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Effect of different sources of nitrogen on growth and yield attributes of custard apple (*Annona squamosa* L.) cv. Sindhan

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Abstract
A field experiment was carried out on "Effect of different sources of nitrogen on growth and yield attributes of custard apple (*Annona squamosa* L.) cv. Sindhan" at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *Kharif-Rabi* season of the year 2019-20. The experiment was laid out in Completely Randomized Design repeated thrice with thirteen treatments. Among the different treatments soil application of 50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter* per plant was recorded significantly maximum total soluble solids (25.19 °Brix), reducing sugar (18.83%), non-reducing sugar (6.20%), total sugar (24.98%) and ascorbic acid (21.05 mg/100 g pulp) and maximum incremental plant height (27.12 cm), incremental plant spread [N-S directions] (54.26 cm), incremental plant spread [E-W directions] (56.20 cm), fruit length (7.38 cm), fruit diameter (7.92 cm), fruit weight (199.54 g), fruit volume (168.65 cc), number of fruits per plant (132.67), fruit yield (22.38 kg/plant), total fruit yield (8.88 tones/ha), soil nutrients and soil microorganisms counts were recorded significantly with soil application of 50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter* per plant.

Keywords: Custard apple, growth, yield, vermicompost, and *azotobacter*

Introduction
Custard apple (*Annona squamosa* L.) is a delicious and important minor fruit crop cultivated in tropical and subtropical climate. It comes under family Annonaceae and is native of the West Indies but also cultivated throughout Central America to Southern Mexico during early times. Young leaves of custard apple contain steroids, alkaloids, saponins, terpenes, tannins, phenolic substances, carbohydrates, mucilage and volatile oil (Kumar and Kumar, 2011) [10, 11]. It has good pleasant flavour, mild aroma and sweet taste. Custard apple is also known as sweetsop, sugar apple, *sharifa*, *sitaphal* and *noi-na* in different parts of India. The ripened fruits are consumed mainly in its fresh form. It has been great demand for custard apple in preparation of ice-cream and pudding. Due to the presence of annonaine, the leaves, stem and other portions of the plant are bitter and so the plant is not grazed by goats and cattle. Moreover, the area under custard apple cultivation is increasing day by day in India. The successfull commercial cultivation of custard apple depends on many factors *viz.*, climate, soil, irrigation, fertilization as well as growing season, *etc.*

Nitrogen is one of the most important element as well as expensive input in horticultural production. Addition of organic and inorganic sources of fertilizers is not only remedy for supplementation and improvement of soil fertility and productivity but also improved soil physical condition which result more water retention as well as increase soil flora and fauna.

Poultry manure is relatively resistant to microbial degradation. However, it is essential for establishing and maintaining optimum soil physical condition and important for plant growth. Poultry manure is very cheap and effective as a good source of nitrogen for sustainable crop production.

Vermicompost is stable granular organic manure when it has added to clay soils loosen the soil and which provides the more passage for the fast entry of air and water. The mucus, associated with earthworm cast being hygroscopic in nature absorbs water, prevents water logging and improves water holding capacity of soil. There are abundant evidences that concentration of exchangeable calcium, sodium, potassium, magnesium, phosphorus and molybdenum are higher in earthworm cast than in surrounding soil. (Hidalgo and Harkess, 2002) [8] observed that application of vermicompost increased percentage pore space and water holding capacity while, decreased the bulk density and percentage of air space in soil.

Azotobacter is a microbial inoculants freely living in the soil which are capable to fixation of nitrogen elements from non-soluble to soluble form through biological process. *Azotobacter* are used in live formulation of beneficial micro-organism and which can apply to root, soil or seed mobilize the availability of nutrients particularly by their biological activity and help to build up the lost micro flora and in turn improve the soil health (Hazarika and Ansari, 2007) [6, 7].

Methods and Materials

The experiment was carried out during *kharif-Rabi* season in the year 2019 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand situated on 22^0 35' North latitude and 72^0 56' East longitudes. The climate is semi-arid and sub-tropical type. Experimental site had soil type of loamy sand, locally known as *"Goradu"*. The soil is well drained and retentive of moisture. The research investigation conducted on 11 years old custard apple plant cv. Sindhan planted at a spacing of 5 x 5 m spacing with medium size canopy, hardy, deciduous and slightly tolerant to drought condition. The experiment was laid out in Completely Randomized Design (CRD) with 13 treatments with three repetitions which includes different nutrient sources at different doses and their combination with azotobacter as given in table.

Treatment	Details
T_1	100% RDN from Urea
T_2	75% RDN from Urea + 25% RDN from Vermicompost
T_3	75% RDN from Urea + 25% RDN from Castor cake
T_4	75% RDN from Urea + 25% RDN from Neem cake
T_5	75% RDN from Urea + 25% RDN from Poultry manure
T_6	50% RDN from Urea + 50% RDN from Vermicompost
T_7	50% RDN from Urea + 50% RDN from Castor cake
T_8	50% RDN from Urea + 50% RDN from Neem cake
T_9	50% RDN from Urea + 50% RDN from Poultry manure
T_{10}	50% RDN from urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*
T_{11}	50% RDN from Urea + 25% RDN from Castor cake + 10 ml *Azotobacter*
T_{12}	50% RDN from Urea + 25% RDN from Neem cake + 10 ml *Azotobacter*
T_{13}	50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter*

The soil application of full dose of *Azotobacter*, different manures and half dose of Urea were applied as basal dose in last week of June whereas, remaining half dose of Urea given in last week of August. One plant was selected randomly in each treatment of respective repetition for recording data on various plant growth traits *i.e.*, incremental plant height (cm) after fruit harvest, incremental plant spread [N-S & E-W directions] (cm), fruit length (cm), fruit diameter (cm), fruit weight (g), fruit volume (cc), number of seeds per fruit, number of fruits per plant, fruit yield (kg/plant and tones/ha.) and soil parameters *i.e.*, available NPK content (kg/ha) and soil microorganisms counts. The data pertaining to all the characters studied were subjected to the statistical analysis of variance technique as described by Steel and Torrie (1980) [21, 22].

Result and Discussion

Growth parameters

The growth parameters were significantly affected by soil application of urea, *azotobacter* and different manures. The significantly maximum incremental plant height (27.12 cm), incremental plant spread [N-S] (54.26 cm) and incremental plant spread [E-W] (56.20 cm) were recorded with soil application of 50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter* per plant (T_{10}) treatment. With the highly significant value (T_{10}), T_{12} and T_{13} (incremental plant height), $T_{6,}$ T_{12} and T_{13} (incremental plant spread [N-S]), T_6 and T_{13} (incremental plant spread [E-W]) were statistically at par with the highly significant value (T_{10}). The improvement in plant growth parameters might be due to the increased chlorophyll content and endogenous hormones in leaves and rhizosphere respectively with inoculation of nitrogen fixers like azotobactor which makes a balance between photosynthates and N-assimilation. Better development of plant root system and possibly synthesis of plant growth regulators like GA, IAA and Cytokines are directly influenced by azotobacter (Gajbhiye *et al*., 2003; Rana and Chandel 2003) [4, 16]. The result was also in accordance with the findings of Gupta and Tripathi (2012) [5], Sharma and Bhatnagar (2014) [17] and Kumrawat *et al.* (2018) [12]. Therefore, increased plant height may be attributed to the increased biological nitrogen fixation. However, the lowest incremental plant height (22.82 cm) was recorded with T_1 and lowest incremental plant spreads (N-S - 48.83 cm; E-W - 50.93 cm) were recorded in T_3 treatment.

Effect on Yield Parameters

The yield parameters of custard apple cv. Sindhan *viz.*, Fruit length (cm), diameter (cm), weight (g), volume (cc), total number of fruits (per plant) and fruit yield (kg per plant) were significantly affected by soil application of urea, *azotobacter* and different manures. The significantly highest values of fruit yield parameters *viz.*, Fruit length (7.38 cm), diameter (7.92 cm), weight (199.54 g), volume (188.89 cc), total number of fruits per plant (132.67) and fruit yield (22.38 kg per plant and 8.88 t/ha) were recorded significantly with soil application of 50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter* per plant (T_{10}) treatment. However, the higher values were statistically at par with T_6, T_5 and T_{13} treatments for fruit length, T_6 for diameter, weight and volume and T_6 and T_{13} for fruit yield. The data also indicated non-significant effect on total number of seeds per fruit. The increment in yield parameters might be due to application of azotobacter along with vermicompost improved the availability of macro and micronutrients and growth promoting hormones (causing more amino acids synthesis) and stimulated cell division and cell elongation (Singh and Singh, 2004) [19]. The efficient partitioning of photosynthesis towards the sink by *Azotobacter* inoculation increased the fruit volume and weight (Rana and Chandel, 2003) [16]. Also, endogenous balance between promoters and inhibitors favoured the fruit promoting processes (Pilania *et al.*, 2010) [15]. The enhanced metabolic activities promoted high carbohydrate and protein synthesis and improved the fruit growth parameters (Singh *et al.*, 1970; Baviskar *et al*., 2011) [20, 2]. The cumulative effect of vermicompost and *Azotobacter* accelerated the growth of inflorescence, number of leaves in autumn season which increased in fruit set percentage and increased various endogenous hormonal levels which is responsible for improved pollen germination and fruit set and ultimately resulted in more number of fruits per plant (Gupta and Tripathi, 2012; Kumar *et al*., 2017) [5, 9]. The increase in yield, besides the improved yield parameters, was also because of CO_2 generation during decomposition of compost in soil (Lieten, 1996) [13]. These findings were also in agreement with Devi *et al.* (2012) [3] and Shukla *et al*. (2014) [18]. However, the minimum fruit length (6.34 cm), fruit weight (165.30 g) and number of fruits per plant (105.33) were recorded with T_8, lowest fruit diameter (6.98cm) and fruit volume (156.23 cc) were recorded with T_3 and minimum total number of seeds per fruit (35.33) and fruit yield (18.05 kg per plant and 7.24 t/ha) were recorded in T_5 treatment.

Effect on Soil Nutrient Status and Microbial Count

The results indicated significant effect of soil application of Urea, *Azotobacter* and different manures on soil nutrient status *viz.*, available nitrogen (kg/ha), available phosphorus (kg/ha) and available potassium (kg/ha) and soil organic carbon (%) and total microbial count, *Azotobacter*, *Azospirillium*, phosphate solubilizing bacteria and potassium mobilizing bacteria (cfu/g soil) in soil. Among the treatments, T_{10} (50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*) was most effective and recorded maximum available nitrogen (318.66 kg/ha), available phosphorus (57.22 kg / ha), available potassium (305.85 kg/ha), organic carbon (0.41%), total microbial count (6.8 x 10^9 cfu/g soil), *Azotobacter* (7.1 x 10^5 cfu/g soil), *Azospirillium* (5.9 x 10^5 cfu/g soil), phosphate solubilizing bacteria (5.1 x 10^5 cfu/g soil) and potassium mobilizing bacteria (6.1 x 10^5 cfu/g soil). However, the higher values were statistically at par with T_{11} and T_{13} for available nitrogen and phosphorus, T_6, T_{12} and T_{13} for available potassium, T_6, T_{11}, T_{12} and T_{13} for soil organic carbon. The improvement in soil nutrient status post-harvest with increasing nitrogen levels in soil was due to integration of organic manures and inorganic sources of fertilizers. Vermicompost favoured mineralization of organic sources of nitrogen as it stimulated the nitrification process and lesser soluble phosphorus by decomposition in the soil. The action of organic acid from vermicompost influenced soil pH and made potassium available from stable complexes or chelated or fixed forms. Application of *Azotobacter* also increased microbial population. The decomposition products serve as energy source for growth and multiplication of microorganism populations in soil (Sharma *et al.*, 2013). However, minimum available nitrogen (257.85 kg/ha), available phosphorus (44.42 kg/ha) and available potassium (64.86 kg/ha) were obtained with T_1 (100% RDN from Urea) treatment.

Table 1: Effect of different sources of nitrogen on plant growth parameters of custard apple cv. Sindhan.

Sr. No.	Treatment details	Incremental plant height (cm)	Incremental plant spread [N-S] (cm)	Incremental plant spread [E-W] (cm)
T_1	100% RDN from Urea	22.82	50.12	53.18
T_2	75% RDN from Urea + 25% RDN from Vermicompost	23.27	50.66	51.49
T_3	75% RDN from Urea + 25% RDN from Castor cake	23.32	48.83	50.93
T_4	75% RDN from Urea + 25% RDN from Neem cake	24.34	49.91	53.84
T_5	75% RDN from Urea + 25% RDN from Poultry manure	23.05	50.41	51.98
T_6	50% RDN from Urea + 50% RDN from Vermicompost	24.71	53.15	54.76
T_7	50% RDN from Urea + 50% RDN from Castor cake	24.48	50.76	52.48
T_8	50% RDN from Urea + 50% RDN from Neem cake	24.44	50.50	53.59
T_9	50% RDN from Urea + 50% RDN from Poultry manure	24.53	51.55	51.75
T_{10}	50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*	27.12	54.26	56.20
T_{11}	50% RDN from Urea + 25% RDN from Castor cake + 10 ml *Azotobacter*	25.05	52.57	52.55
T_{12}	50% RDN from Urea + 25% RDN from Neem cake + 10 ml *Azotobacter*	26.38	53.05	53.58
T_{13}	50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter*	25.60	52.90	54.29
	S.Em±	0.61	0.51	0.81
	C.D. at 5%	1.77	1.48	2.36
	C.V.%	4.31	1.72	2.64

Table 2: Effect of different sources of nitrogen on yield parameters of custard apple cv. Sindhan.

Sr. No.	Treatment details	Fruit length (cm)	Fruit diameter (cm)	Fruit Weight (g)	Fruit Volume (cc)	Number of seeds per fruit	Number of fruits per plant	Fruits yield (kg/plant)	Fruits yield (t/ha.)
T_1	100% RDN from Urea	6.51	7.25	181.35	150.61	44.20	110.33	18.13	7.19
T_2	75% RDN from Urea + 25% RDN from Vermicompost	6.79	7.08	178.85	148.38	40.27	107.00	19.92	7.93
T_3	75% RDN from Urea + 25% RDN from Castor cake	6.77	6.98	166.50	143.93	42.60	108.67	18.59	7.40
T_4	75% RDN from Urea + 25% RDN from Neem cake	6.49	7.12	185.13	154.85	47.00	108.00	19.32	7.73
T_5	75% RDN from Urea + 25% RDN from Poultry manure	6.95	7.38	192.90	162.31	35.33	111.67	18.05	7.20
T_6	50% RDN from Urea + 50% RDN from Vermicompost	7.01	7.71	196.82	166.76	45.80	119.00	21.15	8.67
T_7	50% RDN from Urea + 50% RDN from Castor cake	6.76	7.30	180.99	151.04	38.53	107.67	19.06	7.75
T_8	50% RDN from Urea + 50% RDN from Neem cake	6.34	7.04	165.30	146.96	36.27	105.33	19.15	7.66
T_9	50% RDN from Urea + 50% RDN from Poultry manure	6.75	7.15	166.96	145.52	38.40	108.33	18.43	7.37
T_{10}	50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*	7.38	7.92	199.54	168.65	43.13	132.67	22.38	8.88
T_{11}	50% RDN from Urea + 25% RDN from Castor cake + 10 ml *Azotobacter*	6.59	7.27	174.41	143.42	40.33	117.00	20.13	8.05

T_{12}	50% RDN from Urea + 25% RDN from Neem cake + 10 ml *Azotobacter*	6.69	7.20	173.38	150.19	36.60	119.33	19.52	7.81
T_{13}	50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter*	6.88	7.32	193.26	160.16	41.33	122.00	20.82	8.33
	S.Em±	0.17	0.17	1.96	1.93	4.01	2.11	0.61	0.27
	C.D. at 5%	0.49	0.50	5.70	5.62	11.61	6.13	1.78	0.80
	C.V.%	4.39	4.09	1.87	2.18	17.09	3.21	5.41	6.07

Table 3: Effect of different sources of nitrogen on available NPK and organic carbon in soil of custard apple orchard cv. Sindhan

Sr. No.	Treatments	Available nutrient (kg/ha)			
		Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)	Organic Carbon (%)
	Initial Values	256.54	36.21	261.50	0.30
T_1	100% RDN from Urea	257.85	44.42	264.86	0.30
T_2	75% RDN from Urea + 25% RDN from Vermicompost	264.04	48.29	265.91	0.32
T_3	75% RDN from Urea + 25% RDN from Castor cake	273.30	47.33	273.29	0.33
T_4	75% RDN from Urea + 25% RDN from Neem cake	287.00	46.66	279.89	0.34
T_5	75% RDN from Urea + 25% RDN from Poultry manure	271.15	46.27	287.50	0.34
T_6	50% RDN from Urea + 50% RDN from Vermicompost	280.54	51.51	303.12	0.39
T_7	50% RDN from Urea + 50% RDN from Castor cake	271.74	49.78	289.15	0.32
T_8	50% RDN from Urea + 50% RDN from Neem cake	284.26	46.35	279.76	0.33
T_9	50% RDN from Urea + 50% RDN from Poultry manure	282.90	48.98	277.86	0.31
T_{10}	50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*	318.66	57.22	305.85	0.41
T_{11}	50% RDN from Urea + 25% RDN from Castor cake + 10 ml *Azotobacter*	311.46	52.68	281.67	0.37
T_{12}	50% RDN from Urea + 25% RDN from Neem cake + 10 ml *Azotobacter*	290.13	47.60	292.20	0.38
T_{13}	50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter*	302.33	51.72	293.03	0.36
	S.Em±	7.01	1.91	5.33	0.19
	C.D. at 5%	20.39	5.54	15.50	0.05
	C.V.%	4.27	6.72	3.25	9.68

Table 4: Effect of different sources of nitrogen on microbial count in soil of custard apple orchard cv. Sindhan

Sr. No.	Treatments	Total Count	*Azotobacter*	*Azospirillum*	PSB	KMB
T_1	100% RDN from Urea	4.3×10^7	2.1×10^3	2.7×10^3	3.6×10^4	6.4×10^3
T_2	75% RDN from Urea + 25% RDN from Vermicompost	5.9×10^9	4.8×10^5	5.5×10^5	1.9×10^5	2.0×10^5
T_3	75% RDN from Urea + 25% RDN from Castor cake	5.6×10^9	3.5×10^5	2.1×10^5	2.7×10^5	5.5×10^5
T_4	75% RDN from Urea + 25% RDN from Neem cake	5.2×10^9	5.8×10^5	3.9×10^5	2.9×10^5	2.3×10^5
T_5	75% RDN from Urea + 25% RDN from Poultry manure	5.1×10^9	5.4×10^5	4.8×10^5	4.7×10^5	5.4×10^5
T_6	50% RDN from Urea + 50% RDN from Vermicompost	6.3×10^9	6.2×10^5	4.9×10^5	4.7×10^5	5.3×10^5
T_7	50% RDN from Urea + 50% RDN from Castor cake	6.4×10^9	6.2×10^5	5.7×10^5	2.9×10^5	4.3×10^5
T_8	50% RDN from Urea + 50% RDN from Neem cake	6.1×10^9	4.7×10^5	3.9×10^5	1.7×10^5	3.8×10^5
T_9	50% RDN from Urea + 50% RDN from Poultry manure	6.3×10^5	4.4×10^5	2.4×10^5	4.3×10^5	6.4×10^9
T_{10}	50% RDN from Urea + 25% RDN from Vermicompost + 10 ml *Azotobacter*	6.8×10^9	7.1×10^5	5.9×10^5	5.1×10^5	6.1×10^5
T_{11}	50% RDN from Urea + 25% RDN from Castor cake + 10 ml *Azotobacter*	6.2×10^9	6.1×10^5	4.9×10^5	4.1×10^5	5.1×10^5
T_{12}	50% RDN from Urea + 25% RDN from Neem cake + 10 ml *Azotobacter*	6.1×10^9	4.1×10^5	4.6×10^5	3.8×10^5	4.6×10^5
T_{13}	50% RDN from Urea + 25% RDN from Poultry manures + 10 ml *Azotobacter*	5.8×10^9	5.1×10^5	4.8×10^5	4.4×10^5	5.3×10^5

Conclusion

From the foregoing discussion, it can be concluded that the soil application of 50% RDN from Urea + 25% RDN from Poultry manure + 10 ml *Azotobacter* per plant improve fruit quality while 50% RDN from Urea + 25% RDN from Vermicompost + 10 ml Azotobacter was most effective in soil nutrients and microorganisms of custard apple cv. Sindhan.

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