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Effect of Integrated Nitrogen Management on Growth and Yield of Banana on Inceptisol

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Abstract

Effect of integrated nitrogen management on growth and yield of banana on Inceptisol soil was studied by conducting an experiment at Post Graduate Institute Farm of Mahatma Phule Agricultural University, Dist: Ahmednagar. An experiment was laid out with ten nitrogen substitution treatments through FYM, neem cake and vermicompost in different proportions (25%, 50% and equal nitrogen from these sources) replicated thrice in randomized block design. The recommended dose of banana as 200:40:200g plant^{-1} with seven splits of nitrogen and basal application P_2O_5 and K_2O at planting was carried out for this experiment. The number of functional leaves up to 180 DAP were not significantly influenced by integrated nitrogen management treatments but at later growth stages, substitution of nitrogen either @ 25 or 50% through FYM recorded higher number of functional leaves throughout crop duration period. Application of 50% N: FYM + 50% N: RDF recorded significantly highest pseudostem height while substitution @ 25% N through FYM along with 75% N: RDF recorded significantly higher psedostem girth and leaf area index of banana. Nitrogen substation @ 25% either through FYM, neem cake or vermicompost induced early shooting (flowering) of banana by 14 to 18 days. However, application of 50% N: through neem cake +50% N: RDF recorded significantly less duration from shooting to harvest or for bunch development of banana. Significantly higher yield of banana was recorded with the application of 25% N through FYM along with 75% N: RDF than rest of the treatments.

Keywords: Banana; Nitrogen; FYM; Neem cake; Vermicompost; Growth and yield

Abbreviations: INM: Integrated Nutrient Management; RBD: Randomized Block Design; LAI: Leaf Area Index

Introduction

Integrated nutrient management (INM) system has now assumed great importance firstly because of the present negative nutrient balance and secondly neither the chemical fertilizers alone nor organic sources can achieve the production sustainability of soils as well as crops under highly intensive cropping systems. Integrated and balanced fertilization is the key to enhance nutrient use efficiency of applied nutrients. The meaning of integrated fertilization is embedded in the concept of balanced fertilization because if it is fertilizer and (+) manure, then it is complementary use, but integration is a function of all the factors involved. Conceptually, balanced fertilization would essentially mean rational use of fertilizers and organic manures for supply of plant nutrients in such a manner that would ensure:

a. Efficiency of fertilization.

b. Harnessing best possible positive and synergistic interactions among various other factors of production (seed, water etc).

c. Least adverse effects on environment (leaching, denitrification etc).

d. Minimum nutrient losses.

e. Maintaining high yields commensurate with the biological potential of all the crop variety under the unique soil-climate-agro-ecological set up [1]. Nitrogen is unique among the major nutrients as it originated from the atmosphere and its transformations and transport in the pedosphere and hydrosphere are mediated almost entirely by biological processes.

Nitrogen undergoes various transformation processes in soil. Nitrogen can escape in atmosphere through volatilization, denitrification, leaching from soil-plant system to water bodies causing pollution. The main loss pathways are:

a. Leaching dominantly as NO^3 but also occasionally NH_3 and soluble organic N

b. Dentrification as N_2O, NO and N_2.

c. NH_3 volatilization.

Banana being an exhaustive crops, it is paramount to maintain high degree of soil fertility to ensure high yield of superior quality fruits. Banana is a shallow feeder as it removes substantial amount of nitrogen (300-450kgha^{-1}), phosphorus (50-60kgha^{-1}) and potassium (350-450kgha^{-1}). Banana is of important fruit crop whose growth and productivity are greatly influenced by nitrogen and soil moisture. The choice of fertilizer along with manure, their doses and time of application varies widely with respect to soil type, genotype and agro-climatic region. The growth of banana is positively correlated with yield. [2]. India is the largest producer of banana in the world contributing about 20.54 per cent to the global production. Banana contributes 37 per cent of the total fruit production in India. Southern parts of India are leading in banana production due to presence of suitable conditions. Maharashtra is the second leading state in country after Tamil Nadu with 0.73 lack hectare area, 4.61 million tomes production and productivity ranging from 13.5 to 62.97t ha^{-1} Babu and Sharma [3]. Apart from the availability of genetically high yield potential verities, the lower productivity of banana is the major issue in many parts of Maharashtra. The soil moisture availability, imbalanced fertilization and its management and disease pest infestation are the major reasons for lower productivity in Jalgaon, Dhule, Nandurbar districts of North and Nanded, Parbhani and Hingoli districts of Marathwada region. Therefore, to assess the location wise available manure sources for the substitution of nitrogen with its feasible proportion this experiment was conducted on Inceptisol soils.

Material and Methods

The present investigations were carried out to assess the 'effect of integrated nitrogen management on growth and yield of banana on Inceptisol by conducting a field experiment at Post Graduate Institute, Department of Soil Science & Agricultural Chemistry, Mahatma Phule Krishi Agricultural University, Rahuri during 2005-06. Agro-climatically, the area falls under scarcity zone of Maharashtra with annual average rainfall of 520mm. The soil of experimental area was Inceptisol order belonging to Pather (Sawargaon) soil series and Vertic Haplustepts family. The experimental plot with medium black clay soil having uniform level and texture was clayee with 20.38% coarse sand, 27.80% silt and 51.40% clay with medium depth. The soil is calcareous (free $CaCO_3$: 12.58%) in nature with alkaline pH: 8.68, EC: 0.17 d Sm^{-1} and organic carbon: 0.66%. The alkaline $KMnO_4$-N, Olsen's P and NH_4OAC-K in the experimental soil was 163.70, 15.28 and 571.20kg ha^{-1} respectively.

Table 1: Treatment details.

Treatment	Details
1	RDF (200:40:200g plant^{-1} N, P_2O_5 & K_2O)
2	25% N: FYM + 75% N RDF
3	25% N: Neem cake + 75% N: RDF
4	25% N: Vermicompost + 75% N: RDF
5	50% N: FYM + 50% N: RDF
6	50% N: Neem cake + 50% N: RDF
7	50% N: Vermicompost + 50% N: RDF
8	Fertilizers as per soil test
9	33% N: FYM + 33% Neem cake + 33% N: VC
10	25% N: FYM + 25% N: Neem cake + 25% N: Vermicompost + 25% N: RDF

The experiment was carried out in Randomized Block Design (RBD) with ten integrated nitrogen management treatments replicated thrice with 147 plants under each treatment. The details of treatment are mentioned in Table 1. The tissue cultured (60 days hardened) banana plantlets of variety Grand nine were planted at a spacing of 1.5 X 1.5m. There were total 30 plots each having area of 110.25m^2 comprising 49 plants per plot. Each plot of individual treatment was confined with strong bunds from all the sides to avoid the mixing of manures and fertilizers. The shevri was sown immediately after the plantation of banana along with the South-North and West direction of experimental field as wind break. The recommended dose of banana as 200:40:200 g plant-1 with seven splits of nitrogen and basal application P_2O_5 and K_2O at planting was carried out for this experiment. The fertilizer nitrogen as per the treatment was applied in seven splits; 75% of N was applied in 4 splits at vegetative and remaining 25% applied in three splits at reproductive stage through urea while the recommended P_2O_5 and K_2O was applied as basal dose at planting through single super phosphate and muriate of potash.

Table 2: Nutrient composition of organic manures.

Sr. No.	Parameter	FYM	Neem Cake	Vermicompost
1	Organic Carbon (%)	14.26	11.8	28.1
2	Nitrogen	0.73	5.04	1.6
3	Phosphorus	0.67	0.616	0.92
4	Potassium	0.28	0.38	0.3
5	C:N ratio	31.77	2.34	19.1

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FYM, neem cake and vermicompost were applied to banana on the basis of their nitrogen content as per the treatment. The organic manures used were analyzed for total nitrogen by H_2SO_4 digestion mixture using macro-kjeldhal's method [4] while phosphorus and potassium were estimated by digesting 1g dry manure sample with 10ml triacid mixture (9:3:1 HNO_3:$HClO_4$:H_2SO_4) at 180-200 °C. The nutrient composition of organic manures was mentioned in Table 2. Five plants were selected randomly by taking due care for maintaining uniform symmetry in each plot and tagged permanently for recording biometric observations. The biometric observations viz., number of functional leaves, pseudostem height and girth, leaf area was recorded periodically at 60, 120, 180, 240, 300 days after planting and at harvest (360 DAP). The length & width of fully opened third functional leaf from top for five randomly selected plants were recorded as per the International reference method (MEIR) proposed by Martin-Prevel [5]. The leaf area was calculated by multiplying length and width of leaf with 0.8 factor which was calibrated with the planimeter measurements and showed within +2 per cent accuracy [6]. The leaf area index was calculated by dividing leaf area of plant by the ground area covered by each banana plant. Days required for shooting (flowering) and for shooting to harvest were counted from the day of planting for all the treatment from each plot and average quoted.

Results and Discussion

Table 3: Effect of integrated nitrogen management on periodical number of functional leaves of banana on inceptisol.

Treatment	Days after Planting					
	60	120	180	240	300	360
RDF (200:40:200g plant^{-1} N, P_2O_5 & K_2O)	9.4	12.8	13.2	14.33	15.36	16
25% N: FYM + 75% N: RDF	8.7	12.2	13.4	14.86	16.9	17
25% N: NC + 75% N: RDF	8.4	12	13.33	14.53	16.33	16.33
25% N: VC + 75% N: RDF	8.53	12.06	13.86	14.53	15.98	16.33
50% N: FYM + 50% N: RDF	8.21	12.6	13.73	14.13	16.9	17
50% N: FYM + 50% N: RDF	9.2	12.4	13.4	14.53	15.66	16
50% N: FYM + 50% N: RDF	8	12.06	12.93	15.26	16.01	16.33
Fertilizers as per soil test	9.06	12.53	13.2	13.93	15.96	16
33% N: FYM + 33% NC + 33% N: VC	8.73	12.13	13.46	14.06	16.1	16.16
25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF	8.25	11.93	13	14.66	15.75	16.16
S.E. +	0.311	0.178	0.228	0.113	0.148	0.135
C.D. at 5%	N.S.	0.529	N.S.	0.337	0.44	0.401

Table 4: Effect of integrated nitrogen management on periodical height of banana pseudostem on Inceptisol.

Treatment	Days after Planting					
	Centimeter					
	60	120	180	240	300	360
RDF (200:40:200g plant^{-1} N, P_2O_5 & K_2O)	17.33	39.2	94.33	195.33	196.5	221
25% N: FYM + 75% N: RDF	16.22	32.13	95.66	153	194.33	221.6
25% N: NC + 75% N: RDF	15.06	31.93	86	153.33	197.66	221.16
25% N: VC + 75% N: RDF	12.16	33.13	96.66	157.33	199.08	223.83
50% N: FYM + 50% N: RDF	15.46	31.13	87.66	151.33	199.5	227.5
50% N: NC + 50% N: RDF	16.73	32.93	97.33	150.33	195.33	219.33
50% N: VC + 50% N: RDF	12.8	27.73	87.66	158.33	195	221.33
Fertilizers as per soil test	15.03	36.53	89.33	154	197.66	222
33% N: FYM + 33% NC + 33% N: VC	17.06	39	94	151	194.33	218
25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF	13.4	36.26	92.66	154	189	218.16
S.E. +	0.214	0.482	0.903	1.022	1.791	1.45
C.D. at 5%	636	1.432	2.683	3.034	5.398	4.313

The number of functional leaves, pseudostem height and girth and leaf area index of banana as influenced by integrated nitrogen management are mentioned in Table 3, 4, 5 and 6. The number of functional leaves at 60,120 and 180 DAP were not responded sig-

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nificantly to the substitution of N through organic and inorganic sources. But at later growth stages (ie) after 240,300 and at harvest the number of functional leaves were significantly influenced by integrated nitrogen management treatments. The combination 25% N: FYM + 75% N: RDF and 50% N: FYM + 50% N: RDF recorded significantly higher and same number of functional leaves (16.90 and 17.00) at 300 and 360 DAP respectively. Both these treatments recorded highest number of functional leaves in total crop duration period while lower number of leaves were recorded with 25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF. The non-significant differences for number of functional leaves at early growth stages of banana may be due to slow uptake pattern. Tirkey et al. [7] have also observed the non-significant responses of growth parameters at initial stage of banana may be due to lower requirements of nutrients for plant growth at initial stage.

Table 5: Effect of integrated nitrogen management on periodical girth of banana pseudostem on Inceptisol.

Treatment	Days after Planting Centimeter					
	60	120	180	240	300	360
RDF (200:40:200g plant^{-1} N, P_2O_5 & K_2O)	9.25	20	31.43	46.6	63.73	69.8
25% N: FYM + 75% N: RDF	10.25	23.5	33.66	48.46	64.65	70.43
25% N: NC + 75% N: RDF	8.35	16.06	29.06	46.4	61.8	65.43
25% N: VC + 75% N: RDF	8.73	20.4	32.02	49.93	62.53	66.45
50% N: FYM + 50% N: RDF	9.07	20.4	29.26	44.73	62.76	65.52
50% N: NC + 50% N: RDF	10.02	20.26	32.2	46.13	62.2	65.43
50% N: VC + 50% N: RDF	8.46	18.83	29.4	47.93	61.9	65.17
Fertilizers as per soil test	9.64	20.46	30.8	46.06	61.2	66.16
33% N: FYM + 33% NC + 33% N: VC	8.96	19.9	32.4	46.53	61.83	64.1
25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF	9	20.74	31.86	49.93	63.86	67.43
S.E. +	0.054	0.164	0.448	0.478	0.753	0.576
C.D. at 5%	0.16	0.487	0.133	1.0419	N.S.	1.711

Table 6: Effect of integrated nitrogen management on periodical leaf area index (LAI) of banana on Inceptisol.

Treatment	Days after Planting					
	60	120	180	240	300	360
RDF (200:40:200 g plant^{-1} N, P_2O_5 & K_2O)	0.111	0.686	2.2	5.91	8.39	9.24
25% N: FYM + 75% N: RDF	0.114	0.687	2.57	6.28	9.13	10.84
25% N: NC + 75% N: RDF	0.088	0.471	1.69	5.74	8.84	9.85
25% N: VC + 75% N: RDF	0.096	0.54	2.05	5.85	8.57	9.93
50% N: FYM + 50% N: RDF	0.1	0.38	2.03	5.75	8.76	9.23
50% N: NC + 50% N: RDF	0.133	0.523	2.28	5.42	7.94	9.14
50% N: VC + 50% N: RDF	0.089	0.43	1.97	6.21	8.24	9.8
Fertilizers as per soil test	0.104	0.542	2.11	5.38	8.44	9.92
33% N: FYM + 33% NC + 33% N: VC	0.156	0.605	2.36	5.73	8.61	8.73
25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF	0.088	0.52	2.21	5.88	8.17	9.62
S.E. +	0.006	0.06	0.069	0.0137	0.206	0.126
C.D. at 5%	0.19	0.177	0.204	0.408	0.61	0.373

The magnitude of increase in pseudostem height and girth of banana were increased steadily up to 180 DAP and rapidly between 180 to 240 DAP. However, the magnitude of increase was found to be reduced up to harvest in all the treatments. The magnitude of increase in height and girth of pseudostem at initial growth stage was prominent in inorganic nitrogen application treatment organic or manure N treatments. Substitution of 50% N: FYM + 50% N: RDF recorded significantly highest pseudostem height at 300 DAP (199.50cm) and 360 DAP or at harvest (224.50) than rest of the treatments. Similar results pertaining to rpid increase in plant height was also reported by Reddy [8], Kavino et al. [9,10], Babu and Sharma [3].

The rapid increase in girth of pseudostem of banana was pronounced in inorganic N- replaced treatments at initial growth stage than organic or manure n substituted treatments. The application of 25% N: FYM + 75% N: RDF recorded highest pseudostem girth at 300 DAP (64.65cm) and 360 DAP or at harvest (70.43).

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The addition of organic manures for substitution of nitrogen may have an immobilization effect on nutrients there by leads to slower nutrient availability. Reddy et al. [8] reported the stem girth of banana increased rapidly up to 180 and later marginally up to 360 DAP. Similar trend of results was also quoted by Tirkey et al. [7], Kavino et al. [10] and Babu and Sharma [3].

The leaf area index (LAI) of banana was found significantly influenced by integrated nitrogen management treatments. The magnitude of increase in the LAI of banana was almost more than three times from 60 DAP to 240 DAP in all the integrated nitrogen management treatments. The application of 25% N: FYM + 75% N: RDF recorded significantly higher LAI (10.84) followed by 25% N: VC + 75% N: RDF (9.93) which was found statistically at par with inorganic fertilizer application as per soil test (9.92). The lower LAI (8.73) was recorded with the application of equal proportion of nitrogen through FYM, neem cake and vermicompost. The 25% substitution of nitrogen through FYM along with 75% N RDF might have played important role for increasing the nutrient use efficiency of other nutrients. The correlation analysis of morphological characters of banana as influenced by organic mulches and summarized that the total number of leaves, pseudostem girth and leaf area index were positively correlated with bunch weight and yield of banana. Similar results were also reported by Jaybaskaran et al. [11], Shakila and Manivannan [12] and Kavino et al. [9].

Table 7: Effect of integrated nitrogen management on duration of shooting and yield of banana on Inceptisol.

Treatment	Days Required for Shooting	Days Required for Shooting to Harvest	Yield (t ha^{-1})
RDF (200:40:200 g $plant^{-1}$ N, P_2O_5 & K_2O)	277	120	60.86
25% N: FYM + 75% N: RDF	274	122	73.05
25% N: NC + 75% N: RDF	276	128	65.17
25% N: VC + 75% N: RDF	278	125	65.26
50% N: FYM + 50% N: RDF	276	123	69.55
50% N: NC + 50% N: RDF	282	110	63.79
50% N: VC + 50% N: RDF	278	127	67.04
Fertilizers as per soil test	275	125	67.22
33% N: FYM + 33% NC + 33% N: VC	294	119	50.44
25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF	286	122	64.92
S.E. +	1.743	1.633	3.206
C.D. at 5%	5.176	4.85	9.52

The integrated nitrogen management to banana significantly affected the days required for shooting and shooting to harvest or bunch development (Table 7). The variations in the days required for shooting of banana due to integrated nitrogen management treatment were 18 days. However, less number of days were required for shooting with 25% N: FYM + 75% N: RDF (274) followed by the treatments of inorganic nitrogen application based on soil test (275), 25% N: neem cake + 75% N: RDF (276), 50% N: FYM + 50% N: RDF (276) and RDF (277). Which were statistically at par with each other. Further, significantly higher days for shooting of banana were reported in 33% N: FYM + 33% N: NC + 33% N: VC (294) followed by 25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF (286) and 50% N: NC + 50% N: RDF (282). The application of nitrogen through FYM or neem cake or vermicompost in the proportion of 25% along with 75% recommended dose of fertilizers induced early shooting by 14 to 18 days than other treatment. This might be attributed to the addition of mineral nitrogen along with organic sources narrowed the C:N ratio of organic manures enhanced mineralization resulting in rapid release of nutrients. Further, the stable and consistent supply of nitrogen leads to the early flowering. However, addition of 75 or 100 % nitrogen through FYM, neem cake and vermicompost in equal proportion to banana delayed the shooting by 14-18 days than rest of the treatment. The delay in shooting of banana due to the addition of nitrogen through only organic sources might be ascribed due to the higher quantity of organic manure application leads to the immobilization of soil available nutrients.

The days required for shooting to harvest was ranged between 110-128 days while, total crop duration was 370 to 412 days. An application of 50% N: NC + 50% N: RDF required significantly less period (110) for shooting to harvest followed by the 33% N: NC + 33% N: NC + 33% N: VC (119) and 25% N: FYM + 25% N: NC + 25% N: VC + 25% N: RDF (121). However, all other nitrogen management treatment was found statistically at par with each other for bunch development. Kavino et al. [9] reported the substantial variations in crop duration due to fertilizer treatments Tirkey et al. [13] concluded that application of 250g N $plant^{-1}$ produced the earliest shooting followed by 300g N plant with dwarf Cavendish banana cultivar.

The integrated nitrogen management treatment significantly influenced the banana yield (Table 6). The nitrogen management as 25% N: FYM + 75% N: RDF reported significantly higher yield of banana (73.05t ha^{-1}) followed by 50% N: FYM + 50% N: RDF (69.55t ha^{-1}) and inorganic fertilizer application based on soil test (67.22t ha^{-1}), 50% N:VC + 50% N: RDF (67.04t ha^{-1}), 25% N:VC +

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75% N: RDF (65.26t ha^{-1}), 25% N: NC + 75% N: RDF (50.44t ha^{-1}) and RDF (60.86t ha^{-1}). The application of nitrogen through FYM or vermicompost or neem cake in the proportion of either 25 or 50 per cent reported higher yield of banana. This might be because of adequate supply of both macronutrients and micronutrients to banana. The inadequacy of micronutrients may show some hidden deficiency symptoms in crop plants and become constraint in exploiting higher yield potential. This constraint was overcome by inclusion of organic manure (FYM, vermicompost and neem cake) in the nitrogen management of banana. The incorporation of organic matter into the soil helped to keep soil porous and reduce moisture saturation ultimately improved soil physical, chemical and biological environment. Further, the addition of organic manures enhanced the microbial population and higher enzyme activity which plays a vital role in nutrient transformation, recycling and availability of various nutrients. The yield increase was largely as consequences of higher leaf area index which leads to enhanced growth parameters in turn resulted in higher Yield. The integrated effect resulted on profuse growth of banana leads to the higher synthesis of photosynthates and biomass accumulation. Similar trend of results was also recorded by Meena and Somasundaram [14], Jaybaskaran et al. [11], Tirky et al. [7,13], and Lahav [15].

Ray and Yadav [16] noticed consistently higher banana yield for plant crop (70.70t ha^{-1}), ratoon I (74.00t ha^{-1}) and ratoon II (70.60t ha^{-1}) with the combination of 25% FYM + 75% inorganic fertilizers. While Ushakumari et al. [17] obtained higher yield of banana (66.6t ha^{-1}) with recommended dose of fertilizers (200:200:400g N, P_2O_5 and K_2O $plant^{-1}$) along with 10kg FYM $plant^{-1}$. The application of poultry manure or FYM or press mud along with recommended dose of inorganic fertilizer obtained equally higher yield of banana. Jaybaskaran et al. [11]. The results are in accordance with Arumugam and Manivannan [18-20], Kivino et al. [10], Tirkey et al. [7,13], Reddy et al. [8].

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