DOI : 10.5958/0974-0112.2020.00034.1

Indian J. Hort. 77(2), June 2020: 254-260

Effect of nitrogen and potassium fertigation on growth, yield, quality and nutrient use efficiency of banana under subtropics

Dinesh Kumar*, Ram Kumar, V. K. Singh, K. K. Srivastava and S. Rajan
ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow 226 101, Uttar Pradesh

ABSTRACT

A field experiment was conducted during 2016-19 to standardize the fertilizer dose and scheduling for growth, yield and quality of banana under subtropical conditions at Research Farm of ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow. The highest mean pseudo stem girth (60.24 cm), leaf area (6.922 m^2) and cumulative fruit yield (94.60 t/ha) were recorded in 100 % recommended dose of fertilizer (RDF) of N and K applied (40:25, 30:35, 30:25, 0.15) at different phenological stages of growth. Whereas, maximum B:C ratio (2.10) and Total Soluble Solids (21.7 ^OB) was recorded in 80 % RDF of N and K applied (40:25, 30:35, 30:25, 0.15) at different stages of growth. Where as, mean nutrient use efficiency ((41.40 tons fruit /tons nutrient) was recorded in 60 % RDF of N and K applied (10:10, 40:20, 30:20, 20:40) at vegetative growth, pre-flowering, flowering and bunch development stage in banana cultivar Grand Naine under subtropical conditions.

Key words: *Musa acuminata,* bunch weight, Grand Naine, pseudo stem.

INTRODUCTION

Banana is one of the important and leading fruit crops of tropical and subtropical region of the country. It is being cultivated over an area of 8.41 lakh hectares with annual production of 291.35 lakh tonnes and productivity is 34.64 t/ha (Anon*,*1). The area under banana cultivation is increasing day by day due to profitability under Subtropical region. It is a nutrient exhaustive crop, need optimum amount of nutrients for quality fruit production (Kumar *et al*., 8). The input cost (water and nutrient requirements) of this crop is much higher than other fruit crops, and these input components are important for sustaining the productivity and quality of banana. The existing traditional management practices (farmers practice) have low input use efficiency in the region. In water scarcity area, the available water resources should be utilized properly through water saving device to maximize the productivity and profitability. For that, drip irrigation is most effective and efficient irrigation technology to supply precise amount of water directly to root zone by saving of water through percolation and seepage losses (Doorenbos *et al*., 3) However, drip irrigation alone could not achieve the desire results without incorporating the level of nutrients.

Fertigation is most effective and less expensive method for fertilizer application through drip irrigation, which satisfies the total and temporal requirements of water and nutrients during critical period of plants growth and development (Pramanik *et al.,*10; Fratoni *et al*., 4). This method of application could also save considerable amount of nutrients and water in comparison to conventional method of fertilizer and irrigation application (Pramanik and Patra, 11). In the subtropical region, the resources poor farmers are generally adopting traditional method of irrigation and nutrient application which is quite insufficient. Adoption of drip fertigation system may also help to increase yield and quality parameters due to improve water and nutrient use efficiency (Kachwaya and Chandel, 7). Keeping these in view, the present experiment was under taken to standardize the nutrient dose and scheduling for growth, yield and quality parameters and nutrient use efficiency of banana under subtropical conditions of Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during 2016-2019 at research farm of ICAR-CISH Ist block of Rehmankhera, Lucknow (26° 54' N latitude, 80° 45' E longitude and 127m above mean sea level), Uttar Pradesh, India. The experimental soil had 7.2 pH and 0.27 dsm^{-1} Electrical Conductivity, respectively. The initial levels of organic carbon content 0.39-0.48 %, available P and K content ranged between 8.6-12.6 and 61.4-69.7 mg/kg, respectively and soil showed near optimum fertility status. Bulk density and particle density ranged between 1.36-1.53g/cm^3 and 2.39 to 2.71g/cm^3, respectively. The soil of the experimental site is taxonomically classified as mixed hyperthermic typic ustocrept and derived from Indo-Gangetic

*Corresponding author's Email: dkches@rediffmail.com

alluvium with sandy loan texture. The climate is typically subtropical with hot dry summer and cold in winter month. The mean maximum temperature was 39.05°C in April and minimum 5.1°C in January and average annual rainfall received 861.5 mm during the study period. The planting material of banana cv. Grand Naine (AAA) consisting of one month old tissue cultured plants were planted at 1.8m x1.5m spacing during August 2016. A buffer strip of two meter was maintained between the treatment. The pit of 0.5m × 0.5m × 0.5m dug and mixed with 10 kg well decomposed farm yard manure before planting. Standard cultural operations and adequate plant protection measures were followed uniformly. After planting, drip-fertigation system installed in which a separate lateral line was laid for each treatment and the dripper was inline which is 30 cm apart for maintaining proper moisture near to root zone. The drip irrigation was operated on a daily basis replenishing 80% of USWB class A pan evaporation losses (Hegde and Srinivas, 6). Each treatment consisted of 50 plants of two rows. All the suckers were removed from the plants until flowering.

The experiment was arranged in Randomised Block Design with three replications. There were thirteen treatment combinations consist of T_1- 100 % RDF (250:80:300 g NPK/ plant/cycle) applied N:K (10:10,40:20,30:30,20:40) at vegetative growth, pre flowering, flowering and bunch development stage; T_2 - 100 % RDF applied N:K (20:15, 30:25, 30:30, 20:30) at vegetative growth, pre flowering, flowering and bunch development stage; T_3- 100 % RDF applied N:K (30:20, 20:30, 20:30, 30:20) at vegetative growth, pre flowering, flowering and bunch development stage,T_4 - 100 % RDF applied N:K (40:25, 30:35, 30:25, 0:15) at vegetative growth, pre flowering, flowering and bunch development stage,T_5- 80 % RDF applied N:K (10:10, 40:20, 30:30, 20:40) at vegetative growth, pre flowering, flowering and bunch development stage; T_6-80 % RDF applied N:K (20:15, 30:25, 30:30, 20:30) at vegetative growth, pre flowering, flowering and bunch development stage;T_7- 80 % RDF applied N:K (30:20, 20:30, 20:30, 30:20) at vegetative growth, pre flowering, flowering and bunch development stage,T_8. 80 % RDF applied N:K (40:25,30:35,30:25,0:15) at vegetative growth, pre flowering, flowering and bunch development stage,T_9- 60% RDF applied N:K (10:10,40:20,30:30,20:40) at vegetative growth, pre flowering, flowering and bunch development stage,T_{10}- 60% RDF applied N:K (20:15, 30:25, 30:30, 20:30) at vegetative growth, pre flowering, flowering and bunch development stage,T_{11}. 60 %RDF applied N:K (30:20, 20:30, 20:30, 30:20) at vegetative growth, pre flowering, flowering and bunch development stage; T_{12}. 60 % RDF applied N:K (40:25, 30:35,30:25,0:15) at vegetative growth, pre flowering, flowering and bunch development stage and T_{13}- Recommended Dose of Fertilizers as farmer practice applied 3, 5, 9 and 11 months after planting as well as ratoon crop of banana.

The drip fertigation system was installed to meet the demand of crop water requirement. The water requirement of banana was computed on the basis of cumulative pan evaporation, pan factor, crop coefficient, canopy area and wetted area factor. The drip was scheduled three days interval in summer and six days interval in winter based on evaporation replenishment in plant and ratoon crop of banana. The recommended dose of nitrogen, phosphorus and potassium fertilizers was 250 g ,80g and 300g per plant/year applied through urea (46%), SSP (16%) and muriate of potash (60%), respectively. The soluble fertilizer like Urea and Muriate of Potash were dissolved as per the schedule in fertigation tank, which was connected to drip irrigation line. The fertilizer water mixture was injected into the drip system through a fertilizer injector at a 3-6 days intervals starting from 30 days after planting to crop maturity. The concentration of water soluble fertilizers passing through drip irrigation water was around 1.0-1.5 percent. In the conventional method of surface irrigation, 100% recommended dose of fertilizers were applied in four split at vegetative, pre-flowering, flowering and bunch development stage of plant crop as well as ratoon crop of banana.

Mature bunches were harvested and weighed for working out bunch weight and estimated fruit yield per hectare. The pulp was extracted through muslin cloth and TSS was determined by using hand refractometer (0-32 ^{O}Brix) from 10 randomly collected fruits from 2nd hand of bunch for each treatment. The leaf samples were collected after crop harvest and dried in digital hot oven at 65°C for 72 hours. After drying, the dry leaves were milled to a powder for nutrient analysis. The available nutrients were analysed as per standard method (Singh *et al.,* 14). The data were analysed statistically as per Gomez and Gomez (5) for interpretation of results and drawing conclusions.

RESULTS AND DISCUSSION

A perusal of data on vegetative growth of banana for plant as well ratoon crop is presented in Table 1 indicated that maximum pseudostem height (182.45cm), leaf area (7.550m^2), leaf area index (2.79) were recorded in plant crop; pseudostem girth (58.39cm) in ratoon crop with 100 % RDF of N and K applied 40:25, 30:35, 30:25, 0.15 at vegetative growth, pre-flowering, flowering and bunch development stage. Whereas, pseudostem

Table 1. Effect of N and K fertigation on vegetative growth of banana cv. Grand Naine.

Treatment	Pseudostem height (m)		Pseudostem girth (cm)		Leaf area (m^2)		Leaf Area Index	
	PC	RC	PC	RC	PC	RC	PC	RC
T_1	175.46	165.45	60.16	55.45	7.542	6.325	2.79	2.34
T_2	178.67	167.52	59.51	54.37	7.251	6.212	2.68	2.30
T_3	18023	169.21	61.54	56.28	7.525	6.302	2.78	2.33
T_4	182.45	170.29	62.45	58.39	7.550	6.293	2.79	2.33
T_5	176.37	165.41	58.52	51.25	7.350	5.982	2.72	2.22
T_6	178.31	167.89	59.54	53.78	7.208	6.025	2.66	2.23
T_7	179.45	169.87	60.54	54.27	7.189	6.132	2.66	2.27
T_8	180.01	170.45	61.75	55.37	7.252	6.217	2.68	2.30
T_9	168.24	155.45	59.99	54.27	7.208	5.821	2.67	2.15
T_{10}	170.24	157.37	58.72	53.42	6.997	5.921	2.59	2.19
T_{11}	172.38	158.23	57.24	53.05	6.965	5.892	2.57	2.18
T_{12}	174.45	161.45	59.96	54.97	6.980	5.723	2.58	2.12
T_{13}	175.45	163.24	56.27	55.28	6.452	5.891	2.39	2.18
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	0.32	NS

PC-Plant Crop; RC-Ratoon Crop

height (170.45cm) of ratoon crop and pseudostem girth of plant crop (61.75cm) were recorded with 80% RDF of N and K applied 40:25, 30:35, 30:25, 0.15 at vegetative growth, pre-flowering, flowering and bunch development stage. The leaf area index of ratoon crop was higher with 100 % RDF applied N and K 10:10, 40:20, 30:30, 20:40 at vegetative growth, pre-flowering, flowering and bunch development stage in banana cultivar Grand Naine. The plant growth parameters were increased with split application of 100 % RDF through fertigation might be due to continuous supply of nutrients to entire growth period which might have encouraged the plant in meeting the requirements of nutrients during the critical period of growth. Similar findings were reported by Srinivas *et al*. (15), while working on banana under Bangaluru conditions. The timely application of optimum nutrient directly to the root zone of crop with reduction in nitrogen and potassium losses through leaching and percolation as reported by Mahalaxmi *et al*. (9).

Fruit yield as influenced by different levels of nutrient applied through fertigation in banana (Table 2). Maximum fruit yield was recorded in T_4 treatment of 100 % RDF of N and K applied (40:25, 30:35, 30:25, 0.15) at vegetative growth, pre-flowering, flowering and bunch development stage which is 21.14 higher over control treatment of banana. Whereas, maximum B:C ratio (2.10) was found in the treatment of T_8 i.e. application of 80% RDF of N and K (40:25, 30:35, 30:25, 0.15) followed by T_4 treatment (2.02) i.e. application of 100% RDF of N and K (40:25, 30:35, 30:25, 0.15) at vegetative growth, pre-flowering, flowering and bunch development stage in plant crop as well as ratoon crop. Maximum number of fingers were recorded in 100 % RDF applied (10:10, 40:20, 30:30, 20:40) in plant crop and ratoon crop which is 20.17 and 25.85 % higher over control treatment. Finger weight (117.25 g) was recorded in 80 % RDF of N and K applied 40:25, 30:35, 30:25, 0.15 at vegetative growth, pre-flowering, flowering and bunch development stage in plant crop. The finger size (18.12 × 10.05cm) was recorded in 100 % RDF of N and K applied 20:15, 30:25, 30:30, 20:30 at vegetative growth, pre-flowering, flowering and bunch development stage of banana cultivar Grand Naine. The improvement in fruit yield with N and K fertigation might be due to reduced loss of applied fertilizers by leaching and also timely application of required nutrients as per the crop growth stage directly in the root zone of plant and improving fertilizer use efficiency (Rolston *et al.,*13). These results are inconformity with the work of Reddy *et al*. (12) with increased level of fertigation in banana.

Bunch weight as influenced by nitrogen and potassium fertigation in banana (Fig-1). Maximum bunch weight (31.05 kg) was recorded in T_4 treatment of 100 % RDF of N and K applied (40:25, 30:35, 30:25, 0.15) at vegetative growth, pre-flowering, flowering and bunch development stage closely followed by T_8 treatment of 80 % RDF of N and K applied (40:25, 30:35, 30:25, 0.15) at vegetative growth, pre-

Table 2. Effect of N and K fertigation on yield, B:C ratio and its contributing characters of Grand Naine banana.

Treatment	Yield (t/ha)	B:C ratio	No. of fingers		Finger weight (g)		Finger size (cm)	
	PC+RC	PC+RC	PC	RC	PC	RC	PC	RC
T_1	91.72	1.97	113.66	101.25	102.25	108.59	17.24x9.45	18.29x10.12
T_2	87.88	1.89	108.66	96.45	104.78	109.24	18.12x10.05	18.58x10.16
T_3	91.96	1.98	110.67	98.24	102.75	112.22	17.98x9.98	18.51x10.23
T_4	94.60	2.02	107.33	95.89	109.15	117.84	18.05x10.06	18.65x10.25
T_5	83.34	1.88	95.33	85.29	113.75	117.24	16.15x9.02	17.22x9.92
T_6	83.15	1.87	93.33	82.75	115.28	120.25	15.95x8.98	16.58x9.85
T_7	82.80	1.86	96.00	82.56	116.18	121.38	16.05x9.15	16.56x9.58
T_8	93.02	2.10	104.00	91.37	117.25	121.72	16.27x9.08	17.12x9.45
T_9	83.59	1.93	89.00	78.24	113.75	127.74	15.24x8.67	15.97x9.12
T_{10}	80.53	1.86	90.00	78.12	115.78	125.86	15.87x8.90	16.04x9.56
T_{11}	81.42	1.88	92.00	79.23	115.56	123.35	16.05x8.95	16.67x9.23
T_{12}	82.70	1.91	96.33	82.56	112.25	120.63	16.15x8.98	16.69x9.31
T_{13}	78.09	1.86	94.66	80.45	103.25	118.16	15.72x8.92	16.05x9.09
$LSD_{(0.05)}$	8.35	-	NS	NS	NS	NS	NS	NS

PC-Plant Crop; RC-Ratoon Crop

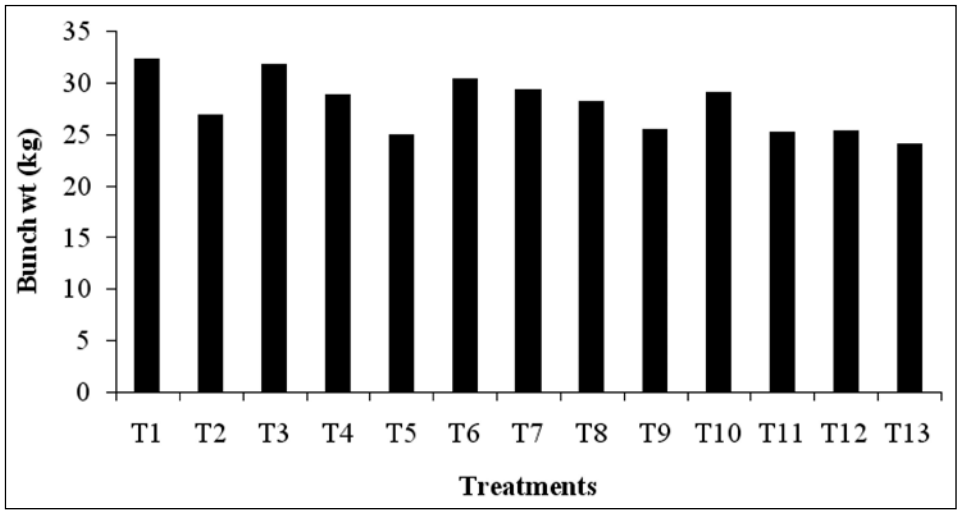

Fig. 1. Effect of N and K fertigation on bunch weight in banana.

flowering, flowering and bunch development stage and T1 treatment of 100 % RDF of N and K applied (10:10, 40:20, 30:30, 20.40) at vegetative growth, pre-flowering, flowering and bunch development stage in banana cultivar Grand Naine. The higher bunch weight was in 100% N and K application might be due to more uptake of split application an per the growth stage improved the bunch weight. Similar findings were reported by Kumar *et al*. (8), while working on banana.

Fruit quality of banana as influenced by nutrient dose and scheduling through fertigation in banana (Table 3). Maximum pulp weight and total soluble solids were recorded in 80% RDF of N and K applied (40:25, 30:35, 30:25, 0.15) at vegetative growth, pre-flowering, flowering and bunch development stage which is 19.90 and 7.46% higher over farmers practice in plant crop. Whereas, fruit acidity was maximum in 100 % RDF of N and K applied 40:25, 30:35, 30:25, 0.15 at vegetative growth, pre-flowering, flowering and bunch development stage which was 8.0% higher over control treatment in plant crop. The improvement in pulp weight and TSS might be due to proper supply and translocation of nutrients

Table 3. Effect of N and K fertigation on fruit quality characters of banana.

Treatment	Pulp weight (g)		Peel weight (g)		TSS (^{0}Brix)		Acidity (%)	
	PC	RC	PC	RC	PC	RC	PC	RC
T_1	70.96	75.50	31.29	33.09	19.5	19.8	0.52	0.50
T_2	73.84	76.85	30.94	32.39	19.7	20.2	0.53	0.51
T_3	73.13	77.54	30.57	34.68	19.2	19.7	0.47	0.45
T_4	77.63	82.88	31.24	34.96	21.4	21.5	0.54	0.52
T_5	83.01	84.89	30.54	32.35	20.2	20.6	0.51	0.53
T_6	83.87	85.01	31.75	35.24	20.7	20.8	0.52	0.50
T_7	85.60	86.11	30.75	35.27	20.5	20.7	0.53	0.51
T_8	87.40	86.47	31.78	35.25	21.6	21.8	0.45	0.43
T_9	84.04	92.16	30.54	35.58	21.5	21.6	0.45	0.42
T_{10}	84.53	91.60	31.59	34.26	21.3	21.5	0.48	0.46
T_{11}	84.86	90.83	30.24	32.52	20.4	20.6	0.48	0.47
T_{12}	81.07	88.09	31.78	34.54	21.3	21.1	0.46	0.44
T_{13}	72.89	86.12	30.54	32.04	20.1	20.4	0.50	0.51
$LSD_{(0.05)}$	11.71	14.70	NS	NS	1.73	1.79	NS	NS

PC-Plant Crop; RC-Ratoon Crop

throughout the growth, shooting and fruit growth development stage. The findings are inconformity with the findings of Hegde and Srinivas (6) and Kumar *et al*. (8).

Data on soil nutrient content as influenced by nitrogen and potassium fertigation in banana (Fig.2) indicated that plant crop have more soil nutrient content than ratoon crop of banana irrespective of treatments. The soil nitrogen content ranged from 82.59 - 106.23 ppm and 75.23 - 96.87 ppm; soil potassium content from 66.96-79.89 ppm and 61.22-71.27 ppm irrespective of treatment. The maximum soil nitrogen content (106.23 and 96.87 ppm) and soil potassium content (79.89 and 71.27 ppm) was recorded in T_4 treatment (100 % RDF applied 40:25, 30:35, 30:25, 0.15 at vegetative growth, pre-flowering, flowering and bunch development stage) in plant crop as well as ratoon crop. The soil phosphorus content ranged from 7.45-10.04 ppm and 7.21-9.51ppm irrespective of treatments.

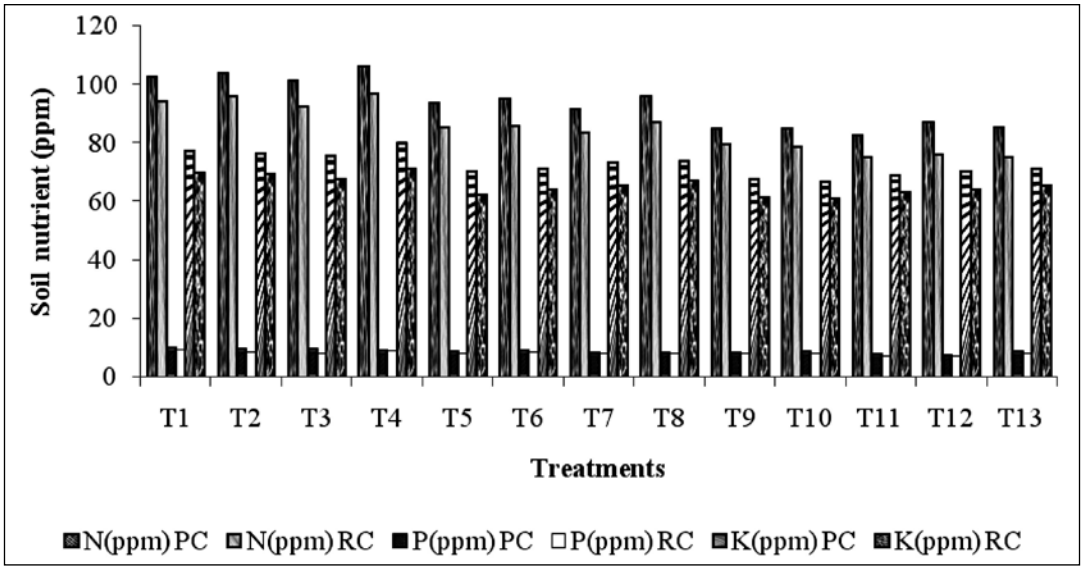

Fig. 2. Effect of N and K fertigation on soil nutrient content in banana.

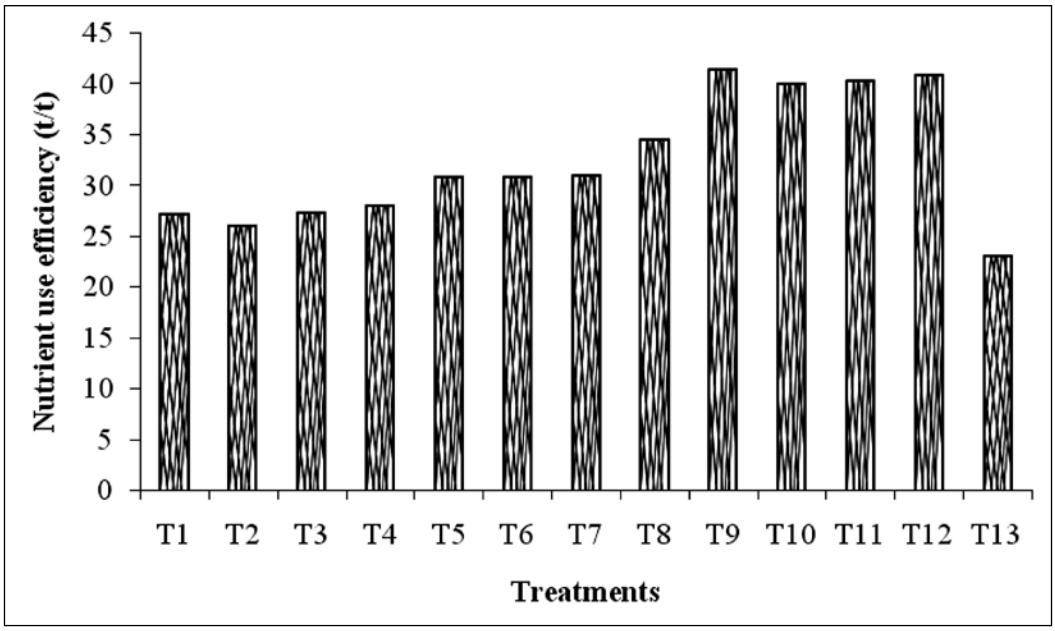

Fig. 3. Effect of N and K fertigation on nutrient use efficiency in banana.

Maximum phosphorus content (10.04ppm and 9.51 ppm) was estimated in T_1 treatment (100% applied N:K (10:10,40:20,30:30,20:40) at vegetative growth, pre flowering, flowering and bunch development stage) of banana cultivar Grand Naine. The soil macro-nutrient play an important role in improving the over all productivity of plant due to uptake of nutrients from soil to aerial part of the plants thereby improvement in the photosynthetic activity and ultimately fruit yield. Similar findings were reported by Kumar *et al.* (8).

Perusal of data (Fig. 3) indicated that fertigation through drip irrigation was found to enhance nutrient use efficiency in all the fertigation treatment over soil application (farmers practice). Maximum nutrient use efficiency (41.40 t/t) was recorded in 60% RDF of N and K applied (10:10, 40:20, 30:20, 20:40) at vegetative growth, pre-flowering, flowering and bunch development stage which is 78.60 % higher over control treatment. This increase in nutrient use efficiency might be due to reduction in the quantity of nutrients applied through fertigation. The banana plant fertigated with recommended dose of fertilizer had higher nutrient use efficiency than farmers practice, which indicated the efficient use of nutrient when applied through drip system. Chauhan and Chandel (2) also reported higher nutrient use efficiency under drip fertigation than soil application.

The recommended dose of nitrogen and potassium (100 and 80 per cent) applied through fertigation (40:25, 30:35, 30:25, 0.15) at different phenological stages of growth performed better in respect to fruit yield, quality and B:C ratio. Whereas, nutrient use efficiency was higher in 60 % RDF applied through fertigation as per the growth stages in banana cultivar Grand Naine under subtropical conditions.

REFERENCES

1. Anonymous. 2015-16. *Horticultural Statistics at a Glance 2017*. Horticulture statistics Division, Department of Agriculture, Cooperation and Farmer Welfare, Government of India.

2. Chauhan, N. and Chandel, J. S. 2008. Effect of fertigation on growth, yield, fruit quality and water use efficiencyof kiwi fruits (*Actinidia deliciosa*). *Indian J. Agri. Sci.* **78**: 389-93.

3. Doorenbos, J., Pruitt, W. O., Aboukhaled, A. and Dastane, A. B. 1984.Guidelines for predicting crop water requirements. FAO Irrigation and Drainage paper No.24, FAO, Rome.

4. Fratoni, M. M. J., Moreira, A., Moraes, L. A. C., Almeida, L. H. C. and Pereira, J. C. R. 2017. Effect of nitrogen and potassium fertilization on banana plants cultivated in the humid Tropical Amazon. *Commu. Soil Sci. Plant Anal.* **48**: 13: 1511-19.

5. Gomez, K. A. and Gomez, A. A.1984. Statistical procedure for agriculture research. 2nd Edition, International Rice Research Institute, John Wiley and Sons, New York, pp.1-340.

6. Hegde, D. M . and Srinivas, K. 1990. Growth, productivity and water use of banana under drip and basin irrigation in relation to evaporation replenishment. *Indian J. Agro.* **35**: 106-12.

7. Kachwaya, D. S. and Chandel ,J. S. 2015. Effect of fertigation on growth, yield, fruit quality and leaf nutrient content of strawberry (*Fragaria* × *ananassa*) cv Chandler. *Indian J. Agric. Sci.* **85**: 1319-23.

8. Kumar ,D., Pandey, V. and Vishal Nath. 2012. Growth, yield and quality of vegetable banana Monthan (Banthal-ABB) in relation to NPK fertigation. *Indian J. Hort.* **69**: 467-471.

9. Mahalakshmi, M., Kumar, N., Jeyakumar, P. and Soorianathasundaram, K. 2001. Fertigation studies in banana under normal system of planting. *South Indian Hort.* **49**:80-83.

10. Pramanik , S., Lal, S., Ray, R. and Patra, S. K. 2016. Effect of drip fertigation on yield, water use efficiency, and nutrients availability in banana in West Bengal, India, *Communications Soil Sci. and Plant Ana.* **47**: 1691-1700.

11. Pramanik, S. and Patra, S. K. 2014. Influenced of fertigation on fruit yield, water use and distribution efficiency and economic of guava (*Psedium guajava* L.). *J. Soil Water Cons.* **13**: 164-69.

12. Reddy, B. M. C., Srinivas, K., Padma, P. and Raghupati, H. B. 2002. Response of Robusta banana to K and K fertigation. *Indian J. Hort.* **59**: 342-48.

13. Rolstom, D.E., Miller, R.J. and Schulbauch, H. 1986. Management principles-fertilization.(In) Trickle irrigation for crop production, Design, operation and management, pp.317. Nakayama and Bucks, DA (Eds.), Elseater Amsterdam.

14. Singh,D., Chhonkar, P. K. and Dwivedi, B. S. 2005. Manual on soil, plant and water analysis. Westville Publishing House, New Delhi. pp. 1-199.

15. Srinivas, K., Reddy, B. M. C., Kumar, S. S. C., Gowda, S. T, Raghupati, H. B. and Padma, P. 2001. Growth, yield and nutrient uptake of Robusta banana in relation to N and K fertigation. *Indian J. Hort.* **58**: 287-93.

Received : September, 2019; Revised : May, 2020;
Accepted : May, 2020