

Original Research Article

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## Effect of Integrated Nutrient Modules on Growth, Yield and Available Plant Nutrients in Banana cv. Grand Naine

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### ABSTRACT

#### Keywords

Banana cv. Grand Naine, Nutrient module, INM, Growth and yield parameters

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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)” through application of different combination of organic and inorganic manures with green manure, *Azospirillum* and PSB. The results indicated that, application of plants 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) recorded the highest growth parameters [pseudostem height (205.05cm), pseudostem girth (27.47cm), number of leaves (16.00), 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 yield per ha (66.02 t)] and the NPK contents in banana leaf, fruit and pseudostem at harvest (3.25%, 0.32% and 2.87 % in leaf, 3.27%, 0.32% and 3.15% in fruit and 3.43%, 0.34% and 3.02% in pseudo stem respectively) followed by T10 and T11 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 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

T<sub>1</sub>. 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<sub>2</sub> –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<sub>3</sub>. 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<sub>4</sub>. 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<sub>5</sub>. 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<sub>6</sub>. 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<sub>7</sub>. VC equivalent to 40% RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40% RDN + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha).

T<sub>8</sub>. PM equivalent to 40% RDN (8.96 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40% RDN + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha).

T<sub>9</sub>. SM equivalent to 40% RDN (10.17 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40% RDN + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha).

T<sub>10</sub>. AG equivalent to 40% RDN (10.52 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40% RDN + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha)

T<sub>11</sub>. BL equivalent to 40% RDN (7.56 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40% RDN + GM (Sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20% RDN + PSB (30.86 kg/ha)

T<sub>12</sub> -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**

The Nitrogen equivalent to 100 % RDN (100 g/plant or 308.60 kg/ha) was supplied through various organic amendments viz., FYM / VC / PM / SM / AG / BL + GM (Sunnhemp @ 8.88 t/ha) + *Azospirillum* (30.86 kg/ha) + PSB (30.86 kg/ha) from T<sub>1</sub> to T<sub>5</sub>.

The Nitrogen equivalent to 60 % RDN was supplied through various organic amendments viz., FYM / VC / PM / SM / AG / BL + GM (Sunnhemp @ 8.88 t/ha) + *Azospirillum* (30.86 kg/ha) + PSB (30.86 kg/ha) and the remaining 40 % RDN was supplied through chemical fertilizers (Urea) from T<sub>6</sub> to T<sub>11</sub>.

T<sub>12</sub> : Control (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 plant nutrition thereby increase the productivity of banana cv. Grand Naine. The influence of integrated nutrient management on growth, yield and nutrient content of plant and the results were subjected to RCBD analysis (Fisher and Yates, 1963). The results of the pooled mean

of the field experiments conducted during the year 2014-15 and 2015-16 are discussed.

### **Results and Discussion**

The results of the pooled mean of the field experiments conducted during the year 2014-15 and 2015-16 are presented 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 pooled mean indicated that, at shooting the highest plant height (205.05 cm) was recorded in T<sub>7</sub> {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + 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<sub>6</sub>, T<sub>10</sub> and T<sub>11</sub> and significantly superior over rest of the treatments. The least pseudostem height was recorded in T<sub>8</sub> (171.53 cm) followed by T<sub>3</sub>. The pseudostem girth was significantly higher with T<sub>7</sub> treatment (27.47 cm) followed by T<sub>9</sub> which was on par with T<sub>1</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub>, T<sub>9</sub>, T<sub>10</sub>, T<sub>11</sub> and T<sub>12</sub> treatments and the least pseudostem girth (24.99 cm) was recorded in plants treated with T<sub>8</sub> treatment.

The highest number of leaves (16.00) was recorded in T<sub>7</sub> {Vermicompost equivalent to 40 % of RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + 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 which was significantly superior over all other

treatments except T<sub>3</sub> and T<sub>8</sub>. The least number of leaves (13.24) was recorded in T<sub>8</sub>. The application of Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + Green manure (sunnhemp @ 8.88 tons/ha) + *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T<sub>7</sub>) recorded significantly higher leaf area (8.87 m<sup>2</sup>) followed by T<sub>1</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>9</sub>, T<sub>10</sub> and T<sub>11</sub>. The integrated nutrient modules recorded the higher leaf area except T<sub>8</sub> as compared to organic nutrient modules. The pooled data indicated that, the highest leaf area index (2.74) at shooting was recorded in T<sub>7</sub> which was on par with T<sub>1</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>9</sub>, T<sub>10</sub> and T<sub>11</sub> 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<sub>7</sub> {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + 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<sub>7</sub> (Vermicompost combination), T<sub>10</sub> (Agrigold combination) and T<sub>11</sub> (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) opined 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<sub>7</sub> (Vermicompost combination), followed by T<sub>10</sub> (Agri-gold combination) and T<sub>11</sub> (Bhumilabh combination) were found to be most promising in obtaining higher growth parameters of banana.

### **Effect 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<sub>7</sub> {Vermicompost equivalent to 40 % RDN (24.20 t/ha) + Chemical fertilizer (Urea 535.73 kg/ ha) equivalent to 40 % RDN + 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<sub>1</sub>, T<sub>10</sub> and T<sub>11</sub> and significantly superior over rest of the treatments (Table 3). The highest mean yield of banana in T<sub>7</sub> 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 (sunnhemp @ 8.88 t/ha) and *Azospirillum* (30.86 kg/ha) equivalent to 20 % RDN + PSB (30.86 kg/ha) (T<sub>7</sub>).

**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 <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	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 <sub>4</sub>	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 <sub>5</sub>	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 <sub>6</sub>	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 <sub>7</sub>	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 <sub>8</sub>	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 <sub>9</sub>	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 <sub>10</sub>	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 <sub>11</sub>	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 <sub>12</sub>	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
S Em+/-	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<sub>1</sub> 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).

T<sub>2</sub> 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).

T<sub>3</sub> 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).

T<sub>4</sub> 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).

T<sub>5</sub> 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).

T<sub>6</sub> 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).

T<sub>7</sub> 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).

T<sub>8</sub> 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).

T<sub>9</sub> 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).

T<sub>10</sub> 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).

T<sub>11</sub> 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).

T<sub>12</sub> -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 <sup>2</sup> )					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 <sub>1</sub>	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 <sub>2</sub>	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 <sub>3</sub>	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 <sub>4</sub>	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 <sub>5</sub>	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 <sub>6</sub>	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 <sub>7</sub>	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 <sub>8</sub>	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 <sub>9</sub>	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 <sub>10</sub>	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 <sub>11</sub>	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 <sub>12</sub>	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<sub>1</sub>- 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<sub>2</sub>- 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<sub>3</sub>- 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<sub>4</sub>- 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<sub>5</sub>- 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<sub>6</sub>- 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<sub>7</sub>- 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<sub>8</sub>- 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<sub>9</sub>- 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<sub>10</sub>- 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<sub>11</sub>- 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<sub>12</sub>-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 <sup>rd</sup> hand	Plot yield (kg)	Yield (t/ha)
T <sub>1</sub>	18.17	10.06	124.27	16.14	14.89	73.21	56.48
T <sub>2</sub>	14.58	9.10	117.77	15.23	13.88	60.44	46.63
T <sub>3</sub>	11.55	8.58	104.28	14.36	13.10	58.35	45.02
T <sub>4</sub>	17.85	10.31	123.43	15.32	14.26	72.72	56.10
T <sub>5</sub>	16.41	9.73	120.39	15.55	14.19	70.04	54.04
T <sub>6</sub>	19.18	10.02	129.53	16.12	15.02	70.52	54.40
T <sub>7</sub>	26.94	11.75	137.38	17.75	16.93	85.57	66.02
T <sub>8</sub>	12.85	9.54	104.43	14.40	13.09	61.69	47.59
T <sub>9</sub>	19.54	10.19	129.83	16.12	15.04	70.83	54.64
T <sub>10</sub>	23.69	10.98	135.91	17.18	16.12	84.27	65.01
T <sub>11</sub>	22.51	10.49	135.16	17.07	16.14	73.66	56.83
T <sub>12</sub>	19.17	9.70	128.02	16.66	15.68	71.21	54.94
<b>S Em+/-</b>	0.65	0.15	1.84	0.31	0.30	4.28	3.30
<b>CD at 5%</b>	1.91	0.44	5.39	0.90	0.87	12.55	9.68

T<sub>1</sub>. 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<sub>2</sub>-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<sub>3</sub>. 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<sub>4</sub>. 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<sub>5</sub>. 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<sub>6</sub> 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<sub>7</sub>. 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<sub>8</sub>. 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<sub>9</sub>. 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<sub>10</sub>. 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<sub>11</sub>. 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<sub>12</sub> -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 nutrient concentration (%) in banana cv. Grand Naine (Pooled mean)

Treatments	Leaf			Fruit			Stem		
	N	P	K	N	P	K	N	P	K
T <sub>1</sub>	2.57	0.24	2.33	2.67	0.25	2.55	2.81	0.24	2.64
T <sub>2</sub>	2.30	0.23	2.21	2.13	0.23	2.43	2.22	0.25	2.46
T <sub>3</sub>	2.26	0.21	2.14	1.64	0.22	2.43	1.72	0.24	2.41
T <sub>4</sub>	2.55	0.23	2.29	2.31	0.23	2.52	2.43	0.25	2.59
T <sub>5</sub>	2.45	0.23	2.24	2.32	0.23	2.44	2.41	0.24	2.51
T <sub>6</sub>	3.01	0.28	2.48	3.06	0.29	2.73	3.18	0.30	2.83
T <sub>7</sub>	3.25	0.32	2.87	3.27	0.32	3.22	3.43	0.34	3.32
T <sub>8</sub>	2.09	0.20	2.04	1.60	0.20	2.27	1.69	0.21	2.24
T <sub>9</sub>	2.95	0.25	2.42	2.67	0.25	2.70	2.81	0.27	2.73
T <sub>10</sub>	3.23	0.30	2.75	3.31	0.30	3.03	3.42	0.32	3.15
T <sub>11</sub>	3.07	0.29	2.62	3.11	0.30	2.91	3.25	0.32	3.00
T <sub>12</sub>	2.96	0.25	2.47	2.98	0.25	2.77	3.12	0.27	2.79
S. Em.±	0.02	0.01	0.01	0.01	0.01	0.05	0.02	0.01	0.04
C.D. at 5%	0.05	0.04	0.04	0.04	0.03	0.15	0.06	0.04	0.12

T<sub>1</sub>. 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<sub>2</sub>-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<sub>3</sub>. 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<sub>4</sub>. 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<sub>5</sub>. 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<sub>6</sub> 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<sub>7</sub>. 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<sub>8</sub>. 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<sub>9</sub>. 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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 T<sub>11</sub>. 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<sub>12</sub> -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



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), fingers /hand (19.00), fingers/bunch (227.94) and the yield (148.41 t/ha) in banana followed by 2.5 kg Sheep manure + 108:108:2205g NPK /plant/year. 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 higher 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.

#### **Effect of integrated nutrient modules on nutrient content in different plant parts of banana (Table 4)**

The pooled data indicated that the highest leaf nitrogen was recorded in T<sub>7</sub> (3.25 %) which was significantly superior over rest of the treatments. The phosphorous content in leaf was highest in T<sub>7</sub> (0.32 %) which was on par with T<sub>6</sub>, T<sub>10</sub> and T<sub>11</sub> and significantly superior over rest of the treatments. The higher potash content in leaf was recorded in T<sub>7</sub> treatment (2.87 %) which was significantly superior over rest of the treatments. The organic treatments recorded comparatively low nitrogen and phosphorous content in leaf compared to integrated nutrient modules.

The pooled data indicated that the highest nitrogen in fruit was recorded in T<sub>10</sub> (3.31%) which was on par with T<sub>7</sub> (3.27 %) followed by T<sub>11</sub> (3.11 %). The phosphorous content in fruit was highest in T<sub>7</sub> (0.32 %) which was on par with T<sub>10</sub> and T<sub>11</sub> and significantly superior over rest of the treatments. The higher potash content in fruit was recorded in T<sub>7</sub> treatment (3.22 %) which was significantly superior over rest of the treatments. The organic treatments recorded comparatively low nitrogen, phosphorous and potash contents in fruit compared to integrated nutrient modules.

The pooled data indicated that the highest nitrogen in stem was recorded in T<sub>7</sub> (3.43 %) which was significantly superior over rest of the treatments. The phosphorous content in stem was highest in T<sub>7</sub> (0.34 %) which was on par with T<sub>10</sub>, T<sub>11</sub> and T<sub>6</sub> and significantly superior over rest of the treatments. The higher potash content in stem was recorded in T<sub>7</sub> treatment (3.32 %) which was significantly superior over rest of the treatments (Table 2). The integrated nutrient modules recorded the superior nitrogen, phosphorous and potash contents in stem compared to organic treatments.

Among the different plant parts, the nitrogen, phosphorous and potash content of pseudostem was higher compared to leaf and fruit in all the treatments.

The present study results were in line with the results reported by Ansari and Hazarika (2009). They opined that, 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 in banana plant.

The integrated nutrient modules favoured higher growth, yield parameters and nutrient concentrations of NPK in different parts of banana which in turn increased bunch yield. Therefore the higher yield per hectare was obtained in T7 (with Vermicompost combination) 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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