ENHANCED WATER USE EFFICIENY UNDER DRIP FERTIGATION IN NENDRAN BANANA

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Drip fertigation, water soluble fertilizers, yield, water saving and water use efficiency

ABSTRACT

The present investigation was taken up with an aim to assess the effects of drip fertigation regime with Water Soluble Fertilizer (WSF) for maximizing the fruit yield, water and fertilizer use efficiency of Banana (Nendran). Water soluble fertilizers were tried at three doses viz., 125, 100 and 75% of recommended NPK by drip fertigation. These were compared with drip irrigation and soil application of Normal fertilizers (NF) as well as farmers' practice of surface irrigation and soil application of NF at 100% recommended dose. Banana suckers were planted at 2 x 2 m spacing). Imported water soluble fertilizers viz., Mono Ammonium Phosphate (12:61:00), Polyfeed (19:19:19), Potassium Nitrate (13:00:45) and Urea were tried under fertigation. Drip irrigation was scheduled based on cumulative pan evaporation rates once in 2 days considering the pan and crop co-efficient values at various stages. The crop factor (Kc) values considered were 0.4, 1.2 and 0.8 at planting, bunch development and maturity stages respectively. Fertigation was scheduled once in 2 days with varying forms of fertilizer grades according to nutrient requirement at varying growth stages. Results from the investigation showed that banana responded well to different fertigation regimes on yield and quality. The total water used under drip irrigation once in 2 days was 1153.4 mm while under surface irrigation it was 2200 mm, thus drip irrigation in Nendran banana has resulted water saving of 47.57%. The water requirement of banana was precisely computed and applied as point source of irrigation directly in the rhizosphere, leading to higher yield per unit of water applied. This has resulted higher water use efficiency of 36.97 kg/ha mm compared to surface irrigation (farmers' method) i.e 11.62 kg/ha mm. Among different fertigation regimes, the yield contributing characters of banana were favorably improved at higher fertigation regime (125% dose with WSF) compared to lower regimes of 100 and 75%. Higher number of hands (5.5 per bunch), number of fingers (61.20), finger length (22.58 cm), finger girth (14.21 cm), finger volume (254.40 cc), pulp/peel ratio (4.28) and finger weight (0.275 kg) were registered under higher fertigation regime of 125% NPK with WSF compared to soil application of NF at 100% dose. In terms of banana productivity, maximum fruit yield of 42.65 tonnes per hectare was achieved by drip fertigation with 125% dose which was 66.73 and 40.62 per cent increase over farmers' method (25.58 tonnes per hectare) and drip irrigation with soil application of NF at 100% dose (30.33 tonnes per hectare) respectively. Higher fertigation regime has also given higher net seasonal income of Rs.241393 (US $ 4494 per hectare) over farmer's method (Rs.144714 (US $ 2695 per hectare). It was concluded that drip fertigation with WSF at 125% dose of fertilizer in Nendran banana has resulted higher water saving, fruit yield water and fertilizer use efficiency.

INTRODUCTION

Banana (*Musa sp)* is the fourth most important global food commodity after rice, wheat and milk in terms of gross value of production. Banana is a globally important fruit crop with 97.5 million tones of production. With total annual production of 16.91 million tones from 490.70 thousand ha with national average of 33.5 t/ha. Maharashtra ranks first in production with 60 t/ha. Banana contributes 37% to total fruit production in India. Banana is one of the major and economically important fruit crop of Maharashtra. Banana occupy 20% area among the total area under crop in India. Maharashtra ranks second in area and first in productivity in India. Banana requires plentiful supply of water for higher production. The total ET demand is around 1600 mm. This is of particular importance since the amount of water present in the universe is only about 1520 million cubic kilometers, 97% is ocean

water and sea salt, 2% is frozen arctic waters and only 1% is water lakes, rivers and underground water, which is potable water for direct use to humans (Shaker, 2004).

The efficient use of water is an important under limited water resource condition. Drip irrigation (trickle or micro irrigation) is a promising system for economizing the use of available irrigation water. It is also necessary to manage the available water efficiently for maximum crop production. Drip irrigation can apply water both precisely and uniformly at a high irrigation frequency compared with furrow and sprinkler irrigation, thus potentially increasing yield, reducing subsurface drainage, providing better salinity control and better disease management, since only the soil is wetted whereas the leaf surface stays dry (Hanson and May, 2007). The goal of micro irrigation is to minimize water use and to increase the efficiency of applied fertilizers. Adoption of drip irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency. The drip irrigation once in 2 days at 24 lit/plant has resulted in 41.6 per cent water saving in Tamil Nadu conditions (Anon, 2003). In Karnataka, drip irrigation at 80 per cent of CPE has brought 25% saving in irrigation water. The yield increase in drip irrigation compared to conventional irrigation method varies from 20 to 100 per cent, whereas saving in water ranges from 40 to 70 per cent besides 50 to 60 per cent saving in labour (Sivanappan, 2004).

Fertigation is yet another superior technology to apply of fertilizers through drip irrigation system for achieving higher water and fertilizer use efficiencies. Application of fertilizers through drip irrigation system (fertigation) can reduce fertilizer usage, minimize leaching by rain and excessive irrigation, maximize the fertilizer use efficiency, allows flexibility in timing fertilizer application, and reduces the labour required for applying fertilizer. Increased growth and yield with drip fertigation has been reported in several crops and the yield increase ranged between 7 -112 per cent depending on the crops, varieties and methods of irrigation. The water and fertilizer saving through drip fertigation system have been reported to be 40–70 and 30–50 per cent respectively (Rekha *et al.,* 2008). This study was conducted to determine the effect of drip fertigation on yield of banana, to study water use efficiency and nutrient use efficiency of Banana under drip fertigation in comparison to farmer practice.

MATERIAL AND METHODS

The experimental location selected was in Puttuvikki of Sundakkamuthur village of Coimbatore located 7 km away from TNAU campus on the south western side. The village is having a tank which gets filled up partially during North east monsoon period of Sep to December. The latitude is 11°N and 77°E longitude at an altitude of 427 m above MSL. The average annual rainfall of Coimbatore is 640 mm, received in 47 rainy days. The mean annual maximum and minimum temperatures were 31.4ºC and 21.2ºC. The soil of the experimental field is well drained clay loam medium in available N, high in available P and K. The pH of the soil is moderately alkaline but the Ec is normal. The irrigation water has mild alkaline pH and the EC is normal. The other cations like Ca, Mg, and anions like anions like CO_3 and HCO_3 are in the normal range only.

Treatments : Three Fertigation levels viz.,T_1 - Drip fertigation with WSF at 125% dose once in 2 days T_2 - Drip fertigation with WSF at 100% dose once in 2 days T_3 - Drip fertigation with WSF at 75% dose once in 2 days were compared with T_4 - Drip irrigation + Soil application of NF at 100% dose once in 2 days and T_5 - Conventional irrigation at 1.0 IW/CPE + soil application of NF (Control) at 100% dose. Banana suckers were planted at 2 x 2 m spacing. The 12 mm laterals were laid out at 2 m apart and drippers of 8 LPH at 2 m interval. The laterals were taken off either side from the 40 mm PVC sub main running at centre of the main field. Here the sub main was connected to 63 mm PVC mainline. Each plot was provided with 40 mm flush valve. One ventury was fitted at the field head succeeded with a 2” mesh filter. For banana, fertigation schedules were prepared with different fertilizer grades according to growth stages and requirements of the crop. Computed fertilizers quantities were dissolved at 1.:5 ratio of fertilizer: water and nutrient stock solution was prepared. At every fertigation, drip system was run for wetting as a first step and then fertigation was done and finally flushing was done 5-10 minutes once in 2 days

Irrigation scheduling

Drip irrigation was scheduled based on evaporation rate once in 2 days from the USWB class A open pan evaporimeter. The irrigation water requirement through drip was computed as described here under.

V = 2 days CPE x K_p x K_c x A x W_p
Where,
V - Volume - lit / plant / once in 2 days
CPE - Cumulative pan evaporation once in 2 days
K_p - Pan co-efficient (0.75)
K_c - Crop co-efficient
A - Area (2 x 2 = 4m^2)
W_p - Wetted percentage (40%)

The depth of irrigation thus varied according to evaporation rate and crop factor at initial, crop develop ment, mid-season and late season stages of the crop. Irrigation time was calculated based volume of water to be irrigated in relation to number of emitters per plant and the discharge rate of emitters.

RESULTS AND DISCUSSION

Yield parameters

No. of fingers/ bunch:

Drip fertigation to banana had significant influence on the number of fingers per bunch. Among the treatments, Significantly higher number of fingers / bunch was recorded under drip fertigation with water soluble fertilizers at 125% NPK dose (61.20) and this was on par in drip fertigation with water soluble fertilizers at 100% NPK dose (59.41) as compared to significantly lower no. of fingers / bunch under surface irrigation + soil application of normal fertilizers (47.65). Similarly in second crop, significantly higher number of finger / bunch was observed under drip fertigation with water soluble fertilizers at 125 % NPK dose (59.85) which was on par with drip fertigation with water soluble fertilizers at 100% NPK dose (58.67).

Number of hands/bunch

The number of hands per bunch were significantly influenced by drip fertigation in banana. Drip fertigation with water soluble fertilizers at 125% NPK dose recorded significantly higher no. of hands / bunch (5.50 & 5.42) followed by drip fertigation with water soluble fertilizers at 100% NPK dose (5.30 & 5.05) in both crop respectively. Surface irrigation and soil application were found to be inferior wherein only 4.63 hands/bunch was recorded. The increase in no. of hands /bunch worked out to 18.70% and 14.40% under drip fertigation at 125% and 100% RDF with water soluble fertilizers respectively over surface irrigation with soil application of normal fertilizers.

Finger weight

The maximum finger weight (0.275 & 0.262 kg) were recorded under drip fertigation at 125 % RDF with water soluble fertilizers in both the crop respectively. The minimum finger weight (0.215 & 0.208 kg) were recorded in surface irrigation with soil application of normal fertilizers. (Table 1.)

Table1. Number of fingers / bunch, number of hands / bunch and finger weight as influenced by drip fertigation

Treatments	Number of fingers / bunch		Number of hands / bunch		Finger weight (kg)	
	First crop	Second crop	First crop	Second crop	First crop	Second crop
T1	61.20	59.85	5.50	5.42	0.275	0.262
T2	59.41	58.67	5.30	5.05	0.270	0.255
T3	54.30	53.91	4.83	4.65	0.256	0.245
T4	53.45	53.05	4.15	4.28	0.250	0.232
T5	47.65	46.28	4.63	4.54	0.215	0.208
SEd	1.181	1.24	0.187	0.19	0.003	0.004
CD (0.05)	2.573	2.49	0.407	0.39	0.007	0.009

The increased bunch weight, fruit diameter and length, number of hands per bunch and number of leaves at flowering and at harvest are resulted under drip irrigation over surface irrigation due to better utilization of water and nutrient by application of water and nutrients in small quantities directly in the root zone of crop based on crop requirement. (Srinivas *et al.,* 2001). In surface method of irrigation all yield attributing characters were found minimum compared to drip method (Hedge and Srinivas, 2000)

Bunch weight

Significantly higher bunch weight was recorded under drip fertigation with water soluble fertilizers at 125% NPK dose (17.06 kg & 16.75 kg) and this was on par with drip fertigation with water soluble fertilizers at 100% NPK dose wherein bunch weight was 16.42 kg & 15.81 kg in I and II crops respectively. Next to this drip fertigation with water soluble fertilizers at 75% NPK dose was also superior in registering higher bunch weight. Whereas, lesser bunch weight of 10.23 & 10.05 kg/bunch was recorded in surface irrigation with soil application of normal fertilizers in both the crop respectively. The increase in bunch weight was 66.66 and 57.31 per cent over surface irrigation with soil application of normal fertilizers in both the crop respectively.(Figure 1.). Increased bunch weight under drip irrigation compared with basin irrigation was also associated with the corresponding significant increase in the number of hands, total number of fingers, finger weight, length and circumference and pulp-peel ratio. (Hegde and Srinivas, 1991)

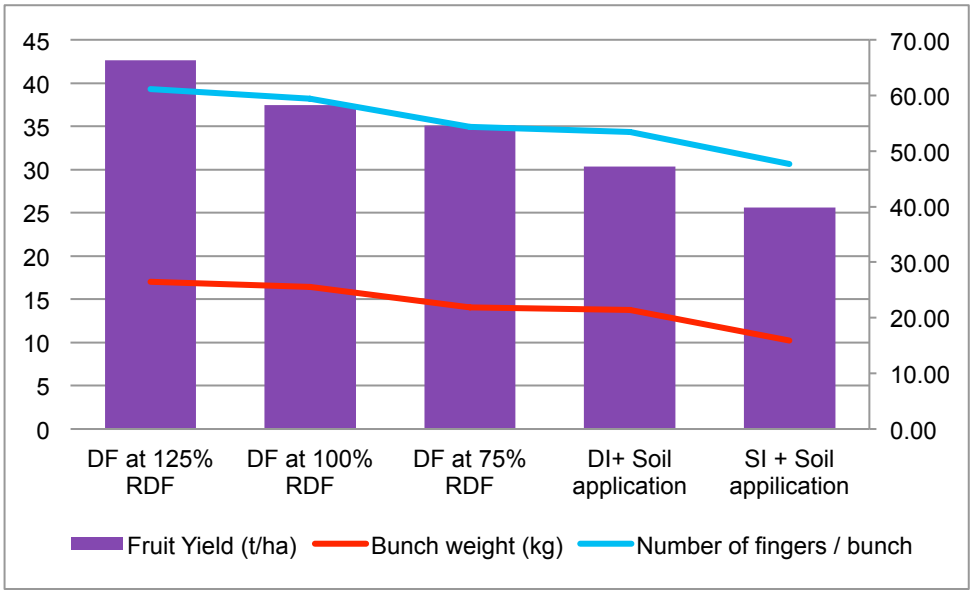

Figure 1. Relationship between fruit yield and yield parameters under drip fertigation in banana

Fruit Yield

Drip fertigation with water soluble fertilizers has excerted significant and favourable influences on fruit yield of Nendran Banana. Significantly higher fruit yield of 42. 65 t/ha and 41.42 t/ha were registered in drip fertigation with water soluble fertilzers at 125% NPK dose in the both crop respectively and next to this drip fertigation with water soluble fertilizers at 100 and 75% doses have registered higher fruit yields in the both crops. Conventional practice of surface irrigation + soil application of 100% normal fertilzers has recorded the lowest yield of 25.58 t/ha and 24.12 t/ha in both the crops respectively. Thus drip fertigation was found to be superior in accounting 66.73 (125 % RDF) and 46.40 (100% RDF) percent increased fruit yield over control in first crop. While, in second crop, similar trend could be seen. (Table 2.). As there is tremendous response to fertilizers applied in banana especially for N & K nutrients, higher dose viz,125% NPK level registered the top most yield under fertigation. The increased banana yield of 41,000 kg/ ha was registered under drip fertigation which was 31% over surface irrigation (Thadchayini and Thiruchelvam, 2005). The surface drip irrigation increased fruit yield of both main and ratoon crop of banana 9.12 and 12.85 per cent, respectively. (Pandey, 2008). It was also observed that the drip method is superior to surface method of irrigation in terms of yield, quality, water saving and cost economics (Pawar *et al.,* 2001).

Table 2. Finger weight and bunch weight in Nendran Banana as influenced by drip fertigation

Treatments	Fruit Yield (t/ha)		Fruit Yield (t/ha)	
	First crop	Yield increase over control (%)	Second crop	Yield increase over control (%)
T1	42.65	66.73	41.42	71.72
T2	37.45	46.40	35.98	49.17
T3	35.08	37.14	34.15	41.58
T4	30.33	18.57	29.56	22.55
T5	25.58	-	24.12	-
SEd	0.63	-	0.58	-
CD (0.05)	1.26	-	1.17	-

Water requirement under drip fertigation

In first crop of banana total water under drip irrigation once in 2 days was 1153.4 mm (drip irrigation requirement + effective rainfall). Under surface irrigation 2200 mm of water was used. In second crop of banana the total water used was 1177.4 mm only as compared to 1950 mm under surface irrigation. Thus water saving was 47.57 and 39.63 percent under drip fertigation compared to surface irrigation in first and second crop respectively (Table 3.). The water saving to the extent of 20% (More *et al.*,1999) 50% in Banana (Pawar *et al.,* 2001) under drip irrigation in Banana was achieved as compared to surface method. Drip irrigation at 80% of evaporation replenishment could bring about nearly 25% saving in irrigation water in banana (Srinivas, 1998).

Table 3. Effect of drip fertigation on water saving in Banana

Treatments	First crop		Second crop	
	Water used (mm)	Water saving (%)	Water used (mm)	Water saving (%)
T1	1153.4	47.57	1177.4	39.62
T2	1153.4	47.57	1177.4	39.62
T3	1153.4	47.57	1177.4	39.62
T4	1153.4	47.57	1177.4	39.62
T5	2200	-	1950.0	-

Water productivity

Drip fertigation is an efficient method to deliver water and nutrients to the root zone of plants because water is directly applied in the effective root zone of crop. Drip fertigation levels had shown profound

influence on water use efficiency in Banana (Figure 2.). The maximum water productivity of 36.97 kg.ha.mm^{-1} and 35.18 kg.ha.mm^{-1} were registered under drip fertigation with water soluble fertilizers at 125% NPK dose in both the crop respectively and followed by drip fertigation with water soluble fertilizers at 100% NPK dose. This indicated that there is an increased response of banana for higher drip irrigation levels. Water productivity was almost doubled under drip fertigation at 75% dose as compared to soil application of fertilizers. The increased water use efficiency recorded under 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. (Bangar and Chaudhari, 2004).

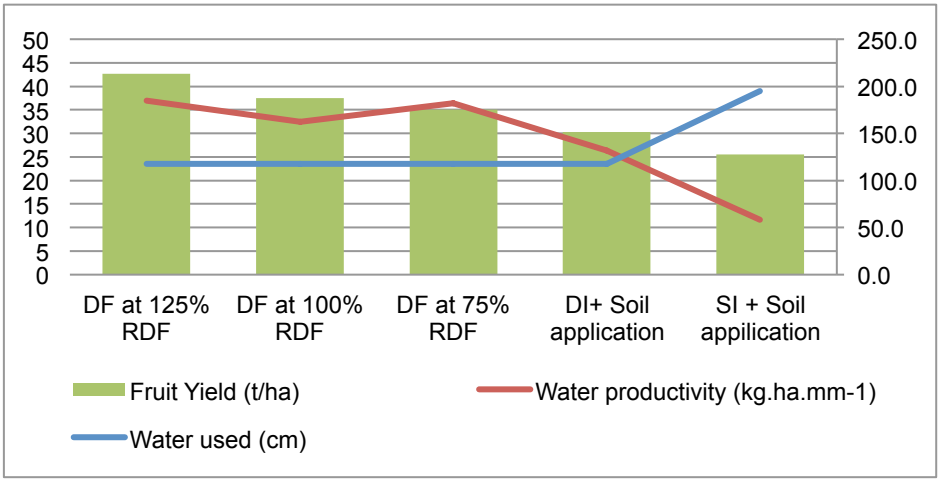

Figure 2. Trend of water requirement, fruit yield and water use efficiency under drip fertigation in banana

Fertilizer productivity as influenced by drip fertigation

In contrast to yield levels, the highest fertilizer productivity (34.646 & 33.728 kg. fruit per kg NPK.ha^{-1}) was associated with drip fertigation with water soluble fertilizers at 75% NPK dose in both crop respectively and followed by drip fertigation with water soluble fertilizers at 100% NPK dose with 27.740 kg fruit per kg NPK.ha^{-1} in Ist crop of banana (Figure 3.). Plants were taller (3%) and flowered 15 days earlier under the drip than the basin irrigation. Fertigation can save from 20% to 50% in fertilizers, while improving the yield and quality as compared with the common methods of fertilizer application (Malakouti, 2004). Application of urea through irrigation system was more efficient than hand broadcasting on soil surface on banana. More yield and significantly higher number of hands per bunch were obtained with fertigation (Arscott, 1970). Fertigation could save soluble fertilizers like urea, sulphate of potash through drip irrigation to the tune of 25% (Srinivas, 1998).

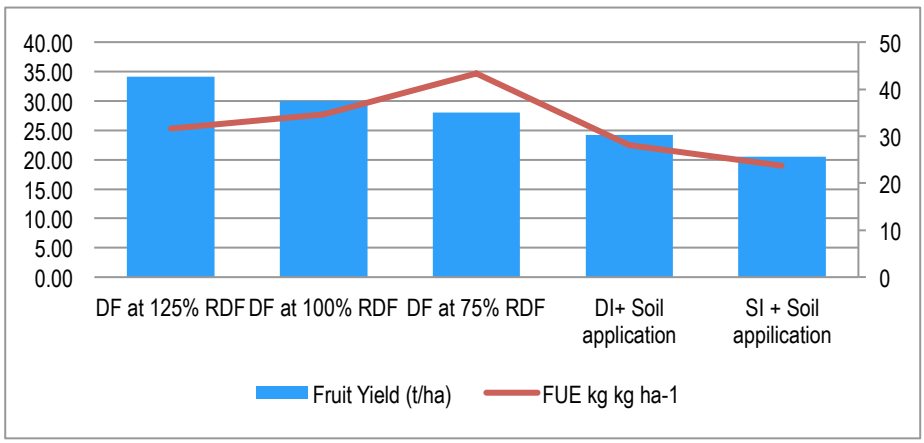

Figure 3. Fruit yield versus fertilizer use efficiency under fertigation in banana

Economic feasibility of drip fertigation in banana

The net income/ha was the highest in drip fertigation with water soluble fertilizers at 125% dose (Rs.241393/ha) followed by Rs.211429 and Rs.202691 under 100 and 75% dose respectively. Obviously lower net seasonal income was obtained under conventional method (Rs. 144741) due to lower yield levels. The economic analysis was proceeded further considering the water saving benefits under drip system. Due to drip irrigation in banana, 47.57 water saving has resulted an additional area coverage of 0.48 ha under drip irrigation. Thus computed gross income from overall area of 1.48 ha was Rs. Rs.472048 under 125% dose as compared to Rs.388264 under 75% dose fertigation level. The marginal benefit : cost analysis showed that due to high cost of water soluble fertilizers drip fertigation at lower dose of 75 % has registered higher extra income per extra rupee invested (4.67 and 4.75) in I and II crops respectively, while it was 4.08 and 4.05 respectively under drip fertigation at 125% dose.

CONCLUSION

Banana is a major cash crop in India, yield and crop quality being critically dependant on supply of water and nutrients. Experiments carried out over two seasons were reported here in which drip fertigation with water soluble fertilizer were compared with drip irrigation with soil application of Normal fertilizers (NF) and farmers' practice of surface irrigation and soil application of NF at 100% recommended dose. It was concluded that drip fertigation with water soluble at 125% were possible to achieve more than two-fold higher water use efficiency, and at the same time reduce fertilizer requirement and raise crop productivity. Bunch yields of banana increased by 35 to 72 percent under drip fertigation with water soluble fertilizers. This was achieved in addition to 25 to 48 percent water saving with higher fertilizer and water use efficiency. Considering the economics affordable farmers could adopt drip fertigation at 125%dose in Nendran Banana for overall higher fruit yield and gross returns, while farmers with resource constraints, 75% dose would be economical.

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