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Nutrient Use and Yield of Banana as influenced by Fertigation

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Abstract: A field experiment was conducted during 2010-2011 in medium deep clay soils at the Research Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra to find out the effect of drip fertigation on yield and nutrient use efficiency of banana (*cv*. Grand naine). The treatments comprised of 100, 80 and 60 per cent recommended dose (RD) of fertigation applied through drip in two schedules (Schedule A-equal, Schedule B crop growth stage), drip irrigation with only N through drip, drip with conventional fertilizers through soil and surface irrigation as control. The drip irrigation increased banana yield by 59.6 percent and saved fertilizer to the tune of 40 per cent. The treatment comprising of 100% RD of fertigation (schedule B) had maximum banana yield (81.84 t ha^{-1}) over surface irrigation (51.26 t ha^{-1}). However, it was at par with 100% RD of fertigation in uniform 16 splits and 80% RD of fertigation . Application of water soluble fertilizers through drip resulted in highest nutrient availability than control treatment. In general,100% RD had the highest nutrient availability than 80% and 40% RD of fertilizer. The nutrient availability was more in treatment in which fertilizers were applied as per growth stages (schedule B) than equal splits (schedule A). The uptake of nutrients was higher in fertigated treatments than other treatments.

Key words: *Banana, fertigation, water soluble fertilizers, yield, nutrient availability and uptake*

Introduction

Banana (*Musa paradisica*) is one of the most widely grown fruit crop all over India. India ranks second after Brazil in production with an area of 0.7703 million ha producing 26.47 million tons of banana with productivity of 34.4 t ha^{-1} (Anonymous 2009). Maharashtra is the second largest producer of banana in India. Water scarcity and increasing fertilizer cost are two major factors affecting its production in the state. Improper use of fertilizer increases input cost and aggravates the environmental pollution. Fertigation is the technique that provides the plant nutrients at the right time and the right place and increases the application frequency and therefore, increases fertilizer recovery (Pawar *et al.* 2013). Application of fertilizer with irrigation water improves yield and fertilizer recovery and provides better timing to meet crop demand throughout the growing season (Mark *et al.* 2009).

Banana plant responds well to irrigation and profitable yields are achieved through improved irrigation techniques like drip irrigation. The water application efficiency in general is higher under drip irrigation and shows unique advantage of water saving (40 to 60%), increased yield (15 to 20%) and labour saving (30 to 40%) as compared to other irrigation systems. Application of irrigation water and fertilizers through drip ensures that the nutrients are placed near

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root zone and also applied at desired amount (Singandhupe *et al*. 2005). The present investigation was undertaken to study the effect of fertigation on yield of banana and its influence on soil fertility status and nutrient uptake under fertigation in Inceptisols.

Material and Methods

The field experiment was conducted during 2010 to 2011 at Research Farm of Interfaculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth Rahuri. Agroclimatically, the area falls under the scarcity zone of Maharashtra with annual average rainfall of 523 mm, which is mostly erratic and uncertain in nature. The clayey soil (80 cm deep) had pH 8.2, available N 173.2 kg ha^{-1} available P 17.2kg ha^{-1} and available K535.0 kg ha^{-1} and moisture content at 1500 and 33kPa respectively It is alkaline in reaction with pH 8.2. The available nitrogen was 173.2 kg ha^{-1} with available phosphorus 17.20 kgha^{-1} and available potassium 535.0 kg ha^{-1}. It is well drained soil. The banana saplings Cv. Grand naine of 2 to 2½ months old developed by tissue culture technology was planted at spacing of 1.5m X 1.5m during first week of July 2010 and harvested in August 2011. For drip fertigation, fertilizers were applied as per schedule as given in table 1. There were 9 treatments *viz*. T_1- Drip irrigation (DI) with 100 % Recommended dose (RD) of fertigation in 16 splits as per schedule A; T_2- DI with 80 % RD of fertigation in 16 splits as per schedule A; T_3- DI with 60 % RD of fertigation in 16 splits as per schedule A; T_4- DI with 100 % RD of fertigation in 16 splits as per schedule B; T_5- DI with 80 % RD of fertigation in 16 splits as per schedule B; T_6- DI with 60 % RD of fertigation in 16 splits as per schedule B; T_7- DI with 100 % RD of Control(CF) (N- drip and P & K through soil); T_8- DI with 100 %RD of CF, T_9-Surface irrigation (SI) with 100 % (control) replicated thrice in Randomized Block Design.

Table 1. Schedule B: proportion of nutrients applied in fortnightly splits.

Month	N(%)	P(%)	K(%)
First 2 months	15	30	10
3-4 months	40	50	20
5-6 months	25	20	30
7 months	20	-	30
8 months	-	-	15

The recommended dose of fertilizer for banana was 200: 40: 200; N: P_2O_5: K_2O g $plant^{-1}$. In water soluble fertilizer treatments, urea (46:0:0), urea phosphate (17: 44:00) and MOP (0:0:60) were used for fertigation whereas, in conventional fertilizer treatments, it was applied through urea, SSP and muriate of potash, respectively. The water soluble fertilizers were applied in equal splits at an interval of 15 days *i.e*. schedule A for treatment 1 to 3 and nutrients were applied as per growth stages to treatment (4 to 6) *i.e.* schedule B (Table 1) and in T_7, all the N was applied through urea in 12 equal splits at an interval of 15 days, whereas P and K was applied as basal dose. In case of T_8 and T_9, the N, P and K were applied through soil N in two splits, 1st at planting and 2nd at 4 months after planting (MAP), P as basal and K at 30, 165, 255 and 300 days of planting.

The fertigation was done using water soluble grades of urea, urea phosphate and muriate of potash through automized fertizer system at 15 days interval. Adequate plant protection measures were adopted as and when required. The amount of water (litres /day) to be applied through drip irrigation was calculated by the climatological approach (Allen *et al*. 1998). The reference evapotranspiration was estimated using Evapotranspiration Monitoring Unit (ICT) installed at research farm. In drip system water was applied on alternate day while in surface irrigation, water requirement was calculated as per the procedure described by Michael (1978).

The plant samples were collected at the harvest of crop. The plant samples were air dried in shade, oven dried at 65°C, ground in a whilley mill having stainless steel blades to pass through 40 mm mesh sieve and digested with H_2SO_4 and H_2O_2 (1:1) as per the standard procedure given by Parkinson and Allen (1975). Nutrient uptake was calculated by multiplying the N, P and K concentration and dry matter production, *i.e.* the nutrient uptake was worked out by multiplying the yield

with nutrient content and dividing by 100. The soil samples collected of harvest were air dried, processed and analyzed for available NPK content in soil (Page *et al*. 1982). The statistical analysis was performed by using analysis of variance for randomized block design as per Panse and Sukhatme (1985).

Results and Discussion

Yield contributing characters

Number of hands per bunch (9.00), and number of fingers per bunch (151.92), bunch weight (18.14 kg), length of fingers (21.40 cm) and girth of fingers (12.87) were maximum in treatment T_4 (Table 2). However, the values in respect of number of hands, fingers per bunch and bunch weight were at par with treatment T_1, (fertigation in 16 splits as per growth stages) T_5 and T_7 (100% RD of CF (N-drip and PK) but significantly superior over other treatments. The surface method of irrigation had lowest values for all the yield contributing parameters.

The banana yield (Table 3) ranged between 51.26 t ha^{-1} (T_9) to 81.84 t ha^{-1} (T_4). The yield under T_4 was significantly superior to other treatments except T_1 and T_5 and was 59.6 % more than conventional method of irrigation and fertilizer application.The better performance of drip fertigation over surface irrigation was due to on application of right quantity of water at right time and at right place which has resulted in sufficient moisture in root zone.

The banana yield under T_7 (N applied through drip) was 73.08 t ha^{-1} and was 42.6 per cent more than T_9 (SI with CF). It indicated that yield of banana can be increased significantly by applying urea through DI than DI alone (without any fertigation) for banana. The banana yield obtained under DI with 100 per cent RD of conventional fertilizers applied through soil (T_8, 68.02 t ha^{-1}) was found to be on par with T_6 (69.44 t ha^{-1}) and T_3 where 60 per cent recommended dose of fertigation was applied. It indicates that fertigation using water soluble fertilizers can save fertilizer dose of banana upto 40 per cent. These results are in confirmation with those reported by Naina *et al.* (2007).

Nutrient availability in soil

The data regarding NPK availability in soil at the time of harvest is presented in table 3. The maximum N availability was observed in 100% RD and decreased with decrease in fertilizer levels. The schedule B, where N was applied as per crop growth stages resulted into significantly maximum N availability (174.60 kg ha^{-1}) in soil. However, it was at par with T_1, T_5 and T_7. The fertigation treatments resulted in more availability of N in soil as compared to conventional fertilizers. As relatively more water was available just beneath the dripper, there was corresponding increase in available N in the soil. These results are in close conformity with those reported by Bangar *et al* (1998).

Table 1/2. Yield contributing characters of banana plant

Treatments	No. of hand/bunch^{-1}	No. of finger/bunch^{-1}	Bunch weight, (kg)	Length of finger (cm)	Girth of finger (cm)
T1	8.67	146.21	17.56	20.83	12.67
T2	8.00	134.08	16.50	20.60	12.40
T3	7.33	121.23	15.54	50.53	12.17
T4	9.00	151.92	18.14	21.40	12.87
T5	8.33	140.64	16.70	20.67	12.35
T6	7.67	123.66	16.25	20.57	12.30
T7	8.67	137.12	17.28	20.27	12.33
T8	8.00	130.88	15.63	20.29	12.27
T9	7.00	116.55	11.53	19.87	11.72
SE ±	0.30	3.51	0.30	0.15	0.17
CD at 5%	0.87	10.16	0.88	0.40	0.48

Table 3. Yield of banana and nutrient availability (kg ha^{-1}) in soil as influenced by different treatments

Treatment	Yield (t ha^{-1})	% increase in yield over control (T_9)	Nutrient availability (kg/ha)		
			N	P	K
T_1	78.02	52.2	173.00	15.60	533.3
T_2	73.36	43.1	171.10	14.20	529.5
T_3	66.10	28.9	166.80	12.00	517.2
T_4	81.84	59.6	174.60	16.60	536.0
T_5	76.81	49.8	172.50	14.90	532.5
T_6	69.44	35.5	167.80	12.90	520.9
T_7	73.08	42.6	172.90	15.20	534.5
T_8	68.02	32.7	170.50	14.90	532.5
T_9	51.26	--	167.50	14.40	523.4
SE ±	1.67	--	0.70	0.55	2.67
CD at 5%	4.89	--	2.10	1.60	7.90

The phosphorus availability in the root zone soil of banana crop was found to be influenced by level of fertilizers (Table 3). The P availability increased in fertigation level as compared to conventional based application of soil. In case of T_7 and T_8, the phosphorus availability was less as compared to fertigation treatments. The maximum availability was observed in 100 per cent RD treatment and it decreased with decease in fertilizer levels. The treatment T_4 resulted in more P availability in the soil (16.60 kg ha^{-1}) at harvest.

The potassium availability in the root zone soil of banana was found to be influenced by level of fertilizers (Table 3). The K availability was higher in fertigation treatments as compared to conventional fertilizers applied through soil. In case of T_7 and T_8, the increase might be due to application of fertilizers in 4 splits. The maximum K availability was observed in 100 per cent RD treatment and that got decreased with fertilizer levels. The T_4 resulted in significantly higher K availability in the soil over all other treatments barring T_1, T_5, T_2, T_7 and T_8.

Nutrient uptake

The NPK uptake by leaves was significantly higher in drip fertigated plots as compared to conventional method of irrigation (Table 4). Treatment T_9 recorded lowest values of NPK uptake (203.7, 41.13

Table 4. Nutrient uptake by banana (kg/ha)$^{-1}$ as influenced by fertigation

Treatments	Uptake in leaves (kg /ha)			Uptake in shoot (kg/ha)			Uptake in fruit (kg/ha)			Total uptake (kg/ha)		
	N	P	K	N	P	K	N	P	K	N	P	K
T1	252.9	51.47	323.0	45.62	15.01	294.9	127.4	24.49	440.8	425.9	90.97	1058.7
T2	230.8	46.17	289.7	43.09	14.11	294.1	110.3	20.36	389.0	384.2	80.64	972.4
T3	215.5	44.35	284.5	37.98	12.62	293.5	84.94	17.97	301.8	338.4	74.93	879.8
T4	274.2	55.43	337.0	48.22	16.51	297.5	134.4	25.87	473.5	456.8	97.83	1107.9
T5	248.8	49.16	314.6	45.13	15.65	295.9	117.9	22.33	428.3	411.9	87.15	1038.2
T6	220.9	42.54	253.5	43.19	14.98	294.3	89.8	18.09	313.6	353.8	75.62	861.5
T7	233.2	45.39	297.1	42.61	14.37	292.6	116.07	21.79	388.9	391.9	8155	978.6
T8	217.9	43.03	272.8	40.36	13.88	292.0	93.97	18.42	324.5	352.2	75.32	889.1
T9	203.7	41.13	251.2	38.52	12.71	271.3	74.3	13.93	264.3	316.5	67.76	786.7
SE ±	7.15	1.25	6.6	1.03	0.56	4.63	6.06	0.62	8.62	10.25	1.23	10.95
CD at 5%	21.4	3.61	19.07	3.05	1.53	13.37	17.6	1.81	24.88	30.76	3.65	32.31

and 251.2 kg^{-1}ha) respectively. The better performance of drip fertigation on nutrient uptake over surface irrigation with CF may be due to higher availability of nutrients. The results revealed that uptake of the NPK in banana shoot increased with increasing levels of fertilizers. The treatment T_4 recorded significantly higher NPK uptake (48.22, 16.51 and 297.5 kg^{-1}ha) over other treatments except T_1 (45.62, 15.61 and 295.9 kg^{-1}ha). The NPK uptakes in banana fruits were significantly higher in drip fertigated treatments as compared to conventional method of irrigation. However, among different fertigation treatments, 100% RD of fertigation in 16 splits as per growth stages resulted in maximum NPK uptakes (134.4, 25.87 and 453.5 kg^{-1}ha) and was significantly superior over other treatment except T_1. DI had significant advantages over SI in terms of nutrient uptake which may be due to increase in water in root zone of banana leading to increase in solubility of nutrients and that might have resulted in higher uptake of nutrients in DI than SI. Treatment T_4 was significantly superior over other treatments in total N, P and K uptakes except T_1. Treatment T_9 (N :316.5, P : 67.76 and K : 786.7 kg^{-1}ha) recorded lowest nutrient uptakes. DI recorded significant increase in uptake over SI treatments. Application of water soluble fertilizers through drip irrigation resulted in higher nutrient uptake owing to frequent and judicious application of irrigation water.

Conclusion

The maximum yield of banana (81.84 t ha^{-1}) was recorded in treatment comprising of 100 per cent RD of fertigation applied as per growth stages in 16 splits at it was at par with T_1 and T_5 treatments. The DI recorded 59.6 per cent increase in yield and 40.0 per cent fertilizer saving over SI. The nutrient availability and uptake was found to be improved under drip fertigation as compared to conventional fertilizer application. It can be concluded that 100 per cent fertigation in 16 fortnight splits as per schedule is the best treatment to improve the yield and nutrient use of Banana (var. Grand naine) cultivated in medium deep soils of Western Maharashtra.

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