Enhancing Growth, Yield and Quality of Banana through Subsurface Drip Fertigation

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Abstract **-** Field experiment was carried out during 2010-2011 at Water Management block, Agricultural College and Research Institute, Madurai, Tamil Nadu, India using banana as test crop. Subsurface drip fertigation of 100 per cent recommended dose of fertilizers (50% P and K as basal, remaining N, P and K as water soluble fertilizers)+liquid bio fertilizers and subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13,KNO_3)+ liquid bio fertilizers were equally effective in increasing growth and physiological parameters of banana. The highest bunch yield, quality parameters and water use efficiency of banana were recorded in subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13,KNO_3)+ liquid bio fertilizers compared to surface irrigation with soil application of recommended dose of fertilizers. It is desirable to maintain more than 3.90, 0.38 and 4.50 per cent NPK respectively in leaf at shooting stage to obtain a higher yield from banana.

Keywords **-** Banana, subsurface drip fertigation, fruit quality, water use efficiency

I. Introduction

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 [6]. 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 [2]. 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 97.38 metric tonnes of banana from an area of 8.25million hectares. Among the horticultural crops, banana contributes maximum to the agricultural gross domestic product (GDP) of India to the tune of 1.99 per cent [7]. Balanced nutrient management is the key to increased plant use efficiency and 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. 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.

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II. Materials And Methods

Field investigation was carried out to evaluate the performance of water soluble and liquid bio fertilizers on banana crop under sub surface drip fertigation system. The field was uniformly leveled and trenches were dug to a depth of 25 cm at 120 x 60 cm spacing. After laying the drip laterals at 25 cm depth the trenches were closed. Then the pits were dug for planting of Rasthali suckers at 180 cm distance in between the two laterals running at 60 cm apart. The planting of suckers was done and irrigation and fertigation schedules were carried out as per the treatments and surface irrigation was given based on IW/CPE ratio of 1.0 with a depth of irrigation at 5 cm. Drip irrigation was given once in three days based on evapotranspiration and fertigation was planned once in six days upto 300 days.. The liquid bio fertilizers were also applied as per the treatment schedule.

The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments consisted of

T_1 - Surface irrigation with soil application of RDF

T_2 - Subsurface drip fertigation of 100% RDF (P as basal, N&K through drip as urea & white potash)

T_3 - Subsurface drip fertigation of 100% RDF as WSF (WSF – urea, 13:40:13, KNO_3)

T_4 - Subsurface drip fertigation of 100% RDF (50% P&K as basal, remaining NPK as WSF)

T_5 - Sub surface drip fertigation of 75% RDF +LBF (P as basal N&K through drip as urea and white potash)

T_6 - Subsurface drip fertigation of 75% RDF as WSF + LBF (WSF- urea, 13:40:13, KNO_3)

T_7 - Subsurface drip fertigation of 75% RDF + LBF (50% P&K as basal remaining NPK as WSF)

T_8 - T2+ LBF
T_9 - T3 + LBF
T_{10} -T4 + LBF
T_{11} -Subsurface drip fertigation with no inorganic + LBF
NOTE:

- Recommended dose of fertilizer (RDF) : 200:35:330 gm NPK/plant
- Source of P : Di ammonium phosphate and 13: 40: 13
- Source of K : White potash and KNO_3
- Source of water soluble fertilizers (WSF): Urea, 13:40:13 and KNO_3
- Liquid bio fertilizers (LBF) : Azospi, Phophofix and Potash Activa @ 2.5 litres/ha each at 2nd, 3rd 4th, 5th and 6th months

III. Results And Discussion

A. Growth and Physiological Characters

In banana plants, moderate height and more girth are desirable as these traits reflect on the bunch size and other related characters, apart from providing better anchorage. Subsurface drip fertigation of 100 per cent recommended dose of fertilizers (50% P and K as basal, remaining N, P and K as water soluble fertilizers) + liquid bio fertilizers and subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13, KNO_3) + liquid bio fertilizers were comparable and recorded higher pseudostem height and pseudostem girth of banana (Table I). The leaf area index, chlorophyll and specific leaf weight plays an important role in photosynthetic activity, as they intercept more of radiant energy from sunlight. The highest leaf area index, chlorophyll content and specific leaf weight were recorded in subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13, KNO_3) + liquid bio fertilizers (Table I). 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 and physiological parameters [4] ,[5].

TABLE I
EFFECT OF SUBSURFACE DRIP FERTIGATION LEVELS ON GROWTH AND PHYSIOLOGICAL CHARACTERS OF BANANA

Treatments	Pseudostem height (cm)	Pseudostem girth (cm)	Leaf area index	chlorophyll-SPAD	Specific leaf weight (mg cm^{-2})
T_1	200.38	58.34	3.16	45.43	0.056
T_2	211.96	60.80	3.74	47.26	0.085
T_3	228.53	67.16	4.30	47.33	0.067
T_4	211.86	63.95	4.20	46.47	0.084
T_5	226.20	60.35	3.68	46.70	0.068
T_6	220.70	62.63	3.82	48.10	0.076
T_7	215.33	59.82	3.91	46.84	0.057
T_8	223.09	61.60	4.39	51.28	0.091
T_9	234.63	69.89	4.75	52.40	0.095
T_{10}	228.68	65.28	4.47	48.55	0.088
T_{11}	198.38	52.50	2.79	42.30	0.046
SE d	6.22	1.96	0.11	1.80	0.0019
CD(P=0.05)	12.98	4.10	0.23	3.76	0.0040

B. Bunch Yield

The bunch yield ranged from 11.45 to 44.51 t/ha in the present investigation (Table II). Among the treatments, subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13,KNO3)+ liquid bio fertilizers recorded the highest bunch yield (44.51 t ha-1) which accounted to 115 per cent yield increase over surface irrigation with soil application of recommended dose of fertilizers. This was followed by subsurface drip fertigation of 100 per cent recommended dose of fertilizers (50% P and K as basal, remaining N, P and K as water soluble fertilizers)+liquid bio fertilizers. This yield increase can be attributed to significantly higher number of hands and fingers per bunch and bunch weight per plant in subsurface drip fertigation over surface irrigation with soil application of recommended dose of fertilizers. The distinctive yield advantage reflected in subsurface drip fertigation treatments was further amplified by the application of liquid biofertilizers through drip irrigation water. Similarly, the direct beneficial effects of Azospirillum with recommended dose of fertilizers in increasing bunch yield was reported in tissue cultured Grand Naine banana [3].

C. Fruit Quality

In high value crops like banana, quality standards have become the most important factor influencing monetary yield. The fruit quality parameters like total soluble solids (TSS), ascorbic acid and sugar content were maximum in subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13,KNO3)+ liquid bio fertilizers (Table II). Higher fruit quality especially higher sugar content 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 [9].

TABLE II
.EFFECT OF SUBSURFACE DRIP FERTIGATION LEVELS ON YIELD, FRUIT QUALITY AND WATER USE OF BANANA

Treatments	Bunch yield (t/ha)	TSS (^{o}brix)	Ascorbic acid (mg/100g)	Total sugar (%)	Total water use (mm)	Water use efficiency (Kg/ ha/ mm)
T_1	20.73	23.66	15.10	21.49	2203.4	9.40
T_2	30.25	24.35	16.47	22.15	1884	16.05
T_3	41.85	24.98	17.79	22.79	1884	22.21
T_4	35.15	24.28	15.32	22.10	1884	18.65
T_5	27.06	24.01	15.40	21.82	1884	14.36
T_6	34.16	24.39	16.36	22.18	1884	18.13
T_7	31.58	24.04	15.25	21.84	1884	16.76
T_8	31.36	22.24	16.52	21.99	1884	16.64
T_9	44.51	26.07	18.42	23.77	1884	23.62
T_{10}	37.67	25.68	17.55	23.45	1884	19.99
T_{11}	11.45	23.55	16.27	21.36	1884	6.07
SE d	1.21	0.61	0.69	0.75		
CD(P=0.05)	2.51	1.28	1.44	1.57		

D. 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 less in the subsurface drip irrigation system compared to surface irrigation (Table II). The increased water use efficiency 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.

E. Leaf NPK

In general, there was an increase in leaf NPK contents in all the treatments up to shooting and thereafter the values declined (Fig. 1, 2, 3). This shows a heavy loading of NPK in leaves during vegetative and shooting stage followed by a decrease in the concentration due to rapid increase in dry matter caused by faster growth of banana crop. It was further observed that the content of NPK was always higher when drip fertigation is integrated with liquid biofertilizers. Figures (1,2,3) illustrate that it is desirable to have more than 3.90, 0.38 and 4.50 per cent NPK respectively in leaf at shooting stage to obtain a higher yield from banana. Different workers have proposed different critical levels of nutrients in third leaf of banana which range from 1.80 to 4.0 per cent for N, 0.17 to 0.29 per cent for P [1] and 1.66 to 5.40 per cent for K [8].

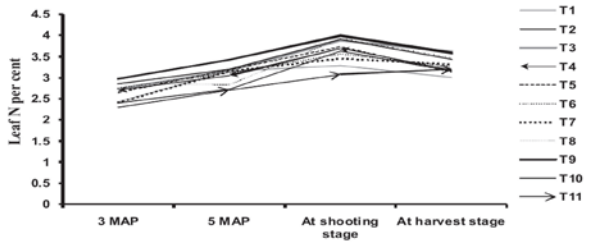

Fig. 1. Effect of subsurface drip fertigation levels on leaf N content of banana

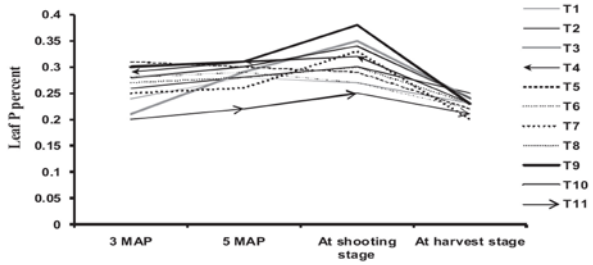

Fig. 2. Effect of subsurface drip fertigation levels on leaf P content of banana

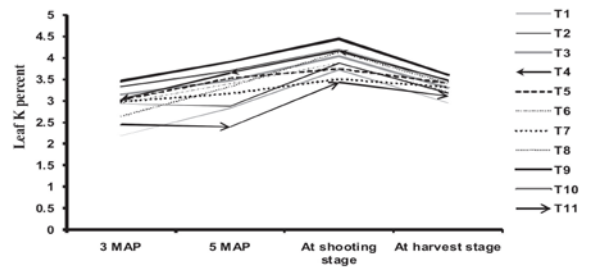

Fig.3. Effect of subsurface drip fertigation levels on leaf K content of banana (MAP-Months after planting)

F. Crop duration

The fertigation treatments were effective in producing relatively early crop by advancing harvest (Table III). In the present investigation, subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO3) + LBF completed the shooting 36 days earlier, harvesting by 14 days, thus, reducing total crop duration by about 50 days (Table 2). The early flowering in subsurface drip fertigation with biofertilizers inoculated plants may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinin to the auxiliary buds resulting in breakage of apical dominance.

TABLE III
EFFECT OF SUBSURFACE DRIP FERTIGATION LEVELS ON CROP DURATION (DAYS) OF BANANA

Treatments	Days to Shooting	Days to Harvest	Crop Duration
T_1	256.3	120.5	376.8
T_2	234.8	113.7	348.5
T_3	228.2	108.8	337.0
T_4	229.3	116.4	345.7
T_5	240.5	119.7	360.2
T_6	238.9	114.6	353.5
T_7	251.4	120.2	371.6
T_8	232.8	112.5	345.3
T_9	220.5	106.2	326.7
T_{10}	224.7	109.9	334.6
T_{11}	260.5	125.3	385.8
SE d	8.15	3.03	11.73
CD(P=0.05)	17.02	6.30	24.47

V. CONCLUSION

The study clearly revealed that subsurface drip fertigation of 100 per cent recommended dose of fertilizers (Urea, 13:40:13,KNO3)+ liquid bio fertilizers at six days interval is an ideal practice in enhancing many of the growth, yield attributes, fruit quality and yield of banana. The next best alternative for getting higher yield is subsurface drip fertigation of 100 per cent recommended dose of fertilizers (50% P and K as basal, remaining N, P and K as water soluble fertilizers)+liquid bio fertilizers. Owing to water saving, subsurface drip irrigation may also provide an opportunity to bring additional area under cultivation.

ACKNOWLEDGMENT

First author express sincere thanks and gratitude to International Panaacea Ltd., New Delhi for financial support in sponsoring the research project.

REFERENCES

[1] D. E. Angeles, M. E. Summer, and E. Lahav. “Preliminary DRIS norms for banana”. *Journal of Plant Nutrition.*1993.vol.16,pp. 1059-1070.

[2] B. B. Bar-Yosef, Sagiv and T. Markovitch, “Sweet corn response to surface and subsurface trickle phosphorous fertigation”. *Journal of Agronomy.* 1989. vol. 81,pp. 443–447.

[3] R.T. Gaikwad, V.P.Bhalerao, C.V. Pujari and N.M. Patil. "Effect of biofertilizers on nutrient uptake and yield attributes of banana". *An Asian Journal of Soil Science*.2010. vol.4,no.2, pp. 271-274.

[4] H. N. Gayathri, K.V. Jayaprasad and P. Narayanaswamy.2004. "Response of bio-fertilizers and their combined application with different levels of inorganic fertilizers in statice (*Limonium caspia*)". *Journal of Ornamental Horticulture.* 2004. vol.7,no.1, pp. 70-74.

[5] M. Lalitha, M. Karunakar Babu, C. Ravisankar and Y. Ashoka Rani. "Effect of bio regulators on chlorophyll content and keeping quality of betelvine (*Piper bete* L.)". *South Indian Horticulture*.2004, vol.52, no.1-6, pp. 270-276.

[6] F. D. Long Dominic, and Thomos Spears. "Water scarcity and modern irrigation". In: *Valmount-water management groups 7002 north 288 street P.O. Box 358, Vally, NE 68064-0358 USA*, 2003. p.16.

[7] C.R. Palwe, T.D. Patil and B.B. Dhakare. "Effect of different levels of potassium and its application on growth and yield of tissue cultured banana cv.Grand Naine". *The Asian Journal of Horticulture.* 2007,2 (2): 235-238.

[8] Noor-Un-Nisa Memon, Kazi Suleman-Memon, Rahell Anwar, Saeed Ahmad and Muhammad Nafees. "Status and response to improved N P K fertilization practices in banana". *Pakistan Journal of Botany*. 2010. vol.42,no.4, pp. 2369-2381.

[9] S.L.Tisdale, W. Nelson and J.D.Beaton. "*Soil fertility and fertilizers"*. Macmillan publishing company Newyork, 1966.