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Effect of nitrogen, phosphorus and potassium fertilization on growth and yield of custard apple (*Annonas squamosa* L.) Cv. Balanagar

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Abstract
Custard apple (*Annona squamosa* L.) 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. A study was undertaken during 2019-2020 and 2020-21 at the at the Horticulture Garden, Department of Horticulture, College of Agriculture, Raichur, Karnataka to find out the effect of N, P and K application on growth and yield 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), T_4-125% RDF (313:157:157 g/plant) and T_5-150% RDF (388:187:187 g/plant). The results revealed that increasing levels of N, P and K (388:187:187 g/plant) (T_5) significantly increased growth and yield of custard apple. However, maximum plant height (3.25 m), canopy volume (19.90 m^3), stem girth (8.05cm), leaf area index (2.87), relative chlorophyll content (56.31 SPAD readings), percent of fruit set (44.71%), fruit length (7.38 cm), fruit diameter (7.85 cm), average fruit weight (184.93 g), fruit volume (196.73 g), number of fruits per plant (84.55) and fruit yield (6.45 t ha^{-1}) were observed in 150% RDF (388:187:187 g/plant) (T_5) as compare to control (T_1).

Keywords: Custard apple, fertilizers, plant growth, yield

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. It occupies an important place among minor fruit crops grown in India. 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 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) [16]. Mandal and Chattopadhyay (1993) [10] 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) [22] and also promotes fruit and seed development (Marschner, 1995) [11]. 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) [5]. 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) [1]. However, little information is available on the effect of combined application of nitrogen, phosphorous and potassium fertilizers on growth and yield 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 growth, and fruit yield 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 laid 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), T_3-100% RDF (250: 125:125 g/ plant), T_4-125% RDF (313:157:157 g/plant) and T_5-150% RDF (388:187:187 g/plant). 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 plant height, canopy volume, stem girth, leaf area index, relative chlorophyll content (SPAD reading), percent of fruit set, fruit length, fruit diameter, fruit volume, average fruit weight, number of fruits per tree, fruit yield, Pooled mean data of two years was taken for statistical analysis in accordance to Panse and Sukhatme (1985) [23].

Results and Discussion

Growth parameters: Pooled data over two years indicates that vegetative growth parameters were significantly influenced by different levels of fertilizers (Table 1).

Significantly maximum plant height (2.55 m), canopy volume (11.60 m^3), stem girth (7.46 cm), leaf area index (2.64) and relative chlorophyll content (55.39) 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 plant height of 2.47 cm, canopy volume 11.22 m^3, stem girth 7.21 cm, leaf area index 2.55 and relative chlorophyll content (53.58). However, lesser growth *viz.*, plant height (2.18 m), canopy volume (9.94 m^3), stem girth (6.47 cm), leaf area index (2.26) and relative chlorophyll content (47.47) were recorded in absolute control (T_1). Maximum plant height, canopy volume, stem girth, leaf area index and relative chlorophyll content may be attributed to application of a higher level of nitrogen producing better vegetative growth. Mahalle *et al*. (2001) [9] also reported in significant results with respect to plant height in custard apple among the various N, P and K treatments. At higher levels of N, the high vegetative growth and yield might be due to increased availability and uptake of nutrients (Dhillon *et al*, 2015) [3]. Growth involves cell growth and development. Cell growth and development is a method which consists of cell division, cell enlargement and cell differentiation (Srinivas *et al.*, 2006) [20]. Vegetative growth is an essential parameter, which decides further reproductive growth of the plant. Similar results were also reported by Pawar and Dingre (2013) [13], Sanjit *et al*. (2014) [17], Pralhad (2014) [14] and Gonge *et al.* (2015) [6] in banana.

Nitrogen, phosphorus and potassium being the major and essential nutrients for plant growth and development that resulted in enhancing growth with increased level of the nutrients. The studies conducted on pomegranate with different doses of N, P, K and FYM proved very useful in boosting the overall growth of the plants (Saraf *et al*., 2004) [18]. Higher level of N P K produced maximum photosynthetic rate and stomatal conductance which ultimately reflected in healthy and vigorous plant growth. Significantly minimum vegetative growth and relative chlorophyll content was recorded under control, this might be due to inadequate or non availability of nutrients at respective growth stages for growth and development of plants. These results were in accordance with Lee *et al*. (2005) [8], Eifediyi and Remison (2009) [4] in apple, Sharma *et al*. (2009) [24] in guava, and Jilani *et al*. (2009) [25], in guava, Kumar *et al.* (2011) in custard apple, and Raut *et al*. (2020) [15, 19] in custard apple.

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

Treatment	Plant height (m)			Canopy volume (m^3)			Stem girth (cm)			Leaf area index			Relative chlorophyll content (SPAD)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	2.04	2.33	2.18	7.90	11.98	9.94	6.20	6.75	6.47	2.11	2.42	2.26	46.10	48.85	47.47
T_2:75% RDF (188:94:94 g/plant)	2.12	2.42	2.27	8.20	12.44	10.32	6.27	7.01	6.64	2.19	2.51	2.35	47.86	50.71	49.28
T_3:100% RDF (250: 125:125 g/ plant)	2.23	2.54	2.38	8.62	13.07	10.84	6.58	7.36	6.97	2.30	2.64	2.47	50.27	53.27	51.77
T_4:125% RDF (313:157:157 g/plant)	2.30	2.63	2.47	8.92	13.52	11.22	6.81	7.62	7.21	2.38	2.73	2.55	52.03	55.13	53.58
T_5: 150% RDF (388:187:187 g/plant)	2.38	2.72	2.55	9.22	13.98	11.60	7.04	7.87	7.46	2.46	2.83	2.64	53.79	56.99	55.39
S.Em±	0.05	0.05	0.05	0.18	0.27	0.22	0.13	0.15	0.14	0.05	0.05	0.05	1.03	1.09	1.06
CD @ 5%	0.14	0.16	0.15	0.54	0.82	0.68	0.41	0.46	0.44	0.14	0.17	0.15	3.17	3.29	3.26

Yield attributing parameters

The observations on percent of fruit set, fruit length, fruit diameter and fruit volume were recorded for two years and presented in table 2.

Significantly highest percent of fruit set (39.18%), fruit length (6.80 cm), fruit diameter (7.23 cm) and fruit volume (180.83 cm^3) 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 percent of fruit set of 37.92%, fruit length 6.77 cm, fruit diameter 7.18 cm and fruit volume of 175.65 cm^3. However, lesser percent of fruit set (32.99%), fruit length (6.04cm), fruit diameter (6.45 cm) and fruit volume (161.27 cm^3) was recorded under absolute control (T_1). The yield 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) was might be due to The higher doses of fertilizers increases the vegetative attributes, more vegetative growth more the photosynthates were effectively translocated from vegetative parts to fruiting parts resulted in increased number of fruits per plant, and average fruit weight per plants increases the fruit length fruit diameter and fruit volume. Similar results were reported by Spizewski and Knaflewski (2004) [26] in pomegranate, Babik and Kowalczyk (2009) [27] in aonla, Eifediyi and Remison (2009) [4] in guava and Shinde *et al.* (2010) [19] in mango and Suresh *et al.* (2011) [21] in custard apple. Nitrogen deficiencies lead to small fruits with poor flavor and quality as reported by Kumar *et al.* (2017) [7] in Banana.

Similarly the observations on average fruit weight, number of fruits per plant and fruits per ha were recorded for two years and presented in table 3. Significantly maximum average fruit weight (162.79 g), number of fruit 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 statistically at par with application of 313:157:157 g NPK plant^{-1} (T_4), which registered a maximum average fruit weight 160.48 g, number of fruit per plant of 52.62 and fruit yield 4.72 t ha^{-1}. However, minimum average fruit weight (148.26 g), number of fruit per plant (46.37) and fruit yield (3.30 t ha^{-1}) values recorded under absolute control (T_1). Application of 388:187:187 g of NPK per plant which is higher application of fertilizer resulted in increased number of fruits per plant 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) [2] who reported maximum number of fruit per plant by integrated application of nutrients in sapota. Mandal and chattopadhyay (1993) [10] 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) [3] in pomegranate, Kumar *et al.* (2017) [7] in Banana, Nadakarni *et al.* (2018) [12] in Pomegranate and Raut *et al.* (2020) [15, 19] in custard apple.

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

Treatment	Percent of fruit set (%)			Fruit length (cm)			Fruit diameter (cm)			Fruit volume (cm^3)		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	31.38	34.60	32.99	6.01	6.07	6.04	6.38	6.52	6.45	154.74	167.80	161.27
T_2: 75% RDF (188:94:94 g/plant)	32.61	35.95	34.28	6.06	6.12	6.09	6.43	6.58	6.51	156.09	169.27	162.68
T_3: 100% RDF (250: 125:125 g/ plant)	34.91	38.49	36.70	6.15	6.2	6.18	6.52	6.67	6.6	158.28	171.65	164.97
T_4: 125% RDF (313:157:157 g/plant)	35.35	40.53	37.92	6.74	6.80	6.77	7.12	7.24	7.18	170.25	187.66	175.65
T_5: 150% RDF (388:187:187 g/plant)	37.27	41.09	39.18	6.78	6.81	6.80	7.15	7.31	7.23	173.55	188.21	180.88
S.Em±	0.71	0.78	0.74	0.19	0.19	0.19	0.2	0.2	0.2	4.78	5.19	4.99
CD @ 5%	2.18	2.40	2.29	0.57	0.59	0.57	0.61	0.62	0.61	14.74	15.99	15.36

Table 3: Effect of different levels of fertilizers on average fruit weight, fruits per plant and fruit yield of custard apple Cv. Balanagar

Treatment	Average fruit weight (g)			No. fruits per plant			Yield (t ha^{-1})		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1: Absolute Control	138.06	159.28	148.26	39.27	53.48	46.37	2.83	3.78	3.30
T_2:75% RDF (188:94:94 g/plant)	141.65	161.49	151.57	40.80	55.57	48.19	3.26	4.40	3.83
T_3:100% RDF (250: 125:125 g/ plant)	145.14	168.55	156.85	43.68	59.49	51.59	3.64	4.92	4.28
T_4:125% RDF (313:157:157 g/plant)	148.63	172.33	160.48	45.55	61.89	52.62	4.13	5.31	4.72
T_5: 150% RDF (388:187:187 g/plant)	151.55	175.11	162.79	46.64	63.51	55.07	4.23	5.56	4.90
S.Em±	2.79	3.46	3.05	0.89	1.21	1.05	0.72	0.96	0.90
CD @ 5%	8.61	10.67	9.40	2.73	3.71	3.22	2.23	2.97	2.60

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