

Original Research Article

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Effect of Integrated Nutrient Modules on Growth, Yield and Quality Parameters of Banana cv. Grand Naine

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ABSTRACT

Keywords

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A field experiment was conducted at new orchard, Department of Horticulture, University of Agricultural Sciences, Dharwad during 2014-15 and 2015-16 on “Integrated nutrient management studies in banana cv. Grand Naine (AAA)” through application of different combination of organic manures and inorganic fertilizers with green manure, *Azospirillum* and PSB. The results revealed that, Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Urea equivalent to 40 % RDN (535.73 kg/ ha) + Green manure (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha) (T₇) recorded the highest growth parameters [pseudostem height (205.05cm), pseudostem girth (27.47cm), number of leaves (16.00), leaf area (8.87 m²), leaf area index (2.74), the least number of days taken for shooting (190.65) and total crop duration(318.89)], yield parameters [bunch weight (26.94 kg), number of hands per bunch (11.75), finger weight (137.38 g), finger length (17.75 cm), plot yield (85.57 kg), yield per ha (66.02 t)] and quality parameters [TSS (23.52⁰ brix), total sugars (20.30%), reducing sugars (20.30 %), non-reducing sugars (17.87%), pulp to peel ratio (3.81) shelf life (6.33 days) and the least starch (3.67 %) and titrable acidity (0.25)] followed by T₁₀ (Agrigold combination) and T₁₁ (Bhumilabh combination) treatments.

Introduction

In India, banana is cultivated in an area of 0.83 million ha with a production of 30 million tonnes (Anon., 2011).

The major banana growing areas are in Tamil Nadu, Maharashtra, Andhra Pradesh, Gujarat, Kerala, Karnataka, West Bengal and Orissa. It is being grown in an area of 1.12 lakh ha with a production of 2.28 lakh tonnes in Karnataka state.

Banana is known to consume more nutrients for its growth, yield and biomass production (Hazarika *et al.*, 2015).

The use of chemical fertilizers alone has deleterious effect on soil physical, chemical and biological properties and productivity in the long run. The availability of organic manures is also one of the limitations for use in banana production. To fulfil the nutrient requirement only through organic or inorganic or bio- fertilizers alone is seldom possible but

integration of all these sources will not only aid in achieving higher yields but also in sustaining the soil fertility status in the long run.

Materials and Methods

The field experiment with an integrated nutrient module consisting of organic manures, chemical fertilizers, green manure and bio-fertilizers in banana cv. Grand Naine was conducted during 2014-15 and 2015-16 at new orchard, Department of Horticulture, University of Agricultural Sciences, Dharwad. The soil type was red with clay texture.

The experiment consists of 12 treatments viz.

Plant crop

T₁. FYM equivalent to 40 % RDN (48.40 t/ha) + VC equivalent to 40 % RDN (24.20 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₂ -FYM equivalent to 40 % RDN (48.40 t/ha) + PM equivalent to 40 % RDN (8.96 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₃. FYM equivalent to 40 % RDN (48.40 t/ha) + SM equivalent to 40 % RDN (10.17 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₄. FYM equivalent to 40 % RDN (48.40 t/ha) + AG equivalent to 40 % RDN (10.52 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₅. FYM equivalent to 40 % RDN (48.40 t/ha) + BL equivalent to 40 % RDN (7.56 t/ha) +

GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₆. FYM equivalent to 40 % RDN (48.40 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha).

T₇. VC equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₈. PM equivalent to 40 % RDN (8.96 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₉. SM equivalent to 40 % RDN (10.17 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha).

T₁₀. AG equivalent to 40 % RDN (10.52 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)

T₁₁. BL equivalent to 40 % RDN (7.56 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)

T₁₂ -Control (RDF 200: 100: 300 g NPK /plant or 617.20:308.60: 925.80 kg NPK/ha + Farm yard manure@ 40 t/ha)

The recommended dose of phosphorous and potash (100 g/plant and 300 g/plant

respectively) was supplied through DAP and MOP.

Ratoon crop

RDF = 100:50:100 NPK g /plant or 308.60:154.20: 308.60 kg NPK/ha) + FYM @ 20 t/ha

Note: 1) FYM- Farm Yard Manure, VC- Vermicompost, PM-Poultry Manure, SM-Sheep Manure, AG-Agrigold, BL-Bhumilabh, GM-Green manure, PSB-Phosphate Solubilizing bacteria. *Azospirillum* (ACD-15) and PSB (*Pseudomonas striata*) were used for the study.

The application of organic manures, chemical fertilizers with green manure and bio-fertilizer will compensate the majority of the plant nutrition thereby increase the productivity of banana cv. Grand Naine. The influence of integrated nutrient module was assessed on growth, yield and quality parameters of banana. The results of the field experiments conducted during the year 2014-15 and 2015-16 are pooled and discussed.

Results and Discussion

The results of the field experiments conducted during the year 2014-15 and 2015-16 are pooled and discussed under different headings.

Effect of integrated nutrient modules on banana growth parameters (Table 1 and 2)

The influence of different integrated nutrient modules on growth parameters which caused the yield variations are discussed here under.

The results of the pooled mean indicated that, at shooting the highest plant height (205.05 cm) was recorded in T₇ {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha)

equivalent to 40 % RDN + Green manure (sunhemp @ 8.88 tons/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)} which was on par with T₆, T₁₀ and T₁₁ and significantly superior over rest of the treatments. The least pseudostem height was recorded in T₈ (171.53 cm) followed by T₃. The pseudostem girth was significantly higher with T₇ treatment (27.47 cm) followed by T₉ which was on par with T₁, T₄, T₅, T₆, T₉, T₁₀, T₁₁ and T₁₂ and the least pseudostem girth (24.99 cm) was recorded in plants treated with T₈. The highest number of leaves (16.00) was recorded in T₇ {Vermicompost equivalent to 40 % of RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (sunhemp @ 8.88 tons/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)} indicating the superiority of integrated nutrient module over organic treatments alone which was significantly superior over all other treatments except T₃ and T₈. The least number of leaves (13.24) was recorded in T₈ (Table 1).

The application vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (sunhemp @ 8.88 tons/ha) + *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T₇) recorded significantly higher leaf area (8.87 m²) followed by T₁, T₄, T₅, T₉, T₁₀ and T₁₁. The integrated nutrient modules recorded the higher leaf area as compared to organic nutrient modules except in T₈. The pooled data indicated that, the highest leaf area index (2.74) at shooting was recorded in T₇ which was on par with T₁, T₄, T₅, T₉, T₁₀ and T₁₁ treatments having integrated nutrient modules and superior over rest of the treatments. The mean least number of days taken for shooting, shooting to harvest and total crop duration (190.65, 128.24 and 318.89 days respectively) was recorded in T₇ {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical

fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (sunhemp @ 8.87 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (Table 2).

The results indicated that, the integrated nutrient modules T₇ (Vermicompost combination), T₁₀ (Agrigold combination) and T₁₁ (Bhumilabh combination) were recorded lesser days taken for shooting, shooting harvest and total crop duration indicating the potentiality of these organic manures along with chemical and bio-fertilizers. These integrated treatments were found to be most promising in obtaining higher growth parameters of banana.

The similar results were also obtained by several other workers. Jayabaskaran *et al.*, (2001) observed significantly higher plant height in Poovan banana by application of poultry manure at 15 kg per plant and followed by application of rice husk ash @ 15 kg per plant. Nachegowda *et al.*, (2004) recorded that the plants applied with 180:108:220 g of NPK + 15 kg of FYM were recorded the highest plant height followed by banana plants supplied with 2.5 kg sheep manure +180:108:220 g NPK/plant/year.

Patil and Shinde (2013) also reported that, treatment with 50 % RDF + FYM (10 kg/plant) + *Azotobacter* (50 g/Plant) + PSB (50 g/plant) + VAM (250 g/plant) recorded significantly the highest number of leaves at different days after planting and at shooting stage.

Effect of integrated nutrient modules on banana yield parameters (Table 3)

The influence of different integrated nutrient modules on yield parameters which caused the yield variations are discussed here under.

The pooled data indicated that, the maximum

mean yield of banana per hectare (66.02 t/ha) was recorded in T₇ {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (Sunhemp @ 8.88 t/ha) + *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)} which was on par with T₁, T₁₀ and T₁₁ and significantly superior over rest of the treatments (Table 3).

The highest mean yield of banana in T₇ was attributed to the higher growth and yield contributing parameters in the same treatment. The mean yield components of banana indicated that the maximum bunch weight (26.94 kg), number of hands per bunch (11.75), finger weight (137.38 g), finger length (17.75 cm), number of fingers on third hand (16.93) were recorded in plants applied with vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (sunhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T₇). The similar results were also recorded with integrated nutrient modules by many scientists in banana. Athani *et al.*, (1999) reported that, maximum number of fingers per bunch, bunch weight (5.10 kg/bunch) and finally fruit yield (15.14 t/ha) was obtained by applying 50 % RDF + vermicompost 2.00 kg/plant in Rajapuri banana. They also reported that, organic matter in the form of vermicompost in combination with inorganic fertilizers increased the yield in banana cv. Rajapuri. Nachegowda *et al.*, (2004) reported that, plants applied with 15 kg FYM + 180:108:220g NPK /plant/year recorded the highest bunch weight (49.47 kg), fruit length (25.19 cm), fruit weight (220.21 g), finger /hand (19.00), fingers/bunch (227.94) and the yield (148.41 t/ha) in banana followed by 2.5 kg Sheep manure + 108:108:220g NPK /plant/year.

Table.1 Influence of different sources of nutrient modules on growth parameters in banana cv. Grand Naine (Pooled mean)

Treatments	Pseudostem height (cm)					Pseudostem girth (cm)					Number of leaves				
	35 DAP	70 DAP	105 DAP	140 DAP	At shooting	35 DAP	70 DAP	105 DAP	140 DAP	At shooting	35 DAP	70 DAP	105 DAP	140 DAP	At shooting
T ₁	40.13	69.63	106.09	139.27	189.33	7.75	10.57	13.40	17.52	27.12	7.16	11.44	11.78	11.79	15.35
T ₂	35.08	66.93	102.84	136.71	183.31	6.46	10.12	13.04	16.86	25.25	6.70	11.37	11.81	11.32	15.03
T ₃	32.78	66.64	101.61	136.20	181.39	6.75	9.68	12.93	16.77	25.62	6.50	10.76	11.29	10.84	14.36
T ₄	38.47	69.83	104.38	137.78	186.27	7.33	10.35	13.31	17.42	26.62	6.01	11.26	11.71	11.46	15.18
T ₅	38.27	67.86	104.77	137.36	185.62	7.23	10.39	13.37	17.07	26.01	7.02	11.44	11.71	11.46	15.27
T ₆	41.05	72.03	109.24	140.95	194.26	8.15	11.28	14.11	17.79	27.25	8.25	11.86	11.83	11.83	15.68
T ₇	51.96	83.65	117.54	146.97	205.05	9.26	11.97	14.85	18.16	27.47	9.37	12.42	12.33	11.90	16.00
T ₈	30.32	65.45	99.77	128.15	171.53	6.65	9.56	12.72	16.14	24.99	5.64	10.01	10.41	10.00	13.24
T ₉	40.33	71.32	106.32	139.02	190.44	7.95	11.03	13.43	17.60	27.26	8.06	11.64	11.76	11.39	15.53
T ₁₀	46.75	79.32	116.31	146.49	203.25	8.76	11.83	14.81	17.81	26.85	8.62	12.25	12.27	11.87	15.80
T ₁₁	42.53	75.04	109.36	142.29	196.96	8.62	11.60	14.30	17.80	26.77	8.35	11.96	12.07	11.61	15.45
T ₁₂	40.94	71.52	106.55	139.57	191.92	7.71	10.67	13.57	17.79	26.75	8.09	11.71	11.75	11.69	15.26
SEm+/-	4.75	4.72	3.42	3.57	4.16	0.71	0.47	0.60	0.51	0.43	0.22	0.38	0.34	0.36	0.51
CD at 5%	13.93	13.85	10.04	10.48	12.20	2.08	1.39	1.76	1.49	1.27	0.65	1.12	1.01	1.05	1.51

DAP: Days after planting

- T₁. FYM equivalent to 40 % RDN (48.40 t/ha) + VC equivalent to 40 % RDN (24.20 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₂. FYM equivalent to 40 % RDN (48.40 t/ha) + PM equivalent to 40 % RDN (8.96 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₃. FYM equivalent to 40 % RDN (48.40 t/ha) + SM equivalent to 40 % RDN (10.17 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₄. FYM equivalent to 40 % RDN (48.40 t/ha) + AG equivalent to 40 % RDN (10.52 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₅. FYM equivalent to 40 % RDN (48.40 t/ha) + BL equivalent to 40 % RDN (7.56 t/ha) + GM (Sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₆. FYM equivalent to 40 % RDN (48.40 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₇. VC equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp@ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₈. PM equivalent to 40 % RDN (8.96 t/ha)+ 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₉. SM equivalent to 40 % RDN (10.17 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₁₀. AG equivalent to 40 % RDN (10.52 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₁₁. BL equivalent to 40 % RDN (7.56 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₁₂ -Control (RDF=617.20:308.60: 925.80 kg NPK/ha + Farm yard manure@ 40 t/ha (plant crop)

Ratoon crop: RDF=308.60:154.20: 308.60 kg NPK/ha) + FYM @ 20/ha accordingly it has been supplied through different sources

FYM- Farmyard manure, VC-Vermicompost, PM-Poultry manure, SM-Sheep manure, AG-Agrigold, BL-Bhumilabh, GM-Green manure, PSB-Phosphate Solubilizing bacteria

Table.2 Influence of different sources of nutrient modules on growth parameters in banana cv. Grand Naine (Pooled mean)

Treatments	Leaf area (m ²)					Leaf area Index					Days		
	35 DAP	70 DAP	105 DAP	140 DAP	At shooting	35 DAP	70 DAP	105 DAP	140 DAP	At shooting	Taken for shooting	Shooting to harvest	Total crop duration
T ₁	1.09	2.35	3.01	3.32	7.52	0.34	0.72	0.93	1.25	2.32	215.24	133.88	339.12
T ₂	0.96	2.31	2.39	3.17	6.30	0.30	0.71	0.74	1.02	1.94	226.91	138.08	364.99
T ₃	0.90	2.07	2.38	3.83	6.03	0.28	0.64	0.73	0.98	1.86	229.15	138.41	367.56
T ₄	0.77	2.27	2.85	3.72	7.25	0.24	0.70	0.88	1.18	2.24	220.96	134.95	355.91
T ₅	1.05	2.33	2.85	3.53	7.09	0.32	0.72	0.88	1.15	2.19	226.42	136.89	363.30
T ₆	1.45	2.52	3.12	4.58	6.69	0.45	0.78	0.96	1.09	2.07	204.46	135.50	339.96
T ₇	1.89	2.82	3.65	2.81	8.87	0.58	0.87	1.13	1.41	2.74	190.65	128.24	318.89
T ₈	0.68	1.83	2.13	3.87	5.30	0.21	0.57	0.66	0.87	1.63	230.66	138.50	369.16
T ₉	1.39	2.41	3.01	4.44	7.66	0.43	0.74	0.93	1.19	2.36	211.41	132.39	343.80
T ₁₀	1.58	2.75	3.50	4.41	8.57	0.49	0.85	1.08	1.37	2.64	195.25	128.26	323.51
T ₁₁	1.49	2.55	3.39	3.66	8.39	0.46	0.79	1.05	1.36	2.59	201.09	129.16	330.24
T ₁₂	1.40	2.44	3.15	3.32	6.83	0.43	0.75	0.97	1.13	2.11	206.93	131.67	338.59
S Em+/-	0.08	0.16	0.29	0.33	0.63	0.02	0.05	0.09	0.10	0.20	0.80	0.55	1.21
CD at 5%	0.24	0.46	0.85	0.96	1.86	0.07	0.14	0.26	0.30	0.57	2.36	1.62	3.55

DAP: Days after planting

- T₁. FYM equivalent to 40 % RDN (48.40 t/ha) + VC equivalent to 40 % RDN (24.20 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₂. FYM equivalent to 40 % RDN (48.40 t/ha) + PM equivalent to 40 % RDN (8.96 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
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- T₅. FYM equivalent to 40 % RDN (48.40 t/ha) + BL equivalent to 40 % RDN (7.56 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₆. FYM equivalent to 40 % RDN (48.40 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
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- T₈. PM equivalent to 40 % RDN (8.96 t/ha)+ 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₉. SM equivalent to 40 % RDN (10.17 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
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- T₁₁. BL equivalent to 40 % RDN (7.56 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
- T₁₂ -Control (RDF=617.20:308.60: 925.80 kg NPK/ha + Farm yard manure@ 40 t/ha (plant crop)

Ratoon crop: RDF=308.60:154.20: 308.60 kg NPK/ha) + FYM @ 20/ha accordingly it has been supplied through different sources

FYM- Farmyard manure, VC-Vermicompost, PM-Poultry manure, SM-Sheep manure, AG-Agrigold, BL-Bhumilabh, GM-Green manure, PSB-Phosphate Solubilizing bacteria

Table.3 Influence of different sources of nutrient modules on yield parameters in banana cv. Grand Naine (Pooled mean)

Treatments	Bunch weight. (kg)	No. of hands per bunch	Finger weight. (g)	Finger length (cm)	No. of Fingers on 3 rd hand	Plot yield (kg)	Yield (t/ha)
T ₁	18.17	10.06	124.27	16.14	14.89	73.21	56.48
T ₂	14.58	9.10	117.77	15.23	13.88	60.44	46.63
T ₃	11.55	8.58	104.28	14.36	13.10	58.35	45.02
T ₄	17.85	10.31	123.43	15.32	14.26	72.72	56.10
T ₅	16.41	9.73	120.39	15.55	14.19	70.04	54.04
T ₆	19.18	10.02	129.53	16.12	15.02	70.52	54.40
T ₇	26.94	11.75	137.38	17.75	16.93	85.57	66.02
T ₈	12.85	9.54	104.43	14.40	13.09	61.69	47.59
T ₉	19.54	10.19	129.83	16.12	15.04	70.83	54.64
T ₁₀	23.69	10.98	135.91	17.18	16.12	84.27	65.01
T ₁₁	22.51	10.49	135.16	17.07	16.14	73.66	56.83
T ₁₂	19.17	9.70	128.02	16.66	15.68	71.21	54.94
S Em+/-	0.65	0.15	1.84	0.31	0.30	4.28	3.30
CD at 5%	1.91	0.44	5.39	0.90	0.87	12.55	9.68

T₁. FYM equivalent to 40 % RDN (48.40 t/ha) + VC equivalent to 40 % RDN (24.20 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₂-FYM equivalent to 40 % RDN (48.40 t/ha) + PM equivalent to 40 % RDN (8.96 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₃. FYM equivalent to 40 % RDN (48.40 t/ha) + SM equivalent to 40 % RDN (10.17 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₄. FYM equivalent to 40 % RDN (48.40 t/ha) + AG equivalent to 40 % RDN (10.52 t/ha) + GM (sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₅. FYM equivalent to 40 % RDN (48.40 t/ha) + BL equivalent to 40 % RDN (7.56 t/ha) + GM (Sunhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₆ FYM equivalent to 40 % RDN (48.40 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₇. VC equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp@ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₈. PM equivalent to 40 % RDN (8.96 t/ha)+ 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₉. SM equivalent to 40 % RDN (10.17 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₀. AG equivalent to 40 % RDN (10.52 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₁. BL equivalent to 40 % RDN (7.56 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₂ -Control (RDF=617.20:308.60: 925.80 kg NPK/ha + Farm yard manure@ 40 t/ha (plant crop)
 Ratoon crop: RDF=308.60:154.20: 308.60 kg NPK/ha) + FYM @ 20/ha accordingly it has been supplied through different sources
 FYM- Farmyard manure, VC-Vermicompost, PM-Poultry manure, SM-Sheep manure, AG-Agrigold, BL-Bhumilabh, GM-Green manure, PSB-Phosphate Solubilizing bacteria

Table.4 Influence of different sources of nutrient modules on quality parameters in banana cv. Grand Naine (Pooled mean)

Treatments	TSS (° brix)	Total Sugars (%)	RS (%)	NRS (%)	Starch (%)	Titration acidity (%)	Pulp to peel ratio	Shelf life (Days)
T ₁	19.82	18.95	16.92	2.03	5.00	0.33	3.25	5.04
T ₂	19.46	18.25	16.55	1.70	5.74	0.36	2.78	4.55
T ₃	19.02	17.88	16.31	1.57	6.08	0.37	2.55	4.53
T ₄	19.54	18.57	16.80	1.77	5.00	0.33	3.12	5.04
T ₅	19.70	18.76	16.97	1.80	5.17	0.33	3.04	4.76
T ₆	21.45	19.49	17.30	2.19	4.33	0.29	3.47	5.41
T ₇	23.52	20.30	17.87	2.43	3.67	0.25	3.81	6.33
T ₈	19.13	17.52	15.98	1.54	6.21	0.39	2.46	4.12
T ₉	20.25	19.07	17.03	2.04	4.92	0.32	3.33	5.38
T ₁₀	22.23	20.10	17.71	2.39	3.67	0.25	3.74	5.80
T ₁₁	22.07	19.31	17.09	2.22	3.84	0.28	3.56	5.68
T ₁₂	20.57	19.13	16.98	2.15	4.48	0.32	3.35	5.46
S Em+/-	0.20	0.39	0.39	0.02	0.05	0.00	0.04	0.08
CD at 5%	0.58	1.15	1.13	0.06	0.16	0.01	0.10	0.24

T₁. FYM equivalent to 40 % RDN (48.40 t/ha) + VC equivalent to 40 % RDN (24.20 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₂-FYM equivalent to 40 % RDN (48.40 t/ha) + PM equivalent to 40 % RDN (8.96 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₃. FYM equivalent to 40 % RDN (48.40 t/ha) + SM equivalent to 40 % RDN (10.17 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₄. FYM equivalent to 40 % RDN (48.40 t/ha) + AG equivalent to 40 % RDN (10.52 t/ha) + GM (sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₅. FYM equivalent to 40 % RDN (48.40 t/ha) + BL equivalent to 40 % RDN (7.56 t/ha) + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₆ FYM equivalent to 40 % RDN (48.40 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₇. VC equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp@ 8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₈. PM equivalent to 40 % RDN (8.96 t/ha)+ 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₉. SM equivalent to 40 % RDN (10.17 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₀. AG equivalent to 40 % RDN (10.52 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₁. BL equivalent to 40 % RDN (7.56 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + GM (sunnhemp @8.88 t/ha) and *Azospirillum* (@ 30.86 kg/ha) equivalent to 20 % RDN + PSB (@ 30.86 kg/ha).
 T₁₂ -Control (RDF=617.20:308.60: 925.80 kg NPK/ha + Farm yard manure@ 40 t/ha (plant crop)
 Ratoon crop: RDF=308.60:154.20: 308.60 kg NPK/ha) + FYM @ 20/ha accordingly it has been supplied through different sources
 FYM- Farmyard manure, VC-Vermicompost, PM-Poultry manure, SM-Sheep manure, AG-Agrigold, BL-Bhumilabh, GM-Green manure, PSB-Phosphate Solubilizing bacteria

Hazarika *et al.*, (2011) reported that, the highest number of fingers per hand (22.87), finger length (22.97 cm), circumference (14.13 cm), finger volume (282.98 cc) and weight of finger (231.67 g) were significantly influenced by 100 % RDF + VAM (50 g/plant) + *Azospirillum* (50 g/plant) + PSB (50 g/plant) + *Trichoderma harzianum* (50 g/plant) in banana.

Patil and Shinde (2013) recorded the highest bunch weight of 19.31 kg in plants inoculated with 75 % RDF + FYM + *Azotobacter* (50 g /plant) + PSB (50 g /plant) + VAM (250 g/plant) in Ardhapuri cultivar of banana. They also reported that, the highest yield of 85.80 t/ha obtained when the plants were treated with 50 % RDF + FYM + *Azotobacter* (50 g/plant) + PSB (50 g/plant) + VAM (250 g/plant) in banana cv. Ardhapuri (AAA). Significant increase in number of fingers per bunch and average bunch weight of 5.0 kg by applying vermicompost + N as inorganic fertilizer in banana reported by Manivannan and Selvamani (2014). They also reported that, maximum bunch weight, more number of fingers per bunch was obtained by applying vermicompost as full N in banana. They also opined that, significantly more finger weight and finger girth was obtained by applying organic + inorganic fertilizers. The maximum number of fingers per bunch, bunch weight (5.10 kg/bunch) and finally fruit yield (15.14 t/ha) was obtained by applying 50 % RDF + vermicompost 2.00 kg/plant in banana.

Influence of different sources of nutrient modules on quality parameters (Table 4)

The mean of the pooled data indicated that, the quality parameters like Total Soluble Solids, Reducing sugars, Non reducing sugars, Total Sugars, Pulp to peel ratio and Shelf life was maximum (23.52⁰ B, 17.87 %, 2.43 %, 20.31 %, 3.81 and 6.33 days respectively) in banana fruits harvested from

plants treated with T₇ {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + Green manure (sunhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)}. Whereas, the least titratable acidity (0.25 %) was recorded in T₇ and T₁₀ treatments followed by T₁₁ treatment. However, the starch was least (3.67 %) in T₇ and T₁₀ treatments. In general the fruit quality parameters were improved in integrated nutrient modules compared to organic treatments.

The main changes in fruit pulp during ripening are the conversion of starch to sugars. As ripening proceeds, pulp to peel ratio was increased from 2.0 in stage 5 to 2.7 in stage 7 when the fruits become fully ripened.

This could be due to the osmotic transfer of moisture from the peel to the pulp as sugar content of pulp increased. It has been suggested that pulp to peel ratio can be considered as a coefficient of ripeness. These changes during ripening period (loss of greenness and increase in yellowness) may occur as a result of the breakdown of the chlorophyll in the peel tissue.

Venkatesh (1995) observed that application of organic manures *viz.*, vermicompost (@ 4 t/ha) and farmyard manure (@ 2.5 t/ha) resulted in significantly higher amount of total sugars and decreased titratable acidity compared to inorganic fertilizers in grape. The results of present study also indicated the same. The results indicated that a progressive increase in total sugar content and decrease in starch content was observed during ripening. Thompson (1996) reported that the softening of banana fruit during ripening is associated with the conversion of starch to sugar, breakdown of pectin substances and the

movement of water from rind of banana to the pulp and this could be the major cause for decreasing the various mechanical properties of banana during ripening. Ushakumari *et al.*, (1997) recorded similar results as that of present study. They obtained significantly more reducing sugar by applying vermicompost as full N in banana cv. Njalipoovan.

They also reported that significantly higher content of total sugar was obtained by applying vermicompost + inorganic fertilizers whereas, significantly less acidity was obtained by applying vermicompost + inorganic fertilizers and vermiculture in-situ and the highest content of non-reducing sugar by applying vermiculture in-situ. This could be due to the hydrolysis of starch into sugar during ripening (Garcia and Lajolo, 1988). Increase in TSS is an important trait of hydrolysis of starch in to soluble sugars such as glucose, sucrose and fructose (Stover and Simmonds, 1987 and Kulkarni *et al.*, 2010).

Mustaffa *et al.*, (2004) opined that application of 2.5 kg compost + 1.0 kg vermicompost + 1.0 kg neem cake + 2.5 kg poultry manure at 3, 5 and 7 months after planting recorded the maximum TSS (29.40⁰ Brix and 32.20⁰ Brix respectively), acidity (0.59 % and 0.61 % respectively), sugar - acid ratio (49.8 and 52.8 respectively), total sugars (25 % and 26.3 % respectively) and low starch (3.2 % and 3.4 % respectively). The lowest quality was recorded in inorganically fertilized fruits of Rasthali and Karpuravalli cultivars of banana respectively.

Hazarika and Ansari (2008) revealed that biochemical constituents *viz.*, TSS, reducing sugar, non-reducing sugar, ascorbic acid, and moisture content of fruits was significantly influenced by different treatments having organic manure and bio-fertilizer along with inorganic fertilizers except sugar-acid ratio

and titratable acidity in banana cv. Jahaji (AAA).

The results of Tangaselvabai *et al.*, (2009) were in line with the present study. They reported that the highest TSS, reducing sugars, non-reducing sugars, total sugars, ascorbic acid and starch was noticed in plants treated with 100:30:330 g NPK/plant in 2 splits + *Azospirillum*, 100 : 30 : 330 g NPK/plant in 2 splits + *Azospirillum*, 75:30:330 g NPK/plant in 2 splits + *Azospirillum*, 220:30:330 g NPK/plant in 4 splits, 100:30:330 g NPK/plant in 2 splits + *Azospirillum* and 100:30:330 g NPK/plant in 2 splits+ *Azospirillum* respectively.

Application of plants with vermicompost equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (urea 535.73 kg/ ha) + Green manure (sunhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T₇) was most superior in increasing the growth, yield and quality parameters.

The integrated nutrient modules favoured higher growth, yield and quality parameters than organic modules followed by T₁₀ (with Agri-gold combination) and T₁₁ (with Bhumilabh combination) indicating the potentiality of these organic manures when used in conjunction with chemical and bio-fertilizers.

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