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Influence of Different Sources Nutrient Modules on Growth, Yield and Soil Properties of Banana cv. Grand Naine

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A B S T R A C T

The present study was conducted in the experimental plot at Main Agricultural Research Station (MARS), College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka during 2014-15 and 2015-16 on "Integrated nutrient management studies in banana cv. Grand Naine (AAA)". Application of plants with combination of organic manures + Green manure and *Azospirillum* was carried out to assess the influence on growth, yield and soil properties of banana. The results indicated that combined 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 (sunnhemp @ 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 (8.87m^2), 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) and the yield per ha (66.02 t)] followed by T10 and T11 treatments. After the completion of the experiment the organic carbon was found to increase in organic treatments (T_1 to T_5) from 0.65 % to 0.72 %, whereas it was decreased from 0.65 % to 0.57 % in integrated treatments (T_6 to T_{12}). The available N in soil was significantly higher in organic treatments than integrated treatments. The available phosphorous was decreased in organic treatments compared to integrated treatments. The available potash recorded higher status in organic treatments compared to integrated 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-fertilizer 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

T_1 - 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).

T_2 – 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).

T_3 - 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).

T_4 - 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).

T_5 - 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).

T_6 - 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).

T_7 - 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).

T_8 - 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).

T_9 - 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).

T_{10} - 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)

T_{11} - 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)

T_{12} - 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

The recommended dose of phosphorous and potash (50 g / plant and 100 g / plant respectively) was supplied through DAP and MOP. 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 crop productivity of banana cv. Grand Naine. The influence was assessed on growth, yield and available NPK in the soil. The results of pooled mean of the field experiment conducted during the year 2014-15 and 2015-16 are discussed.

Results and Discussion

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

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

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

The pooled mean results indicated that at shooting the highest plant height (205.05 cm) was recorded in T_7 {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + RDN 40 % through fertilizer + Green manure (sunnhemp @ 8.88 tons/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)} which was on par with T_6, T_{10} and T_{11} and significantly superior over rest of the treatments. The least pseudostem height was recorded in T_8 (171.53 cm). The pseudostem girth was significantly higher with T_7 treatment (27.47 cm) followed by T_9 which was on par with T_1, T_4, T_5, T_6, T_9, T_{10}, T_{11} and T_{12}.

The highest number of leaves (16.00) was recorded in T_7 {Vermicompost equivalent to 40 % of RDN (24.20 t/ha) + RDN 40 % through fertilizer + Green manure (sunnhemp @ 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.

The application vermicompost equivalent to 40 % RDN (24.20 t/ha) + RDN 40 % through fertilizer + Green manure (sunnhemp @ 8.88 tons/ha) + *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T_7) recorded significantly higher leaf area (8.87 m^2) followed by T_1, T_4, T_5, T_9, T_{10} and T_{11}. The pooled data indicated that, the highest leaf area index (2.74) at shooting was recorded in T_7 which was on par with T_1, T_4, T_5, T_9, T_{10} and T_{11} 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 T_7 {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through fertilizer + Green manure (sunnhemp @ 8.87 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha). The results indicated that, the integrated nutrient modules T_7 (with Vermicompost combination), T_{10} (with Agrigold combination) and T_{11} (with 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.

The similar results were also obtained by several 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 DAP and at shooting stage.

The integrated nutrient module particularly T_7 (Vermicompost combination), followed by T_{10} (Agri-gold combination) and T_{11} (Bhumilabh combination) were found to be most promising in obtaining higher growth parameters of banana.

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

The pooled data indicated that, the maximum mean yield of banana per hectare (66.02 t/ha) was also recorded in T_7 {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + 40 % RDN through chemical fertilizer (Urea 535.73 kg/ ha) + Green manure (Sunnhemp @ 8.88 t/ha) + *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha)}which was on par with T_1, T_{10} and T_{11} significantly superior over rest of the treatments (Table 3).

The highest mean yield of banana in T_7 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) + 40 % RDN through urea + Green manure (sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T_7).

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 (148.41t/ha) in banana followed by 2.5 kg Sheep manure + 108:108:2205g 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

T_1- 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).

T_2-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).

T_3- 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).

T_4- 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).

T_5- 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).

T_6 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).

T_7- 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).

T_8- 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).

T_9- 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).

T_{10}- 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

T_{11}- 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)

T_{12} -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

T_1- 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).
T_2-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).
T_3- 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).
T_4- 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).
T_5- 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).
T_6 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).
T_7- 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).
T_8- 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).
T_9- 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).
T_{10}- 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
T_{11}- 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)
T_{12} -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 3rd 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

T_1- 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).
T_2-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).
T_3- 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).
T_4- 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).
T_5- 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).
T_6 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).
T_7- 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).
T_8- 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).
T_9- 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).
T_{10}- 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
T_{11}- 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)
T_{12} -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 soil characteristics in banana cv. Grand Naine (Pooled mean)

Treatments	Soil pH (1:2.5)	EC (dS/m)	Organic C (%)	Avail N (kg/ha)	Avail P_2O_5 (kg/ha)	Avail K_2O (kg/ha)
T_1	7.24	0.14	0.72	319.95	24.05	133.50
T_2	7.27	0.11	0.68	302.95	22.50	118.80
T_3	7.34	0.12	0.69	306.68	23.90	118.65
T_4	7.16	0.12	0.70	311.25	21.55	133.35
T_5	6.98	0.16	0.71	314.98	23.90	132.90
T_6	6.93	0.11	0.57	264.48	28.20	118.90
T_7	6.91	0.11	0.59	271.53	30.70	130.85
T_8	7.37	0.10	0.58	268.20	26.30	125.80
T_9	7.07	0.14	0.59	271.10	28.20	118.60
T_{10}	7.04	0.12	0.61	281.88	29.30	123.65
T_{11}	7.20	0.11	0.59	271.93	28.80	130.85
T_{12}	7.11	0.16	0.63	285.18	30.70	130.40
S Em+/-	0.02	0.01	0.01	1.73	0.80	0.68
CD at 5%	0.06	0.02	0.01	5.08	2.36	2.00

T_1- 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).
T_2-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).
T_3- 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).
T_4- 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 (@30.86kg/ha) equivalent to 20% RDN + PSB (@ 30.86kg/ha).
T_5- FYM equivalent to 40% RDN (48.40 t/ha) + BL equivalent to 40% RDN (7.56 t/ha) + GM (Sun hemp @ 8.88 t/ha) and Azospirillum (@ 30.86kg/ha) equivalent to 20% RDN + PSB (@ 30.86kg/ha).
T_6 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 (@ 30.86kg/ha).
T_7- 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) + Azospirillum (@ 30.86kg/ha) equivalent to 20% RDN + PSB (@ 30.86kg/ha).
T_8- 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).
T_9- 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).
T_{10}- 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
T_{11}- 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)
T_{12} -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 harjianum* (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 + *Azatobacter* (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, 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) by applying 50 % RDF + vermicompost 2.00 kg/plant in banana.

The effect of integrated nutrient modules on soil properties (Table 4)

At the start of experiment, the organic carbon (0.65%) and available NPK were medium (285, 28.75 and 156.25 kg/ha). The soil pH was neutral (7.38) and EC (0.25 dS/m) was non saline. The results of the pooled data indicated that, the organic carbon was found to enhance in organic treatments (T_1 to T_5) from 0.65 % to 0.72 %, whereas it was decreased from 0.65 % to 0.57 % in integrated treatments (T_6 to T_{12}). The available N in soil was significantly higher in organic treatments than integrated treatments. The available phosphorous was decreased in organic treatments compared to integrated treatments. The available potash recorded higher status in integrated nutrient modules compared to organic modules except T_1, T_4 and T_5 (Table 4).

The combined application of inorganic fertilizer and bio-fertilizers in banana significantly increased the available NPK status and organic C in soil after harvest (Hazarika *et al.*, 2011). The integrated use of organics with 100 % recommended dose of NPK (P as rock phosphate) along with bio-fertilizers increased nitrogen, phosphorus and potassium concentration availability in soil after harvest in banana (Hazarika *et al.*, 2015). The results of the present study were in line with Hazarika *et al.*, (2011). They reported that, the least pH was recorded in soils where the plants applied with 100 % RDF + Vermicompost (4.69) and the highest organic carbon 0.85 %, available nitrogen 296.64 (kg/ha), available P_2O_5 37.33 (kg/ha) and available K_2O 223.66 (kg/ha).

The results of the present study also indicated increase in available nitrogen status in organic nutrient modules (Angelova *et al.*, 2013). However, in integrated nutrient modules the nitrogen status was found to decline. This may be attributed to the higher uptake of nutrients resulted in higher yields in integrated treatments as compared to organic treatments.

Available phosphorus decreased due to application of organics to soil (Angelova *et al.*, 2013). This indicates that, the application of organic nutrient modules would reduce the available phosphorous as found in the present study. The combined application of vermicompost with NPK fertilizers resulted in higher content of phosphorous as compared to FYM in combination with NPK fertilizers or control. Higher levels of available phosphorous in the treatments which received either vermicompost or FYM in combination with chemical fertilizers than control. Similar results were also recorded in the present study where integrated nutrient modules were imposed compared to organic nutrient modules

(Mariangela Diacono and Francesco Montemurro, 2010). The integrated nutrient module would maintain the available potash or might increase as compared to the organic nutrient treatment which was confirmed with the present study results.

Application of recommended dose of nitrogen in integrated manner would be a better nutrient module. 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 (sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T_7) was most superior in increasing growth and yield parameters of banana besides reducing the crop duration followed by T_{10} (Agri-gold combination) and T_{11} (Bhumilabh combination) indicating the potentiality of organic manures when used in conjunction with chemical and bio- fertilizers.. The integrated nutrient modules favoured higher availability of soil nutrients which enhanced nutrient concentrations of NPK in different plant parts of banana and in turn the yield.

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