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Effect of Nitrogen, Phosphorus and Potassium Fertilization on Yield and Quality of Custard Apple (*Annonas squamosa* L.) Cv. Balanagar

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ABSTRACT: Custard apple (*Annona squamosa* L.) can tapa 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. The area under custard apple is increasing in India on commercial scale. However, fully grown-up plants of this cultivar show variability in fruit yield with small sized fruits which fetch poor market price. Improving the marketable yield of good quality fruits has always been a challenge for growers. A study was undertaken during 2019-2020 and 2020-21at the Horticulture Garden, Department of Horticulture, College of Agriculture, Raichur, Karnataka to find out the effect of N, P and K application on yield and quality of custard apple Cv. Balanagar. The experiment consisted of 5 treatments comprising T_1 (control), $T_2$75% RDF (188:94:94 g/plant), T_3-100% RDF (250: 125:125 g plant^{-1}), T_4-125% RDF (313:157:157 g/plant) and T_5-150% RDF (388:187:187 g plant^{-1}). The results revealed that increasing levels of N, P and K (388:187:187 g plant^{-1}) (T_5) significantly increased yield and quality of custard apple. However, minimum days from flowering to fruit set (12.61 days), maximum percent of fruit set (39.18 %), fruit weight (162.79 g), number of fruits per branch (12.22),pulp weight (62.54 g), peel weight (62.98 g)pulp to seed ratio (3.61),fruits per plant (55.07) and fruit yield (4.90 t ha^{-1}), ascorbic acid (27.04 mg/100g pulp), titrable acidity (0.375 %), Total soluble solids (26.61°B), TSS/acid ratio (66.21), Non reducing sugars (3 %) Reducing sugars (15.34 %) were observed in 150% RDF (388:187:187 g/plant) (T_5) as compare to control (T_1).

Keywords: Custard apple, fertilizers, yield, quality.

INTRODUCTION

The edible fruits of genus *Annona* are collectively known as annonaceous fruits. Annonaceae family consists of 40 genera and genus *Annona* has 120 species. Annonas are very delicious, tropical fruit crop. Among them, custard apple (*Annona squamosa* L.) is considered the best. It has got pleasant flavour, mild aroma and sweet taste have a universal acceptance. Custard apple is also known as sugar apple, sweetsop, *sharifa*, *sitaphal* and *noi-na* in different parts of growing regions. Fruits are good source of sugar (20%), iron, calcium, phosphorus and ascorbic acid. Custard apple is one of important minor fruit crops grown in India. It can tap a considerable volume of soil with an extensive root system under natural habitat. However, the fertile soil is hardly sufficient to give economic yields. In sand culture grown custard apple saplings nitrogen deficiency 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). Mandal and Chattopadhyay (1993) reported application of fertilizers at 240 g N, 240 g P and 240 g K per plant per year produced quality fruits in custard apple. The area under custard apple is increasing in India on commercial scale. However, fully grown-up plants of this cultivar show variability in fruit yield with small sized fruits which fetch poor market price. Improving the marketable yield of good quality fruits has always been a challenge for growers. Balanced nutrition of plants along with good cultural practices can help in improving quality fruit with high yields. Nitrogen is one of the most important elements for high productivity and growth of fruit plants Titus and Kang (1982) and also promotes fruit and seed development Marschner (1995). Phosphorus is used by plants to

help form new roots, make seeds, fruit and flowers. It's also used by plants to help fight disease. Similarly, potassium is considered as a quality improving element in fruit crops. Imbalanced use of nutrients or widespread use of N fertilizers alone leads to poor quality of fruits Ganeshamurthy *et al.* (2011). High rates of N can be utilized by plant only in the presence of required K levels. Similarly, potassium (K) is the most abundant nutrient in the fruit, where it influences the size, firmness, skin color, TSS and acidity Brunetto *et al.* (2015). However, little information is available on the effect of combined application of nitrogen, phosphorous and potassium fertilizers on yield and quality in custard apple. Keeping in view the above, the present experiment was designed to study the effect of different combined doses of N, P and K fertilizers on fruit yield and quality of Balanagar variety of custard apple plants.

MATERIAL AND METHODS

The present research was carried out at the Horticulture Garden, Department of Horticulture, College of Agriculture, Raichur, Karnataka, during 2019-20 and 2020-21. The study was conducted on uniform 5 year old custard apple *cv.* Balanagar at a spacing of 4.5 × 4.5 m (494 plant ha^{-1}). The experiment was carried out in Randomized Block Design (RBD) and all the treatments were replicated four times and 2 plants were kept in each treatment. Plants were applied with different combined doses of NPK including of 5 treatments namely T_1 (control), T_2- 75% RDF (188:94:94 g plant-$^{-1}$), T_3-100% RDF (250: 125:125 g $plant^{-1}$), T_4-125% RDF (313:157:157 g $plant^{-1}$) and T_5-150% RDF (388:187:187 g $plant^{-1}$). The soil of the experimental field was clay loamy with a pH of 7.0-7.3. Nitrogen was applied through urea, phosphorus in the form di ammonium phosphate, and potassium in the form of murate of potash. The treatments were imposed during June with the onset of monsoon. Observations were recorded on two plants in each replication on days to fruit set, percent of fruit set, average fruit weight, number of fruits per branch, pulp weight, peel weight, pulp to seed ratio, fruits per plant, yield, ascorbic acid, titrable acidity, total soluble solids, TSS/acid ratio, non-reducing sugars, reducing sugars. Pooled mean data of two years was taken for statistical analysis in accordance to Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Yield attributing parameters. Pooled data over two years indicates that yield parameters were significantly influenced by different levels of fertilizers (Table 1 and 2).

Significantly minimum days to fruit set (12.61 days), maximum percent of fruit set (39.18 %), fruit weight (162.79 g), fruits per branch (12.22), pulp weight (62.54 g), peel weight (62.98 g), pulp to seed ratio (3.61) number of fruits per plant (55.07), and fruit yield (4.90 t ha^{-1}), were recorded with the application of 388:187:187 g NPK $plant^{-1}$ (T_5) which was on par with application of 313:157:157 g NPK $plant^{-1}$ (T_4), which registered lesser days to fruit set (12.81), percent of fruit set (37.92%), average fruit weight (160.48 g), number of fruits per branch (11.85), pulp weight (60.89 g), peel weight (61.17 g), pulp to seed ratio (3.41) number of fruits per plant (52.62), and fruit yield (4.72 t ha^{-1}). However, lesser yield attributes *viz.*, percent of fruit set (32.99 %), fruit weight (148.26 g), number of fruits per branch (10.29), pulp weight (55.68 g), peel weight (55.17 g), pulp to seed ratio (3.04) number of fruits per plant (46.37), and fruit yield (3.30 t ha^{-1}), were recorded in absolute control (T_1).

Table 1: Effect of different levels of fertilizers on yield parameters of custard apple Cv. Balanagar.

Treatment	Days to fruit set (Days)			Percent of fruit set (%)			Average fruit weight (g)			Fruits per branch			Pulp weight (g)		
	2019-20	2020-21	Mean	2019-20	2019-20	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	14.21	14.01	14.11	31.38	34.60	32.99	138.06	159.28	148.26	6.33	14.25	10.29	54.13	57.94	55.68
T_2 :75% RDF (188:94:94 g/plant)	14.07	13.87	13.97	32.61	35.95	34.28	141.65	161.49	151.57	6.58	14.81	10.69	56.17	59.62	57.90
T_3:100% RDF (250: 125:125 g/ plant)	13.95	13.75	13.85	34.91	38.49	36.70	145.14	168.55	156.85	7.04	15.85	11.45	57.63	60.03	58.53
T_4:125% RDF (313:157:157 g/plant)	12.92	12.85	12.81	35.35	40.53	37.92	148.63	172.33	160.48	7.21	16.06	11.85	59.68	62.11	60.89
T_5: 150% RDF (388:187:187 g/plant)	12.70	12.52	12.61	37.27	41.09	39.18	151.55	175.11	162.79	7.51	16.93	12.22	61.17	63.92	62.54
S.Em±	0.29	0.28	0.29	0.71	0.78	0.74	2.79	3.46	3.05	0.14	0.32	0.23	1.20	1.18	1.15
CD @5%	0.89	0.88	0.88	2.18	2.40	2.29	8.61	10.67	9.40	0.44	0.99	0.71	3.50	3.76	3.63

Table 2: Effect of different levels of fertilizers on yield parameters of custard apple Cv. Balanagar.

Treatment	Peel weight (g)			Pulp to seed ratio			Fruits per plant			Yield (t ha^{-1})		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	56.12	50.42	55.17	3.05	3.03	3.04	39.27	53.48	46.37	2.83	3.78	3.30
T_2 :75% RDF (188:94:94 g/plant)	57.84	57.19	57.52	3.17	3.14	3.16	40.80	55.47	48.19	3.26	4.40	.83
T_3:100% RDF (250: 125:125 g/ plant)	59.61	59.44	59.33	3.39	3.37	3.38	43.68	59.49	51.59	3.64	4.92	4.28
T_4:125% RDF (313:157:157 g/plant)	60.23	62.11	61.17	3.48	3.41	3.45	45.55	61.89	52.62	4.13	5.31	4.72
T_5: 150% RDF (388:187:187 g/plant)	62.11	63.84	62.98	3.62	3.59	3.61	46.64	63.51	55.07	4.23	5.56	4.90
S.Em±	1.23	6.44	5.39	0.07	0.06	0.07	0.89	1.21	1.05	0.72	0.96	0.90
CD @5%	3.78	19.84	16.60	0.21	0.20	0.21	2.73	3.71	3.22	2.23	2.97	2.60

The fewer days taken for flowering to fruit set might be due to higher application of NPK which helped in synthesis and deposition of photo-assimilates. This might have led to better growth, fruit bud differentiation (FBD) and increased flower production. Agrawal *et al*. (2010); Yadav *et al*. (2011) supported the findings of the present study. Similar trend it was also reported in other fruit crops like guava by Dikshit *et al.* (2010); Archana (2019). The highest fruit set was observed in increased application of fertilizers leads to more available nutrient in soil it increased uptake of nutrients which resulted in enhanced synthesis of hormones like auxins and gibberellins. Water applied through drip irrigation nearer to the root zone always maintains soil moisture in field capacity range and no moisture stress occurred during the flowering and fruit development stage and thereby the fruit drop was minimized. This might have resulted in higher per cent of fruit set. Similar results were also made by Singh *et al*. (2006) in mango and Krishnamoorthy (2012) in cocoa and also these results are in accordance with Ramniwas *et al*. (2012) who reported that it might be due to higher availability of nutrients during the plant growth stages. It might have improved the fruit set. Similar results were also reported by Kumar *et al*. (2017) in banana, Nadkarni *et al*. (2018) in pomegranate and Al-Dosary *et al.* (2022) in pomegranate. Number of fruits per branch and plant was found maximum with the application of higher level of N P K with FYM. This may be due to the increased synthesis of metabolites due to higher nutrient levels and their translocation to the fruits. Water given by drip irrigation maintains moisture content in soil and reduces fruit drop and increases the fruit set there by increasing the no of fruits per branches and plant. These results are also in accordance with the findings of Shirgure *et al.* (2001) in pomegranate, Mahalakshmi *et al*. (2001) in guava, Thakur and Singh (2004) in guava, and Suresh *et al*. (2011) in custard apple, Raut *et al.* (2020) in custard apple. Application of 313:157:157 g NPK plant^{-1} significantly increased weight of pulp and peel weight. This might be ascribed to the increased synthesis of metabolites and more uptakes of nutrients, and their translocation to the fruits there by increased the peel and pulp weight by increased the fruit weight. These results are in accordance with Thakur and Singh (2004). Kumar *et al*. (2017) in custard apple reported that proper supply and translocation of nutrients throughout the growth stage increased peel and pulp weight.

Application of 388:187:187 g of NPK per plant which is higher application of fertilizer resulted in increased yield per hectare. This might be due to increased photosynthesis, better plant growth and dry matter accumulation in addition to increase in number of flowers, fruit retention capacity, fruit size, fruit volume and fruit weight. The increase in number of fruits might be attributed to the fact that there was increasing level of nutrients in assimilating area of crop due to rational partitioning of dry matter to economic sink the yield attributes were increase the above result are inconformity with findings of Dalal *et al*. (2011) who reported maximum number of fruit per plant by integrated application of nutrients in sapota. Mandal and Chattopadhyay (1993) reported maximum yields due to increasing doses of fertilizers due to vigorous vegetative growth, development and reproduction in custard apple. Results are in accordance with Dhillon *et al*. (2015) in pomegranate, Kumar *et al*. (2017) in banana, Nadakarni *et al*. (2018) in Pomegranate and Raut *et al.* (2020) in custard apple.

Quality attributing parameters. The observations on quality parameters were recorded for two years and presented in Table 3 and 4.

Table 3: Effect of different levels of fertilizers on quality parameters of custard apple Cv. Balanagar.

Treatment	Ascorbic acid (mg/100g pulp)			Titrable acidity (%)			Total soluble solids (°B)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	22.54	22.99	22.77	0.431	0.415	0.423	22.35	22.46	22.40
T_2 :75% RDF (188:94:94 g/plant)	23.42	23.89	23.66	0.427	0.411	0.419	23.22	23.34	23.28
T_3:100% RDF (250: 125:125 g/ plant)	25.08	25.58	25.33	0.423	0.407	0.415	24.86	24.99	24.92
T_4:125% RDF (313:157:157 g/plant)	25.59	25.92	25.81	0.389	0.375	0.382	25.23	25.01	25.12
T_5: 150% RDF (388:187:187 g/plant)	26.77	27.31	27.04	0.381	0.370	0.375	26.54	26.68	26.61
S.Em±	0.51	0.52	0.51	0.009	0.008	0.009	0.50	0.51	0.51
CD @5%	1.57	1.60	1.58	0.027	0.026	0.026	1.55	1.56	1.56

Table 4: Effect of different levels of fertilizers on quality parameters of custard apple Cv. Balanagar.

Treatment	TSS/acid ratio			Non reducing sugars (%)			Reducing sugars (%)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	54.52	56.97	55.75	2.33	2.73	2.53	12.84	12.99	12.92
T_2 :75% RDF (188:94:94 g/plant)	56.66	59.20	57.93	2.42	2.83	2.63	13.35	13.50	13.43
T_3:100% RDF (250: 125:125 g/ plant)	60.66	63.38	62.02	2.59	3.03	2.81	14.29	14.46	14.37
T_4:125% RDF (313:157:157 g/plant)	61.23	64.98	63.18	2.67	3.02	2.85	14.62	15.03	14.84
T_5: 150% RDF (388:187:187 g/plant)	64.76	67.66	66.21	2.77	3.24	3.00	15.25	15.43	15.34
S.Em±	1.23	1.28	1.26	0.05	0.06	0.06	0.29	0.29	0.29
CD @5%	3.79	3.96	3.87	0.16	0.19	0.18	0.89	0.90	0.90

Significantly highest ascorbic acid (27.04 mg/100g pulp), minimum titrable acidity (0.375 %), Total soluble solids (26.61°B), TSS/acid ratio (66.21), Non reducing sugars (3 %) Reducing sugars (15.34 %) were recorded with the application of 388:187:187 g NPK plant^{-1} (T_5) which was statistically at par with application of 313:157:157 g NPK plant^{-1} (T_4), which registered a ascorbic acid of 25.81 mg/100g pulp, minimum titrable acidity 0.382 %, Total soluble solids 25.12°B, TSS/acid ratio 63.18, Non reducing sugars 2.85 %, Reducing sugars of 14.84 %. However, ascorbic acid (22.77 mg/100g pulp), lesser titrable acidity (0.423 %), Total soluble solids (22.40°B), TSS/acid ratio (55.75), Non reducing sugars (2.53 %) Reducing sugars (12.92 %). The quality attributing characters were significantly influenced by either application of 388:187:187 g NPK plant^{-1} (T_5) and application of 313:157:157 g NPK plant^{-1} (T_4) over the control (T_1).

The higher ascorbic acid was noticed with higher application of fertilizers. These results are in confirmation with Sheikh and Manjula (2009) who also recorded highest physico chemical fruit characters along with ascorbic acid content with higher doses of nitrogen along with recommended dose of phosphorus and potash with split doses in pomegranate. Boora and Singh (2012) in their findings analyzed that ascorbic acid increased significantly with the application of higher levels of nitrogen in Sapota cv. Cricket Ball. Higher ascorbic acid with the higher levels of nitrogen might be attributed to increase in synthesis and catalytic activity of several enzymes and co- enzymes which are instrumental in ascorbic acid synthesis. An increased trend of TSS was observed in custard apple fruits with graded levels of NPK. This increased level of TSS might be due to metabolic process of the plant like accumulation of sugar and other soluble components from hydrolysis of protein and oxidation of ascorbic acid. This was reported earlier by Suresh *et al.* (2011); Raut *et al.* (2020) in custard apple. Increased level of potassium application results in reduced acid content of fruits. This could be due to the fact that under low potassium level, phosphoenol pyruvate (PEP) was apparently shunted into alternate pathways resulting in shortage of acetyl Co-A Sohnika *et al.* (2017) in mango. Hence, oxaloacetate appeared to be preferentially formed from PEP in plants with low levels of K and accumulation of these organic acid derivatives. Neutralization of organic acid due to high K level in tissues could have also resulted in reduction in acidity Suresh *et al.* (2011) in custard apple and Kumar *et al*. (2017) in banana. The sugar acid ratio showed with the maximum value in treatment application of 388:187:187 g NPK plant^{-1} (T_5). As the fruit maturity approaches in custard apple acidity decreases in proportion to TSS, which gives a fruit excellent sugar acid blend and is one of the most desirable characters of excellent fruit quality. These findings are in accordance with Singh *et al.* (2006) who found TSS to increase and titrable acidity to decrease with higher doses of N in pomegranate cv. Ganesh. Prasad and Mali (2000) found that total sugars, reducing sugars and non-reducing sugars were highest at optimum level of N in pomegranate cv. Jalore Seedless. Singh (2013) also recorded sugar content to increase with N level. Fatma *et al*. (2018) also recorded the same phenomenon and suggested that application of N significantly enhanced fruit quality. More reducing sugar in the treatments might be due to higher applications of N as it plays an important role in transformation of organic acids to sugars.

CONCLUSION

This investigation clearly indicated that application of application of 150% RDF (388:187:187 g/plant) (T_5) treatment had beneficial effect on increasing yield and quality attributes of custard apple Cv. Balanagar.

FUTURE SCOPE

Although there are aspects of current fertilizer practice which do not exactly conform to what is now recommended, if farmers achieved complete compliance with the recommendations the effect on efficiency of fertilizer N P K wouldnot be large. A greater improvement in efficiency can come only through a better understanding of the way fertilizers is used.

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Conflict of Interest. None.

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