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Effect of inorganic and organic sources of nutrients on physico-chemical composition and shelf life of custard apple (*Annona squamosa* L.) cv. Balanagar

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Abstract
The field study was carried out at Custard apple Research Station, Ambejogai, Dist. Beed. The experiment was laid out in Randomized Block Design (RBD) with fourteen treatments and three replications. The results indicated that there was maximum fruit weight (221.13 g) recorded in T_4 (100% RDF +*Azotobacter* + PSB) while the lowest values for these observations were recorded under control treatment (T_{14}). As regards to the fruit quality, the physical attributes as length of fruit (8.33 cm) recorded maximum in treatment T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by treatment T_3 (100% RDF +FYM + *Azotobacter*), width of fruit (8.60 cm), pulp weight (90.17 g) and peel weight (110.22 g), pulp to peel ratio (0.85), percentage of pulp (42.25%), percentage of peel (49.62%), number of seeds per fruit (36 seeds) maximum in T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by treatment T_6 (75% RDF + FYM + *Azotobacter* + PSB) and minimum seed weight (18.20 g) were found significantly higher in the treatment T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by treatment T_3 (100% RDF + FYM + *Azotobacter*) while the lowest values for these observations were recorded under control treatment (T_{14}). The biochemical attributes viz., total soluble solids (23.80%), reducing sugar (14.11 %), non- reducing sugar (3.46%), total sugars (17.57%), ascorbic acid (37.22 mg per 100 g of pulp), minimum acidity (0.32%) observed in treatment T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by treatment T_3 (100% RDF +FYM + *Azotobacter*).

Keywords: Composition, azotobactor, inorganic, PSB, physio-chemical quality, FRBD, VAM

Introduction
Custard apple (*Annona squamosa* L.) is the most ancient dry land fruit crop in India. They are originated from tropical region of America and widely distributed throughout the tropics and subtropics. It belongs to family Annonaceae and comprises of 40 genera and 120 species of which only five of them produce edible fruits. Among the annonas, custard apple (*Annona squamosa* L.) is valued more than other fruits. The origin of different species of annona is reported to be at different regions. *Annona squamosa* L. is originated in Central America. The fruits are medium in size (250-300 g), globular, green skin, conspicuous reticulation on fruit surface, non-acidic, having good quality and sweet pulp. Edible portion or pulp of fruit is creamy, granular with good blend of sweetness and acidity which vary with the species. Fruit pulp contains proteins, fatty acids, fibre, carbohydrates, minerals and vitamins (Lizana and Reginato, 1990) [6]. The pleasant flavour and mild aroma have universal liking. The fruit contains vitamin C and minerals such as calcium, phosphorus and potassium.

Custard apple has slightly granular, creamy, yellow or white, sweet pulp with good flavour and low acidity, thus it is considering the sweetest fruit of the other annonas (FAO, 1990) [3]. Fruit contains sugar 16-20 per cent and lipids 0.35 per cent of edible part of fruit (Leal, 1990) [5].

It has many health and nutritional benefits. It is a rich source of dietary fibre, which helps in digestion. It contains magnesium, which plays a vital role in relaxing muscles and protecting heart against diseases. Flesh of the fruit is used for the preparation of milk shakes and ice-cream. It can be made a delicious sauce for cake and puddings by blending the seeded flesh with mashed banana and with a little cream. The seeds of the fruits have insecticidal and abortifacient properties. Similarly, seed oil is suitable for soap making and seed cake can be used as manure (Naidu and Saetor, 1954) [7].

Custard apple has many alkaloids, such as aporohine, romerine, norocoydine, squamonine corydine, norisocroriydine, glaucine and anononaine in different parts of the plant (Kowlska and Putt, 1990) [4].

Use of biofertilizers results in reducing the inorganic fertilizer application and at the same time increasing the crop yield besides maintaining soil fertility is well recognised. In other words, biofertilizers based on renewable energy sources and are eco-friendly compared to commercial fertilizers (Verma and Bhattacharyya, 1994) [9]. Custard apple is very hardy to soil and agro-climatic conditions and gives good response to manuring in terms of increasing fruit production and quality of fruits. Fertilizer experiment conducted in India showed that custard apple has given good response to balance use of inorganic fertilizers along with organic manures and biofertilizers. It is reported that, application of organic and chemical fertilizers not only increases the yield but also improved the fruit quality in custard apple (Anon., 2008) [1]. It has been also reported that the application of biofertilizers is more effective than organic manures in enhancing fruit quality parameters, also the inoculation of *Azotobacter* and PSB along with inorganic fertilizers proved effective in increasing quality parameters like TSS, total sugars etc. (Anon., 2008) [2].

Table 1: Nutritional composition of custard apple (per 100 g of Pulp)

S. No.	Constituents	Values
1.	Carbohydrates	20-25.2 g
2.	Protein	1.17-2.47 g
3.	Fat	0.5-0.6 g
4.	Crude fibre	0.9-6.6 g
5.	Calcium	17.6-27 mg
6.	Phosphorus	14.7-32.1 mg
7.	Iron	0.42-1.14 mg
8.	Thiamine	0.075-0.018 mg
9.	Riboflavin	0.086-0.175 mg
10.	Niacin	0.528-1.190 mg
11.	Ascorbic acid	15.0-44.4 mg

2. Material and methods

The details of the material used and methods adopted during the course of the present investigation are described in this chapter under different headings:

Table 1: Details of the treatments

S. No.	Treatment no.	Treatment details
1.	T_1	100 % RDF (250 g N, 125g P_2O_5 and 125g K_2O tree^{-1})
2.	T_2	100 % RDF + FYM + *Azotobacter* + PSB
3.	T_3	100% RDF + FYM + *Azotobacter*
4.	T_4	100 % RDF + *Azotobacter* + PSB
5.	T_5	100 % RDF + FYM + PSB
6.	T_6	75% RDF + FYM + *Azotobacter* + PSB
7.	T_7	75% RDF + FYM + *Azotobacter*
8.	T_8	75% RDF + *Azotobacter* + PSB
9.	T_9	75% RDF + FYM + PSB
10.	T_{10}	50 % RDF + FYM + *Azotobacter* + PSB
11.	T_{11}	50% RDF + FYM + *Azotobacter*
12.	T_{12}	50 % RDF + *Azotobacter* + PSB
13.	T_{13}	50 % RDF + FYM + PSB
14.	T_{14}	Control (Absolute)

FYM @ 20 Kg tree^{-1}
Azotobacter and PSB @ 80 g each tree^{-1}

Table 2: Chemical composition of organic manures and fertilizers

Organic Manures / Fertilizers	Nutrient contents		
	N (%)	P_2O_5 (%)	K_2O (%)
Urea	46	-	-
Single Super Phosphate	-	16	-
Muriate of Potash	-	-	60
Farm Yard Manure	0.75	0.20	0.50

3. Results and discussion

3.1. 1. Physical quality attributes

The data in relation to different physical quality aspects of fruits as length of fruit, width of fruit, weight of pulp, weight of peel, per cent of pulp, per cent of peel, pulp to peel ratio, number of seeds and weight of seed are presented in Table 3 and 4.

3.1.2. Length of fruit (cm)

It is clear from the data that, the length of fruit was significantly affected by different combinations of inorganic and biofertilizers. The treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) recorded maximum fruit length (8.33 cm) which was statistically at par with T_3 (7.60 cm), T_{10} (7.31 cm), T_7 (7.26 cm) and T_5 (7.06 cm). The minimum fruit length (4.26 cm) was observed in control (T_{14}).

3.1. 3 Width of fruit (cm)

The results regarding width of fruit revealed that, the width of fruit was also significantly affected by various combinations of inorganic and biofertilizers. The maximum width of fruit (8.60 cm) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (7.70 cm) and T_5 (6.54 cm). The minimum width of fruit (3.96 cm) was recorded in control.

3.1. 4. Number of seeds per fruit (no.)

The results regarding number of seeds per fruit revealed that, the number of seeds per fruit was also significantly affected by various combinations of inorganic fertilizers and biofertilizers. The maximum number of seeds per fruit (36.00 seeds) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (35.00), T_3 and T_4 (34.00). The minimum number of seeds per fruit (28.00 seeds) was recorded in control (T_{14}).

3.1. 5. Weight of seed (g)

It is obvious from the data that, the weight of seed was significantly affected by different treatments of fertilizers. Minimum weight of seeds (18.20 g) was recorded in the treatments of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (19.28 g) and T_6 (20.50 g). The maximum weight of seeds (24.31 g) was observed in control (T_{14}).

Table 3: Effect of inorganic and biofertilizers on physical qualities of fruit.

Treatment no.	Treatments	Fruit length (cm)	Fruit width (cm)	Number of seeds/fruit (no.)	Weight of seed (g)
T_1	100 % RDF (250 g N, 125 g $P_2 0_5$ and 125 g $K_2 0$ tree^{-1})	5.36	4.52	30	21.14
T_2	100 % RDF + FYM + *Azotobacter* + PSB	8.33	8.60	28	18.20
T_3	100% RDF + FYM + *Azotobacter*	7.60	6.18	31	19.28
T_4	100 % RDF + *Azotobacter* + PSB	6.94	6.20	31	22.55
T_5	100 % RDF + FYM + PSB	7.06	6.54	33	22.21
T_6	75% RDF + FYM + *Azotobacter* + PSB	6.90	7.70	30	20.50
T_7	75% RDF + FYM + *Azotobacter*	7.26	4.08	32	22.31
T_8	75% RDF + *Azotobacter* + PSB	5.72	6.00	34	22.95
T_9	75% RDF + FYM + PSB	5.90	6.20	34	22.21
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	7.31	5.46	33	22.51
T_{11}	50% RDF + FYM + *Azotobacter*	5.42	6.10	32	22.26
T_{12}	50 % RDF + *Azotobacter* + PSB	5.92	6.49	35	22.36
T_{13}	50 % RDF + FYM + PSB	4.66	4.18	34	21.82
T_{14}	Control	4.26	3.96	36	24.31
S.E.±		0.34	0.29	1.47	1.00
C.D at 5%		0.96	0.86	4.27	2.93

3.1.6. Weight of pulp (g)

It is clear from the data that, the pulp weight of fruit was significantly influenced by different treatments of inorganic and biofertilizers. The maximum weight of pulp (90.17 g) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_4 (89.72 g), T_6 (89.32 g), T_3 (87.29 g), T_{10} (84.92 g) and T_7 (84.67 g). The minimum weight of pulp (70.12 g) was observed in control (T_{14}).

3.1.7. Weight of peel (g)

It is clear from the data that, the peel weight of fruit was significantly influenced by different treatments of inorganic fertilizers and biofertilizers. The maximum weight of peel (110.22 g) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_4 (108.86 g), T_6 (108.18 g), T_3 (102.74 g), T_{10} (101.46 g) and T_7 (100.21 g). The minimum weight of peel (88.10 g) was observed in control (T_{14}).

3.1.8. Per cent of pulp (%)

The results clearly showed that, the per cent of pulp was significantly affected by different treatments of inorganic fertilizers and biofertilizers. The highest per cent of pulp (42.25%) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (41.11%), T_6 (40.97%) and T_7 (40.86%). The lowest per cent of pulp (38.41%) was observed in control (T_{14}).

3.1.9. Per cent of peel (%)

The results regarding per cent of peel revealed that, the per cent of peel was also significantly affected by various combinations of inorganic and biofertilizers. The highest per cent of peel (49.62%) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (49.42%) and T_5 (49.58%). The minimum per cent of peel (48.27%) was recorded in control (T_{14}).

3.1.10. Pulp to peel ratio (%)

The results clearly showed that, the pulp to peel ratio was significantly affected by different treatments of inorganic fertilizers and biofertilizers. The greatest pulp to peel ratio (0.85) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2). The minimum pulp to peel ratio (0.79) was observed in treatment (T_5) and (T_{14}).

Table 4: Effect of inorganic and biofertilizers on physical qualities of fruit.

Treatment no.	Treatments	Weight of pulp (g)	Weight of peel (g)	Per cent of Pulp (%)	Per cent of Peel (%)	Pulp: Peel ratio
T_1	100 % RDF (250 g N, 125 g $P_2 0_5$ and 125 g $K_2 0$ tree^{-1})	76.20	92.81	40.07	48.80	0.82
T_2	100 % RDF + FYM + *Azotobacter* + PSB	90.17	110.22	42.25	49.62	0.85
T_3	100% RDF + FYM + *Azotobacter*	87.29	102.74	41.11	48.39	0.84
T_4	100 % RDF + *Azotobacter* + PSB	89.72	108.86	40.57	49.22	0.82
T_5	100 % RDF + FYM + PSB	79.26	99.79	39.38	49.58	0.79
T_6	75% RDF + FYM + *Azotobacter* + PSB	89.32	108.18	40.97	49.42	0.82
T_7	75% RDF + FYM + *Azotobacter*	84.67	100.21	40.86	48.36	0.84
T_8	75% RDF + *Azotobacter* + PSB	82.43	97.56	40.61	48.07	0.84
T_9	75% RDF + FYM + PSB	79.10	94.22	40.45	48.18	0.83
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	84.92	101.46	40.65	48.57	0.83
T_{11}	50% RDF + FYM + *Azotobacter*	81.28	96.58	40.61	48.26	0.84
T_{12}	50 % RDF + *Azotobacter* + PSB	78.26	92.60	40.50	47.92	0.84
T_{13}	50 % RDF + FYM + PSB	74.51	90.86	39.80	48.53	0.82
T_{14}	Control	70.12	88.10	38.41	48.27	0.79
S.E.±		3.96	4.61	1.88	2.32	0.04
C.D at 5%		11.51	13.41	NS	NS	0.11

3.2 Biochemical attributes

The data pertaining to Total Soluble Solids, Reducing sugar, Non-reducing sugar, Total sugar, Ascorbic acid and Acidity percentage are presented in Table 5.

3.2.1 Total Soluble Solids (%)

The maximum TSS (23.80%) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which are statistically at par with T_3 (23.50%), T_6 (23.20%), T_4 (22.50%), T_{10} (22.30%) and T_7 (22.10%). The minimum TSS (17.40%) was observed in control (T_{14}).

3.2.2. Reducing sugar (%)

The maximum reducing sugar (14.11%) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (13.92%), T_6 (13.75%), T_4 (13.46%), T_{10} (13.10%), T_7 (12.87%), T_5 (12.60%), T_8 (12.56%) and T_{11} (12.22%). The minimum reducing sugar content (9.40%) was recorded in control (T_{14}).

3.2.3 Non-reducing sugar (%)

The maximum non-reducing sugar (3.46%) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (3.29%), T_6 (3.21%), T_7 (3.15%), T_4 (3.10%) and T_3 (3.00%). The minimum reducing sugar content (2.10%) was recorded in control (T_{14}).

3.2.4 Total sugar (%)

The maximum total sugar (17.57%) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (17.21%), T_6 (16.96%), T_4 (16.56%), T_{10} (16.10%) and T_5 (15.41%). The minimum total sugar (11.50%) was observed in control (T_{14}).

3.2.5 Ascorbic acid (mg/100g pulp)

The maximum ascorbic acid content (37.22 mg/100g pulp) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (31.10 mg/100g pulp), T_6 (28.41 mg/100g pulp), T_4 (22.16 mg/100g pulp), T_{10} (20.49 mg/100g pulp) and T_5 (19.61mg/100g pulp). The minimum ascorbic acid content (15.11mg/100g pulp) was recorded in control (T_{14}).

3.2.6 Acidity (%)

Minimum acidity (0.32%) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (0.34%), T_3 (0.35%), T_4 (0.37) and T_{10} (0.39%). The highest acidity (0.51%) was observed in control (T_{14}).

Table 5: Effect of inorganic and biofertilizers on chemical composition of custard apple fruit.

Treat. no.	Treatments	Total Soluble Solids (%)	Ascorbic acid (mg/100g fruit pulp)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)	Acidity (%)
T_1	100 % RDF (250 g N, 125 g P_20_5 and 125 g K_20 tree^{-1})	19.30	15.80	11.20	2.20	13.40	0.48
T_2	100 % RDF + FYM + *Azotobacter* + PSB	23.80	37.22	14.11	3.46	17.57	0.32
T_3	100% RDF + FYM + *Azotobacter*	23.50	31.10	13.92	3.29	17.21	0.35
T_4	100 % RDF + *Azotobacter* + PSB	22.50	22.16	13.46	3.10	16.56	0.37
T_5	100 % RDF + FYM + PSB	21.80	19.61	12.60	2.85	15.41	0.42
T_6	75% RDF + FYM + *Azotobacter* + PSB	23.20	28.41	13.75	3.21	16.96	0.34
T_7	75% RDF + FYM + *Azotobacter*	22.10	19.21	12.87	3.15	16.02	0.40
T_8	75% RDF + *Azotobacter* + PSB	21.60	17.86	12.56	2.73	15.29	0.43
T_9	75% RDF + FYM + PSB	21.10	17.42	11.95	2.52	14.74	0.48
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	22.30	20.49	13.10	3.00	16.10	0.39
T_{11}	50% RDF + FYM + *Azotobacter*	20.90	16.70	12.22	2.41	14.63	0.41
T_{12}	50 % RDF + *Azotobacter* + PSB	19.80	16.14	11.72	2.28	14.00	0.48
T_{13}	50 % RDF + FYM + PSB	18.34	15.66	10.29	2.14	12.43	0.49
T_{14}	Control	17.40	15.11	9.40	2.10	11.50	0.51
S.E.±		1.03	1.06	0.59	0.24	0.75	0.02
C.D at 5%		2.98	3.07	1.71	0.70	2.18	0.06

3.3 Shelf life (days)

It is evident from the data that, shelf life of fruits was significantly influenced by different combinations of inorganic and biofertilizers, presented in Table 6, Maximum shelf life of fruits (12.00 days) was observed in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which were significantly superior over rest of the treatments. The minimum shelf life of fruits (5.20 days) was observed in control (T_{14}).

Table 6: Effect of inorganic and biofertilizers on shelf life of custard apple fruit

Treat. no.	Treatments	Shelf life of custard apple (days)
T_1	100 % RDF (250 g N, 125 g P_20_5 and 125 g K_20 tree^{-1})	6.00
T_2	100 % RDF + FYM + *Azotobacter* + PSB	12.00
T_3	100% RDF + FYM + *Azotobacter*	10.00
T_4	100 % RDF + *Azotobacter* + PSB	8.50
T_5	100 % RDF + FYM + PSB	8.00
T_6	75% RDF + FYM + *Azotobacter* + PSB	9.00
T_7	75% RDF + FYM + *Azotobacter*	8.70
T_8	75% RDF + *Azotobacter* + PSB	7.30
T_9	75% RDF + FYM + PSB	7.90
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	8.10
T_{11}	50% RDF + FYM + *Azotobacter*	7.30
T_{12}	50 % RDF + *Azotobacter* + PSB	7.00
T_{13}	50 % RDF + FYM + PSB	6.80
T_{14}	Control	5.20
S.E.±		0.83
C.D at 5%		2.41

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