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Effect of Subsurface Drip Fertigation on Growth and Yield of Banana

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Field experiment was carried out during 2009-2010 and 2010-2011 at Agricultural College and Research Institute, Madurai. There were nine treatments replicated thrice in RBD using banana cv. G9 as test crop. The results indicated that the growth, yield attributes, fruit yield and quality characters were higher under the fertigation treatment with the application of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc @25 kg / ha as soil application. However this was on par with application of 100 per cent RDF where in 50 per cent of P and K were applied as basal and the remaining NPK applied as WSF through drip. Surface irrigation with soil application of fertilizers accounted for lesser growth, yield attributes, fruit yield and quality characters when compared to drip irrigation with fertigation. Surface irrigation accounted for higher total water use of 2099 mm where as drip irrigation accounted for only 1665 mm resulting in a saving of 21 per cent. Higher water use efficiency, water productivity, net income and B:C ratio were recorded under drip fertigation of 100 per cent RDF wherein 50 percent of P and K applied as basal and the remaining NPK applied through drip along with soil application of 25 kg of sulphozinc / ha.

Key words: Banana, subsurface drip fertigation, water soluble fertilizers,water productivity

Subsurface drip system is potentially more efficient in arid and semi arid regions of India because it provides water directly to the root zone, minimizing evaporative losses. In subsurface drip irrigation system, inline drippers are placed below the ground surface to conserve water, control weeds and minimize runoff (Longo Dominic and Thomos Spears, 2003). Subsurface drip irrigation has the inherent advantage of securing system safety against pilferage, damage by animals and farm machinery during intercultural operations. Further, under subsurface drip irrigation, when fertigation is combined, nutrient use efficiency could be as high as 90 per cent compared to 40- 60 per cent in conventional fertilizer application methods (Bar-Yosef, *et al.,* 1989). Adoption of subsurface drip fertigation system may also help in increasing yields and quality parameters due to improved irrigation, nutrients and energy use efficiencies.

India is the largest producer of banana in the world with the production of 97.38mt of banana from an area of 8.25 mha. Among the horticultural crops, banana contributes the maximum to the agricultural gross domestic product (GDP) of India to the tune of 1.99 per cent (Palwe *et al*., 2007). Balanced nutrient management is the key to achieve the required crop yield in an efficient, economical and sustainable manner. This may indicate that the need for the application of different nutrients at specific times, in a particular order to derive the maximum benefit from the application of a given quantity of nutrients.

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Banana being a gross feeder requires high amount of nutrients for proper growth, development and optimum production. Subsurface drip irrigation has tremendous potential in enhancing the banana productivity. But specific studies on amount of irrigation water and depths of placement of drip lateral for banana crop under subsurface drip irrigation do not appear to have caught the attention of researchers' so far. Hence, this experiment was planned to study the effect of subsurface drip fertigation on growth, yield and quality of banana

Materials and Methods

Field experiment was conducted at Agricultural College and Research Institute, Madurai during 2010 and 2011 to study the effect of subsurface drip fertigation on growth, yield and quality of banana cv. G9. The soil of the experimental field comes under Madukkur series, a member fine loamy mixed, Isohyperthermic family of *Typic Haplustalf*. The texture of soil was sandy clay loam with cation exchange capacity of 19.5 cmol (p^+) kg^{-1}. The pH was 7.4 with EC of 0.48 dS m^{-1}. The organic carbon content was 0.36 per cent. The available N, P and K were 165, 8.9 and 170 kg ha^{-1} respectively.

The field was uniformly leveled and the trenches were dug to a depth of 30 cm at 120×60 cm spacing.

The same trenches were closed after laying the laterals at 25 cm depth. Then, the pits were dug for planting of G9 seedlings at 180 cm distance in between the two laterals running at 60 cm apart. The drip laterals had inline emitters spaced at 30 cm apart and the discharge rate of each emitter was 1.44 liters per hour. Mini fertigation cans were fixed at the head of each lateral. Subsurface drip irrigation was scheduled at 100 per cent PE once in three days and fertigation was given once in six days starting from 15 days after planting to 300 days after planting. For surface method, irrigation was scheduled at 5.0 cm depth with IW / CPE ratio of 0.8. The irrigation water quality was neutral and non saline with safer limits of SAR and RSC values.

The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of F_1 - Soil application of recommended P and K and N through drip ; F_2 - 50% RDF -50% P and K as basal remaining NPK as WSF through drip ; F_3 - 75% RDF -50% P and K as basal remaining NPK as WSF through drip ; F_4 - 100% RDF -50% P and K as basal, remaining NPK as WSF through drip ; F_5 - F_1 + sulphur @25 kg as soil application ; F_6 - F_2 + sulphur @25 kg as soil application ; F_7 - F_3 + sulphur @25 kg as soil application ; F_8 - F_4 + sulphur @25 kg as soil application ; F_9 - Surface irrigation with soil application of recommended NPK ;

Note:

Water Soluble Fertilizers (WSF) - Urea, 28:28:0 and KNO_3

Fertigation 15 days onwards once in 6 days

Recommended Fertilizer dose (RDF) - 200:35:300 g/plant

Results and Discussion

Growth parameters

In banana, plants with moderate height and more girth are desirable as these traits reflect on the bunch size and other related characters, apart from providing better anchorage. Application of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc@25 kg/ ha as soil application and application of 100 per cent RDF wherein 50 per cent of P and K were applied as basal and the remaining NPK applied as WSF through drip were comparable and recorded higher psuedostem height and psuedostem girth of banana (Table 1). Higher frequency of irrigation and increased availability of soil moisture under subsurface drip fertigation might have led to effective absorption and utilization of available nutrients and better proliferation of roots resulting in quick canopy growth. The banana crop under drip irrigation system performed better in plant growth and flowered earlier in comparison with surface irrigation (Ahmed *et al*., 2010).

Table 1. Effect of subsurface drip fertigation on growth of G_9 Banana

Treatment	Height at harvest (cm)		Girth of psuedostem at harvest (cm)	
	2010	2011	2010	2011
F_1 - Soil application recommended P and K, N through drip	184.5	196.6	75.6	70.7
F_2 - 50% RDF -50% P and K as basal remaining NPK as WSF through drip	180.3	185.5	69.2	64.3
F_3 -75% RDF -50% P and K as basal remaining NPK as WSF through drip	192.6	203.5	76.5	74.2
F_4 -100% RDF -50% P and K as basal, remaining NPK as WSF through drip	206.0	215.1	83.8	79.8
F_5-F_1 + sulphur @25 Kg as soil application	189.9	200.2	75.4	72.1
F_6-F_2 + sulphur @25 Kg as soil application	182.3	191.3	71.0	68.8
F_7-F_3 + sulphur @25 Kg as soil application	198.8	206.0	80.3	75.4
F_8-F_4 + sulphur @25 Kg as soil application	208.9	217.4	85.5	80.4
F_9-Surface irrigation with soil application of recommended NPK	166.0	171.6	66.7	60.1
SEd	10.3	9.3	6.8	3.4
CD (P=0.05)	20.5	18.7	13.6	6.8

In case of soil application of fertilizers with furrow irrigation, fertilizers were applied on a wider area, which has resulted in faster depletion of nutrients from the rhizosphere. Further, the faster rate of infiltration in furrow irrigation has resulted in water deficit, which might have led to many changes in plant anatomy, such as decrease in cell size and intercellular spaces, limiting cell division and elongation that had reflected in restricted plant growth (Guinn *et al*., 1981 and Aruna *et al.,* 2007).

Yield attributes

The yield attributing characters like number of hands and number of fingers per bunch were significantly higher under subsurface drip fertigation of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc@25 kg/ha as soil application. In the present study, the superiority of fertigation treatments was obvious from the dramatic increase in finger weight also. Among the treatments, subsurface drip fertigation of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc@25 kg/ha as soil application produced higher finger weight. Higher values of these yield

Table 2. Effect of subsurface drip fertigation on yield attributes of G_9 Banana

Treatment	No. of hands per bunch (No.)		No. of fingers per bunch (No.)		Average weight of finger (g)	
	2010	2011	2010	2011	2010	2011
F_1 - Soil application of recommended P and K, N through drip	8.4	8.3	126.6	122.4	162.9	160.1
F_2 - 50% RDF -50% P and K as basal remaining NPK as WSF through drip	8.9	8.9	131.2	127.5	165.9	162.4
F_3 - 75% RDF -50% P and K as basal remaining NPK as WSF through drip	9.1	9.1	136.1	132.8	170.3	168.2
F_4 - 100% RDF -50% P and K as basal, remaining NPK as WSF through drip	9.8	9.8	144.8	145.0	175.6	173.5
F_5 - F_1 + sulphur @25 kg as soil application	8.5	8.4	127.9	124.0	163.9	160.5
F_6 - F_2 + sulphur @25 kg as soil application	9.0	8.9	132.1	130.2	167.0	165.0
F_7 - F_3 + sulphur @25 kg as soil application	9.3	9.3	136.9	133.6	171.7	169.7
F_8 -F_4 + sulphur @25 kg as soil application	9.9	10.0	145.4	146.2	176.5	175.0
F_9- Surface irrigation with soil application of recommended NPK	8.1	59.9	120.2	118.9	155.6	153.8
SEd	0.2	0.2	4.5	4.5	7.7	7.5
CD (P=0.05)	0.3	0.4	9.1	9.0	15.4	14.9

attributes were due to satisfactory supply of nutrients at critical growth stages of banana crop. These observations are in agreement with Palwe *et al.* (2007) and Jeyabaskaran *et al.* (2003).

Application of 150 per cent of potassium as sulphate of potash in 4 splits (2,4,6 and 8 months after planting) recorded the highest bunch characters such as number of hands, total number of fingers per bunch, finger length, finger circumference, finger weight and pulp : peel ratio as reported by Ramesh Kumar and Kumar (2008) is also concomitant to the present finding.

Bunch yield

Subsurface drip fertigation significantly enhanced the fruit yield of banana. Among the treatments, fertigation of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc@25 kg/ ha as soil application recorded the highest bunch yield. However this was on par with application of 100 per cent RDF where in 50 per cent of P and K were applied as basal and the remaining NPK applied as WSF through drip. This yield increase can be attributed to significantly higher number of hands and fingers per bunch and bunch weight per

Table 3. Effect of subsurface drip fertigation on bunch yield and fruit quality of G9 Banana

Treatment	Fruit yield (t/ha)		TSS (%)	
	2010	2011	2010	2011
F_1 - Soil application recommended P and K, N through drip	53.7	52.3	20.7	20.2
F_2 - 50% RDF -50% P and K as basal remaining NPK as WSF through drip	58.3	57.3	21.5	21.4
F_3 - 75% RDF -50% P and K as basal remaining NPK as WSF through drip	62.4	60.5	22.4	22.3
F_4 - 100% RDF -50% P and K as basal, remaining NPK as WSF through drip	71.2	69.2	23.5	23.5
F_5 - F_1 + sulphur @25 Kg as soil application	56.4	55.7	21.0	21.0
F_6 - F_2 + sulphur @25 Kg as soil application	60.7	58.7	21.8	21.6
F_7 - F_3 + sulphur @25 Kg as soil application	64.8	62.8	22.7	22.5
F_8 - F_4 + sulphur @25 Kg as soil application	72.2	71.0	23.7	23.7
F_9 - Surface irrigation with soil application of recommended NPK	50.2	49.5	20.2	20.2
SEd	2.9	2.7	1.2	1.1
CD (P=0.05)	5.81	5.8	5.3	2.3

plant in subsurface drip fertigation over surface irrigation with soil application of recommended dose of fertilizers. Similarly, the beneficial effect of drip fertigation in increasing bunch yield was reported in tissue cultured Grand Naine banana by Soumya *et al*. (2008) and Gaikwad *et al.* (2010).

Fruit quality

A marked effect on fruit quality was observed in the present study due to fertigation levels. The fruit quality parameter viz., total soluble solids (TSS) was maximum under drip fertigation of 100 per cent recommended dose of fertilizers (RDF) in which 50 per cent of P and K was applied as basal and the remaining NPK as WSF through drip along with sulphozinc @25 kg/ha as soil application (Table 4). This increase in TSS might be due to accumulation of sugar and other soluble components from hydrolysis of protein and oxidation of ascorbic acid. These observations are in conformity with those of Natesh Beena *et al.* (1993) and Tirkey *et al.* (2003). Better fruit quality can be explained by the role of potassium which is involved in carbohydrate synthesis, breakdown and translocation and synthesis of protein and neutralization of physiologically important organic acids (Tisdale *et al*., 1966).

Water use studies

Subsurface drip irrigation is an efficient method to deliver water and nutrients to the root zone of plants because water is directly applied in subsoil layer to the effective root zone of crop. Since the loss of water was minimum, the water requirement was

Table 4. Effect of treatments on water use efficiency, water productivity and economics

Treatment	Total water used (mm)		WUE (kg $ha^{-1}mm^{-1}$)		Water productivity (Rs. ha^{-1} mm^{-1})		Net income Rs.ha^{-1}		B:C Ratio	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
F_1 - Soil application of recommended P and K, N through drip	1665	1600	32.2	32.7	193.5	228.6	207972	286592	2.8	4.6
F_2 - 50% RDF -50% P and K as basal remaining NPK as WSF through drip	1665	1600	35.0	35.8	210.2	250.7	244015	330208	3.3	5.7
F_3 - 75% RDF -50% P and K as basal remaining NPK as WSF through drip	1665	1600	37.5	37.8	224.8	264.5	264565	348433	3.4	5.7
F_4 - 100% RDF -50% P and K as basal, remaining NPK as WSF through drip	1665	1600	42.8	43.3	256.7	302.8	313245	405219	3.7	6.1
F_5 - F_1 + sulphur @25 Kg as soil application	1665	1600	33.9	34.8	203.3	243.7	223364	309792	2.9	4.9
F_6 - F_2 + sulphur @25 Kg as soil application	1665	1600	36.5	36.7	218.9	256.9	257549	338608	3.4	5.7
F_7 - F_3 + sulphur @25 Kg as soil application	1665	1600	38.9	39.3	233.3	274.8	277654	363763	3.5	5.8
F_8 - F_4 + sulphur @25 Kg as soil application	1665	1600	43.4	44.4	260.1	310.6	318117	416969	3.8	6.2
F_9 - Surface irrigation with soil application of recommended NPK	2099	2040	24.2	23.7	144.9	169.9	208894	286135	3.2	5.7

less in the subsurface drip irrigation system compared to surface irrigation (Table 4). The increased water use efficiency and water productivity recorded under subsurface drip fertigation system was mainly due to better performance of the crop and increased yield by effective utilization of available water and nutrients that were supplied at regular intervals throughout the crop period to meet the crop demand. Regarding total water used under drip and surface irrigation indicated that there was a saving of 440 mm of water under drip irrigation accounting for 21%. The net income and B:C ratio worked out for different treatments showed that100% recommended dose of fertilizer (RDF) in which 50 percent of P and K was applied as basal and the remaining NPK as water soluble fertilizers through drip irrigation along with sulphur @25 kg ha^{-1} as soil application registered higher net income and B:C ratio. An increased WUE under drip fertigation was reported by Muralidhar (1999) and Bangar and Chaudhari (2004).

Conclusion

The study revealed that subsurface drip fertigation of 100% RDF wherein 50% P and K applied as basal and the remaining as WSF starting from 6 to 300 days after planting along with sulphur @25 kg ha^{-1} as soil application registered higher fruit yield, net income, B:C ratio, WUE and water productivity in banana.

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