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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.

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