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Effect of inorganic and biofertilizers on vegetative growth and reproductive growth parameters of custard apple (*Annona squamosa* L.) Cv. Balanagar

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Abstract
This study was conducted to determine "Effect of inorganic and biofertilizers on growth, yield and quality of custard apple (*Annona squamosa* L.) Cv. Balanagar". 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 significant variation in growth parameters of custard apple due to application of different inorganic and biofertilizers treatments. All the plant growth parameters studied viz., increase in plant height (51.55 cm), increase in tree spread (east-west 47.55 cm and north-south spread 49.80 cm), increase in stem girth (6.80 cm) and plant volume (13.31 m^3) were significantly higher with the treatment T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by treatment T_3 (100 % RDF + FYM + *Azotobacter*) and T_6 (75% RDF + FYM + *Azotobacter* + PSB) while the lowest values for these parameters were obtained under control treatment (T_{14}). Reproductive growth parameters viz., maximum number of flowers per meter cube (21.00 flowers), number of fruits per meter cube (16.00 fruits), maximum fruit set % (76.21%) recorded in treatment T_2 (100% RDF + FYM + *Azotobacter* + PSB) followed by T_3 (100 % RDF + FYM + *Azotobacter*) and minimum number of days required for flowering (151.00 days), fruit set (10.10 days) and fruit maturity (100.00 days) recorded in treatment of T_2 (100% RDF + FYM + *Azotobacter* + PSB) which was at par with treatment T_6 (75% RDF + FYM + *Azotobacte*r + PSB).

Keywords: Composition, azotobactor, inorganic, PSB, growth, vam

1. 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. Annonaceous fruits form an important part of diet of the people in the South India. 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 from there; it was distributed to Mexico and Tropical America (Popenoe, 1974) [10]. 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) [7]. 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) [4]. Fruit contains sugar 16-20 per cent and lipids 0.35 per cent of edible part of fruit (Leal, 1990) [6].

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) [8]. 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) [5].

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

(Navaneethakrishnan and Nattar, 2011).

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) [11]. An assessment of nutrient efficiency revealed that nitrogen deficiency is universal and will be continued. Nitrogen has many functions in plant life. Being as a part of protein, nitrogen is an important constituent of protoplasm. It is also responsible for the biosynthesis of enzymes, nucleoproteins, amino acids, amines, amino sugars, polypeptides, chlorophylls and encourages cell division. Phosphorus is a component of ADP, ATP, DNA and various RNA. It plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in the living plant. It promotes early root formation and growth. It also improves the quality of fruits. Potassium is the third important nutrient, essential for protein synthesis, in fruit formation. Potassium has a great impact on crop quality.

The custard apple gives better response to fertilizer application in respect to yield and quality of fruits. But, the low productivity of custard apple may be due to less adoption of improved crop management technology in respect of planting system, nutrition, plant protection and irrigation etc. Among several other factors affecting the productivity of fruit trees, as custard apple trees removes large amount of nutrients from soil, balance fertilization seems to be an important factor governing the productivity of custard apple trees. Large scale use of chemical fertilizers causes problem of ground water and environmental pollution through leaching, volatilization and denitrification. The disproportionate of chemical fertilizers has widened soil imbalance in terms of NPK ratio. The occurrence of multinutrient deficiencies and overall decline in productive capacity of soil has been widely reported due to non-judicious fertilizer use (Chhonkar, 2008) [3]. 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, 2].

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	Treat. 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 Vegetative Growth Parameters

Data in respect of increase in plant height, spread, stem girth and plant volume are presented in Table 3.

3.1.1 Height of Plant (cm)

The results revealed that, the plant height was significantly influenced by different treatments of inorganic and biofertilizers. The maximum increase in plant height (51.55 cm) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which were significantly superior over rest of the treatments. The minimum increase in tree height (29.10 cm) was found in control (T_{14}).

3.1.2 Plant Spread (cm)

In respect of spread, the results indicated that increase in plant spread was significantly influenced due to different treatments of inorganic and biofertilizers. The maximum increase in east-west spread (47.55 cm) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (45.95 cm), T_7 (43.80 cm) and T_3 (42.90 cm). The minimum increase in east- west spread (29.10 cm) was observed in control (T_{14}).

The increase in north- south spread was also significantly affected by various combinations of inorganic and biofertilizers. The maximum increase in north- south spread (49.80 cm) was recorded in the treatments of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (46.54 cm) and T_6 (43.56 cm). The minimum increase in north- south spread (20.80 cm) was recorded in control (T_{14}).

Table 3: Effect of inorganic and biofertilizers on plant growth parameters (Plant height, spread, stem girth and plant volume).

Treat. no.	Treatments	Increase in plant height (cm)	Increase in plant spread		Increase in stem girth (cm)	Plant volume (m^3)
			East- West (cm)	North-South (cm)		
T_1	100 % RDF (250 g N, 125 g P_20_5 and 125 g K_20 tree^{-1})	31.90	36.60	26.90	4.25	9.19
T_2	100 % RDF + FYM + *Azotobacter* + PSB	51.55	47.55	49.80	6.80	13.31
T_3	100% RDF + FYM + *Azotobacter*	46.95	42.90	46.54	6.70	12.17
T_4	100 % RDF + *Azotobacter* + PSB	41.00	41.70	40.66	6.24	10.68
T_5	100 % RDF + FYM + PSB	40.05	40.30	36.00	5.51	11.38
T_6	75% RDF + FYM + *Azotobacter* + PSB	45.50	45.95	43.56	6.55	12.00
T_7	75% RDF + FYM + *Azotobacter*	43.60	43.80	41.00	6.09	10.42
T_8	75% RDF + *Azotobacter* + PSB	39.70	40.95	33.51	5.35	10.34
T_9	75% RDF + FYM + PSB	33.90	36.45	31.30	4.80	10.45
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	44.90	40.60	32.82	5.89	9.80
T_{11}	50% RDF + FYM + *Azotobacter*	38.40	39.70	35.20	5.06	9.58
T_{12}	50 % RDF + *Azotobacter* + PSB	34.55	35.70	33.00	4.43	9.25
T_{13}	50 % RDF + FYM + PSB	30.10	30.40	26.00	4.16	9.15
T_{14}	Control	29.10	29.10	20.80	3.85	9.01
S.E.$\pm$		1.86	1.82	1.97	0.29	0.50
C.D at 5%		5.41	5.30	5.72	0.83	1.45

3.1.3 Stem Girth (cm)

The data in respect of increase stem girth revealed that the stem girth was significantly influenced due to different treatments of inorganic and biofertilizers. The maximum increase in stem girth (6.80 cm) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (6.70 cm), T_6 (6.55 cm), T_4 (6.24 cm) and T_7 (6.09 cm). The minimum increase in stem girth (3.85 cm) was observed in control (T_{14}).

3.1.4 Plant Volume (m^3)

The data in respect of plant volume revealed that the plant volume was significantly influenced due to different treatments of inorganic and biofertilizers. The maximum plant volume (13.31 m^3) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (12.17 m^3), T_6 (12.00 m^3), T_5 (11.38 m^3) and T_4 (10.68 m^3). The minimum increase in plant volume (9.01m^3) was observed under control (T_{14}).

3.2 Reproductive growth parameters

The data regarding number of flowers per meter cube, number of fruits per meter cube, per cent fruit set, days required for flowering, fruit set and fruit maturity are presented in Table 4.

3.2.1 Number of days required for flowering

The results revealed that, the number of days required for flowering was significantly affected by different fertilizers treatments. The maximum number of days required for flowering (178.00 days) was recorded in the treatment (T_{14}) and minimum number of days required for flowering (151.00 days) was recorded in treatment of 100% RDF + FYM + *Azotobacter* + FYM (T_2).

3.2.2 Number of flowers per meter cube

The results revealed that, the number of flowers per meter cube was significantly affected by different treatments. The maximum number of flowers per meter cube (21.00 flowers) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was at statistically par with T_3 (19.00), T_6 (18.00), T_4 (17.00) and T_7, T_{10} and T_{11} (16.00). The minimum number of flowers per meter cube (8.00) was recorded in control (T_{14}).

Table 4: Effect of inorganic and biofertilizers on reproductive growth parameters.

Treat. no.	Treatments	Number of flowers/m^3	Number of fruits/m^3	Fruit set (%)	Days required for flowering	Days required to fruit set	Days required to fruit maturity
T_1	100 % RDF (250 g N, 125 g P_20_5 and 125 g K_20 tree^{-1})	11.00	7.00	63.64	173.24	15.36	128.00
T_2	100 % RDF + FYM + *Azotobacter* + PSB	21.00	16.00	76.21	151.00	10.10	100.00
T_3	100% RDF + FYM + *Azotobacter*	19.00	14.00	73.69	155.33	11.30	114.00
T_4	100 % RDF + *Azotobacter* + PSB	17.00	12.00	70.59	165.10	13.46	118.00
T_5	100 % RDF + FYM + PSB	14.00	9.00	64.29	167.00	13.96	121.00
T_6	75% RDF + FYM + *Azotobacter* + PSB	18.00	13.00	72.22	153.00	10.80	110.00
T_7	75% RDF + FYM + *Azotobacter*	16.00	11.00	68.76	168.67	13.52	115.00
T_8	75% RDF + *Azotobacter* + PSB	15.00	9.00	60.00	171.00	14.10	120.00
T_9	75% RDF + FYM + PSB	13.00	8.00	61.53	174.00	15.10	122.00
T_{10}	50 % RDF + FYM + *Azotobacter* + PSB	16.00	11.00	68.75	157.00	13.20	117.00
T_{11}	50% RDF + FYM + *Azotobacter*	16.00	10.00	62.50	169.33	13.73	123.00
T_{12}	50 % RDF + *Azotobacter* + PSB	12.00	8.00	66.67	172.64	14.92	126.00
T_{13}	50 % RDF + FYM + PSB	10.00	6.00	60.00	174.52	15.62	130.00
T_{14}	Control	8.00	4.00	50.00	178.00	16.00	132.00
S.E.$\pm$		0.71	0.47	3.79	7.81	0.69	5.70
C.D at 5%		2.06	1.36	11.01	NS	2.00	16.56

3.2.3 Number of fruits per meter cube
The results revealed that, the number of fruits per meter cube was also significantly affected by different treatments. The maximum number of fruits per meter cube (16.00 fruits) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (14.00), T_6 (13.00) and T_4 (12.00) superior over rest of the treatments. The minimum number of fruits per meter cube (4.00) was observed in control (T_{14}).

3.2.4 Per cent fruit set
The per cent fruit set was also significantly influenced due to various treatments. The maximum per cent fruit set (76.21%) was recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_3 (73.69%), T_6 (72.22%), T_4 (70.59), T_7 (68.76%), T_5 (64.29%) and T_{10} (62.21%). The minimum per cent fruit set (50.00%) was observed in control treatment (T_{14}).

3.2.5 Days required to fruit set
The results regarding days required to fruit set have also shown significantly differences due to different treatments. The minimum days for fruit set (10.10 days) was required in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (10.80), T_3 (11.30), T_{10} (13.20), T_4 (13.46), T_7 (13.52). The maximum days for fruit set (16.00) were required in control (T_{14}).

3.2.6 Days required to fruit maturity
It is clear from the data that, the days required to fruit maturity were significantly affected by different combinations of inorganic and biofertilizers. The minimum days for fruit maturity (100.00 days) were recorded in the treatment of 100% RDF + FYM + *Azotobacter* + PSB (T_2) which was statistically at par with T_6 (110.00) and T_3 (114.00). The maximum days for fruit maturity (132.00) were recorded under control treatment (T_{14}).

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