* (1972), and Munshi and Verma (1998) for this character. However in case of cross IC-274014 × MM-28, dominance variance was found significant but additive genetic variance was non-significant. The average degree of dominance was high (3.55). The heritability (7.39%) and genetic advance (0.93%) were very small. These results are in agreement with Singh *et al.* (1990) and Moon *et al.* (2004).

In case of total soluble solids (TSS) content, genetic variation obtained from biparental progenies of cross IC-274014 × Punjab Sunehri, it was inferred that dominance variance was highly significant but additive genetic variance was non-significant. The average degree of dominance was more than one (1.92). The heritability and genetic advance were 34.83% and 4.05%, respectively. Contrasting to above results, both additive genetic and dominance variance were significant in case of cross IC-274014 × MM-28 but the value of additive genetic variance (1.527) was more than twice to the value of dominance variance (0.640). The heritability and genetic advance were 64.66% and 12.06 %, respectively. The average degree of dominance was near to one (0.92). In the earlier studies, Singh *et al.* (1976) found that additive component of variance was high for TSS in cross Hara Madhu × Early Gold, whereas Chadha *et al*. (1972) and Munshi and Verma (1998) reported partial dominance for this character.

The predominance of dominance variance and average degree of dominance being more than one suggests the possibility of high yielding and superior F_1 hybrids. Therefore, the heterosis breeding remains suitable option of breeding for the characters such as number of fruits per vine, fruit weight, total fruit yield per vine, rind thickness and total soluble solids (TSS) content where F_1 hybrids are expected to give better performance than inbred lines. In this crop, both types

Table 1. Analyses of Variance of North Carolina Design-III in cross IC- 274014 x Punjab Sunehri and IC-274014 x MM-28

Source of variation	Degree of freedom	Days taken to first pistillate flower opening		Number of fruits per vine		Fruit weight		Total fruit yield per vine		Rind thickness		Flesh Thickness		TSS content	
		IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28
Tester	1	0.48	5.27	7.05	0.72	0.23	0.17	8.92	0.37	124.16	2.61	0.52	0.4	34.04	80.55
F_2 (S) (Additive)	7	3.35**	2.08	0.52**	0.50*	0.02	0.03**	0.22**	0.15	0.19	0.43*	0.04*	0.07	0.9	3.19*
(Dominance)	7	1.09	3.82*	0.38**	0.18	0.03*	0.02*	0.29**	0.25*	0.39*	0.62**	0.03	0.17*	2.27**	2.81*
Within FS families	32	0.65	1.32	0.14	0.16	0.01	0.01	0.07	0.08	0.15	0.17	0.01	0.06	0.4	0.89
TSS	47														

* Significant at 5% level
** Significant at 1% level

Table 2. Additive genetic variance, dominance variance, degree of dominance, heritability and genetic advance (%) of different characters in cross IC-274014 x Punjab Sunehri and IC-274014 x MM-28

Characters	Additive genetic variance (62A)		Dominance variance (62 D)		Environmental variance (δ^2E)		Average Degree of dominance		Heritability (%)		Genetic Advance (%)	
	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28	IC-274014 x Punjab Sunehri	IC-274014 x MM-28
Days taken to first female flower opening	1.805**	0.508	0.146	0.833*	0.123	0.774	0.4	1.81	87	24.01	1.29	0.54
Total fruit yield / vine (kg)	0.103**	0.043	0.072**	0.055*	0.006	0.047	1.18	1.61	56.73	29.47	16.33	9.23
Number of fruits / vine	0.251**	0.224*	0.080**	0.007	0.036	0.102	0.8	0.25	68.3	67.22	14.67	16.6
Fruit weight (kg)	0.004	0.007**	0.007**	0.003*	0.004	0.001	1.73	0.94	29.95	61.43	6.45	11.67
Rind thickness (mm)	0.023	0.171*	0.079*	0.149**	0.108	0.057	2.63	1.32	10.93	45.29	2.02	10.36
Flesh thickness (cm)	0.019*	0.006	0.005	0.038*	0.009	0.037	0.7	3.55	58.84	7.39	5.39	0.93
TSS content (%)	0.336	1.527*	0.621**	0.640*	0.006	0.194	1.92	0.92	34.83	64.66	4.05	12.06

* Significant at 5% level
** Significant at 1% level

of genetic variances were recorded in different magnitudes among different cross combinations. By adopting population improvement methods, superior inbred line can be developed after accumulating additive gene effects for different characters and high yielding possess high total soluble solids (TSS) inbred lines can be utilized to develop superior hybrids (Chahal and Gosal, 2002).

References

Anonymous, 2009. *Package of practices for cultivation of vegetables*. Pp 2-4 Punjab Agricultural University, Ludhiana.

Anonymous, 2011. *Vegetables and Melons Outlook*. http://faostat.fao.org

Anonymous, 2013. Indian Horticulture Database. National Horticulture Board pp-4

Chadha, M. L., Nandpuri K. S. and Singh, S. 1972. Inheritance of quantitative characters in muskmelon. *Indian J Hort.*, 29**:** 174-178.

Chahal, G. S. and Gosal, S. S. 2002. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Narosa Publishing House. New Delhi, pp 320.

Choudhary, B. R., Fageria, M. S. and Sudhakar, P. and Rai, M. 2006. Combining ability studies for economic attributes in muskmelon (*Cucumis melo* L.) *Indian J Hort.*, 1: 158-162.

Comstock, R. E. and Robinson, H. F. 1952. Estimation of average dominance of genes. In: *Heterosis, Gowen*, J W (Ed.), Iowa State colleges Press-Ames, pp: 494-515.

Dhaliwal, M. S. and Lal, T. 1996. Genetics of some important characters using line × tester analysis in muskmelon. *Indian J Genet Pl Breed.*, 56: 207-213.

Hamdi. A., El-Chareib, A. A., Shafey, S. A. and Ibrahim, M. A. M. 2003. Genetic variability, heritability and expected genetic advance for earliness and seed yield from selections in lentil. *Egypt J Agric Res.*, **81:** 125-137.

Kearsey M. J. and Pooni, H. S. 1996. The Genetic Analysis of Quantitative Traits. Chapman and Hall, London, pp 86-91.

Moon, S. S., Verma, V. K. and Munshi, A. D. 2004. Gene action for yield and its components in muskmelon (*Cucumis melo*. L.). *Ann Agric Res.*, 25: 24-29.

Munshi, A. D. and Verma, V. K. 1998. A note on gene action in muskmelon (*C.melo L.*). *Veg Sci*., 25: 93-94.

Shukla, S., Bhargava, A., Chattergee, A., and Singh, S. P. 2004. Estimates of genetic parameters to determine variability for foliage yield and its different quantitative and qualitative traits in vegetable amaranth (*Amaranthus tricolor*). *J Genet & Breed*., 58**:** 169-176.

Singh. D., Nandpuri, K. S. and Sharma, B. R. 1976. Inheritance of some economic quantitative characters in an intervarietal cross of muskmelon (*C. melo* L.). *J Res Punjab Agric Univ*., 13: 172-176.

Singh, M. J., Lal, T. and Randhawa, K. S. 1990. Genetic analysis for fruit yield and quality traits in muskmelon. *J Res Punjab Agric Univ*., 27: 577-584.

Songsri, P., Joglloy, S., Kesmala, T., Vorasoot, N., Akkasaeng, C. P. A. and Holbrook, C. 2008. Heritability of drought resistant traits and correlation of drought resistance and agronomic traits in peanut. *Crop Sci*., 48: 2245-2253.

Tazeen, M., Nadia, K. and Farzana, N. N. 2009. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in synthetic elite lines of wheat. *J Food Agric Environ*., **7:** 278-282.

Zalapa, J. E., Staub, J. E. and McCreight, J. D. 2006. Generation means analysis of plant architectural traits and fruit yield in melon. *Plant Breed.*, 125: 482-487.

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Screening of date palm varieties for resistance against post harvest fruit rot

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Abstract

The experiments were conducted at Date palm farm, Agricultural Research Station SKRAU, Bikaner during Kharif 2013 and *Kharif* 2014 to record the incidence percentage of different post harvest diseases on date palm fruits for screening of date palm varieties for resistance. Eight varieties *viz.*, Zahidi, Sayar, Khalash, Nagal Hilali, Ruziz, Khasab, Halawy and Barhee were selected Seven fungal rot pathogens were isolated from infected date plam fruits *viz.*, *Botryodiplodia, A. niger, A. flavus, Rhizopus sp., Fusarium sp. and Penicillium sp.* In first year of the experiment, none of the varieties were found resistant where as six varieties *viz.*, Zahidi, Sayar, Khalash, Nagal Hilali, Ruziz, and Khasab were found moderately susceptible and two (Halawy and Barhee) were found Susceptible. In second year two varieties *viz.*, Khasab, Khalash were found Resistant, where as six varieties *viz.*, Zahidi, Sayar, Ruziz, Zijaj, Nagal Hilali and Halawy were found moderately susceptible and none of the varieties were found susceptible.

Key words: *Date palm, post harvest diseases, resistance, screening.*

Introduction

Date palm (*Phoenix dactylifera* L.) is an important fruit crop. It belongs to the genus *Phoenix* which is characterized by pinnate leaf palm by the upward and lengthwise folding of the pinnate and furrowed seeds. It is oldest cultivated fruit trees belonging to the family *Palmaceae* in which only 130 palm species grow naturally beyond the tropics, mostly in the subtropics.

The date palm is distributed in Iraq, Saudi Arabia, Iran, United Arab Emirates, Oman, Egypt and Algeria, which are the main date palm producing countries in the world (Chandra *et al*., 1990). The evidence for cultivation of date palm in India has been obtained from excavation of *Mohanjodaro* (Haider *et al*., 2012). The major date palm growing states in india are Rajasthan and Punjab. It is cultivated in hyper partially irrigated western plains of Rajasthan, i.e. Bikaner, Jaisalmer, Jodhpur, some part of Sri Ganganagar and Churu which have hot arid climates and in some parts of Punjab. Being tolerant to drought and salinity, it is a potential fruit palm of dry and arid parts of the country (Trifi *et al*., 2000). Therefore, Rajasthan qualifies to be an ideal home for commercial cultivation of date palm,since majority of agro climatic conditions, such as 25-40°C temperature for flowering and rain free condition for fruit ripening required for cultivation of this crop are partly or fully fulfilled in Rajasthan. The varieties like Halawy, Zahidi, Khalas, Barhee and Khadrawy have been found suitable for production of higher yield in western Rajasthan (Singh e*t al.,* 2003). Post harvest diseases causes huge losses to the date industries in both quality and quantity of production. The date palm is severely affected by various diseases caused by fungus, bacteria, nematodes and phytoplasma. Among the diseases, date palm is severly affected by several diseases like **f**ruit rots caused by *Aspergillus niger*, *Aspergillus phoenicum, Alternaria alternata, Phomopsis, Penicillium roseum, Penicillium corylophilum, Botryodiplodia* and *Rhizopus stolonifer.*

Post harvest fruit rots cause considerable loss when humid and rainy weather occur during the ripening season. Fruit rots are a major constraint and occur whenever dates are grown. The economic importance of fruit rots vary greatly from year to year since its incidence is governed by climatic conditions particularly, high humidity and rain. (Calcat, 1959)

During last several years, the incidence as well as intensity of fungal fruit rots of date palm increased considerably. Keeping in view of the seriousness of the disease and economical importance of this fruit plant, the present investigation was done.

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Material and Methods

Samples; All samples were collected from date palm farm, Agricultural Research Station, SKRAU, Bikaner.

Identification of different microorganisms causing post harvest fruit rots in date palm

The harvest fruit (rotted *doka* stage) & eight varieties of date palm were placed in sterilized petri dishes having blotter paper (Whatman No.42) at temperature range of 26-30 °C in controlled conditions. The supplement supply of sterilized distilled water was given when requires. After 15 days colonies developed in fruit of different varieties were viewed under microscope for its identification. Isolates were maintained in PDA slants for further studies. Each treatment was replicated four times. The frequency in percent was also calculated.

Varietal screening against fruit rots.

Eight varieties of date palm *viz.*, Zahidi, Sayar, Khalash, Nagal Hilali, Ruziz, Khasab, Halawy and Barhee were examined naturally to record the incidence percentage of different diseases on fruits and varieties screened against fruit rots at *doka* stage for two successive *kharif* seasons 2013 and 2014. Severity was calculated on the basis fruits of area damaged with 0-5 scales as given below:

0 - No infection
1 - 0-10% fruit damaged
2 - 11-25% fruit damaged
3 - 26-50 % fruit damaged
4 - 51-75% fruit damaged
5 - 76-100% fruit damaged

The severity and PDI were calculated using following formula

$$PDI = \frac{\text{Sum of all numerical rating}}{\text{Total No. of fruit examined x Maximum ratting}} \times 100$$

Post harvest fruit rots studies were done through Blotter Paper Technique, three fruits were kept in each petri-dish with three replication of each cultivar. The varieties were categorized in the following categories:

Category	% Severity
Resistant (R)	: 0-5% disease severity
Moderately resistant (MR)	: 5.1-20 % disease severity
Susceptible (S)	: 20.1-50% disease severity
Highly susceptible (HS)	: 0.1- above % disease severity

Results and Discussion

The harvested fruits (rotted *doka* stage) of 8 varieties of date palm were taken for the identification/presence of micro-organism under laboratory controlled condition. The cultivars of date fruits were observed to infected by seven fungi. It was notices that the fungal *Aspergillus niger, Aspergillus flavus, Rhizopus sp, Botryodiplodia*, *Mucor* sp. *Fusarium* sp. and *Penicillium sp.* appeared on tested varieties of date palm with varying frequency during both kharif season, of 2013 and 2014.The data presented in Table-1 revealed that eight screened varieties were infected by fruit rots caused by *Botryodiplodia, A. niger, A. flavus, Rhizopus* sp., *Fusarium* sp., *Mucor* sp. and *Penicillium* sp. Fruit rot percentage were ranging between 8.35 to 21.15 per cent and 6.67 to14.67 per cent during *kharif* 2013 and *kharif* 2014 respectively. Post harvest fruit rots in percentage were ranging from16.31 to33.33 per cent and 4.00 to 33.33 per cent during *Kharif,* 2013 and *Kharif,* 2014, respectively (Table-2). Among them, none was found resistant during kharif 2013 but two varieties namely Khasab and Khalash were found resistant during *kharif* 2014. Six varieties *viz.*, Zahidi, Sayar, Khalash, Nagal Hilali, Khasab and Ruziz were recorded moderately susceptible to the disease having 5.1-20 per cent infection during *kharif* 2013 and six varieties *viz.*, Zahidi, Sayar, Nagal Hilali, Barhee, Ruziz and Halawy were found moderately susceptible during *kharif* 2014. Highest fruit rot infection was recorded in variety Barhee (21.15%), followed by Halawy (20.21%). None of the tested varieties were found highly susceptible during both the season. Similar results were obtained by Bokhary (2010) where six different varieties of date-palm *viz.* Sukhari, Saggae, Rotana, Kholasi, Rashoodia and Nabtat Ali were screened for seed borne fungi. Eleven species *Alternaria*, *Eurotium*, and *Fusarium* (two species), *Aspergillus*, *Drechslera*, *Penicillium*, *Rhizopus*, and *Curvularia* (one species each) belonging to nine different genera of fungi were isolated. Karampour and Pejman(2007) isolated many fungal species from affected date palm trees showing Date Bunch Fading (DBF) disorder. These include *Alternaria sp*., *Aspergillus flavus*, *A. niger*, *Penicillium sp*., *Fusarium sp*., *Trichoderma sp*., and *Thielaviopsis paradoxa*.

Table 1. Presence of M.O. causing post harvest fruit rots in different variety of date palm (A=*Kharif* 2013, B=*Kharif* 2014)

S.No.	Varieties	*Botryodiplodia*		*Aspergillus niger*		*Aspergillius flavus*		*Rhizopus sp*		*Fusarium sp.*		*Mucor sp.*		*Penicillium sp.*	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Zahidi	+50	+50	+50	+75	+50	+50	+25	+50	-	+15	-	-	+25	+20
	Sayar	+25	+25	+50	+25	+25	+25	+25	+50	-	+50	-	-	+25	-
	Barhee	+50	+50	+75	+25	+75	+25	+50	-	-	-	-	-	+25	-
	Nagal Hilali	+25	+25	+50	+25	+50	+25	-	-	-	-	-	-	-	-
	Ruziz	-	-	-	+25	-	+25	-	+25	-	+25	-	+25	-	-
	Khasab	+50	+50	+50	+25	+75	+50	+75	-	-	+25	-	-	+25	+50
	Khalash	+50	+50	+50	+75	+50	+75	+75	-	-	+25	-	-	+25	+50
	Halawy	+50	+50	+50	+75	+50	+75	+25	-	-	-	-	-	+25	-

Table 2. Varietal screening against fruit rots (*Kharif* 2013 and *Kharif* 2014)

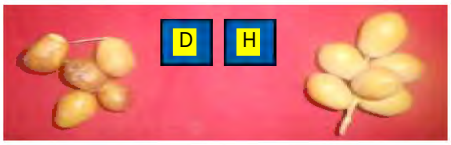
S.No.	Varieties	*Fruit rots in percentage		*Post harvest fruit rots in percentage	
		Kharif 2013	Kharif 2014	Kharif 2013	Kharif 2014
	Zahidi	8.33(16.77)	6.67 (14.97)	30.36(33.38)	16.67 (24.09)
	Sayar	11.66(19.95)	10.67(19.05)	30.66(33.62)	31.33(34.03)
	Barhee	21.15(27.37)	11.33(19.66)	33.33(35.26)	33.33(35.26)
	Nagal Hilali	18.13(25.18)	13.33(21.41)	20.33(26.78)	24.67(29.78)
	Ruziz	17.66(24.80)	10.00(18.43)	21.66(27.72)	25.33(30.21)
	Khasab	10.33(18.72)	2.67(9.40)	16.31(23.81)	4.00(11.53)
	Khalash	12.21(20.44)	4.67(12.48)	31.66(35.25)	24.67(29.78)
	Halawy	20.21(26.64)	14.67(22.52)	27.66(31.72)	33.33(35.26)
	SEm	3.07	2.90	5.99	6.21
	CD at 5%	9.20	8.69	8.46	8.78

*** Average of 3 replicati ons. Figures in parenthesis are angular transformed values .**

Table 3. Classification of date palm cultivars on the basis of their reaction

S.No.	Categories	Disease Severity (%)	Varieties	
			Kharif 2013	*Kharif* 2014
1	Resistant (R)	0-5%	Nil	Khasab, Khalash
2	Moderately resistant (MR)	5.1-20 %	Zahidi, Sayar, Khalash, Nagal Hilali, Ruziz, and Khasab	Zahidi, Sayar, Ruziz, Barhee, Nagal Hilali and Halawy,
3	Susceptible (S)	21.1-50%	Halawy and Barhee	Nil
4	Highly Susceptible (HS)	Above 51.1%	Nil	Nil

Plate 1. Varietal screening and post harvest fruit rots of date palm.

S. No.	Variety	Fruit rot	Post harvest fruit rot
	Zahidi		
	Sayar		
	Barhee		
	Nagal Hilali		
	Ruziz		
	Khasab		
	Khalash		
	Halawy		

Note; (D=Diseased H= Healthy)

References

Bokhary, H. A. 2010. Seed-borne fungi of date-palm, *Phoenix dactylifera* L. from Saudi Arabia. *Saudi J. of Biological Sci.*, 17: 327329.

Calcat, A. 1959. Disease and pest of date palm in Sahara and north Africa FAO. *Plant Protect. Bull*, 8: 5-10

Chandra, A., Swaminathan, R., Choudhary, N. L., Manohar, M. S. and Pareek, O.P. 1990. Performance of date palm cultivars in Thar desert. *Indian J. of Hort.*, 47:28-33.

Haider, N., Nabulsi, I. and Ali, N. M. 2012. Phylogenetic relationships among date palm (*Phoenix dactylifera* L.) cultivars in Syria using RAPD and ISSR markers. *J. Plant Biol. Res.*, 1(2): 12-24.

Karampour, F. and Pejman, H. 2007. Study on possible influence of pathogenic fungi on date bunch fading disorder in Iran . *Acta Hort.*, 736: 431-437.

Singh, R. S., Bhargava, R. and Dhandar, D. G. 2003. Status and prospects of Date palm propagation. *Curr. Agric*, 27: 9-16.

Trifi, M., Rhouma, A. and Marrakchi, M. 2000. Phylogenetic relationships in Tunisian date palm (*Phoenix dactylifera* L.) germplasm collection using DNA amplification fingerprinting. *Agronomi*e, 20: 665- 671.

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Effect of different sources of nitrogen on various physiological parameters and their correlation with yield of cabbage (*Brassica oleracea* var. capitata L.)

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Abstract

A field experiment to study the effect of organic and inorganic sources of nitrogen on various physiological parameters of cabbage was conducted at Horticulture Farm, SKN College of Agriculture, Jobner. Results showed that the number of leaves, leaf area, photosynthesis, transpiration, stomatal conductance and chlorophyll content increased significantly with the integrated application of nitrogen as compared to control. The highest values for these parameters were recorded with the application of nitrogen 50% through urea + 50% through vermicompost. The yield increased maximally and significantly when nitrogen was supplied as 50% through urea + 50% through vermicompost. It is concluded that the application of 50% nitrogen through urea + 50% nitrogen through vermicompost registered a significant higher values of physiological parameters in cabbage which was followed by 50% nitrogen through urea + 50 % nitrogen through poultry manure.

Introduction

Cabbage (*Brassica oleracea* var. capitata L.) is one of the most important member of genus Brassica grown in world. It is the native of Western Europe and Northern shore of Mediterranean region (Thompson and Kelly, 1957). In India, this crop was introduced during Mughal period. Basically, cabbage is a slow growing biennial crop of temperate region. However, its cultivation is equally successful in tropical and sub-tropical regions. It is the most common vegetable crop available during winter all over India. The area under cabbage cultivation in India is 0.25 million hectares with annual production of about 5.29 million tonnes. (Anon., 2008).

It is well documented that growth, yield and quality of plants are greatly influenced by a wide range of nutrients. Nitrogen is an essential macronutrient which has great significance in plant growth, development and metabolism. Its availability is directly associated with vigorous vegetative growth and deep green colour of plants. Nitrogen is a constituent of several macro and micro molecules including amino acids, proteins, vitamins and nucleic acid and is found to be associated with carbohydrates utilization and protein biosynthesis. The deficiency of nitrogen leads to chlorosis, poor vegetative growth, reduced yield and quality of leafy vegetables (Singh, 1989). Deficiency of these major nutrients is quite common in most of the Indian soils (Arakeri et al., 1956). The soil of our region is sandy with high pH, low water holding capacity and deficient in nitrogen content. Therefore, application of nitrogen is essential in these soils for proper plant growth and development.

It is a well known that nitrogen increases the growth and yield of most of the crops, particularly leafy vegetables including the cabbage. Application of nitrogen through inorganic fertilizers can enhance the growth and yield to considerable extent but the soil fertility and productivity can not be retained for a longer period. Therefore, it is important to supplement the urea with inorganic sources of nitrogen. In Indian conditions, it is more important owing to the availability of sufficient F.Y.M., vermicompost and poultry manure in mixed farming system. The FYM is rich source of organic matter and able to replenish most of the macronutrients being taken up by crop (Abdel-Nasser and Hussein, 2001). Poultry manure is a concentrated source of nitrogen and other nutrients. It is well documented that it is an excellent source of organic manures which increases uptake of several nutrients (Abusaleha 1992; Jose *et al.*, 1988). Vermicompost means a mixture of worm casting, organic materials, humus, living earthworms, their cocoons and other organisms. Earthworm reduces the C:N ratio, increases humic acid, cation exchange capacity and water soluble

carbohydrates (Talashilkar *et al.*, 1999).

Thus, the manures not only provide plant nutrients but also improve the soil physical and chemical properties by providing binding effect to soil aggregates. They also improve the cation exchange capacity, water holding capacity, and phosphate availability, fertilizer use efficiency and microbial activity in the soil. A low nitrogen loss due to slow release of nutrients from these organic manures is an added advantage of the application of organic manures (Abusaleha and Shanmugavelu, 1988).

Pillai *et al.* (1985) has reported that the integration of chemical fertilizers with manures can better maintain soil fertility and sustain crop productivity. In vegetable production, role of organic manures is more important than other cereal crops. Therefore, it is hypothesized that the yield and quality of cabbage can be enhanced to a great extent by application of nitrogen through a combination of urea with different organic sources of nitrogen.

Keeping all these points in mind, an investigation was conducted to evaluate the effect of organic and inorganic sources of nitrogen on some physiological parameters and their correlation with yield of cabbage (*Brassica oleracea* var. capitata L.)

Materials and Methods

The experiment was conducted on Golden Acre variety of cabbage at Horticulture Research Farm, S.K.N. college of Agriculture, Jobner. The climate of this region is semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5C) and winter (-1C). The average rainfall of this area is 500 mm, most of which occurs during the period of July to mid September. The soils of experimental site was loamy sand (85.2% samd 9.2% silt and 5.4% clay), pH of 8.0, electrical conductivity of 1.20 dS^{-1}, available carbon 0.16% and available N, P_2O_5 and K_2O of 130, 15.20 and 140 kg ha^{-1}, respectively.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. The randomization of treatments was done with the help of random number table (Fisher, 1950). The treatments comprised total 17 combinations including control. The seeds were first raised in nursery and then transplanted in field after 6 weeks. The distance between plant to plant as well as row to row was kept at 45 cm. Nitrogen was applied at the rate of 150 kg ha^{-1} as per zonal recommendation. For treatments, nitrogen was supplied through FYM, vermicompost, poultry manure and urea. A full dose of FYM, vermicompost, poultry manure were applied at the time of transplanting, while urea was applied in two split doses i.e. half at the time of sowing and remaining half dose 30 days after transplanting. Phosphorus and potash were applied as basal in all plots @ 80 kg ha^{-1} P_2O_5 and 75 kg ha^{-1} K_2O through SSP and KCl, respectively. Standard practies were employed for all other inputs and inter-culture operation.

Five plants were randomly selected in each plot and tagged. The following observations were recorded from these plants.

Leaf area per plants (cm^2)

Leaf area per plant was measured directly with help of leaf area meter (LICOR-3100, Lincoln, USA). The fully expanded green leaves were detatched from the plants and leaf area was determined immediately to avoid wilting of leaves.

Photosynthesis, transpiration and stomatal conductance

Photosynthesis was measured by infra red gas analyzer (CID-301, Vancouver, USA). Top most expanded leaf was enclosed in the assimilation chamber and the rate was monitored at which the CO_2 concentration changed over a definite time interval. The system automatically calculated the rate of photosynthesis on the basis of preloaded flow and leaf area. The leaf transpiration rate and stomatal conductance were also measured directly by infra red gas analyzer (CID 301, Vancouver, USA) on the same leaf as described for the photosynthetic rate. All these measurements were taken at 10.00-11.00 in triplicates.

Chlorophyll content in leaves

Chlorophyll content was determined using the method of Hiscox and Israelstom (1979) with slight modifications. 50 mg fresh leaf material was used for chlorophyll estimation. The material was taken in test tube to which 5.0 ml DMSO was added. These tubes were tightly capped and placed in an oven at 60C for 6 h. Finally, the tubes were thoroughly shaken and extracted solvent was decantated to read at 645 and 663 nm in spectrophotometer (Systronics, India). The amount of total chlorophyll was calculated as advocated by Arnon (1949).

Yield and Yield attributes

Data on growth, yield and quality attribute recorded were subjected to randomized block design (RBD) as advocated by Fisher (1950). Analyses of variance were calculated and critical difference (CD) at 5% level of significance was tested through 'F' test as given in tables and appendices.

Results and Discussion

Leaf area

Table 1 shows that the application of nitrogen through various sources either alone or in combination significantly increased the leaf area at harvest. Application of nitrogen 50% through urea + 50% through vermicompost (T_8) registered maximum leaf area (2010.6 cm^2) and proved significantly superior to

rest of the treatments. However, application of nitrogen 50% through urea + 50% through poultry manure (T_{12}) did not exhibit significant difference with T_8 where the leaf area was 1876.5 cm^2. It was further noted that treatments T_8 and T_{12} enhanced the leaf area by 38.3 and 29.1 per cent, respectively over control.

It is apparent from the data (Table 2) that there was a significant effect of different doses of organic and inorganic sources of nitrogen in improving the rate of photosynthesis over control at all growth stages.

Observations recorded at 30 days after transplanting revealed that application of different organic manures either alone or in combination with urea brought about perceptible variation in rate of photosynthesis of cabbage at 30 days after transplanting. The maximum rate of photosynthesis (62.32 mol CO_2 m^{-1} s^{-1}) was recorded with the application of nitrogen 50% through urea + 50% through vermicompost (T_8) followed by application of nitrogen 50% through urea + 50% poultry manure (T_{12}) where the photosynthesis rate was 59.35 mol CO_2 m^{-1} s^{-1}. Both the treatments were highly significant over rest of the treatments. The treatment T_8 and T_{12} increased the photosynthesis to the tune of 58.65 and 51.09 percent, respectively over control.

Data recorded at the time of harvesting further indicated (Table 2) that photosynthesis rate at harvest was significantly increased by the application of different organic and inorganic sources of nitrogen either alone or in combination over control. Application of nitrogen 50% through urea + 50% through vermicompost (T_8) was recorded maximum rate of photosynthesis (73.56 mol CO_2 m^{-1} s^{-1}), whereas it was at par with application of nitrogen 50% through urea + 50% poultry manure (T_{12}). It was proved a significantly increase of 60.08 percent over control.

It is obvious from the data (Table 2) that the rate of transpiration shows the positive response to the application of organic and inorganic sources of nitrogen either alone or in combination at 30 days after transplanting as well as at harvest.

At 30 days after transplanting, the rate of transpiration significantly increased with the application of organic and inorganic sources of nitrogen either alone or in combination at this stage. The highest rate of transpiration (3.26 m mol H_2O $m^{-1}s^{-1}$) was recorded with the application of nitrogen 50% through urea + 50% through vermicompost (T_8) followed by application of nitrogen 50% through urea + 50% poultry manure (T_{12}). Further, it was also noticed that this treatment was significantly higher over rest of the treatments including control.

Data recorded at the time of harvesting (Table 2) revealed that application of organic and inorganic sources of nitrogen brought about significant variations in rate of transpiration at this stage. Among all the treatment combinations a maximum rate of transpiration i.e. 3.86 m mol H_2O $m^{-1}s^{-1}$ was recorded in the treatment T_8 (50% N through urea + 50% N through vermicompost) which was significantly higher over control as well as all the treatments except T_{12} (50% N through urea + 50% N through poultry manure), where the transpiration rate was 3.70 m mol H_2O $m^{-1}s^{-1}$. The treatment T_8 and T_{12} increased the transpiration rate to the order of 159.03 and 148.15 percent, respectively over control.

It is clear from the data (Table 2) that integrated application of nitrogen brought about significant variation in stomatal conductance over control at all growth stages.

At 30 days after transplanting application of nitrogen 50% through urea and 50% through vermicompost (T_8) registered maximum stomatal conductance (38.4 cm s^{-1}) followed by T_{12} (50% nitrogen through urea +50% through poultry manure), where the stomata conductance was 34.8 cm s^{-1}. Further, treatment T_8 was significantly higher than rest of the treatments including control.

It is explicit from the data (Table 2) recorded at the time of harvesting that application of organic and inorganic sources of nitrogen either alone or in combination has produced pronounced effect on stomatal conductance at this stage.

Among all the treatments, application of nitrogen 50% through urea and 50% through vermicompost (T_8) produced the maximum stomatal conductance (43.7 cm s^{-1}) which is significantly higher over rest of the treatments. However, the variations in stomatal conductance recorded in treatment T_8 and T_{12} were statistically identical. The increase in stomatal conductance by treatment T_8 and T_{12} were to the tune of 96.84 and 81.98 percent, respectively over control.

It is obvious from the data (Table 3) that the chlorophyll content in leaves showed a positive response to the application of organic and inorganic sources of nitrogen either alone or in combination at all growth stages.

Data recorded at 30 days after transplanting (Table 3) revealed that application of organic and inorganic sources of nitrogen either alone or in combinations significantly increased the chlorophyll content in leaves at this stage. Application of nitrogen 50% through urea and 50% through vermicompost (T_8) registered maximum chlorophyll content (0.687 mg g^{-1} f. w.) followed by application of nitrogen 50% nitrogen through urea + 50% through poultry manure (T_{12}), where the chlorophyll content was 0.661 mg g^{-1} f. w. This treatment was significantly higher over rest of the treatments including control (0.517 mg g^{-1} f. w.).

At harvest, application of organic and inorganic sources of nitrogen brought about significant variation in chlorophyll content in leaves (Table 3).

Among all the treatment combinations, maximum chlorophyll content 1.167 mg g^{-1} f. w. was recorded with the application of nitrogen 50% through urea and 50% through vermicompost (T_8) which was significantly higher over control as well as all other treatments except application of nitrogen 50% through urea + 50% through poultry manure (T_{12}), where the chlorophyll content was 1.108 mg g^{-1} f. w. The treatment T_8 and T_{12} were increased the transpiration rate to the order of 20.72 and 14.00 percent, respectively over control.

Physiological parameters like photosynthesis, transpiration, stomatal conductance, chlorophyll content, etc. are directly linked with plant growth and development. Application of nitrogen significantly affects the rate and duration of these processes (Satchithanantham and Bandara, 2000; Wang *et al.*, 2001).). In present investigation also increased rate of photosynthesis with nitrogen application has been observed. However, different sources of nitrogen and their combinations affected the photosynthesis rate differentially (Table 2). Transpiration and stomatal conductance also increased significantly by application of nitrogen in cabbage. Again, the organic and inorganic sources of nitrogen affected these processes significantly (Table 2). The trend for all these observations was similar at 30 days after transplanting and at the time of harvesting.

Nitrogen is required for the synthesis of chlorophyll which is a major substrate of photosynthesis. In present investigation, higher rates of photosynthesis with nitrogen might be associated with chlorophyll synthesis. The increased chlorophyll content with different sources of nitrogen in present study strengthens this hypothesis. As indicated in Table 3, the chlorophyll content of cabbage increased significantly with integrated supply of nitrogen. Maximum chlorophyll content was recorded with nitrogen 50% through urea + 50% through vermicompost which was followed by nitrogen 50% through urea + 50% through poultry manure.

It is well known fact that stomata play important role in regulation of various physio-biochemical processes. The photosynthesis and transpiration are directly linked with stomatal regulation. Our results indicate that enhanced rate of photosynthesis has increased the O_2/CO_2 gas exchanges and the transpiration rate increased linearly. This increased transpiration provided a favourable environment to the leaves by cooling effect. Secondly, the enhanced transpiration might have increased the water and ion absorption through xylem from soil. These ions might have helped in various processes including the synthesis of pigments. The stomatal conductance is inversely correlated with stress conditions. The enhancement of stomatal conductance by nitrogen application in present investigation suggests the idea of availability of sufficient water for various plant processes. The similar pattern of stomatal conductance at harvest suggests that the effect of nitrogen retained upto harvest in cabbage.

On the basis of the combined effect of these physiological observations it can be inferred that application of nitrogen enhanced the pigment synthesis which resulted in increased rate of photosynthesis. The

Table 1. Effect of organic and inorganic sources of nitrogen on number of leaves and leaf area per plant in cabbage

Treatment	Number of leaves (per plant)	Leaf area (cm^2)
Control	17.10	1453.5
100% N (urea)	20.61	1749.1
75% N (urea) + 25% N (FYM)	19.65	1719.7
50% N (urea) +50 % N (FYM)	19.81	1735.4
25% N (urea) +75% N (FYM)	18.53	1649.2
100% N (FYM)	17.41	1566.9
75% N (urea) + 25% N (VC)	20.09	1796.9
50% N (urea) +50 % N (VC)	22.34	2010.6
25% N (urea) +75% N) (VC)	19.82	1744.2
100% N (VC)	18.85	1658.8
75% N (urea) + 25% N (PM)	18.38	1619.3
50% N (urea) +50 % N (PM)	20.85	1876.5
25% N (urea) +75% N (PM)	19.49	1715.1
100% N (PM)	18.21	1607.9
50% N (urea) + 25% N (FYM) + 25% N (VC)	19.18	1695.9
50% N (urea) +25 % N (FYM) + 25% N (PM)	19.68	1733.8
50% N (urea) + 25% N (VC)+ 25% N (PM)	20.32	1828.6
SEmß	0.65	51.22
CD (P=0.05)	1.85	147.19

VC= Vermicompost, PM= Poultry manure

Table 2. Effect of organic and inorganic sources of nitrogen on rate of photosynthesis in cabbage at different growth stages

Treatment	Photosynthesis (μ mol CO_2 m^{-2} s^{-1})		Transpiration (mmol H_2O m^{-2} s^{-1})		Stomatal conductance (cm s^{-1})	
	30 DAT	At harvest	30 DAT	At harvest	30 DAT	At harvest
Control	39.28	45.95	1.28	1.49	18.8	22.2
100% N (urea)	56.92	67.16	2.64	3.08	29.6	34.7
75% N (urea) + 25% N (FYM)	52.84	61.95	2.21	2.60	25.6	30.2
50% N (urea) +50 % N (FYM)	51.45	60.60	2.08	2.40	23.4	27.3
25% N (urea) +75% N (FYM)	48.15	57.68	1.66	1.97	21.4	25.8
100% N (FYM)	46.76	55.57	1.43	1.67	20.6	24.2
75% N (urea) + 25% N (VC)	55.38	65.14	2.43	2.84	28.1	33.1
50% N (urea) +50 % N (VC)	62.32	73.56	3.26	3.86	38.4	43.7
25% N (urea) +75% N) (VC)	57.36	67.22	2.85	3.37	32.9	38.2
100% N (VC)	50.41	59.22	2.03	2.39	22.6	27.3
75% N (urea) + 25% N (PM)	56.97	67.02	2.67	3.14	30.7	35.8
50% N (urea) +50 % N (PM)	59.35	70.26	3.11	3.70	34.8	40.4
25% N (urea) +75% N (PM)	53.02	62.32	2.28	2.69	26.7	31.4
100% N (PM)	49.71	57.85	1.95	2.28	21.9	26.1
50% N (urea) + 25% N (FYM) + 25% N (VC)	53.36	62.30	2.37	2.78	27.3	32.3
50% N (urea) +25 % N (FYM) + 25% N (PM)	51.78	61.18	2.12	2.47	24.7	28.9
50% N (urea) + 25% N (VC)+ 25% N (PM)	57.86	68.84	2.97	3.53	32.7	37.1
SEmß	1.36	1.28	0.076	0.094	1.43	1.44
CD (P=0.05)	3.92	3.69	0.219	0.270	4.12	4.14

VC= Vermicompost, PM= Poultry manure ; DAT= Days after transplanting

Table 3. Effect of organic and inorganic sources of nitrogen on chlorophyll content in leaves of cabbage at different growth stages

Treatment	Chlorophyll content (mg g^{-1} f. w.)	
	30 DAT	At harvest
Control	0.517	0.965
100% N (urea)	0.573	1.049
75% N (urea) + 25% N (FYM)	0.568	1.041
50% N (urea) +50 % N (FYM)	0.563	1.036
25% N (urea) +75% N (FYM)	0.548	0.992
100% N (FYM)	0.534	0.979
75% N (urea) + 25% N (VC)	0.593	1.086
50% N (urea) +50 % N (VC)	0.687	1.167
25% N (urea) +75% N) (VC)	0.551	0.997
100% N (VC)	0.543	0.985
75% N (urea) + 25% N (PM)	0.572	1.046
50% N (urea) +50 % N (PM)	0.661	1.108
25% N (urea) +75% N (PM)	0.545	0.989
100% N (PM)	0.539	0.981
50% N (urea) + 25% N (FYM) + 25% N (VC)	0.562	1.043
50% N (urea) +25 % N (FYM) + 25% N (PM)	0.556	1.025
50% N (urea) + 25% N (VC)+ 25% N (PM)	0.617	1.082
SEmß	0.018	0.025
CD (P=0.05)	0.053	0.072

VC= Vermicompost, PM= Poultry manure ; DAT= Days after transplanting

higher rate of stomatal conductance at the same time suggests that the stomatal regulation was favuorable, thus enhancing photosynthetic assimilation via increased transpiration and ion absorption. These factors might have resulted in increased growth and productivity of cabbage which is evident from the data presented elsewhere in this chapter. Enhancement in photosynthetic rate and related parameters with interactive effects of nitrogen fertilizers have also been reported in maize, soybean and wheat (Satchithanantham and Bandara; 2000; Wang *et al.*, 2001; Lu *et al.*, 2001).

Reference

Abdel-Nasser, G. and Hussein, A. H. A. 2001. Effect of different manure sources on some soil properties and sunflower plant growth. I. Soil physical and chemical properties. *Alexendria J. Agril. Res*., 46: 227-251.

Abusaleha. 1992. Effect of different sources and forms of nitrogen on the uptake of major nutrients in okra. *J. Hort.,* 49: 192-196.

Abusaleha and Shanmugavelu, K. G 1988. Studies on the effect of organic vs inorganic source of nitrogen on growth, yield and quality of okra. *Indian J. Hort*., 45: 312-318.

Anon. 2008. Vital Horticulture Statisticcs. Govt of India. New Delhi

Arnon D. I. 1949. Copper enzymes in isolated chloroplasts-polyphenol oxidase in *Beta vulgaris*. *Plant Physiol*., 24: 1-15.

Arakeri, H. R., Chetan, G. V., Satyanarayan, P. and Donahai, R. L. 1956. Soil management in India. Asia Publishing House, Bombay.

Fisher, R. A. 1950. Statistical method for research workers. Oliver and Boyd, Edinburg, London

Hiscox, J. D. and Israelstom, G. F. 1979. A method for the extraction of chlorophyll from leaf tissues without masceration. *Canadian J. Bot.,* 57: 1332-1334.

Jose, D., Shanmugavelu and Thamburaj, S. 1988. Studies of efficacy of organic vs inorganic form of nitrogen in Brinjal. *Indian J. Hort*., 45: 100-103.

Lu, C. M., Zhang, J. H., Zhang, Q. D., Li, L. B. and Kuang, T. Y. 2001. Modification of PS II photochemistry in nitrogen deficient maize and wheat plant. *J. Plant Physiol*., 158: 1423-1430.

Pillai, K. G., Devi, S. L. and Shetty, T. K. P. 1985. Research achievements of All India Co-ordinated Agronomic Research Project. *Fert. News*., 30: 26-34.

Satchithanantham, S. and Bandara, D. C. 2000. Physiological responses of maize (*Zea mays* L) to the interactive effects of nitrogen fertilizer and water regimes. *Trop. Agril. Res*., 12: 22-32.

Singh, S. P. 1989. Production technology of vegetable crops. Agricultural Research Communication Centre, Karnal, Haryana.

Talashilkar, S. C., Bhangarath, P. P. and Mehta, J. 1999. Changes in chemical properties during composting of organic residues as influenced by earthworm activity. *J. Indian Soc. Soil Sci*., 47: 50-53.

Thompson, C. H. and Kelly, C. W. 1957. Vegetable Crops. Mc Graw Hill Book Co. USA 275-295.

Wang, L. G., Wu, J. C., Wang, J. G., Zhang F. S. and Yuan, W. B. 2001. Influence of balanced fertilizer application on physiology and growth of continuous cropping soybean seedlings. *Soybean Sci*., 20: 235-237.

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Effect of plant growth regulators on yield and economic feasibility of 'Nagpur Mandarin' (*Citrus reticulata* Blanco.)

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Abstract

An investigation was carried out at Fruit Research Farm, Department of Fruit Science at College of Horticulture and Forestry, Jhalawar during July, 2012 to April, 2013 to study the individual effect of plant growth regulators on yield and economic feasibility of Nagpur mandarin (*Citrus reticulata* Blanco.). The physical characters of fruit like maximum increase in diameter (horizontal and vertical), weight, volume and number of sacs per fruit was recorded with the spray of 100 ppm GA_3, which was closely followed by 30 ppm 2,4-D. The maximum number of fruit per tree, fruit retention per cent, yield per plant and per hectare and economic feasibility was recorded with the spray of 30 ppm 2,4-D which was significantly higher to control.

Key words: *NAA, GA_3, 2,4-D, Triacontanol, yield and economic feasibility.*

Introduction

In India, citrus fruits have a prominent place among popular and extensively grown tropical and subtropical fruits after mango and banana. Mandarin (*Citrus reticulata* Blanco) is considered to be one of the most important cultivated species among citrus and is being commercially grown in certain specific region of the country like Nagpur mandarin in Central India; this crop occupies the first position among the citrus in India with respect to area and production. Nagpur Santra is finest variety and very popular in India as well as in world for its good quality fruits. Fruit size big, subglobose, average weight 110-125 gm, rind medium thick, fairly loosely adherent, surface is also relatively smooth but, segment found in 10-15 number and number of seeds 1-2 per segment, colour of peel pale orange yellow. Fruit have mild flavor, excellent quality, juicy, TSS 10-12^0 brix, and acidity 0.50-0.70%. The total production of oranges in India is 3255.0 thousand MT from an area of 324.0 thousand hectares with the productivity of 10 MT/ha. In Rajasthan, mandarin covers 15.2 thousand hectares area and the productivity of 17.9 MT/ha (NHB, Database, 2011). In the state, In Jhalawar district mandarin where it is grown over 22,500 ha area, 13,000 ha of which are in the fruit bearing stage and the production is 2 lac tonnes (Anonymous, 2012).

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A lot of research has been done on the use of PGR to improve fruit size, delay in fruit maturity and overcome rind staining in citrus. However, limited studies have been conducted to evaluate the complete profile of fruit quality in response to growth regulators application to citrus during fruit development. The auxins and gibberellins are widely used to control the fruit drop in citrus and to improve the quality of fruit (Almeida *et al.*, 2004). The application of plant growth regulators can provide significant economic advantages to citrus growers when used in properly as these have proven effective in stimulating a number of desired responses such as increase in fruit size and delay in fruit maturity (Coggins Jr and Hield, 1968). Nawaz *et al.* (2008) reported that 2,4-D, NAA and GA_3 treatments reduced pre harvest drop of Kinnow mandarin compare to control, significantly. Application of Gibberellic acid (GA_3) before or at full bloom increased fruit size and pedicel length.

Materials and Methods

The present investigation was carried out on six years old mandarin **(***Citrus reticulata* Blanco.) cv. 'Nagpur' of uniform size and growth at the Fruit research farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar during first week of July, 2012 to last week of April, 2013. The experiment was consisting of 17 treatments having four levels of each NAA (50, 100, 150 and 200 ppm), GA_3 (25, 50, 75 and 100 ppm), 2,4-D (10, 20, 30 and 40 ppm) and triacontanol (5, 10, 15 and 20 ppm) along with water

spray as control. The experiment was laid out in randomized block design with three replications. The growth regulators, after weighing was dissolved in small quantity of 95 per cent absolute alcohol and 2,4-D was directly diluted in distilled water . Stock solution was first prepared for each growth regulator by diluting with distilled water. The solution of required concentration was then prepared by further dilutions of the measured volume of stock solution with distilled water. Spray of growth regulators were done at first week of July, 2012 under all treatments as per treatment for each plant taking equal volume of the solution. Spraying was done in the evening with a compressed air hand sprayer. The control plant was sprayed with distilled water. The data generated during the experimentation were subjected to statistical analysis of variance. The significance of the treatments was tested through 'F' test at 5 per cent level of significance.

Results and Discussion

It is evident from the present results that application of various plant growth regulators at different concentrations significantly improved physical characteristics of fruits like horizontal diameter, vertical diameter, weight, volume of fruit, number of sacs per fruit, number of fruits per tree, fruit retention and yield of fruits as compared to control are presented. The data recorded on horizontal and vertical diameter of fruit clearly indicate that application of GA_3 at 100 ppm exhibited maximum horizontal and vertical diameter of fruit (8.03 cm) and (8.23 cm) which was found to be at par with 30 ppm 2,4-D (7.64 cm) and (7.83 cm) treatment. The minimum horizontal diameter of fruit (6.12 cm.) and vertical diameter of fruit (5.64 cm.) was recorded at control (Table-1). The results obtained in present investigation are supported by the findings of Chao *et al*. (2011) in mandarin.

Application of plant growth regulators had significantly increased the weight and volume of fruits over control. However, in the present study, the maximum fruit weight (191.22 g) was recorded by 100 ppm GA_3 treatment closely followed by 30 ppm 2,4-D (184.22 g) as compared to minimum at control (135.56 g) (Table-1). Similarly, the maximum volume of fruit (247.56 cc.) was recorded at 100 ppm GA_3 treatment that was followed by 30 ppm 2,4-D (211.89 cc) while the minimum volume (145.44 cc) was recorded in control (Table-1). The increase in weight and volume of fruit due to GA_3 treatment were also recorded by Reddy and Prasad (2012) in pomegranate and Chao *et al*. (2011) in mandarin.

The maximum number of sacs per fruit of 12.56 was recorded at 100 ppm GA_3 treatment closely followed by 30 ppm 2,4-D. However, the minimum number of sacs per fruit of 9.89 was recorded at control, respectively. The variation in the number of sacs per fruit due to different plant growth regulators might be attributed to difference in enzymetion alluding during cell division and cell differentiation phases of fruit developments.

The application of plant growth regulator treatments had significantly increased the number of fruits per tree and fruit retention per cent over control are presented in Table 1. The maximum number of fruits per tree (126.0) was recorded at 30 ppm 2,4-D treatment as compared to minimum (100.67) in control. Similarly the maximum fruit retention per cent (70.68%) was recorded at 30 ppm 2,4-D treatment closely followed by 10 ppm 2,4-D (69.21%) treatment. The minimum fruit retention of 56.42 per cent was recorded at control. The application of 2, 4-D at 40 ppm gave significantly maximum number of fruits (64.00) Reddy and Prasad (2012) in pomegranate. Similar beneficial effect of 2,4-D on number of fruit per tree and fruit retention was also recorded by Ashraf *et al*. (2013) in Kinnow mandarin.

The effect of plant growth regulators on yield of Nagpur mandarin fruits are presented in Table 1. The data showed that the application of different plant growth regulators at various concentrations had significantly increased the yield of Nagpur mandarin fruits over control in the present investigation. Amongst the various plant growth regulator treatments attempted the maximum yield of 21.80 kg/plant and (6.08 tonnes/ha.) was recorded at 30 ppm 2,4-D treatment followed by 10 ppm 2.4-D treatment. The minimum yield of (12.94 kg/plant and 3.60 tonnes/ha.) was observed at control. The increase in yield of Nagpur mandarin fruits by application of 2,4-D and GA_3 treatments may be attributed to the fact that partitioning of assimilates by 2,4-D and GA_3 more towards the fruit development and better translocation of assimilates further leads to improvement in yield contributing characters like size and weight of fruits as evident by the present study which finally increased the yield (Khalid *et al*., 2012) in 'Kinnow' mandarin. Similar results were also observed by application of 2,4-D treatment in 'Nova' mandarin as reported by (Greenberg *et al*., 2006) and in Nagpur mandarin as reported by (Ingle *et al*., 2001).

The economics of different plant growth regulator treatments used at various concentrations in the present investigation are calculated and presented in Table 2. The economic feasibility of various treatments clearly showed that the application of 30 ppm 2,4-D treatment has resulted the maximum gross return of Rs. 1,21,600/ha which was Rs. 49600/ha excess over control. Further, the highest net profit (Rs. 48,855/ha) was estimated at 30 ppm 2,4-D treatment which was 67.85 per cent higher than control, which was closely followed by 10 ppm 2,4-D and 100 ppm GA_3. Ingle *et al*.

(2001) revealed that foliar application of 2, 4-D at 10 ppm treatment increased the fruit weight, volume, TSS, ascorbic acid, peel and yield over control in Nagpur mandarin. Amiri *et al.* (2008) found that spray of 2, 4-D in Italian orange and is an effective and economical way to reduce citrus pre harvest fruit drop. The application of 20 ppm 2,4-D treatment was observed by Nawaz *et al.* (2008) whose findings revealed that the the lowest fruit drop of 12.95% and increased number of fruits/plant and fruit weight/plant in Kinnow mandarin. The highest percent increase in net profit due to 30 ppm 2,4-D treatment may be because of highest yield and qualitative fruits under this treatment as evident from the present results discussed earlier in the text. Therefore, among the various plant growth regulator treatments attempted under present investigation, the application of 30 ppm 2,4-D was found to be most economic and desirable treatment.

The relative economics of the various plant growth regulator treatments was also worked out. On

Table 1. Effect of plant growth regulators on per cent increase in Physical characteristics and yield of Nagpur mandarin

Treatments	Diameter of fruit (cm)		Weight of fruit (g)	Volume of fruit (cc)	No. of sacs/fruit	No. of fruits/tree	Fruit retention (%)	Yield (kg/plant)	Estimated yield (tonnes/ha)
	Horizontal	Vertical							
T_0	6.12	5.64	135.56	145.44	9.89	100.67	56.42 (69.43)	12.94	3.60
T_1	6.80	5.97	144.11	155.22	10.89	115.67	67.42 (85.27)	16.67	4.64
T_2	7.02	6.50	150.22	171.78	11.11	112.33	66.32 (83.89)	16.87	4.69
T_3	6.82	6.22	143.11	164.22	11.56	109.33	66.24 (83.78)	15.65	4.35
T_4	7.13	7.44	164.89	189.44	11.11	110.33	65.07 (82.17)	18.19	5.06
T_5	7.26	7.27	141.11	149.89	11.44	107.67	69.04 (87.08)	14.12	3.93
T_6	6.97	6.71	145.56	177.78	10.56	110.33	66.50 (84.11)	16.06	4.46
T_7	6.59	6.37	167.78	181.78	11.44	106.67	67.49 (85.36)	17.89	4.98
T_8	8.03	8.23	191.22	247.56	12.56	113.33	65.29 (82.53)	21.67	6.03
T_9	6.43	6.38	172.11	190.22	11.11	117.67	69.21 (87.34)	21.68	6.03
T_{10}	7.46	7.39	149.44	164.22	11.78	123.67	67.25 (85.06)	18.48	5.14
T_{11}	7.64	7.83	184.22	211.89	12.11	126.00	70.68 (89.05)	21.80	6.08
T_{12}	6.97	6.75	144.22	173.78	10.89	119.67	64.60 (81.61)	17.26	4.80
T_{13}	6.90	6.26	156.44	160.56	11.44	101.67	62.96 (79.32)	15.91	4.42
T_{14}	7.40	7.34	164.22	181.56	10.89	107.67	64.17 (81.03)	17.68	4.92
T_{15}	7.08	6.37	164.22	186.78	10.44	105.33	59.93 (74.88)	17.30	4.81
T_{16}	6.65	6.28	152.11	172.78	10.56	114.67	61.20 (76.79)	17.44	4.85
SEm	0.20	0.25	7.95	10.66	0.42	3.12	1.03	0.50	0.14
C.D. at 5%	0.59	0.72	22.89	30.69	1.21	8.98	2.99	1.44	0.40

(**T_0**- Control, **T_1**- NAA 50ppm, **T_2**- NAA 100ppm, **T_3**- NAA 150ppm, **T_4**- NAA 200ppm**,** **T_5**- GA_3 25ppm, **T_6**- GA_3 50ppm, **T_7**- GA_3 75ppm, **T_8**- GA_3 100ppm, **T_9**- 2,4-D 10ppm, **T_{10}**- 2,4-D 20ppm, **T_{11}**- 2,4-D 30ppm, **T_{12}**- 2,4-D 40ppm, **T_{13}**- Triacontanol 5ppm, **T_{14}**- Triacontanol 10ppm, **T_{15}**- Triacontanol 15ppm, **T_{16}**- Triacontanol 20ppm)

Table 2. Economic feasibility of plant growth regulator treatments in mandarin cv. Nagpur mandrin

Treatments		Additional treatment cost	Yield (tones/ha)	Gross return (@ Rs. 20/kg)	Excess income over control	Net profit due to treatment	% Increase in yield over control	% Increase in net profit over control
Control	(T_0)	-	3.60	72,000	-	-	-	-
NAA 50 ppm	(T_1)	914.50	4.64	92,800	20,800	19,885	28.89	27.62
NAA 100 ppm	(T_2)	1129.00	4.69	93,800	21,800	20,671	30.28	28.71
NAA 150 ppm	(T_3)	1343.50	4.35	87,000	15,000	13,656	20.83	18.97
NAA 200 ppm	(T_4)	1558.00	5.06	1,01200	29,200	27,602	40.56	38.39
GA_3 25 ppm	(T_5)	2515.00	3.93	78,600	6,600	4,085	9.17	5.67
GA_3 50 ppm	(T_6)	4330.00	4.46	89,200	17,200	12,870	23.89	17.88
GA_3 75 ppm	(T_7)	6345.00	4.98	99,600	27,600	21,255	38.33	29.52
GA_3 100 ppm	(T_8)	7960.00	6.03	1,20,600	48,600	40,640	67.50	56.44
2,4-D 10 ppm	(T_9)	714.85	6.03	1,20,600	48,600	47,885	67.50	66.51
2,4-D 20 ppm	(T_{10})	729.70	5.14	1,02800	30,800	30,070	42.78	41.76
2,4-D 30 ppm	(T_{11})	744.55	6.08	1,21,600	49,600	48,855	68.89	67.85
2,4-D 40 ppm	(T_{12})	759.40	4.80	96,000	24,000	23,240	33.33	32.28
Triacontanol 5 ppm	(T_{13})	2350.00	4.42	88,400	16,400	14,050	22.78	19.51
Triacontanol 10 ppm	(T_{14})	4000.00	4.92	98,400	26,400	22,400	36.67	31.11
Triacontanol 15 ppm	(T_{15})	5650.00	4.81	96,200	24,200	18,550	33.61	25.76
Triacontanol 20 ppm	(T_{16})	7300.00	4.85	97,000	25,000	17,700	34.72	24.58

the basis of relative economics it can again be suggested that 30 ppm 2,4-D treatment was found to be most effective and desirable on the basis of early maturity and highest yield coupled with superior nutritional qualities of mandarin cv. 'Nagpur' fruit. Among the various plant growth regulators tried, 2,4-D and GA_3 were found to be most effective for increasing the yield of mandarin cv. 'Nagpur' fruit. Of the two most effective treatments i.e. 30 ppm 2,4-D and GA_3 100 ppm, the 2,4-D treatment is economically cheaper than GA_3. Therefore, based on the findings the Nagpur mandarin growers may be advised to preferably spray the Nagpur mandarin plant with 30 ppm 2,4-D in the month of July to get better yield of 'Nagpur' mandarin crop with superior quality.

References

Ashraf, M.Y., Asshraf, M., Akhtar, M., Mahmood, K. and Saleem, M. 2013. Improvement in yield, quality and reduction in fruit drop in Kinnow (*Citrus reticulata* Blanco.) by exogenous application of Plant Growth Regulators, Potassium and Zinc. *Pak. J. Bot.*, 45(SI): 433-440.

Amiri, N.A., Arzani, K., Malakouti, M.J. and Barzegar, M. 2008. Investigation of pre harvest drop and its relation with auxin amount in abscission zone of Italian orange fruit (*Citrus sinensis* cv. Italian). *J. Agric. Sci. & Nat. Res.,* 15(5): 77-86.

Almeida, I., Leite, I.M., Rodrigues, J.D. and. Ono, E.O. 2004. Application of plant growth regulators at pre-harvest for fruit development of 'PERA'oranges. *Braz. Arch. Biol. Technol.*, 47(4): 658-662.

Chao, C.C.T., Khoung, T., Zheng, Y.S. and Lovatt, C.J. 2011. Response of evergreen perennial tree crops to gibberellic acid is crop load-dependent. I: GA_3 increases the yield of commercially valuable 'Nules' Clementine Mandarin fruit only in the off-crop year of an alternate bearing orchard. *Hort. J. A. Scientia., 130 (4): 743-752.*

Coggins Jr, C.W. and Hield, H.Z. 1968. Plant-growth regulators In: The Citrus Industry (Eds.): W. Reuther, L.D. Batchelor and Webber, H.J. Vol. II pp

371-389. Revised edition Uni. Calif., USA.

Greenberg, Kaplan, I., Fainzack, M., Egozi, Y. and Giladi, B. 2006. Effect of Auxins sprays on yield, fruit size, fruit splitting and the incidence of creasing of 'Nova' mandarin. *Acta Hort.*, 727.

Ingle, H.V., Rathod, N.G. and Patil, D.R. 2001. Effect of growth regulators and mulching on yield and quality of Nagpur mandarin. *Annals Plant Phys., 15 (1): 85-88.*

Khalid, S., Malik, A.U., Khan, A.S., and Jamil, A. 2012. Influence of exogenous applications of plant growth regulators on fruit quality of Young 'Kinnow' Mandarin (*Citrus nobilis* × *C. deliciosa*) Trees. *Int. J. Agric. Biol*., 14 (2): 229234.

Nawaz, M.A., Ahmad, W., Ahmad, S. and Khan, M. M., 2008. Role of growth regulators on preharvest fruit drop, yield and quality in Kinnow mandarin. *Pak. J. Bot., 40(5): 1971-1981*.

Reddy, P.A. and Prasad, D.M. 2012. Effect of plant growth raguletors on fruit characters and yield of pomegranate (*Punica granatum L*.) cv. Ganesh. *Int. J. P. A. E. Sci.,* 2 (2): 2331-4490.

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Underutilized fruits of South Western Rajasthan used in medicinal, nutritional and economic security of tribal's: A case study

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Abstract

The South Western Rajasthan is endowed of plant biodiversity with special mention of semi-arid underutilized fruit and vegetables. The present study emphasized that in ancient times these fruits and vegetables were largely used by the natives of tribal area as a prime source of natural medicine and food using their traditional wisdom. They used them in the form of fresh fruits, dry fruits, fruit juice, fruit powder, *arak*, *chutney*, paste, lotion, pickle, nutritive wine, drugs, *triphala* and *chyavanprash* etc. But in present scenario, because of changing food habits, taste and prevalence of several food myths and taboos the new generation of tribals discontinued consuming underutilized fruits and vegetables. Because they are unaware about the importance of consuming underutilized fruits and vegetables in daily diet. It has resulted into malnutrition among those people who discontinued consuming locally available underutilized fruits and vegetables along with multiple nutrient deficiency disorders. Significantly high prevalence of nutrients deficiency and occurrence of clinical symptoms of protein energy malnutrition (14.4%), anaemia (33.0%), iodine deficiency disorder (17.0%), vitamin A deficiency (22.0), vitamin C deficiency (12.40%), calcium deficiency (18.0%) and zinc deficiency (19.20%) were observed in non-consuming groups of tribals. It was also evident from the study that the consuming group has more traditional wisdom for therapeutic uses of available underutilized fruits and vegetables. Also the study results revealed that the underutilized horticultural crops have the potential to give economic security to tribals by giving employment and by fetching good returns from their sale in raw form as well as value added products.

Keywords: *Underutilized fruits, nutritional security, tribals, traditional foods, non-consuming group.*

Introduction

Aravali range is a treasure of underutilized horticultural crops, and if exploited properly has the potential of transforming the economy of this tribal dominated region of Rajasthan because the crops are of explicit quality with great nutritional, medicinal, organoleptic, economic and traditional importance. Some of the important underutilized fruit crops are *Pilu, Jamun, Sitaphal, Mahuva*, Mulberry, *Kainth, Ber, Ker, Karonda, Khirni*, Date palm, Tamarind, *Bael, Aonla* etc., medicinal plants are *Safed musli, Mulathi, Googal, Aloe vera,* etc. and vegetable crops are Clusterbean, *Kachri, Khimp, Khejri* pod, *Kakri (Balam khera*) which are the main source of livelihood for the poor tribals and can play an important role in overcoming the problem of malnutrition (Gajanana *et al*., 2010). In ancient times these horticultural crops were used as major source of medicine and nutritive food by tribal population. These people were well acquainted with different ways of using available fruit and vegetable for curing various diseases and act as source of nutrition. Also, earlier tribal had knowledge about processing (drying, modified mixed dry product, healthy liquor, *arak*, paste, lotion and fresh stored products) of fruits and vegetables which were otherwise available in plenty during a particular season. Besides their nutritional importance and as a source of household income, this fruit diversity also has a cultural and social value and contributes to the stability of ecosystems (Arora, 1998; Nandal and Bhardwaj, 2013a). But in changed scenario the tribals (*adivasis*) are suffering from various deficiency diseases due to faulty eating habits, cultural myths and taboos for foods, improper dietary composition, poverty, ignorance, lack of awareness leading to malnutrition and health insecurity. In present times the tribal population has reduced use of these valuable planting materials in daily life. The main reason for this is lack of awareness about their potential and low erratic bearing habit of these fruit plants.

Besides, some of these fruits are not acceptable in the market in fresh form due to their acidic nature and stringent taste. Hence, there is a need to

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concentrate on research efforts in diversification and popularization of such underutilized fruit crops for medicinal, nutritional and economic security of tribal population. Thus, product development and diversification of value added products have become very important for underutilized fruit production. The country is successful in evolving appropriate processing technologies for the profitable utilization and value addition of these fruits. As a result products like jam, jelly, preserve, beverages, pickle, dehydrated fruits and vegetables have been developed and they are having good commercial potential as well as beneficial in solving nutritional deficiency problems in tribal areas (Gopalan *et al.*, 1989; Goyal and Sharma, 2009). The importance of these lesser known fruits is increasing day by day because health conscious people realized the importance of new useful terms such as caloric sweetness, insecticide compounds and medicinal value. Most of the underutilized fruits are rich source of vitamins (ascorbic acid, thiamine, niacin, pyridoxine, folacin), minerals, fat, protein and dietary fibre (Gopalan *et al*., 1989; Nandal and Bhardwaj, 2013b).

Materials and Methods

A field survey was conducted during the years 2012-2013 for exploring the use of underutilized fruits in preparation of traditional foods for medicinal, nutritional and economic security of tribals of South Western Rajasthan. During survey the information was recorded on effect of consuming underutilized fruits and vegetables on nutritional security and prevalence of nutritional deficiency disorders from two groups first group were 100 persons of underutilized fruit and vegetable consumers and second group of 100 persons were non-consumers. Each group has members of different age groups i.e. Children < 5 years, children > 5 years, men, women, pregnant women, from five tribal dominated villages (Kerlapadar, Muri, Aamli, Rajpura and Fatehpura) of district Sirohi. Further, the relevant information regarding nutritional value, value addition and processing potential of the underutilized fruits was obtained from 100 middle aged housewives (aging 30-50 years) through direct interview method. During the survey the information about traditional wisdom of tribals for therapeutic uses of different locally grown and available underutilized fruits have been recorded from two age groups of 100 persons i.e. 20-30 years and 60-70 years old and data was presented in percentage. The medicinal importance of underutilized fruit and vegetables was collected by direct interview method from 5 local *Vaid* and reputed experts with the help of a pre-tested questionnaire. Economics of plantation of underutilized fruits in tribal area of district Sirohi was determined by a team of four experts from the field of horticulture, economics, plant physiology and forestry alongwith a progressive tribal farmer.

Results and Discussion

Nutritional deficiency diseases and occurrence of clinical signs and symptoms

The observations recorded during survey clearly indicated that the per cent prevalence of nutritional deficiency and occurrence of clinical symptoms was significantly higher in non-consumer group of tribals than the consumer group (Table 1). The results indicated that the non-consumer group of tribal population was more prone to (children < 5 years-20 %, children > 5 years-15 %, men- 7 %, women- 13 %, pregnant women-17 %) in suffering from Protein Energy Malnutrition. Major nutrient deficiency clinical symptoms like growth retardation with poor physical growth, reduced immunity, lesser in height and weight than normal body weights were present in this group than the underutilized fruit consumer group (children < 5 years- 8%, children > 5 years- 3%, men- 1%, women- 4 %, pregnant women- 6%). During baseline health survey it was also reported that the 40 per cent women, 45 per cent of the pregnant women, 23 per cent men, 27 per cent children > 5 years and 30 per cent of children < 5 years age group of non-consumers were suffering from iron deficiency anaemia. Clear iron and folic acid deficiency symptoms like tiredness, paleness of conjunctive, spoon shaped nails, pitting oedema, paler skin, sore tongue, low blood pressure and regular headache were present in non-consumers of all age groups than consumer groups. It was also observed that 17.0 per cent population suffered from iodine deficiency symptoms (Swollen front of the neck, protruding eyes, severe mental retardation, stunted physical growth, enlarged head, deafness, hypothyroidism with fatigue, weight gain, weakness and depression) in non-consumer group whereas only 5.0 per cent in consumer group. Vitamin A deficiency was also prevalent in non-consumer group of tribals with 22.0 per cent suffering from xerophthalmia, night blindness and rough skin (Table 1). It was also evident that the adult tribals consuming underutilized fruit and vegetable in daily diet were free from vitamin A deficiency symptoms. Significantly high prevalence of vitamin C deficiency (12.40%), calcium deficiency (18.0%) and zinc deficiency (19.20%) were observed in non-consuming group of tribals. They suffered from different visual symptoms i.e weak teeth and bones, slow growth, skin lesions and were more susceptible to infections. Whereas the underutilized fruit and vegetables consuming group was more healthy, nutritionally secure and having high working capacity rather than the non-consuming group. Maximum tribal children were suffering from iron deficiency anaemia, protein energy

malnutrition and severely malnourished due to unawareness and ignorance about nutritional value of underutilized fruits and vegetables and their uptake in daily diets (Nandal and Bhardwaj, 2013b).

Nutritional values of underutilized fruits

Underutilized fruits and vegetables *viz.*, a*onla*, dates, *sitaphal*, *ber*, *rayan*, *pilu*, *ker*, *Aloe vera*, *kachri*, *khimp*, *khejri* pods, *phog*, *bael* and tamarind contribute significantly in maintaining tribal population nutrition, especially as very good source of vitamins {ascorbic acid (vitamin C), carotenoids (vitamin A), thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3), pyridoxine (vitamin B_6), folacin}, minerals, fat, protein and dietary fibre (Wargovich, 2000; Nandal and Bhardwaj, 2013a). Some underutilized fruits like wood apple (7.10 mg100g^{-1} pulp), *phog* (6.05 mg100g^{-1} pulp) are very good source of protein, Tamarind (17.01 mg100g^{-1} pulp) and *karonda* (39.14 mg100g^{-1} pulp) are richest source of iron, *kumquat* (2575 IU) and drumstick (190 IU) are excellent source of vitamin A, *aonla* (500-625 mg100g^{-1} pulp), *ber* (85 mg100g^{-1} pulp) and chinese jujube (188-544 mg100g^{-1} pulp) are very good source of vitamin C, *phog* (11.81-11.90 mg100g^{-1} pulp) and wood apple (3.70-3.75 mg100g^{-1} pulp) have good amount of fat, *bael* (31.80 mg100g^{-1} pulp), tamarind (67.40 mg100g^{-1} pulp) and date palm (70 mg100g^{-1} pulp) are very good source of carbohydrate, *khimp* (156.30 mg100g^{-1} pods) and *phog* (211.14 mg100g^{-1} seeds) are richest source of calcium. Underutilized fruits such as *ber*, *bael*, *ker*, *phog*, *khimp*, *khejri* pod and *kachri* are more nutritious than other commercial fruits (Anonymous, 2010). The cluster bean (*Cyamopsis tetragonoloba* L.) is an important vegetable, it is rich source of protein (3.2 g), fibre (3.2 g), carbohydrate (10.8 g), calcium (130 mg), phosphorus (57 mg) and iron (0.6 mg) in per 100 g of fresh pods. The mature fruits of *kachri* (*Cucumis callosus*) are available abundantly in south western Rajasthan, it is one of the components of the delicious vegetable popularly known as *panchcuta*. It has 1.28 g fat, 1.21 g fibre, 43 Kcal energy and 29.81 mg vitamin C in 100g^{-1} of fresh fruit. *Ker* (*Capparis decidua*) also a lesser known fruit of Rajasthan is very good source of protein (4.24 g), fat (2.0 g), fibre (4.24 g), carbohydrate (18.2 g), energy (107 Kcal) and vitamin C (50 mg) in 100 g^{-1} of fresh fruit. *Khimp* pod (*Leptadenia pyrotechnia*) are rich in protein (3.13 g), fat (1.84 g), fibre (23.18 g), energy (68 Kcal), vitamin C (39.0 mg), iron (3.48 mg), calcium (156 mg) and phosphorus (317 mg) in 100 g of fresh pods. The unripe green pods of *khejri* (*Prosopis cineraria* Druee) commonly known as *sangri* and it is very good source of digestive protein (5.1 g), fiber (6.7 g), carbohydrate (14.15 g) and energy (82 Kcal) in 100 g of fresh pods. The seeds of *phog* (*Calligonum polygonoides* Linn) are rich in protein (6.05 g), fat (11.81 g), fibre (15.73 g), carbohydrate (57.31 g), energy (360 Kcal), vitamin C (4.30 mg), iron (3.52 mg), calcium (211 mg) and phosphorus (427 mg) in 100 g of fresh weight of seeds. Most of the tribal food resources are available in plenty during a particular season but all have not been utilized to desired extent due to many reasons like unawareness, taste and unavailability of standardized processing and value addition methods (Anonymous, 2010). Thus, people residing in tribal areas hardly get considerable advantage from the abundantly available resources. The solution of the problem lies only in evolving the techniques of value addition, providing market and educating the tribals about nutritional quality of underutilized commodities. Processing and value addition of underutilized fruits and vegetables into more useful, easily digestible, tasty and convenient products ultimately improves the economic value of underutilized commodities and provide nutritional security to the tribals.

Therapeutic uses of underutilized fruits

There is considerable traditional wisdom regarding various therapeutic uses of underutilized fruits. But in present time new generation (20-30 years youth) of tribals is ignorant about the medicinal uses and methods of clinical application of underutilized fruits, whereas the old age (60-70 years) tribal persons have very good knowledge about therapeutic application and methods of use (Table 2). The data presented in table 2 showed that the older tribal population have very good traditional wisdom about therapeutic uses of underutilized fruits like *aonla* (69%), date palm (60%), *sitaphal* (80%), *ber* (55%), *rayan* (86%), *jamun* (60%), *pilu* (90%), *ker* (60%), dhrthkumari (80%), *kachri* (40%), *khimp* (30%), *khejri* (90%) and *tarbuj* (60%), whereas the new generation has very less traditional wisdom about different uses of underutilized fruits in tribal area. Underutilized fruits are major source of raw material for drugs and traditional medicines. It is widely accepted that underutilized fruits are of explicit quality with great nutritional, medicinal, organoleptic, economic and traditional importance. Numbers of underutilized fruits are used in pharmaceutical drugs as source of valuable remedies for treating dreaded modern ailments such as cancer, diabetes, jaundice, asthma, and nutritional deficiency (Wargovich, 2000; Anonymous, 2010; Nandal and Bhardwaj, 2013b). *Bael* is used in 60 patented drugs. *Aonla* is the component of most famous *ayurvedic* medicine *chyavanprash*. *Ber* is used in *joshanda*, *jamun* seed in diabetes and black mulberry in docking of AIDS virus on human cell. Fruits, nuts and vegetables in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke and other chronic diseases (Hyson,

2002; Goldberg, 2003; Nandal and Bhardwaj, 2013a). Some components of fruits and vegetables (phytochemicals) are strong antioxidants and function to modify the metabolic activation and detoxification/ disposition of carcinogens, or even influence processes that alter the course of the tumor cell (Wargovich, 2000; Nandal and Bhardwaj, 2013b). The stem and bark of *Khejri* is used for curing boils, leprosy, dysentery, asthma, piles and tumours (Saroj, 2004). Daily use of *aloe* juice shows significant improvement in glycaemic control, lipid profile and BMI of Type -2 diabetes (Deepti *et al*., 2007; Nandal and Bhardwaj, 2012). A list of underutilized fruits having therapeutic uses and traditionally used by tribals for health security is given in table 2.

Economic value of underutilized fruits

Underutilized fruits are the source of sustainable income in tribal areas. But the tribal farmers knew about the economic value of only some underutilized fruits like *aonla* (70%), sitaphal (95%), *ber* (87%), *rayan* (92%), *pilu* (55%) and tamarind (70%). Whereas economics of some underutilized fruits is higher but popularity is very less like date palm (30%), *ker* (30%), *Aloe vera* (20%), *khimp* (25%), *phog* (12%) and *bael* (22%) (Table 3). Number of plant parts produce like root, leaves, flowers, fruits, gum etc. have high economic value in market. Many economically useful fruits, vegetables and medicinally viable plants like *aonla*, *ber*, custard apple, *jamun*, tamarind, *bael*, *ker*, *lasoda*, *khejri*, *karonda*, dates, *tumba*, *kumtia*, *kachari*, *pilu* etc. were either propagated or naturally available in the tribal areas of Rajasthan (Anonymous, 2011; Nandal and Bhardwaj, 2013a). The tribal especially women and children collected these fruits and useful plant parts from widely scattered trees and bushes in the region repeatedly during the harvesting season. A part of their collection was retained with them for their own consumption in raw or dried form and surplus was sold to the local traders or along road sides (Anonymous, 2011; Nandal and Bhardwaj, 2013a). The market of underutilized fruit in turn was influenced by a number of factors like consumer preference, processability, value addition, export, domestic consumption, foreign demand which again was based on knowledge about the health promoting qualities and nutritional value of the crops (Chundawat, 2003).

Value addition of underutilized fruits

Accurate statistics in regard to quantity production and processing was unavailable for underutilized fruits because a sizeable quantity of the fruits produced were self-consumed, exchanged or sold locally which remained unreported. The majority of fruit species in Rajasthan were not cultivated on a large-scale or commercial basis, but rather grow wild or planted in home gardens or field boundaries. The results presented in table 4 showed that the maximum tribal women (85%), knew about preservation of the fruit and vegetable by dehydration method. Whereas 60 per cent women were also familiar about pickling of fruit and vegetable and 45 per cent have good knowledge about preparation of fruit and vegetable chutney. All advance technologies of fruit and vegetable preservation like making preserve (1.0%), glazed fruits (0.0%), sauce (5.0%), frozen puree (0.0%), canning (2.0%) and confectionary (0.0%) were less popular among tribal women. Normally, the fruits were collected from the wild forest and sold fresh on a seasonal basis, with limited processing (Azam-Ali, 2003). The volume processing was very high for all the species, as it refers to primary processing, which mainly involves the removal of pulp and drying. The socio-economic status of rural families can be improved through value addition of underutilized fruits (Anonymous, 2011; Nandal and Bhardwaj, 2013a). It can facilitate optimum utilization of available resources and can have great future in waste land fruit production. *Pachcutta* was most common processed product of underutilized fruits (Pareek and Samadia, 1998). The establishment of agro-processing industries in rural and tribal areas was necessary not only to meet the ever increasing demand for processed products but also to enhance real farm income in future (Anonymous, 2011). Value addition will also generate required employment potential for tribal workers. Processing of underutilized fruits and vegetables into more useful and convenient products, ultimately improves the economic value of any product, which is the most vital component of value addition (Goyal and Sharma, 2006) (Table 4). *Ber* pulp was used for making drinks (Kiradoo and Goyal, 2005), fresh *ker* fruits used as vegetable and pickle, immature fruits were also dried for subsequent use as vegetable in off season (Sen, 2003).

All the underutilized fruits and vegetables available in South-Western Rajasthan had great nutritional, medicinal and sensory appeal. There is a considerable traditional wisdom available on various therapeutic uses of underutilized fruits along with a great potential in the field of processing and value addition. In the present socio-economic scenario, when the tribals are facing the problems of hidden hunger, macro and micro-nutrient deficiencies, poverty, unemployment. The wise and proper utilization of underutilized horticultural crops can prove to be a promising solution after realizing their health and employment potential. The underutilized crops can be a rich and easily available source of macro and minor nutrients in sufficient amounts to prevent and cure deficiency disorders. They are the source of ayurvedic medicine because of having therapeutic properties.

They can fetch self employment opportunities through marketing of raw fruits and vegetables. Along with it, employment can be generated by value added product preparation through processing. Also, a good future scope lies in the field of value addition in view of abundant availability, palatability, quality and therapeutic uses of underutilized fruits and vegetables. Hence it can be concluded that exploitation of underutilized fruits and vegetables can provide a solution to nutrition, livelihood and economic security of tribals by using available traditional wisdom as well as modern food processing technology.

Table 1. Major nutritional deficiency diseases, their symptoms and prevalence in tribal areas of district Sirohi

Name of Disease	Symptoms of disease	Prevalence of nutritional deficiency and occurrence of visual symptoms (N=200)											
		Children < 5 years %		Children > 5 years %		Men (%)		Women (%)		Pregnant Women %		Mean %	
		NC	C	NC	C	NC	C	NC	C	NC	C	NC	C
Protein Energy Malnutrition (PEM)	Growth retardation with po or physical growth, reduced immunity, lesser in height and weight than expected, kwashiorkor (presence of oedema) and nutritional marasmus (severe wasting)	20.0	8.0	15.0	3.0	7.0	1.0	13.0	4.0	17.0	6.0	14.4	4.4
Iron deficiency anaemia	Pale skin, f atigue, brittle fingernails, sore tongue, brittle hair, shortness of breath, rapid heartbeat, unusual food cravings, low blood pressure, low immunity, headache, decreased appetite	30.0	9.0	27.0	8.0	23	9.0	40	13.0	45	15.0	33.0	10.8
Iodine Deficiency Disorder (IDD)	Swollen front of the neck, protruding eyes, severe mental retardation, stunted physical growth, enlarged head, deafness, hypothyroidism with fatigue, weight gain, weakness and depression	22.0	7.0	17.0	4.0	12.0	4.0	11.0	3.0	23.0	9.0	17.0	5.4
Vitamin A Deficiency	Xerophthalmia and Night Blindness-inflammation of the cornea, eye lesions, dry eyes, bitots spots ;dry and rough skin; decreased immunity; growth retardation and loss of appetite	23.0	3.0	22.0	7.0	17.0	0.0	23.0	0.0	25.0	5.0	22.0	3.0
Vitamin C Deficiency	Scurvy with skin bruises and bleeding, swollen or painful joints, decreased immunity, poor digestion, soft gums, slow healing wounds and fractures, loss of appetite	12.0	5.0	13.0	3.0	10.0	2.0	12.0	2.0	15.0	7.0	12.4	3.8
Calcium Deficiency	Weak teeth that easily fall out, lack of sleep, premenstrual cramps, high blood pressure, osteoporosis in adults	15.0	3.0	15.0	4.0	10.0	2.0	20.0	7.0	30.0	9.0	18.0	5.0
Zinc Deficiency	Slow growth in children, loss of hair, skin lesion s, peeling skin, slow healing of wounds, frequent and recurring infections, severe diarrhoea	12.0	3.0	20.0	7.0	17.0	4.0	22.0	9.0	25.0	9.0	19.2	6.4

(N=200) = 100 NC (Non-consumer of underutilized fruits) + 100 C (Consumer of underutilized fruits)

Table 2. Frequency of awareness about traditional wisdom for therapeutic uses of underutilized fruits and vegetables in different age group of tribals.

Common Name	Botanical Name	Traditional wisdom for different uses	Therapeutic uses	Frequency of awareness (n=100)	
				20-30 years	60-70 years
Aonla	*Emblica officinalis*	Triphala, dry fruits chyavanprash, Amal ki rasayan, Dhatri loha, Saptamrit	Cures haemorrhage, Diarrhoea, dysentery, anaemia, cough	17.0	69.0
Date palm	*Phoenix dactylifera*	Dry fruits, *chuhara*, fruit powder, nutritive paste (date *pak*)	Supply instant energy, natural laxative, nicotinic content cures intestinal disturbances, checks growth of pathological organisms	8.0	60.0
Sitaphal	*Annona reticulata*	Fresh fruits, fruit powder, fruit *pak*, fruit paste	Storehouse of Vitamin C acts as antioxidant, Vitamin A present is good for hair, eyes, healthy skin, rich source of dietary fibre so helps in digestion, expectorant, coolant, stimulant, haematinic	13.0	80.0
Ber	*Ziziphus nummularia*	*Chuhara*, dry and fresh fruits, drugs	Helps in blood purification and improves digestion	15.0	55.0
Rayan	*Mimusops hexandra*	Dry and fresh fruits, nutritive drugs	Cures anaemia, improves haemoglobin content in blood	5.0	86.0
Jamun	*Syzygium cumini*	Fermented drugs, fruit juice, fresh fruits, *Jaambukasav, Madhumehdaman churna*	Cures Stomach ache, anaemia, improves haemoglobin in blood, diabetes	40.0	60.0
Pilu	*Salvadora oleoides*	Nutritive drugs, fresh fruits, juice	Helps in blood purification and digestion	5.0	90.0
Ker	*Capparis deciduas*	Dry and fresh fruits, roasted fruits, powder, *pachcutta*	Cures biliousness, asthma, inflammations, fever, cough, stomach pain, vomi tting, arthritis, diabetes and hypertension, laxative	15.0	60.0
Dhrth-kumari	*Aloe barbedensis* Mill	Juice, *pak*, jam, powder, *arck, bhasm, drugs, Kumaryasav, Rajpravradhanivati*	Antioxidant, bactericidal, fungicidal, purgative, controls arthritis, diabetes and cholesterol level	10.0	80.0
Kachri	*Cucumis callosus*	Dry and fresh fruits, *pachcutta*, fruit powder	Exert cooling effect on body, improves appetite, easy bowel movement, relieves stomach pain, vomitting and constipation	25.0	40.0
Khimp	*Leptadenia pvrotechnica* Forsk.	Dry and fresh pods, pod powder, *bhasm and arck*	Cures constipation, arthritis and good for health	2.0	30.0
Khejri pods	*Prosopis cineraria*	Dry and fresh pods, pod powder, pod *pak*, pod paste, *pachcutta*	Help in blood purification, cures skin disease, respiratory problem and piles, cures ringworm infection, dyspepsia and fevers.	10.0	90.00
Tarbuj	*Citrullus lanatus*	Fresh fruits, juice and drugs	Relieves constipation and diarrhoea, cardiac and kidney troubles.	20.0	60.0
Phog	*Calligonum polygonoides*	Fresh fruit pulp, dry powder and *phog-pak*	Exert cooling effect on body and provide good health	1.0	25.0
Bael	*Aegle marmalos*	Fruit powder, pulp, fruit pak, paste, drugs, *Bilb giri*	Appetizer, stomachic, cooling, restore vitality	20.0	70.0

Table 3. Economics of plantation of underutilized fruits in tribal areas of district Sirohi

S.N.	Name of fruit & vegetables	Number of plants ha^{-1}	Average yield (qt $plant^{-1}$)	Average yield (qt.ha^{-1})	Average market rate (Rs. qt^{-1})	Expected income (Rs. ha^{-1})	Frequency of awareness (%) (n= 100)
1	*Aonla*	100	40	40	400	16,000	70.0
2	Dates	100	35	35	2000	70,000	30.0
3	*Sitaphal*	277	30	83	1000	83,000	95.0
4	*Ber*	156	45	70	1000	70,000	87.0
5	*Rayan*	100	20	20	2500	50,000	92.0
6	*Jamun*	100	50	50	2500	125,000	45.0
7	*Pilu*	156	10	15	1500	22,500	55.0
8	*Ker*	400	10	40	2000	80,000	30.0
9	*Aloe vera*	33000	2 kg leaves	660	200	1,32,000	20.0
10	*Kachri*	-	-	50	500	25,000	40.0
11	*Khimp*	-	-	30	1000	30,000	25.0
12	*Khejri* pods	100	25	25	2000	50,00	40.0
13	*Phog*	400	12	48	500	24,000	12.0
14	*Bael*	100	50	50	1500	75,000	22.0
15	Tamarind	100	80	80	1200	96,000	70.0

Table 4. Frequency of awareness about processed/value added products of underutilized fruits and vegetables in tribal women.

S.N.	Name of processed products	Name of underutilized fruits and vegetables	Frequency of awareness (n= 100)
1	Jam	Jamun, *karonda*, *aonla* , tamarind, *sitaphal*, *bael*, *ber* , mulberry, wood apple etc.	7.0
2	Jelly	Tamarind, *jamun*, *karonda* etc.	3.0
3	Preserve	*Ber, aonla, bael, ker, sangari, karonda* etc.	1.0
4	Candy	Aonla, ber, karonda, datepalm, tamarind etc.	7.0
5	Glazed fruits	Tamarind, *ber, aonla* etc.	0.0
6	Juice/ beverage /squash	Tamarind, *bael*, *jamun, karonda*, *phalsa*, *ber, aonla*, pomegranate, mulberry, wood apple etc.	15.0
7	Wine	Mahuva, wild apricot, date palm, *karonda*, *ber*, Indian fig etc.	10.0
8	Chutney	*Karonda*, tamarind, *ker, aonla* , wood apple etc	45.0
9	Sauce	*Karonda*, tamarind, wood apple, pomegranate	5.0
10	Pickle	*Aonla, karonda, ker, lasoda, sangari, kachri, khimp* , immature mango, *ber,* tamarind etc.	60.0
11	Dehydration	*Bael, karonda, ker, phalsa, ber, kachari, sangari, khimp* , mulberry, date palm, *lasoda*, tamarind, *aonla*, custard apple etc.	85.0
12	Frozen puree	Tamarind, *bael, karonda, ker, phalsa* , tamarind, custard apple etc.	0.0
13	Canning	*Ber, aonla, jamun, ker* etc.	2.0
14	Confectionary	*Aonla*, tamarind, immature mango etc.	0.0

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References

Anonymous, 2010. Baseline survey of nutritional status of tribals of Sirohi district of Rajasthan. Krishi Vigyan Kendra, Sirohi, pp 13-15.

Anonymous, 2011. Baseline survey about utilization and future prospects of underutilized fruits available in Sirohi district of Rajasthan. Krishi Vigyan Kendra, Sirohi, pp 14-20.

Arora, R.K. 1998. Genetic resources of native tropical fruits in Asia: Diversity, distribution and IPGRI's emphasis on their conservation and use. In: Proc. IPGRI-ICAR-UTFANET Regional training course on the conservation and use of germplasm of tropical fruits in Asia. Bangalore, India, 18-31 May 1997, (Arora R.K. and V. Ramanatha Rao (eds.), Tropical fruits in Asia: Diversity, Maintenance, Conservation and Use, pp 35-40.

Azam-Ali, S. 2003. Assessment of the current status of post harvest handling, processing and marketing of underutilized tropical fruits in Bangladesh, India, Nepal, Sri Lanka and Vietnam, International Centre for Underutilized Crops, University of Southampton, pp 100-105.

Chundawat, B.S. 2003. Constraints in the cultivation of underexploited horticultural crops. In: Proceeding of winter school on "Exploitation of underutilized horticultural crops" at MPUAT, Udaipur, pp 233-234.

Deepti, A., Madhu, G., Agrawal, R.P. 2007. Oral intervention of *Aloe vera* juice on glycemic control and lipid profile in Type-2 diabetes. In: Proceeding of 13th Annual Conference Indian Society of Parental Entral Nutrition, AIIMS, New Delhi, pp 45-60.

Gajanana, T.M., Gowda, I.N.D. and Reddy, B.M.C. 2010. Exploring market potential and developing linkages-A case of underutilized fruit products in India. *Agricultural Economics Research Review*, 23: 437-443.

Goldberg, G. 2003. Plants: Diet and Health. In: The report of a British Nutrition Foundation Task Force. Blackwell Science, Oxford U.K., pp 347-350.

Gopalan, C., Ramashastri, B.V., Balasubramanian, S.C., Rao, N.B.S., Deosthale, Y.G. and Pant, K.C. 1989. Nutritive value of Indian Foods, (National Institute of Nutrition, ICMR Hyderabad).

Goyal, M. and Sharma, S. K. 2006. Prospects and dimensions for utilization of Arid Foods. Yash Publishing House, Bikaner, pp. 101-103.

Goyal, M. and Sharma, S. K. 2009. Traditional wisdom and value addition prospects of arid foods of desert region of North West India. *Indian J. of Traditional Knowledge*, 8: 581-585.

Hyson, D. 2002. The health benefits of fruits and vegetables. A scientific overview for health professionals. Produce for better Health Foundation, Wilmington DE, 20-45.

Kiradoo, V. and Goyal, M. 2005. Processing and shelf life study of *Ber* (*Ziziphus manuritiana*) Products, In: Proceeding of 37th Annual Meeting, (National Institute of Nutrition, Nutrition Society of India, Hyderabad).

Nandal, U. and Bhardwaj, R.L. 2012. Aloe vera: A novel source of nutrition and medicine- A Review. *Annals of Agri -Bio Research*, 17: 128-138.

Nandal, U. and Bhardwaj, R. L. 2013a. Role of underutilized fruit in nutritional and economical security of tribal's- A review. *Critical Reviews in Food Science and Nutrition*, 54:880890.

Nandal, U. and Bhardwaj, R.L. 2013b. Role of fruit juices in nutritional and health security. Indian *Food Packer*, 67 (2):113-122.

Pareek, O.P. and Samadia, D.K. 1998. A booklet on beneficial *Kachri*, (NRCAH, ICAR, Bikaner), pp 1-25.

Saroj, P.L. 2004. Aloe *(Aloe barbedensis)* prospects and dimensions for utilization of arid foods, Edited by Goyal, M. and Sharma, S.K., (Yash Publishing House, Bikaner).

Sen, N.L. 2003. Underutilised horticulture crops: Trends, challenge and opportunities in the 21st century. In: Proceeding of winter school on "Exploitation of underutilized horticultural crops" at MPUAT, Udaipur, 224-231.

Wargovich, M. J. 2000. Anticancer properties of fruits and vegetables. *Horticulture Science*, 35:573-575.

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Example varieties for DUS testing in muskmelon (*Cucumis melo* L.)

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Abstract

The present study was carried out for morphological characterization of thirteen reference varieties of muskmelon (*Cucumis melo* L.) to validate DUS testing guidelines using plant descriptors adopted from the DUS guidelines of PPV&FRA. Among 34 morphological characteristics studied, 19 were visually assessed and 15 were measured. Under results, no intra-varietal variation was observed for any of the visual characteristics examined. Further, the expression of characters in different varieties remained same for the three consecutive years confirming the uniformity and stability of the variety for visual characteristics. The varieties were grouped into different categories for each character based on 34 descriptors which may be used as reference varieties. The morphological characterization of extant varieties was completed to establish distinctness of the candidate variety from all other varieties to utilize these varieties as reference material for protection of other varieties under PPV&FR Act. A strict maintenance breeding of the reference varieties, including the example varieties, and use of alternate example varieties for conduct of DUS testing in muskmelon, if needed, are also suggested.

Key words: *DUS test, Example variety, PPV&FR Act, Muskmelon.*

Introduction

The "Protection of Plant Varieties and Farmers' Rights Act" (PPV&FR Act, 2001) was passed by the Government of India in 2001 with the objective of providing an effective system of protection against unlawful commercial exploitation of new plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants. The Protection of Plant Varieties and Farmers' Rights Authority, New Delhi established by the Government has the responsibility of implementing the provisions of this Act. The examination of a new plant variety for establishment of distinctiveness, uniformity and stability is known as "Distinctiveness, Uniformity and Stability (DUS) test". The success of DUS test trials rest on a set of general principles and specific guidelines. The evaluation of a variety for DUS generates a description of the variety using its relevant morpho-physiological characteristics which have been recognized universally as undisputed descriptors for characterization and DUS testing of plant varieties. The use of morphological descriptors in sequential order is useful and convenient to differentiate the varieties from each other. A variety is identified on the basis of a set of characteristics differing from other known varieties of that species. A guideline to conduct DUS test is required for describing a variety, assessing the level of uniformity of characteristics and the stability of expression of those in different growing locations over the years. For the purpose of an objective comparison and uniform evaluation by the DUS testing personnel, example varieties are identified and included in the Table of Characteristics to exemplify the characteristic state of expression. These example varieties must exhibit the specific state of a characteristic without any ambiguity. A strict maintenance breeding for genetic purity of all the example varieties is warranted for a valid DUS testing for proper implementation of PPV&FR Act (Chakrabarty *et al.*, 2012). In India, the great variability exists in muskmelon genotypes and the true character expression in the example varieties assume a greater significance under PPV&FR Act, 2001 for their protection on a set of relevant characteristics prescribed in the 'Minimal Descriptors of Vegetable crops' for muskmelon (Srivastava *et al.*, 2001). Therefore, the present study carried out with the objective to 'validate DUS testing guidelines of the

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example varieties of muskmelon for the states of expression of various characteristics'.

Material and Methods

The study material comprised genetically pure seed of 13 extant varieties of muskmelon (*Cucumis melo* L.) *viz*., Arka Jeet, Arka Rajhans, MHY-3, MHY-5, RM-43, RM-50, Durgapura Madhu, Kashi Madhu, Pusa Madhuras, Pusa Sharbati, GMM-3, Punjab Sunehri and Hara Madhu. The seeds of all extant varieties were sown with five rows of 5.6m length keeping a row to row and plant to plant spacing of 2.5m and 0.8m respectively in Randomized Block Design replicated thrice. The experiments were carried out at three locations namely Central Institute for Arid Horticulture (CIAH), Bikaner (Rajasthan), Indian Institute of Vegetable Research (IIVR), Varanasi (UP) and Indian Institute of Horticultural Research (IIHR), Bengaluru (Karnataka) for three consecutive years from 2011 to 2013 during summer season. All recommended package of practices were followed during three consecutive years.

All cultivars under study were evaluated for 34 DUS characters at specified stage of crop growth period when characters under study had full expression following the guidelines of IPGRI, 1988, Srivastava *et al.*, 2001 and UPOV, 2006. The oobservations for the assessment of distinctiveness and stability were made on 10 plants or parts of plants from each replication selected randomly. The assessment of uniformity of characteristics in the plot as a whole was done visually by a single observation of a group of plants or parts of plants. The stages of observations were as follows.

I. Observations on the cotyledon were made just before the development of the first true leaf.

ii. All observations on the leaf were recorded on fully developed but not old leaves, preferably between the 5th and 8th node when the plant had at least one fruit set.

iii. All observations on the fruit traits were made on 1st or 2nd well developed mature fruit.

iv. All observations on the ovary were recorded on the day of anthesis.

v. All observations on width were recorded at the maximum point of width of the part concerned.

vi. All observations on the seeds were made on fully developed, matured and dry seeds, after washing and drying.

The type of assessment of characteristics indicated in Table 1 is as follows:

MG: Measurement by a single observation of a group of plants or parts of plants

MS: Measurement of a number of individual plants or parts of plants.

VG: Visual assessment by a single observation of a group of plants or parts of plants.

VS: Visual assessment by observations of individual plants or parts of plants.

Results and Discussion

Among the 13 muskmelon varieties, considerable variation was observed for all the important characters under study. The states of expression of a particular trait along with example varieties of muskmelon are depicted in Table 1.

Table 1. Example varieties validated for the state of the characteristics

S. No.	Characteristics	State of expression	Example varieties	Type of assessment
1.	Cotyledon: length (cm)	Short (<2.75)	Punjab Sunehri	MS
		Medium (2.75-3.25)	Arka Jeet	
		Long (>3.25)	RM-50, Pusa Madhuras	
2.	Cotyledon: width (cm)	Narrow (<1.5)	Kashi Madhu, Durgapura Madhu	MS
		Medium (1.5-1.75)	GMM-3, RM-43	
		Broad (>1.75)	Pusa Madhuras	
3.	Leaf blade: length (cm)	Short (<8)	RM-43	MS
		Medium (8-10)	Kashi Madhu	
		Long (>10)	MHY-3, Durgapura Madhu	
4.	Leaf blade: width (cm)	Narrow (<11)	GMM-3, RM-43	MS
		Medium (11-13)	Kashi Madhu	
		Broad (>13)	Pusa Madhuras	

5.	Leaf blade: depth of lobes (depth of terminal lobe)	Weak	MHY-3	VG
		Medium	GMM-3	
		Strong	RM-50	
6.	Leaf blade: length of terminal lobe (cm)	Short (<2.5)	-	MS
		Medium (2.5-4.5)	Kashi Madhu	
		Long (>4.5)	RM-50	
7.	Leaf blade: dentation of margin	Weak	RM- 43	VG
		Strong	Kashi Madhu, RM-50	
8.	Leaf blade: petiole length (cm)	Short (<7)	RM-43, Durgapura Madhu	MS
		Medium (7-9)	Pusa Madhuras, MHY - 5	
		Long (>9)	RM-50, Hara Madhu	
9.	Appearance of first perfect/ pistillate flower in 50% plants from date of sowing (days)	Early (<45)	Durgapura Madhu	MG
		Medium (45-50)	MHY-3, RM -43, Kashi Madhu	
		Late (>50)	-	
10. (*)	Sex expression (at full flowering)	Monoecious	-	VG
		Andromonoecious	Kashi Madhu, Pusa Madhuras, Hara Madhu, Durgapura Madhu	
		Others	-	
11.	Male sterility	Absent	Kashi Madhu, Pusa Madhuras, Hara Madhu, Durgapura Madhu	VG
		Present	-	
12.	Ovary: length (cm)	Short (<1)	Punjab Sunehri	MS
		Medium (1-1.5)	MHY-5	
		Long (>1.5)	Durgapura Madhu, RM 50	
13.	Ovary: width (cm)	Narrow (<0.6)	Kashi Madhu	MS
		Medium (0.6-0.8)	Hara Madhu	
		Broad (>0.8)	MHY-5	
14.	Ovary: pubescence	Sparse	Arka Jeet	VG
		Dense	Kashi Madhu	
15.	Fruit: length (cm)	Short (<10)	Arka Jeet	MG
		Medium (10-15)	Pusa Madhuras	
		Long (>15)	Durgapura Madhu	
16.	Fruit: diameter (cm)	Narrow (<9)	RM-43, Arka Jeet	MG
		Medium (9-12)	RM-50	
		Broad (>12)	GMM-3, Kashi Madhu	
17. (*)	Fruit: shape in longitudinal section	Ovate	MHY-5	VG
		Oval	-	
		Elongated globe	Arka Rajhans	
		Round	-	
		Oblate (Flat globe)	GMM-3, Kashi Madhu	
		Obovate	Durgapura Madhu	
		Cylindrical	-	

18. (*)	Fruit: rind colour	Creamy white	-	VG
		Yellow	Kashi Madhu	
		Yellow Green	Durgapura Madhu	
		Orange	Arka Jeet	
		Others	-	
19.	Fruit: patches	Absent	Arka Jeet, MHY-3	VG
		Present	Kashi Madhu, GMM-3	
20.	Fruit: peduncle at maturity	Slipable	Kashi Madhu	VG
		Non-slipable	Hara Madhu	
21.	Fruit: shape at peduncle end	Pointed	Durgapura Madhu	VG
		Rounded	Hara Madhu, Pusa Madhuras	
		Truncate	Kashi Madhu	
22.	Fruit: shape at blossom end	Pointed	Durgapura Madhu	VG
		Intermediate	-	
		Truncate	Kashi Madhu	
23.	Fruit: diamete r of blossom end scar (cm)	Small (<1)	Arka Jeet, Durgapura Madhu	MS
		Medium (1-2)	Pusa Madhuras	
		Large (>2)	Kashi Madhu	
24.	Fruit: surface	Smooth	Arka Jeet, MHY-3	VG
		Grooved	RM-43, Kashi Madhu	
25. (*)	Fruit: sutures	Absent	Arka Jeet, MHY-3	VG
		Present	Hara Madhu, Kashi Madhu	
26.	Fruit: suture colour	Creamy	Arka Rajhans	VG
		Green	Kashi Madhu, Hara Madhu	
		Others	-	
27. (*)	Fruit: surface netting	Absent	Arka Jeet, MHY-5	VG
		Moderate	RM-50, Punjab Sunehri	
		Dense	-	
28.	Fruit: flesh thickness at position of maxim um fruit diameter (cm)	Thin (<2)	Arka Jeet	MS
		Medium (2-3)	MHY-5	
		Thick (>3)	GMM-3	
29.(*)	Fruit: flesh colour	Creamish white	Arka Jeet	VG
		Grey orange	GMM-3	
		Yellowish green	Durgapura Madhu	
		Green	Hara Madhu	
		Orange	Kashi Madhu	
30.	Fruit: flesh texture	Mealy	Hara Madhu	VS
		Intermediate	-	
		Crispy	Kashi Madhu	
31.	Fruit: flavour	Mild	Arka Rajhans	VG
		Medium	Kashi Madhu, Durgapura Madhu	
		Strong	-	

32.	Seed: length (cm)	Short (<1)	Kashi Madhu, Hara Madhu	MS
		Long (>1)	Pusa Madhuras	
33.	Seed: width (cm)	Narrow (<0.4)	Durgapura Madhu	MS
		Broad (>0.4)	Pusa Madhuras	
34.	Seed: colour	Creamy white	Kashi Madhu, Arka Jeet	VG
		Yellowish	Durgapura Madhu, Hara Madhu	

(*) Grouping trait

The example varieties are expected to be highly uniform and stable in expression of the characteristics at a particular state. It is applicable for the qualitative characteristics which are least influenced by environmental conditions. The number of example varieties should be less in number to reduce cost of DUS testing and for easy maintenance of the set of example varieties which involve high cost due to cross pollination of muskmelon. More than one example variety for a state of expression of a characteristic is desirable in case the variety deteriorates for the given characteristic and/or it does not express in some growing condition and areas. The reference varieties are of utmost importance in DUS testing for comparing characteristic states of the candidate varieties. Any chance of impurity of seed in the set of reference varieties would lead to wrong or invalid DUS test result. Therefore, maintenance of genetic purity to the highest level in the reference varieties is a basic requirement for the successful conduct of DUS test. It is also suggested that a periodical review of all example varieties be undertaken at all the DUS test centres to validate the set of example varieties.

The varieties characterized for DUS were grouped into different categories for each character which could be used as reference varieties. These varieties can be used in the varietal improvement programme of muskmelon for desirable traits. Genetic improvement of desirable varieties can also be done through gene combinations from unadapted sources having resistance against biotic/ abiotic stresses. These test guidelines apply to all varieties, hybrids and parental lines of muskmelon (*Cucumis melo* L.) including *C. melo* L. subsp. *cantalupensis* and *C. melo* L. subsp. *reticulatus*. It is concluded that the developed DUS descriptors can be effectively used for identification and grouping of varieties and comparing candidate varieties for registration under PPV&FR Act.

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References

Anonymous. 2007. Specific DUS test guidelines for twelve notified crops-Rice (*Oryza sativa* L.). *Plant Variety Journal of India*, 1: 15169.

Chakrabarty, S.K., Joshi, M.A., Singh, Y. and Dadlani, M. 2012. Example varieties for DUS testing of rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences*, 82(12): 1011-1015.

Choudhary, B.R., Kumar, S. and Sharma S.K. 2012. Genetic variability and inter-trait association in muskmelon (*Cucumis melo* L.) under arid conditions. *Crop Improvement*, Special Issue: 473-474.

IPGRI. 2003. Descriptors for Melon (*Cucumis melo* L.). International Plant Genetic Resources Institute, Rome, Italy.

PPV&FR Act. 2001. Protection of Plant Varieties and Farmers' Rights Act (No. 53 of 2001). Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, Krishi Bhavan, New Delhi.

Singh, B., Chaubey, T., Upadhyay, D.K., Jha, A. and Pandey, S.D. 2012. Morphological characterization for DUS testing of cabbage (*Brassica oleracea* var. *capitata* L.) cultivars. *Progressive Horticulture*, 44(1): 170-173.

Sood, S., Sood, R. and Vidyasagar. 2011. Morphological characterization of bell pepper (*Capsicum annuum* var. *grossum*) genotypes and their application for distinctness, uniformity and stability testing. *Indian Journal of Agricultural Sciences*, 81(3): 240-

246.

Srivastava, V., Mahajan, R.K., Gangopadhyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal Descriptors of Agri-Horticultural Crops- Part II. Vegetable Crops*. PB Mission Leader National Agricultural Technology Project on Plant Biodiversity (NATP-PB) and NBPGR, New Delhi. Monnto Publishing House, New Delhi. 52.

UPOV. 2006. Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability, Melon (*Cucumis melo* L.). pp. 1-58. TG/104/5-Add., Geneva. www.upov.int /edocs/t gdocs/ en/ tg104.doc.

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Effect of soaking time of cow urine and rooting media on seed germination of Kagzi lime (*Citrus aurantifolia* Swingle)

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Abstract

The experiment was conducted to study the effect of soaking time of cow urine and rooting media on seed germination of Kagzi lime. Twenty-one treatment combinations consisting of three main plot treatments of cow urine C_o (seed soaked in distilled water for 12 hrs.), C_1 (Seed soaked in 10% cow urine for 24 hrs.) and C_2 (Seed soaked in 10% cow urine for 12 hrs.). Seven sub plot treatments of rooting media M_o (only soil), M_1 [soil + FYM (3:1)], M_2 (Soil + vermicompost (3:1)], M_3 [soil + FYM (1:1)], M_4 [soil + vermicompost (1:1)], M_5 [soil + FYM (1:3)] and M_6 [soil + vermicompost (1:3)] were replicated thrice in split plot design. The observations were recorded replication wise by selecting five random plants for seven parameters, which includes seed germination and seedling growth. The results revealed that minimum days taken to start germination, taken to 50% germination and maximum percentage of germination was observed in (C_1) seed soaked in 10% cow urine for 24 hrs. Similarly, the treatment C_1 significantly increased the growth characters *viz*., number of roots/seedling, height of seedling, number of leaves/seedling and leaf area index. As regards the rooting media, M_6 significantly influences all the parameters. It was also superior to rest of the rooting media. Among the interactions of cow urine and rooting media, no any interaction was found significantly superior, but C_1M_6 treatment combination gave superior results over remaining treatment interactions.

Key words: *Cow urine, rooting media, kagzi lime, F.Y.M, vermicompost, germination*

Introduction

Kagzi lime (*Citrus aurantifolia* Swingle) is one of the most important tropical and subtropical fruit after than Mandarin and Sweet orange of rutaceae family. In India, Kagzi lime occupies, 2,58,000 hectare area with the annual production of 2.569 million tonnes (Anonymous, 2014). Due to, which there is tremendous scope of this crop to capture the market throughout the year. It is successfully grown in state of Andhra Pradesh, Maharastra, Tamil Nadu and Madhya Pradesh. In M.P., it is mostly grown as commercial crop in east and west Niwar and some part of Malwa and Mahakaushal region.

Lime is usually propagated by seeds and maximum germination can be obtained by sowing of freshly extracted seed up to 2 days only, which are polyembryonic in nature. The seedlings are almost true to the type and free from virus infection. Raising seedlings of Kagzi lime is often associated with many problems. Under field condition, it is common observation that the seed germination is poor and secondly the seedling growth is slow. The rate of mortality is also very high due to which it is difficult to raise a large population. Plant takes about 1½ to 2 years duration for planting in orchards due to slow growth rate of seedling (Singh *et.al*., 2004). There are some difficulties in the cultivation of the crop and the present investigation has been undertaken with an intense urged to overcome them.

In recent year, lots of research work has been done on different aspects of growth regulators. The important aspects among them are the most appropriate growth regulators for encouraging germination and further growth. To overcome this crisis some alternatative for growth regulator should be brought up which may be as efficient as growth regulators, easy to access and cheap. This has diverted the attention once again towards the chemical, cane sugar, cow urine, which were in use as a growth regulators. Cow urine proving feasible may

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bring a breakthrough in the present context as it is free of cost and easily available. Cow urine contains nitrogen, sulphur, ammonia, copper, iron, urea, uric acid, phosphate, sodium, potassium, manganese, carbolic calcium, salt, vitamins, lactose, enzyme, water, creatinin, aurum hydroxide etc. (Sankaranarayana *et.al*., 1994)**.** In view of above facts, the experiment was conducted to study the effect of soaking time of cow urine and rooting media on seed germination and seedling growth of Kagzi lime .

Materials and Methods

The experiment was conducted at Fruit Research Station, Imalia, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). In this experiment the response of cow urine and different rooting media was evaluated for germination and vegetative growth of Kagzi lime seeds. The experiment was laid out in split plot design with three replications. For rooting media, soil, FYM and Vermicompost are obtained. Polybags of 20 cm length and 30 cm diameter with 200 gauge thickness were used. Fully ripened and healthy fruits of uniform size were taken and seeds were extracted carefully. Extracted seeds were washed in running water and dried under shade condition. Cow urine was taken from desi breed at morning time.Ten treatments combination consisting of three main plot treatments of cow urine C_0 (seed soaked in distilled water for 12 hrs.), C_1 (Seed soaked in 10% cow urine for 24 hrs.), and C_2 (Seed soaked in 10% cow urine for 12 hrs.) and seven sub plot treatments of rooting media M_0 (only soil), M_1 [soil + FYM (3:1)], M_2 (Soil + vermicompost (3:1)], M_3 [soil + FYM (1:1)], M_4 [soil + vermicompost (1:1)], M_5 [soil + FYM (1:3)] and M_6 [soil + vermicompost (1:3)] were replicated thrice in split plot design.

Three treated seeds were sowed at 1-2 cm depth in polythene bags which were consisted in different rooting media. After germination only one seedling was retained, other was removed. Intermittent hand weeding was done as and when needed. Roger (0.2%) was sprayed thrice i.e. after emergence of seedling, one month after emergence and two months after emergence. 1% urea was sprayed twice on the seedling once 60 days after sowing. The standard horticultural practices were adopted for raising the seedlings. Parameters regarding seed germination and growth were recorded *viz.*, Days taken to start germination, Days taken to 50% germination, Percentage of germination, Height of seedling (cm.) Number of leaves/seedling, Leaf area index (cm^2) and number of roots per seedling. The data collected during the investigation were analyzed statistical by the method of "Analysis of variance". The significance of various treatments was judged as suggested by Gomez and Gomez (1984) applying "F" Test.

Results and Discussion

Days taken to start germination

The data taken pertaining to days to start germination was recorded and statisticaliy analyzed. A perusal of data presented in Table 1 indicates that treatment of cow urine and rooting media significantly decreased the days taken to start germination. Under this experiment, C_1 (seed soaked in 10% cow urine for 24 hrs.) recorded significantly minimum days taken to start germination after sowing (13.33) followed by C_2 (seed soaked in 10% cow urine for 12 hrs.), which recorded 13.76. C_0 (control) taken significantly maximum days to start germination, which at par with C_2. As regards the rooting media, M_6 [soil + vermicompost (1: 3)] was recorded the significantly minimum days taken to start germination (12.55) followed by M_5 [soil + FYM (1: 1)] and M_4 [soil vermicompost (1:1)] which recorded 13.11 and 13.44 respectively and the treatment did not defer significantly each other. M_0 (only soil) showed significantly maximum days taken to start germination, which is at par with M1. It is emphasized from the table that interaction of cow urine and rooting media are found non significant, however minimum days taken to start germination 11.66 was noted under the combination of C_1M_6 [seed soaked in 10% cow urine for 24 hrs and soil + vermicompost (1:3)]. The results are inconformity to the results as reported by Rajwar *et al.,* (2007) in case of wild Ber (*Zizyphus rotundifolia).*

Days taken to 50% germination

The tabulated result clearly shows that treatments of cow urine and rooting media significantly influence the days taken to 50% germination (Table 2). It indicates that the cow urine C_1 (seed soaked in 10% cow urine for 24 hrs.) recorded significantly minimum days taken to 50% germination (18.42) after sowing followed by Cow urine C_2 (seed soaked in 10% cow urine for 12 hrs.), which recorded 19.85 days taken to 50% germination, while C_0 (control) recorded significantly maximum (20.76) days taken to 50% germination. Among the rooting media, M_6 [soil + vermicompost (1:3)] taken significantly minimum days to 50% germination (16.55), followed by M_5 [soil + FYM (1:3)]. The probable reason may be that the medium M_6 creates sufficient porus space, better drainage of water and sufficient aeration for better rooting of seed or may be due to increased physiological activities of seed, essential for cell division, cell enlargement or both. These results are in conformity with the result of Deol and Uppul, (1990). M_0 (only soil) recorded the significantly maximum days taken to 50% germination (23.00), which is at par with M_1 [soil + FYM (3:1)]. As regard interaction, the interaction of cow urine and media are found non

significant, however, minimum days taken to 50% germination (15.00) was recorded under the combination of C_1M_6 [seed soaked in 10% cow urine for 24 hrs and soil + vermicompost (1:3)]. Similar findings have already been reported by Bertocci *et al.*, (1997) in germination response of Papaya.

Percentage of germination

Pertaining to percentage of germination was recorded at 30 days after sowing and data was statisticalil analyzed. The results elucidated in Table 3 indicates that the treatment of cow urine and rooting media significantly increased the percentage of germination. It is clear from the statistical data that maximum (67.29) percentage of germination was observed under C_1 (seed soaked in 10% cow urine for 24 hrs.) at 30 days after sowing followed by C_2 (seed soaked in 10% cow urine for 12 hrs.), which recorded 63.4 but not significant better than control. Increase percentage of germination due to cow urine may be due to fact that perhaps cow urine activated the embryos and estimated the release of enzyme in endosperm, which in turn liberate the food substances required by quick growing embryo and seedling. These findings are in agreement with results of Pandey and Singh (2000) in germination of guava seeds. In case of rooting media, M_6 [soil + vermicompost (1:3)] recorded significantly maximum (80.70) percentage of germination followed by M_5 [soil + FYM (1:3)] and M_4 [soil + vermicompost (1:1)], which recorded 74.07 and 72.22, respectively. M_0 (control) showed significantly minimum percentage of germination 45.92 followed by M_1 [soil + FYM (3:1)] 52.21. However, maximum germination percentage (84.44) was recorded under the combination of C_1M_6 [seed soaked in 10% cow urine for 24 hrs and soil + vermicompost (1:3)]. More or less similar results have been reported by Singh, *et al.* (2000).

Height of seedlings

An effect of application of cow urine and

Table 1. Effect of soaking time of cow urine and rooting media on days taken to start germination of Kagzi lime.

Treatments	Media							Mean
Cow urine	M_0	M_1	M_2	M_3	M_4	M_5	M_6	
C_0	16.33	15.66	15.00	14.66	14.00	13.66	13.33	14.66
C_1	15.00	13.66	13.66	13.33	13.00	12.66	11.66	13.33
C_2	15.33	14.66	13.66	13.66	13.00	13.00	12.66	13.76
Mean	15.55	14.77	14.11	13.88	13.44	13.11	12.55	

Treatments	S.Em±	C.D at 5% level
C (cow urine)	0.24	0.98
M (media)	0.36	1.03
CxM (interaction)	0.67	NS

Table 2. Effect of soaking time of cow urine and rooting media on days taken to 50% germination of Kagzi lime.

Treatments	Media							Mean
Cow urine	M_0	M_1	M_2	M_3	M_4	M_5	M_6	
C_0	24.00	22.66	21.66	20.66	19.33	19.00	18.00	20.76
C_1	22.00	20.66	19.33	18.00	17.33	16.66	15.00	18.42
C_2	23.00	21.00	20.66	20.33	18.66	18.66	16.66	19.85
Mean	23.00	21.44	20.55	19.66	18.44	18.11	16.55	

Treatments	S.Em±	C.D at 5% level
C (cow urine)	0.150	0.57
M (media)	0.60	1.70
CxM (interaction)	1.031	N.S

Table 3. Effect of soaking time of cow urine and rooting media on percentage of germination of Kagzi lime.

Treatments	Media							Mean
Cow urine	M_0	M_1	M_2	M_3	M_4	M_5	M_6	
C_0	42.21	47.77	54.44	59.99	70.00	71.10	77.66	60.45
C_1	49.99	56.66	62.21	66.66	74.44	76.66	84.44	67.29
C_2	45.55	52.21	56.66	63.33	72.22	74.44	79.99	63.40
Mean	45.92	52.21	57.77	63.33	72.22	74.07	80.70	

Treatments	S.Em±	C.D at 5% level
C (cow urine)	0.94	3.70
M (media)	1.88	5.40
CxM (interaction)	3.26	NS

rooting media significantly influenced the vegetative growth of plant. The data on the height of seedlings were recorded at 60, 75, 90, 105, 120 and 135 days after sowing (Table 4). Among the different concentrations of cow urine, C_1 (seed soaked in 10% cow urine for 24 hrs.) recorded the significantly higher plant height (6.45, 7.45, 8.60, 9.55, 10.51 and 11.76 cm at 60, 75, 90, 105, 120 and 135 days after sowing respectively), followed by C_2 (seed soaked in 10% cow urine for 12 hrs.) which recorded 5.94, 6.98, 8.00, 8.93, 9.80 and 10.82 cm at various stages respectively.

This may be due to Cow urine seems to affect physiochemical characteristics of seed and thus give positive response to germination, emergence, vigour and plant height of seedlings. Similar results were also recorded by Parameswari *et al.* (2001) in tamarind seed. The table 4 further indicates that M_6 [soil + vermicompost (1:3)] recorded significantly higher plant height (8.05, 9.17, 10.41, 11.53, 12.56 and 13.93 cm at various stages,respectively), followed by M_4 [soil + vermicompost (1:1)] might be due to vermicompost which had supplied available plant nutrients and brought about a favorable soil environment, which ultimately increased the nutrient and water holding capacity of soil. It is much closed related with Kumar and Satyawati (2007) in *Jatropha curcus*. Whereas, M_0 (control) reported significantly minimum height of seedling (4.08, 4.69, 5.39, 5.88, 6.30, and 7.05) at various stages, respectively followed by M_1 [soil + FYM 3:1)].

Number of leaves/seedling

The data pertaining to number of leaves/ seedling was recorded after 60 to 135 days after sowing

Table 4. Effect of soaking time of cow urine and rooting media on height of seedling at various stages of Kagzi lime.

Treatments	Days after sowing					
Cow urine	60	75	90	105	120	135
C_0	5.43	6.38	7.33	8.26	9.11	9.85
C_1	6.45	7.45	8.60	9.55	10.51	11.76
C_2	5.95	6.98	8.00	8.93	9.80	10.82
SEM ±	0.04	0.04	0.05	0.05	0.07	0.13
C.D at 5% level	0.17	0.18	0.21	0.22	0.25	0.52
Media						
M_0	4.08	4.69	5.39	5.88	6.30	7.05
M_1	5.06	5.95	6.96	7.85	8.71	9.61
M_2	5.43	6.48	7.50	8.45	9.29	10.24
M_3	5.64	6.88	7.89	8.91	9.85	10.62
M_4	6.84	7.85	9.01	10.03	11.11	12.24
M_5	6.50	7.54	8.70	9.76	10.83	12.00
M_6	8.05	9.17	10.41	11.53	12.56	13.93
SEM ±	0.14	0.13	0.14	0.14	0.15	0.23
C.D at 5% level	0.39	0.39	0.41	0.40	0.43	0.65

at a regular interval of 15 days under different treatments of cow urine and rooting media. Among the cow urine, C_1 (seed soaked in cow urine for 24 hrs.) and among rooting media, M_6 [soil + vermicompost (1:3)] produced the maximum number of leaves/seedling at all the successive stages of seedling growth. It is apparent from Table 5 that cow urine C_1 produced significantly more number of leaves seeding 8.30, 11.39, 13.94, 15.84, 18.51 and 21.51 at 60, 75, 90, 105, 120 and 135 days after sowing respectively, followed by C_2. While C_0 (control) produced significantly minimum number of leaves *i.e.,* 6.83, 9.31, 11.30, 13.34, 15.25 and 17.60 at various stage, respectively sowing. Shaban (2010) who reported that the probable reason of enhances more number of leaves per plant in cow urine treated seed that it might have resulted in more production of photosynthets and their translocation through phloem to the whole plant might be responsible for improving the vegetable growth which finally helps in increase number of leaves per seedling. It further reveals the rooting media, M_6 [soil + vermicompost (1:3)] produced the significantly maximum number of leaves/ Seedling 9.27, 13.50, 17.27, 20.83, 24.43 and 28.38 at various stages, respectively, followed by rest of the rooting media. These results are in consonance with the findings as reported by Verma and Prasad (2005). Among the interactions, the interaction between cow urine and rooting media not produced significantly higher number of leaves/seeding.

Leaf area index

As far as the leaf area index (LAI) is concerned, maximum (2.55 cm^2) LAI was found under C_1 (seed soaked in 10% cow urine for 24 hrs.) at 135 days after sowing. The value of LAI increased due to maximum length and width of leaves produced by synergistic effect of cow urine and their movement increased the synthesis of biomass and accumulation of photosynthates that is responsible for higher leaf area index. The improvement of leaf area index in cow urine treated seeds has been reported by Shirol *et al.* (2005) in Khirnee seeds. Among the rooting media, M_6 [soil + vermicompost (1:3)] encouraged significantly larger leaf area index 1.018, 1.513, 1.990, 2.452, 2.828 and 3.227 cm^2 at 60, 75, 90, 105, 120 and 135 days after sowing, respectively (Table 6). It was superior to rest of the rooting media. Whereas, M_0 (only soil) showed significantly minimun leaf area index at various stages. It is possible due to rapid multiplication of new cells in higher ratio of vermicompost rooting media which helped increasing in term of length and width of leaves as reported by Norman *et al.*,(2003). Vermicopost contains macro and micro nutrients, enzymes, pro vitamins and growth hormones which are very effective in producing the superior length and width of leaves. Similar results were reported by Vijayananthan and Kumar (2006).

Number of roots/ seedling

The number of roots/seedling was measured at 60 and 135 days after seed sowing. The statistical

Table 5. Effect of soaking time of cow urine and rooting media on number of leaves/seedling at various stages of Kagzi lime.

Treatment	Days after sowing					
Cow urine	60	75	90	105	120	135
C_0	6.83	9.31	11.30	13.24	15.25	17.60
C_1	8.30	11.39	13.94	15.84	18.51	21.51
C_2	7.54	10.39	12.61	14.80	16.90	19.67
SEM ±	0.093	0.115	0.20	0.20	0.22	0.19
C.D at 5% level	0.365	0.452	0.79	0.77	0.88	0.75
Media						
M_0	5.63	6.90	7.63	8.44	9.03	10.27
M_1	6.07	7.53	9.03	9.58	10.50	12.41
M_2	7.26	9.21	10.51	12.33	13.80	16.53
M_3	7.80	11.05	13.38	15.82	18.34	21.16
M_4	8.90	12.74	15.86	17.79	21.57	24.82
M_5	7.96	11.60	14.64	17.62	20.54	23.62
M_6	9.27	13.50	17.27	20.83	24.43	28.38
SEM ±	0.273	0.271	0.50	0.64	0.76	0.81
C.D at 5% level	0.783	1.066	1.42	1.83	1.93	2.32

Table 6. Effect of soaking time of cow urine and rooting media on leaf area index (cm^2) at various stages of Kagzi lime.

Treatments	Days after sowing					
Cow urine	60	75	90	105	120	135
C_0	0.773	1.081	1.362	1.623	1.866	2.161
C_1	0.922	1.288	1.600	1.914	2.208	2.551
C_2	0.844	1.185	1.500	1.773	1.989	2.355
SEM ±	0.023	0.013	0.023	0019	0.043	0.021
C.D at 5% level	0.093	0.051	0.092	0.076	0.172	0.083
Media						
M_0	0.516	0.685	0.831	0.930	1.063	1.190
M_1	0.716	0.960	1.222	1.357	1.531	1.725
M_2	0.837	1.126	1.355	1.567	1.769	2.008
M_3	0.887	1.243	1.495	1.887	2.182	2.512
M_4	0.992	1.419	1.873	2.220	2.527	3.010
M_5	0.958	1.348	1.678	1.990	2.249	2.810
M_6	1.018	1.513	1.990	2.452	2.828	3.227
SEM ±	0.045	0.042	0.057	0.066	0.087	0.089
C.D at 5% level	0.129	0.121	0.165	0.192	0.250	0.255

analysis of data (Table 7) revealed that the C_1 (seed soaked in 10% cow urine for 24 hrs.) induced the significantly maximum 9.77 and 29.02 number of roots/plant at 60 and 135 days after sowing, respectively. The minimum number of roots were noted under untreated treatment (C_0) at both stages, which is at par with C_2. This may be due to disinfectant action of cow urine, which might have avoided the basal portion of seed from decreasing and must have provided congenial environmental conditions for early initial of rooting. These findings are similar to the findings of Kumar *et al.*,(2012). In case of rooting media combination, the media M_6 [soil + vermicompost (1:3)] showed significantly the maximum 12.48 and 37.99 number of roots at both stages. Whereas, interaction of cow urine and rooting media are not significantly increase number of roots /plant at both stages of growth. The results of the present study are in consonance with the findings of Bisen *et al.*, (2010) who reported that the media M_6 creates sufficient porus space letting the excess water drain away, permitting adequate aeration for the better root length and number of roots/seedling. More or less similar results were also reported by Jain and Parmar (1993) and Arancon *et al.*, (2004) in strawberry.

Table 7. Effect of soaking time of cow urine and rooting media on number of roots/ seedling of Kagzi lime.

Treatments	Days after sowing	
Cow urine	60	135
C_0	7.96	23.95
C_1	9.7	29.02
C_2	8.78	26.42
SEM ±	0.23	0.25
C.D at 5% level	0.89	0.98
Media		
M_0	4.15	14.68
M_1	6.16	19.27
M_2	7.41	23.42
M_3	9.75	26.87
M_4	11.28	32.46
M_5	10.52	30.54
M_6	12.48	37.99
SEM ±	0.40	0.95
C.D at 5% level	1.15	2.73

References

Anonymous, 2014. 2nd Advance Estimate of Area and Production of Horticulture Crops, NHB, Gurgaon.

Arancon, N.Q., Edwards, C.A., Bierman, P., Welch C. and Metzger, J.D 2004. Influence of vermicompost on field strawberries: Effects on growth and Yields. *Bioresource Technology*, 93 (2):145-153.

Bisen, A., Pandey, S.K. and Mishra, S.P. 2010. Efficacy of bioregulators and rooting media on rooting and survival of air layers of guava. *Annals of Plant and Soil Research*, 12 (2):115-118.

Bertocci, F., Vecchio, V. and Casini, P. (1997). Effect of seed treatment on germination response of Papaya (*Carica papaya* L.). *Adv. Hort. Sci.*, 11:99-102.

Deol, L.S. and Uppul, D. K. 1990. Effect of different rooting media on rooting and growth hard wood and semi hard wood cutting of pomegrabate (*Punica granatum* L.). *Punjab Horti. J.*, 30(1-4): 140-144.

Gomez, K. A. and Gomez, A. A., 1984. Statistical procedures for agricultural research 2nd Ed., John Wiely and Sons, New York, NY.

Jain, P.K. Parmar, K.L. 1993. Response in hardwood cuttings of pomegranate (*Punica granatum* L.) treated with rooting media, IBA and Boran. *JNKVV, Res. J.*, 27 (10): 56-58.

Kumar, Ashwini and Sharma, Satyawati. 2007. Comparative study of effect of FYM and vermicompost on *Jatropha curcus* raised through cutting. In abstract, International Conference on Sustainable Agriculture for Food, Bio energy, Livelihood Security held at J.N.K.V.V, Jabalpur from 14-16, Feb. 40-41.

Kumar, Rajesh, Misra, K. K., Misra, D. S. and Brijwal, M. 2012. Seed germination of fruit crops: A Review. *Hort. Flora Research Spectrum*, 1(3): 199-207

Norman Q.A., Stephen, L., Clive, A. E. and Atiyeh, R. 2003. Effects of humic acids derived from cattle, food and paper waste vermicomposts on growth of green house plants. *Pedobiologia*, 47(5-6): 731-744.

Pandey, D. and Singh H.P.2000. Effect of seed pretreatment on promotion of germination in guava. *Ann. Agric. Res.*, 21:279-281.

Parameswari, K., Srimathi, P. and Malarkodi, K. 2001. Standardization of dormancy breaking treatment in tamarind (*Tamarindus indica* L.) *seed. Legume Research*, 24 (1) 60-62.

Rajwar,D.K., Shanker, R., Singh, S.K. and Bhagat, B.K. 2007. Seed germination and seedling growth of wild Ber (*Zizyphus rotundifolia* L.). *J. Res. Birsa Agric. Univ.*, 19:107-109.

Singh, D.K., Singh, B. and Sen, S.K. 2004.Role of pre-sowing seed treatment with different chemicals and seed sizes on the germination behavior and seedling growth of Ber (*Zizyphus mauritiana* L.).. *Env. and Eco.*, 22: 439-442.

Sankaranarayana, R.M., Kumar, Vijay and Rangasamy P. 1994. Cow urine ideal seed germination in Tamarinds, *Indian Hort. J.*, 38(4): 15.

Singh, R.R., Kaushik, J. C. and Singh, Jigar. 2000. Effect of soil media on germination shoot and root length and number of nodules of three nitrogen fixing tree species seedlings. *Indian Journal of Forestry*, 23(2): 157-159.

Shaban, A. E. A. 2010. Improving seed germination and seedling growth of some mango rootstocks. *American Eur Asian J. Agric. and Env. Sci.*, 7: 535-541.

Shirol, A.M., Hanamashetti, S.I., Kanamadi,V.C., Thammaiah, N. and Patil, S. 2005. Studies on pre-soaking, method and season of grafting of Sapota rootstock *Khirnee. Karnataka J. Agric. Sci.*, 18:96-100.

Verma, P. and Prasad, A. 2005. Vermicomposting: A potential technology for solid waste management. *Agrobios Newsletter*s, 4(5): 33-35.

Vijayananthan, K. and Kumar, M. G.2006. Vermiliquids: A better substitutes for synthetic hormones. *Agrobios Newsletters*, 4(10):8-9.

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Phenology, floral biology and pollination in bael varieties under rainfed semi-arid conditions of western India

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Abstract

The present paper deals with phenological events, flower biology, foraging behaviour of flower visitors, pollen germination (*in-vitro*) and stigma receptivity of different bael (*Aegle marmelos* Correa) varieties under rainfed hot semi-arid conditions of western India. Phenology of all the plants in terms of leaf initiation started from 1st week of May to 4th week of June, leaf fall initiation from 2nd week of April to 4th week of June. The inflorescence pattern was observed specific in each variety *i.e.*, axillary uniparous cyme, axillary biparous cyme, terminally axillary multiparous cyme. The peak period of flowering among all the varieties was early1st fortnight of June. Inkling of flower opening in different varieties started from 4.00 A.M. to 9.00 A. M. but peak period of anthesis was noticed between 5.00 to 7.45 A. M.. As soon as flowers open, different kinds of insects like honey bees, bugs, butterflies, ants, houseflies start visiting flowers during 6-9 P.M. in a large number to collect forage materials and help in pollination. Visually, the floral morphology of different variety appeared to be more or less similar, but the quantitative as well as qualitative characters of different floral organs were differed in terms of arrangement and number of petals and sepals. The number of flowers per inflorescence was recorded the maximum in Pant Shivani (24.67) followed by NB-16 (23.93) and Pant Sujata (21.24) and it was recorded the minimum in Pant Urvashi and CISHB-1 (6.97). A single flower of variety produced an average of 45.98 anthers being maximum in Pant Urvashi (61.23) and least was observed in Pant Aparna (36.67). Stigma receptivity was observed maximum at the day of anthesis in Pant Urvashi (68.53%) and one day after anthesis in NB-7 (14.37%) among all the varieties. All the varieties had pollen viability more than 95 % being highest in NB-7.

Key words : Beal, floral biology, pollilation.

Introduction

Bael (*Aegle marmelos* Correa) occupies an important place among the indigenous fruit of India not only because of its religious significance but also due to its high medicinal and nutritive values and ability to grow under aberrant agro-climatic conditions. It is considered to be one of the richest sources of riboflavin (Mukharjee and Ahmed, 1957) and known to provide lots of minerals and vitamins to diet (Barthakur and Arnolds, 1989). Owing to its hardy nature, bael can be grown successfully in wider range of habitats of arid, semi-arid to mesophytic conditions (Arya, 1986). Its cultivation can be done successfully in even alkaline and stony soils having pH range 5-10 (Jauhari and Singh, 1971, Ram and Singh, 2003, Srivastava and Singh, 2000). In western India, a wide range of genotypes of naturally grown trees is available contributing to wide genetic diversity in their morphological characters. In order to initiate any crop improvement programme, it would be imperative to generate information regarding growth and flowering behavior. Distinct changes in plants like flushing pattern, leaf defoliation, flowering and fruiting mainly determine phenological behaviour in trees.Van Schaik *et al.*, (1993) opined that the phenological events are not mutually independent; flowering may be partly or wholly dependent on leafing activity. Nevertheless, tree species with similar leaf phenology often differ in the timing of their flowering and fruiting (Seghieri *et al.*, 1995).The knowledge of floral biology, including pollination is prerequisite for any rational breeding programme and determination of extent of seed and fruit setting. Seeds and fruits are the economic products of more than 90% of flowering plants. Good fruit set and high crop yield generally depend on viable pollen grains. It is evident that fruit retention till maturity in bael is very low when compared to the number of flowers actually produced. However, the causes of low fruit production are uncertain, in part because many aspects of the reproductive biology of bael are not thoroughly studied. The purpose of the present study is to generate information by reporting on different bael varieties related to phenology, floral biology and pollination behavior, ?ower structure and development

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during the pre fertilization period, stigma receptivity, foraging behavior of insect visitations and the pollination mechanism.

Materials and Methods

The present investigation was carried out at Experimental Farm of the Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals, Gujarat during the year 2013-14. A total of twelve varieties *viz.*, CISH-B-1, CISH-B-2, NB-5, NB-7, NB-9, NB-16, NB-17, Pant Aparna, Pant Shivani, Pant Sujata, Pant Urvashi and Goma Yashi were established through *in-situ* patch budding during 2003. The experiment was laid out in randomized block design and each variety was considered as treatment, hence sample from twelve varieties were taken for study. Uniform cultural practices were followed during the course of study. Twenty shoots spread over four directions on each selected trees, ten flowers were earmarked randomly and ten floral buds were scored for different desired attributes. The structure of the flower, their position and number in the inflorescence, the morphology of separate floral parts were assessed. Observations on phenological events were recorded during the deciduous, vegetative, ?owering and fruiting phases of the plant. Average number of ?owers in an in?orescence was counted from the tagged ?owering branches. Observation on different phonological events were derived in all the varieties trees from leaf flush initiation; leaf fall initiation; leaf fall completion; initiation of bud, initiation of flowering; duration and mode to consummate anthesis, chronology of flower opening within inflorescence, anther dehiscence, mode and duration of pollination, stigma receptivity on the day of anthesis,one day before and a day after anthesis were estimated by the method as described by Dafni (1992)and pollen viability were recorded in May during the experiment. Stigma receptivity was measured by Perex Test. Pollen viability per cent was carried out using 1% acetocarmine stain test (Johnsen, 1940). The data were analyzed as suggested by Gomez and Gomez (1984).

Result and Discussion

Different phenological events

Results of study on various pheonological events divulged that the varieties (12) exhibited dissimilar pattern. The inflorescence among all the varieties differed with regards to morphology and phenological characteristics *viz*., type of inflorescence, number of floral parts, inflorescence etc.

Leaf defoliation and initiation

Phenologically, all the varieties had long leaf fall period of 21-25 days, starting from 2nd week of April in variety Pant Aparna, Pant Sujata and Goma Yashi which completes in 3rd, 4th and 2nd week of May, respectively. Variety Pant Shivani had 2nd week of April to 3rd week of April, Pant Urvashi had 3rd week of April to 2 nd week of May, whereas NB-5, NB-7, NB-9 had leaf fall from 3rd, 2 nd, 1st week of May, respectively which completes in the 4th week of May. Variety CISHB-1 had 4 th week of March to 2 nd week of April; CISHB-2 had 1stweek of June to 3rd week of June. NB-16 had 1st week of June to 2 nd week of May. Leaf initiation started from 4 th week of April in CISHB-1, Pant Shivani; 2 nd week of May in NB-9; 3 rd week of May in Goma Yashi, 4th week of May in NB-16, NB-17 and Pant Urvashi; 1st week of June in NB-5, NB-7, Pant Aparna, Pant Sujata, which proceeded from the top of the tree towards the lower branches. (Singhal *et al*., 2010).

Flowering, anthesis and dehiscence

Inkling of bud emergence in all the varieties started from different time, but it lasted from April to late June. The peak period of it was observed during 2nd fortnight of May in all the varieties. All the buds are globose, spheroid in shape in each variety and green in colour which commenced to full bloom from 13th May to 26th June among all the varieties (Table1). It was observed early blooming in (mid May) in the varieties CISHB-1, NB-16, Pant Urvashi and in Goma Yashi, the peak period started from 6th June to 11th June whereas rest of the varieties had blooming in between 20th May to 26th June while peak period started from 7th June to 12th June. The varieties which has long flowering period may serve as a long-term resource (Bertin, 1982 and Dobkin, 1984) whereas flowering phenology of different cultivar affects reproductive success (Ollerton and Diaz, 1999) which allows the presence of a constant population of pollinators (Stiles, 1977; Waser and Real, 1979). There were deviation in the time of initiation and termination of the anthesis was observed between 5 to 8 A.M. among all the varieties of bael. It was observed early initiation (5.00A.M.) in the variety NB-7, NB-9, Pant Shivani and Pant Sujata. No flowers of any variety opened completely before 5 .00 A.M and followed specific time under semi-arid condition of western India (Table 1). During anthesis flowers starts loosening their floral part which later on blooms completely. Some flowers opened all petals at the time while other petals start opening one by one which takes 45 to 60 minutes in complete opening which may vary flower to flower. In the inflorescence, lower side bud opened earlier as compare to rest of buds localized centrally in all varieties whereas varieties had anthesis vice versa where centrally located buds which were opened first compare to lateral buds. After anthesis within half an hour, the hint of the anthers dehiscence

started which continued between 5.45- 8.30 A.M. The pollens were coming outside by bursting the anther centrally by pore. The anthers and floral organs shrunk and turn into brick red after dehiscence as time passed on. The findings regarding anthesis clarified that anthesis and anther dehiscence in bael varieties took place early in the morning (5.30 -8.30 A.M.) where low temperature and high humidity prevailed. More or less similar results were obtained by Singh (1989), Misra and Bajpai (1975), Srivastava and Singh (2000) and Kumar *et.al.* (1977) in bael cultivars. Among the varieties where reproductive success is limited by the pollen, any floral trait that contributes to pollination success should be selected (Uma Shanker and Ganeshaiah, 1990). Higher flower to fruit production ratio is a universal phenomenon in plants and the low frequency of fruit production might reflect resource constraints and pollen limitation (Cao *et al.,* 2005).

Pollen viability and stigma receptivity

In newly opened flowers of all the varieties, pollen viability is about 95 % or more than in the different varieties. Stigma receptivity after anthesis was recorded highest on same day within hour in all the varieties being the maximum in Pant Urvashi (68.53%) followed by Goma Yashi (65.19%) and it was least in NB-7 (45.27%) whereas similar trait was recorded between 7.95 - 15.52 % and 3.62-14.37% one day before and after the anthesis respectively, which showed considerable difference in their values which had lesser percentage of stigma receptivity (Table 3). Pollen viability among all the varieties had more than 95% which more or less similar findings with respect to pollen viability have been reported in the various underexploited fruits by Singh and Singh (2005) in mahua, Suranyi (1991)in apricot, Thimmaraju *et. al.* (1997), Singh *et al.* (2014) in *Morinda*, Singh *et al. (*2014) in bael, Singh and Singh (2005) in Mahua, Singh *et al.* (2007) in jamun, and Singh and Singh (2005) and Singh *et. al.* (2006 and 2010) in tamarind.

Pollination

As soon as flower started opening, large number of honey bees (*Apis dorsata*), and beetles, houseflies and butterflies less in number arrived and started the visiting the flowers for the foraging purpose and they directly enter on the central portion of the flower whether it completely opened or just started to open due to which large number of pollens stick to their abdomen and legs. Effective pollination occurred through the honeybees which visited the flower 5-23 times in 1 hour and carried highest number of pollen grains (29.65) than the rest of pollinators (Table 4).

Honeybees have been recognized as e?ective pollinators in many tropical trees (Cruden *et al.,* 1990; Sedgley *et al.,* 1992; Carthew, 1993; Ish-Am and Eisikowitch, 1993; Visuthitepkul and Moncur, 1993). They forage on bael flower only in the forenoon and recognized as ultimate pollinators than others, because their presence was noticed in plenty and carried large number of pollen grains, but the presence of other pollinators were less in number and carried less pollen grains owing to their foraging behavior and had less contact to the pollen grains.

Inflorescence morphology

Data presented in table 2 and 3 divulged considerable variations in their morphological characters of inflorescence among the varieties. Generally, all the varieties have axillary cymose with long peduncle type of inflorescence which was biparous, multiparous and uniparous. It was axillary biparous in CISHB-1, CISHB-2, NB-7, Pant Aparna, and Pant Urvashi; terminally multiparous cyme in NB-5 and NB-16; terminally biparous cyme in Pant Shivani and rest of the varieties had axillary multiparous cyme. and differed in their length and number of flowers. Pant Sujata had the highest inflorescence length (10.85 cm) followed by Pant Aparna (10.82 cm), CISHB-2 (10.54 cm), NB-7 (9.37 cm) and NB-5 (8.73 cm) and the same was the lowest in Pant Shivani (5.67 cm) followed by Pant Urvashi (6.52cm) and NB-9 (6.74 cm). The maximum number of flowers per inflorescence was observed in the variety Pant Shivani (24.27) followed by NB-16 (23.22), Pant Sujata (21.18) and it was least in the variety CISHB-1(6.03) followed by NB-7(11.13). Larger number of flowers are important for effective pollination (Hedegrat, 1976) Varieties of the bael have a virtually similar ?oral morphology *viz.,* stalked, bracteolate, erect, sweet-scented, complete, actinomorphic, bisexual, slender pediillate, calyx shallow, united at the base short, broad teeth and pubescent outside, petals oblong-oval, dotted with glands, blunt and thick, hypogynous, anthers were long linear cream in colour having white short filaments. Ovary oblong-ovoid, slightly tapering into the thick short style which is again somewhat thicker at upward and capitates stigma. Corolla was also differed in their colour *i.e.* light green (NB-5and NB-17), whitish green (CISHB-1, NB-9, Pant Shivani and Goma Yashi) and greenish white (CISHB-2, NB-6, NB-16, Pant Aparna, Pant Sujata and Pant Urvashi) among the varieties. The aestivation of sepals and petals also varied among different variety *i.e.* imbricate to quincuncial. It was observed imbricate aestivation in CISHB-1, NB-5, NB-7, Pant Aparna, Pant Sujata and Pant Urvashi whereas rest of the varieties had quincuncial aestivation observed.

The quantitative characters of the floral parts varied significantly among all the bael varieties. The

flowers were mostly tetramerous, but number of sepals and petals varied from 4 to 6 among the varieties. Varieties namely CISHB-1, NB-5, NB-7, NB-17 and Pant Urvashi had two kinds of flower which having 4 sepals-4 or 5 petals and 5 sepals and 4 or 5 petals (tetramerous and pentamerous). NB-9, Pant Shivani had tetramerous flowers, Pant Aparna, Goma Yashi and Pant Sujata had 5 - 6 sepals from it one was unequal in size compare to rest of the sepals. Similarity was also observed in the case of petals where it was 5-6 in number in Pant Sujata. There were variability in the number of anthers which ranged between 36.67- 61.23 among all the variety where it was maximum in Pant Urvashi (61.23) and least number of anthers were observed in Pant Aparna (36.67) followed by CISHB-2 (38.43), NB-5 (38.95)and NB-9 (39.57). Singh and Singh (2005) and Singh *et. al.* (2006 and 2010) have reported similar kind of inflorescence morphology in tamarind.

Table 1. Phenological changes in different bael varieties under rainfed conditions of western India.

Variety	Leaf fall initiation	Leaf fall completion	Leaf initiation	Flower bud emergence	Flowering duration	Time of athesis	Time of dehiscence
CISHB-1	4th week of March	2nd week of April	4th week of April	25 Apr-21 June	14 May - 24 June	5.30-7.00 A.M	6.30-8.15 A.M
CISHB-2	1st week of June	3 rd week of June	4th week of June	26Apr-18 June	21 May-26 June	5.15-6.45 A.M	6.00-7.45 A.M
NB-5	3 rd week of May	4th week of May	1st week of June	5 May -24 June	26 May-22 June	5.30-7.30 A.M	6.15-8.00 A.M
NB 7	2nd week of May	4th week of May	1st week of June	30 April-13 June	24 May-20June	5.00-7.00 A.M	6.30-8.30 A.M
NB-9	1st week of May	4th week of May	2nd week of May	7 May-29 June	16 May - 26 June	5.00-8.00 A.M	5.30-8.15 A.M
NB-16	1st week of May	2nd week of May	4th week of May	11 May -29 June	13 May-27 June	6.00-7.45 A.M	6.30-8.35 A.M
NB-17	4th week of April	3 rd week of May	4th week of May	1 May-22 June	26 May-21 June	5.30-7.30 A.M	6.30-8.20 A.M
Pant Aparna	2nd week of April	3 rd week of May	1st week of June	7 May-20 June	16 May-20 June	5.15-7.45 A.M	6.30-8.30 A.M
Pant Shivani	2nd week of April	3 rd week of April	4th week of April	3 May - 20June	20 May-19 June	5.00-6.30 A.M	5.45-8.15 A.M
Pant Sujata	2nd week of April	4th week of May	1st week of June	16 May -8 June	24 May-18 June	5.00-7.00 A.M	6.30-8.00 A.M
Pant Urvashi	3 rd week of April	2nd week of May	4th week of May	10 May -26 June	18 May-23 June	5.15-6.45 A.M	6.30-8.15 A.M
Goma Yashi	2nd week of April	2nd week of May	3 rd week of May	23 April-21 June	13 May-14 June	5.30-7.30 A.M	6.25-8.30 A.M

Table 2. Floral Morphology of different bael Varieties under rainfed conditions of western India.

Varieties	Type of Inflorescences	Flower colour	Flower character	No.of sepal		Number of Petal	
				C	R	C	R
CISHB-1	Axillary biparous cyme ,	Whitish gren	Bracteolate , ,actinomorphic,imbricate	4	5	4	5
CISHB-2	Axillary biparous cyme ,	Greenish white	Bracteate, bracteolate , actinomorphic, quincuncial aestivation	4	5	4	5
NB-5	Terminally,multiparous cyme ,	Light green	Ebracteate, bracteolate , ctinomorphic, Imbricate aestivation	4	5	4	5

NB-7	Axillary biparous cyme ,	Greenish white	Bracteate, bracteolate , actinomorphic, Imbricate aestivation	4	5	4	5
NB-9	Axillary uniparous cyme,	Whitish gren	Bracteate, bracteolate , ctinomorphic, quincuncial aestivation	4	5	4	5
NB-16	Terminally mutiparous cyme ,	Greenish white	Ebracteate, Bracteolate , actinomorphic, quincuncial aestivation	4	5	4	6
NB-17	Axillary multiparous cyme ,	Light green	Bracteate, bracteolate, actinomorphic, quincuncial aestivation	4	5	4	5
Pant Aparna	Axillary biparous cyme,	Greenish white	Bracteolate , actinomorphic,imbricate aestivation	4	5, 6, hafly cleved	4	5
Pant Shivani	Terminally biparous cyme	Whitish green	Ebracteate, bracteolate, actinomorphic, quincuncial aestivation	4	5	4	5
Pant Sujata	Axillary multiparous cyme ,	Greenish white	Bracteolate , actinomorphic, Imbricate aestivation	4	5,6	4	5
Pant Urvashi	Axillary biparous cyme ,	Greenish white	Bracteolate , actinomorphic, imbricate aestivation	4	5	4	5
Goma Yashi	Axillary cyme, multiparous	Whitish green	Bracteolate, actinomorphic, quincuncial aestivation	4	5, 6	4	5

R-Rare, C- Common

Table 3. Stigma receptivity and pollen viability of different bael varieties under rainfed conditions.

Varieties	Infloros cence length (cm)	Number of flower / inflorosce nce (cm)	Average number of anthers per flower	Stigma receptivity at the day before anthesis (%)	Stigma receptivity at the day of anthesis (%)	Stigma receptivity 1 day after anthesis (%)	Pollen Viability (%)
CISHB-1	08.58	06.03	46.35	15.52	54.31	08.43	96.17
CISHB-2	10.54	18.12	38.43	11.93	58.54	12.13	95.35
NB-5	08.73	20.85	38.95	12.53	57.35	14.32	95.42
NB-7	09.37	11.13	39.57	09.64	45.27	14.37	98.62
NB-9	06.74	20.24	55.00	12.53	52.28	04.23	95.25
NB-16	08.65	23.22	48.23	10.70	55.83	09.48	97.34
NB-17	07.63	18.00	43.68	15.45	52.48	11.37	95.23
Pant Aparna	10.82	12.31	36.67	10.72	57.34	06.33	96.15
Pant Shivani	05.67	24.27	49.43	11.13	56.31	03.62	96.83
Pant Sujata	10.85	21.18	46.34	14.82	59.15	04.15	95.30
PantUrvashi	06.52	13.24	61.23	15.13	68.53	07.82	97.48
Goma Yashi	06.83	10.15	40.95	07.95	65.19	10.57	97.13
C.D at 5 %	0.77	1.35	4.36	1.71	3.54	0.80	08.71

Table 4. Pollinators visit, and pollen load carried and duration to bael

Insects	Visitation Time	Number of visits/flower	Duration of stay on flower (min)	Pollen load/insect
Honey bees	6-9 pm	5-23	1-5	29.65
Houseflies	6-9 pm	1-5	1-5	16.75
Beetles	6-9 pm	1-2	1-15	15.53
Butterflies	6-9 pm	2-7	1-5	09.00
Ants	6-9 pm	1-5	2-7	05.34

Reference

Arya, H. C. 1986. Clonal multiplication of tree species in the Thar Desert through tissue culture. *Forest Ecology and Management,* 16:201-208.

Barthakur, N. N and Arnold, N. P. 1989. Certain organic and inorganic constituents in bael (*Aegle marmelos* Correa) fruits. *Trop. Agric.,* 3 (11): 10-14

Bertin, R. I. 1982. Floral biology, hummingbird pollination and fruit production of Trumpet Creeper (*Campsis radicans*, Bignoniaceae*). Am. J. Bot*., 69: 122-134.

Cao, G. X., Zhong, Z. C., Xie D. T. and Liu. Y. 2005. The relationship between reproductive allocation, fruit set and individual size of *Camellia rosthorniana* in different communities. *Acta Phytoecol Sin*, 29: 361-366.

Carthew, S. M. 1993. An assessment of pollinators visitation to Banksia spinulosa. *Australian Journal of Ecology*, 18: 257268.

Cruden, R.W., Baker, K. K., Cullinan, T. E., Disbrow, K..A.., Douglas, K.L., Erb, J.D, Kirsten, K.J., Malik, M..L, Turner, E.A, Weier, J.A. and Wilmot, S. R. 1990. The mating systems and pollination biology of three species of Verbena (Verbenaceae). *Journal of Iowa Academy Science*, 97: 178183.

Dafni, A. 1992. Pollination ecology: a practical approach. Oxford University Press, Oxford, UK.

Dobkin, D.S. 1984. Flowering patterns of long lived Heliconia inflorescences: implications for visiting and resident nectarivores. *Oecologia*, 64: 245-254.

Gomez, K. A. and Gomez, A. A.1984. *Statistical Procedure for Agricultural Research* (2nd Edn.), John Wiley and Sons Inc., New York.

Hedgegart, T. 1976. Breeding systems, variation and genetic improvement of teak (*Tectona grandis* L.f.): In Burley J, Styles BT, eds. Tropical trees, variation, breeding and conversation, *Linnean Society Symposium Series* 2. New York: Academic Press.

Ish-Am G, Eisikowitch. 1993. The behaviour of honey bees (Apis mellifera) visiting avocado (*Persea americana*) ?owers and their contribution to its pollination. *Journal of Apicultural Research*, 32: 175186.

Jauhari, O. S. and Singh, R. D. 1971. Bael: valuable fruits. *Indian J. Hort*., 948-53.

Johansen, D. A. 1940. Plant micro technique. Mc Graw Hill Company, New York.

Kumar, Ram, Hoda M N and Singh D K .1997.Studies on floral biology of custard apple(*Annona squamosa* L.). *Indian J. Horti*., 34:252-6.

Misra, R. S. and Bajpai P. N. 1975. Floral biology of jamun (Syzigium cumini Skeels.) *Indian J. Horti.*, 32:15-24.

Mukharjee, B, and Ahmed, K. 1957. Riboflavin . *Pakistan Journal Biology and Agriculture Science*, 1:47-51.

Ollerton, J. and A. Diaz. 1999. Evidence for stabilizing selection acting on flowering time in *Arum maculatum* (Araceae): the influence of phylogeny on adaptation. *Oecologia*, 119: 340-348.

Ram, D. and Singh, I. S. 2003. Physico-chemical studies on bael (*Aegle marmelos* Correa) fruits. *Progressive Horticulture*, 35 (2): 199-201.

Sedgley, M, Khen, C.V., Smith, R.M., Harbard, J. 1992. Insect visitors to ?owering branches of *Acacia mangium* and *Acacia auriculiformis*. In: Carron LT, Aken KM, eds. Breeding technologies for tropical Acacias. The Australian Centre for International Agricultural Research *(*ACIAR) Proceedings 37: 5156.

Seghieri J, Floret Ch, Pontanier R. 1995. Plant phenology in relation to water availability: herbaceous and woody species in the savannas of northern Cameroon. *Journal of Tropical Ecology*, 11: 237254.

Singh, A.. K., Singh, Sanjay, Singh, R. S., Joshi, H. K., and Sharma, S. K. 2014. Characterization of bael varieties under rainfed hot semi-arid environment of western India. *Indian Journal of Agricultural Sciences,* 84 (10):80-86

Singh, A. K., Singh, Sanjay and Joshi, H. K. 2014. Characterization of *Morinda tomentosa* Heyne ex Roth genotypes under rainfed conditions of western India. *Indian Journal of Agricultural Sciences,* 84 (11):115-22.

Singh, S. and Singh, A. K. 2005. Studies on genetic diversity in Mahua (*Bassia latifolia*) under semi arid ecosystem of Gujarat. *Indian J. Agric. Sci.*, 75: 519-23.

Singh, Sanjay and Singh, A. K. 2005. Studies on variability in tamarind (*Tamarindus indica* L) from Gujarat. *Progressive Horticulture*, 37:

280-284.

Singh, Sanjay, Joshi, H. K., Singh, A. K, Lenin,V. Bagle, B. G. and Dhandar D. G. 2007. Reproductive biology of jamun (*Syzygium cuminii* Skeels) under semi arid tropics of western India. *The Horticultural Journal*, 20 (2): 76-80.

Singh, Sanjay, Singh, A. K., Malik, S. K. and Joshi, H. K. 2010. Reproductive biology of tamarind (*Tamarindus indica* L.) under semi arid tropics of western India. *Indian Journal of Plant Genetic Resources*, 23 (2):212-216.

Singh, V. P. and Mishra, K. K. 2004. Estimation of variability parameters for floral traits and yield in bael (*Aegle marmelos* Correa). *Prog. Hort*., 2:253-58.

Singhal V.K., Salwan A., Puneet Kumar, Jaspreet Kaur. 2011 Phenology ,pollination and breeding system of Aegle marmelos (Linn.)correa (Rutaceae)from India. *New Forest* , 42 : 85-100.

Srivastava, K. K. and Singh, H. K. 2000. Floral biology of bael (*Aegle marmelos*) cultivars. *Indian J. Agric. Sci.*, 70: 797-798.

Stiles, F.G. 1977. Co adapted competitors: the flowering seasons of hummingbird-pollinated plants in a tropical forest. *Science*, 198:1177-1178.

Suranyi, D. 1991. Floral morphological characteristic of Hungarian apricot varieties. *Acta Horticulture*, 293: 303-310.

Thimmaraju, K. R.., Narayana Reddy M. A., Swamy, N. and Sulladmath U. V. 1997. Studies on floral biology of tamarind (*Tamarindus indica* L*). Mysore J. Agric. Sci.*, 11: 293-298.

Van Schaik, C. .P.., Terborgh J. W. and Wright, S.J. 1993. The phenology of tropical forests: adaptive significance and consequences for primary producers. *Annual Review of Ecology and Systematics*, 24: 353377.

Visuthitepkul S, Moncur MW. 1993. Floral biology of Petford *Eucalyptus camaldulensis* Dehnh. In: Drysdale RM, John SET, Yapa AC, eds. *Proceedings of the International Symposium on Genetic Conservation and Production of Tropical Forest Tree Seed*, Chiang Mai, Thailand: ASEAN-Canada Forest Tree Seed Centre Project, Muak-lek, Thailand, 182189.

Waser, N.M. and L.A. Real. 1979. Effective mutualism between sequentially flowering plant species.

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Studies on physiological parameters in tissue culture and sucker plants of date palm (*Phoenix dactylifera* L.) cultivars

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Abstract

Production of planting material in date palm (*Phoenix dactylifera* L.) is the major constraint in commercial cultivation. This is on account of fact that rate of sucker production is limited and differ from variety to variety. Therefore, for production of planting material, recourse to tissue culture has been taken. Presently, at global level, few organizations are producing tissue culture plants but their performance is yet to be ascertained. Accordingly, the present study was planned to compare the photosynthetic parameters in 4 years old tissue culture/ sucker plants of date palm cv. Khalas and Khuneizi at vegetative growth stage. It was observed that in cv. Khuneizi the plants obtained from tissue culture/ sucker do not differ much in their photosynthetic parameters. However, in cv. Khalas the rate of photosynthesis at vegetative growth stage was higher as compared to plants obtained from sucker. Similar trend was observed for other parameters also such as transpiration rate, carboxylation efficiency and water use efficiency. Data on morphometry of leaflet also revealed that leaflets of cv. Khuneizi (Tissue culture and sucker) were at par but in cv. Khalas the leaflets of tissue culture plants were significantly larger than that of sucker plants. Therefore, our results demonstrate that plants obtained from tissue culture and sucker do not differ much in terms of photosynthetic parameters under arid conditions

Keywords: *Date palm, Photosynthesis, sucker, tissue culture, arid conditions*

Introduction

Date palm (*Phoenix dactylifera* L.) is an economically important fruit tree of arid region. Date cultivation has historical records dating back to 6000 BC along Tigris and Euphrates River in Iraq and to 2000 BC at Mohenjodaro along river Indus. It is one of the oldest plants cultivated by the man and its origin is either Mesopotamia or Gulf region. All parts of date plant is utilized in different ways since its cultivation (Chao and Krueger, 2007). In Indus valley, date palm is believed to have been introduced by the Soldiers of Alexander the Great in the fifth century B.C. and during the Muslim invasions at the beginning of the eight-century A.D. At present, some wild old grooves of seedling date palm are present on the coastal belt in Kachchh region of Gujarat which harbours a wide genetic variability in fruit characters (Murlidharan, 2008).

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Despite the fact that western Rajasthan and part of Haryana, Punjab and Gujarat are suitable for commercial cultivation, now the farmers are coming forward to take this as commercial crop. This is on account of the fact that expansion of date palm is restricted due to lack of quality planting material. In order to develop planting material, recourse to tissue cultured has been adopted. At present some private and research very few organizations are producing tissue-cultured plants and are supplying to farmers and developmental agencies. However, their actual performance under field condition is yet to be ascertained. Accordingly, the present study was conducted to compare the morphometeric and physiological parameters in 4 years old tissue culture and sucker plants of date palm cultivars, with a view to assess the variation between them. The results obtained constitute the text of the present communication.

Materials and Methods

Tissue culture and sucker raised plants of cvs.

Khuneizi and Khalas constitute the material of the present study. The suckers of both the cultivars were collected from Regional Fruit Research Station, P.A.U., Abohar, Punjab and tissue culture plants of both the cultivars were obtained from M/s A.V. Thomas & Company, Cochin (Kerala). All the plants were planted in date palm block of ICAR-CIAH, Bikaner farm.

The studies were conducted during 2001-2002 on four-year-old plants maintained under normal cultural operations. For morphometeric comparison, the data on plant height, length of leaf, length and width of leaflet (pinnae) were recorded. The observations on leaf/leaflet were taken on fully expended leaf.

The data on photosynthetic parameters were recorded on fully expanded inner side middle pinnae using Infra Red Gas Analyser (Model LI-6200, LICOR, USA). The observations were recorded on 3 plants for each treatment and data was pooled to arrive at mean values. The carboxylation efficiency was calculated as ratio of photosynthetic rate and internal CO_2 concentration and water use efficiency as ratio of photosynthetic rate to transpiration as described by Das *et al.* (1999). The data thus obtained was subjected to statistical analyses using MSTAT Software.

Results and Discussion

i) Plant morphometry

a) Cv. Khalas

Plant morphometeric parameters of sucker and tissue-cultured plants of cv. Khalas are presented in Table 1. Perusal of data reveals that plant height in sucker-raised plant was 266.66 ± 57.73 cm whereas the plants raised through tissue culture were shorter with magnitude of 120.0 ± 50.0 cm. The comparison of means reveals that the plants raised from tissue culture were significantly shorter than that of plants raised through sucker/offshoots.

Perusal of data on length of leaf reveals that the fully expanded leaf of sucker raised plant was 140.2±59.56 cm long whereas that from tissue culture plants was 110.2±30.09 cm. Comparison of means reveals that the two are at par. Data on leaflet length and width also follow identical trend. The length of leaflet of sucker-raised plant was 23.6±2.5 cm and 2.56±0.18 cm wide. The values show that there is no major difference between the two groups.

B) Cv. Khuneizi

The data collected on plant morphometeric parameters of cv. Khuneizi is presented in Table 2. Perusal of data reveals that plants raised through tissue culture are shorter (126.0±13.87) as compared to those obtained through sucker (180.0±12.24cm). The comparison of means reveals that the difference in plant height is statistically significant.

The data on length of leaf reveals that the leaves of sucker-raised plants are longer (170.6±16.3cm) as compared to those obtained from tissue culture raised plants (107.8±9.03cm). The comparison further shows that the difference is statistically significant. Identical trend is also demonstrated by data on length of leaflet. Perusal of data reveals that leaflet is longer in sucker-raised plants (31.2±1.09cm) as compared to plants raised through tissue culture (27.2±0.83cm).

ii) Photosynthetic parameters

a) Cv. Khalas

The data on photosynthetic parameters of cv. Khalas are presented in Table 3. During the present study, the data on net photosynthesis rate, stomatal resistance, transpiration rate, carboxylation efficiency and water use efficiency was recorded. It was observed that net photosynthesis rate was marginally higher in plants raised through tissue culture (15.34±1.05µmol $m^{-2}s^{-1}$) as compared to plants raised through suckers (13.41±0.16µmol $m^{-2}s^{-1}$). Comparison of mean reveals that the two values are at par and do not show any difference.

Stomatal resistance does not show any difference in magnitude in two groups under study. Its value was 0.077±0.011cm s^{-1} in sucker-raised plants and 0.102±0.003cm s^{-1} in tissue culture raised plants.

Similar trend was also observed in transpiration rate which was 6.84± 0.2 mmol $m^{-2}s^{-1}$ in sucker raised plants and 6.5 ± 0.2 mmol $m^{-2}s^{-1}$ in tissue culture raised plants. The values were non-significant.

Both the groups demonstrated similar carboxylation efficiency too. It was 0.048 ± 0.002 µmol CO_2 fixed $m^{-2}s^{-1}ppm^{-1}$ of internal CO_2 in sucker plants and 0.058±0.0003 µmol CO_2 fixed $m^{-2}s^{-1}ppm^{-1}$ of internal CO_2 in tissue culture raised plants, which was statistically significant. The difference between sucker and tissue culture plants with respect to water use efficiency was non-significant.

b) Cv. Khuneizi

The data pertaining to photosynthetic parameters are presented in Table 4. The perusal of data

reveals that net photosynthesis rate was higher in tissue culture plants (12.06±2.46µmol $m^{-2}s^{-1}$) as compared to sucker raised plants. However, comparison of means show that the difference was non-significant.

Data on stomatal resistance revealed that the magnitude was relatively high in sucker-raised plants as compared to tissue culture raised plants. However, this difference was also statistically non significant on mean comparison.

Both types of plants were at par in their transpiration rates. The transpiration rate of sucker-raised plant was 5.46 mmol $m^{-2}s^{-1}$ whereas in tissue culture raised plant it was 5.37 mmol $m^{-2}s^{-1}$. Data on water use efficiency also revealed a non-significant

Table 1. Plant morphometric parameters of sucker and tissue culture raised plants of Khalas

	Plant parameters in cm			
	Plant height	Length of leaf	Length of leaflet	Width of leaflet
Khalas (Sucker)	266.66±57.73	140.2±59.66	25.2±3.83	3.16±0.35
Khalas (Tissue culture)	120.00±50.00	110.0±30.09	23.6±2.5	2.56±0.18
CD at 5%	0.048	NS	NS	NS

Table 2. Plant morphometric parameters of sucker and tissue culture raised plants of Khuneizi

	Plant parameters in cm			
	Plant height	Length of leaf	Length of Leaflet	Width of leaflet
Khuneizi (Sucker)	180.0±12.24	170.6±16.3	31.2±1.09	2.93±0.115
Khuneizi (Tissue Culture)	126.00±13.87	107.8±9.03	27.2±0.83	2.63±0.115
CD at 5%	0.023	NS	NS	NS

Table 3. Photosynthetic parameters of sucker and tissue culture raised plants of Khalas

	Photosynthetic parameters				
	P_N(µmol/$m^{-2}s^{-1}$)	Stomatal Resistance (cm s^{-1})	Transpiration (mmol $m^{-2}s^{-1}$	Carboxylation efficiency	Water use efficiency (µmol/ mmol)
Khalas (Suckers)	13.41±0.16	0.077±0.011	6.84±0.2	0.048±0.002	1.946±0.04
Khalas (Tissue culture)	15.34±1.05	0.1022±0.003	6.5±0.2	0.058±0.0003	2.30±0.20
CD at 5%	NS	NS	NS	0.014	NS

Table 4. Photosynthetic parameters of sucker and tissue culture raised plants of Khuneizi

	Photosynthetic parameters				
	P_N (µmol/m^{-2} s^{-1}	Stomatal Resistance (cm s^{-1})	Transpiration (mmol m^{-2} s^{-1})	Carboxylation efficiency	Water use efficiency (µmol/ mmol)
Khuneizi (Suckers)	10.69± 0.020	0.221± 0.02	5.46±0.03	0.037	1.95± 0.15
Khuneizi (Tissue culture)	12.06± 2.46	0.134± 0.002	5.37±0.01	0.027	2.24± 0.105
CD at 5%	NS	0.02	NS	NS	NS

difference between the mean value obtained for sucker raised (1.95) and tissue culture raised (2.24) plants. Similarly, observation was also recorded in their carboxylation efficiency 0.037 for sucker and 0.027 for tissue cultured plants and the differences was non significant.

Use of tissue culture plants has become a common practice to develop commercial orchards. This is on account of fact that such plants provide uniformity in genetic material. In date palm too, numerous attempts have been made to raise tissue culture plants (Reuveni, 1979; Tissert, 1979; Meter, 1983; Shakib *et al.*, 1994). At present, a large number organizations are engaged in production of tissue cultured plants (Zaid and de Wet,1999). The evaluation of tissue cultured and sucker raised plants of Barhee was conducted in Kachchh, Gujarat where it has been demonstrated that initially for 1-3 years tissue culture plants have better growth than sucker plants but later they have same magnitude (Murlidharan *et al.*, 2010).

Despite, this very little has been done to compare the plants raised from different techniques for their morphological and physiological parameters. It has been demonstrated that in vitro raised plants show morphological, structural, physiological and biochemical differences from these produced conventionally. These include reduced epicuticular wax, altered leaf anatomy, excessive water loss and stomatal abnormalities (Zaid and Hughes, 1995a,b,c). In another study conducted using tissue culture and offshoot raised plants of Barhee, it was shown that there were no difference in 81 out of 97 morphological and biochemical parameters investigated (Hajian, 2007).

However, in this study, the plants were of 4 years of age and did not show any morphological variations. The only difference observed was in the height of plant that was more in plants raised through sucker as compared to tissue cultured plants. Thus, the results reveal that in morphometric parameters, both the types of plants were at par.

Comparison of photosynthetic parameters has not been compared in date palm. However, in banana attempts were made and it has been recorded that plants raised from suckers were at par with those raised from tissue culture (Shivashankara et al., 2001). The results are also in line with those obtained in banana. In both the cultivars under study all the parameters such as net photosynthesis rate, stomatal resistance, carboxylation efficiency and water use efficiency do not vary with type of planting material used. Although, Zaid and Hughes (1995c) reported that in vitro plants have more water loss as compared to these produce conventionally. But in this study the transpiration rate remained at par in both the cultivars when compared in field condition.

Thus, from the above findings it can be inferred that irrespective of source of planting material, the field established plants do not differ much in terms of morphological and physiological parameters.

References

Chao, C. C. T. and Krueger, R. R. 2007. The date palm (*Phoenix dactylifera* L.): overview of biology, uses, and cultivation. *Hort. Science*, 42 (5): 1077-1082

Das, C., Sengupta, T., Salim, P.K., Mishra, A.K., Sen, S.K. and Saratchandra, B. 1999. Quantitative analysis of photosynthetic parameters in mulberry leaf. *Indian Journal of Plant Physiol.*, 4(3): 171-174.

Hajian, S. 2007. Quantity and quality comparison of offshoot and tissue cultured Barhee date palm trees. Proc. III International Date Palm Conference, *Acta Hort* 736, ISHS, 2007, pp 293-300.

Mater A. A. 1983. Plant regeneration from callus cultures of *Phoenix dactylifera* L. *Date Palm Journal*, 2: 1, 157-77.

Muralidharan, C.M., Tikka, S.B.S. and Verma, P. 2008. Date palm cultivation in Kachchh. Technical bulletin No. 02/ 2008. Date Palm Research Station, S.D. Agricultural University, Mundra- Kachchh, pp 36.

Muralidharan, C.M., Verma, P., Badiyavedra, D. A. 2010. Field performance of tissue culture date palm cv. Barhee in arid ecosystem of Gujarat. In. Souvenier, National Workshop on Date palm, CIAH, Bikaner, 4th Oct, 2010, pp 144-150.

Reuveni, O. 1979. Embryogenesis and plantlet growth of date palm (P. dactylifera L.) derived from callus tissues. *Plant Physiol.*, 63: 138.

Shakib, A.M., Khoshkam, S., Majidi, E. 1994. Plant regeneration of datepalm variety Estamaran by tissue culture. *Seed and Plant*, 9: 3-4, 8-11

Shivashankara, K.S., Kumar, V. and Reddy, B.M.C.

2001. Physiology of growth differences between tissue culture plants and sucker in dwarf Cavandish and Robusta banana. *Indian J. Hort*., 58(3): 244-245

Tisserat, B. 1979. Propagation of datepalm (*Phoenix dactylifera* L.) in vitro. *J. Expt. Bot.*, 30: 1275-83.

Zaid, A and de Wet, P.F. 1999. Date palm propagation. In Date palm cultivation. (Ed. Zaid, A.) FAO Plant production and protection paper 156.

Zaid, A. and Hughes 1995a. A comparison of stomatal functions and frequency of in vitro, in vitro polyethylene glycol treated and greenhouse grown plants of date palm *(Phoenix dactylifera* L). *Tropical Agriculture* (Trinided), 72: N 2 : 130-134.

Zaid, A. and Hughes 1995b. In vitro acclimatization of date palm (*Phoenix dactylifera* L.) plantlets: a quantitative comparison of epiculticular leaf wax as a function of polyethylene glycol treatment. *Plant Cell Reports*, 15: 111-114

Zaid, A. and Hughes 1995c. Water loss and polyethylene glycol-mediated acclimatization of in vitro grown seedlings of 5 cultivars of date palm (*Phoenix dactylifera* L.) Plantlets. *Plant and Cell Reports*, 14: 385-388.

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SHORT COMMUNICATION

Changes in chemical parameters of bael [*Aegle marmelos*(L.) Correa] fruits of different cultivars during growth and development

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Bael fruit [*Aegle marmelos* (L.) Correa] is known in India from pre-historic time, Hiuen Tsiang, the Chinese Buddhist pilgrim who came to India in 1629 A.D. noted the presence of this tree along with other trees in this region (Sambamurthy and Subrahmanyam, 1989). Bael is a very hardy tree and can be also grown well in swampy, alkaline or stony soils having p^H range from 5 to 8 and up to an altitude of 1200 meters (Orwa *et al.*,2009). It is grown in almost all the states of India. Utilization of bael in day-to-day life has great nutritional, environmental as well as commercial importance. It has been in use from time immemorial in traditional systems of medicine for relieving constipation, diarrhoea, dysentery, peptic ulcer and respiratory infections. The fruits have a pleasant aroma which is not destroyed even during processing. There is a lot of potential for processing bael fruits into various products like preserve, squash, dehydrated slices, toffee, R.T.S. and bael powder etc. which can be very easily popularized in domestic as well as International markets. The dried bael fruit is used for the preparation of 'No Caffeine Tea' in Thailand. Therefore, the present studies were carried out to know the seasonal changes in biochemical constituents in different cultivars during growth and development of bael fruits. These study have been decided the maximum nutritive value and as per need fruits could be harvested.

The studies were carried out on 20 year old uniform and healthy trees growing at N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) The branches were tagged on four sides of the tree and experiment was laid out in C.R.D. with three replications. First sampling was done on July, 2011 and subsequent samples were taken at 30 days interval in NB-4, NB-5, NB-7 and NB-9 after fruit set up to maturity of fruits. The T.S.S. was estimated at ambient temperature by ERMA made Refractometer (0-32) and these values expressed as per cent T.S.S. The acidity, ascorbic acid and sugars were estimated by methods as described by Ranganna (2010). Total carotenoids content was determined by method as suggested by Sagar and Samuel (2008). The total phenols was estimated by the method described by Singhleton and Rossi, 1965 and Singhleton *et al.*, 1999.

The data on changes in T.S.S. content of bael fruits are presented in Table 1. Data show that T.S.S. content of fruits was increase up to 60 DAFS and then started decreasing up to 120 DAFS thereafter T.S.S. content was started increasing again in all the cultivars up to maturity of fruits. The T.S.S. content was maximum (29.10%) in NB-4 followed by NB-9 (27.20%). The increasing, followed by decreasing and again increasing trend in T.S.S. content during growth and development of bael fruits probably due to difference in rate of accumulation of food materials and hydrolysis of polysaccharides into sugars. Kaushik *et al.* (2002) and Roy and Singh (1978) reported that T.S.S. of bael fruits increased continuously with growth and development which are contradictory to the present finding in which increasing followed decreasing followed by increasing in T.S.S. content was observed in bael fruits.

The per cent acidity content was showed decreasing trend in all the cultivars during growth and development of fruits Table 2. The minimum acidity content was recorded in NB-9 cultivars followed NB-4 during entire period of growth and development. NB-7 was significantly higher in acidity content among all cultivars. The acidity content was minimum on 240 DAFS as compare to 30 DAFS in all the cultivars of bael. The decreasing trend in acidity content might be due to rapid utilization of organic acids and conversion of organic acids into their salts and sugars (Ruffner *et al*., 1975). Significantly variation in acidity content among cultivars could be due to cultivar effects. The findings is supported by other workers who have reported that titrable acidity of fruits was decreased with growth in bael (Kaushik *et al*., 2002) and (Nidhi and Gehlot, 2007).

Data show that reducing sugars, non-reducing and total sugars content was increased in all the cultivars during with the growth and development of fruits (Table 3). The maximum reducing sugars, non-reducing and total sugars content was recorded in NB-9 followed by NB-4 during entire period of observation in comparison to other cultivars. After 240 DAFS, NB-9 was significantly observed to be higher in reducing sugars content in comparison to other cultivars. There was no significant difference in total sugars content among the cultivars on 210 and 240 DAFS. The increase in reducing sugars content of fruits might be due to conversion of starch into sugars during growth and development of fruits. The tendency of increment in non-reducing sugars during growth and development might be due to availability of starch amount to hydrolyze into sugars and the increase in total sugars might be because of increase in reducing and non-reducing sugars resulting from the conversion of starch into sugars and variation may account for the cultivars The results are in line with the findings of Roy and Singh (1978) and Mukhopadhyay *et al*. (2002) in bael fruits,

The data recorded on changes in ascorbic acid content during growth and development of fruits in bael cultivars are presented in Table 4. Data show the significant difference in ascorbic acid content between NB-9 and NB-7. The maximum ascorbic acid was recorded in NB-9 (21.75mg/100g) followed by NB-4 (19.90mg/100g) on 240 DAFS. Overall ascorbic acid content increased in all four cultivars of bael with the growth and development of their fruits up to 240 DAFS. The gradual increase in ascorbic acid content could be associated with the greater synthesis of glucose-6-phosphate, which served as a precursor for its synthesis in fruits (Mapson, 1970). The results are confirmed by Selvaraj *et al*. (1999) who reported that ascorbic acid content increased during fruit maturation and ripening of Guava, similar results are also accordance with the findings of Singh *et al*. (1998) in Kinnow mandarin.

The data on changes in total carotenoids content during growth and development of bael fruits are presented in Table 5. Data show continuous increase in total carotenoids content in all the cultivars during the growth and development of fruits. On 240th DAFS, the total carotenoids content was higher in all the cultivars than initial day of observation; however, NB-9 was significantly higher in comparison to others on 240 DAFS. Increase in total carotenoids might have taken place because of the unmasking of these pigments and conversion of chlorophyll into carotenoids as the fruits approached to maturity. The results are similar to Kaushik and Yamdagni (1999) who reported more than 4 fold increase in carotenoids during fruit maturation in bael fruits. The findings is also supported by similar reports of Singh *et al*. (1998) in Kinnow Mandarin.

Data furnished in Table 6 show that total phenol content was continuously decreased during growth and development of fruits in all cultivars. The maximum total phenol content was observed in NB-9 followed by NB-5 during entire period of growth and development. Total phenol content was higher on 30th DAFS in all the cultivars of bael which was decreased when fruits proceeded towards maturity. The possible reason of decrease in total phenols in fruits might be due to reduction in tannins begun with increase in sugar synthesis and the original acrid taste of fruit diminished. The finding is supported by other workers who have also reported that during growth and development total phenol content decreased in bael fruits Roy and Singh, (1980), Kaushik *et al.* (2000) and in papaya (Abu-Gaukh *et al.*, 2010).

Table 1. Changes in total soluble solids content (%) during growth and development of fruits

Cultivars	T.S.S. at different intervals (days)							
	30	60	90	120	150	180	210	240
NB-4	28.10	32.10	22.10	19.20	22.10	23.10	27.10	29.10
NB-5	25.10	26.10	20.20	16.20	19.20	20.00	21.20	26.20
NB-7	22.20	28.10	19.20	18.20	20.10	21.00	22.10	24.10
NB-9	30.10	31.20	21.10	14.10	19.00	20.20	22.10	27.20
SEm±	0.574	0.663	0.455	0.341	0.449	0.480	0.507	0.486
C.D. at 5%	1.872	2.162	1.483	1.111	1.464	1.565	1.655	1.585

Table 2. Changes in acidity content (%) during growth and development of fruits

Cultivars	Acidity content at different intervals (days)							
	30	60	90	120	150	180	210	240
NB-4	0.54	0.51	0.50	0.48	0.46	0.43	0.38	0.35
NB-5	0.58	0.55	0.53	0.51	0.48	0.44	0.39	0.36
NB-7	0.61	0.57	0.54	0.52	0.49	0.45	0.42	0.37
NB-9	0.52	0.50	0.48	0.44	0.42	0.41	0.37	0.33
SEm±	0.013	0.012	0.012	0.008	0.010	0.008	0.009	0.006
C.D. at 5%	0.043	0.039	0.038	0.025	0.032	0.025	0.028	0.020

Table 3. Changes in sugars content (%) during growth and development of fruits

Treatments	Sugars content at different intervals (days)											
	30			60			90			120		
	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total
T1 (NB-4)	3.10	6.65	9.75	3.75	7.60	11.35	4.00	8.55	12.55	4.65	8.40	13.05
T2 (NB-5)	2.05	6.65	8.70	3.15	6.75	9.90	3.70	7.90	11.60	4.00	7.65	11.65
T3 (NB-7)	2.20	5.70	7.90	3.25	6.60	9.85	3.80	6.65	10.45	4.10	7.20	11.30
T4 (NB-9)	3.15	6.65	9.80	4.00	8.50	12.50	4.20	8.65	12.85	4.90	8.70	13.60
SEM ±	0.060	0.146	0.206	0.070	0.162	0.239	0.096	0.155	0.197	0.101	0.182	0.247
C.D. at 5%	0.196	0.475	0.672	0.229	0.530	0.779	0.312	0.504	0.642	0.330	0.592	0.807
Treatments	Sugars content (%)											
	150			180			210			240		
	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total	Reducing	Non-Reducing	Total
T1 (NB-4)	4.75	8.55	13.30	4.95	8.65	13.60	5.05	9.00	14.05	5.05	9.20	14.25
T2 (NB-5)	4.45	8.25	12.70	4.75	8.40	13.15	4.85	8.80	13.65	4.90	8.95	13.85
T3 (NB-7)	4.55	8.00	12.55	4.80	8.15	12.95	4.90	8.30	13.20	4.95	8.55	13.50
T4 (NB-9)	5.00	8.80	13.80	5.10	8.90	14.00	5.15	9.25	14.40	5.20	9.50	14.70
SEM ±	0.103	0.168	0.264	0.076	0.158	0.193	0.062	0.156	0.241	0.061	0.182	0.219
C.D. at 5%	0.335	0.547	0.861	0.249	0.514	0.629	0.202	0.508	0.787	0.199	0.593	0.713

Table 4. Changes in ascorbic acid content (mg/100g) during growth and development of fruits

Cultivars	Ascorbic acid at different intervals (days)							
	30	60	90	120	150	180	210	240
NB-4	10.50	11.00	11.50	12.70	14.65	15.89	18.05	19.90
NB-5	9.70	9.85	10.25	12.05	13.80	15.30	16.90	18.50
NB-7	9.30	9.55	10.10	11.70	13.10	14.00	16.15	17.25
NB-9	11.00	11.20	12.70	13.30	15.00	17.65	19.20	21.75
SEm±	0.203	0.255	0.258	0.272	0.319	0.314	0.388	0.447
C.D. at 5%	0.662	0.831	0.840	0.888	1.041	1.023	1.264	1.457

Table 5. Changes in total carotenoids content (µg/100g) during growth and development of fruits

Cultivars	Total carotenoids at different intervals (days)							
	30	60	90	120	150	180	210	240
NB-4	14.20	14.50	14.90	17.00	20.90	23.10	26.20	30.75
NB-5	14.50	14.80	15.20	18.60	21.10	24.50	29.30	32.50
NB-7	13.00	13.10	13.55	15.20	18.08	20.04	23.90	27.10
NB-9	15.40	16.20	17.50	20.10	24.50	29.20	33.80	37.30
SEm±	0.309	0.280	0.352	0.384	0.498	0.426	0.685	0.742
C.D. at 5%	0.009	0.914	1.147	1.253	1.625	1.390	2.234	2.420

Table 6. Changes in total phenols content (mg/100g) during growth and development of fruit

Cultivars	Total phenols at different intervals (days)							
	30	60	90	120	150	180	210	240
NB-4	71.50	70.00	62.50	57.30	46.70	40.00	35.20	30.80
NB-5	72.60	71.20	63.40	58.00	47.10	42.80	36.00	31.50
NB-7	69.80	65.40	61.00	55.80	42.30	38.00	34.10	28.60
NB-9	74.50	72.50	66.60	59.00	48.60	43.20	38.90	32.40
SEm±	0.706	1.131	1.128	0.605	1.057	0.718	0.813	0.626
C.D. at 5%	2.302	3.687	3.678	1.972	3.448	2.340	2.653	0.042

References

Abu-Goukh, A.B.A., Shattir, A.E.T. and Mahdi, E.F.M. 2010. Physico-chemical changes during growth and development of papaya fruit (chemical changes). *Agric. and Biol. J. North America*, **1** (5): 871-877.

Kaushik, R.A. and Yamdagni, R. 1999. Changes in bio-chemical constituents of bael fruit during growth and development. *J. Med. Arom.Pl. Sci*., 21 (1): 26-28.

Kaushik, R.A., Yamdagni, R. and Dhawan, S.S. 2000. Physico-chemical characteristics Seasonal changes of bael (*Aegle marmelos* Correa) fruit at green and ripe stage of maturity. *Haryana J. Hort., Sci*., 29 (1/2): 44-45.

Kaushik, R.A., Yamdagni, R. and Dhawan, S.S. 2002. Seasonal changes during growth and development of bael (*Aegle marmelos* Correa) fruit. *Haryana J. Hort. Sci*., 31 (1/2): 32-34.

Mapson, L.W. 1970. Vitamins in fruits. In " biochemistry of fruits and their products". Ed. A.C. Hulme Vol. 1, Academic Press, London and New York. pp 369.

Mukhopadhyay, P., Gongopadhyay, D. and Mazumdar, B.C. 2002. Further studies on qualitative constituents of bael (*Aegle marmelos* Correa) fruits grown in the Sunderbans area of West Bengal. *Indian Agricult.*, 46 (1/2): 97-102.

Nidhi, and Gehlot, R. 2007. Studies on physico-chemical character tics of fresh bael and guava fruits. *Research on Crops*, 8 (1): 189-190.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. 2009. Agro-forestry data base, 4.0.

Ranganna, S. 2010. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill, New Delhi.

Roy, S. K. and Singh, R.N. 1980. Studies on changes during development and ripening of bael fruit. *Punjab Horticultural Journal*., 20 (3/4): 190-197.

Ruffner, H.P., Koblet, W. and Rast, D. 1975. Galacogenesis in the ripening berries of grapes (*Vitis vinifera*). *Vitis*, 13 (4): 319-328.

Sagar, V.R. and Samuel, D.V.K. 2008. Laboratory Manual on Analysis of Fruit and Vegetable Products. Discipline of Post Harvest Technology, IARI, New Delhi.

Sambamurthy, A.V.S.S. and Subrahmanyam, N.S. 1989. Fruits and Nuts, A text Book of Economic Botany, Wiley Eastern Limited, New Delhi, pp.697-698.

Selvaraj, Y., Pal, D.K., Raja, M.E. and Rawal, R.D. 1999. Changes in chemical composition of guava fruits during growth and development. *Indian J. Hort.*, 56 (1): 10-18.

Singh, H.K., Singh, O.P., Dutt, S.N. and Dutt, A.S. 1998. Studies on fruit growth and development in kinnow. *Indian J. Hort*., 55 (3): 177-182.

Singleton, V.L. and Rossi, J.A. Jr. 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungtic acid reagent. *American Journal of Ecology and Viticulture*, 16: 144-158.

Singleton, V.L., Orthofer, R. and Lamuela-Raventos, R.M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteau reagent. *Methods in Enzymology*, 299 : 152-178.

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SHORT COMMUNICATION

Spathe Initiation and Bunch Characteristics in Date Palm cultivars under arid condition

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The date palm (*Phoenix dactylifera* L.) is one of the important and potential fruit crop of arid irrigated regions of India. It is being grown in the states of Gujarat and Rajasthan. Recently, its plantation has been successfully done in the dry areas of Tamil Nadu. It requires almost rain free conditions during the fruiting season particularly at the time of fruit ripening because of spoilage of fruits due to rains. Such conditions are partially or completely met in the Thar desert especially in Western districts of Rajasthan (Bikaner, Jaisalmer and Barmer) and parts of Kacchh district of Gujarat. It is very hardy tree and is high tolerance to salt, $EC_e \times 10^3 = 18$. The demand and consumption of date palm fruits in India of all three types *viz.*, table dates, soft dates and dry dates is high but the production is very less. Farmers have not yet commercialized date palm cultivation mainly due to lack of information regarding suitable cultivars for the region. The performance of date palm cultivars was therefore, studied under the Bikaner agro-climatic conditions.

Eight date palm (*Phoenix dactylifera* L.) cultivars grown at an orchard in Date palm Research Centre, SKRAU, Bikaner were used in this investigation. Eight date palm cultivars were included *viz.* Halawy, Barhee, Zahidi, Khadrawy, Khuneizi, Khalas, Shamran and Nagal for study. The trees were about 30 years age old. Three replications (two trees in each replication) were selected from each cultivar. Period of spathe initiation, colour turning stage and full doka stage were recorded. For bunch characteristics viz., length of bunch, length of bunch stalk, number of strands, number of berries per strand and length of strand during the first week of February to Last week of August, 2011-12. All bunch characteristics were based on 10 samples per tree.

Spathe initiation and fruit ripening (colour turning and doka stage)

The data presented in Table 1 give the detailed information of spathe initiation timings of different date palm cultivars. During both the years, the spathe initiation started almost at the same time (month of February) in cultivars, *viz*. Khuneizi, Halawy, Khadrawy and Shamran and in remaining cultivars, *viz*. Barhee, Zahidi and Khalas, the spathe emerged in month of March. According to Chandra *et al*. (1990), the earliest spathe initiation occurred in Khadrawy and very late in cv. Barhee. Similarly, Chandra and Chaudhary (1990) also reported the similar findings but the timings were somewhat late compared to present findings. It has been reported that it varies from year to year even at a particular location and cultivars (Chandra *et al.*, 1990).

The details of attaining initiation of *doka* in fruits of different cultivars under study have been presented in Table 2. In first year, colour turning stage (initiation of *doka*) was attained in the month of June-July. The cultivars Nagal, Khuneizi and Halawy attained this stage between 10-15th June, whereas, the cultivars Zahidi, Khadrawy and Khalas attained it in last week of June (20-27 June) and cultivars Shamran and Barhee in first week of July. Similar trend was observed during second year.

The details of attaining full *doka* in fruits of different cultivars under study have been given in Table 2. During first year (2011), the full *doka* stage of fruits was attained earliest in cv. Nagal (30 June) followed by Halawy (2 July), Khuneizi (7 July), Zahidi (14 July) and Khalas (21 July). Barhee fruits reached at this stage at the last (2 August). During second year (2012), almost similar trend was observed. Similar findings were observed by Chandra *et al.* (1990) and Dahiya *et al.* (2001). Chandra *et al.* (1990) reported that *doka* was formed earliest in Halawy. These stages may vary due to cultivars and location. It may also change from year to year due to climatic changes (Chandra *et al.*, 1990).

Bunch characteristics

The average bunch length varied from 33.75 cm in Nagal to 71.19 cm in Barhee. The length of bunch stalk was between 30.81 cm in Nagal and 60.44 cm in Barhee. The number of strands per bunch was in 60.08 in Barhee followed by 43.50 in cultivar in Khuneizi and minimum in 32.67 in Khadrawy. The number of berries

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per strand was maximum of 18.70 in Barhee, 16.31 in Zahidi and 14.04 in Khadrawy and minimum of 9.45 in Nagal whereas the average length of strand varied from 11.01 cm in Khalas, 11.65 cm in Khalas to 17.96 cm in Zahidi (Table 3.).

In another study at Bikaner, it was reported that maximum number of bunches per palm were recorded in cv. Barhee (*Anon*., 1995). Chandra and Chaudhary (1990) reported maximum average number of bunches in cv. Halawy. In the present study, the maximum length of bunch was recorded in cv. Barhee and minimum in cv. Nagal. It is in conformity to earlier report at Bikaner during the year 1995 (*Anon*., 1995). Earlier study at Bikaner also revealed maximum bunch stalk length in Barhee (*Anon*., 1995 and Chandra and Chaudhary, 1992).

Present findings regarding number of strands are in conformity with the findings of Chandra and Chaudhary (1992) and Chandra *et al.* (1995). In contrast, other Researchers observed higher values of strand length at Bhojka, Bikaner and Abohar (Chandra and Chaudhary, 1992 and *Anon*., 2007). Maximum number of berries per strand were recorded in cv. Barhee and minimum in cv. Nagal. The results are in conformity with earlier findings at Date Palm Research Centre, Bikaner which also mentioned maximum berries per strand in Barhee (*Anon*., 1995).

The bunch parameters varies from cultivars, age and location. The lower values of bunch parameters were may be due to deficit irrigation, application of manures and fertilizers, cultural operations including hoeing and weeding.

Table 1. Spathe initiation of date palm cultivars

S. No.	Cultivars	Spathe initiation			
		2011		2012	
		From	To	From	To
1.	Shamran	28, Feb	19, Mar	07, Mar	04, Apr
2.	Nagal	24, Feb	04, Mar	05, Mar	23, Mar
3.	Khuneizi	26, Feb	17, Feb	12, Mar	08, Apr
4.	Halawy	22, Feb	10, Mar	08, Mar	28, Mar
5.	Barhee	20, Mar	23, Apr	24, Apr	12, May
6.	Zahidi	02, Mar	27, Mar	04, Apr	22, Apr
7.	Khadrawy	25, Feb	23, Apr	05, Mar	29, Mar
8.	Khalas	11, Mar	30, Apr	09, Apr	2, May

Table 2. Fruit ripening of date palm cultivars

S. No.	Cultivars	Colour turning stage		Full *Doka* stage	
		2011	2012	2011	2012
1.	Shamran	01, Jul -05, Jul	25, Jul -30, Jul	17, Jul -22, Jul	10, Aug - 15, Aug
2.	Nagal	10, Jun -22, Jun	15, Jun - 22, Jun	30, Jun -05, Jul	07, Jul -12, Aug
3.	Khuneizi	15, Jun - 29, Jun	30, Jun -05, Jul	07, Jul -12, Jul	18, Jul -16, Aug
4.	Halawy	12, Jun - 27, Jun	28, Jun -03, Jul	02, Jul -09, Jul	12, Jul - 20, Jul
5.	Barhee	07, Jul - 11, Jul	30, Jul -06, Jul	02, Aug -11, Aug	19, Aug -28, Aug
6.	Zahidi	20, Jun -27, Jun	02, Jul -12, Jul	14, Jul -22, Jul	24, Jul - 02, Aug
7.	Khadrawy	25, Jun - 29, Jun	12, Jul -25, Jul	17, Jul -25, Jul	01, Aug -10 Aug
8.	Khalas	27, Jun - 04, Jul	10, Jul -19, Jul	21, Jul -28, Jul	29, Jul -05, Aug

Table 3. Bunch Characteristics of date palm cultivars

S. No.	Cultivars	Length of bunch (cm)	Length of bunch stalk (cm)	Number of strands per bunch	Number of berries per strand	Length of strand (cm)
1.	Shamran	58.33	46.24	40.57	12.10	13.05
2.	Nagal	33.75	30.81	40.42	9.45	12.07
3.	Khuneizi	40.86	35.06	43.50	12.99	17.96
4.	Halawy	51.79	41.79	41.54	13.17	13.75
5.	Barhee	71.19	60.44	60.08	18.70	14.06
6.	Zahidi	62.23	51.99	33.46	16.31	12.58
7.	Khadrawy	44.84	37.31	32.67	14.04	11.01
8.	Khalas	51.97	41.82	38.73	10.36	11.65
	S.Em $\pm$	1.98	1.82	1.52	0.54	0.48
	CD at 5%	5.72	5.27	4.39	1.57	1.37

Refrences

Anonymous. 1995. Annual Report, All India Coordinated Research Project on Arid Zone fruits, ICAR, Technical document.

Anonymous. 2007. Annual Report, All India Coordinated Research Project on Arid Zone fruits, ICAR, Technical document.

Chandra, A., Chaudhary, N.L. and Manohar, M.S. 1995. Bunch characteristics and yield potential of promising date palm varieties at Bikaner. National Symposium in Advances in Research and Development in Horticulture for Export at CCS Haryana Agricultural University (Hisar) , Jan 28-30, 1995. Pp 5.

Chandra, A. and Chaudhary, N.L. 1990. Performance of date palm cultivars in Thar desert. Part II. *Curr. Agric*., 14: 1-4.

Chandra, A. and Chaudhary, N.L. 1992. Bunch characteristics and their co-relation in date palm cultivars at Bikaner. *Curr. Agric*., 16 (1-2): 79-83.

Chandra, A., Swaminathan, R., Chaudhary, N.L., Manohar, M.S. and Pareek, O.P. 1990. Performance of date palm cultivars in Thar dessert. Part I. *Indian J. Hort*., 47(1): 28-33.

Dahiya, D.S., Bhatia, S.K., Chharia, A.S. and Singh, D. 2001. Performance of date palm cultivars under semi arid conditions of Hissar, India. In Proc. : The IInd International conference on date palm, 25-27 March 2001, Al-Ain, UAE. Pp. 789.

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SHORT COMMUN ICATION

Papaya cultivation brought socio-economic and nutritional security in Sirohi tribals of Rajasthan: A case study

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Cultivation of fruits played a pivotal role in diversification of agriculture alongwith food and nutritional security of ever growing population. Papaya (*Carica papaya*) is a tropical fruit having commercial importance because of its high nutritive and medicinal value. India leads the world in papaya production with an annual output of about 3.6 million tonnes (Anonymous, 2009). Sirohi is among the top districts in papaya cultivation in Rajasthan. Presently, papaya is an important fruit crop of the district and cultivated in 563 ha. (Anonymous, 2011). It is used as ripened fruit and vegetable and easy to digest. Papain prepared from dried latex of its raw fruits is used in meat tendering, manufacturing chewing gum, cosmetics, for degumming silk and to give shrink resistance to wool. In addition, it is also used in pharmaceutical, textile and garment industries, cleaning paper and adhesive manufacturing, sewage disposal and so on (Anonymous, 2002). The average yield of papaya is 550 q ha^{-1}, but the farmers were facing some problems in papaya cultivation like availability of quality seed and seedling, pollination problems due to single sex plant, lower shelf-life of fruit, fruit marketing, lack of advance knowledge about papaya production, resulting in poor plantation and lowered economic return. So, KVK, Sirohi has developed institutional and technical models for poverty alleviation, sustainable development in agriculture and equitable development of rural farmers and raised the income of tribal's by providing them quality training in various aspects of horticulture (especially papaya production), technical resources (demonstration, exposure visit, exhibition), technical guidance for agricultural inputs (seed, fertilizer and pesticides), quality planting material (papaya seedling variety Red lady), formation of farmers interest groups (papaya village) and marketing (harvesting, grading, packing and transportation) of papaya fruits. The Taiwan Red-Lady variety of papaya fruit has brought smile on the faces of several papaya farmers in Sirohi district. The imported variety of the fruit has brought wonders owing to its great quality, long shelf life, hermaphrodite nature, fruit taste and, of course, profitability. KVK provided quality seedling of variety Red lady with locally standardized package of practices and formed papaya growers groups for increased papaya plantation. Farmers groups or organizations were to protect and increase the interest of farmers, increase production, enhance knowledge and skills, use of appropriate technologies and improving quality of life (Shan, 1995). Nutrition garden is especially important in rural areas where people have limited income-earning opportunities and poor access to markets. Home gardens are also becoming an increasingly important source of food and income for poor households in rural tribal areas. These gardens have an established tradition and offer great potential for improving household food security and alleviating micronutrient deficiencies. A well-developed home garden has the potential, when access to land and water is not a major limitation, to supply most of the non-staple foods that a family needs every day of the year, including roots and tubers, vegetables and fruits, legumes, herbs, spices, animals and fish. Roots and tubers are rich in energy and legumes are important sources of protein, fat, iron and vitamins. Green leafy vegetables and yellow- or orange-coloured fruits provide essential vitamins and minerals, particularly folate, and vitamins A, E and C and other bio-active compound. Papaya fruit is a rich source of vitamin A and C with different minerals. It has a high nutritive and medicinal value, so provide nutritional security to the rural and tribal families (Mohanty, 2012 and Nayak *et al.,* 2012).

The study was conducted in the working area of Krishi Vigyan Kendra-Sirohi. Main target group was tribal farmers engaged in papaya cultivation. The farmers groups were divided in two categories on the basis of crop production i.e. field crop grower and field crop grower with papaya cultivation. The present study was conducted to know the impact of papaya production on socio-economic development and nutritional security of farmer's families. All the

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commercial papaya growers were main respondents for collection of socio-economic observations from whole district. Data was collected from selected five villages of the district for measuring nutritional security through backyard nutritional gardening. From each village 50 farm women and total 250 women were selected through equal allocation using purposive sampling technique with the hope of representing the whole experimental area.

For this study a well designed questionnaire was developed and pre-tested. Primary data was collected with the help of a questionnaire. For studying socio-economic impact all the prominent commercial papaya growers (243 farmers) were interviewed. Two hundred fifty farm women respondents of the selected five villages were interviewed for nutritional security observations during experimentation of last four years. The respondents were interviewed in their houses, farms, gram sabha meetings and working labour was interviewed directly at the time of working at papaya fields. These places were selected for the convenience of respondents and for creating congenial situation, where both sides (researcher and respondent) exchanged their views frankly and informally by the help of local personnel (village level workers). The questionnaire mostly contained closed end questions and it was designed in English but the questions were asked in Hindi and local language (Marwari) in order to avoid confusion. During interview every effort was made to explain the questions and its purpose, to collect correct and reliable information. For supporting the results of primary data (labour record of progressive farmers), the secondary information was collected from published and unpublished sources. After collection of data, a tally sheet was prepared which facilitated the enumeration of answer of each question. By using descriptive statistics the data was analyzed by calculating simple percentages. The data was arranged in tables in very simple manner for clarity.

Contribution in district economy

The results shown in Table 1 indicated that papaya cultivation played very important role in district economy since last four years. Due to short duration, high yield, good market value the farmers started earning three to four times more than field crops production. More than 2.36 lakh papaya plants were planted in 95 hectare area. Out of total plantation, 13 per cent plants got damaged before production, remaining plants (2.05 lakhs) were producing 89.0 kg fruits during economic production life. Total production of papaya during last four years was 18.19 thousand tonns and their market value was Rs. 14.57 crores (3.64 crores per annum) (Table 1). Total net return of papaya was Rs. 12.02 crores (3.00 crores per annum) with 4.77 benefit: cost ratio as reported during experimentation (2008-2011) in the district. Number of farm families involved in papaya production was 243 and in primary processing of papaya was 155 with 40,565 mandays employment generation during last four years (Table 1). Similar results were also reported by Biswas (2010) mentioning that papaya produces more income per unit area only next to banana and have high nutritive and medicinal value.

Contribution in nutritional security

The results in Table 2 depicted that the nutrition garden with papaya plants play very important role in increased fruit consumption of the rural families. Before establishment of nutrition garden average fruit consumption was very low (161.0 kg/year), whereas in papaya based nutrition garden (5-15 plants) fruit consumption of the farm families increased and started consuming 280 kg more fruits than without nutrition-garden families. Similar results were also reported by Mohanty, 2012 and Nayak *et al.* 2012.

Effect on socio-economic status

The results in Table 3 depicted that the papaya grower earned 111.11 per cent more than field crop growers. By adopting papaya cultivation, employment generation increased upto 192 mandays /ha, which means an increase of about 18240 mandays in 192 ha area of the district. Socioeconomic status of tribal farmers was directly affected by papaya cultivation. The papaya producers made cemented houses (37%), purchased utility facilities like radio, T. V., C. D. player, bed, storage bin etc. (40%), maintained bank account with more than Rs. 10,000 balance (52%), gave good education to children (27%), purchased improved agricultural implements (32%), had active participation and interaction with extension workers (68%), had personal transportation facilities (58%), maintained telephone or mobile facilities (42%), greater adoption of new technology (42%), better understanding of urban society (27%), greater awareness about health and hygiene (27%), participation in social works (29%), change in behavior and thought (28%). Women participation in decision making was also increased by adoption of papaya production (32%) as compared to 15 per cent in field crop growers respondents. Biswas (2010) and Bhardwaj *et al.* (2011) also reported that the growing of papaya played significant role in the socio-economic development of the country as provider of food, foreign exchange earner, employment and income generator.

Effects of various constraints identified in popularizing papaya cultivation

The results in Table 4 showed that there were different problems faced by the respondents of the study area. The field crop growers faced more problems than

the papaya growers. The papaya growers faced minimum problems, like capital problem (20%), adoption of technology (32%), availability of technology (32%), marketing problems (48%), credit availability (37%), restriction of society (15%), transportation (25%), distance from market (35%), education facilities (30%), water scarcity (50%), fruit glut (20%), lack of regulated market (25%), lack of storage facilities (40%), exploitation by commission agent (17%), availability of quality seed and seedling (15%) and transportation of seedling (22%). Similar results were also reported by Ahmad *et al.* 2007; Bhardwaj *et al.* 2011.

In tribal and rural areas poverty is also a major problem due to lack of capital. Farmers faced difficulties in obtaining credit which is generally due to the lengthy and time consuming procedure, illegal demands of revenue staff and bank functionaries. Market plays a dual role i. e. supply of inputs and consumes farmer's surplus produce. There was no proper formal market available in the study area that would enable the farmers to the sell their products in time. Lack of transportation facilities was the main hurdle in marketing of fruits. Availability of input supply like seedling, pesticides, fertilizer, and advance technology like hi-tech horticulture facilities was greatly affected due to the distance from market. Lack of irrigation facility and good quality water was a big constraint in raising papaya. The fruit being perishable in nature poses problem in marketing. Development of infrastructure facilities for transportation to primary markets, standardization of packaging techniques are aspects which need special attention. Processing facilities also need to be created in the area for value addition.

The interventions of Krishi Vigyan Kendra Sirohi relating to popularization of papaya production by supply of quality seedling, farm inputs, training opportunities and field demonstrations increased the quality production of papaya manifold and contributed immensely to socio-economic development of the tribal farmers in Sirohi. A significant change was observed in

Table 1. Income and employment generation through papaya production and primary processing in district Sirohi

Particulars	Year of papaya plantation			
	2008-09	2009-10	2010-11	2011-12
Source of papaya plants				
Papaya seedlings prepared by farmers	9850	14500	20000	12700
Seedlings prepared by KVK-Sirohi	24970	20000	14900	11750
Seedlings prepared by private nurseries	25000	24441	32453	25569
Total plantation in last 4 years	59820	58941	67353	50019
Total area in papaya cultivation (ha) (2 x 2 meter spacing)	24.0	24.0	27.0	20.0
Field mortality and other damage of papaya plants (13%)	7777	7662	8756	6502
Total fruit producer plants	52043	51279	58597	43517
Average yield of papaya/plant (kg) (In two-three year economic life of papaya)	85.0	85.0	90.0	95.0
Total yield of papaya (ton)	4423.65	4358.71	5273.73	4134.11
Average market rate (on field marketing), (70% farmers sale on field)	5.0 (3096.56 ton)	6.0 (3051.10 ton)	6.0 (3691.61 ton)	7.0 (2893.87 ton)
Average market rate (whole sale in market) (20% farmers sale on field)	10.0 (884.73 ton)	10.0 (871.74 ton)	11.0 (1054.74 ton)	13.0 (826.82 ton)
Average market rate (retail marketing) (10% farmers sale on field)	15.0 (442.36 ton)	15.0 (435.87 ton)	17.0 (527.38 ton)	18.0 (413.41 ton)
Total income (Rs. in lakhs)	309.655	335.6205	427.1726	384.4713
Net income (Rs. in lakhs)	249.66	272.02	352.92	328.47
B:C ratio	4.16	4.28	4.75	5.87
Number of farm families involved in papaya production	50	65	72	56
Number of farm families involved in papaya primary processing	35	40	43	37
Total employment generation per year (man days/annum)	10248	10248	11529	8540

socioeconomic condition of respondents as they started earning upto Rs. 2.25 lakh/ha per annum. Papaya based nutrition garden increased fruit consumption of the farm families. Thus, papaya production proved a milestone in tribal farmer's empowerment by providing social, economic, employment, health and nutrition security. Based on the findings of this research work, it can be concluded that papaya growers are the key persons for improving their socio-economic status. Also, they faced certain problems like inadequate support from government and donor agencies for credit facilities, access to markets, storage facilities, appropriate technology and small farm machineries which need to solved.

Table 2. Contribution of papaya plantation in nutritional security through backyard nutrition gardening

Particulars	Year of backyard nutritional garden establishment			
	2008-09	2009-10	2010-11	2011-12
Establishment of backyard nutritional garden	825	1113	1530	1532
Number of plants in nutritional garden	5-15	5-15	5-15	5-15
Survived plants in nutritional garden	8	7	6	7
Average yield of papaya (kg) (40 kg/year upto 3 years)	320	280	240	280
Average fruit intake of family before gardening (kg/year)	150	162	157	175

Table 3. Socio-economic impact of papaya plantation on respondent groups

Essential components	Field crop grower	Field crop grower with papaya cultivation
Average annual income (Rs.)	135000	285000
Employment generation (mandays/ha)	235	427
Construction of cemented houses	13.0	37.0
Utility facilities (Radio, TV, CD player, bed , storage bin etc.	19	40
Bank account with more than Rs. 10000 balance	17	52
Children education in good school	15	27
Improved agricultural implements	15	32
Participation and interaction with extension workers	35	68
Personal transportation facilities (cycle, motorcycle, car)	20	58
Adoption of new technology	17	42
Understanding about urban society	17	42
Awareness about health and hygiene	19	27
Participation in social works	23	29
Change in behaviour and thought	16	28
Telephone and Mobile facilities	30	47
Women participation in decision making	13	32

Table 4. Effect of various constraints identified in popularising papaya plantation in tribal areas

Constraints	Field crop growers	Field crop grower with papaya cultivation
Capital problem	52	20
Adoption of technology	63	32
Availability of technology	65	32
Marketing problems	52	48
Production technology of papaya	65	15
Credit availability	60	37
Restrictions of society	42	15
Transportation	55	25
Distance from market	57	35
Education facilities	70	30
Water scarcity	60	50
Fruit glut	00	20
Lack of regulated market	30	25
Lack of storage facilities	28	40
Exploitation by commission agent	35	17
Availability of quality seed	00	15

References

Ahmad, M., Nawab, K., Zaib, U. and Khan, I. A. 2007. Role of women in vegetable production: A case study of four selected villages of district Abbottabad. *Sarhad Journal of Agriculture*, 23(4): 1173-1179.

Anonymous, 2002. Hand Book of Horticulture, edited by Dr. K.L. Chadha, published by Directorate of information and publications of Agriculture, ICAR, KAB, Pusa, New Delhi 110012.

Anonymous, 2009. Indian Horticulture Database-2009. Ministry of Agriculture, Government of India, Gurgaon, pp. 5.

Anonymous, 2011. Agricultural vital. Ministry of Agriculture, Government of Rajasthan, Jaipur, pp. 29-35.

Biswas, B.C. 2010. Success stories of papaya farmers. *Fertilizer Marketing News*, 41 (2): 15-18.

Bhardwaj, R.L. Singh, N. Meena, C.B. Dadhich, S.K. Agrawal, S.K. and Ojha, S.N. 2011. Baseline survey about "Role of papaya plantation in district economy" in Sirohi district of Rajasthan. Krishi Vigyan Kendra, Sirohi.

Jamali, K. 2009. The role or rural women in agriculture and its allied fields: A case study or Pakistan. *European Journal of Social Science*, 7(3): 71-77.

Mohanty, M. 2012. Household food security through homestead gardening-A study in rural Odisha. Abstracts of global conference on women in agriculture, New Delhi.

Nayak, H., Ram, N., Singh, S., Singh, L.B., Subhash Chand, Singh, D.R., Ambast, S.K. and Singh, A.K. 2012. Kitchen garden: A household source of nutrition. Abstracts of global conference on women in agriculture, New Delhi.

Shan, L.F. 1995. Building farmer's organizations system in a developing country: Taiwan's Experience, Published by Maw Chang Book Company 2F-3, No. 88, Section 3, Taiwan, R.O.C, pp. 235-246.

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SHORT COMMUN ICATION

Effect of plant growth regulators on yield and quality of guava (*Psidium guajava* L.) cv. Allahabad safeda

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Guava (*Psidium guajava* L.) is one of the most important and extensively cultivated tropical crop of India. It is good source of vitamin-C, pectin, also contains fair amount of calcium and widely used for making of jelly. The ascorbic acid content of guava is four-five times higher than the citrus fruit. It is hardy fruit which can be grown in alkaline and poorly drained soil. Important guava growing states in the country are Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Andhra Pradesh, West Bengal, Tamil Nadu, Gujrat, Punjab, Assam, Karnataka, Orissa, Kerala and Rajasthan. Allahabad district of Uttar Pradesh has the reputation of growing the best quality of guava fruits in the world (Mitra and Bose, 1990).The three times flowering seasons have been observed in North Indian conditions while two flowering seasons have been reported in the climatic condition of Assam. This fruit crop has immense potential in increasing productivity and yield sustainability in Assam. In Assam, guava occupies 4.522 thousand hectare of area and it produces 87.195 MT of guava with 19282 kg per hectare of productivity (Anon., 2009).The plant growth regulators play very important role in flower induction in many plants. The process of pollination and fertilization induces production of growth regulators in the ovary, the ovary enlarge and fruit development is initiated. However, good fruit set is prevented by adverse weather which hinders pollen production, pollination and fertilization and also low level of auxin. The auxin from the pollen grain and pollen tube might be responsible for the early stage of fruit growth. However, small amount of pollen necessary to pollinate a flower may not carry enough auxin to account for early fruit development. The growing pollen tube may secrete auxin which helps in fruit growth (Muir, 1942). Exogenous application of plant growth regulators (PGRs) not only increases the number of flower but also increases the quality of fruit and retention capacity of on the tree till maturity and reduces fruit drop.

The percentage of flowering and fruiting, poor fruit retention, poor yield and quality fruits are of major concern of the fruit growers. So, the present investigation was undertaken to find out response of plant growth regulators on yield and quality of guava.

The study was conducted in the orchard of Assam Agricultural University, Jorhat during 2009. Six years old plants of uniform size planted at 6 x 6 m in square system were selected for the studies. The experiment was laid out under Randomized Block Design with 11 treatments having three replications. The Orchard is located at 26°47N latitude and 94°12E longitude having an elevation of 86.6 meters above the mean sea level. The experimental location was considered to be well drained with a uniform topography. The climate condition of Jorhat as a whole is sub-tropical humid having hot and dries summer and cold winter. The average monthly rainfall was 36.53 to 137.46 mm with heavy rains from April to September month. During the experimentation September and July was recorded hottest and coldest month, respectively. Chemical analysis was done by AOAC 1975.

Details of the treatments

There were five plant growth regulators selected for the experiment. These regulators were used in two concentrations in each. For reference letters keys were used as notation to designate the growth regulators and their concentration.

Growth Regulators	Concentration	Notation
Control	Water spray	T_0
2,4-D	10 ppm	T_1
2,4-D	20 ppm	T_2
NAA	50 ppm	T_3
NAA	100 ppm	T_4
GA_3	50 ppm	T_5
GA_3	100 ppm	T_6
Ethrel	50 ppm	T_7
Ethrel	100 ppm	T_8
CCC	500 ppm	T_9
CCC	1000 ppm	T_{10}

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Yield

The fruit retention per shoot at harvest was the final yield of crop. The highest yield (37.13kg/plant) was found in 50 ppm GA_3 treatment and lowest yield (12.16kg/pant) was found in control. The increase yield under this growth regulators treatment was associated with increase the number of fruit, low percentage of fruit drop, more fruit retention and increased fruit size and weight. This result is in conformity the earlier report by Shawky *et al.*, 1978 in mango and Shikhamany and Reddy, 1989 in grape.

Pulp weight and juice content

A marked increase in pulp weight and juice content was recorded when the plants were sprayed with different growth regulators. The highest pulp weight (173.0g) and juice content (63.17 cc) were recorded under 50 ppm GA_3 treatment while lowest pulp weight (75.40g) and juice content (25.23 cc) were recorded under control. The possible reason in this regard might be due to an enhanced deposition of solids in increased cell size and intercellular space which coupled with accumulation of water as reported by Coombe, 1960 in seeded and seedless variety of grape.

TSS

The effect of various plant growth regulators on total soluble solids content was found to be significant. The highest TSS content (12.50%) was recorded in 50 ppm GA_3 treatment while minimum (7.90%) was found in control. This significant response in improving TSS content of fruit might be explained that GA_3 stimulated the functioning of number of enzyme in the physiological process which probably caused and increased in TSS content of fruit as reported by Singh *et al.*, 1986 in mango.

Titrable acidity

Titrable acidity influenced significantly by various treatment. The lowest Titrable acidity (0.16%) was found in 50 ppm GA_3 treatment while maximum acidity (0.34%) was reported under control. The reason for reduction in acidity in growth regulators applied treatments may be due to rapid utilization of organic acid during respiration at maturity as reported by Thakur *et al.*, 1990 in litchi.

Ascorbic acid

The ascorbic acid content of fruit pulp was significantly influenced by the various treatments. The highest ascorbic acid content (135.30mg/100g) was reported in 50 ppm GA_3 while lowest (64.27mg/100g) was found in control. The possible reason for increase in ascorbic acid of fruit by GA_3 treatment might be due to perpetual synthesis of glucose-6-phosphate throughout the growth and development of fruit which is thought to be the precursor of vitamin-C as reported by Kumar and Singh, 1993 in mango.

Total sugar

The highest total sugar content (10.13%) was found in 50 ppm GA_3 while lowest (6.30%) was reported under control. The possible reason for increased sugar content in GA_3 treatment might be due the increased the activity of the hydrolytic enzyme which converted the complex polysaccharides into simple sugar. Growth regulators also increase translocation of photosynthetic metabolites from other parts of the plant towards to developing fruits. This finding is in conformity with the result of Kumar *et al.*, 1998 in guava.

Reducing sugar

It is clear from the Table 2 that the reducing and non-reducing sugar content were affected due to various growth regulators. The maximum reducing sugar (5.30 %) was recorded under 50 ppm GA_3 (T_5) treatment and minimum reducing sugar content (3.80 %) was found under control (T_0). The maximum non-reducing sugar (4.80 %) was under 50 ppm GA_3 (T_5) and minimum (2.50 %) was found in control (T_0) .The reason for increase in the content of reducing sugar and non-reducing sugar might be due to delayed the ripening of fruit and provided a long period of fruits to be remained on tree during which they accumulated more carbohydrates within them as reported by Singh *et al.* (1986) in mango.

Seed content and pulp-seed ratio

It is evident from Table 1 that the highest seed weight (6.67 g) was recorded under 50 ppm GA_3 (T_5) treatment and lowest (3.60 g) in 100 ppm NAA (T_4) treatment. The reason for increasing in seed weight might be due to larger size and maximum fruit weight and also larger seed size in 50 ppm GA_3 (T_5) treatment. The lowest seed weight was under 100 ppm NAA (T_4), it might be due to small size of seed.

The data presented in Table 2 revealed that maximum (31.3) pulp-seed ratio was found under 100 ppm GA_3 (T_6) and minimum (16.7) was under control (T_0). The possible reason for increasing pulp-seed ratio under GA_3 treated plant might be due to more pulp content and reduced seed weight of fruit.

Sugar-acid ratio

A marked increase in reducing sugar-acid ratio was recorded when the plants were sprayed with different growth regulators (Table 2). The highest ratio (33.13) was recorded under 50 ppm GA_3 (T_5) treatment

Table1 . Effect of plant growth regulators on quality parameters of guava:

Treatments	Yield/plant	Pulp weight (g)	Juice content (cc)	Seed weight (g)	TSS (%)	Total sugar (%)	Ascorbic acid (mg/100g)	Titrable acidity (%)
Control	12.17	75.40	25.23	4.50	7.90	6.30	64.27	0.34
2,4-D-10 ppm	19.73	85.20	29.50	4.73	11.50	9.50	115.27	0.18
2,4-D-20 ppm	16.23	104.9	37.63	4.20	9.40	8.00	84.47	0.27
NAA-50 ppm	25.97	103.0	39.33	5.67	11.20	9.20	104.40	0.19
NAA-100 ppm	15.70	104.6	39.17	3.60	10.10	8.50	89.73	0.25
GA_3-50 ppm	37.13	173.0	63.17	6.67	12.50	10.30	135.30	0.16
GA_3-100 ppm	28.93	140.1	50.83	4.50	10.40	8.70	92.33	0.24
Ethrel-50 ppm	23.10	124.3	46.23	4.87	9.90	8.20	88.40	0.27
Ethrel-100 ppm	26.50	102.0	34.77	4.00	8.80	7.10	73.83	0.30
CCC-500 ppm	24.23	113.3	47.33	4.20	10.70	8.90	98.43	0.22
CCC-1000 ppm	32.53	101.1	34.27	4.23	10.40	8.70	92.37	0.24
S.Em. ±	0.472	0.84	1.13	0.23	0.19	0.19	2.48	0.01
CD (5%)	0.984	2.48	2.35	0.49	0.40	0.40	5.19	0.3

Table 2. Effect of plant growth regulators on quality parameters of guava:

Treatments	Reducing sugar (%)	Non-reducing (%)	Pulp-seed ratio	Reducing sugar-acid ratio	Fruit Colour at maturity	Pulp texture	Benefit:Cost ratio
Control	3.80	2.50	16.7	11.20	Light green	Smooth	1.10:1
2,4-D-10 ppm	5.10	4.40	18.0	28.63	Light green	Smooth	1.78:1
2,4-D-20 ppm	4.30	3.70	25.0	15.90	Light green	Smooth	1.47:1
NAA-50 ppm	4.80	4.40	18.1	25.27	Light yellow	Granular	2.34:1
NAA-100 ppm	4.47	4.03	29.1	17.97	Light yellow	Granular	1.41:1
GA_3-50 ppm	5.30	4.83	25.9	33.13	Light green	Granular	3.19:1
GA_3-100 ppm	4.90	3.80	31.3	20.60	Light green	Granular	2.30:1
Ethrel-50 ppm	4.40	3.80	25.5	16.50	Light yellow	Granular	2.08:1
Ethrel-100 ppm	3.80	3.30	25.5	12.70	Light yellow	Granular	2.37:1
CCC-500 ppm	4.90	4.00	27.0	22.37	Light green	Smooth	2.05:1
CCC-1000 ppm	4.60	4.10	23.9	18.13	Light green	Smooth	2.60:1
S.Em. ±	0.14	0.19	0.92	1.646			
CD (5%)	0.30	0.39	2.72	3.434			

and lowest ratio (11.20) was observed under control (T0). The reason for increasing sugar- acid ratio by GA_3 treated fruit might be due related to increased sugar content and reduced acid content of fruits.

Pulp texture and Fruit colour

The data presented on Table 2 showed the effect of plant growth regulator on texture and colour of fruits. However, texture was ranged from smooth to granular and colour from light green to light yellow.

Table.1. Effect of plant growth regulators on quality parameters of guava:

References:

A.O.A.C. 1975. Official method of analysis Published by Agricultural Chemists. Washington, D.C

Anonymous, 2009. NEDFi Databank, Directorate of Horticulture and F. A., Govt. of Assam, http:// databank.nedfi.com.

Coombe, B.G. 1960. Relationship of growth and development to changes in sugars, auxins and gibberellin in fruit of seeded and seedless varieties of *vitis*. *Plant Physiol.*, 35: 241-250.

Freed, M. 1966. Method of vitamin Assay. The Association of vitamin Chemist, Inter Science Publishers, New York, 3rd ed. P. 287.

Kumar, P. and Singh S. 1993. Effect of GA_3 and Ethrel on ripening and quality of mango cv. Amrapali. *The Hort. J.,* 6 (1): 19-24.

Kumar, S.P. Singh, C. Verma, A.K. and Jain, B.P. 1998. Effect of potassium, nitrogen and gibberellic acid on yield attributed of guava (*Psidium guajava* L.). *Journal of Research, Birsa Agri. Univ.,* 10: 52-55.

Lane, J.H. and Eynon, 1923. Determination of reducing sugar by mean of fehling solution with methylene blue as internal indicator. J. *Soc. Chem. Industry.,* 13: 32-37.

Mitra, S. K. and Bose, T. K. 1990. Guava. In: Fruits Tropical and Sub- tropical (Eds. T. K. Bose and S. K. Mitra), Naya Prokash Calcutta, 278-303.

Muir, R.M. 1942. Growth hormone as related to the setting and development of fruit in *Nicotiana tabacum. Am. J. Bot.,* 29: 716-720.

Shawky, I., Zidan, Z., Thomi, A.El. and Dashan, D. 1978. Effect of GA_3 sprays on lime of blooming and flowering malformation in Taimour mango. *Egyptian J. Hort.,* 5 (2): 123-132.

Shikhamany, S.D. and Reddy, N.N. 1989. Effect of growth retardant on growth, yield and quality in grape cv. Thompson Seedless. *Ind. J. Hort.,* 46 (1): 31-37.

Singh, I.P. Singh, B.P. and Singh, S.P. 1986. Effect of 2, 4-D and GA_3 on fruit drop and fruit quality of mango (*Mangifera indica* L.) cv. Samar Bahist Chausa. *Haryana .J. Hort. Sci.,* 15(1-2): 29-32.

Singh, I.P., Singh, B.P. and Singh, S.P. 1986. Effect of 2, 4-D and GA_3 on fruit drop and fruit quality of mango (*Mangifera indica* L.) cv. Samar Bahist Chausa. *Haryana J. Hort. Sci.,* 15 (1-2): 29-32.

Thakur, S., Kumar, R., Brahmachari, V.S. and Sharma, R.K. 1990. Effect of different growth regulators on fruit set, retention and size of litchi. *Ind. J. Hort.,* 47(3): 305-308.

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SHORT COMMUNICATION

Impact of intercrop on incidence of *ber* fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae) under hot arid eco-system

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Ber (*Ziziphus mauritiana* Lamk.) is an important fruit tree grown under the arid and semi-arid region of India. Among the various insect pests infesting *ber*, fruit fly (*Carpomyia vesuviana* Costa) is most destructive and it destroys on an average of 24 persent of fruits (Lakra and Singh, 1984). The existing management strategies are solely relies upon the chemical pesticides and usage of bio-pesticides is also very limited. Use of synthetic chemicals is not economical and less attractive, while considering associated health hazards and environment. Summer ploughing, is an ecologically sound alternative to chemical control, which destroy the residual pupa and it is a recommended cultural practice against tephritid flies. However, often it fails to avoid the migrating population due to lack in synchronized soil cultivation among the growers. In this context, the intercropping of non host or pest repelling plants may be promising cultural method to check the pest intensity, for achieving more monetary return from a unit area per time. Growing annual crops like cluster bean and green gram between the *ber* rows as intercrops is a common and suggested practice under arid ecosystem as it increased on an average of 10 persent higher monetary returns over sole *ber* crop system (Patel *et al*. 2003). Intercrop also manipulates confusing environment and acts as repellents to arthropods to find its host. This could be an alternative method to curb the pests and boost the natural enemy populations in organic agriculture as it needs to avoid the use of synthetic pesticides (Lal *et al*., 2002). The possible alteration in microclimate and site-specific allelopathic interaction surrounding vegetation led the changes in incidence of insect pests and natural enemies. Though ample work has been done on *ber* fruit fly management, a meagre work is carried out in intercropping based management strategies. Hence, the present study was conducted to investigate the influence of intercropping on fruit fly incidence under hot arid ecosystem.

The experiment was conducted in existing ten year old *ber* cv. Gola tree plantation in the Experimental Block of Central Institute for Arid Horticulture, Bikaner, Rajasthan. Six treatments *viz*., *ber* + radish, *ber* + mustard, *ber* + coriander, *ber* + marigold, *ber* + barley and *ber* (sole crop as control) were imposed in the randomized block design with three replications. Sowing of annual crops was done during *rabi* 2008-09. Treatments were also imposed in three different spacing environments *viz*., 16 m x 12 m, 8 m x 8 m and 6 m x 6 m in the *ber* block, specially, developed to conduct the *ber* based farming system for hot arid environment. The recommended agronomic practices were carried out for both main crop (*ber*) and intercrops. The data on incidence of fruit fly were recorded from the first fortnight of October to till harvest. The observation was taken from randomly selected three branches/ treatment at fortnight interval. The per cent incidence was computed by subtracting total infested fruits with total number of fruits per branch. The data were analyzed with standard statistical package.

Among the six treatments, all the five intercrop combinations (Table 1) showed less incidence of fruit fly over sole *ber* (control), which was statistically significant. The trend was similar in all three different environments (spacing). At 16 m x 12 m spacing, the least damage of fruit fly was recorded in the combinations, *ber* + marigold (0.25 %) followed by *ber* + radish (0.51%) and *ber* + mustard (0.88%). The treatment consists of *ber* + coriander showed minimum fly attack (1.18%) followed by *ber* + mustard (1.56%) in 8 m x 8m planted rows. Under 6 m x 6 m spacing *ber* + marigold combination recorded least incidence (1.47%) followed by *ber* + radish (1.70 %), *ber* + mustard (2.27%) and *ber* + coriander (2.78%). *Ber* + mustard combination was comparatively better against fruit fly in all three different environments (Table 2.). The fruit

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fly attack was low (1.10%) in the wider row spaced (16 m x 12 m) combinations and it was inverse in closer planted rows of *ber* trees (Figure 1). The shade and slight alteration in microclimate around the canopies could be the reason for more fruit fly activity. Intercropping affects the pests by changing microclimate through change in canopies and physical factors (Goel and Tiwari, 2004); diverted orientation due to alteration in crop architecture (Elanchezhyan and Baskarom, 2008) and poly-culture create plant diversity, which affects the population dynamics of insect pests (Sinha *et al*., 2007). The results revealed that, the intercropping of non host plants could be unfavorable for fruit fly to finds its host and the reason might be due to either repellent action of annual intercrops or due to diversified environment. The marigold was found promising at 16 m x 12 m and 6 m x 6 m row spacing, while coriander gave encouraging results at 8 m x 8 m. The present result confirm the earlier findings marigold repelled Mexican bean beetle in bean, coriander repelled aphids in rose (Kianmatee and Ranamukharachchi, 2007) and low stem gall incidence on cotton in combination of cotton with marigold (Vaiyapuri *et al*., 2007). The study concludes

Table 1. Mean damage (%) of *ber* fruit fly (*Carpomyia vesuviana*) on *ber* based intercropping system

Treatments	Environments (spacing)			CD (0.05) bt/w spacing environments
	16 m x 12 m	8 m x 8 m	6 m x 6 m	
T1- *Ber* + radish	0.51 (0.74)^{a}	3.35 (1.82)^{ab}	1.70 (1.29)^{ab}	0.62
T2- *Ber* + coriander	1.10 (1.05)^{a}	1.18 (1.06)^{a}	2.78 (1.66)^{b}	0.38
T3- *Ber* + marigold	0.25 (0.62)^{a}	2.99 (1.72)^{ab}	1.47 (1.21)^{a}	0.33
T4- *Ber* + mustard	0.88 (0.93)^{a}	1.56 (1.24)^{b}	2.27 (1.50)^{ab}	0.31
T5- *Ber* +barley	1.27 (1.09)^{a}	2.81 (1.65)^{ab}	3.03 (1.74)^{bc}	NS
T6- *Ber* (sole)	2.61 (1.61)^{b}	4.51 (2.12)^{c}	4.87 (2.21)^{c}	0.23
SEd	0.21	0.19	0.12	
CD (0.05) *bt/w intercrop combinations	0.47	0.42	0.27	

Figure in parenthesis are *sqrt* transformed values

Table 2. Mean damage (%) of fruit fly (*Carpomyia vesuviana*) in intercrops combinations with different spacing environments

Spacing (meter)	*Ber* + radish	*Ber* + coriander	*Ber* + marigold	*Ber* + mustard	*Ber* + barley	*Ber* (sole)
16 x 12	0.51 (0.74)^{a}	1.10 (1.05)^{a}	0.25 (0.62)^{a}	0.88 (0.93)^{a}	1.27 (1.09)	2.61 (1.61)$_{a}$
8 x 8	3.35 (1.82)^{b}	1.18 (1.06)^{a}	2.99 (1.72)^{c}	1.56 (1.24)^{ab}	2.81 (1.65)	4.51 (2.12)$_{b}$
6 x 6	1.70 (1.29)^{ab}	2.78 (1.66)^{b}	1.47 (1.21)^{b}	2.27 (1.56)^{b}	3.03 (1.74)	4.87 (2.21)$_{b}$
Row means	1.84	1.69	1.57	1.54	2.37	3.99

Figure in parenthesis are *sqrt* transformed values

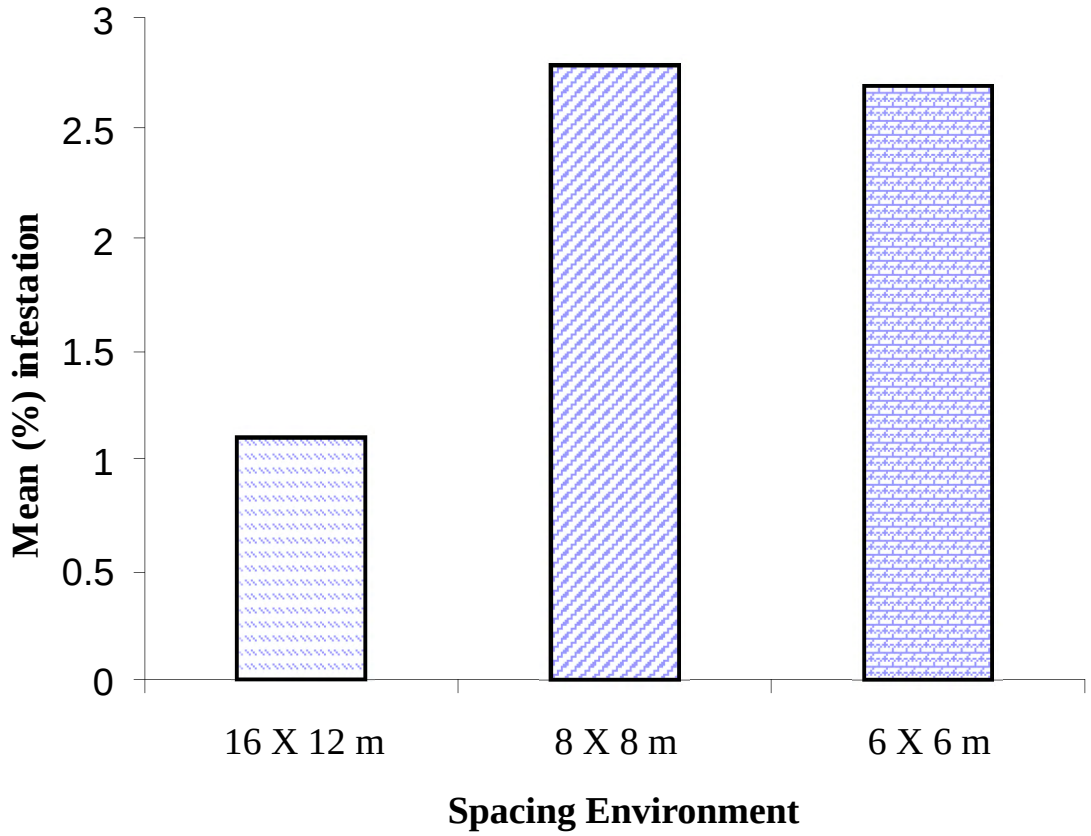

Figure 1. Damage level of fruit fly *Carpomyia vesuviana* Costa in different spacing environment

that, intercropping of pest repellent crops like mustard and marigold could be a viable option to curb the fruit fly incidence; thereby reducing the expenses on pesticide application. Further, such intercropping practices also brings additional monetary return in the *ber* based diversified farming through harvest of the intercrops.

References

Elanchezhyan, K. and Baskaran, M. 2008. Evaluation of intercropping system based modules for the management of major pests of brinjal. *Pest Management in Horticultural Ecosystem*, 14 (1): 67-73.

Goel, R. and Tiwari, M. 2004. Effect of intercropping on the incidence of *Lipaphis erysimi* in mustard. *Annals of Plant Protection Sciences*, 12: 435-436.

Kianmatee, S. and Ranamukharachchi, S.L. 2007. Pest repellent plants for management of insect pests of Chinese kale, *Brassica oleracea* L. *International Journal of Agriculture & Boilogy*, 9 (1): 64-67.

Patel, B.M., Patel, S.I., Patel, S.K and Patel, S.B. 2003. Intercropping studies in *ber* (*Ziziphus mauritiana* Lamk.). *Agricultural Science Digest*, 23 (2): 113-115.

Lal, O.P., Sinha, S.R. and Srivastava, Y.N. 2002. Role of intercropping on population build up of *Lipaphis erysimi* on cabage under field conditions. *Annals of Plant Protection Science*s, 10: 377-378.

Lakra, R.K and Singh, Z. 1984. Calendar of losses due to *ber* fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae) in different *Ziziphus* spp. in Haryana. *Indian Journal of Entomology*, 46(3): 261-269.

Sinha, S.R., Singh, R. and Sharma, R.K. 2007. Management of insect pests of okra through insecticides and intercropping. *Annals of Plant Protection Sciences*, 15(2): 321-324.

Vaiyapuri, K., Mohamed, A. M., Palanivelan, S., Somasundaram, S. and Sathyamoorthi, K. 2007. Influence of intercropping unconventional green manures on pest incidence and yield of cotton. *Journal of Applied Sciences Research*, 3(12): 1710-1711.

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SHORT COMMUNICATION

Production of flavonoids in plant parts of *Prosopis cineraria*

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Nutritional information is used increasingly by public agencies and agricultural industries to promote fresh produce. Consumers are looking for variety in their diets and are aware of the health benefits of fresh fruits and vegetables. Of special interests are food source rich in antioxidants like flavonoids. In addition to meeting nutrient intake levels, greater consumption of fruits and vegetables is associated with stroke, and cancers of mouth, pharynx, oesophagus, lungs and colon. Flavonoids are common constituents of many plant species which impart color to flowers and fruits and correlation between flower colour and attraction of insects for pollination is well known. Flavonoids have many biological effects including anti-allergic, anti-anginal, anti- inflammatory, anti-hepatoxic, anti-ulcer, anti-viral and anti-spasmolytic and are of interest in the investigation of disease processes and potential drugs.

Prosopis cineraria (Mimosaceae) locally called khejri, is a boon to the people due to its myriad virtues. It distributes discontinuously in dry and semidry regions. This tree provides fodder, fuel, timber and also has nitrogen fixing ability with micro symbiotic affinity. Its unripped pods (Sangri) are used for preparation of curies and pickles. This plant is used in pregnancy as a safeguard against miscarriage. The smoke of leaves is good for eyes troubles. The bark is used as a remedy for rheumatism, cough common cold, asthma and scorpion sting (Rastogi and Mehrotra, 1995; Bhatacharjee, 2001). Endogenous production of flavonoids has been reported in various arid zone plants (Saleh *et al*, 1982; Singh *et al*, 1988), *Dalbergia louvelli* (Beldjoudi *et al*, 2003), *Centaurea napifolia* (Akkal *et al*, 2003) and *Vigna aconitifolia cultivars* (Tyagi and Nag, 2004).

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As fruit (Sangri) of *P.cineraria* is among widely consumed vegetables in arid zone of India and to authors' knowledge there has been no systematic study on the flavonoids of sangri, the aim of present study was to quantify the amount of flavonoid in various parts of *P. cineraria* to see if the consumption of this plant will provide the recommended intake and also to find out which plant part has higher amount of flavonoid content.

Prosopis cineraria (L.) Druce plant parts such as roots, shoots, pods with seeds and pods without seeds as identified and authenticated by taxonomist, collected at their luxuriant growth from Central Institute of Arid Hotriculture, Bikaner (Rajasthan) India, were dried, powdered and used for estimation of flavonoid content.

Isolation of flavonoids

All the dried tissues were separately extracted in a Soxhlet with hot ethanol (Et OH) (Subramanian and Nagrajan, 1969) (100 ml/g dry weight of tissue) and filtered. The filtrate was dried *in vacuo* and the residue extracted with petroleum ether, ethyl ether (Et_2O) and ethyl acetate (EtOAc) in succession. The Et_2O fraction was analysed for free flavonoids while the EtOAc fraction was hydrolyzed to cleave glycosides by refluxing with 7% H_2SO_4 (30ml) for 2 hours. The mixture was filtered, the filtrate extracted with EtOAc, neutralized with 5% NaOH, then dried *in vacuo* and analyzed for flavonoids.

Identification of flavonoids

The isolates were examined by TLC (Slica gel G coated plates) along with standard reference compounds, apigenin, isorhamnetin, isovitexin, kaempferol, luteolin, myricetin, quercetin, vitexin and esculetin. The plates developed in n-butanol-acetic acid-water (4:1:5, upper layer) were seen under uv light, placed in a chamber saturated with NH_3, and were sprayed separately with 5 % ethanolic ferric chloride solution. Each of the isolates were purified by preparative TLC (in a similar solvent system as for TLC). Isolates (each spot separately) were eluted with EtOAc and crystalized from $CHCl_3$. The purified isolates were subjected to mp, mmp, uv and ir spectral studies for identification.

Quantification of flavonoids

The quantitative estimation of the flavonoids was carried out colorimetrically (Kariyone *et al.*, 1953; Naghski *et al*., 1975; Mabry *et al*., 1970).

Flavonoids isolated were identified as quercetin (Rf.0.82, uv fluorescent-bluish yellow, NH_3-yellow, $FeCl_3$- bluish grey, mp=309°- 311°C, uv max-258,303,375 nm in ethanol) and Kaempferol (Rf-0.93, uv fluorescent- bright yellowish blue, NH_3-deep yellow, $FeCl_3$- brownish, mp= 271° 272°C, uv max 263, 324, 368 nm in ethanol) The characteristic ir spectral peaks were found to be superimposable with those of their respective standard reference compounds of quercetin and kaempferol.

The quantity of isolated quercetin and kaempferol in various plant parts is represented in Table 1. The total flavonoid content was found to be maximum (2.23mg/gdw) in the roots of *P.cineraria* and minimum (0.86mg/gwd) in the shoot. Among all the plant parts analyzed, roots showed the maximum kaempferol (0.97mg/gdw) and quercetin (1.26mg/gdw) while shoot showed minimum amount of kaempferol (0.24mg/gdw) and quercetin (0.62mg/gdw) however the concentration of these flavonoids in fruits was close to roots. In fruits the amount of these compounds was found to be more than the shoot but less than the roots.

Beldjoudi *et al* (2003) isolated four new flavonoids along with thirteen known compounds from heartwood or *Dalbergia louvelli* whereas Akkal *et al*., (2003) identified quercetin alongwith other four flavonoids from aerial parts of *Centaurea napifolia*. Yang *et al* (2003) reported eleven flavonoids including querectin and kaempferol from *Theobroma grandi florum* while Tyagi and Nag (2004) isolated and identified querectin and kaempferol from seeds and leaves of *vigna aconitifolia* cultivars.

It is suggested that plants of arid zone have biosynthetic potential to produce flavonoids in different plant parts which is regarded as one of the essential constituent of antioxidants. Although flavonoids research has been ongoing for couple of years, the work in the last five years has led to a vast increase in authors understanding of this familiar group of secondary metabolite.

Table 1. Flavonoid content from *Prosopis cineraria*

Flavonoid	Concentration (mg/gdw)			
	Root	Shoot	Fruit with seeds	Fruit without seeds
Kaempferol	0.97	0.24	0.82	0.68
Quercetin	1.26	0.62	1.12	0.97
Total	2.23	0.86	1.94	1.65

References

Akkal, S., Benayache, F., Behtamene, A., Medjroubui, K., Seguim, A and Tillequin, F. 2003. Flavonoids aglycoms from *Centaurea napifolia*. *Chemistry Compounds*, 39 (2):219-220.

Beldjoudi, N., Mambu, L., Labaied, M., Grellier, P., Ramanitrahasimbola, D., Rasoanaivo, P., Martin, M.T and Frappier, F. 2003. Flavonoids from *Dalbergia louvelli* and their antiplasmodial activity. *Journal of Natural Products*, 66(11):1447-1450.

Bhatacharjee, S.K. 2001. *Hand book of medicinal plants.* (Pointer publication, Jaipur).

Kariyone, T. Hashimoto, y and kimura, M. 1953. Microbial Studies on plant components. IX. Distribution of Flavonoids in plants by paper Chromatography. *J. Phaema. Soc.*, 73: 253-256.

Malbry, T.J., Markham, K.R and Thomas, M.B. 1970. *In: The Systematic Identification of Flavonoids* (Springer- verlay, Berlin):119.

Naghski, J., Feriske, C. Sand Couch, I.F. 1975. Use of paper chromatography for the estimation of quercetin in rutin. *J. Am. Phaem. Assoc.*, 40: 613-616.

Rastogi, P.R, and P. Mehrotra. 1995. *Compendium of Indian medicinal Plants* (A CDRI Series, New Delhi)

Saleh-Nabiel, A.M., Ahmed, A and Abdalla, M. F. 1982. Flavonoids glycosides of *Tribulus pentandrus* and *T. terrestris*. *Phytochemistry*, 21(8):2995-3000.

Singh,V., Mathur,K., Sethia, M and Nag, T.N. 1987. Flavonoids of some arid zone plants of Rajasthan. *Indian J. Phaem. Sci.*, 50(2):133

Subramanian, S.S and Nagarajan, S. 1969. Flavonoids of the seeds of *Crotolaria retusa* and *C. Striata*. *Curr. Sci.*, 38:65.

Tyagi, S and Nag, T.N. 2004 Flavonoids of Moth bean cultivars as antimicrobial agents. *Indian J. Plant Physiol.*, 4(1):59-61

Yang, H., Protiva, P., Cui, B., Ma, C., Bagett, S., Hequet, V., Mori, S., Weistein, I.B. and Kennely, E.J. 2003. New bioactive polyphenols from *Theobroma grandiflorum. Journal of Natural Products*, 66(11):1501-1504

INDIAN JOURNAL OF ARID HORTICULTURE
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SHORT COMMUNICTION

Effect of nitrogen, phosphorus and bio-fertilizers on quality of Indian Bean (*Lablab purpureus* L. var. *typicus*)

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Indian bean or Dolichos bean (*Lablab purpureus* L. var. *typicus*) belongs to the family Fabaceae (2n = 22). The crop is grown for its green pods which consumed as vegetable when pods are immature, tender and green. Its dry seeds are also used in various vegetable food preparations. The nutritional composition of edible green pods contain 86% moisture, 2.0% fibre, 4.0% protein, 1.0% fat, 7.10% carbohydrate, 48 Kcal energy, 210mg calcium, 68mg phosphorus, 1.0mg iron, 668IU vitamin A, 0.08mg thiamine, 0.11mg riboflavin, 0.75mg niacin and 9.3mg vitamin C (Gopalan *et al*., 2004).

Indian bean is affected by inadequate availability of nutrients in the soil and being a leguminous crop, it is highly responsive to nitrogenous fertilizer application especially in early stage. It also requires large quantity of phosphorus for optimum growth and yield. The modern day intensive crop cultivation requires the use of chemical fertilizers. However, due to hike in the prices of chemical fertilizers and also with a view to maintain the ecosystem of soil, it has become necessary to minimize the use of chemical fertilizers by adding organic ones to the soil more particularly biofertilizers of microbial origin. To enhance the plants capacity to utilize such nutrients effectively including in the soil, *Rhizobium*, PSB and VAM inoculation has been considered to be effective. When the seed of legumes crops are inoculated with *Rhizobium* and sown, it increased microbial population in the *rhizosphere*, thereby increasing the amount of microbiologically fixed nitrogen for the plant growth. The inoculation of seed with right strain of *Rhizobium* culture increases the seed yield over no inoculation. About 93-99 per cent of the total phosphorus is insoluble and hence directly not available to plants. Researchers in the few decades established that VAM helps in phosphorus nutrition by not only increasing its availability but also increasing its mobility (Kristek *et al.,* 2005). The PSB culture was also proved broad spectrum bio-fertilizer which increase yield of crops (Legumes, vegetables *etc*.) by 10-30 per cent and supplement phosphorus upto 30 kg ha^{-1} (Tilak and Annapurna, 1993). Use of PSB culture increased nodulation, crop growth, nutrient uptake and crop yield (Shrivastava and Ahlawat, 1995).

Investigation on the effect of biofertilizers with graded doses of nitrogen and phosphorus on quality of Indian bean cv. Arka vijay was carried out at Horticulture farm, S.K.N. College of Agriculture, Jobner, Jaipur during *kharif* season 2013-14. Soil texture was loamy sand, Soil pH 8.2, ECe 1.35 dSm^{-1}, organic carbon 0.15 %, Available nitrogen 135 kg ha^{-1} and phosphorus 16.25 kg ha^{-1}. The experiment was laid out in split plot design with 20 treatments and replicated four times. The treatments consisted of four levels of nitrogen and phosphorus (0, 50% RDF, 75% RDF, 100% RDF ha^{-1}) in main plots and five levels of inoculation with bio-fertilizers (control, PSB, VAM, *Rhizobium* and PSB + VAM + *Rhizobium*) in sub plots. Observations on nitrogen content and its uptake, phosphorus content and its uptake, crude protein content and crude fibre content (%) of pods were recorded.

The results of the present study indicate that among the treatments application revealed that significant increase in protein content from 2.91 per cent in control to 3.51 per cent with 75% RDF (22.5 kg N and 37.50 kg P_2O_5/ha) (Table1) has been observed in the present investigation because of increased N concentration in green pod which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen concentration might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in green pod is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. These

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results are in close conformity with the findings of Kasturikrishna and Ahlawat (2000), Singh *et al*. (2006) and Pandya and Bhatt (2007).

The increasing levels of N and P also significantly increased N and P concentration in green pods. This might be due to improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N and P in plant parts. Since the nutrient uptake is a function of its content in crop plant and green pod yield of the crop. The increase in these parameters due to N and P fertilization led to an increased uptake of nutrient in the present study.

Inoculation with PSB, VAM, *Rhizobium* alone and PSB + VAM + *Rhizobium* significantly enhanced the nitrogen and phosphorus concentration in green pod and protein content in green pod over control. Thus, inoculation with PSB + VAM + *Rhizobium* proved superior to other treatments. The increase in these values due to inoculation of seed with *Rhizobium* was probably due to more fixation of nitrogen resulting into better utilization of nutrients by plants, which led to more chlorophyll formation and ultimately nitrogen and phosphorus concentration in green pod and protein content in pods. Significant increase in nitrogen and phosphorus concentration of green pod was also observed with PSB and VAM. PSB and VAM enhanced the availability of phosphorus to plants, which might have utilized by the crop in greater root development and nodulation that in turn resulted in higher nitrogen fixation in the soil by nodules. Thus, increased availability of nitrogen and phosphorus might have resulted in greater uptake by the plants for proper development and ultimately increased their content in plants. VAM increased nutrient uptake through reduction of the distance that nutrient must diffuse to

Table 1. Effect of fertility levels and bio-fertilizers on crude protein, crude fibre content, nitrogen and phosphorus content in pods and nitrogen and phosphorus uptake.

Treatments	Protein content (%)	Crude fibre (%)	Nitrogen content (%)	Nitrogen uptake (kg/ha)	Phosphorus content (%)	Phosphorus uptake (kg/ha)
Fertility levels						
F_0 (0 % RDF)	2.91	1.90	0.453	20.55	0.417	17.79
F_{50} (50 % RDF)	3.13	1.82	0.508	34.23	0.447	30.86
F_{75} (75 % RDF)	3.49	1.82	0.573	42.56	0.493	37.52
F_{100} (100 % RDF)	3.51	1.71	0.576	42.98	0.510	39.81
SEm ±	0.08	0.04	0.012	0.87	0.007	0.66
CD (P=0.05)	0.26	0.12	0.037	2.78	0.024	2.10
Bio-fertilizers						
B_0 (Control)	3.01	1.85	0.482	30.85	0.454	28.73
Bp (PSB)	3.24	1.84	0.526	34.56	0.465	30.14
Bv (VAM)	3.26	1.84	0.528	34.93	0.469	32.80
Br (Rhizobium)	3.35	1.81	0.543	35.93	0.460	31.02
Bpvr (PSB+VAM+Rhizobium)	3.45	1.75	0.559	39.13	0.486	34.80
SEm ±	0.06	0.03	0.010	0.58	0.007	0.45
CD (P=0.05)	0.17	0.08	0.030	1.65	0.021	1.27

plant roots by accelerating the rate of nutrient absorbing surface (Bowen *et al*. 1975) and finally by chemically modifying the availability of nutrient for uptake by plant through *mycorrhizal hyphae* (Somani, 2004).

The combined inoculation with PSB + VAM + *Rhizobium* was more beneficial in enhancing all the above parameters due to increased solubility of phosphorus and higher nitrogen fixation in nodules, leading to increased availability of nitrogen and phosphorus. The greater uptake of nitrogen and phosphorus might be due to increased content of these nutrients in green pod. These results corroborate the findings of Rasal (1996), Tanwar *et al.* (2003), Jain and Trivedi (2005) and Vikram and Hamzehzarghani (2008).

References

Bowen, G.D., Bevege, D.I. and Mosse, B. 1975. The phosphate physiology of vesicular arbuscular mycorrhizae. In : Endomycorrhizas, Eds. Sanders, F.E., Mosse, B. and Tinker, P.B. Academic Press, London : 241-260.

Gopalan, C., Rama Sastri B.V. and Balasubramanian, S.C. 2004. Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad.

Jain, P.C. and Trivedi, S.K. 2005. Response of soybean to phosphorus and biofertilizers. *Legume Research,* 28 : 30-33.

Kasturi Krishna, S. and Ahlawat, I.P.S. 2000. Effect of moisture stress and phosphorus, sulphur and zinc fertilizers on growth and development of pea (*Pisum sativum* L.). *Indian Journal of Agronomy,* 45 (2) : 353-356.

Kristek, S., Kristek, A. and Pavlovic, H. 2005. The influence of mycorrhizal fungi (*Glomus sp*.) on field pea plant survival along with in drought caused stress conditions. *Plant, soil and Environment,* 51(9) : 385-389.

Pandya, C.B. and Bhatt, V.R. 2007. Effect of different nutrient levels on yield and nutrient content of fodder cowpea. *Legume Research,* 30 (3) : 218-220.

Rasal, P.H. 1996. Effect of phosphomicrobials and *Rhizobium* on green gram. *The Madras Agricultural Journal,* 83 : 399-401.

Shrivastava, T.K. and Ahlawat, I.P.S. 1995. Response of pea to phosphorus, molybdenum and biofertilizers. *Indian Journal of Agronomy***,** 40 : 630-635.

Singh, A.K., Tripathi, P.N., Kumar, R.P., Srivastava, A.K. and Singh, R. 2006. Response of nitrogen, phosphorus levels and *Rhizobium* inoculation on nutrient uptake, yield and protein content of cowpea. *Journal of Soil and Crops,* 16 (2) : 475-477.

Somani, L.L. 2004. Handbook of Biofertilizer. *Agrotech Publishing Academy,* Udaipur : 1168.

Tanwar, S.P.S., Sharma, G.L. and Chahar, M.S. 2003. Effect of phosphorus and biofetilizer on yield, nutrient concentration and uptake by blackgram (*Vigna mungo* L. Hepper). *Legume Research,* 26 (1) : 39-41.

Tilak, K.V.B.R and Annapurna, K. 1993. Effect of PSB in different crop. *Proc. of India National Academic Science,* 59 (3-4) : 315-324.

Vikram, A. and Hamzehzarghani, H. 2008. Effect of phosphate solubilizing bacteria on nodulation and growth parameters of greengram (*Vigna radiata* L. Wilczek). *Research Journal of Microbiology,* 3 (2) : 62-72.

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SHORT COMMUNICATION

Effect of different spacing and nitrogen levels on growth, yield, quality and monetary returns of cauliflower (*Brassica oleracea* var. *botrytis* L.*)* under North Gujarat condition.

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Cauliflower (*Brassica oleraceavar. botrytis* L.) is one of the most popular vegetable crops among the cole crops. Cauliflower was introduced in India from London by Dr. Jenson in 1822 and in such a short period of its introduction, In India, cauliflower is cultivated in an area about 347 lakh ha with an annual production of about 6569 thousand MT (Anon., 2010). Advance technology for cauliflowers cultivation is use of hybrid varieties and drip irrigation. In the plains, cauliflowers are available from September to May. In Gujarat, it is cultivated in 19,815 ha with a production of 3,56,747 MT (Anon., 2009-10) and productivity of 18 MT ha^{-1}. There is great potential for increasing the productivity per unit area by use of optimum plant spacing and cultural practices in cauliflower. Spacing and plant population per unit area plays an important role for growth and development of the crop. Higher plant population can be achieved by reducing the distance between rows and plants. The yield of cauliflower is directly influenced with proper manuring and fertilization. Therefore, in recent thus much emphasis has been given for the use of major nutrients (N, P, and K). Nitrogen is an essential nutrient required by the plant for its growth, development and reproduction. An adequate supply of nitrogen is associated with vigorous vegetative growth. Nitrogen is a constituent of protein, nucleic acid and chlorophyll etc. It is helpful in large size compact curd development. Hence, the present study was undertaken to find out the Hence, the present study was undertaken to find out the "effect of different spacings and nitrogen levels on growth and yield cauliflower (*Brassica oleracea* var. *botrytis L.)* under North Gujarat conditions" *rabi* 2010-11.

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An experiment was conducted at Horticulture Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during *rabi* 2010-11. The experiments consist of four planting spacing (S_1-30 cm X 20 cm, S_2-30 cm X 30 cm, S_3-45 cm X 30 cm and S_4-45 cm X 45 cm) having in main plots and four levels of nitrogen (N_1-100 kg ha^{-1}, N_2-150 kg ha^{-1}, N_3-200 kg ha^{-1} and N_4-250 kg ha^{-1}) under sub plot treatments and replicated thrice in split plot design. The soil of experimental field was sandy loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and rich in potassium. The cauliflower variety "Early Kunwari" was sowing in nursery bed with seed rate of 500 g ha^{-1} and five week age old seedling with six leaf stage was used for transplanting in main field.

Effect of spacing

The results showed that the significant variation was observed in all growth characters, yield and economics (Table 1 & 2) *viz.*, Plant height at 30 DAT and at harvest, number of leaves per plant 30 DAT and at harvest, curd yield, protein and ascorbic acid content, net returns and B: C ratio. Significantly maximum plant height (22.62 cm and 33.65 cm at 30 DAT and at harvest, respectively), number of leaves per plant (12.27 and 27.87 at 30 DAT and harvest, respectively), diameter of curd (14.57 cm), B: C ratio (3.74) were observed in treatment S_3 (45 cm X 30 cm), while average weight of curd (831.40 g) and protein content (2.69%) was observed in treatment S_4 (45 cm X 45 cm). However, higher curd yield (297.41 q ha^{-1}) and net returns (Rs. 161588) was obtained under treatment S_1 (30 x 20 cm). In wider spacing better availability of nutrient, sunlight, moisture and space to plants consequently improve plant vigor and growth. These findings are in agreement. Less number of plants led

better utilization of moisture, space and sunlight, which might be led to better accelerated photosynthates, vegetative and productive growth. Ultimately diameter and yield of curd was increase. These findings are in agreement with the result of Mannan *et al*.

Effect of nitrogen levels

The results (Table 1 & 2) showed that the significant variation was observed in all growth characters *viz.*, Plant height at 30 DAT and at harvest, number of leaves per plant at 30 DAT and at harvest. Significantly highest plant height (22.47 cm and 33.36 cm at 30 DAT and at harvest, respectively), number of leaves per plant (12.05 and 25.87 at 30 DATP and harvest, respectively), diameter of curd (14.83 cm), average weight of curd (628.06 gm), curd yield (269.60 q ha^{-1}), net returns (Rs. 180006 ha^{-1}) and B: C ratio (6.05) were observed higher in treatment N_3 (200 kg N ha^{-1}). This might have increased nitrogen supply which helped in the expansion of leaf area and increased

Table 1. Effect of different spacing and varying levels of nitrogen on growth and yield attributes of cauliflower

Treatments	Plant height (cm)		Number of leaves $plant^{-1}$		Diameter of curd (cm)	Average weight of curd (g)
	At 30 DAT	At harvest	At 30 DAT	At harvest		
S_1: 30 X 20 cm	20.35	29.20	10.67	22.05	11.30	357.48
S_2: 30 X 30 cm	21.06	30.71	11.33	23.40	13.59	505.51
S_3: 45 X 30 cm	22.62	33.65	12.27	27.87	14.57	616.76
S_4: 45 X 45 cm	22.04	31.87	12.04	26.07	13.59	831.40
S.Em±	0.40	0.84	0.24	0.81	0.47	22.20
C.D. (*P*=0.05)	1.51	2.89	0.84	2.81	1.62	76.58
N_1: 100 kg ha^{-1}	20.33	29.38	11.07	23.75	11.56	518.58
N_2: 150 kg ha^{-1}	21.13	30.97	11.45	24.30	13.00	545.11
N_3: 200kg ha^{-1}	22.47	33.36	12.05	25.87	14.83	628.06
N_4: 250kg ha^{-1}	22.22	31.72	11.73	25.47	13.57	619.40
S.Em±	0.43	0.67	0.20	0.53	0.34	10.95
C.D. (*P*=0.05)	1.26	1.94	0.59	1.55	0.99	31.88

Note: DAT = Day after transplanting

Table 2. Effect of different spacing and varying levels of nitrogen on growth and yield attributes of cauliflower.

Treatments	Curd yield (q ha^{-1})	Quality		Net return (Rs. ha^{-1})	BCR
		Protein (%)	Ascorbic acid (mg/100g)		
S_1: 30 X 20 cm	297.41	2.49	57.85	161588	3.12
S_2: 30 X 30 cm	279.17	2.55	59.63	160885	3.58
S_3: 45 X 30 cm	248.42	2.60	59.64	145544	3.74
S_4: 45 X 45 cm	195.33	2.69	59.40	109245	3.32
S.Em±	9.51	0.09	1.95	---	---
C.D. (*P*=0.05)	32.82	NS	NS	---	---
N_1: 100 kg ha^{-1}	235.19	2.32	55.23	152978	5.35
N_2: 150 kg ha^{-1}	252.44	2.53	59.00	166528	5.70
N_3: 200kg ha^{-1}	269.60	2.63	59.10	180006	6.05
N_4: 250kg ha^{-1}	263.11	2.83	63.19	174564	5.86
S.Em±	5.21	0.06	1.28	----	---
C.D. (*P*=0.05)	15.16	0.18	3.73	----	----

Note: DAT = Day after transplanting and BCR: Benefit cost ratio

chlorophyll content which accelerated the photosynthetic rate and in turn increased the supply of carbohydrates to the plant. These results are in close agreement with the findings of Singh (2004). The better availability of nitrogen might have also favoured to metabolic and auxin activities in the plants and ultimately resulted in increased size, weight and yield of curd. While, protein content (2.83%) and ascorbic acid content (63.19 mg/100 g) was recorded higher with the application of 250 kg N ha^{-1}. This might be due to fact that the protein content is essentially the manifestation of N concentration in curd. Hence, increased N concentration under equal rate of nitrogen application might have increased the protein content of curd. These findings are in accordance with the results of *Ducsay et al. (2004),* Mal *et al.* (2005).

References

Anonymous, 2009-10. District wise area, production and yield of important vegetable crops, in Gujarat state, Krishi Bhawan, Sector 10-A, Gandhinagar.

Anonymous, 2010. Area and production of vegetable. NHB data base 2010.

Ducsay, L., Varga, L. and Ryant, P. 2004. Effect of nitrogen application on the uptake of selected micro elements and the content of vitamin C in Brassica pekinensis. *Acta Univrsitatis Agriculture et Silviculture Mendelianae Brunensis,* 52 (2) : 115-119.

Mal K., Yadav R.L. and Paliwa R. 2005. Effect of chemical weed control and nitrogen levels in cauliflower *Indian Journal of Horticulture,* 62 (3) 257-259

Singh, A.K. 2004. Effect of nitrogen and phosphorus on growth and curd yield of cauliflower var. snowball-16 under cold arid region of ladakh. *Haryana J. Hort. Sci.,* 33 (1& 2): 127-129 .

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SHORT COMMUNICATION

Response of Onion (*Allium cepa L.*) to Different Levels of NPK and FYM Under Arid Condition of Rajasthan

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Onion (*Allium cepa* L.) is one of the commonest and indispensable vegetable cum condiment crop grown for local consumption, export and processing. Among the different methods of irrigation, drip irrigation is the most important one which was developed originally as a sub irrigation system. India is the second largest producer of onion after China grown in about 10.03 lakh hectare area with the production of 145.61 lakh tonne of bulbs in the country and productivity is about 13.99 tonne per hectare (Anonymous, 2011). In Rajasthan total area of onion is about 73456 hectare with 664215 tonnes production and 9042 kg per hectare productivity (Anonymous 2011), (Thimmaiah (1989):, Singh *et al.* (2003):, Krishnamurthy and Sharanappa (2005) :,Mandloi *et al.* (2008) :, Hari *et al.* (2009)). In Rajasthan, the area under drip irrigation is 30300 ha (Alam and Kumar, 2007). Fertilizer-use efficiency (FUE) was worked out as a factor of total economic yield from all harvests by quantity of fertilizer applied and expressed as kg yield/kg NPK. (FUE) was worked out as a factor of total economic yield from all harvests by quantity of fertilizer applied and expressed as kg yield/kg NPK.Therefore, present investigation will be helpful in evaluating the efficiency of applied nitrogen, phosphorus and potassium with FYM on the growth and yield of onion under drip irrigation with saline water.

A field experiment was conducted during *Rabi* 2012-13. The region is characterized by deep, coarse sandy soil. Experiment consisted of 16 treatment combinations comprising of four NPK levels (0,75,100 and 125 % RDF kg ha^{-1}) with four FYM levels (0,10,20 and 30 t ha^{-1}). It was conducted in split plot design with four replications. To raised nursery beds onion verity Nasik Red (N-53) of 3 m x 1 m x 0.15 m in size were prepared. Water soluble urea, muriate of potash and mono potassium phosphate were applied as per treatments after transplanting through drip irrigation. FYM was applied 20 days before transplanting as per the treatment combinations in their respective plots, mixed and irrigated.

$$EUF = \frac{\text{Yeld (kg/ha)}}{\text{Total quantity of nutrient applied (kg/ha)}}$$

Gross returns (Rs. ha^{-1}): = Returns from fruit of onion (Rs. ha^{-1})

Net returns (Rs. ha^{-1}): = Gross returns (Rs. ha^{-1}) Total cost of cultivation (Rs. ha^{-1})

$$\text{B:C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

Doses of fertilizer application have shown significant impact on fertilizer use efficiency of onion in the table. It was recorded with the application from 100% recommended dose of NPK fertilizer (12.18 kg kg^{-1} of fertilizer) to 75% recommended dose of NPK fertilizer (12.18 kg kg^{-1} of fertilizer) but at 125% recommended dose of NPK fertilizer, significant decrease the fertilizer use efficiency as compared to 100% recommended dose of NPK fertilizer through drip irrigation. The present findings are in good accordance with the results of Veeranna *et al.* (2001), Singhandhupe *et al.* (2003), Hongal and Nooli (2007), Arunadevi (2005), and Badr and Abou Ei-Yaized (2007) and Vijaykumar *et al.* (2010). Fertilizer use efficiency of onion increased significantly with the application of 10, 20 and 30 t FYM ha^{-1}, and the maximum fertilizer use efficiency of 9.92 kg kg^{-1} of fertilizer was recorded with FYM 3 t ha^{-1} in the table. This might be due to greater multiplication of soil microbes which could have converted organically bound nutrients to inorganic form (Bellakki and Badanur, 1997). Organic manures being a source of nutrients favor and encourage soil microbial activity, enhances phosphorus activity, slow down release on nitrogen, reduces leaching losses, particularly of nitrogen and potassium and ultimately improved fertilizer use efficiency. The similar results have also been reported by Prakash *et al*. (2002) Bhattacharya *et al*.(2004) and Chaturvedi and Chandel (2005) in Soybean and Kumawat and Jat (2005) in barley, Ray *et al.* (2005) in okra and Mali *et al. (*2006) in cucumber, Ullah *et al.* (2008) in brinjal, Kumar and Sharma (2004) in tomato, Ansari (2008) in potato, Mgbeze and Abu (2010) in African Yam.

Doses of fertilizer application have shown

significant impact on B:C ratio and net returns in the table. A significantly higher B:C ratio and net return was recorded with the 100% recommended dose as compared to control and 75% recommended dose of NPK fertilizer through drip irrigation. This might be due to the fact that under the treatments the cost of input added was low as compared to increase and value of output obtained; therefore, higher bulb yields resulted in higher net returns. These findings are similar to those of Thimmaiah (1989), Mandloi *et al.* (2008) and Shinde *et al. (*2013) in onion, Singh *et al.* (2003) in potato, Madhuri *et al.* (2006) in turmeric. B:C ratio and net returns increased significantly with the application of 10, 20 and 30 t FYM ha^{-1}, and the maximum and significant net returns (Rs 97745.50 per hectare) and B:C ratio (2.32) were recorded with FYM 30 t ha^{-1} in the table. This might be due to the fact that under these treatments the cost of input added was low as compared to output obtained, therefore, higher bulb yields resulted in higher net returns. These findings are similar to those of Choudhary and Chandra (2006a) who reported maximum net return of Rs. 52,882 and B:C ratio 4.89 by the application of vermicompost @ 9 t ha^{-1} as compared to ne t return of Rs. 50,469 and B:C ratio of 4.66 by the application of 60 : 30 : 30 kg NPK ha^{-1}. The

Table 1. Effect of NPK-drip fertigation and FYM levels on FUE, net returns and B:C ratio

Treatments	FUE (kg/kg of nutrient)	Net returns (Rs. ha^{-1})	B:C ratio
Fertilizer levels (NPK kg ha^{-1})			
(i) Control	-	54562	1.96
(ii) 75 % RDF (75:37.5:75)	10.80	81770	2.17
(iii) 100% RDF (100:50:100)	12.18	97746	2.32
(iv) 125% RDF (125:62.5:125)	10.87	100388	2.28
S.Em.±	0.41	2787	0.04
C.D. (5%)	1.30	8915	0.14
FYM levels (tonne ha^{-1})			
(i) Control	6.79	52100	1.83
(ii) 10	8.41	77345	2.15
(iii) 20	8.72	95705	2.33
(iv) 30	9.92	109316	2.42
S.Em.±	0.40	1862	0.03
C.D. (5%)	1.17	5339	0.07

above finding are also in conformity with the findings of Mandloi *et al.*(2008) and Chatoo *et al.* (2010) in onion, Yadav and Luthra, (2005) in vegetable pea, Kalalbandi *et al.*(2007) in cabbage and Sharma and Bhalla (1995) and Bairwa *et al.* (2009) in Okra.

References

Arunadevi, K. 2005. Performance evaluation of drip irrigation and fertigation on the yield and water use efficiency of mulberry. Ph. D. Thesis, Tamil Nadu Agricultural University, Coimbatore.

Alam, A. and Kumar, A. 2007. Micro irrigation system past, present and future. Eds. Singh, H.P., Kaushish, S.P., Kumar, A., Murthy, T.S. and Samuel, irrigation J.C. in micro irrigation, CBIP,17.

Ansari, Abdullah Adil 2008. Effect of vermicompost on the productivity of potato (*Solanum tuberosum*), spinach (*Spinacia oleracea*) and turnip (*Brassica compestris*). *World Journal of Agricultural Sciences,* 4 (3): 333-336.

Bellakki, M.A. and Badanur, V.P. 1997. Long term effect of integrated nutrient management on properties of vertisols under dry land Agriculture. *Journal of the Indian Society* of *Soil Science,* 45: 438-442.

Bhattacharya, R. Prakash, V., Kundu, S., Srivastava, A.K. and Gupta, H.S. 2004. Effect of long-terms manuring on soil organic carbon, bulk density and water retention characteristics under soybean-wheat cropping sequence in North-Western Himalayas. *Journal of* the *Indian Society* of *Soil Science,* 52: 238-242.

Chaturvedi, S. and Chandel, A. S. 2005. Influence of organic and inorganic fertilization on soil fertility and productivity of soyabean. *Indian Journal of Agronomy,* 50 : 311 313.

Badr, M.A. and Abou El-Yazied, A.A. 2007. Effect of fertigation frequency from subsurface drip

irrigation on tomato yield grown on sandy soil. *Australian Journal of Basic and Applied Sciences*, 1(3) : 279-285.

Bairwa, H.L., Shukla, A. K. Mahavar, L.N., Kaushik, R.A. Shukla, K.B and Ameta, K.D. 2009. Response of integrated nutrient management on yield, quality and physiological characteristics of okra cv. Arka Anamika. *Indian Journal of Horticulture,* 66 (3): 310-314.

Choudhary, M.K. and Chandra, Atul. 2006. Effect of integrated nutrient management on yield and yield attributing characters in okra and its residual effect on succeeding crop radish. *Indian Journal of Arid Horticulture*, 1(1): 25-27.

Chattoo, M. A., Najar, G. R., Mir, S. A. and Faheema, S. 2010. Effect of organic manures and inorganic fertilizer on growth, yield nutrient uptake and economics of onion cv. Yellow Globe. *Journal of eco-friendly Agriculture*, 5(1) : 12 14.

Hongal, M.M. and Nooli, S.S. 2007. Nutrient movement in fertigation through drip-a review. *Journal of Agricultural Review,* 28 (4), 301-304.

Hari, G. S., Kumar A. K., and Reddy, A. V. 2009. Effect of organic manures in combination with 'N' fertilizers on growth and yield of onion (*Allium cepa* L.) under irrigated conditions of Central Telangana Zone of Andhra Pradesh. *Research on Crops*, **10**(1): 103-104.

Kumar, Pradeep and Sharma, S.K. 2004. Integrated nutrient management for sustainable cabbage tomato cropping sequence under mid hill conditions of Himachal Pradesh. *Indian Journal of Horticulture*, 61(4) : 331-334.

Kalabandi, B. M., Dabhade, R.S. and More, S.S. 2007. Effect of organic and inorganic fertilizers on growth, yield and quality of cabbage (*Brassica oleracea* var. capitata). *Asian Journal of Horticulture*, 2(2): 144 147.

Mali, M.D., Musmade, A.M., Kulkarni, S.S., Prabhu, T. and Birade, R.M. 2006. Effect of organic manures on yield and nutrient uptake of cucumber (*Cucumis stivus* L.) cv. Himangi. *South Indian Horticulture*, 53(1-5): 100-115.

Madhuri, S., Poinkar, Shembekar, R.Z., Neha Chopde, Nisha, B., Archana, K. and Kishor, D. 2006. Effect of organic manure and biofertilizer on growth and yield of turmeric (*Curcuma longa* L.). *Journal of Soil and Crops*, 16(2): 417-420.

Mgbeze, G.C. and Abu, Y. 2010. Effects of NPK and farm yard manure on the growth and development of the African yam bean (*Sphenostylis stenocarpa* Hochst ex a rich). *African Journal of Biotechnology*, 9 (37): 6085-6090.

Prakash, Y.S. Bhadoria, P.B.S. and Rakhit, A. 2002. Comparative efficacy of organic manures on the changes in soil properties and nutrient availability in an Alfisol. *Journal of* the *Indian Society* of *Soil Science*, 50: 219-221.

Ray, R., Patra, S.K., Ghos, K.K. and Sahoo, S.K. 2005. Integrated nutrient management in okra *(Abelmoschus esculentus* L. Moench) in a river basin. *Indian Journal of Horticulture*, 62(3): 260-264.

Singh, K. and Singh, R.P.1965. Effect of various sources and levels of nitrogen on growth of and fruiting response of bhindi. *Horticulturist*, 1: 76-80

Singh, N., Sharma, R. C. and Singh, B. P. 2003. Effect of NPK fertigation and planting patterns on yield and economics of potato under drip irrigation. *Journal of the Indian Potato Association*, 30(1/2):69-70.

Singh and hupe, R.B., Rao, G.G.S.N. Patil, N.G. and Brahmanand, P.S. 2003. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop. *European Journal of Agron*omy, 19 : 372-40.

Shinde, K. G., Bhalekar, M. N. and Patil, B. T. 2013. Response of foliar feeding of water soluble fertilizers in onion. *Journal of Agriculture Research and Technology*. 38(1):11-14.

Thimmiah, D. 1989. Studies on effect of nitrogen, phosphorus and potassium on growth and yield of onion (*Allium cepa* L) Bellary Red. *M. Sc. (Agri). Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Ullah, M.S., Islam, M.A., Islam, M.A. and Haque, T. 2008. Effect of organic manures and chemical fertilizers on the yield of brinjal and soil properties. *Journal of the Bangladesh Agricultural University*, 6(2): 271-276.

Veeranna, H.K., Abdul Khalak, A.A., Farooqhi and Sujith, G.M. 2001. Effect of fertigation with normal and water soluble fertilizers compared to drip and furrow methods on yield, fertilizer and irrigation water use efficiency in chilli. *Micro Irrigation*, pp. 461-466.

Vijayakumar, G., Tamilmani, D. and Selvaraj P.K. 2010. Irrigation and Fertigation Scheduling under Drip Irrigation in Brinjal (*Solanum melongena* L.) Crop. *International Journal of Biodiversity Science and Management, 1(2) : 72-76.*

Yadav, V.S. and Luthra, J.P. 2005. Effect of organic manures at different levels of phosphorus on yield and economics of vegetable pea. *Udyanika*, 11(2): 119-121.

INDIAN JOURNAL OF ARID HORTICULTURE
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SHORT COMMUNICATION

Potential and scope of rainfed horticulture in Jammu subtropics

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The fruit industry in Jammu and Kashmir State forms the backbone of the state's economy and possesses great potential for horticulture development. The horticulture sector of J&K state is most vibrant sector for economic development. Area under horticultural crops has increased from mere 12 thousand hectares in 1953-54 to 5.58 lakh hectares. The major contributor to Gross domestic product of J&K is horticulture (Wani, 2008, Wani, 2009,). The state is basically a mono-cropped and rainfed economy with 40% area in Jammu division and 60% in Kashmir division. The major crops include rice, maize and wheat. Recently the farmers have also started cropping cash crops and oil seeds .However horticulture alone earns INR 1500 Crores with 75 % of the temperate fruits of India coming from Jammu and Kashmir .The Horticulture business employs over 2,50,000 people in the state. Over 20% of the total cultivated area is under horticulture crop (Chandra, 2014).

The Jammu division of the Jammu and Kashmir state is classified into three distinct agro-climatic zones. In Jammu division, largest fruit growing belt is in sub-tropical zone which is characterized by hot summers, severe dry winters and monsoons. The fruits commonly grown in this zone are citrus (kinnow, santra, and lemons), mango, guava, litchi, low chilling cultivars of peach and grapes. The low chilling cultivars of peach, plum and strawberry also have a great scope in this area.

Topography of Jammu and Kathua districts and parts of Rajouri district is more or less plain with a mild slope whereas, the topography of mid hills and high hills is undulating and sloppy. The climate is generally subtropical in the plains and temperate in the hills. Parts of Udhampur and Doda districts are drought prone in summers. The three agro-climatic zones are:-

1. **Sub-tropical zone:** It comprise both irrigated and unirrigated areas and goes upto an altitude of 500 meter above sea level. The kandi and unirrigated areas are primarily rainfed and their production is dependent on good precipitation during summer monsoons. The main fruits grown in the area are mango, citrus litchi, grapes, peach, pear, strawberry, guava, aonla, ber, jamun and phalsa.
2. **Intermediate zone:** - It falls between altitudes of 500 to 1050 meter above mean sea level. The zone receives sufficient monsoon during summer. The main fruits grown in this area are citrus, peach, olive, kiwi and strawberry.
3. **Temperate zone:** - Area falling above 1050 meter comprises this zone. This zone is also predominantly with very small irrigated area. The fruit crops grown in the area are apple, walnut, almond, peach, apricot, cherry and pecan nuts.

The sub-montane and low hills of Jammu division of J&K state represents the typical example of rainfed farming where farmers are totally dependent upon the mercy of nature. The sub mountain tract of Jammu (J&K), arising from Punjab plains with gentle, rugged undulating to escarpment topography, touching dry hillocks, consisting of Shivalik range and lying in the outer Himalayas is called Kandi belt (Kumar 2004). The soil of the kandi region varies from sandy loam to clay loam with gravels and stones. High intensities of rain during the monsoon season erode the fertile soil year by year and most of the runoff goes waste. Many villages in kandi areas face acute shortage of water in summer season even for domestic purposes. Water harvesting and *in-situ* moisture conservation techniques with diversification of crops are the key solution to solve the problems to some extent. Most of the farmers are growing maize, fodder crops and some pulses in kharif and wheat, mustard and chickpea in Rabi season with total dependence on rain water which is the only source of water in rainfed area. But due to the climatological shift for the last few years there have been long dry spells in Rabi as well as kharif season leading to drought conditions and sometimes total drought is faced by the farmers of the area. Dryland areas with scarce and uncertain rainfall produce low, unstable and often uneconomic yields of various crops. These lands owing to poor management practices are subjected to the processes of degradation and as are not able to sustain arable crops, particularly during the drought period. With the erratic rainfall, degraded soils,

poor crops and livestock productivity coupled with poor socio-economic base, the farmers living in this agro-ecosystem are unable to improve their income and find alternative options of income generation. Hence it becomes imperative to think about evolving certain alternate farming systems for such lands by introduction of a farming system based on agri-horticulture cropping which will be remunerative for the farmer. This new systems will ensure the increase in net profit of the farmer. The large variety of fruits produced in the state reach only to the relatively affluent upper and middle strata of the society who constitute only a minority of the Indian population. Therefore, to meet the minimum dietary requirement of the population, it is not enough to increase the production only but it is essential to reduce the cost of production also.

Keeping in view the climate, soil, topography etc, there is a tremendous scope for pushing up fruit cultivation in Jammu division. The ever increasing population pressure and the constant pressure for fuel and food have made it essential to look for additional land that can be utilized for satisfying some of these demands. The vast stretches and varieties of wastelands that exists throughout the length and breadth of Shivalik ranges of Jammu region are the areas which attract attention as the potential lands that could be identified, developed and put to gainful use by growing fruit crops like ber, mango, pomegranate, guava, aonla, phalsa, bael, behera, harad, etc. As rain fed belt is vital for achieving food security both at the state as well as the national level, strenuous efforts are needed to boost the agriculture production in this region. With the efforts of state agricultural department, the seed replacement rate has gone up over the last four years from 10 % to 24.78 % in Paddy and from 10.79% to 29.77% in wheat (Mir 2013). Similar strategy needs to be planned for increasing fruit production in rainfed areas of Jammu. Also, thrust should be given to introduction of latest technology and farm mechanization to reduce the production costs to make the sector more profitable.

Strategies to be followed for increasing fruit production under rain- fed conditions of Jammu subtropics

To stabilize production and win the confidence of orchardists in rain- fed region, work on following aspects is a priority

1. Evaluation of suitable region specific varieties. Some of the promising varieties of different fruit species suitable under rainfed conditions of sub-montane and low hills of Jammu division are being maintained at Rainfed Research Sub-Station for Sub-Tropical Fruits, Raya, Jammu
2. Survey, collection and evaluation of large number of indigenous plant types of economic significance, wild in rainfed areas with special emphasis on drought resistance as well as quality attributes and conservation there of.
3. Improvement work on ber, bael, wood apple, aonla and annona.
4. Maintenance of directory of lands and location under marginal situation such as dry land, bald hills, hilly terrains etc., with full information about their agro-ecological features. Then evolution of drought resistant crops which perform well under moisture stress conditions and earmarking them for various situations in rain fed regions
5. Generation of information on soil status for optimizing water utilization in rainfed area for fruit crops.
6. Development of efficient water use technology for increased production under rainfed conditions
7. Development of effective plant protection measures against powdery mildew, black spot disease of ber, rust of aonla and insect pests like ber fruit fly and pomegranate butter fly which have become constrains in fruit crop production in this area.
8. Standardization of techniques for faster multiplication of planting material and establishment of nurseries to raise and supply drought tolerant fruits crops plant to prospective growers
9. Developing suitable technologies for reducing post harvest losses and supporting cottage industries based on rainfed fruits

S. No.	Name of fruit plants	Varieties
1.	Citrus:	
	i. Mandarin	Nagpur Santra, Cleoptra mandarin, Kinnow mandarin
	ii. Galpal	
	iii. Sweet lime	
	iv. Eureka lemon	Pine apple, Blood red, Jaffa, Valencia late, Mosambi, Red blush, Duncan, Marsh seed less.
	v. Sweet orange	
	vi. Grapefruit	
2.	Mango	Amarpali, Dusheshari, Bombay green, Langra, Chausa, Fazli, Malika, Totapuri , Baramasi, Kala amb, Jirraiwalla amb, Brota amb, Badda amb, Selection 1 , Selection 2, Selection 3, Selection 4, Selection 5, Arun , Varun, Rajiv, Ram kela
3.	Aonla	NA-7, Chakaiya, Banarsi, Kanchan, Desi
4.	Ber	Mecca, Raya Selection, Gola, Small Apple, Ranjri Selection
5.	Guava	Allahabad Safada, L-49, Apple Coloured, Banarsi Surkha, Hybrid-1, Hybrid-2
6.	Bael	NB-5, NB-9
7.	Karonda	Pink yellow, Green pink
8.	Phalsa	Purple round
9.	Tamarind	Saharanpuri, Local

References

Anonymous. 2008. *Digest of Statistics 2007-08*. Directorate of Economics and Statistics, Government of Jammu and Kashmir

Kumar V. 2004. Land use mapping of Kandi belt of Jammu region. Cited at *link.springer.com/content/pdf/10.1007/BF03030857.pdf*

Mir G.H. 2013. Multipronged strategy to promote agriculture and allied sectors. *Daily Excelsior*, March 16

Ratna Chandra 2014. Sustainability through Organic Agro- Biotechnology with special reference to Jammu & Kashmir scenario. *International Journal of Genetic Engineering and Biotechnology*, 5(2): 169-178

Wani, G.M. 2008. Article in Kashmir centric food security vision, 2008

Wani, G.M. 2009. Article in Kashmir centric food security vision, 2009

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SHORT COMMUNICATION

Impact of weather parameters on incidence of major sucking pests of okra

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Okra or Lady's finger (*Abelmoschus esculentus* (L.) Monech) commonly known as "Bhindi" belongs to the family Malvaceae. It is native of tropical Africa. The crop can be grown throughout the year, commonly cultivated in *Kharif* and *Summer* seasons and resembles cotton in its habit. It is very popular due to its high nutritional and medicinal values. It is being cultivated all over India with major share in the states of Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Maharashtra. The major okra growing districts in Rajasthan are Alwar, Bundi, Kota, Chittorgarh, Jaipur, Sriganganagar and Dausa.

The production of okra in Rajasthan is static and poor per unit area. One of the main factors responsible for the low yield is due to insect pests, mainly sucking pests. Okra is also known as a house of pests and disease which require special attention to combat them at proper time and in proper manner. About 72 species of insects have been recorded on okra (Srinivas Rao and Rajendran, 2003), of which, the sucking pests comprising of leafhopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius), thrips (*Thrips tabaci* Lindeman) and mite (*Tetranychus cinnabarinus* Boisduval) causes significant damage to the crop.

The development and population buildup of a pest is greatly affected by weather parameters like temperature, relative humidity and rainfall. Therefore the present investigation was undertaken to find out correlation between abiotic factors and sucking pests.

To study the seasonal incidence of major sucking pests the okra variety Parbhani Kranti was sown on 30th July 2012 in a plot of 10 x 10 m. keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. All the agronomic were followed as per recommendation of package of practices of zone IC.

The observations of major sucking pests *viz.*, jassid, *Amrasca biguttula biguttula* Ishida, whitefly, *Bemisia tabaci* Gennadius and thrips, *Thrips tabaci* Lindeman were recorded at weekly interval during morning hours.. The population of these pests was counted at fully opened leaves from five randomly selected plants. In all, three leaves (One from top, middle and lower canopy) from each plant were taken for recording the pest population.

Meteorological data regarding atmospheric temperature (maximum and minimum), relative humidity and total rainfall were obtained from meteorological observatory, Agriculture Research Station, Bikaner from July to November. Correlation coefficients (r-value) for jassid, whitefly and thrips and abiotic factors responsible for seasonal variations were worked out. The meteorological data are presented in Table-1.

Incidence of sucking pests

Jassid

The data presented in table 1 revealed that, the population of jassid appeared on crop in the 33rd standard week (1.68 jassid/3 leaves) and remained up to 46th standard week (0.60 jassid/3 leaves). The maximum incidence of jassid (32.96 jassid/3 leaves and 25.88 jassid/3 leaves) was observed in 38th and 37th standard week. Jassid population started from 33rd standard and increased up to the 38th standard week (third week of September) and declined gradually till the crop was matured in November. The population of jassid ranged from 0.60 to 32.96 jassid per three leaves. The results are in agreement to those of Meena *et al.* (2010) and Kumawat and Jat (2011) who reported peak of jassid on okra in the second and third week of September and then decline gradually.

Whitefly

Perusal of the data indicated that whitefly was active throughout the crop season. Whitefly incidence started in 33rd standard week and remained upto 46th standard week, population varied from 1.0 to 18.16 whitefly per three leaves. At vegetative growth stage the population was very low but it increased gradually and

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reached to its peak in the 41st standard weeks (18.16 whitefly/3 leaves) and then declined. The present results are in conformity with that of Kumawat and Jat (2011) who reported incidence of whitefly on okra crop in the month of August and peak activity was noticed in the month of October.

Thrips

The data presented in Table 1 and depicted in Fig.1 reveals that incidence of thrips was observed in the 33rd standard week (1.40 thrips/3 leaves). The population increased gradually with slight up and down and reached to its peak (12.12 thrips/3 leaves) in the 38th standard week thereafter, it was decreased gradually. The population of thrips on okra crop ranged from 1.40 to 12.12 thrips per three leaves throughout the crop period. Earlier Patel (1992) and Varandharajan and Veeravel (1995) observed the incidence of thrips in August and peak in the month of September support the present findings.

Correlation of sucking pests with weather parameters

Jassid

The incidence of jassid started when maximum and minimum temperature was 33.2 °C and 24.92 °C and relative humidity was 74.36 per cent and rainfall 43 mm. The jassid population increased gradually and reached to its peak (32.96 jassid/3 leaves) at 34.9 °C maximum and 23.31 °C minimum

Table 1. Seasonal incidence of major sucking pests of okra in relation toweather parameters.

Standard Meteorological Weeks	Duration		Temperature (0C)		Relative Humidity (%)	Total Rainfall (mm)	Sucking pests population /3 leaves		
	From	To	Max.	Min.			Jassid	Whitefly	Thrips
33	13.8.2012	19.8.2012	33.2	24.92	74.36	43	1.68	1.00	1.40
34	20.8.2012	26.8.2012	35.7	25.97	62.43	7	6.56	5.50	5.33
35	27.8.2012	2.9.2012	35.3	26.02	69.29	17	7.30	3.20	6.52
36	3.9.2012	9.9.2012	33.3	25.12	78.00	69	19.68	4.30	8.43
37	10.9.2012	16.9.2012	34.5	25.84	69.93	0	25.88	7.10	10.20
38	17.9.2012	23.9.2012	34.9	23.31	50.35	0	32.96	10.75	12.12
39	24.9.2012	30.9.2012	35.8	21.54	49.78	0	17.24	8.33	9.00
40	1.10.2012	7.10.2012	37.6	19.18	32.93	0	10.60	15.14	6.33
41	8.10.2012	14.10.2012	36.6	17.92	32.00	0	5.46	18.16	3.42
42	15.10.2012	21.10.2012	33.3	16.34	49.14	0	3.60	4.25	2.20
43	22.10.2012	28.10.2012	31.9	14.33	40.86	0	2.68	2.12	3.12
44	29.10.2012	4.11.2012	32.9	13.11	40.50	0	2.00	1.16	2.60
45	5.11.2012	11.11.2012	32.3	12.03	34.43	0	1.11	2.33	2.00
46	12.11.2012	18.11.2012	30.9	9.8	36.97	0	0.60	1.66	1.62

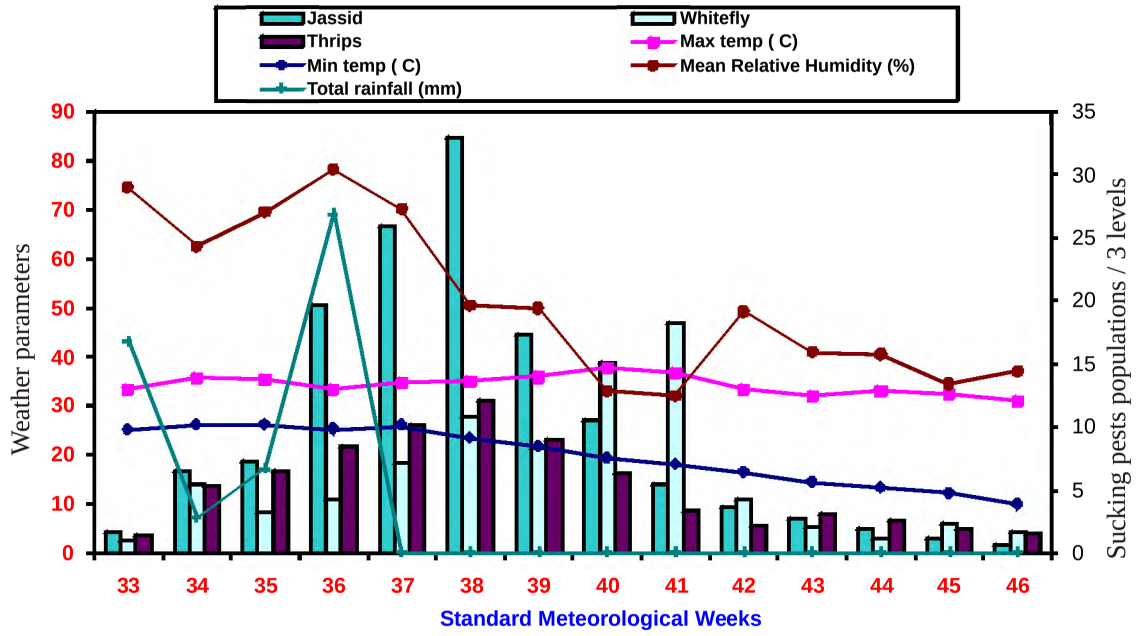

Fig 1. Meterological data and incidence of sucking pests.

temperature. The data presented in Table 2 revealed that the maximum and minimum temperature shows positive significant correlation (r = 0.38 and r = 0.58, respectively) with the jassid population, whereas, positive significant correlation (r = 0.36) was found between relative humidity however, rainfall shows positive non significant correlation (r = 0.10) with jassid population (Table 2). The present results are in conformity with Bhute *et al* (2012) who found a significant positive correlation with maximum temperature and jassid population. Patni and Pareek (2000) who reported significant positive correlation with the minimum temperature also support the present finding.

Whitefly

The data indicated in Table 2 shows that maximum (r =0.31) and minimum temperature (r =0.19) had significant positive correlation with whitefly. The present results are in conformity with those of Acharya and Singh (2007), Anitha and Nandihalli (2008) and Bhute *et al* (2012) who found a significant positive correlation with maximum temperature and whitefly population. These results corroborate with the findings of Patni and Pareek (2000) and Kumawat and Jat (2011) who reported significant positive correlation with the minimum temperature and whitefly population. The results obtained during the course of investigation indicated that the relative humidity (r = -0.34) and rainfall (r = -0.27) exhibited a significant negative correlation with whitefly population. The present results are in agreement with Anitha and Nandihalli (2008) and Bhute *et al* (2012) who reported significant negative correlation.

Thrips

The data indicated in Table 2 revealed that three weather parameters namely maximum (r =0.49), minimum temperature (r =0.64) and relative humidity (r =0.37) had significant positive correlation with thrips population. The present results are in conformity with Khan *et al* (2008) and Selvaraj and Adiroubane (2012) who found a significant positive correlation with temperature and thrips population. The average rainfall (r =0.07) exhibited non significant positive correlation with thrips population. The present results are in agreement with Chhatrola *et al*. (2003), and Khan *et al* (2008) who reported significant positive correlation, with mean relative humidity and rainfall with thrips population.

Table 2. Correlation co-efficient (r-value) between population of major sucking pest of okra and weather parameters.

S.No.	Weather Parameters	Jassid	Whitefly	Thrips
1.	Maximum Temperature (^{0}C)	0.38**	0.31**	0.49**
2.	Minimum Temperature (^{0}C)	0.58**	0.19*	0.64**
3.	Relative Humidity (%)	0.36**	-0.34**	0.37**
4.	Rainfall (mm)	0.10 NS	-0.27**	0.07 NS

*Significant at 5% level
**Significant at 1% level
NS = Non-significant

References

Acharya, V.S. and Singh, A.P. 2007. Effect of dates of sowing on incidence of whitefly on cotton, *J. Cotton Res. Dev.,* 21(2): 242-247.

Anitha, K.R. and Nandihalli, B.S. 2008. Seasonal incidence of sucking pests in okra ecosystem. *Karnataka Journal of Agricultural Sciences*.,21(1): 137-138.

Bhute, N. K., Bhosle, B. B., Bhede, B. V., More, D. G. 2012. Seasonal incidence of major sucking insect pests of Bt cotton and their natural enemies in Marathwada region. *Journal of Cotton Research and Development*.,26: 2, 238-242.

Chhatrola, D.P., Vyas, H.J. and Baraiya, K.P. 2003. Influence of abiotic factors on population build up of thrips, *Thrips tabaci* Lindeman in garlic. *Indian Journal of Plant Protection.*, 31 (2):98-100.

Khan, M. A., Abdul Khaliq, Subhani, M. N., Saleem, M. W. 2008. Incidence and development of *Thrips tabaci* and *Tetranychus urticae* on field grown cotton. *International Journal of Agriculture and Biology*.,10: 2, 232-234.

Kumawat, S.C. and Jat, B.L. 2011. Management of pest complex of okra (*Abelmoschns esculentus* L. Moench) with special reference to bio-rational approaches. M.Sc. (*Agri*.) thesis, submitted to Swami Keshwanand Rajasthan Agricultural University, Campus- Jobner.

Meena, N. K., Kanwat, P. M., Meena, A. and Sharma, J. K. 2010. Seasonal incidence of jassids and whiteflies on okra, *Abelmoschus esculentus* (L.) Moench in semi-arid region of Rajasthan. *Annals of Agri Bio Research*.,15: 1, 25-29.

Patel, V.N. 1992. Studies on insect pest of chillies, their association with leaf curl disease and evaluation of pest management tactis, Ph.D. (Agri.) thesis submitted to Rajasthan Agriculture University, Udaipur.

Patni, S.K. and Pareek, B. L. 2000. Effect of date of sowing and eco-friendly insecticides on the incidence and management of major insect pests of okra*(Abelmoschus esculentu* Moench) M.Sc. Thesis submitted to Swami Keshwanand Rajasthan Agricultural University, Campus Jobner.

Selvaraj, S. and Adiroubane, D. 2012. Influence of weather parameters on the incidence of thrips, *Thrips tabaci* Lindemann in cotton. *Journal of Cotton Research and Development.*,26: 2, 234-237.

Varadharajan, S. and Veeravel, R. 1995. Popualtion dynamics of chilli thrips *Scirtothrips dorsalis* Hood in Annamalianagar. *Indian J. Ecology.*,22:(5) 27-30.

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SHORT COMMUNICATION

Traditional vegetables and their use pattern among the farming communities of western Rajasthan.

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In Rajasthan, the hot arid zone covers 12 district of whole western Rajasthan. It covers the 61 % area of the Rajasthan State and characterized by an annual rainfall between 100-500 mm with a coefficient of variation (CV) varying from 40 -70 per cent. low and erratic rainfall combined with extremes of temperature (450-500 cal/cm^2/day); low relative humidity; high potential evapo-transpiration value ranging from 1600 mm in eastern part and 1800 mm in western part of the region (Yadav and Soni,2008). The relative humidity (RH) is highest during monsoon season (July August) and may go upto 60-80 %. Other important characteristics of hot arid zones of the country are, hot and high wind velocity ; poor soil condition, ground water is poor, brackish and saline in reaction; high sunshine and abundant solar energy leading to high rate of evapotranspiration (average 05-10 mm; poor vegetation; frequent occurrence of drought and frost; difficult to execute agro-techniques; difficulty in post harvest handling and marketing owning to limited and inefficient transportation and marketing facilities. In such harsh and hard climatic conditions, the local farmers grow several traditional vegetables for their own use and surplus for earning money and livelihood. These vegetables are used not only as fresh in current season but also through out the year after converting them in some preservation form of in the form of value addition. They are the major rich source nutrition and daily food staff. The farmers/farming communities prepare various traditional value added products of above vegetables using their own talent/traditional knowledge for their own consumption and selling surplus to local people/markets to earn money too. Thus, the present study was conducted to evaluate the traditional vegetables and their use pattern among the farming communities in hot arid region of western Rajasthan.

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The present study was conducted during 2012-2014 in two districts of hot arid zone of western Rajasthan namely; Bikaner and Churu. These districts were selected purposively because they are presently major district of hot arid zone and majority of the farmers of these districts grow various traditional vegetables for their consumption and value addition purpose of the same. Further, two Tehsil were selected randomly from each so selected districts for study purpose. Thus, a total of 04 Tehsils were selected randomly amongst all above districts. Further, 05 villages (one big, one medium and one small village to avoid sampling biasness) were selected from each so of selected Tehsils for the study point of view. Thus, a total of 20 villages (including big, medium, and small) were selected for the study. Further, 09 farmers (03 big, 03 medium and 03small farmers were selected to avoid sampling biasness) were selected randomly amongst each of so selected 30 villages. In this way, a total of 180 farmers (respondents) were selected for the present study to get their targeted responses and inferences of the study. The farmers/ respondents were individually contacted and interviewed. In addition, to strengthen the individual response and clarification about some facts, group discussions with respondents were also held as per need. The data/ responses of farmers/ respondents were recorded on a semi-structured specially prepared for this study. At the end, the targeted data/information so collected were coded, decoded, compiled, tabulated and analyzed with help of reliable statistical tool and techniques like average, percentage, frequencies, etc. to get final inferences of the study.

Tradtional vegetables grown :

During the study, it was found that *kankora, kundru*, pods of *khinp (Leptadeia pyrotechnica)*, amaranth(chandlai), fenugreek, drumstick, chenopod (*bahtua*), spiny brinjal, sangari of khejri, indian aloe, spinach, carrot, brinjal, bottle gourd, radish, sangari of radish, onion, fog flower buds, clusterbean pods, mothbean pods and products, cowpea pods and products, green gram pods and products, land caltrops, mustard leaves, gram leaves, black nightshade(*makoa)*, *giloy,* etc. are the major traditional vegetables which are

grown in hot arid regions and used as fresh in current season or throughout the year after converting them in the form of value addition. Except these, *kachari, mateera*, snapmelon, round melon, etc. are the other major traditional vegetables which used by the farmers / local peoples of the hot arid region as afresh in current season or in the form value added vegetables through the year. Similar type of finding were reported by Meena, *et.al*, 2009 that the major arid vegetables grown and consumed in different forms by the farmers of hot arid environment on small scale (0.10 ha) to large scale (2.50 ha) in different cropping systems during Karif were: mateera (*Citrullus lanatus*), snapmelon, kachari (*cucumis callosus*), brinjal, bottle gourd, ridge gourds, clusterbean, round melon, Indian aloe, okra, tomato, chilli, etc. The use pattern as observed/reported during the study by the respondents/user is presented in nutshell in Table 1. The local people of the hot arid regions have a lot of experiences and ancestral knowledge through which they prepare various value added products arid fruits and vegetables for earning money and for their own consumption in future. Such kind of major value added products as reported by the local peoples are as follows.

Table 1, reveals that several kind of traditional vegetables are consumed by the farming communities grown by the farmers in study area (Bikaner and Nagaur district) of the hot arid region of western Rajasthan. The majority of the farmers/ local people of the study areas use the vegetables as fresh or after dehydration or value addition in their daily diet throughout the year. They convert them in form of value addition in different forms and use them as preserved fruits/ vegetables as their daily dietary food stub. The farmers of the study area, had a lot of own wisdom and experiences through which they prepare various value added products of arid fruits and vegetables for earning money and for their own consumption. The major value added products as

Table 1. Use pattern of major traditional vegetables among the farming communities.

Sr. No.	Vegetable	Mode of conversion and consumption	consumers (%)
1	Mateera loia	Vegetable, chutney, *rayata*	62-89
2	*Kachri*	Vegetable (pure and mixed both), pickle, powder, *chatuney*	92-100
3	Snapmelon	*Vegetable* (pure and mixed both), *pickle, shek, Jam*	88 -100
4	Brinjal	Vegetable, *bhurita/ chatuney*	55 -78
5	Bottle gourd	Vegetable, *bhurita/ chatuney, rayata*	54 -74
6	Round melon (Local)	Vegetable, *chatuney, rayata*	76-86
7	Indian aloe	Vegetable, pickle, *chatuney*	27-38
8	Clusterbean (veg. - local)	Vegetable (pure and mixed both), pickle	96 -100
9	Khejri sangari	Vegetable(pure and mixed both),, p ickle, matur e *Khokha* powder	91 - 100
10	Ker	Vegetable, pickle, *chatuney, powder,*	51-71
11	Fogala (dried flowers buds of Phog)	Vegetable(pure and mixed both),, *rayata*	45-61
12	Fenugreek	Vegetable(pure and mixed both), *rayata,* spice, mixed forms	38 - 58
13	Moth bean	*Vegetable/ dal* (pure and mixed both), *papad, mangodi. kari, rayat, chapati*	68-82
14	Green gram	*Vegetable/ dal* (pure and mixed both), *papad, mangodi. kari, rayat, chapati*	49 - 69
15	Cow pea	*Vegetable/ dal* (pure and mixed both), *mangodi. Kari, chapati*	48 - 70
16	Khinpoli (pods of Khinp)	Vegetable, pickle *Rayata, Chauney*	39 - 58
18	Local mashroom	Vegetable, pickle	35-57

prepared by farmers/ local peoples by using their own indigenous technological knowledge (ITKs)/ traditional technological knowledge were: pickles of *sangari* of khejri, kachri, ber, ker, lasora, tumba, clusterbean, local mushroom, carrot, chilli, round melon, Indian aloe, karonda, aonla, brinjal, etc. The dehydrated products like dehydrated pods *(sangari*) of *khejri*, clusterbean, khinp, mothbean, green gram; dehydrated kachri, snapmelon(fofalia), round melon, local mushroom, bottle gourd, carrot, *ker, lasora*; dehydrated leaves of gram, fenugreek, bathua, mustard, carrot, spinach, flower buds of Phog (*fogle)*; *shek*/ juice of mattera, kachri, snapmelon, bottle gourd, bitter gourd, ber, aonla; jam/ jelly of karonda, ber, aonla, snapmelon, kachri, bottle gourd; dry powder of kachri, ker, lasora; rousted seeds, m*agaj, laddu*, cold drinks, oil, sweets of mateera seeds; *rayata* and other recipes of fog, bathua, bottle gourd, fenugreek, round melon, spinach, kinpoli, etc. were prepared by farmers/ local peoples regularly as per season and availability of the above fruits and vegetables**.** Meena *et. al.*, 2012, also found during his research study that there was high demand and consumption of value added products of *kachri* in localities/ local markets/villages of the hot arid regions of western Rajasthan. Immature fruits of snapmelon are generally used as salad, while ripe fruits are consumed as dessert. In recent times, the juice of snapmelon is gaining popularity as a refreshing drink due to its cooling effects (Pareek *et al.*, 1999). Snapmelon is rich in nutritional attributes; 100 g edible fruit of snapmelon contains 15.6 g carbohydrates, 18.6 mg vitamin C, and provides 74.0 kcal energy (Goyal and Sharma, 2009).

References

Goyal, M. and Sharma, S.K. 2009. Traditional wisdom and value addition prospects of arid foods of desert region of NorthWest India. *Ind J Trad Knowl.* 8:581585

Meena, S. R., Singh, R.S. and Singh, D. 2012. Inspirational factors in adoption and production of *Kachri* (C*ucumis callosus)* on large scale in hot arid parts of western Rajasthan: An assessment. *Indian Journal of Arid Horticulture,* 7(1-2): 16-21.

Meena, S. R., More, T.A., Singh, D. and Singh, I.S. 2009. Arid vegetable production potential and income generation. *Indian Res. J. Ext. Edu*., 9(2):72-75.

Pareek, O.P., Vashistha, B.B., Samadia, D.K. 1999. Genetic diversity in drough hardy cucurbits from hot arid zone of India. *IPGRI Newslett. Asia Pacific Oceania,* 28:2223.

Yadav, N. D. and Soni, M. L. 2008. Integration of horticultural crops into farming system in hot arid zone of western Rajasthan. In: Hi-tech Production of Arid Horticulture. (Eds). More, T. A. *et. al.* pp. 367 371. Published by Central Institute for Arid Horticulture, Bikaner 334 006 Rajasthan.

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Pareek, O.P. 2001. Ber. In : Hughes, A., Haq, N and Smith, R.W. (Ed.), International Centre for Underutilised Fruits, South Hampton, U.K. pp. 290-292/ Pp.18.

Splittstoesser, W.E. and Mohamed Yaseen, Y. 1991. In vitro shoot regeneration of tamarind (Tamarindus indica L.) and Carob (Ceratonia siliqua) with thidiazuron. In Proceeding of the Inter-American Society for Tropical Horticulture. 35-37 th Ann. Meeting, Vina-del-mar, Chile.7-12 oct: 6-8.

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