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Effect of integrated nutrient management on growth and yield of pineapple (cv. Kew)

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Abstract
The work was carried out during 2014- 2016 at Horticulture farm under Department of Horticulture and Post Harvest Technology, Institute of Agriculture, Visva Bharati, Sriniketan to study the Effect of Integrated Nutrient Management on Growth and Yield of Pineapple (cv. Kew). The experiment was carried out in a Randomized Block Design with three replications. Treatment consisted of 9 treatment combinations viz., T_1= Control; T_2= 20t/ha FYM + 100% of recommended dose of fertilizer (RDF) of NPK; T_3= 30t/ha FYM + 75% of RDF of NPK; T_4= 5 t/ha Vermicompost + 100% of RDF of NPK; T_5= 7.5 t/ha Vermicompost + 75% of RDF of NPK; T_6= 20t/ha FYM + 100% of RDF of NPK + bio fertilizer (Azotobactor + phosphate solubalizing bacteria or PSB); T_7= 30t/ha FYM + 75% of RDF of NPK + bio fertilizer; T_8= 5 t/ha Vermicompost + 100% of RDF of NPK + bio fertilizer; T_9= 7.5 t/ha Vermicompost + 75%NPK + bio fertilizer. The result revealed that all the growth and yield characteristics are significantly affected by different levels of organic and inorganic treatment combination. With respect to different plant growth parameters like plant height, total no of leaf, D-leaf initiation days, D-leaf length, D-leaf width and plant grith found effective with treatment combination T_9 (7.5t/ha vermicompost + 75% RDF of NPK + bio fertilizer). Among all the treatment received 7.5t/ha vermicompost, 75% RDF of NPK and bio fertilizer recorded the highest flowering and fruiting, maximum estimated yield along with better nutrient uptake. From different treatment combinations on FYM, NPK and bio fertilizer, it can be concluded that Growth and yield is faster in nutrient applied plants especially were organic and inorganic nutrients has been applied with biofertilizers.

Keywords: pineapple, FYM, NPK, bio fertilizer, yield

Introduction
Pineapple (*Ananas comosus* L. Merr.) is the most important representative of the Brome liaceae family and is cultivated worldwide all around the tropical and subtropical regions for local consumption and international export. West Bengal is leading pineapple producing state in India followed by Assam. Pineapple is an herbaceous, perennial, self-sterile, monocotyledonous plant of about 90-100 cm in height, with spreading leaves, which give the plant a rosette appearance. In pineapple plant, stomata remain closed during the day, thereby reducing moisture loss. Because of this an ordinary system of photosynthesis does not work, and the plants use CAM system (Crassulacean acid metabolism), in which CO_2 is released to organic acids (mainly citric and malic), which accumulate in leaves at night and are reduced to sugars during day. Pineapple can grow well in low soil fertility areas, but the best production is obtained with high fertile soils. High soil organic matter is also desirable along with beneficial microbes. Soil in the red and lateritic zone of West Bengal has low pH, low organic matter content, and thereby less water holding capacity. Excessive and indiscriminate use of chemical fertilizers may lead to the soil more problematic by further increasing soil acidity with declining organic matter content poor health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor yields. Hence, application of organic manure in judicious combination to chemical fertilizers facilitates profitable and sustainable crop production along with maintenance soil fertility. It is a holistic approach, where we first know what exactly is required by the plant for an optimum level of production, in what different forms these nutrients should be applied in soil and at what different timings in the best possible method and how best these form should be integrated to obtain highest productive efficiency on the economically acceptable limits in an environment friendly manner.

Objectives

The major objectives of the study are as follows:

1. To discern the relationships between different combinations of nutrients and growth attributing factors of the plant
2. to advocate the most suitable combination of nutrients for maximum yield

Materials and Methods

The experiment was conducted at Horticulture farm under Department of Horticulture and Post Harvest Technology, Institute of Agriculture, Visva Bharati, Sriniketan. Uniform suckers of Kew pineapple variety were planted in double hedge row system with the spacing of 25cm x 35cm x 90cm and bed size was 3m x 0.7m = 2.1m^2. The whole experiment was conducted using Randomized Block Design with three replications. The experiment was consisting of 9 treatment comprising:

T_1 : Control
T_2 : 20t/ha FYM + 100% of recommended dose of fertilizer (RDF) of NPK
T_3 : 30t/ha FYM + 75% of RDF of NPK
T_4 : 5 t/ha Vermicompost + 100% of RDF of NPK
T_5 : 7.5 t/ha Vermicompost + 75% of RDF of NPK
T_6 : 20t/ha FYM + 100% of RDF of NPK + bio fertilizer (Azotobactor + phosphate solubalizing bacteria or PSB)
T_7 : 30t/ha FYM + 75% of RDF of NPK + bio fertilizer
T_8 : 5 t/ha Vermicompost + 100% of RDF of NPK + bio fertilizer
T_9 : 7.5 t/ha Vermicompost + 75%NPK + bio fertilizer

N and K were given at 4 split doses. Half dose of N and K along with entire P was given as basal at the time of planting and rest amount of N and K was given three times at after every two months of interval. 10 g each of Azotobactor and Phosphate Solubalizing Bacteria with 500g FYM applied half during planting and rest half 8 months after planting.

Observation was recorded on growth and yield attributes on plant height at 9 and 11 month (cm), no. of leaf at 9 and 11 month, D-leaf initiation days (days), D-leaf length (cm), D-leaf width (cm), plant grith (cm), NPK content of D-leaf (g/kg), Days to flower initiation (days), Days to 50% flowering (days), Flowering percentage (%), chlorophyll content (mg/100g), fruit length with crown, fruit circumference, fruit weight with crown, and estimated yield with crown.

Results & Discussion

Effect on growth

The pooled mean data presented in table 1 and 2, showed the significant variations almost all the growth character of pineapple. The analysis of the variance indicates that the plant height was significantly affected with application of different treatment combinations of vermicompost, NPK and bio fertilizer. The plant height at 9 and 11 month was recorded highest at T_9 (61.11cm and 71.22cm respectively). The total no. of leaf at 9 month was increased with the increasing level of NPK and vermicompost. The total no of leaf was recorded highest in T_2 (37.79) which was significantly at par with T_8 (36.68) and again no. of leaf at 11 month was found highest at T_8 (48.86) which was statistically at par with T_2 and T_9 and lowest was recorded in T_1 (control). D-leaf initiation was initiated early in T_9 (204.35 days) which were followed by T_6, T_5 and T_7. D-leaf length (75.58 cm), D-leaf width (7.73cm), plant girth (37.49cm) was found to be the highest at T_9 and lowest was recorded in T_1. Peduncle girth was found non-significant. Plant height, plant girth, initiation of D-leaf (days) and overall vegetative growth of pineapple are considered to be important factors to judge the vigor in pineapple crop. The plant treated with 7.5 t/ha Vermicompost + 75% RDF of NPK + Bio fertilizer (T_9), resulted in maximum plant height, total numbers of leaf, leaf length and width, and highest plant girth of pineapple plant. This increase may be due to improvement of physical properties of soil and it could also be because of continuous supply of available nutrient from organic and inorganic form and effect of bio active substance produced by common application of bio fertilizer. Organic manure application, also improved the aeration in the soil, which ultimately improved the physiological activities inside the plants. The similar result was reported by Shivakumar (2010) [7] and Suresh *et al*. (2010) [8] in papaya and Jeyabaskaran *et al*. (2001) [3] in banana.

Table 1: Effects of INM on plant height at 9 and 11 month (cm), total no. of leaf on 9 and 11 month, D-leaf initiation (days) and D-leaf length (cm)

Treatment	Plant Height at 9 month (cm)			Plant height at 11 month (cm)			Total number of leaf at 9 month			Total Number of leaf at 11 month			D- leaf initiation days			D-Leaf length (cm)		
	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean
T1	49.95	40.81	45.38	57.92	50.37	54.14	27.84	25.47	26.65	37.81	35.47	36.67	219.81	218.93	219.35	69.41	67.91	68.65
T2	59.93	56.24	58.08	69.32	64.55	66.75	39.78	35.81	37.79	49.64	45.81	47.45	208.74	218.96	213.84	76.67	70.57	73.25
T3	56.97	53.82	55.37	65.72	60.14	62.85	36.56	31.89	34.22	46.53	41.83	43.92	209.56	217.45	213.56	73.14	68.56	70.55
T4	55.71	52.25	53.95	63.14	59.91	61.54	35.76	30.75	33.25	45.57	40.36	42.96	208.33	218.34	213.15	72.78	67.45	69.51
T5	58.44	54.81	56.64	64.73	62.81	63.35	35.87	33.23	34.55	46.61	43.11	44.85	205.66	209.71	207.65	72.38	69.45	70.85
T6	56.14	52.96	54.53	64.41	60.38	62.35	35.66	31.63	33.64	46.99	41.63	43.85	206.67	211.66	208.83	72.67	67.65	69.86
T7	54.93	50.62	52.76	62.85	59.33	60.92	35.45	30.76	33.10	45.36	40.81	43.05	202.65	208.92	205.75	72.62	67.13	69.85
T8	60.23	56.85	58.52	70.17	65.64	67.85	37.41	36.02	36.68	50.58	46.34	48.46	208.63	213.62	211.12	77.55	73.59	75.25
T9	64.83	57.47	61.11	73.52	68.96	71.22	35.54	36.54	36.04	50.45	46.94	48.45	202.25	206.53	204.35	77.83	73.28	75.58
CD(0.05%)	2.56	1.85	2.01	2.15	2.03	2.38	1.25	1.10	1.26	2.16	1.98	2.03	4.88	4.86	5.25	2.74	2.33	3.21
SEm±	0.74	0.67	0.72	0.67	0.68	0.81	0.40	0.36	0.42	0.72	0.63	0.74	1.77	1.72	1.70	0.85	0.76	0.89

T1: Control; T2: 20t/ha FYM + 100% of RDF of NPK T3: 30t/ha FYM + 75% of RDF of NPK; T4: 5t/ha Vermicompost + 100% of RDF of NPK; T5: 7.5 t/ha Vermicompost +75% of RDF of NPK; T6: 20t/ha FYM + 100% of RDF of NPK + Bio fertiliser; T7: 30t/ha FYM + 75% RDF of NPK + Bio fertiliser; T8: 5T/ha Vermicompost + 100% of RDF of NPK + bio fertilizer; T9: 7.5 t/ha Vermicompost + 75% RDF of NPK + Bio fertilizer

Nutrient uptake

Maximum N content was observed maximum in T_9 (1.411g/kg) followed by T_8 (1.321g/kg) and minimum was found in control (0.906 g/kg). Likewise, maximum P was recorded in T8 (1.303g/kg) followed T_9 (1.279g/kg) and K content was again found maximum at T_9 (2.352g/kg) depicted from table no. 2. Minimum was recorded in control in all three nutrient contents. The higher total content and uptake of plant macro (N, P and K) and micro-nutrients (Zn and Fe) by pineapple plant might be obtained due to higher accumulation of all the above nutrients in soil by the application of large amount of chemical fertilizers as well as organic manures. The results are in agreement with those of Patel (2012) [5] and Patil (2013) [6].

Table 2: Effects of INM on D-leaf width (cm), plant grith (cm), peduncle grith (cm), NPK content of D-leaf (mg/100g)

Treatment	D-Leaf width (cm)			Plant Girth (cm)			Peduncle girth (mm)			Nitrogen content of D leaf (G/kg)			Phosphorus content of D leaf (G/kg)			Potassium content of D leaf (G/kg)		
	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2ndyr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean
T1	6.85	6.22	6.58	33.13	33.32	33.22	29.83	28.52	29.15	0.912	0.901	0.906	0.817	0.802	0.809	1.611	1.501	1.556
T2	7.09	7.01	7.05	35.34	35.45	35.39	34.56	31.59	33.07	1.086	1.067	1.077	1.026	1.005	1.016	1.714	1.703	1.708
T3	7.24	7.18	7.21	36.86	36.29	36.57	34.85	31.65	33.25	1.155	1.142	1.148	0.984	0.997	0.991	1.822	1.816	1.819
T4	7.23	7.17	7.23	35.35	35.71	35.53	35.89	31.17	33.45	1.182	1.179	1.181	1.118	1.107	1.112	1.984	1.971	1.977
T5	7.37	7.29	7.33	36.23	36.89	36.56	35.47	31.78	33.55	1.198	1.181	1.189	1.102	1.094	1.098	2.025	2.012	2.018
T6	7.13	7.11	7.12	36.56	36.87	36.71	34.42	32.89	33.65	1.213	1.204	1.209	1.265	1.254	1.260	2.173	2.160	2.167
T7	7.36	7.28	7.32	34.63	34.59	34.55	36.56	32.73	34.64	1.207	1.195	1.201	1.241	1.229	1.235	2.246	2.242	2.244
T8	7.15	7.09	7.12	35.25	35.76	35.45	34.63	31.72	33.15	1.327	1.316	1.321	1.311	1.296	1.303	2.245	2.230	2.237
T9	7.75	7.71	7.73	37.34	37.65	37.49	35.84	33.23	34.53	1.416	1.405	1.411	1.288	1.271	1.279	2.356	2.347	2.352
CD (0.05%)	0.33	0.36	0.40	0.94	0.98	1.03	NS	NS	NS	0.036	0.039	0.035	0.031	0.029	0.032	0.035	0.031	0.026
SEm±	0.12	0.14	0.16	0.31	0.34	0.32	NS	NS	NS	0.012	0.013	0.012	0.010	0.010	0.010	0.012	0.010	0.009

T1: Control; T2: 20t/ha FYM + 100% of RDF of NPK T3: 30t/ha FYM + 75% of RDF of NPK; T4: 5t/ha Vermicompost + 100% of RDF of NPK; T5: 7.5 t/ha Vermicompost +75% of RDF of NPK; T6: 20t/ha FYM + 100% of RDF of NPK + Bio fertiliser; T7: 30t/ha FYM + 75% RDF of NPK + Bio fertiliser; T8: 5T/ha Vermicompost + 100% of RDF of NPK + bio fertilizer; T9: 7.5 t/ha Vermicompost + 75% RDF of NPK + Bio fertilizer

Effect on flowering and fruiting

A reference to data presented in Table no. 3 flower was initiated early T9 (290.53 days), early 50% flowering has been recorded in T_6 (305.96 days) followed by T_9 (311.95 days) and maximum flowering percentage was recorded in T_9 (80.75%). Fruit length with crown and fruit circumference was recorded maximum in T_9 (36.61 cm and 36.75cm) respectively. The earliness in flowering might be due to the higher net assimilation rate on account of better growth leading to the production of endogenous metabolites earlier in optimum level enabling early flower. These results are in conformity with the findings reported by (Ghosh *et al*. 2013) [1] in pineapple, Yadav *et al*. (2011), Shivakumar (2010) [7] and Suresh *et al.* (2010) [8] in papaya and Hazarika and Ansari (2010) [2] in Banana.

It is also observed from the pooled mean data of table no. 3 that fruit length with crown was maximum in T_9 which was statistically at par with T_2 and T_8. Increase in fruit attributes could be due to the increase in morphological traits such as plant height, girth, number of leaves, leaf area, faster rate of leaf production and also higher nutrient uptake by the plant. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher carbohydrates could have promoted the growth rate and in turn increased better fruit development.

Table 3: Effects of INM on days to flower initiation (days), days to 50% flowering (days), flowering percentage (%), slip production per plant, leaf chlorophyll content (mg/100g) and fruit Circumference (cm) of pineapple cv. Kew

Treatment	Days to flower initiation (days)			Days to 50% flowering (days)			Flowering percentage (%)			Slip production per plant			Leaf chlorophyll content (mg/100g)			Fruit circumferance (cm)		
	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean
T1	299.91	335.83	317.85	329.14	337.86	333.45	50.14	45.96	48.44	5.25	4.48	4.865	136.91	136.15	136.57	33.64	30.23	31.93
T2	291.96	310.56	300.95	318.76	326.63	322.65	79.15	74.26	76.65	8.93	8.25	8.55	145.14	144.94	145.45	35.58	31.37	33.47
T3	304.83	312.54	308.65	313.54	319.99	316.45	68.88	61.14	64.95	6.48	6.17	6.25	146.83	146.37	146.55	34.44	31.36	32.85
T4	305.32	315.13	310.21	313.97	320.17	317.44	60.93	54.17	57.57	6.86	6.36	6.45	148.56	148.98	148.75	35.68	31.57	33.55
T5	302.67	317.81	309.97	311.62	321.63	316.63	71.57	68.83	70.15	6.39	5.91	6.15	147.54	147.86	147.67	37.93	32.28	35.05
T6	306.43	313.96	309.95	302.35	309.53	305.96	63.36	57.97	60.64	6.83	6.39	6.55	148.84	148.95	148.85	35.77	31.43	33.55
T7	307.56	315.67	311.21	317.57	329.17	323.39	60.19	54.29	57.15	6.18	5.83	5.95	145.18	145.63	145.39	34.65	31.76	33.15
T8	289.84	306.93	298.35	308.33	319.38	313.85	80.54	75.15	77.84	8.13	7.47	7.75	145.97	145.74	145.83	37.61	31.32	34.45
T9	279.56	301.59	290.53	306.28	317.75	311.95	82.74	78.84	80.75	7.41	7.18	7.25	156.97	157.54	157.22	38.82	34.69	36.75
CD(0.05%)	5.84	6.02	5.70	5.88	6.40	6.22	3.21	3.20	3.11	0.43	0.37	0.48	3.70	3.83	4.39	1.33	1.27	1.32
SEm±	1.80	1.90	1.82	1.83	2.12	2.04	1.04	1.02	1.03	0.15	0.12	0.14	1.23	1.27	1.46	0.40	0.38	0.42

T1: Control; T2: 20t/ha FYM + 100% of RDF of NPK T3: 30t/ha FYM + 75% t/ha Vermicompost +75% of RDF of NPK; T6: 20t/ha FYM + 100% of RDF of NPK + Bio fertiliser; T7: 30t/ha FYM + 75% RDF of NPK + Bio fertiliser; T8: 5T/ha Vermicompost + 100% of RDF of NPK + bio fertilizer; T9: 7.5 t/ha Vermicompost + 75% RDF of NPK + Bio fertilizer

Effect on fruit development

Slip production per plant was found maximum and minimum in T_2 (8.55) and T_1 (4.865) respectively his may be due to that N increased slip production per plant and it is evident that increased number and size of slips produced was the result of increased vegetative growth caused by combined use of FYM and NPK.

Leaf chlorophyll content was observed highest at T_9 (157.22 mg/100g) and lowest at T_1 (136.57 mg/100g) this may be due to the chlorophyll content in leaves indicates the efficiency of photosynthesis, where the solar energy is converted into chemical energy. N, P and K were utilized efficiently by the plant, which resulted in producing maximum photosynthetic in terms of high biomass and trans-locating the assimilated materials to the developing sink. The role of nitrogen and

potassium in the functioning of chlorophyll is well established. These results in accordance with results reported by Kuttimani *et al.* (2013) [4] in papaya. In general, treated plants registered more photosynthetic rate and transpiration.

Effects on yield

Depicted from the pooled mean data presented in Table no. 4 that fruit weight with crown was recorded maximum in T_7 (1627.8g)which was followed by T_5 (1615.8 g). Estimated yield with crown was highest in T8 (77.42 t/ha) which was statistically at par with T_9 (76.06 t/ha).It is clear from the result that the nutrient management through integrated manner comprising chemical, organic and bio-fertilizers provided the best results in terms of fruit weight. The lowest fruit weight observed with T_1 is due to no nutrient application Higher fruit yield (t/ha) in pineapple was realized due to increase in fruit length and diameter. Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which turn led to good crop growth and yield Ghosh *et al.* (2013) [1] in pineapple and (Shivakumar 2010) [7] in papaya.

Table 4: Effects of INM on fruit length with crown (cm), fruit weight with crown (cm), estimated yield of pineapple cv. Kew

Treatment	Fruit Length with crown (cm)			Fruit weight with crown (g)			Estimated yield with crown (t/ha)		
	1st yr	2nd yr	mean	1st yr	2nd yr	mean	1st yr	2nd yr	mean
T1	27.43	25.88	26.65	1242.0	1095.1	1168.5	47.69	32.21	39.95
T2	36.53	34.15	35.34	1585.2	1413.5	1498.4	80.29	67.17	73.73
T3	36.65	31.13	33.93	1631.4	1411.2	1521.8	71.91	55.21	63.56
T4	34.65	32.87	33.71	1584.3	1353.8	1469.1	61.78	46.93	54.35
T5	35.55	33.21	34.37	1737.6	1494.1	1615.8	79.59	65.81	72.7
T6	34.27	33.41	34.06	1692.5	1482.3	1587.4	68.63	54.98	61.80
T7	35.25	30.84	33.04	1719.3	1536.4	1627.8	66.21	53.38	59.79
T8	37.75	33.17	35.46	1671.5	1428.2	1549.9	86.15	68.69	77.42
T9	37.42	35.18	36.61	1493.7	1447.5	1470.6	79.09	73.03	76.06
CD(0.05%)	1.92	1.85	2.11	28.21	29.1	27.5	3.68	3.31	3.56
SEm±	0.65	0.61	0.64	9.41	9.78	9.18	1.22	1.10	1.19

T1: Control; T2: 20t/ha FYM + 100% of RDF of NPK T3: 30t/ha FYM + 75% of RDF of NPK; T4: 5t/ha Vermicompost + 100% of RDF of NPK; T5: 7.5 t/ha Vermicompost +75% of RDF of NPK; T6: 20t/ha FYM + 100% of RDF of NPK + Bio fertiliser; T7: 30t/ha FYM + 75% RDF of NPK + Bio fertiliser; T8: 5T/ha Vermicompost + 100% of RDF of NPK + bio fertilizer; T9: 7.5 t/ha Vermicompost + 75% RDF of NPK + Bio fertilizer

Conclusion

The result revealed that all the growth and yield characteristics are significantly affected by different levels of organic and inorganic treatment combination. With respect to different plant growth parameters like plant height, total no of leaf, D-leaf initiation days, D-leaf length, D-leaf width and plant grith found effective with treatment combination T_9 (7.5t/ha vermicompost + 75% RDF of NPK + bio fertilizer). Among all the treatment received 7.5t/ha vermicompost, 75% RDF of NPK and bio fertilizer recorded the highest flowering and fruiting, maximum estimated yield along with better nutrient uptake. From different treatment combinations on FYM, NPK and bio fertilizer, it can be concluded that Growth and yield is faster in nutrient applied plants especially were organic and inorganic nutrients has been applied with biofertilizers.

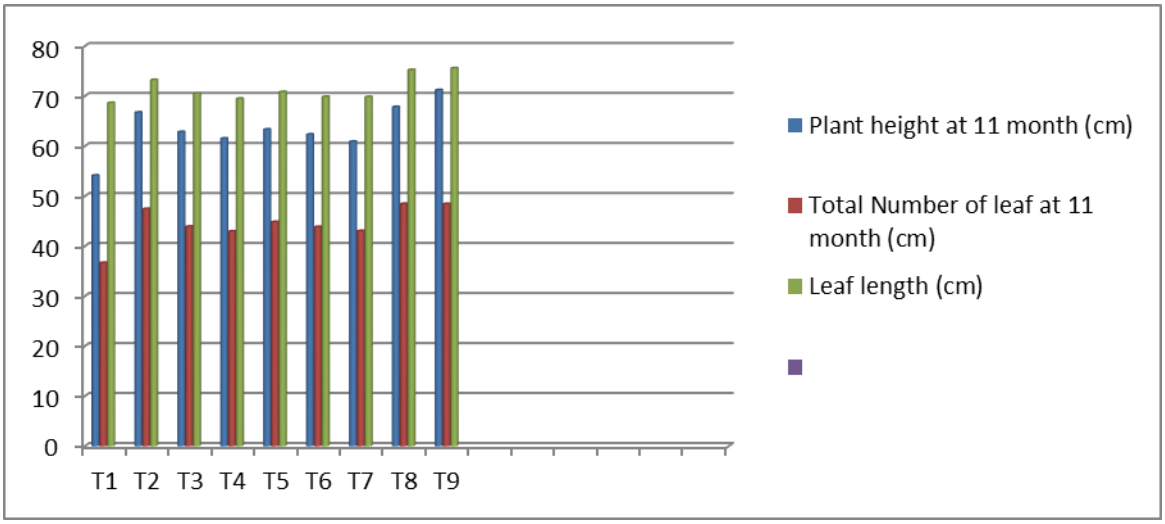

Fig 1: Effect of INM on plant height (cm) and total leaf at 11 month and leaf length (cm)

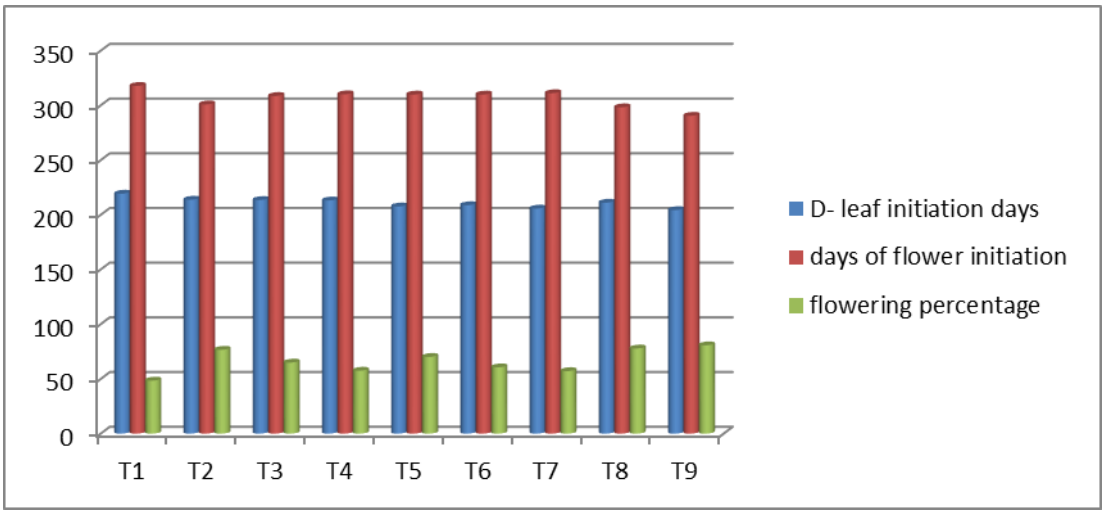

Fig 2: Effect of INM on D-leaf initiation (days), days of flower initiation (days) and flowering percentage (%)

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