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Accessing the higher production with integrated nutrient management in Custard apple cv. Arka Sahan

Umesh Kumar Chanderia, Deepak Singh, Yagini Tekam, Kartikey Pandey and Bharati Choudhary

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M. P.) – 482004

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ABSTRACT

The experiment evaluated different levels of recommended doses of fertilizers (RDF), farmyard manure (FYM), vermicompost, and biofertilizers like Azotobacter (AZB) and Phosphorus Solubilizing Bacteria (PSB) in custard apple cv. Arka Sahan. Treatment 75% RDF + VC @ 2 kg/plant + AZB + PSB (T_9) showed the highest plant height (400 cm), plant spread (East-West 409.96 cm, North-South 481.36 cm), number of branches (58.92), fruits per plant (31.5), and yield per plant (9.08 kg). The highest fruit weight (350.65 g) was recorded with 50% RDF + VC @ 4 kg/plant + AZB + PSB (T_{10}), while 100% RDF + 20 kg FYM (T_2) resulted in the maximum stem girth (37.49 cm). These findings underline the efficacy of integrated nutrient management in enhancing the growth and yield of custard apple cv. Arka Sahan, offering valuable insights for its cultivation under Madhya Pradesh's conditions.

Introduction

Custard apple (*Annona squamosa* L.) is a tropical fruit tree, also known as sugar apple, sweetsop, sharifa, sitaphal and noi-na in different parts of growing regions. It is part of the Annonaceae family, with over 120 species and 40 genera, only five of which are edible. The custard apple is known to have originated from the West Indies and South America. Currently, custard apple cultivation is practised in several countries including Australia, Brazil, Chile, Egypt, India, Israel, Philippines, Spain, Sri Lanka and the USA (Nakasone and Paull, 1998).

Among the Annonas, the Sugar apple (*Annona squamosa* L.) holds important value. Custard apple is a small, semi-deciduous, much branched shrub or small tree 3 to 8 m tall with a broad, open crown or irregularly spreading branches and a short trunk, not buttressed at base. Branches with light brown bark and visible leaf scars, inner bark is light yellow in colour and slightly bitter, twigs become brown with light brown dots. Custard apple is considered as a crop for a wasteland and successfully grown in sandy, rocky gravel and heavy soil, even in sandy loam soils. Custard apple can tap a considerable volume of soil with its extensive root system under natural habitat. However, the natural fertility of soils is rarely sufficient to give economic yields.

In sand culture grown custard apple saplings had nitrogen deficiency that was characterized by restricted growth of plants with pale green to yellowish leaves.

Phosphorus deficiency leads to growth reduction, appearance of brown necrotic bands at the tips and margin of leaves, while potassium deficiency produces marginal scorching of leaves (Sadhu and Ghosh, 1976). However, in most of the orchard, poor nutrition is one of the major causes of low productivity. Plants need sufficient nutrients

Corresponding author: kmr.uk@rediffmail.com (Dr. U.K. Chanderia)

in proper balance for normal growth and development. Depletion soil nutrients pose a major threat to sustainability of fruit production and underline the need for maintaining it by tapping other plant nutrient sources. The reduction in the soil fertility has resulted in low productivity of the crop. Besides, the increasing cost of fertilizers and their negative effect on soil health has led to intensified attempts to the use of biofertilizers and organic matter along with inorganic fertilizers.

Integrated Nutrient Management (INM) is an approach to managing nutrient requirements in crops that aims to optimize nutrient use efficiency, improve soil health, and enhance crop productivity. This approach involves the judicious use of organic and inorganic fertilizers, along with other agronomic practices, to meet the nutrient needs of the crop while minimizing environmental impacts. This approach is necessary to achieve high crop yields and maintain optimal nutrient levels in the soil, thereby ensuring the production of high-quality fruits (Ganeshamurthy *et al.*, 2015).

Material and Methods

The experiment was conducted during crop season 2021-22 and 2022-23 with nine-year-old plants of custard apple cultivar Arka Sahan in the experimental orchard of AICRP-Arid Zone Fruit at Jabalpur center under the Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The experimental location is located at 23°22'16.6"N latitude and 79°96'85.9"E longitude with an altitude of 1273 feet. Experiment was conducted comprising 10 treatments namely T_1 (100 % RDF), T_2 (100 % RDF + 20 kg FYM), T_3 (75% RDF + FYM @ 5 kg/plant), T_4 (50% RDF+FYM @ 10 kg/plant), T_5 (75% RDF + FYM @ 5 kg/plant + AZB + PSB), T_6 (50% RDF + FYM @ 10 kg/plant + AZB + PSB), T_7 (75% RDF + Vermi compost @ 2 kg/plant), T_8 (50% RDF + Vermicompost @ 4 kg/plant), T_9 (75% RDF + Vermicompost @ 2 kg/plant+ AZB+PSB), T_{10} (50% RDF +Vermi compost @ 4 kg/plant+ AZB + PSB).

The recommended dose of fertilizer (RDF) consisted of 250g of nitrogen (N), 125g of phosphorus (P2O5), and 125g of potassium (K2O).

The recommended dose of fertilizer (RDF) per plant consisted of 250 g of N, 125 g of P_2O_5, and 125 g of K_2O. Additionally, 80g of Azotobacter (AZB) and 80g of phosphorus solubilizing bacteria (PSB) were applied per tree. The soil condition of experimental orchard is vertisol having dark colour and is described as having a medium to deep depth. The experiment was carried out in Randomized block design (RBD) with three replications having single plant per treatment. Orchard was established in high density planting following 6m x 6m of spacing for plant to plant and row to row.

The physical attributes of the plants were meticulously measured using standardized techniques. Plant height was determined using an altimeter and expressed in centimetre, while stem girth was measured with vernier callipers. Plant spread was recorded at noon using a meter tape, capturing measurements in both East-West and North-South directions, and the average plant spread in each direction were calculated in meters. The average fruit weight was assessed using an electronic weighing machine and recorded in grams. Additionally, the number of branches, fruits per plant and yield per plant were counted and recorded.

For statistical analysis, pooled mean data from two consecutive years were used to ensure the robustness and reliability of the results. Analysis of variance (ANOVA) was performed using the R statistical package to evaluate the significance of the treatment effects.

Result and Discussion

The data obtained from present study showed that various treatment doses of integrated nutrients are significantly affecting plant height, stem girth, plant spread in east-west and north-south direction, number of branches, average weight of fruit, number of fruits per plant and yield per plant. Growth parameters viz, plant height, stem girth, plant spread in east-west and north-south directions, and number of branches are presented in Table 1 and Table 2 in which the treatments differ significantly from each other.

The maximum plant height (360.39 cm, 440.5 cm and 400.45 cm), maximum plant spread in east-west (450.45 cm, 531.46 cm and 490.96 cm), in north- south direction (431.25 cm, 530.46 cm and 481.36 cm) and higher number of branches (54.2, 63.63 and 58.92) was observed under T_9 (75% RDF + Vermicompost @ 2 kg/plant+ AZB + PSB) in the year 2021-22, 2022-23 and pooled data, respectively. The significant increase in plant height is due to the improvement of physical properties of soil, higher nutrient uptake, increased activity of microorganisms with the vermicompost can improve plant growth, reduce nitrogen losses which were manifested in the form of enhanced growth as also confirmed by Kumar *et al.* (2008).

Phosphate solubilizing bacteria (PSB) play an essential role in P cycling and promoting plant growth by increasing its P uptake in rhizosphere soils. Most PSB produces indole-3-acetic acid (IAA) which enables plant cells to grow, RNA/protein synthesis thus increasing plant growth. Canopy spread is more in east-west direction. Nitrogen, Phosphorus and Potassium in combination with vermicompost, AZB, PSB fertilizer can enhance vegetative growth in plants. Plants often have a greater exposure to sunlight when positioned in an east-west direction, since this alignment enables them to harness solar radiation from the eastern horizon at sunrise to the western horizon during sunset, so maximising their daily light intake. Positive response of Azotobacter and PSB were also reported in mango by Yadav *et al.* (2011). These results are in close conformity with the findings of Singh *et al.* (2009).

The data presented in Table 3 and Fig. 1 clearly demonstrate the significant impact of INM treatments on fruit weight, number of fruits per plant, and yield per plant of custard apple cv. Arka Sahan. Higher number of fruits per plant (27, 36 and 31.5) and maximum yield/ plant (5.86 kg, 12.3 kg and 9.08 kg) were also reported in T_9 (75% RDF + Vermicompost @ 2 kg/plant+ AZB + PSB) in the year 2021-22, 2022-23 and pooled data, respectively. The observed increase in the number of fruits per plant might potentially be attributed to the favourable impact of INM on the extraction of nutrients from the soil by crops, as well as the solubilization effect of plant nutrients via the addition of vermicompost, Azotobactor and Phosphate solubilizing bacteria (Subbiah *et al.*, 1982).

The rise in number of fruits can potentially be attributed to the increase in nutrient levels in the assimilating area of the crop, which is a result of the rational partitioning of dry matter to the economic sink. This allocation of resources has led to an increase in the yield attributes. These findings are consistent with the research conducted by Dalal *et al.* (2004), who observed a higher number of fruits per plant and yield per plant through the integrated application of nutrients in sapota. In their study, Mandal and Chattopadhyay (1993) observed that higher dosages of fertilisers resulted in increased yields in custard apple. This effect was ascribed to the promotion of strong vegetative growth, as well as enhanced development and reproduction of the plant.

Maximum stem girth (32.55 cm, 42.42 cm and 37.49 cm) was recorded under T_2 (RDF 100% + 20 kg FYM) in the year 2021-22, 2022-23 and pooled, respectively. Nitrogen, phosphorus, and potassium are vital elements that have an impact on the augmentation of stem diameter via the facilitation of cellular division, elongation and the establishment of robust with well organized stems. Optimal potassium levels are associated with enhanced water absorption and translocation mechanisms inside the plant, hence facilitating an increase in stem diameter and promoting overall plant development (Marschner, 2012).

Maximum average fruit weight (261.27 g, 440.04 g and 350.65 g) was recorded in T_{10} (50% RDF + VC @ 4 kg/ plant+ AZB+PSB) in the year 2021-22, 2022-23 and pooled data, respectively. Improvement in fruit weight in response to organic source of nutrients, also have been reported by Yadav *et al.* (2007) in aonla and Yadav *et al.* (2011) in mango. The optimal delivery of plant nutrients is crucial in ensuring the right quantity of nutrients is available during the whole time of fruit development. This eventually leads to the accumulation of greater photosynthesis, resulting in increased fruit weight and other physical characteristics (Lal and Dayal, 2014).

Table 1. Effect of INM on plant height and stem girth of custard apple

Treatments	Plant height (cm)			Stem girth (cm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
RDF 100% (T_1)	298.16	324.6	311.38	19.20	26.56	22.88
RDF 100% + 20 kg FYM (T_2)	306.34	376.6	341.47	32.55	42.42	37.49
75% RDF + FYM @ 5 kg/plant (T_3)	222.01	290.26	256.14	23.97	30.50	27.24
50% RDF + FYM @10 kg/plant (T_4)	350.32	431.16	390.74	25.40	32.50	28.95
75% RDF + FYM @ 5 kg/plant +AZB+PSB (T_5)	234.3	294.26	264.28	27.63	35.47	31.55
50% RDF + FYM @ 10 kg/plant +AZB+PSB (T_6)	268.31	328.33	298.32	24.83	32.98	28.90
75% RDF + VC @ 2 kg/plant (T_7)	302.77	390.46	346.62	24.25	31.75	28.00
50% RDF + VC @ 4 kg/plant (T_8)	258.39	320.7	289.55	19.75	25.56	22.66
75% RDF + VC @ 2 kg/plant+ AZB+PSB (T_9)	360.39	440.5	400.45	24.60	31.60	28.10
50% RDF + VC @ 4 kg/plant+ AZB+PSB (T_{10})	313.29	374.06	343.68	23.45	30.50	26.98
SEm±	5.06	0.68	1.14	1.0	0.58	0.26
CD (p=0.05)	15.02	2.03	3.27	2.97	1.73	0.74

Table 2. Effect of IMN on plant spread and number of branches of custard apple

Treatments	Plant spread East- West (cm)			Plant spread North-South (cm)			Number of branches		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
RDF 100% (T_1)	255.31	322.60	288.96	316.52	370.50	343.51	34.60	41.53	38.07

RDF 100% + 20 kg FYM (T_2)	386.60	450.60	418.60	338.08	408.49	373.29	32.31	41.47	36.89
75% RDF + FYM @ 5 kg/plant (T_3)	358.67	415.60	387.14	311.52	370.83	341.18	22.04	30.34	26.19
50% RDF + FYM @10 kg/plant (T_4)	371.54	444.30	407.92	337.06	406.20	371.63	19.09	26.29	22.69
75% RDF + FYM @ 5 kg/plant +AZ-B+PSB (T_5)	377.08	454.60	415.84	383.21	445.43	414.32	40.20	50.20	45.20
50% RDF + FYM @ 10 kg/plant +AZ-B+PSB (T_6)	390.36	470.50	430.43	348.15	410.53	379.34	26.41	32.77	29.59
75% RDF + VC @ 2 kg/plant (T_7)	421.74	491.36	456.55	392.04	460.62	426.33	38.21	48.53	43.37
50% RDF + VC @ 4 kg/plant (T_8)	401.50	470.93	436.22	359.82	410.76	385.29	27.81	35.50	31.66
75% RDF + VC @ 2 kg/plant+ AZ-B+PSB (T_9)	450.45	531.46	490.96	431.25	531.46	481.36	54.20	63.63	58.92
50% RDF + VC @ 4 kg/plant+ AZ-B+PSB (T_{10})	422.52	492.43	457.48	418.61	492.43	455.52	49.25	56.02	52.64
SE(m)±	13.95	0.55	3.12	11.62	0.63	2.61	1.64	0.57	0.39
CD (p=0.05)	41.44	1.63	8.95	34.53	1.87	7.46	4.87	1.71	1.12

Table 3. Effect of INM on fruit traits and yield of custard apple

Treatments	Fruit weight (g)			Number of fruits/ plant			Yield/ plant (kg)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
RDF 100% (T_1)	238.74	301.30	270.02	16	22	19	3.81	6.63	5.22
RDF 100% + 20 kg FYM (T_2)	204.82	301.77	253.30	22	33	27.5	4.50	9.96	7.23
75% RDF + FYM @ 5 kg/plant (T_3)	223.18	329.97	276.58	21	30	25.5	4.68	9.90	7.29
50% RDF + FYM @10 kg/plant (T_4)	203.22	321.84	262.53	24	32	28	4.86	10.30	7.58
75% RDF + FYM @ 5 kg/plant +AZB+PSB (T_5)	234.10	333.30	283.70	18	27	22.5	4.18	9.00	6.59
50% RDF + FYM @ 10 kg/plant +AZB+PSB (T_6)	225.68	339.41	282.54	19	29	24	4.28	9.83	7.06
75% RDF + VC @ 2 kg/plant (T_7)	217.00	323.69	270.35	26	35	30.5	5.65	11.33	8.49
50% RDF + VC @ 4 kg/plant (T_8)	230.03	353.16	291.60	15	21	18.5	3.44	7.77	5.60
75% RDF + VC @ 2 kg/plant+ AZB+PSB (T_9)	217.23	341.47	279.35	27	36	31.5	5.86	12.30	9.08
50% RDF + VC @ 4 kg/plant+ AZB+PSB (T_{10})	261.27	440.04	350.65	16	24	20	4.17	10.56	7.37

SEm±	8.05	7.71	2.49	0.71	0.54	0.2	0.09	0.3	0.07
CD (p=0.05)	23.93	22.91	7.15	2.12	1.61	0.57	0.29	0.89	0.21

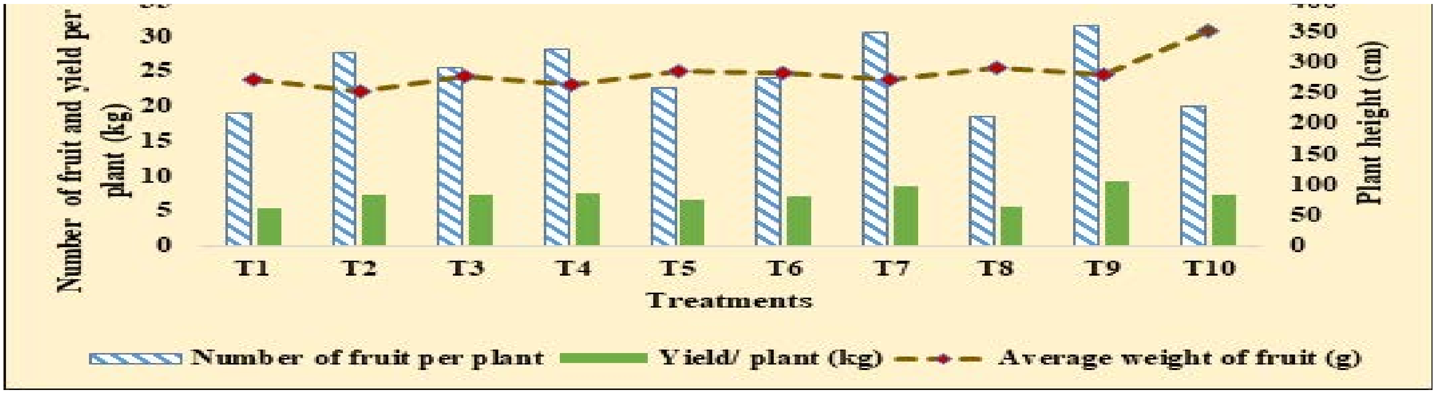

Fig. 1. Effect of INM on fruit traits and yield of custard apple (pooled data)

Conclusion

In conclusion, integrated nutrient management treatments significantly enhanced plant growth and yield parameters of custard apple. The treatment consisting of 75% RDF + vermicompost @ 2 kg/plant + AZB + PSB (T_9) consistently improved vegetative growth, including plant height, canopy spread, branch number, fruit count, and yield per plant. Additionally, the application of 50% RDF + vermicompost @ 4 kg/plant + AZB + PSB (T_{10}) resulted in the highest fruit weight. These findings underscore the effectiveness of combining reduced chemical fertilizers, organic inputs, and biofertilizers, reinforcing INM as a sustainable strategy to enhance custard apple yield.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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