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IMPACT OF HIGH DENSITY PLANTING AND FERTIGATION ON LEAF AND SOIL NUTRIENT STATUS OF BANANA (*MUSA ACUMINATA* L.) CV. GRAND NAINE FOR MAIN AND RATOON CROP

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Abstract

An experiment was conducted to study the impact of high density planting and fertigation on leaf nutrient status of banana cv.Grand Naine. The plant density and fertigation levels did not influence nitrogen levels in leaf at shooting stage. The plant densities significantly influenced the phosphorous levels in 3rd leaf with highest (0.66) in S_1(1.8 × 1.8 m). The potassium levels differed significantly due to fertigation and plant densities and the highest (1.64 and 1.64) was recorded in F_1 (100% RDF) and S_1 at shooting stage. However, at harvest stage the NPK status differed significantly. The highest NPK content was recorded in F_1 and S_1. The nutrient status of soil before and after harvest was found non-significant due to plant densities and fertigation treatments in main crop. In ratoon crop, the leaf N and K at shooting was not influenced by plant densities and fertigation levels. The leaf nutrient status of P was found significant, recording the highest in F_1 (0.54%) and S_1 (0.58%). At harvest stage, N and K in leaf was highest in F_1 (1.24 and 0.75%) and S_1 (1.29 and 0.84%). The P content was highest (0.24%) in F_1 and was not significant due to plant densities and their interactions. The soil nutrient status (N, P and K) after harvest of ratoon crop was found non-significant due to plant densities and fertigation levels. The soil K in respect of plant densities was significant, with highest (218.11) in S_1.

Key words : Banana, planting density, fertigation, leaf and soil nutrient status.

Introduction

Banana belongs to the family Musaceae of the order Scitaminae and is very important fruit of India. Banana is a very important fruit crop among small and marginal farmers in developing country like India. Its year round availability facilitates permanent source of income not only to farmers, but also to the traders and retailers which made it more prominent. To improve nutritional status of growing population, the productivity of cheaply available fruit like banana need to be drastically increased. High density planting (HDP) is one of the recent and novel concepts of increasing productivity without affecting the quality of fruits. This system of planting (HDP) has been successfully implicated in fruit crops such as mango (Santharam, 1999), citrus (Goswami *et al*., 1993) and banana (Sathiamoorthy and Mustaffa, 2001), since it results in the optimum utilisation of natural resources as banana plant, mostly feeds from the surface of the soil, it is paramount important to maintain a high degree of soil fertility, if production is to be maintained at an economical level over long periods. The choice of fertilizers, dosage of nutrients, time and method of application, etc. vary widely with respect to agro-climatic conditions and cultivars.

Moreover, applying fertilizers through drip irrigation systems creates more appropriate and timely crop cultivation. Fertigation has vast potential in improving nutrient use efficiency, saving labour towards weeding, energy in application, reducing the cost of production, reducing the environmental pollution and helps in maintaining the soil health besides to meet the specific

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nutritional requirements of the crop. (Holder and Gumbs, 1983). It reduces the production cost and necessary the potential of ground water pollution caused by fertilizer leaching. In this context, the present investigation was conducted on banana cv. Grand naine to study the impact of HDP and fertigation on leaf and soil nutrient status before and after the experimentation to know the extact use of nutrients by the crop. Hence, these two technologies show great impact not only on growth and yield of crop but also on the movement and uptake of nutrients from soil to leaf.

Materials and Methods

The present investigation was conducted during 2013-15 at Horticultural Research Station, Aswaraopet, Khammam Dist. The investigation was carried out by planting tissue culture banana plant at three spacing levels *viz*., S_1-under 1.8×1.8 m (3086 pl/ha), S_2 -2.0×1.25×1.25 m (4414 pl/ha), S_3- 2.5×1.25×1.25 m (3657 pl/ha) and three fertigation levels *viz*., F_1-100 per cent, 75 per cent and 50 per cent (Recommended Dose Fertilizer).

Fertigation levels

F_1- 100% N and K – 300 g N and 300 g K_2O $plant^{-1}$ (652 g urea and 500 g MOP per plant).

F_2- 75% N and K – 225 g N and 225 g K_2O $plant^{-1}$ (489 g urea and 375 g MOP per plant).

F_3- 50% N and K – 150 g N and 150 g K_2O $plant^{-1}$ (326 g urea and 250 g MOP per plant).

Details of split application for main crop

F_1- The total quantity of 652 g urea and 500 g MOP per plant were applied in 30 equal splits @ 22.0 g urea and 17.0 g MOP (each split) at weekly intervals.

F_2- The total quantity of 489.0 g urea and 375.0 g MOP per plant were applied in 30 equal splits @ 16.0 g urea and 13.0 g MOP (each split) at weekly intervals.

F_3- The total quantity of 326.0 g urea and 250.0 g MOP per plant were applied in 30 equal splits @ 11.0 g urea and 8.0 g MOP (each split) at weekly intervals

Details of split application for ratoon crop

F_1- The total quantity of 652.0 g urea and 500 g MOP per plant were applied in 20 equal splits @ 32.6 g urea and 25.0 g MOP (each split) at weekly intervals.

F_2- The total quantity of 489.0 g urea and 375.0 g MOP per plant were applied in 20 equal splits @ 25.0 g urea and 19.0 g MOP (each split) at weekly intervals.

F_3- The total quantity of 326.0 g urea and 250.0 g MOP per plant were applied in 20 equal splits @ 16.0 g urea and 12.5 g MOP (each split) at weekly intervals.

Leaf nutrient analysis

Leaf nutrient status (N P K) at shooting stage (3rd leaf) and harvest

For estimating leaf Nitrogen, Phosphorous and Potassium contents, center half of a 10 cm strip of lamina from both sides of the mid rib (including mid rib) of third youngest leaf (index leaf) was taken at shooting and at harvest stage of both main and ratoon cropsfor estimation of leaf N, P and K content.

Nutrient content in the leaf

Nitrogen

Total nitrogen in the leaf samples was estimated by Microjeldahl's method after digesting the samples with concentrated H_2SO_4 and catalytic mixture (Jackson, 1973) and expressed in per cent on dry weight basis.

Phosphorus

The phosphorus content of the leaf samples was estimated in the triacid digested samples by adopting Venadomolybdate reagent as suggested (Jackson, 1973) and expressed in per cent on dry weight basis.

Potassium

The potassium content in leaf samples was estimated by using flame photometer as outlined by Jackson (1973) and expressed in per cent on dry weight basis.

Soil sampling

Soil samples were collected from the experimental plot and analyzed.

Method of soil analysis

The soil samples were analyzed for physical and chemical characters *viz*., pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium.

Available nitrogen

This was estimated by alkaline potassium permanganate method and the values were expressed in kg/ha (Subbaiah and Asija, 1956; Jackson, 1973).

Available phosphorus

The available phosphorus in soil was extracted by Bray's extractant No. 1. The phosphorus in the aliquot was determined by using molybdate stannous chloride

method using spectrophotometer and expressed in kg/ha (Olsen *et al*., 1954; Jackson, 1973).

Available potassium

The available potassium was extracted from the soil with neutral normal ammonium acetate solution and the aliquot was fed to flame photometer for potassium estimation and expressed in kg/ha (Muhr, 1965; Jackson, 1973).

Results and Discussion

Leaf nutrient status of main crop

At shooting stage (3rd leaf)

The data recorded on leaf nutrient status with influence of plant densities and fertigation on cv. Grand Naine are tabulated in table 1.

Nitrogen (%)

The effect of plant density, fertigation and their interaction levels did not influence the nitrogen levels in leaf at shooting stage. However, irrespective of fertigation levels, highest content of N (1.97) was recorded by S_1 treatment closely followed by S_3 (1.96) and lowest in S_2 (1.83). On the other hand, in respect of fertigation levels, highest mean content of N was recorded in F_1 (1.94) followed by F_2 (1.92) and least in F_3 (1.89). The interaction treatments $S_1 \times F_1$ recorded highest leaf N content of 1.99 per cent closely followed by $S_3 \times F_1$ (1.98), $S_1 \times F_2$ (1.97) and $S_3 \times F_2$ (1.96) and the least was in $S_2 \times F_3$ (1.79).

Phosphorus (%)

The levels of phosphorus in 3rd leaf due to fertigation treatment and interactions of plant densities and fertigation levels were not significant. However, the plant densities significantly influenced the phosphorus levels in leaf. The highest (0.59) phosphorus content was recorded in S_1 followed by S_3 (0.54) and S_2 (0.47).

Potassium (%)

The potassium status in the leaf was found significant due to plant densities and fertigation levels. The highest K content (1.64) was registered in F_1, which was on par with F_2 (1.58) and lowest was noticed in F_3 (1.45), which was inturn on par with F_2. The highest K content (1.64) in leaf was recorded in S_1 and was on par with S_3 (1.61) but superior over S_2 (1.42).

The interaction of plant densities and fertigation levels influenced the leaf K status. The interaction of plant densities with three levels of fertigation treatments was found significant. S_1 with fertigation levels was significant. The highest K status (1.72) was recorded in $S_1 \times F_1$ and $S_3 \times F_1$, which was on par with $S_1 \times F_2$ (1.68) and $S_3 \times F_2$ (1.61) and lowest (1.32) was registered in $S_2 \times F_3$. Similar trend was noticed in other interactions. The results revealed that wider spacing and higher fertigation level result in highest K content in leaves than that of closer spacing. The results revealed that the maximum utility of NPK was noticed in high density planting compared to wider spacing. Hence, lowest percent of NPK recorded in the leaves of high density planting contributed for higher yield.

At harvest stage (3rd leaf)

Nitrogen (%)

The leaf nutrient status of nitrogen (N) in 3rd leaf was significantly influenced by plant densities and fertigation levels (table 1). The highest N content (1.87) was recorded in F_1 which followed by F_2 (1.69) and F_3 (1.44). The N content was significantly influenced by plant densities, with highest in S_1 (1.77), which was on par with S_3 (1.75) and superior over S_2 (1.49). The interactions were also significant, with highest in $S_1 \times F_1$ (1.98), which was on par with $S_3 \times F_1$ (1.97) and lowest was recorded in $S_2 \times F_3$ (1.32).

Phosphorus (%)

The highest phosphorus (P) content (0.49) was recorded in F_1, which was on par with F_2 (0.47) and superior over F_3 (0.43). In plant density treatments, the highest P content (0.53) was recorded in S_1, followed by S_3 (0.44) and S_2 (0.41). Among the interaction treatments the highest P content was registered in $S_1 \times F_1$ (0.56), which was on par with $S_1 \times F_2$ (0.54) and lowest levels were recorded in $S_2 \times F_3$ (0.39).

Potassium (%)

The highest K content (1.08) in leaf was recorded in F_1, which was superior over F_2 (1.00) and F_3 (0.87). The plant densities significantly influenced the K status in leaf with highest in S_1 (1.06) followed by S_3 (0.96) and S_2 (0.93). The interaction effect of plant densities and fertigation was found non significant.

The applied N, P and K were utilized efficiently by the plant, which might have resulted in producing maximum photosynthates in terms of high biomass and translocating the assimilated minerals to the developing sink. The role of nitrogen and potassium in the function of chlorophyll was well established. N is the chief constituent of chlorophyll, protein and amino acids, the synthesis of which will accelerate through increased supply of N (Kohli *et al*., 1980). In the present experiment high rate of NPK application increased the availability of these nutrients in the soil and optimum supply of water

Table 1 : Effect of spacing and fertigaion on Leaf nutrient status of NPK at Shooting and harvesting stages of Banana cv. Grand Naine (Main and Ratoon crop).

Tretments	Leaf nutrient status at(3rd leaf) Shooting stage						Leaf nutrient status at (3rd leaf)harvest stage					
	Main			Ratoon			Main			Ratoon		
	N (%)	P(%)	K(%)	N (%)	P(%)	K(%)	N (%)	P(%)	K(%)	N (%)	P(%)	K(%)
Factor A Spacing												
S_1	1.97	0.59	1.64	1.87	0.58	1.69	1.77	0.53	1.06	1.29	0.23	0.84
S_2	1.83	0.47	1.42	1.66	0.43	1.35	1.49	0.41	0.93	1.13	0.21	0.60
S_3	1.96	0.54	1.61	1.71	0.5	1.64	1.75	0.44	0.96	1.19	0.21	0.76
Factor B Fertigation												
F_1	1.94	0.56	1.64	1.82	0.54	1.6	1.87	0.49	1.08	1.24	0.24	0.78
F_2	1.92	0.52	1.58	1.73	0.49	1.55	1.69	0.47	1	1.21	0.21	0.75
F_3	1.89	0.51	1.45	1.7	0.48	1.53	1.44	0.43	0.87	1.16	0.2	0.66
Factor AxB Spacing and Fertigation intaractions												
$S_1 \times F_1$	1.99	0.61	1.72	1.88	0.6	1.75	1.98	0.56	1.12	1.33	0.25	0.88
$S_1 \times F_2$	1.97	0.59	1.68	1.88	0.57	1.68	1.81	0.54	1.08	1.28	0.23	0.86
$S_1 \times F_3$	1.95	0.57	1.52	1.86	0.56	1.64	1.51	0.49	0.98	1.25	0.22	0.77
$S_2 \times F_1$	1.86	0.48	1.48	1.71	0.46	1.36	1.66	0.44	1.08	1.16	0.21	0.64
$S_2 \times F_2$	1.84	0.46	1.46	1.68	0.41	1.35	1.48	0.41	0.96	1.15	0.21	0.62
$S_2 \times F_3$	1.79	0.46	1.32	1.6	0.42	1.33	1.32	0.39	0.76	1.08	0.2	0.54
$S_3 \times F_1$	1.98	0.58	1.72	1.86	0.56	1.68	1.97	0.47	1.04	1.22	0.24	0.81
$S_3 \times F_2$	1.96	0.52	1.61	1.64	0.48	1.63	1.79	0.45	0.97	1.19	0.2	0.78
$S_3 \times F_3$	1.93	0.51	1.51	1.63	0.47	1.62	1.49	0.41	0.88	1.16	0.19	0.68
Factor A(SE m ±)	0.071	0.019	0.03	0.05	0.01	0.03	0.029	0.007	0.009	0.011	0.007	0.013
Factor A(CD 5%)	NS	0.059	0.093	NS	0.04	NS	0.08	0.02	0.02	0.03	NS	0.04
Factor B(SEm ±)	0.07	0.019	0.03	0.05	0.01	0.03	0.029	0.007	0.009	0.011	0.007	0.013
Factor B(CD 5%)	NS	NS	0.093	NS	0.04	NS	0.08	0.02	0.02	0.03	0.02	0.04
Factor A× B(SEm ±)	0.12	0.031	0.05	0.1	0.02	0.06	0.051	0.013	0.016	0.019	0.013	0.023
Factor A×B(CD 5%)	NS	NS	0.152	NS	0.08	NS	0.15	0.03	NS	0.05	NS	0.07

Table 2 : Effect of spacing and fertigaion on soil nutrient status of NPK at before harvesting and after harvesting stages of Banana cv. Grand Naine (Main and Ratoon crop).

Tretments	Soil nutrient status before harvest (main crop)			Soil nutrient status after harvest					
				Main			Ratoon		
	N (%)	P(%)	K(%)	N (%)	P(%)	K(%)	N (%)	P(%)	K(%)
Factor A Spacing									
S_1	192.29	21.76	327.22	169.99	17.51	249.42	179.79	14.87	218.11
S_2	185	22.35	329.15	171.63	15.49	233.19	177.15	14.15	205.31
S_3	187.03	22.43	327.01	170.91	16.39	242.21	177.72	14.34	210.99
Factor B Fertigation									
F_1	189.68	22.03	329.58	171.48	16.85	245.15	179.18	14.63	214.18
F_2	187.84	22.44	327.68	170.15	16.42	241.31	177.93	14.49	211.16
F_3	186.81	22.08	326.12	170.9	16.12	238.35	177.56	14.24	209.07
Factor AxB Spacing and Fertigation intaractions									
$S_1 \times F_1$	194.78	21.69	329.17	172.41	17.95	254.62	181.67	15.12	221.33
$S_1 \times F_2$	192.16	22.05	328.72	169.28	17.38	249.38	179.33	14.98	217.34
$S_1 \times F_3$	189.92	21.55	323.76	168.29	17.2	244.26	178.38	14.52	215.67
$S_2 \times F_1$	185.62	21.9	330.42	173.08	15.93	235.67	177.24	14.39	208.86
$S_2 \times F_2$	184.23	22.52	329.26	169.75	15.34	233.18	177.13	14.14	205.42
$S_2 \times F_3$	185.16	22.64	327.77	172.07	15.19	230.72	177.08	13.93	201.64
$S_3 \times F_1$	188.64	22.5	329.15	168.96	16.67	245.17	178.62	14.38	212.35
$S_3 \times F_2$	187.12	22.75	325.05	171.42	16.53	241.37	177.33	14.36	210.72
$S_3 \times F_3$	185.34	22.04	326.84	172.34	15.97	240.08	177.21	14.27	209.89
Factor A(SEm ±)	1.98	0.23	1.5	1.45	0.25	2.63	1.04	0.29	2.07
Factor A(CD 5%)	NS	NS	NS	NS	NS	NS	NS	0.89	6.2
Factor B(SEm ±)	1.98	0.23	1.5	1.45	0.25	2.63	1.04	0.29	2.07
Factor B(CD 5%)	NS	NS	NS	NS	NS	NS	NS	0.89	NS
Factor Ax B(SEm ±)	3.44	0.41	2.61	2.51	0.43	4.57	1.8	0.51	3.58
Factor AxB(CD 5%)	NS	NS	NS	NS	NS	NS	NS	1.55	NS

near root zone resulted in better absorption of nutrients.

Leaf nutrient status of ratoon crop

At shooting stage

The results with respect of leaf nutrient status as influenced by plant densities and fertigation in the leaf at shooting stage are presented in table 2. The leaf nitrogen and potassium at shooting were not influenced by plant densities and fertigation levels. However, the leaf nutrient status of phosphorus (P) was found significant. The highest P content (0.54) was recorded in (F_1), which was significantly followed by (F_2) (0.49) and F_3 (0.48). In plant densities the P content was highest (0.58) in S_1, which was superior over S_3 (0.50) and S_2 (0.43). The interaction effect in $S_3 \times F_1$ (0.56) was significant over $S_3 \times F_3$ (0.47) and was on par with $S_3 \times F_2$ (0.48). The nutrient status was not significant in other interactions.

At harvest stage

The data pertaining to leaf nutrient status (NPK) at (3rd leaf) harvesting stage of banana cv. Grand Naine in ratoon crop are presented in table 2.

The Nitrogen (N) and Potassium (K) contents in leaf at harvest stage were significantly influenced by treatments. Nutrient status of both N and K in leaf was highest in higher dose of fertigation (1.24 and 0.78) and wider spacing (1.29 and 0.84) compared to high density (1.13 and 0.60) and lowest fertigation level (1.16 and 0.66). In interaction, the higher dose of fertigation with plant densities recorded highest nutrient status of N and K in leaf. The phosphorus content was found non significant with regard to plant densities and interactions of densities with fertigation. This might be due to immobile nature of phosphorus in the soil. However, it was significant in fertigation levels. The highest P content was recorded in F_1 (0.24), which was superior over F_2 (0.21)

and F_3 (0.20).

Soil nutrient status of main crop

Before experiment

The data recorded on available nutrient status of soil before experiment are presented in table 1. The effect of plant densities and fertigation levels on nutrient status of soil before experiment was found non significant.

After harvest

The observations registered on available nutrient status of soil after harvest of main crop are represented in table 1. The influence of plant densities and fertigation levels on nutrient status of soil after harvest was non significant. The soil potassium in respect of plant densities was significant, with more K levels (249.42) recorded in S_1 (wider spacing) and was superior over S_3 (242.21) and S_2 (233.19). The lowest K content was noted in high density planting system (S_2).

Soil nutrient status after harvest of ratoon crop

The data recorded in respect of soil nutrient status after harvest of ratoon crop of banana cv. Grand Naine are compiled in table 2. The soil nutrient status (N, P, K) after harvest of ratoon crop was found non significant due to plant densities.

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