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Conjunctive use of bio-fertilizers and organics for improving growth, yield and quality of banana cv. Grand Naine

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ABSTRACT

The present investigation was carried out to find out the response of combined application of bio-fertilizers and bio-control agents with organic manures and inorganic fertilizers on growth, yield and quality of tissue cultured banana cv. Grand Naine. The results indicate that growth; yield attributing characters and yield as well as fruits quality were significantly influenced by integration of bio-fertilizers, organic manures and inorganic fertilizers. The maximum pseudostem height (266.55 cm), girth (72.63 cm), number of suckers (8.07), were observed in the treatment consisting of 100% RDF + mycorrhiza (AM) + *Azospirillum* + PSB + *Trichoderma harzianum* (T_8). This treatment also recorded superiority in yield attributing characters like hands per bunch (10.20), fingers per hand (22.87), fingers per bunch (187.00), weight of second hand (3.76 kg), bunch weight (24.42 kg) and yield (75.35 t/ha). The quality parameters of fruits in terms of moisture, titrable acidity, ascorbic acid, TSS, total, reducing and non-reducing sugars as well as sugar: acid ratio were also influenced by combined use of organic, inorganic and biological sources of nutrients. Hence, 100% RDF + AM + *Azospirillum* + PSB + *Trichoderma harzianum* can be considered as best INM treatment for enhancing growth, yield and quality of banana in Mizoram.

Key words: Banana, Grand Naine, vegetative growth, INM, quality, yield.

INTRODUCTION

Among all the fruits, banana is plentiful, most nourishing and relatively cheaper source of nearly all essential nutrients including vitamins and minerals and very rich source of energy. It has been widely acclaimed as an instant energizer, hence widely favoured by sportsmen. The banana plant requires all the three major nutrients, *viz.* N, P and K for their growth, development and yield. Generally these requirements are fulfilled by supplying chemical fertilizers. However, regular, excessive and unbalanced use of inorganic fertilizers may lead to health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor yields (Singh and Singh, 13).

Hence, there is an urgent need to think of alternate source of safe fertilizers, which may enhance crop yields without having adverse effects on soil properties. Bio-fertilizers have been considered as a cheap, eco-friendly way of improving soil fertility status. Bio-fertilizers like *Azotobacter* fix atmospheric nitrogen and enhances the production of various field crops (Umar *et al.*, 15). N-fixing bacteria possess unique potential of fixing atmospheric nitrogen either by living symbiotically or non-symbiotically or to transform native soil nutrients, from non-usable to usable form through biological process. *Azotobacter* and *Azospirillum* have also been found to promote synthesis of growth promoting substances like auxins, gibberellins, cytokinins and antibiotic metabolites which, in turn, improved resistance against biotic and abiotic stress (Awasthi *et al.*, 2). Inoculation of these N-fixing microorganisms in the soil not only increases the yield but also save 20-40% nitrogen inputs. Likewise, application of organic manures like FYM to soil not only improve soil physical properties, pH, water holding capacity but also add important nutrients to the soil, thus increase the nutrient availability and its ultimate absorption by plant. The combined application of bio-fertilizers along with inorganic fertilizers and organic manures can increase sustainable economic yield by maintaining chemical, physical, and biological balance in the soil plant system (Hazarika *et al*., 7).

Keeping in view all the above background information and research gaps, the present investigation was undertaken to find out the most effective INM packages for growth, yield and quality of tissue cultured banana cv. Grand Naine.

MATERIALS AND METHODS

The present study was conducted at Experimental Farm, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl during 2008 to 2010 on banana cv. Grand Naine. The

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experimental field was situated at 23°44´45.6´´ N latitudes and 92°41´04.5´´ E longitudes and the elevation was 855 m above msl. The soil of the experimental plot was sandy loam; the available N, P and K were 274.20 kg ha^{-1}, 25.20 kg $ha^{-1}$and 126.93 kg ha^{-1} with 0.61% organic carbon and the soil was acidic in reaction with pH 4.82. The experiment was laid out in Randomized Block Design (RBD) with eleven treatments and three replications and 16 plants were there in each replication. Well rotten FYM @ 15 kg per pit and vermicompost @ 2 kg/pit was applied before planting. Bio-fertilizers and bioagents, *viz. Azospirillum*, PSB, arbuscular mycorrhiza (AM) and *Trichoderma harzianum* were procured from M/s Amit Biotech Pvt. Ltd. Kolkata were amended in the soil at the time of planting @ 50 g/plant. Secondary hardened tissue cultured plants were planted at a spacing of 1.8 m × 1.8 m. The recommended dose of fertilizers @ 200 g N, 100 g P_2O_5 and 300 g K_2O per plant were applied as per treatment schedule. Whole P_2O_5 along with half of K_2O were applied at the time of planting and rest half of K_2O was applied at shooting, *i.e.* eight month after planting. Nitrogenous fertilizer were applied in three split doses, *i.e*. 100 g one month after planting, 50 g four month after planting and 50 g seven month after planting.

The various treatments comprising of organic manures, bio-fertilizers and inorganic fertilizers were as follows: T_0 = Control (without any fertilizer), T_1 = 100% Recommended dose of NPK + FYM (RDF), T_2 = 100% Recommended dose of NPK + Vermicompost, T_3 = 100% RDF + *Azospirillum* T_4 = 100% RDF + *Trichoderma harzianum*, T_5 = 100% RDF + AM, T_6 = 100% RDF + PSB, T_7 = 100% RDF + AM + *Azospirillum* + PSB, T_8 = 100% RDF + AM + *Azospirillum* + PSB + *T. harzianum,* T_9 = 75% RDF + AM + *Azospirillum* + PSB + *T. harzianum,* and T_{10} = 50% RDF + AM + *Azospirillum* + PSB + *T. harzianum.* Observations on various growth and yield characters were recorded as per standard procedures. Moisture content of the fruit was determined by the oven dry method as described by Ranganna (11). Pulp TSS of the fruit was determined by Zeiss hand refractometer (0-32°Brix). Titrable acidity, reducing sugar, total sugars and non-reducing sugar were estimated by adopting the standard methods of AOAC (1). Freed's visual titration method (5) was followed for estimating ascorbic acid content of the fruit pulp. The data were analyzed statistically as per Panse and Sukhatme (9). To establish the relationship between various parameters, the data were subjected to correlation analysis.

RESULTS AND DISCUSSION

The data presented in Table 1 reveal that various growth and yield attributing characters were significantly influenced by different combinations of organic manures, bio-fertilizers and inorganic fertilizers. Maximum vegetative growth in terms of pseudostem height (266.55 cm) and girth (72.63 cm) were recorded in treatment with 100% RDF + AM + *Azospirillum* + PSB + *T. harzianum* (T_8), whereas the minimum height (233.20 cm) and girth (62.90 cm) was recorded in control. The increased vegetative growth in this treatment might also be attributed due to the increased biological nitrogen fixation, better organic nitrogen utilization, better development of root system and the possible synthesis of plant

Table 1. Effect of INM on growth and yield attributing characters of banana.

Treatment	Pseudostem height (cm)	Pseudostem girth (cm)	No. of suckers	Planting-shooting interval (days)	Shooting-harvesting interval (days)	Crop duration (days)
T_0	233.20	62.90	4.53	242.47	120.80	363.27
T_1	244.01	67.29	5.40	236.27	112.53	349.00
T_2	253.03	66.93	5.80	224.40	116.33	340.80
T_3	255.74	68.84	5.93	220.73	115.60	336.73
T_4	256.76	67.50	6.47	218.47	110.80	329.47
T_5	255.99	67.05	6.53	217.40	113.60	330.97
T_6	258.09	67.96	6.73	229.33	115.27	311.27
T_7	256.20	68.40	6.60	225.20	106.67	332.07
T_8	266.55	72.63	8.07	210.53	97.13	307.80
T_9	262.49	69.82	7.73	214.13	98.53	312.73
T_{10}	255.81	70.55	7.20	216.87	103.53	320.40
$CD_{0.05}$	4.21	2.20	0.63	6.72	3.73	NS

growth regulators like IAA, GA and cytokinins with the combined application of bio-fertilizers, organic manures and chemical fertilizers (Singh and Singh, 13). Incorporation of bio-fertilizers with FYM and inorganic fertilizers should have led to better mobilization of bound nutrients and improvement in the physical condition of the soil facilitating deeper penetration of the roots and higher nutrient extraction from the soil. This in turn might have enabled the plant to put up better growth leading to greater plant height and girth (Trivedi *et al.*, 14). Bhalerao *et al.* (3) also observed similar trend in plant height and girth in banana by using INM.

Highly significant difference was observed among different treatments in sucker production (Table 1). The highest number of suckers per plant was recorded in with T_8 (8.07), which was significantly higher than all other treatments except T_9 (7.73), while the lowest was recorded in control (4.53). T_8 also recorded the minimum days was for shooting (210.53 days), while, maximum was recorded in control (242.47 days). The earliness in flowering with the integration of chemical fertilizers, organic manures, bio-fertilizers and bioagents might be due to simultaneous transport of growth substances like cytokinin to the auxiliary buds and break the apical dominance. This resulted in a better sink for transportation from vegetative to reproductive phase. Earlier, similar interpretation was given by Hazarika and Ansari (6), and Bhalerao *et al.* (3) in banana. T_8 also recorded the minimum shooting-harvesting interval (97.13 days), however, it was statistically *at par* with T_9, while, the maximum was in control (120.80 days). The shortest shooting-harvesting might be due to the higher net assimilation rate on account of better vegetative growth leading to the production of endogenous metabolites earlier in optimum level enabling early flower bud initiation and thereby early shooting, fruiting and maturity (Hazarika, 8).

An inquisition of data presented in Table 2 revealed that T_8 also recorded the highest number of hands per bunch (10.20), fingers per hand (22.87) and fingers per bunch (187.00). The increase in number of hands and fingers per bunch might be attributed to the fact that in case of banana, all the embryonic flowers are hermaphrodite and the transformation of femaleness or maleness of flowers depends on the availability of nutrients and moisture to the meristimatic cells at differentiation stage (Hazarika, 8). As depicted in Table 2, the variation among the treatments in second hand weight was significant. The significantly highest weight was recorded in T_8 (3.76 kg), T_{10} (3.35 kg) and T_9 (3.27 kg), respectively, but both of these were statistically at par. The control recorded the significantly the lowest value of second hand weight (1.76 kg). It was also revealed that treatment T_8 increased the bunch weight significantly over rest of the treatments (24.42 kg). The increase in bunch weight was also found to be associated with corresponding increase in number of hands per bunch and number of fingers. The results are in line with the findings of Patil and Shinde (10) in banana, who reported maximum bunch weight by conjunctive use of bio-fertilizers, organic manures with inorganic fertilizers. Likewise, among the treatments, the highest yield of 75.30 t ha^{-1} was recorded in T_8, followed by T_9 (69.10 t ha^{-1}) and T_{10} (63.06 t ha^{-1}),

Table 2. Effect of INM on yield attributes and yield of banana.

Treatment	Hands/bunch	Fingers/hand	Fingers/bunch	Second hand wt. (kg)	Bunch wt. (kg)	Yield (t/ ha)
T_0	7.73	15.80	117.40	1.78	15.67	40.33
T_1	8.40	17.40	128.87	2.21	17.58	54.11
T_2	8.43	17.47	124.73	2.34	18.16	55.96
T_3	8.87	17.87	132.67	2.39	18.76	56.78
T_4	9.33	17.20	138.93	2.59	19.61	60.48
T_5	9.40	17.87	140.93	2.74	19.67	60.69
T_6	8.93	19.33	139.33	2.66	19.81	61.10
T_7	9.27	19.80	151.93	2.91	19.38	59.81
T_8	10.20	22.87	187.00	3.76	24.42	75.35
T_9	9.67	20.20	167.93	3.27	20.43	69.10
T_{10}	8.87	19.93	176.07	3.35	22.65	63.06
$CD_{0.05}$	0.43	1.21	12.95	0.22	1.34	3.79

respectively. The lowest yield of 40.33 t ha^{-1} was recorded in control. The increased in number of fingers per hand and hands per bunch and ultimately the yield might be due to the fact that bio-fertilizers not only increased the availability of nutrients to the plant roots but also increased their translocation from root to flower through plant foliage (Singh and Singh, 13). The enhanced level of nutrients and auxin due to the application of bio-fertilizers from the integration of nutrients could have diverted the photo-assimilates to the developing flower buds and helped in the conversion of flowers to more femaleness to produce higher number of fingers as well as hands, which in turn also increased the bunch weight and yield. This finding is in close conformity with the findings of Bhalerao *et al.* (3) who recommended application of full dose of NPK, FYM and bio-fertilizers.

It is also revealed from the data presented in Table 3 that lowest fruit moisture content (70.91%), titrable acidity (0.25%) and highest ascorbic acid (10.03 mg/100 g), TSS (22.64), total sugars (18.75), reducing sugar (9.33%) and sugar: acid ratio (76.10) were obtained in the treatment T_8, *i.e.* 100 per cent RDF + AM + *Azospirillum* + PSB + *Trichoderma harzianum*. The increase in TSS with combination of inorganic fertilizers with organic manures, bio-fertilizers and bio-control agents might be due to accumulation of sugars and other soluble components from hydrolysis of protein and oxidation of ascorbic acid. The results in this study are in close conformity with the results of Rathi and Bist (12). The increase in reducing, non-reducing and total sugars with combined use of organic manures, bio-fertilizers and inorganic fertilizers could be attributed due to quick metabolic transformation of soluble compounds and more conversion of organic acid into sugar. The increase in sugar content was also might be due to the degradation of polysaccharides into monosaccharide. The increased in sugar: acid ratio is due to increase in total sugars, TSS content and decrease in acidity, which favourably improved the sugar: acid ratio. The beneficial effects of combined application of inorganic fertilizers with organic manures along with bio-fertilizer on fruit quality were also observed by Dutta *et al.* (4). The increase in relatively higher moisture content and pulp: peel ratio in the treatment might be due to osmotic withdrawal of moisture content from the skin of the fruit to the pulp and increase moisture content as well as pulp-peel ratio (Yadav *et al.*, 16).

The present investigation revealed that 100 per cent recommended dose of NPK in combination with FYM, AM, *Azospirillum,* PSB and *Trichoderma harzianum* significantly increased the growth, yield and quality of tissue cultured banana cv. Grand Naine besides strengthening the crop cycle.

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Table 3. Effect of INM on quality parameters of banana.

Treatment	Moisture (%)	Titrable acidity (%)	Ascorbic acid (mg/100 g)	TSS (ºBrix)	Reducing sugar (%)	Total sugars (%)	Non reducing sugar (%)	Sugar: acid ratio
T_0	82.28	0.30	5.59	17.82	8.20	16.87	8.27	56.06
T_1	77.62	0.29	6.36	19.68	8.30	17.23	8.93	58.76
T_2	73.86	0.30	7.50	19.43	8.08	17.20	8.45	58.07
T_3	74.67	0.25	8.28	19.78	8.20	17.48	9.28	69.35
T_4	73.12	0.28	8.33	20.59	8.19	17.77	9.58	62.52
T_5	74.62	0.28	7.33	21.38	8.44	17.77	9.33	64.69
T_6	74.12	0.26	8.58	20.62	8.57	18.11	9.54	69.36
T_7	72.87	0.27	7.45	19.63	9.06	18.33	9.27	68.54
T_8	70.91	0.25	10.03	22.64	9.33	18.75	9.43	76.10
T_9	72.59	0.26	8.48	20.51	8.88	18.39	9.51	70.77
T_{10}	73.35	0.26	9.27	21.60	8.81	18.31	9.50	71.16
$CD_{0.05}$	2.94	0.01	1.10	0.76	0.38	0.38	0.50	4.01

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