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Effect of integrated manuring and growth regulators on yield and quality of pineapple (*Ananas comosus* L. Merr.)

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Abstract
A trial was conducted to find out the best treatment combination for an experiment "Effect of integrated manuring and growth regulators on yield and quality of pineapple" with an objective to get high, uniform yield and quality of pineapple by integrated application of manure and growth regulators. The result revealed that 50% of recommended NPK + 50% of N through organic recycling with vermicmpost + vermiwash + biofertilizers (*Azotobacter* and *Azospirillum*)+ NAA @10ppm and 75% of recommended NPK + 25% of N through organic recycling with vermicompost + NAA@10ppm.. Perform best treatment combination with respect to yield and qualitative characters like, Crown length(17.90 cm), Fruit length(15.72cm), TSS(16.55 ^{0}Brix), Fruit Girth (36.50 cm), Pulp content (75.99gm), Pulp peel ratio (5.43), Total sugar (12.84%), reducing sugar(4.96%), Non reducing sugar(8.98%), Ascorbic acid (24.26mg/100gm pulp) and Fruit weight with crown (1362.22 gm), fruit yield per plot (40.59 kg) and yield per ha (45.10 t/ha). Whereas crown weight (261.29 gm) have significant variation found in 50% of recommended NPK + 50% of N through organic recycling with vermicmpost+ vermiwash + biofertilizer(*Azotobacter* and *Azospirillum*)+Ethrel @25ppm.

Keywords: Pineapple, vermicompost, vermiwash, biofertlizer, yield, quality, PGR

Introduction
Pineapple (*Ananas comosus* L. Merr) is an important herbaceous monocot crop belongs to the family Bromeliaceae. India is having an area of 103413 ha and production of 2593207tonnes (FAO, 2011). In India, highest area under pineapple is in Assam (16.24 t/ha) and West Bengal leading the production with 310.00 million tonnes (Annual Report of NHB and Ministry of Agriculture Govt. of India 2017). Pineapple is a good source of carotene and ascorbic acid and is fairly rich in vitamins B and B2 (Lal and Pruthi, 1995) [8]. Fruit is high in the enzyme bromelain and the antioxidant vitamin C. It is a good source of dietary fiber.
A major limitation that affects pineapple growers is the phenomenon of natural flowering, which results in unscheduled fruiting. All the plants do not flower at a time, over the whole field in one season. This causes not only great difficulty in the uniform harvesting of the crop but also keeps the land under the same crop for a longer time, thus, proper cultural requirements of the crop needs the immediate attention of the Horticulturists. Besides the use of the uniform planting materials and looking to proper and timely application of plant nutrient and water, the use of synthetic growth regulators have inspired workers for their practical use to induce uniform flowering and development of good quality fruits.

Materials and Methods
Accordingly, the present investigation entitled "Effect of integrated manuring and growth regulators on yield and quality of pineapple (*Ananas comosus* L. Merr.)" The present investigation was carried out in the existing one year old pineapple plantation taken as a component crop in coconut based cropping system model in a paired row system of planting with 90 x 60 x 30 cm spacing conducted in the experimental site of All India Coordinated Research Project on Palms, Bhubaneswar operated under the Department of Fruit Science & Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar during July 2014 to June2016. The experiment was conducted in a Split Plot Design with 18 different treatment with 3 replication combinations. Variety used as component crop in pineapple is "Queen" variety. Treatment combination are M_1G_1,M_1G_2 ,M_1G_3 ,M_1G_4 ,M_1G_5, M_1G_6, M_2G_1, M_2G_2, M_2G_3, M_2G_4, M_2G_5, M_2G_6, M_3G_1, M_3G_2, M_3G_3, M_3G_4, M_3G_5, M_3G_6. Where, M_1 – 100% N

through organic recycling with vermicompost + vermiwash + biofertilizer (*Azotobacter* and *Azospirillum*), M_2- 50% of recommended NPK + 50% of N through organic recycling with vermicmpost + vermiwash + biofertilizer (*Azotobacter* and *Azospirillum*), M_3– 75% of recommended NPK+ 25% of N through organic recycling with vermicompost and G_1– NAA@10ppm, G_2- Ethrel@25ppm,G_3– Ethrel@50ppm, G_4 - GA_3@ 50ppm, G_5 - GA_3@ 100ppm , G_6 - Control (only water). Characters taken for this investigation are Fruit weight with crown, Fruit girth, Crown length, Fruit yield per plot, Fruit yield per ha, Pulp peel ratio, pulp content, TSS, Reducing sugar, Non reducing sugar, Total sugar content, ascorbic acid with the objective to get uniform yield and high quality content in pineapple by integrated application of manure and growth regulators.

Results and Discussion

Significant variation found in fruit weight with crown in the treatment of M_3G_1 (1362.23 g) is more with minimum weight in M_2G_6 (832.61g). It is observed that the highest crown length (17.90 cm) was recorded in the treatment combination M_2G_1 which was statistically at par with the treatment combinations M_3G_1 (17.07 cm), whereas, the lowest crown length (13.08 cm) was recorded in the treatment combination M_1G_5 which was on par with M_1G_6 (13.30 cm), M_1G_4 (13.93 cm).

This increase in fruit weight with crown might be due to the increase in the combination effect of chemical fertilizer, organic fertilizer provided best results regarding the estimated weight due to proper balanced nutrition reported by Bhwomick *et al.*,(2017) [2], Baraily & Deb (2018) [1] in pineapple and beneficial effect of NAA@10ppm enhanced growth of fruit tissue with NAA application. The beneficial effect of NAA on fruit weight has been also reported by Pal *et al*. (2015) [11], Bose *et al*., (1983) [4] & Santha *et al.* (1983)

From the pooled data, it is indicated that the maximum fruit length (15.72 cm) and fruit girth (36.50 cm) was recorded in the treatment combination M_2G_1 and minimum fruit length (12.67 cm),fruit girth (31.40 cm) was recorded in the treatment combination M_1G_6. Along with maximum crown weight (261.29 g) was recorded in the treatment combination M_2G_2 and the minimum (82.70 g) crown weight was recorded in the treatment combination M_3G_5. This might be due to cell enlargement reported by Pal *et al.* (2015) [11], Bowden (1969) [5], Puruseth (1977) in pineapple. Maibangsa & Ahmed (2000) reported that NAA was more effective in increasing fruit length, weight & yield than GA_3.

Maximum fruit yield per plot (40.59 kg) and fruit yield per ha. (45.10 t/ha) was found in treatment combination M_3G_1 and the minimum fruit yield per plot (16.67 kg) and fruit yield per ha (17.26 t/ha) was estimated in the treatment combination M_2G_6.

It was observed from the table no 1 that the maximum pulp content (75.99%) and pulp: peel ratio (5.43) was computed in the treatment combination M_2G_1 which was significantly superior to all other treatments. The minimum pulp content (52.80%) was recorded in the treatment M_1G_6 along with pulp: peel ratio (2.86) was estimated in treatment combination of M_2G_6. This might be due to the increased efficiency of microbial action to fix atmospheric nitrogen, increased in availability of phosphorous and secretion of growth promoting substances which accelerated the physiological process like carbohydrates synthesis. Similar results have also been reported by Liu & Liu (2012) [9], Biswal *et al*., (2015) [3] in pineapple.

The maximum TSS (16.55 ^{0}Brix) was recorded in the treatment combination M_2G_1 which was at par M_2G_2 (16.02 ^{0}Brix), M_2G_1 (16.02 ^{0}Brix) and minimum TSS (13.20 ^{0}Brix) was recorded in the treatment combination M_1G_6. Similar finding of the increasing in TSS have been reported by Darnaudery *et al,* (2016), Tewodros *et al,* (2018) in pineapple. Irrespective of growth regulators treatment application of NAA@10ppm was significantly more effective compared to other treatments. This might be due to the quick metabolic transformation of starch and protein in soluble compound and rapid translocation of sugar from leaves to the developing fruit. Similar results of increasing in TSS have been reported by Pal *et al*. (2017), Bhwomick *et al*. (2011).

The highest amount of reducing sugar (4.96%) non-reducing sugar (8.98%), total sugar (12.84%) was estimated in the treatment combination M_2G_1 which was on par with the treatment combinations M_2G_2 (4.92%) and the lowest amount of reducing sugar (3.21%) and total sugar (10.43%) was estimated in the treatment combination M_1G_6 but the lowest amount of non-reducing sugar (6.49%) was estimated in the treatment combination M_1G_4. Total sugar percentage was recorded higher with treatment having balanced nutrition or treatments received nutrition from chemical and either organic or from bio-fertilizer sources in both years of pooled mean. The results of present study are accordance with the finding of Baraily & Deb (2018) [1], Bhowmick *et al.* (2017) [2], Isuwan (2014) [7], Liu and Liu (2012) [9] in pineapple and quick metabolic transformation of starch & pectin into soluble compound & rapid translocation of sugar from leaves to the developing fruit. Similar results have been reported by Bhowmick *et al*., (2017) [2], Pal *et al*., (2015) [11] in pineapple.

Ascorbic acid content was maximum recorded in (24.26mg/100gm pulp) treatment combination of M_2G_1 and minimum value of ascorbic acid (14.45mg/100gm pulp) was estimated in the treatment combination M_1G_6. Similar results have also been reported by Liu & Liu (2012) [9], Biswal *et al*., (2015) [3] in pineapple.

Table 1: Effect of integrated manuring and growth regulators on yield and quality of pineapple

Interaction effect	Pooled data (2014-2016)													
	Fruit weight with crown (gm)	Fruit length (gm)	Fruit Girth (gm)	Crown Length (gm)	Crown weight (gm)	Fruit Yield per plot (kg)	Fruit Yield (t/ha)	Pulp: Peel ratio	Pulp Content (%)	TSS	Reducing sugar (%)	Non-Reducing sugar (%)	Total Sugar (%)	Ascorbic acid (%)
M_1G_1	966.55	14.45	33.70	15.91	153.29	27.99	31.09	4.37	64.64	14.90	4.12	8.17	11.41	22.06
M_1G_2	914.88	14.20	33.20	14.86	254.12	19.78	21.98	3.61	55.64	14.69	4.04	7.26	10.78	18.43
M_1G_3	926.88	14.30	33.30	14.83	200.60	20.11	22.35	4.07	60.88	14.42	3.34	7.30	10.59	16.84
M_1G_4	895.67	13.70	33.00	13.93	88.47	18.45	20.50	4.29	61.22	14.27	3.28	6.49	10.57	19.80
M_1G_5	877.65	13.78	32.71	13.08	145.80	17.68	19.65	3.73	57.96	13.87	3.34	6.63	10.60	20.39
M_1G_6	794.38	12.67	31.40	13.27	119.50	15.53	17.26	2.98	52.80	13.20	3.21	7.26	10.43	14.45
M_2G_1	1067.60	15.72	34.10	16.46	233.30	30.89	34.32	5.43	75.99	16.55	4.96	8.98	12.84	24.26
M_2G_2	1034.46	15.57	33.72	15.70	261.29	23.37	25.96	4.24	62.07	16.37	4.92	7.73	12.70	18.04
M_2G_3	1045.58	15.57	33.70	15.30	252.30	23.50	26.11	4.17	61.48	16.25	4.07	8.51	12.55	19.08

M_2G_4	949.15	14.58	33.26	15.80	197.40	20.80	23.11	4.36	62.67	16.29	3.93	7.61	12.52	19.69
M_2G_5	966.12	14.60	33.47	14.65	199.60	19.99	22.21	4.54	59.09	15.95	4.03	7.40	12.36	21.13
M_2G_6	832.61	14.10	32.51	13.70	238.30	16.67	18.52	2.86	56.59	15.57	3.91	8.27	12.14	15.62
M_3G_1	1362.22	16.67	36.50	17.90	108.50	40.59	45.10	4.92	65.93	15.62	4.55	8.19	11.91	23.66
M_3G_2	1258.83	16.42	35.69	17.16	247.30	29.63	32.92	3.96	58.85	15.75	4.59	7.99	11.70	17.87
M_3G_3	1312.00	16.52	35.79	17.36	230.79	29.88	33.20	3.95	61.73	15.35	3.80	7.67	11.44	18.46
M_3G_4	1175.67	15.65	34.50	16.57	122.50	26.54	29.49	4.10	61.76	15.42	3.75	6.94	11.43	19.33
M_3G_5	1198.38	15.52	34.52	16.85	82.70	25.87	28.75	4.21	60.06	15.22	3.74	6.73	11.33	20.64
M_3G_6	955.89	15.22	33.27	15.78	149.71	20.04	22.26	3.40	56.80	14.75	3.62	7.51	11.10	14.71
SE (m) ±	15.880	0.181	0.111	0.303	9.305	0.406	0.451	0.045	0.780	0.058	0.072	0.076	0.034	0.380
CD(P=0.05)	55.947	NS	0.379	1.026	31.122	1.215	1.353	0.131	2.350	0.179	0.218	0.228	0.102	1.166

Conclusion

The salient findings of the present study entitled "Effect of integrated manuring and growth regulator on yield and quality of pineapple (*Ananas comosus* L. Meer.)" clearly reveals that significant variation found in treatment 50% of recommended NPK + 50% of N through organic recycling with vermicmpost + vermiwash + biofertilizers (*Azotobacter* and *Azospirillum*)+ NAA @10ppm and 75% of recommended NPK + 25% of N through organic recycling with vermicompost + NAA@10ppm. with respect to Crown length, Fruit length, TSS, Fruit Girth, Pulp content, Pulp peel ratio, Total sugar, reducing sugar, Non reducing sugar, Ascorbic acid and Fruit weight with crown, fruit yield per plot and yield per ha.

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