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Influence of fertigation scheduling through drip on growth and yield of banana in western Maharashtra

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ABSTRACT

Field experiments was conducted on clay loam soil in western Maharashtra for three consecutive years (2007-2010) to study the response of drip-fertigation on growth, yield, quality and economics of banana cv. Grand Naine. The experiment was laid out in a randomized block design with nine treatments replicated three times. The experiment comprised of 100, 80 and 60 per cent water soluble fertilizers applied through drip in two schedules and results were compared with three control treatments. The study indicated the beneficial effects of drip irrigation in terms of 23 per cent increase in yield and 45.3 per cent water saving whereas drip with fertigation resulted into 24 to 46% increase in banana yield with equal amount of water saving as compared to conventional method. The results revealed that drip fertigation significantly increased growth, yield contributing and quality characters as compared to conventional fertilizers. Fertigation as per the growth stages proved superior as compared to uniform splits for all the characters including yield. The 100 per cent recommended dose of fertilizer through drip as per crop growth stages showed 46.22 per cent increase in yield (83.62 t/ha). However, it was on par with 80% fertigation treatments (79 t/ha). The banana fruit yield obtained under 60% fertigation (68 t/ha) produced 19% more yield as compared to conventional fertilizer application through soil (57.4 t/ha) indicating 40% fertilizer saving due to fertigation. Maximum water use efficiency (69.5 kg/ha-mm) was obtained in treatment where 100% water soluble fertilizers were applied through drip as per crop growth stages.

Key words: Fertigation, water soluble fertilizers, drip irrigation, banana.

INTRODUCTION

Banana contributes 37% to the total fruit production in India. Southern parts of India is leading in banana production due to presence of suitable climatic conditions. Maharashtra is second the leading state in country after Tamil Nadu, having an area of 0.73 lakh ha with a production of 4.61 million tonnes and productivity ranging from 13.5 to 62.97 t ha^{-1} (Anon, 3; Ashok Kumar *et al.*, 4).

Water and nutrient are the two key factors in the growth of banana. A number of research experiments have clearly demonstrated that for high productivity of banana, application of recommended doses of essential nutrients at appropriate growth stages are necessary (Pandey *et al.*, 12; Thangaselvabai *et al.*, 16). More of nitrogen and potassium are required for its growth and production as compared to phosphorus and it should be applied in small doses at shorter intervals (Nalina *et al.*, 11). The drip fertigation has some advantages over conventional fertilizer application method since it provides the most effective way of supplying nutrients directly at the site of a high concentration of active roots and as needed by the crop. Scheduling fertilizer applications on the basis of need offers the possibility of reducing nutrient element losses associated with conventional application (Solaimalai *et al.*, 14). Application of fertigation can enhance the fertilizer use efficiency, nutrient uptake, improves quality parameters substantial saving of fertilizer upto 30% (Guerra *et al.*, 7) and thus, it resulted into significantly increase total mass of plant, improved phenological characteristics and bunch characteristics, higher fruit yield and quality of banana over conventional fertilizers application (Reddy *et al.*, 13). Therefore, application of water soluble or liquid fertilizers through drip irrigation (fertigation) has encouraged as a strong alternative to straight fertilizers for banana fruit. However, there is dearth of information regarding optimal schedule of drip fertigation for banana without which the fertigation may lead towards loss of nutrients with poor timing and excessive application of fertilizers. Therefore, present study was undertaken with main objective to standardize fertigation schedule for banana and to assess its effect on growth, yield and quality of banana.

MATERIALS AND METHODS

The field experiment was conducted during three consecutive seasons from 2007 to 2010 at research

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farm of MPKV, Rahuri. Agroclimatically, the area falls under the scarcity zone of Maharashtra with annual average rainfall of 520 mm, which is mostly erratic and uncertain in nature. The experimental plot was uniform and levelled with well drained, medium black clay soil, alkaline in nature with pH as 8.30. The soil depth was 60 cm with hydraulic conductivity and organic carbon as 1.0 cm/h and 0.65%, respectively. The soil texture was clay with 23.5% coarse sand, 26% silt and 50.5% clay with medium depth. The bulk density of soil was 1.27 g/cm^3 and electrical conductivity was 0.32 dSm^{-1}.The soil was high in available N (205 kg/ha), and P (12.50 kg/ha) and very high in available K (530 kg/ha) content. The soil was having moisture contents at field capacity, permanent wilting point and available soil moisture as 37.28, 20.27 and 17.14%, respectively. The tissue cultured banana plants (*var.* Grand Naine) were planted at a spacing of 1.5 m × 1.5 m twice during 1st week of December 2007 and 2009 was harvested during the November 2008 and 2010, respectively. The first ratoon (suckers) was allowed from the 2nd fortnight of November 2008 and was harvested during October, 2009.

The field experiment was laid out in Randomized Block Design (RBD) with nine treatments replicated thrice with 24 plants under each treatment. The treatment details are as T_1: Drip with 100% water soluble fertilizers in 16 splits as per schedule A; T_2: Drip with 80% water soluble fertilizers in 16 splits as per schedule A; T_3: Drip with 60% water soluble fertilizers in 16 splits as per schedule A; T_4: Drip with 100% water soluble fertilizers in 18 splits as per schedule B; T_5: Drip with 80% water soluble fertilizers in 18 splits as per schedule B; T_6: Drip with 60% water soluble fertilizers in 18 splits as per schedule B; T_7: Drip with 100% conventional fertilizers (N through drip and P, K through soil); T_8: Drip with 100 % conventional fertilizers (N, P, and K through soil); T_9: Surface irrigation with 100% conventional fertilizes (N, P, and K through soil); Under schedule A all the fertilizers were applied in 16 uniform splits at an interval of 15 days; whereas in schedule B the fertilizers were applied in 18 splits apportioned as per growth stages as tabulated below.

Month	Nitrogen (%)	Phosphorus (%)	Potassium (%)
First 2 months (4 splits)	15	30	10
3-4 months (4 splits)	40	50	20
5-6 months (4 splits)	25	20	25
7-8 months (4 splits)	20	-	30
9 months (2 splits)	-	-	15

The recommended dose of fertilizer considered for banana was 200:40:200 N: P_2O_5: K_2O, g/plant. In water soluble fertilizer treatments, urea (46:0:0), urea phosphate (17:44:0) and MOP (0:0:60) were used for fertigation. In treatment T_7, all the 'N' was applied through urea in 16 equal splits at an interval of 15 days.

The drip irrigation system was installed to meet out crop water requirement and for fertigation of water soluble fertilizers. The reference evapotranspiration was estimated using Evapotranspiration Monitoring Station (ICT International make, Australia) installed at research farm. Considering the crop factor as per stages (Allen *et al.*, 2) and wetted area factor, the water requirement of the banana was computed. The lateral lines of 16 mm diameter LDPE pipes were laid along the crop rows and each lateral served each row of crop. The laterals were provided with on-line dripper of 4 lph discharge capacity. The spacing between two adjacent lateral and emitter within plot was 1.50 and 0.75 m, respectively. In case of surface irrigation, 80 mm depth of irrigation was applied at 75 mm of cumulative pan evaporation. The depth of water in surface method of irrigation was estimated using standard methodology (Michel, 10). The quantity of water applied in surface irrigation was measured by using Replogal flume. The growth parameters yield and its attributing characters of the fresh as well as ratoon banana were recorded.

RESULTS AND DISCUSSION

All the biometric characters pooled over the three years were found maximum in drip irrigated and fertigated treatments as compared to conventional method of irrigation and fertilizer application (Table 1). The treatment T_4 (100% WSF in 18 splits as per the growth stages) resulted into higher and significantly superior values of all growth parameters. However, values under T_4, T_1, T_2 and T_5 were on par with each other. The average height of plants under treatment T_4 was 3.05 m which was higher than the average plant height of other treatments. The maximum values of stem girth (58.97 cm) and number of functional leaves (8.33) were observed in T_4, however, it was at par with all drip fertigated treatments. The significantly lower values of growth contributing characters were obtained for all the parameters in conventional method of irrigation and fertilizer application. This fact is

Table 1. Average biometric characters of two fresh and one ratoon banana crop under different treatments of water soluble fertilizers.

Treatment	Plant height (m)	No. of functional leaves	Stem girth (cm)	Mean days to flowering	Mean days to maturity
100% WSF(A)	3.03	8.33	58.42	244	331
80% WSF(A)	3.01	8.00	58.11	247	333
60% WSF(A)	2.95	7.78	57.67	250	339
100% WSF(B)	3.05	8.33	58.97	245	328
80% WSF(B)	2.97	7.89	58.42	252	336
60% WSF(B)	2.93	7.56	58.07	259	338
100% CF (NTD)	2.92	7.33	58.20	252	342
100% CF + DI	2.92	7.11	58.05	263	356
100% CF + SI	2.68	6.78	55.07	294	388
CD at 5%	0.43	0.08	0.80	1.32	5.13

supported by the works of Kavino *et al.* (8) that the higher number of functional leaves, pseudostem height, girth, greater leaf area coupled with reduced crop duration can be achieved with fertigation.

The data presented in Table 1 indicated that the early emergence of flowers by 31 days was observed in case of plants under drip irrigation (263 days) as compared to surface irrigation (294 days). While, in fertigation treatments early emergence of flowers by 35 to 50 days was recorded as compared to conventional method. The increase in vegetative growth and early emergence of flowers in T_4 was due to availability of moisture as well as nutrients at optimum level in drip fertigated treatments as compared to lowest values in T_9. The mean days to maturity was also observed to be reduced by 32 days in drip irrigated plots as compared to conventional method of irrigation. The fertigation reduced days to maturity to 328 to 342 as compared to 388 in conventional method. It showed that total crop duration can be reduced by 32 days by drip and further 20 days by using fertigation through drip. This fact is supported by the works of Kumar *et al.* (9) that application of nitrogen and potassium significantly improved the plant growth of banana.

The average yield and yield contributing characters of two fresh and one ratoon banana crop are presented in Table 2. The pooled data for three years revealed that the fertigation significantly increased the yield and yield contributing characters of banana as compared to drip irrigation without fertigation. The average yield contributing characters like length of fingers (23.0 cm), girth of fingers (13.17

Table 2. Yield and yield contributing characters as influenced by water soluble fertilizers on banana.

Treatment	Finger length (cm)	Finger girth (cm)	No. of hands/ bunch	No. of fingers/ bunch	Bunch weight (kg)	Yield (t ha^{-1})
100% WSF(A)	22.6	12.98	8.33	144.6	17.81	79.17
80% WSF(A)	21.9	12.77	8.11	138.6	16.27	72.32
60% WSF(A)	21.2	12.17	7.44	130.4	15.26	67.82
100% WSF(B)	23.0	13.17	8.33	147.6	18.66	82.94
80% WSF(B)	21.9	12.72	8.11	140.2	17.02	78.99
60% WSF(B)	21.7	12.16	7.56	134.1	15.90	70.67
100% CF (NTD)	22.3	12.64	8.00	140.2	17.10	74.31
100% CF + DI	21.2	12.22	8.00	134.7	15.69	69.71
100% CF + SI	20.2	10.65	7.56	126.1	12.92	57.40
CD at 5%	1.12	0.81	N.S.	10.01	0.64	6.02

cm) and bunch weight (18.66 kg) were observed maximum in treatment T_4 where 100% WSF fertilizers were applied in 18 splits as per growth stages of crop. However, the values in respect of number of hands and number of finger per bunch (8.33 and 147.6) in treatment T_4 were on par with treatment T_1 (100% WSF in uniform 16 splits at an interval of 15 days), T_5 (80% RD as WSF in 18 splits as per growth stages) and T_2 (80% WSF in uniform 16 splits at an interval of 15 days) but, significantly superior over all other treatments. The values of yield contributing characters recorded in T_7 (Only 'N' through drip) were also sizably high and were on par with T_4.

The banana yield data (Table 2) pooled over three years was found to be ranged between 57.40 to 82.94 t/ha. Among various treatments, the highest average yield of 82.94 t/ha of banana was recorded in treatment T_4 where 100% WSF fertilizers were applied in 18 splits as per growth stages of crop. It was at par with T_1 (100%WSF in uniform 16 splits at an interval of 15 days) and T_5 (80% RD as WSF in 18 splits as per growth stages) but was significantly superior over all other treatments. The minimum yield of 57.40 t/ha was obtained in surface method of irrigation (T_9). The reasons of low yield in surface irrigation might be that crop had to undergo water stress between two irrigations. The drip method resulted into 14.20% increase in yield as compared to conventional method of irrigation; whereas, 100% and 60% fertigation and only 'N' through drip treatments resulted into 46.22, 17.88 and 25.39% increase in yield respectively, over conventional method. The results are in conformity with Srinivas and Raghupathi (14).

The banana yield obtained under T_7 (only N applied through drip) was 74.31 t/ha indicated that incurring slightly more cost, yield of banana can be increased sizably by applying only urea through drip irrigation for banana. The yield obtained in the treatment of drip with conventional method of fertilizer application (T_8) was 69.71 t/ha. It was on par with T_6 and T_3 (70.67 and 67.82 t/ha, respectively) where only 60% recommended dose was applied in the form of WSF through drip. It indicated that fertigation saved 40% fertilizer quantity. Dahiwalkar *et al.* (5) also reported saving in fertilizer and increase in yield due to fertigation in banana.

The TSS, pulp: peel ratio, acidity and organoleptic scores were observed to be improved due to drip and fertigation significantly as compared to conventional method of irrigation (Table 3). The maximum TSS (21.34%), pulp: peel ratio (2.55) and minimum acidity (0.32%) were recorded in treatment T_4 (100% WSF in 18 splits as par crop growth stages). However, the values were at per with T_1 and T_5. Application of fertilizers as per growth stages also had a positive effect on TSS content. It is observed that as the fertilizer level increased, TSS content also increased. Acidity decreased with increase in fertilizer level. Increased moisture stress in surface irrigated treatments resulted into increased acidity of fruit.

From the data it is also observed that treatment T_4 was superior to other treatments in colour and appearance, flavour, texture, taste, and overall acceptability. The fruits from T_4 treatment were found soft in texture and uniform in ripening. Regarding taste of fruit the T_4 treatment fruits (8.05) were sweeter than all other treatments and T_9 (6.85) treatment fruits had a little acidic flavour. The reasons for low quality of fruits in surface irrigation might be the high application of irrigation water leached down the nutrients below

Table 3. Quality of banana as influenced by different drip-fertigation treatments.

Treatment	TSS (%)	Acidity (%)	Pulp: peel ratio	Colour and appearance*	Flavour*	Texture*	Taste*	Overall acceptability*
100% WSF(A)	20.84	0.33	2.48	7.90	8.15	8.25	8.00	7.85
80% WSF(A)	20.33	0.35	2.48	7.45	8.10	8.00	7.75	7.60
60% WSF(A)	20.00	0.36	2.47	7.35	7.90	7.85	7.40	7.55
100% WSF(B)	21.34	0.32	2.55	8.15	8.25	8.20	8.05	8.05
80% WSF(B)	20.67	0.36	2.53	7.65	8.10	7.95	7.85	7.80
60% WSF(B)	20.67	0.36	2.49	7.55	8.10	7.75	7.65	7.55
100% CF (NTD)	20.33	0.33	2.48	7.80	7.95	7.80	7.75	7.60
100% CF + DI	20.17	0.35	2.46	7.80	7.55	7.85	7.20	7.35
100% CF + SI	18.00	0.37	2.43	7.40	7.30	7.65	6.85	6.80
CD at 5%	1.09	0.013	0.43	NS	NS	NS	NS	NS

*Score value

the root zone of crop. Similar result trends were also reported by Deolankar and Firke (6).

The drip method of irrigation resulted into lowest water requirement (1192.60 mm) as compared to surface method of irrigation (2170.93 mm) and thus resulted into 45.3% water saving (Table 4). The 100% recommended dose of fertilizer applied through drip resulted into 46.22% increase in yield with 45.3% water saving, whereas only drip (without any fertigation) resulted into 22.8% increase in banana yield with similar water saving. The treatment T_6 (60% WSF in 18 splits) resulted into 24% increase in yield with 40% saving in fertilizer and 45.3% saving in water. The drip irrigation and fertigation treatments resulted into higher values of water use efficiency (60.8 to 71.7 kg/ ha-mm) as compared to surface method of irrigation (26.90 kg/ha-mm). The water use efficiency was increased to the tune of 2.26 times than conventional method. This is in confirmation with the findings of Agrawal and Agrawal (1) that drip can increase the crop yield in addition to water savings.

Hence, it can be concluded from the present investigation that drip fertigation at 80% of recommended dose of water soluble fertilizers in 18 fortnightly splits as per schedule B through drip irrigation is useful to banana growers in increasing the yields, saving the fertilizers and water.

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Table 4 Water use of banana (average of three years 2007-2010) as influenced by different treatments.

Treatment	Water applied (mm)	Effective rainfall (mm)	Total water use (mm)	FWUE (kg/ha-mm)	Water saving over control (%)	Increase in yield over control (%)
100% WSF(A)	1083.30	109.30	1192.60	66.4	45.43**	39.63*
80% WSF(A)	1083.30	109.30	1192.60	60.6	45.43	27.74
60% WSF(A)	1083.30	109.30	1192.60	56.8	45.43	19.37
100% WSF(B)	1083.30	109.30	1192.60	69.5	45.43	46.22
80% WSF(B)	1083.30	109.30	1192.60	66.2	45.43	39.36
60% WSF(B)	1083.30	109.30	1192.60	59.2	45.43	24.51
100% CF (NTD)	1083.30	109.30	1192.60	62.3	45.43	30.84
100% CF + DI	1083.30	109.30	1192.60	58.4	45.43	22.81
100% CF + SI	1986.67	184.27	2170.93	26.4	--	--

*Increase in yield over T_9, **Saving in water over T_9

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