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Effect of different levels of nutrients on vegetative growth of pineapple cv. Kew

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Abstract
A field experiment entitled Effect of different levels of nutrients on vegetative growth of pineapple cv. Kew was conducted at College of Horticulture, Sirsi, UHS, Bagalkot, Karnataka during 2017-2019. The experiment was carried out in split plot design with three replications. The main treatments comprising T_1: Control, T_2: Azotobacter, T_3: PSB, T_4: VAM and Sub treatments - S_1: 80% RDN + 20% RDN through Vermicompost, S_2:80% RDN + 20% RDN through FYM, S_3:100% RDN + $ZnSO_4$ (10 kg/ha) + Boron (5 kg/ha), S_4: RDN (350:130:440 NPK kg/ha) control, S_5: S_1 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_6: S_2 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha). The result revealed that all the growth parameters are significantly affected by different levels of organic, inorganic nutrients and biofertilizer treatment combination. With respect to different plant growth parameters like number of leaves (41.40), D leaf length (64.00 cm), D leaf breadth (3.64 cm), leaf length (64.00 cm), leaf breadth (3.67 cm) and leaf area (8853.11 cm^2) were found effective with treatment combination T_2S_5 [*Azotobacter* (5 kg/ha) + 80% RDN+20% RDN through vermicompost +$ZnSO_4$ (10 kg/ha) + Boron (5 kg/ha)]. Whereas, T_3S_5 [PSB (5 kg/ha) + 80% RDN + 20% RDN through vermicompost + $ZnSO_4$ (10 kg/ha) + boron (5 kg/ha)] recorded higher plant height (80.53 cm).

Keywords: Pineapple, biofertilizer, RDN

1. Introduction
Pineapple (*Ananas comosus* (L.) Merr.) is an important monocotyledonous, monocarpic, xerophytic perennial herb exhibiting CAM photosynthesis. It is one of the most important commercial fruits of the world. Costa Rica ranks first in pineapple production in the world followed by Brazil and Philippines. India is having an area of 1.21 lakh ha and production of 2.03 million tones with productivity of 16.8 MT/ ha (Annon, 2017) [1]. In India, highest area under pineapple is in Assam (18.74 m.ha). While, West Bengal is leading the production with 336.11 million tones and the highest productivity is in Karnataka with 59.97 MT/ha (Annon, 2017) [1].

Pineapple is one of the most important commercial fruit crops of the tropical and sub-tropical regions of the world. It is highly valued because of its excellence in canning and processing for the production of nutritious and value added products like jam, jelly, candy, canned pineapple, squash, etc. Pineapple fruit is a good source of vitamin A, B, C and minerals (Krishan *et al*., 2017) [7].

From the few decades, pineapple is being commercially cultivated in Uttara Kannada, Dakshina Kannada and Shimoga districts of Karnataka. In Uttara Kannada, Banavasi is the main geographical place of its commercial cultivation. The farmers are cultivating the crop with inorganic fertilizers and they are getting optimum yield rather than profitable yield. Off late, yield reductions are also reported from many of the traditional pineapple growing villages in and around Banavasi area which may be due to deficiency of nutrients and depletion of soil fertility. In this scenario, this study is formulated to assess the utilization of organic manures, biofertilizers and inorganic fertilizers including micronutrients to improve yield and quality of the pineapple.

Hence the present study was formulated with the use of vermicompost & farm yard manure as the source of nutrients through organics, bio-fertilizers such as *Azotobacter*, PSB & AM along with RDN in different combinations to augment the availability of nutrients and enhancement in the yield and quality parameters in pineapple is envisaged.

Material and Methods

The experiment was carried out to study the Effect of different nutrient levels on growth and yield of pineapple cv. Kew at Department of Fruit Science, College of Horticulture, Sirsi, University of Horticultural Sciences, Bagalkot during 2017-2019. Uniform suckers of pineapple cv. Kew were planted in a double hedge row system with the spacing of 30cm × 60cm × 90cm. The whole experiment was conducted using Split Plot Design with three replications. The experiment consisting of 4 main treatments and 6 sub treatments.

Main treatments

T_1: Control
T_2: Azotobacter
T_3: PSB
T_4: VAM

Sub treatments –

S_1: 80% RDN + 20% RDN through Vermicompost
S_2:80% RDN + 20% RDN through FYM
S_3:100% RDN + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)
S_4: RDN (350:130:440 NPK kg/ha) control
S_5: S_1 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)
S_6: S_2 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)

Nitrogen and potassium were given in 4 split doses at 3 months interval. One split dose of N and K along with entire P was given as basal dose at the time of planting and the remaining quantity of N and K was given in three split doses at every 3 months interval. Azotobacter, PSB and VAM with FYM was applied half at the time of planting and rest half 6 months after planting.

Observations were recorded on growth parameters such as, plant height (cm), Number of leaves, D leaf length (cm), D leaf width (cm) at 4, 8 and 12 months after planting and leaf length (cm), leaf breadth (cm) and leaf area (cm^2) at the time of flowering *i.e* 12 months after planting. The leaf area (cm^2) was computed by using the following formula.

Leaf area (cm^2) per plant = L × B × K × Number of leaves where K = constant (0.99)

Results and Discussion

Plant height and number of leaves

Among main treatments, T_2 recorded significantly the highest plant height (32.22 cm, 60.78 cm and 73.54 cm) at 4, 8 and 12 month after planting. At 8 and 12 MAP, T_2 recorded significantly higher number of leaves (31.00 and 35.83 respectively) which was on par with T_3 (29.96 and 35).This significant improvement in plant height and number of leaves could be due to the application of biofertilizer which helps the plants to increase the dehydrogenase, alkaline phosphatase, nitrogenase and hydrolysis enzyme activities mainly due to increase in the rhizosphere microbial population as a consequence of the inoculation treatments. Further, free living N_2 fixers such as *Azotobacter* can affect plant growth not only by fixing N_2 but also by altering microbial balance, solubilizing fixed soil phosphorus and suppressing pathogenic microorganisms by producing metabolites that stimulate plant development (Bohane *et al.*,2016) [3].

In case of sub treatments, the treatment S_5 recorded significantly highest plant height (34.59, 63.00 and 77.98 cm) and higher number of leaves at 4, 8 and 12 MAP, (16.24, 32.79 and 38.40) respectively. In this treatment, vermicompost has been used a source of supplying 20% RDN. The significant increase in plant height and number of leaves could be due to vermicompost presence in these treatments as the vermicompost have much finer structure than ordinary compost and contain nutrients in forms that are readily available for plant uptake. It is rich in micro and macronutrients, vital plant promoting and humus forming substances, Nitrogen fixers and humus forming micro-organisms. Increase in plant growth may also be due to presence of earthworms which improves the soil fertility in vermicompost treatments. Further, the growth response of the plants for vermicompost appears more like hormone-induced activity associated with the high levels of humic acids and humates in vermicompost (Chaitra *et al*., 2018 [5], Canellas *et al*., 2002 [4]). The present findings are in accordance with the results reported by Dhomane *et al*. (2011) [6] in guava, Singh *et al*. (2010) [12] in strawberry and Nandi *et al*. (2013) [8] in pomegranate.

Among the interactions, the plant height at 4 and 8 MAP was highest at T_2S_5 (37.67 and 65.90 cm respectively). However, T_3S_5 recorded higher plant height (80.53 cm) at 12 MAP which was on par with T_2S_5 (79.13 cm). Among the interactions, T_2S_5 was recorded the higher number of leaves at 4, 8 and 12 MAP (17.67, 35.33 and 41.40) which was on par with T_3S_5 (17.20, 34.67 and 39.70).The improvement in vegetative parameters may also be due to improvement of physical properties of soil with the inclusion of vermicompost and it could also be because of continuous supply of available nutrients from organic and inorganic form of nutrients applied and also due to the effect of bio active substances produced by the application of bio fertilizers. Similar reports also reported in strawberry (Singh *et al*., 2015) [11].

D leaf length and D leaf breadth

At 4, 8 and 12 MAP, T_2 recorded significantly higher D- leaf length (23.04, 52.49 and 57.95 cm). Among the sub treatments, treatment S_5 registered higher D- leaf length (24.65, 54.29 and 59.92 cm) at 4, 8 and 12 MAP respectively. Among interactions, treatment T_2S_5 recorded the highest D-leaf length (26.50, 61.33 and 64.00 cm) followed by T_3S_5 (25.93, 55.93 and 60.73 cm) at 4, 8 and 12 MAP respectively.

Among main treatments, T_2 recorded significantly higher D-leaf breadth at 4 and 12 MAP with 2.53 and 3.30 cm. Among sub treatments, the treatment S_5 recorded higher D-leaf breadth (2.50, 2.67 and 3.31 cm). The treatment T_2S_5 recorded the highest D-leaf breadth (2.65 and 2.85 cm) at 4 and 8 MAP, respectively. It is clear from the Table 2 that the D-leaf length and breadth has increased continuously from 4 months after planting to flowering (12 months after planting) and significantly varied among the most of the treatments. Such enhanced vegetative growth parameters due to application of nutrients through organics, inorganics and micronutrients in pineapple was reported by Omotoso and Akinrinde (2013) [9] and Bhugaloo (1998) [2].

Leaf length, leaf breadth and leaf area at the time of flowering

Among main treatments (Table 3), the highest leaf length (55.61 cm), leaf breadth (3.34 cm) and leaf area (6493.33 cm^2) were recorded in T_2 treatment which was on par with T_3 (55.20 cm, 3.18 cm and 6102.82 cm^2). Hence, the increased leaf dimensions and resultant leaf area in plants treated with *Azotobacter* and PSB, could be attributed to the enhanced availability of N and P. Such augmented leaf area is also observed in strawberry plants inoculated with *Azotobacter* in combination with 60 kg N/ha (Rana and Chandel, 2003) [10].

Among different sub treatments, the maximum leaf length (57.13 cm), leaf breadth (3.48 cm) and leaf area (7767.11 cm^2) were found in S_5 treatment. Among different interactions, higher leaf length (64.00 cm), leaf breadth (3.67 cm) and leaf area (8853.11 cm^2) were recorded in T_2S_5 which was on par with T_3S_5 (59.83 cm and 3.57 cm). The maximum leaf area which is a factor of higher leaf length, breadth and presence of maximum number of leaves is a precursor for sustaining better growth and yield of crops in general and pineapple in particular.

Table 1: Effect of organic, inorganic nutrients, biofertilizers and their interaction on plant height and number of leaves of pineapple cv. Kew

Main Treatment	Plant height (cm)			Number of leaves / plant		
	4 MAP	8 MAP	12 MAP	4 MAP	8 MAP	12 MAP
T_1	28.11	54.26	68.84	13.68	27.50	31.36
T_2	32.22	60.78	73.54	15.37	31.00	35.83
T_3	30.46	58.37	71.22	15.03	29.96	35.00
T_4	29.18	55.54	69.76	14.17	28.92	33.82
S.Em±	0.62	1.01	1.27	0.30	0.61	0.80
C.D. @ 5%	1.51	2.48	3.10	0.74	1.48	1.96
C.V. (%)	6.19	5.32	5.37	6.20	6.20	7.07
Sub Treatment						
S_1	31.70	59.67	74.76	15.75	30.92	37.03
S_2	27.23	55.02	69.13	13.57	26.48	32.21
S_3	31.69	59.13	72.58	15.18	30.90	34.82
S_4	26.43	51.70	63.48	12.77	26.19	30.83
S_5	34.59	63.00	77.98	16.24	32.79	38.40
S_6	28.28	54.91	67.12	13.85	28.79	30.72
S.Em±	0.56	1.19	1.49	0.33	0.62	0.73
C.D. @ 5%	1.13	2.40	3.02	0.66	1.24	1.48
C.V. (%)	4.55	5.09	5.16	5.51	5.14	5.29
Interaction						
T_1S_1	29.03	59.53	74.17	14.23	30.00	34.87
T_1S_2	26.20	54.73	64.93	13.00	23.33	30.67
T_1S_3	29.10	56.13	71.33	14.50	31.33	32.27
T_1S_4	24.40	46.00	63.53	12.17	24.00	28.33
T_1S_5	32.60	59.90	74.47	14.00	30.17	36.33
T_1S_6	27.30	49.23	64.60	14.17	26.17	25.67
T_2S_1	34.50	63.20	78.27	16.77	33.17	38.67
T_2S_2	28.80	57.07	73.07	14.77	27.83	33.73
T_2S_3	32.50	62.50	71.20	15.97	31.33	35.00
T_2S_4	28.00	54.87	63.20	12.50	27.00	32.53
T_2S_5	37.67	65.90	79.13	17.67	35.33	41.40
T_2S_6	31.83	61.13	76.40	14.53	31.33	33.67
T_3S_1	32.00	57.87	75.53	16.47	31.83	38.33
T_3S_2	28.27	52.80	67.93	13.70	27.17	32.63
T_3S_3	33.83	62.07	74.00	15.60	30.67	36.33
T_3S_4	27.63	56.13	63.33	13.93	26.27	32.80
T_3S_5	33.50	64.13	80.53	17.20	34.67	39.70
T_3S_6	27.50	57.20	66.00	13.27	29.17	30.20
T_4S_1	31.27	58.07	71.07	15.53	28.67	36.27
T_4S_2	25.67	55.47	70.60	12.80	27.57	31.80
T_4S_3	31.33	55.80	73.80	14.67	30.27	35.67
T_4S_4	25.70	49.80	63.83	12.47	27.50	29.67
T_4S_5	34.60	62.07	77.80	16.10	31.00	36.17
T_4S_6	26.50	52.07	61.47	13.43	28.5	33.33
M at S						
S.Em±	1.12	2.38	2.98	0.66	1.23	1.47
C.D. @ 5%	2.25	4.81	6.03	1.32	2.49	2.97
S at M						
S.Em±	1.19	2.40	3.00	0.67	1.28	1.56
C.D. @ 5%	2.54	5.03	6.30	1.41	2.70	3.33

Main treatments- T_1: Control, T_2: Azotobacter, T_3: PSB, T_4: VAM, **Sub treatments** - S_1: 80% RDN + 20% RDN through Vermicompost, S_2: 80% RDN + 20% RDN through FYM, S_3:100% RDN + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_4: RDN (350:130:440 NPK kg/ha) control, S_5: S_1 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_6: S_2 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)

Table 2: Effect of organic, inorganic nutrients, biofertilizers and their interaction on D leaf length and D leaf breadth of pineapple cv. Kew

Main Treatment	D leaf length (cm)			D leaf breadth (cm)		
	4 MAP	8 MAP	12 MAP	4 MAP	8 MAP	12 MAP
T_1	20.77	47.26	53.30	2.22	2.31	2.90
T_2	23.04	52.49	57.95	2.53	2.54	3.30
T_3	21.65	50.64	54.86	2.33	2.55	2.87
T_4	20.76	47.94	53.72	2.26	2.45	2.90

S.Em±	0.44	1.24	1.04	0.03	0.04	0.13
C.D. @ 5%	1.07	3.03	2.54	0.08	0.10	0.31
C.V. (%)	6.09	7.49	5.67	4.31	5.10	12.56
Sub Treatment						
S_1	22.59	50.26	57.04	2.43	2.59	3.18
S_2	18.50	47.89	52.55	2.31	2.26	2.84
S_3	22.54	50.23	55.38	2.33	2.58	3.03
S_4	19.89	46.48	52.33	2.10	2.25	2.72
S_5	24.65	54.29	59.92	2.50	2.67	3.31
S_6	21.15	48.35	52.52	2.35	2.42	2.88
S.Em±	0.47	1.02	1.17	0.06	0.05	0.08
C.D. @ 5%	0.96	2.06	2.36	0.13	0.10	0.16
C.V. (%)	5.38	5.04	5.21	6.67	5.04	6.28
Interaction						
T_1S_1	22.00	47.17	53.33	2.36	2.49	3.07
T_1S_2	17.37	47.20	49.00	2.22	2.28	2.82
T_1S_3	21.33	48.80	58.07	2.18	2.45	2.98
T_1S_4	19.28	46.67	53.33	2.02	1.99	2.60
T_1S_5	24.30	46.50	56.00	2.54	2.43	3.19
T_1S_6	20.33	47.20	50.07	2.01	2.22	2.74
T_2S_1	24.40	54.00	59.90	2.62	2.65	3.65
T_2S_2	19.43	48.97	53.33	2.47	2.14	3.00
T_2S_3	23.83	54.33	58.47	2.46	2.66	3.29
T_2S_4	20.28	47.33	55.33	2.38	2.31	2.98
T_2S_5	26.50	61.33	64.00	2.65	2.85	3.64
T_2S_6	23.80	49.00	56.67	2.61	2.60	3.21
T_3S_1	21.63	52.00	58.60	2.49	2.67	3.17
T_3S_2	18.70	48.73	50.67	2.13	2.39	2.53
T_3S_3	22.17	52.13	55.33	2.39	2.67	2.97
T_3S_4	20.67	46.07	49.67	2.02	2.35	2.35
T_3S_5	25.93	55.93	60.73	2.54	2.78	3.31
T_3S_6	20.80	49.00	54.13	2.42	2.42	2.90
T_4S_1	22.33	47.87	56.33	2.23	2.54	2.84
T_4S_2	18.50	46.67	57.20	2.43	2.21	2.99
T_4S_3	22.83	45.67	49.67	2.30	2.53	2.87
T_4S_4	19.33	45.83	51.00	2.00	2.37	2.96
T_4S_5	21.87	53.40	58.93	2.27	2.60	3.09
T_4S_6	19.67	48.2	49.20	2.36	2.45	2.67
M at S						
S.Em±	0.95	2.04	2.34	0.13	0.10	0.15
C.D. @ 5%	1.91	4.12	4.72	0.26	0.20	0.31
S at M						
S.Em±	0.97	2.23	2.37	0.12	0.10	0.19
C.D. @ 5%	2.04	4.81	4.99	0.25	0.21	0.42

Main treatments- T_1: Control, T_2: Azotobacter, T_3: PSB, T_4: VAM, **Sub treatments** - S_1: 80% RDN + 20% RDN through Vermicompost, S_2: 80% RDN + 20% RDN through FYM, S_3:100% RDN + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_4: RDN (350:130:440 NPK kg/ha) control, S_5: S_1 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_6: S_2 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)

Table 3: Effect of organic, inorganic nutrients, biofertilizers and their interaction on leaf length, leaf breadth and leaf area in pineapple cv. Kew

Main Treatment	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2)
	12 MAP	12 MAP	12 MAP
T_1	51.26	3.04	5346.85
T_2	55.61	3.34	6493.33
T_3	55.20	3.18	6102.82
T_4	51.85	3.04	5545.67
S.Em±	1.36	0.05	120.10
C.D. @ 5%	3.33	0.12	293.88
C.V. (%)	7.63	4.68	6.14
Sub Treatment			
S_1	53.76	3.31	6772.92
S_2	52.92	2.85	4803.86
S_3	55.42	3.17	5976.93
S_4	49.74	2.98	4715.93
S_5	57.13	3.48	7767.11
S_6	51.92	3.12	5196.26
S.Em±	1.10	0.05	156.32
C.D. @ 5%	2.22	0.11	315.94
C.V. (%)	5.04	4.22	6.52

Interaction			
T_1S_1	53.72	3.03	5913.61
T_1S_2	47.91	2.76	4151.44
T_1S_3	56.30	3.14	5914.52
T_1S_4	48.67	2.85	4181.11
T_1S_5	52.33	3.42	7455.49
T_1S_6	48.61	3.05	4464.94
T_2S_1	56.41	3.62	7824.52
T_2S_2	51.63	2.91	4966.61
T_2S_3	57.00	3.42	6332.94
T_2S_4	51.30	3.20	5073.10
T_2S_5	64.00	3.67	8853.11
T_2S_6	53.33	3.21	5909.68
T_3S_1	58.22	3.54	7832.35
T_3S_2	53.96	2.90	4818.54
T_3S_3	54.15	2.84	5559.33
T_3S_4	50.33	3.06	5016.10
T_3S_5	59.83	3.57	7932.64
T_3S_6	54.72	3.17	5457.97
T_4S_1	46.69	3.06	5521.19
T_4S_2	58.17	2.81	5278.84
T_4S_3	54.23	3.27	6100.94
T_4S_4	48.67	2.80	4593.40
T_4S_5	52.33	3.26	6827.18
T_4S_6	51.01	3.06	4952.46
M at S			
S.Em±	2.20	0.11	312.64
C.D. @ 5%	4.45	0.22	631.88
S at M			
S.Em±	2.43	0.11	309.64
C.D. @ 5%	5.23	0.23	645.65

Main treatments- T_1: Control, T_2: Azotobacter, T_3: PSB, T_4: VAM, **Sub treatments** - S_1: 80% RDN + 20% RDN through Vermicompost, S_2: 80% RDN + 20% RDN through FYM, S_3:100% RDN + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_4: RDN (350:130:440 NPK kg/ha) control, S_5: S_1 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha), S_6: S_2 + $ZnSO_4$ (10kg/ha) + Boron (5 kg/ha)

Conclusion

The results revealed that all the vegetative growth parameters are significantly affected by different levels of biofertilizers, organic and inorganic treatment combinations. With respect to plant growth parameters like plant height, number of leaves, D leaf length, D leaf breadth, leaf length, leaf breadth and leaf area found effective with treatment combination T_2S_5 [*Azotobacter* (5kg/ha) +80% RDN+20% RDN through vermicompost +$ZnSO_4$ (10 kg/ha) + Boron (5 kg/ha)]. From this investigation, it is clear that treatment with the combination of inorganics, organics, micronutrients and bio-fertilizers showed better performance compared with their individual effects.

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