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EFFECT OF INM ON GROWTH, YIELD AND QUALITY OF CUSTARD APPLE (*ANNONA SQUAMOSA* L.) CV. SINDHAN

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ABSTRACT

The present investigation entitled "Effect of INM on growth, yield and quality of custard apple (*Annona squamosa* L.) cv. Sindhan" was carried out at Fruit Research Station, Madhadi Baugh Farm, Department of Fruit Science, College of Horticulture, Junagadh Agricultural University, Junagadh during the year 2022-23. The experiment was laid out in Randomized Block Design with three replications and nine treatments. The result revealed that application of different treatments of INM was found significant for growth, yield and quality parameters *viz.*, maximum incremental plant height (66.00 cm), incremental canopy spread (N-S) (84.33 cm) and incremental canopy spread (E-W) (90.67 cm), maximum fruit weight (224.10 g), fruit length (7.58 cm), fruit girth (7.50 cm), maximum number of fruit per tree (129.83), fruit yield (kg/tree) (27.87 kg) and fruit yield (t/ha) (7.72 ton) was recorded with application of 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant and maximum TSS (30.13 ^{0}Brix), total sugar (23.72%), reducing sugar (19.81%) and non-reducing sugar (3.89%) and Fe (14.49 ppm) and Zn (7.65 ppm) content from pulp were recorded in 75% RDF + Sea weed extract @ 1.5% per plant. The soil analysis parameters were also significantly influenced by INM for increasing the organic carbon (0.73%) and available phosphorus (44.07 kg/ha) by application of 50% RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant while, available nitrogen (315.78 kg/ha) and potassium (367.45 kg/ha) under 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant.

Key words : Custard apple, INM, RDF, Azotobacter, Growth, Yield and quality.

Introduction

Custard apple (*Annona squamosa* L.) is known as Sitaphal or sugar apple and one of the most important dry land fruit crops in India. Custard apple belongs to family Annonaceae and comprises of 40 genera and 120 species of which only five of them are edible. Among the annonas, custard apple (*Annona squamosa* L.) is more valued than other. Other species are *Annona reticulate* (Ramphal), *Annona cherimola* (Laxmanphal), *Annona atemoya* (Hanumanphal). It is called as a 'poor man's fruit'.

The origin of different species of annona is reported to be in different regions. *Annona squamosa* L. is originated in Central America from there; it was distributed to Mexico and Tropical America (Popenoe, 1974). In India, the area under custard apple cultivation is about 47 thousand hectares with 407 thousand MT production with productivity 8.66 MT/ha (Anonymous, 2020). Out of these, Gujarat contributes 7900 ha area with 79.567 thousand MT of production with productivity 10.07 MT/ha (Anonymous, 2023). Custard apple is mostly cultivated in Gujarat state in Ahmedabad, Aravalli, Bhavnagar, Dahod, Junagadh, Mahisagar, Panchmahal and Vadodara from which Junagadh district contributes 702 hectares area and 6.479 thousand MT production (Anonymous, 2023).

By ensuring the availability of nutrients in the soil for succeeding crop seasons, integrated nutrient management strategies foster long-term sustainability in production. It is normal practice to utilize organic fertilizers to increase

fruit crop yields while avoiding the usage of chemicals and unfavorable environmental effects. Because organic manures are more environmentally benign and have favorable impacts on both ecosystems and fruit crops, these are preferred over chemical fertilizers due to their high cost and restricted purchasing power (Kumar *et al*., 2017)

Materials and Methods

The present experiment entitled "Effect of INM on growth, yield and quality of custard apple (*Annona squamosa* L.) cv. Sindhan" was carried out at Fruit Research Station, Madhadi Baugh Farm, Department of Fruit Science, College of Horticulture, Junagadh Agricultural University, Junagadh during 2022.

The experiment was carried out in Randomized Block Design with three replications and nine treatments comprised of 100% RDF per plant (T_1), 75% RDF + 2.5 kg Vermicompost per plant (T_2), 50% RDF + 5 kg Vermicompost per plant (T_3), 75% RDF + 50 ml *Azotobacter* + 50 ml PSB per plant (T_4), 50% RDF + 100 ml *Azotobacter* + 100 ml PSB per plant (T_5), 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6), 50% RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant (T_7), 75% RDF + Sea weed extract @ 1.5% per plant (T_8) and 50 % RDF + Sea weed extract @ 3% per plant (T_9). The spacing of the plant was 6 m × 6 m.

Observations recorded

Plant growth parameters

Incremental plant height (cm)

The tree height of plant was measured from the ground level to highest growing point of stem of each treatment and replication with the help of meter tape and then average was carried out and expressed in centimeter. Tree height measured at the beginning of the experiment minus height at the end of growing season, and considered as incremental plant height.

Incremental tree canopy spread (NS and EW) (cm)

The tree's canopy spread was measured in two directions, North-South and East-West, using a meter tape at a height, where the spread was greatest and represented in centimeters. The plant spread was measured in centimeter (cm) in two directions (East-West and North-South) once at the beginning of the experiment and again after the end of growing season. Canopy spread measured at the beginning of the experiment minus end of growing season was considered as incremental canopy spread.

Yield and yield attributing parameters

Fruit weight (g)

The weight of five randomly taken fully mature fruits, under each treatment was recorded with the help of electronic weighing balance and the average fruit weight was expressed in grams (g).

Fruit length (cm)

The length of fruits was measured from randomly selected five fruits from each treatment and replication with the help of digital *Vernier calipers* and then average was carried out and expressed in centimeter.

Fruit girth (cm)

The girth of the fruit was measured from randomly selected five fruits from each treatments and replication at the middle portion where maximum circumference point of the fruit with the help of digital *Vernier calipers* and average were worked out and recorded as fruit girth in centimeter.

Number of fruits per tree

The numbers of fruit per tree were recorded at each harvest and total number calculated at last harvesting by summation of values of all picking.

Fruit yield (kg/tree)

The weight of harvested fruits at each picking was recorded from each tree. Final values of each harvest were summed and recorded as yield in kg per tree.

Fruit yield (t/ha)

The final yield per hectare was obtained by multiplying average yield per plant by total number of plants per hectare and expressed in tonnes per hectare.

Quality parameters

TSS (^{0}Brix)

A digital hand refractometer was used to determine the total soluble solids of the fruit juice. Before usage, the refractometer was calibrated with purified water. The readings were recorded for each sample by putting a drop of juice on the prism and value was recorded and expressed in degree brix (^{0}Brix).

Total sugars (%)

Sample of 0.1 g was mixed and crushed with 10 ml of 2.5 N methanol. Then 0.1 ml aliquot was taken and added 0.9 ml distilled water to make final volume of 1.0 ml. 1.0 ml of phenol 5% and 5.0 ml of 96% H_2SO_4 were added one by one. Then all samples were put in water bath for 10-15 minutes. Spectrophotometer reading was taken at 490 nm wavelength (Rangana, 1986).

Total sugars (%) = Sample O.D. × Standard O.D × Dilution factor × 100

Reducing sugar (%)

Reducing sugar was estimated by Dinitrosalicylic acid method described by Sadasivam and Manickam (1999). Samples of 0.1 g were extracted with 10 ml of 80% methanol and crushed well. From the supernatant 0.1 ml aliquot was pipetted out and further 1.9 ml of distilled water was added to make final volume of 2.0 ml. Then 2.0 ml of Dinitrosalicylic acid reagent was added. Then all samples were heated in boiling water-bath for few minutes. After cooling, added 6.0 ml of distilled water. Spectrophotometer reading was taken at 565 nm wavelength. By use of the following formula reducing sugar content was calculated:

$$\text{Reducing sugar}\,(\%) = \frac{\text{O.D.} \times \text{G.F.} \times 100}{\text{Sample weight}\,(0.1\text{g}) \times \text{Aliquot taken}\,(0.1\text{ ml})} \times 100$$

Non-reducing sugar (%)

Non reducing sugar is calculated by using following formula:

Non-reducing sugars (%) = Total sugars (%) – Reducing sugars (%)

Fe and Zn content from custard apple pulp

Iron and Zinc was estimated in dry pulp digest obtained from wet digestion by microwave digestion system (0.25 g sample + 6.5 ml HNO_3 + 0.25 ml H_2O_2). Fe and Zn content in pulp digest can be determined by MP-AES (Microwave Plasma-Atomic Emission Spectrometer).

Soil analysis

Soil profile samples were collected from the custard apple orchard. Soil analysis was done twice, before start and secondly at the end of the experiment. Separate samples were taken from the soil at the depth of 15-30 cm and mixed together. The mixed soil sample were air dried, grind in mortar and pestle. Passed through 2 mm sieve and used for further chemical analysis as per standard procedure given for collection and preparation of soil samples by Piper (1966) and used for analysis of different parameters.

Organic carbon (%)

The determination of soil organic carbon is based on the Walkley Black's (1934) chromic acid wet oxidation method. Oxidisable matter in the soil is oxidized by 1 N $K_2Cr_2O_7$ solution. The reaction is assisted by the heat generated when two volumes of H_2SO_4 are mixed with one volume of the dichromate. The remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the soil sample.

$$\text{Organic carbon}\,(\%) = \frac{\text{Z} \times 0.003 \times 100}{2 \times \text{Wt. of soil sample}\,(0.5\text{g})}$$

Available nitrogen (kg/ha)

It was determined with alkaline potassium permanganate method as Suggested by Subbiah and Asija (1956). Twenty grams of soil sample was taken in one-liter distillation flask, added 20 ml of distilled water followed by 100 ml of $KMnO_4$ (0.32%) solution. Then 100 ml of 2.5 % NaOH was added and fixed the distillation assembly quickly possible and start distillation. The liberated ammonia was collected in 250 ml conical flask containing 20 ml boric acid and the collected ammonia was titrated with standard 0.02 N H_2SO_4 solutions. Results were calculated in kilogram of nitrogen ha^{-1}.

$$\text{Available N}\,(\%) = \frac{\text{Z} \times 0.00014 \times 100}{2 \times \text{Wt. of soil sample}\,(20\text{g})}$$

Available N in ppm = % × 10,000

Available N in kg/ha = ppm × 2.24

Available phosphorus (kg/ha)

The available phosphorus in the soil was determined through the Olsen's method (Olsen *et al*., 1954). Soil sample 2.5 g was taken in 100 ml conical flask and 1g Darco G 60 and 50 ml 0.5% $NaHCO_3$ solution was added. After shaking the flask for 30 minutes, filtered the content through Whatman No. 40 filter paper. Then 5 ml extract was transferred by pipette into 250 ml volumetric flask and 5 ml ammonium molybdate solution was added. After adding 1 ml of diluted stannous chloride ($SnCl_2$) solution, the volume was made up upto 25 ml and shake well. The intensity of blue colour so developed was read after 10 minutes on spectrophotometer at 660 nm as suggested by Dickman and Bray (1940). The phosphorus content was computed and expressed in kg ha^{-1}.

$$\text{Available P in ppm} = \text{G.F.} \times \frac{\text{X}}{5} \times \frac{25}{5} \times 100$$

Available P in kg/ha = ppm × 2.24

Available potash (kg/ha)

To determine the available potassium in soil, 5 g soil sample was taken into 100 ml conical flask and 25 ml neutral normal ammonium acetate was added, shacked the content for 5 minutes and then filtered through Whatman filter paper no. 1. The potassium concentration in extract was determined by flame photometer as

suggested by Jackson (1974). Potassium was computed in kg/ha.

Available K in ppm = Y × 5

Available K in kg/ha = ppm × 2.24

Economics of fruit production

Cost of Cultivation (` ha^{-1})

In order to evaluate the effectiveness of different treatments and ascertain the most remunerative treatment, the expenses incurred for all the cultivation operations from preparatory tillage to final harvesting including cost of inputs *viz.*, bio pesticides, irrigation, weeding and labour cost etc. applied to each treatment were calculated on the basis of prevailing local charges.

Gross Returns (` ha^{-1})

The gross realization in terms of rupees per hectare was worked out taking into consideration of fruit yields from each treatment and local market prices.

Net Returns (` ha^{-1})

A net return of each treatment was calculated by deducting the total cost of cultivation from the gross returns.

Benefit: cost ratio

The benefit cost ratio was worked out by using the following formula:

$$BCR = \frac{\text{Gross realization (` ha}^{-1})}{\text{Total cost of cultivation (` ha}^{-1})}$$

Statistical analysis

Collected data was statistically analyzed as per the method given by Panse and Sukhatme (1985). The appropriate standard error of mean (S. Em.±) and the critical difference (CD) were calculated at 5 % level of probability.

Results and Discussion

Photo 1 : General view of experimental site.

The results presented in Tables 1, 2, 3 and 4 demonstrate that the application of Integrated Nutrient Management (INM) had a significant impact on the growth, yield and yield-attributing parameters, quality parameters and Fe and Zn content of custard apple in this experiment.

Plant growth parameters

The data obtained from the investigation clearly indicated that the application of various Integrated Nutrient Management (INM) treatments had a significant influence on the growth parameters of the plants, including the incremental plant height and the incremental tree canopy spread in both the north-south and east-west directions.

The maximum incremental plant height (66.00 cm) was noted effective with the application of 75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6), which was at par with T_1, T_2, T_4 and T_7 treatments (56.83 cm, 60.00 cm, 57.83 cm and 65.33 cm, respectively). Similarly, maximum incremental canopy spread (N-S) (84.33 cm) was noted with the application of 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6) and it was at par with treatment T_7 (71.86 cm). The maximum incremental canopy spread (E-W) (90.67 cm) was noted with the application of 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6). It was at par with treatment T_2, T_3, T_4 and T_7 (83.67 cm, 79.33 cm, 80.67 cm and 87.00 cm, respectively).

The synergistic effects of using bio-fertilizers, inorganic and organic manure, and both can be blamed for the reported outcomes. This integration enhanced the soil's biological and physical properties, improving its fertility and the plant's availability of nutrients. Similar findings have been reported by Bhatnagar and Singh (2015), Sharma *et al*. (2016), and Sharma *et al*. (2014) in custard apple; Bakshi *et al*. (2018) in mandarin; Talang *et al*. (2017) in mango and Godage *et al*. (2013) in guava further validating the positive effects of these practices on plant growth and yield.

Yield and yield attributing parameters

The collected data clearly indicated that application of different treatment of INM produced significant effect on yield parameters such as fruit weight, fruit length, fruit girth, number of fruit per tree, fruit yield.

Significantly, maximum fruit weight (224.10 g), fruit yield (kg/tree) (27.87 kg) and fruit yield (t/ha) (7.72 ton) were found with application of 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6). Similarly, maximum fruit length (7.58 cm) was also obtained in 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6), which was

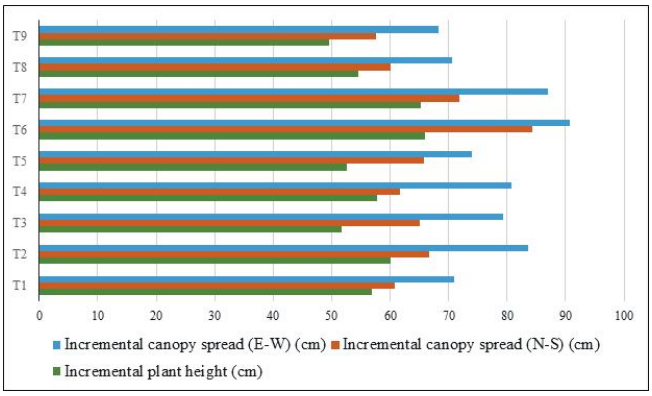

Fig. 1 : Effect of INM on growth attributing parameters of custard apple (*Annona squamosa* L.) cv. Sindhan.

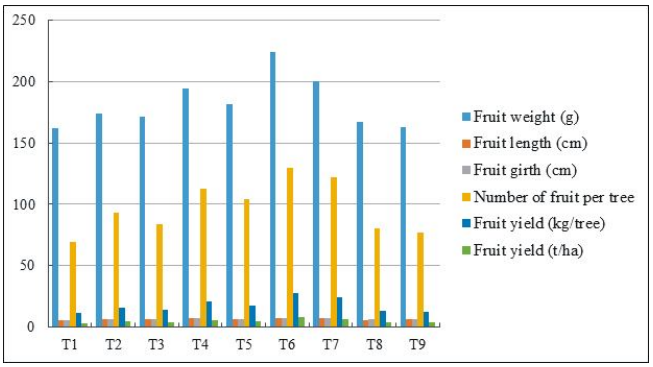

Fig. 2 : Effect of INM on yield and yield attributing parameters of custard apple (*Annona squamosa* L.) cv. Sindhan.

Table 1 : Effect of INM on plant growth parameters of custard apple (*Annona Squamosa* L.) cv. Sindhan.

S. no.	Treatments	Incremental plant height (cm)	Incremental canopy spread (N-S) (cm)	Incremental canopy spread (E- W) (cm)
T_1	100 % RDF per plant	56.83	60.83	71.00
T_2	75 % RDF + 2.5 kg Vermicompost per plant	60.00	66.67	83.67
T_3	50 % RDF + 5 kg Vermicompost per plant	51.67	65.00	79.33
T_4	75 % RDF + 50 ml *Azotobacter* + 50 ml PSB per plant	57.83	61.67	80.67
T_5	50 % RDF + 100 ml *Azotobacter* + 100 ml PSB per plant	52.67	65.83	74.00
T_6	75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant	66.00	84.33	90.67
T_7	50 % RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant	65.33	71.86	87.00
T_8	75 % RDF + Seaweed extract @ 1.5 % per plant	54.57	60.00	70.67
T_9	50 % RDF + Seaweed extract @ 3 % per plant	49.50	57.50	68.33
S. Em.±		**3.566**	**4.244**	**4.849**
C. D. at 5 %		**10.69**	**12.72**	**14.54**
C. V. %		**10.81**	**11.14**	**10.72**

comparable to treatments T_4 (6.81 cm) and T_7 (6.94 cm). Maximum fruit girth (7.50 cm) was found in 75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6) and it was at par with treatment T_4, T_5 and T_7 (6.92 cm, 6.68 cm and 6.99 cm, respectively). The highest number of fruits per plant (129.83) was recorded with T_6, which was on par with T_7 (122.33).

The constant availability of vitamins and nutrients, which encouraged cell division and expansion, finally led to greater fruit production, which could be responsible for the marked improvement in fruit output and yield attributes. The application of organic sources of nutrients and bio-fertilizers improved fertilizer use efficiency, leading to enhanced fruit length, diameter and weight, thereby maximizing fruit yield per tree. Similar findings have been reported by Raut *et al*. (2020) in custard apple; Parasana *et al.* (2021), and Parsana *et al.* (2023) in custard apple; Kanwar *et al.* (2020) in papaya; Singh and Varu (2013) in papaya; Musmade *et al*. (2010) in acid lime; Ramamurthy *et al.* (2006) in mandarin; Reddy and Swami

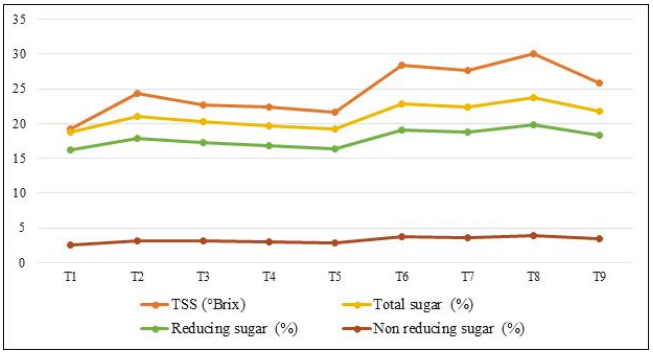

Fig. 3 : Effect of INM on quality parameters of custard apple (*Annona squamosa* L.) cv. Sindhan.

Table 2 : Effect of INM on yield and yield attributing parameters of custard apple (*Annona squamosa* L.) cv. Sindhan

S. no.	Treatments	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Number of fruit per tree	Fruit yield (kg/tree)	Fruit yield (t/ha)
T_1	100 % RDF per plant	162.12	5.47	5.70	69.00	11.15	3.09
T_2	75 % RDF + 2.5 kg Vermicompost per plant	173.88	6.18	6.30	92.83	15.72	4.35
T_3	50 % RDF + 5 kg Vermicompost per plant	171.10	5.93	6.41	84.00	14.33	3.97
T_4	75 % RDF + 50 ml *Azotobacter* + 50 ml PSB per plant	194.16	6.81	6.92	112.50	20.82	5.77
T_5	50 % RDF + 100 ml *Azotobacter* + 100 ml PSB per plant	181.76	6.72	6.68	104.00	17.68	4.90
T_6	75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant	224.10	7.58	7.50	129.83	27.87	7.72
T_7	50 % RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant	200.18	6.94	6.99	122.33	23.95	6.63
T_8	75 % RDF + Sea weed extract @ 1.5% per plant	167.55	5.82	6.10	80.17	13.00	3.60
T_9	50 % RDF + Sea weed extract @ 3% per plant	163.31	6.02	6.16	76.83	12.40	3.43
S. Em.±		**4.885**	**0.272**	**0.292**	**4.103**	**1.246**	**0.346**
C. D. at 5 %		**14.65**	**0.82**	**0.88**	**12.30**	**3.74**	**1.04**
C. V. %		**4.65**	**7.38**	**7.75**	**7.34**	**12.38**	**12.38**

Table 3 : Effect of INM on quality parameters of custard apple (*Annona squamosa* L.) cv. Sindhan.

S. no.	Treatments	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
T_1	100 % RDF per plant	19.20	18.77	16.18	2.59
T_2	75 % RDF + 2.5 kg Vermicompost per plant	24.37	21.10	17.92	3.18
T_3	50 % RDF + 5 kg Vermicompost per plant	22.63	20.35	17.29	3.06
T_4	75 % RDF + 50 ml *Azotobacter* + 50 ml PSB per plant	22.43	19.62	16.84	2.91
T_5	50 % RDF + 100 ml *Azotobacter* + 100 ml PSB per plant	21.60	19.21	16.30	2.78
T_6	75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant	28.47	22.82	19.06	3.76
T_7	50 % RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant	27.67	22.37	18.72	3.63
T_8	75 % RDF + Sea weed extract @ 1.5 % per plant	30.13	23.71	19.81	3.89
T_9	50 % RDF + Sea weed extract @ 3 % per plant	25.90	21.82	18.34	3.48
S. Em.±		**0.855**	**0.608**	**0.632**	**0.158**
C. D. at 5 %		**2.56**	**1.82**	**1.89**	**0.47**
C. V. %		**5.99**	**4.99**	**6.13**	**8.41**

(1986), Dheware and Waghmare (2009) and Patel *et al.* (2009) in sweet orange; Ram *et al.* (2012) and Sutariya *et al.* (2018) in phalsa; and Baviskar *et al.* (2011) in sapota.

Quality parameters

The data revealed that application of different treatment of INM produced significant effect on quality parameters such as TSS, total sugar, reducing sugar and non-reducing sugar.

Table 4 : Effect of INM on Fe and Zn content from pulp of custard apple cv. Sindhan.

S. no.	Treatments	Fe (ppm)	Zn (ppm)
T_1	100% RDF per plant	8.26	4.59
T_2	75% RDF + 2.5 kg Vermicompost per plant	12.36	5.48
T_3	50 % RDF + 5 kg Vermicompost per plant	11.23	6.79
T_4	75 % RDF + 50 ml *Azotobacter* + 50 ml PSB per plant	9.94	5.40
T_5	50 % RDF + 100 ml *Azotobacter* + 100 ml PSB per plant	10.05	5.10
T_6	75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant	12.38	7.02
T_7	50 % RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant	11.30	7.06
T_8	75% RDF + Sea weed extract @ 1.5% per plant	14.49	7.65
T_9	50 % RDF + Sea weed extract @ 3 % per plant	14.18	7.11
S. Em.±		**0.664**	**0.391**
C. D. at 5 %		**1.99**	**1.17**
C. V. %		**9.93**	**10.84**

The maximum TSS (30.13 °Brix) and total sugar (23.71%) was found with application of 75% RDF + Sea weed extract @ 1.5 % per plant (T_8) and it was at par with treatment T_6 and T_7 (28.47 and 27.67°Brix respectively). Similarly, reducing sugar (19.81%) was higher in 75 % RDF + Sea weed extract @ 1.5% per plant (T_8), which was comparable to treatments T_2, T_6, T_7 and T_9 (17.92%, 19.06%, 18.72% and 18.34%, respectively) and non-reducing sugar (3.89%) was observed in application with 75 % RDF + Sea weed extract @ 1.5% per plant (T_8) and it was at par with treatment T_6, T_7 and T_9 (3.76%, 3.63% and 3.48%, respectively).

An increase in quality parameters might be due to the application of seaweed extract the functioning of a number of enzymes might have been stimulated, affecting the physiological processes, which in turn hydrolyzed starch and helped in the metabolic activity during the change of available starch into sugar, thereby resulted into higher total sugars content. Similar findings have been reported by El-Shamma *et al*. (2017) in avocado; Hassan *et al*. (2009) in banana; Singh and Brahamchari (1999), Ram *et al*. (2007) in guava; Ahmed *et al*. (2013) in orange and Omar *et al*. (2017) in date palm.

Fe and Zn content from custard apple pulp

The data indicated that the influence of INM on Fe and Zn content from pulp of custard apple was found significant.

The Fe content (14.49 ppm) was higher in 75% RDF + Sea weed extract @ 1.5 % per plant (T_8). It was at

Table 5 : Effect of INM on soil analysis parameters of custard apple cv. Sindhan.

S. no.	Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Organic carbon (%)
T_1	100 % RDF per plant	284.11	31.09	361.02	0.51
T_2	75 % RDF + 2.5 kg Vermicompost per plant	297.13	34.61	341.20	0.59
T_3	50 % RDF + 5 kg Vermicompost per plant	274.70	33.27	338.61	0.64
T_4	75 % RDF + 50 ml *Azotobacter* + 50 ml PSB per plant	303.92	42.24	345.78	0.54
T_5	50 % RDF + 100 ml *Azotobacter* + 100 ml PSB per plant	270.90	40.63	343.16	0.55
T_6	75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant	315.78	42.97	367.45	0.70
T_7	50 % RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant	309.32	44.07	361.33	0.73
T_8	75 % RDF + Sea weed extract @ 1.5 % per plant	276.48	31.07	334.16	0.48
T_9	50 % RDF + Sea weed extract @ 3 % per plant	269.86	29.79	328.10	0.46
S. Em.±		**8.961**	**1.314**	**8.314**	**0.015**
C. D. at 5 %		**26.86**	**3.94**	**24.93**	**0.05**
C. V. %		**5.37**	**6.21**	**4.15**	**4.51**

Table 6 : Effect of INM on gross return, net return and benefit cost ratio of custard apple cv. Sindhan.

S. no.	Yield (t/ha)	Marketable yield (t/ha)	Fixed cost (` ha^{-1})	Variable cost (` ha^{-1})	Total cost of cultivation (` ha^{-1})	Gross return (` ha^{-1})	Net return (` ha^{-1})	Benefit cost ratio
T_1	3.09	2.72	59320	19203.66	78523.66	108768	30244.34	1.39
T_2	4.35	3.83	59320	15240.26	74560.26	153120	78559.74	2.05
T_3	3.97	3.49	59320	14776.78	74096.78	139744	65647.22	1.89
T_4	5.77	5.08	59320	15101.76	74421.76	203104	128682.24	2.73
T_5	4.90	4.31	59320	17999.78	77319.78	172480	95160.22	2.23
T_6	7.72	6.79	59320	23464.26	82784.26	271744	188959.74	3.28
T_7	6.63	5.83	59320	26324.78	85644.78	233376	147731.22	2.72
T_8	3.60	3.17	59320	12774.96	72094.96	126720	54625.04	1.76
T_9	3.43	3.02	59320	13346.18	72666.18	120736	48069.82	1.66

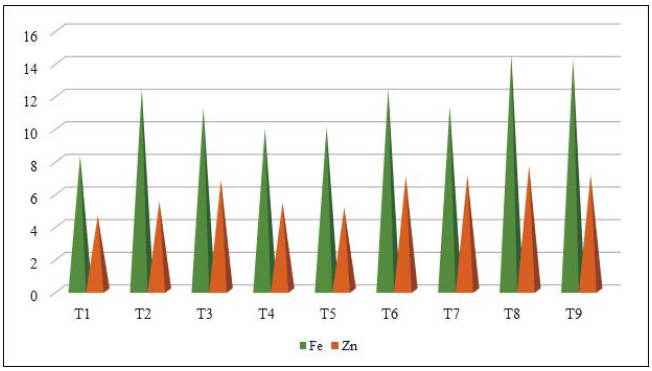

Fig. 4 : Effect of INM on Fe and Zn content from pulp of custard apple cv. Sindhan.

par with treatment T_9 (14.18 ppm) and maximum Zn (7.65 ppm) was found in 75% RDF + Sea weed extract @ 1.5% per plant (T_8) and which was comparable to treatments T_9, T_7, T_6 and T_3 (7.11, 7.06, 7.02 and 6.79 ppm, respectively).

An increase Fe and Zn content might be due to the fact that the foliar spray of seaweed extract fertilizer can improve the absorption of minerals and promote the transportation and accumulation of mineral salts to fruits. These results are consistent with the results reported by Basak (2008) in apple.

Soil analysis parameters

The data obtained from the investigation clearly indicated that the application of various Integrated Nutrient Management (INM) treatments had a significant influence on the soil analysis parameters including the organic carbon, available N, P and K.

Maximum organic carbon (0.73 %) was found in 50% RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant (T_7) and which was at par with treatment T_6 (0.70%). Similarly, maximum available phosphorus (44.07 kg/ha) was also found in 50% RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant (T_7) and which was at par with treatment T_6, T_4 and T_5 (42.97, 42.24 and 40.63 kg/ha, respectively). While, maximum available nitrogen (315.78 kg/ha) was noted with application of 75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6) and which was at par with treatment T_7, T_4 and T_2 (309.32, 303.92 and 297.13 kg/ha, respectively). Similarly, maximum available potassium (367.45 kg/ha) was also noted with application of 70 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6) and which was at par with treatment T_7, T_1, T_4 and T_5 (361.33, 361.02, 345.78 and 343.16 kg/ha, respectively).

Economics of fruit production

Economic is the main deliberation which helps in taking a decision regarding the adoption of a new technology. The net income in rupees per hectare was worked out from fruit yield, their average price and the inputs used during the period of experimentation.

The net return was worked out from the yield of custard apple by taking in to consideration the prevailing prices of custard apple fruit and inputs used during experimentation. The data revealed that the treatment application of 75 % RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant (T_6) gave maximum net realization of ` 188959 per hectare with a BCR of 3.28 followed by treatment of 50% RDF + 5 kg Vermicompost + 100 ml *Azotobacter* + 100 ml PSB per plant ($T_7$) gave net realization about ` 147731 per hectare with a BCR of 2.72.

These results are in close agreement with the earlier findings of Dwivedi (2013), Dwivedi and Agnihotri (2018), Tyagi *et al*. (2021) in guava and Talang *et al*. (2017) in mango.

Conclusion

Based on the results obtained from the present investigation, it can be concluded that application of 75% RDF + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB per plant as a basal dose resulted in enhanced plant growth parameters, yield and yield attributing parameters and also gave maximum net realization and benefit cost ratio. While, 75% RDF + Sea weed extract @ 1.5% per plant as a foliar spray of sea weed extract enhanced the fruit quality parameters and increase Fe and Zn content from pulp of custard apple. Hence, it can be concluded that, the soil application of 75 % RDF (11.25 kg FYM and 150:75:150 g NPK per plant) + 2.5 kg Vermicompost + 50 ml *Azotobacter* + 50 ml PSB was beneficial for higher yield and benefit cost ratio in custard apple under South Saurashtra agro-climatic condition.

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