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Effect of integrated plant nutrient management on yield and economics of banana (*Musa paradisiaca*)

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ABSTRACT

Field experiment was conducted during 2010-11 and 2011-12 at tribal farmer's field at Jambughora taluka of Panchmahal district of Gujarat to study the effect of integrated plant nutrient management on yield and economics of banana (*Musa paradisiaca* L.) under semiarid irrigated conditions. The results of study revealed that the application of 75% RDF of NPK+ FYM (15 kg/ plant) + neem cake (1.0 kg/plant) + bio-fertilizer (*Azosprillum* and PSB each @ 20 g/plant), recorded the maximum number of hands (10.60 and 11.90), number of fingers (142.90 and 147.90), bunch weight (25.90 and 26.6 kg/plant) and total yield (78.90 and 79.80 tonnes/ha) during both the years of experimentation, respectively. Similarly, net income (₹ 276500 and 279750) and B: C ratio (3.30 and 3.30) was recorded maximum in same treatment, i. e. T7 (75% RDF of NPK+ FYM@ 15 kg/ plant+ neem cake @ 1.0 kg/plant + bio-fertilizer) during both the years of experimentation under semiarid irrigated condition of western India.

Key words: Banana, BiofertiIizers, Chemical fertilizers, Farmyard manure (FYM), Neem cake

Banana (*Musa paradisiaca* L.) is mainly produced in tropical and sub-tropical regions of the world and recognized as the fourth most important food in terms of gross value after paddy, wheat and milk products. Banana is a cheap source of energy and vitamins like A, C, B_6 and other minerals with traces of fat. Banana production in India is 27.0 m tonnes from an area of 0.77 m ha with the productivity of 34.40 tonnes. The major banana growing states in India are Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar and West Bengal (Anon. 2013). In order to enhance the production and productivity, it requires judicious applications of nutrients because of its rapid growth, adventitious root systems and short life space. It is estimated that 50 tonnes of banana in one ha removes 320 kg N, 32 kg P_2O_5 and 925 kg K_2O every year (Lahav and Turner 1983). Though, the application of inorganic fertilizers increases the yield substantially, but could not sustain the fertility status of the soil (Bharadwaj and Omanwar 1994) and has caused several undesirable consequences in the fragile agro climatic condition, leading to gradual decline in productivity.

Considering the present situation of soil quality and environmental security, it becomes important to go for integrated plant nutrient management, involving various sources of organic manures and bio-fertilizers besides using chemical fertilizers in banana.

Integrated plant nutrient management (IPNM) found to be beneficial for maintenance of soil fertility and plant nutrient supply to optimum level for sustaining desired crop productivity through optimization of benefits from all possible sources of plant nutrients in integrated manner. The basic principle of IPNM is the maintenance of soil fertility, sustainable agricultural productivity and improving farmer's profitability through judicious and efficient use of organic manure, green manure, bio-fertilizers, chemical fertilizers, etc. Conjunctive use of FYM with recommended levels of inorganic fertilizers improves the soil fertility with increased yield of the crop. Grand Naine is a important variety due to excellent fruit quality, immunity to *Fusarium* wilt etc (Singh and Chundawat 2002). However, its requirement of nutrients through organic sources along with inorganic fertilizers is not well documented. Keeping these aspects in view, the present investigation was carried out to find out the suitable combination of organic, inorganic and bio-fertilizers for enhanced and sustainable production under semiarid conditions of western India.

MATERIALS AND METHODS

The experiment was conducted during 2010-11 and 2011-12 at tribal farmer's field Jambughora taluka, Panchmahal district, Gujarat under irrigated conditions. Throughout the experiment, the mean annual rainfall was 638.8 mm and 763.8 mm during first and second year, respectively. The soil of the different farmers field was medium black, having pH 7.42 to 8.20, electrical

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conductivity (EC) 0.31 to 0.35 dS/m, low in organic carbon (0.28 to 4.6 %), low in available nitrogen (191 to 205 kg/ha), phosphorus (13.6 to 17.5 kg/ha) and potassium (441 to 480 kg/ha) for 2010-11 and 2011-12, respectively. The plantation of Grand Naine was done in *kharif* season for first year in randomized block design comprising seven treatments replicated thrice. The field was uniformly leveled and the pits were dug out to a dimension of 45×45×30 cm at 1.8m×1.8m spacing (3 086 plants/ha). The treatment details were as follows: T_1 control, T_2 50% recommended dose of NPK, T_3 75% recommended dose of NPK, T_4 100 % recommended dose of NPK, T_5 50% recommended dose of NPK + FYM@ 15 kg/plant, T_6 75% recommended dose of NPK+ FYM@ 15 kg/plant + neem cake @ 1.0 kg/plant, T_7 75% recommended dose of NPK+ FYM@ 15 kg/plant + neem cake @ 1.0 kg/plant + bio-fertilizer (*Azosprillum* and PSB @ 20 g/plant each at the time of planting). Recommended fertilizer dose of 200:40:200 g of N, P_2O_5 and K_2O per plant was applied during both the years. Out of 200 g N, 3/4th N was applied in 4 equal splits in vegetative phase at 30, 60, 120 and 150 days after planting and remaining 1/4th N in 3 equal splits in reproductive phase at 200, 245 and 300 days after planting. Total quantity of phosphate was applied at the time of planting while potash was applied in 4 equal splits at planting, 150, 245 and 300 days after planting. Bio-fertilizers, i.e. *Azospirillum* and PSB @ 20 g each/plant were applied in the soil at the time of planting during both the years of experimentation. The data were statistically analyzed as advocated by Gomez and Gomez (2010). Soil samples were analysed for pH and EC in 1:2.5 soil suspension ratio, organic carbon was determined by digestion, micro Kjeldhal distillation and titration following the standard methodology in a kjeldhal-N analyzer system and multiplying with a conversion factor of 6.24 by Nelson and Sommers (1982). The phosphorus content was estimated by phospho-molybdic blue color method (Jackson 1973). The potassium content was estimated in a flame photometer using neutral 1N NH_4OAC as extracting. Different organic sources were analyzed for their total NPK content by using methods given by Tondon (1993).

RESULTS AND DISCUSSION

Yield parameters

Results of study on yield and yield attributes characters revealed the significant effect of integrated nutrient management practices on production and productivity of Banana Grand Naine. An application of 75% recommended dose of NPK (150 g N, 30 g P_2O_5 and 150 g K_2O kg/plant) with 15 kg FYM +1.0 kg neem cake/plant and bio-fertilizers *(Azosprillum* and PSB @ 20 g/plant each at the time of planting) (T_7) recorded the maximum bunch weight, number of hands and fingers/bunch and total yield (Table 1). During 2010-11 and 2011-12, the highest bunch weight (25.9 and 26.6 kg/plant), number of hands (10.6 and 11.9) and fingers (142.9 and 147.9/bunch), finger weight (188.0 and 192.1 g) and maximum yield (78.9 and 79.9 tonnes/ha) were recorded with the same treatment. However, bunch weight was comparable with T_6 (25.3 kg/plant), T_4 (24.8 kg) and T_5 (23.7 kg) during 2010-11 and with T_6 (25.9 kg/plant), T_4 (25.4 kg), and T_5 (24.1 kg) during 2011-12. Similarly, total yield was on par with T_6 (72.1 tonnes/ha), T_4 (68.9 tonnes/ha), and T_5 (65.7 tonnes/ha) during first year and T_6 (73.1 tonnes/ha), T_4 (69.1 tonnes/ha), and T_5 (66.2 tonnes/ha) during second year. Kuttimani *et al*. (2013) reported plant height, pseudostem girth, minimum days for harvesting, increased number of hands/bunch and bunch weight/plant due to use of organics in integrated manner with inorganic fertilizers. Sukhada (1996) reported significant yield increase in banana by using PSB and *Azospirillum brasilense.*

The increment of yield owing to the application of 75 per cent recommended dose of NPK (150 g N, 30 g P_2O_5

Table 1 Effect of integrated plant nutrient management on yield parameters of banana

Treatment	2010-11					2011-12				
	Bunch weight (kg/plant)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)	Bunch weight (kg/ plant)	Number of hands/ bunch	Total no. of fingers/ bunch	Finger weight (g)	Yield (t/ha)
T_1	18.6	8.6	122.3	138.3	51.8	19.1	9.1	126.4	131.2	54.2
T_2	21.5	9.3	129.0	146.3	62.7	21.8	10.2	131.5	136.4	64.4
T_3	22.3	9.8	135.2	149.2	66.1	22.7	10.8	138.2	145.9	66.9
T_4	24.8	10.0	137.3	179.0	68.9	25.4	10.9	144.8	184.6	69.1
T_5	23.7	9.9	138.0	168.3	65.7	24.1	10.7	139.7	171.2	66.2
T_6	25.3	10.4	141.5	186.3	72.1	25.9	11.5	142.8	178.6	73.1
T_7	25.9	10.6	142.9	188.0	78.9	26.6	11.9	147.9	192.1	79.9
SEd	0.32	0.21	0.78	0.54	0.23	0.33	0.19	0.67	0.70	0.56
CD(P=0.05)	0.67	0.45	1.66	1.16	0.52	0.73	0.43	1.47	1.47	1.18

T_1 (Control), T_2 (50% RDF of NPK), T_3 (75% RDF of NPK), T_4 (100 % RDF of NPK), T_5 (50% RDF of NPK + FYM@ 15 kg/ plant), T_6 (75% RDF of NPK+ FYM@ 15 kg/ plant + neem cake @ 1.0 kg/plant), T_7 (75% RDF of NPK+ FYM@ 15 kg/ plant+ neem cake @ 1.0 kg/plant + bio-fertilizer).

and 150 g K_2O kg/plant) with 15 kg FYM +1.0 kg neem cake/plant and bio-fertilizers *(Azosprillum* and PSB @ 20 g/plant each at the time of planting) was 34.34 and 32.19% as compared to control. Similarly, application of 75 per cent recommended dose of NPK (150 g N, 30 g P_2O_5 and 150 g K_2O kg/plant) with 15 kg FYM +1.0 kg neem cake/plant registered 32.8 and 30.6 % higher yield over control during 2010-11 and 2011-12, respectively. Higher yield response owing to application of organics ascribed to improve physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which in turn led to good crop growth and yield. Humus substance present in organic product could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. These products would help the better availability and utilization of nutrients. All these positive effect might have facilitated quick mobilization and availability of nutrients that would aid in increased plant height, number of leaves, leaf area, leaf area index and photosynthetic rate. This in turn would have assisted for the increased yield of banana. This is in confirmation with the findings of Patel *et al*. (2010) in banana.

Economics

The mean data on cost of cultivation (₹/ha), gross return (₹/ha), net return (₹/ha) and benefit- cost (B: C) ratio is presented in Table 2. Higher gross returns of ₹ 394 500 and ₹ 399 500 were recorded during 2010-11 and 2011-12 respectively with the application of 75 per cent recommended dose of NPK (150 g N, 30 g P_2O_5 and 150 g K_2O kg/plant) with 15 kg FYM +1.0 kg neem cake/ plant and bio-fertilizers *(Azosprillum* and PSB @ 20 g per plant (T_7) followed by 100% recommended dose of fertilizer (T_4) (₹ 344 500 and ₹ 345 500) during 2010-11 and 2011-12 respectively and the lowest gross return was obtained in control (₹ 259 000 and ₹ 271 000) during both the years, respectively followed by T_4, T_6 and T_5 treatments.

During both the years of the study, the net return was higher (₹ 276 500 and ₹ 279 750) with the application of 75% recommended dose of NPK (150 g N, 30 g P_2O_5 and 150 g K_2O kg/plant) with 15 kg FYM +1.0 kg neem cake/ plant and bio-fertilizers *(Azosprillum* and PSB @ 20 g/plant (T_7) followed by 100% RDF (T_4) however the minimum net return of ₹ 150 923 and ₹ 159 923 was obtained with control (T_1) during 2010-11 and 2011-12 respectively followed by T_4, T_6, T_5 and T_3 during both the years.

Benefit-cost ratio

The benefit-cost ratio was computed the highest (3.3) with 75% RDF of NPK+ FYM@ 15 kg/ plant+ neem cake @ 1.0 kg/plant + bio-fertilizer (T_7) followed by T_4, T_6 and T_5 during 2010-11. During 2011-12, the same treatments (T_7) recorded the maximum benefit-cost ratio (3.3) followed by T_4 and T_6. The lowest benefit-cost ratio was recorded 2.4 and 2.4 during 2010-11 and 2011-12 respectively control (T_1).

Efficacy of different fertilizer treatments was worked out by computing the gross and net returns and benefit cost ratio. Application of 75% recommended dose of fertilizer along with + FYM@ 15 kg/ plant+ neem cake @ 1.0 kg/ plant + bio-fertilizer resulted in higher yield which was reflected in terms of bunch weight yield/ha resulting in higher gross return. When the net profit and benefit-cost ratio were considered application of 100% RDF along with FYM@ 15 kg/ plant+ neem cake @ 1.0 kg/plant + bio-fertilizer the maximum net profit with a high benefit-cost ratio during both the years.

Soil chemical properties

The pH and electrical conductivity after harvest of banana were found to decrease slightly in the treatments wherever organics were used. However, organic carbon content and soil available N, P, K were maintained / improved in almost all treatments where organics were used (Table 3). The similar findings are also reported by Barakat *et al.* (2011) in banana.

Nutrient uptake

In general, 6.37 to 6.97 kg N, 1.25 to 1.51 kg P and 13.73 to 14.37 kg K were required to produce one tonne of banana. Uptake of NPK kg/ha and kg/tonne was reduced

Table 2 Effect of integrated nutrient management on economics of banana cultivation

Treatment	2010-11					211-12				
	Cost of cultivation (₹/ha)	Yield (t/ha)	Gross income (₹/ha)	Net income (₹/ha)	B: C ratio	Cost of cultivation (₹/ha)	Yield (t/ha)	Gross income (₹/ha)	Net income (₹/ha)	B: C ratio
T_1	108077	51.8	259000	150923	2.4	111077	54.2	271000	159923	2.4
T_2	109597	62.7	313500	203903	2.9	111597	64.4	322000	210403	2.8
T_3	112847	66.1	330500	217703	2.9	113847	66.9	334500	220653	2.9
T_4	116242	68.9	344500	228258	3.0	116242	69.1	345500	229258	3.0
T_5	114542	65.7	328500	213958	2.8	115942	66.2	331000	215058	2.8
T_6	117977	72.1	360500	242523	3.0	117677	73.1	365500	247823	3.1
T_7	118000	78.9	394500	276500	3.3	119750	79.9	399500	279750	3.3

Cost of fertilizers and organics: N = ₹ 12/kg, P_2O_5 = ₹ 21/kg, K_2O = ₹ 8/kg, FYM = ₹ 500/tonne, `Neem cake = ₹ 7000/tonne, Selling rate of banana = ₹ 5000/tonne

Table 3 Effect of integrated plant nutrient management on soil chemical properties of Grand Naine banana (Av. of 2 years) after harvesting.

Treatment	pH	EC (dS/m)	Organic carbon (%)	Average nutrients (kg/ha)		
				N	P_2O_5	K_2O
T_1	8.30	0.34	0.27	209	18.5	520
T_2	8.13	0.34	0.32	211	20.6	519
T_3	8.10	0.31	0.35	216	19.2	523
T_4	8.18	0.27	0.48	221	21.8	531
T_5	8.15	0.32	0.30	211	19.4	519
T_6	8.08	0.29	0.34	219	20.4	523
T_7	8.01	0.25	0.46	231	19.5	533
SEd	0.08	0.008	0.018	2.73	0.18	4.79
CD(P=0.05)	0.17	0.018	0.04	5.96	0.40	10.43

Table 4 Effect of integrated plant nutrient management on nutrient uptake by Grand Naine banana (Av. of 2 years)

Treatment	2010-11 (kg/ha)			2011-12 (kg/tonne)		
	N	P	K	N	P	K
T_1	455	91	1009	6.58	1.40	13.98
T_2	435	83	938	6.42	1.27	13.73
T_3	409	75	845	6.48	1.25	13.77
T_4	449	89	965	6.44	1.33	13.85
T_5	444	81	918	6.37	1.27	13.79
T_6	385	69	815	6.41	1.31	13.86
T_7	485	98	1089	6.97	1.51	14.37
SEd	3.72	4.81	4.06	0.03	0.02	0.05
CD(P=0.05)	8.12	10.48	8.84	0.08	0.04	0.12

as the percentage of inorganic fertilizers was reduced and percentage of organic was increased. Highest uptake kg/ha and kg/tons was obtained in the treatment where 75 % recommended dose of NPK with 15 kg FYM per plant and bio-fertilizers were applied (Table 4). The similar findings are also reported by Bhalerao *et al.* (2009) and Hazarika and Ansari (2010) in banana.

Results of study in the Grand Naine banana influnces by various combination of organic and inorganic sources of nutrients revealed that combined application of 75 % recommended dose of NPK with 15 kg FYM/plant and bio-fertilizers *(Azosprillum* and PSB @ 20 g per plant each at the time of planting) positively influenced the yield attributes along with economics considering the yield of banana. It is revealed from the study that application of 75 % recommended dose of NPK along with 15 kg FYM/plant and bio-fertilizers can be a viable practice for sustainable banana production. 75% RDF along with 15 kg FYM per plant and bio-fertilizers also responded well and recorded high B: C ratio with less quantity of input. Hence, the integrated nutrient management practice, 75% recommended dose of fertilizer combined with 15 kg FYM/plant and bio-fertilizers in banana crop, has been found to be an ideal option to improve yield besides being economically competitive and productive under the soil and climatic conditions of western India.

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