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EFFECTS OF INORGANIC FERTILIZATION ON GROWTH, YIELD AND FRUIT QUALITY OF PLANTAIN cv. NENDRAN

S. K. Mahato, C. P. Suresh and Ravi Kumar Kuna*

Department of Pomology and Post Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari -736 165, Cooch Behar (West Bengal), India.

Abstract

A trial was conducted to investigate the effect of different rates of nitrogen and potassium fertilization on growth, yield and fruit quality on Plantain cv. Nendran in the Terai Zone of West Bengal, at an Experimental Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari (West Bengal), India during 2008-10. The experimental plants were subjected to the following nine different treatment combinations of inorganic fertilizers (urea + single super phosphate + muriate of potash) having 150, 200 and 250 g N/plant; 300, 350 and 400 g K/plant and 80 g P/plant, respectively were compared with control (*i.e.* No N and K applied). The highest values of macronutrients availability were obtained under $N_{250} P_{80} K_{400}$ g/plant. Leaf N, P and K content were increased with nitrogen and potassium applied as compared with the control. It is clear that adding N and K fertilizer at higher dose resulted in greater bunch weight and number of fingers than the control. Fruit total soluble solids; total sugars and TSS/acid ratio were significantly increased with increasing N and K application rates compared with the control. Generally, it could be concluded that the treatment $N_{250} P_{80} K_{400}$ g/plant) seems to be the promising treatment which produced the highest vegetative growth, yield and improved fruit quality under these experimental conditions due to improving nutritional status of studied soil.

Key words : Nendran, NPK, growth, yield, quality, soil.

Introduction

India is the second largest diversified country of indigenous banana in the world. Among different banana cultivars, Nendran is included under plantain types having an AAB genome constitution. Presently, plantains are of less importance than banana in terms of world trade in the genus but in West and Central Africa about 70 million people are estimated to derive more than one quarter of their food energy requirement from plantains (Robinson, 1996). This crop forms the fruit diet of more than 400 million peoples, ranks fourth in the category of stable food products, after rice, wheat and milk (FAO, 1999). It is an important source of food in south India, but not known to be an important food in North-East India (Sebastian, 2006). In general, Nendran is moderately vigorous. Higher and earlier yields were recorded when NPK nutrients were supplied entirely through inorganic form of fertilizers. Inflorescence emergence is accelerated and the period until harvest was shortened, compared with plants receiving no adequate NPK nutrients. Therefore, banana require considerable amounts of mineral nutrients to maintain yields. Nitrogen, potash and phosphorus are the major nutrients required in bulk quantities and can either be supplied by fertile soils or by commercial fertilizers (Zake *et al*., 2000).

Most of the quality parameters of fruit are significantly influenced by growing (pre-harvest) conditions. Monselise and Goren (1987) have reported that the pre-harvest factors having greatest influence on quality are climate, nutrition and plant growth regulators (PGR). Secondary factors are soil quality and management, rootstock, irrigation, pruning and crop load manipulation. Banana being a heavy feeder, it require maximum amount NPK of nutrients for growth and development. On comparison with organic manure, inorganic fertilizers give prominent growth and quality parameters of banana. Higher and earlier yields were recorded, when NPK nutrients were supplied entirely through inorganic form of fertilizers. Substitution of inorganic form of nutrients with organic form of manures decline the bunch weight (Soorianathasundaram *et al.*, 2001). Therefore, banana require considerable amounts of mineral nutrients to maintain yields.

***Author for correspondence:** E-mail: ravikuna2050@gmail.com

The optimum amount required from nitrogen or potassium for banana plants differed, according to soil and variety (Abou-Aziz *et al*., 1987). Potassium was also found to have an active role in the uptake and translocation of nitrogen since deficiency in potassium depressed the nitrogen absorption (Hewitt, 1955; Warner and Fox, 1977). Application of nitrogen at higher levels in combination with potassium substantially increases the soil nitrogen status (Suresh *et al*., 2002). On the other hand, potassium is required in greater amounts for banana as mentioned by many researchers. Its deficiency apparently decreased growth, number of green leaves and yield of banana plants (Abou-Aziz *et al*., 1987; Twyford and Walmsley, 1974; Abd-El-Kader *et al*., 1994).

In context of North Bengal, this area is rich of different genomes of banana mostly AAB and ABB. The popular varieties, which are cultivated in this region are Malbhog, Munua, Kanchkela, Chinichampa etc. As the people of Bengal have greater affinity towards consuming chips and this offers a great scope for introduction of Nendran (AAB), which is very popular in Kerala and Tamil Nadu for chips. As it is a new cultivar for this region, the performance and standardization of package of practices is most important before introducing the cultivar and very scanty information is available in respect of Plantain cv. Nendran in Bengal. Banana being an exhaustive crop, the proper fertilizer application has to be resorted for obtaining highest yields, which may influenced by the soil elemental status of plantain orchard. This investigation tended to increase the efficiency use of the recommended fertilization rates of both nitrogen and potassium.

Materials and Methods

The experiment was conducted at the Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2008-2010. The site is located 26°19' N latitude and 89°29' E longitude and having an attitude of 43 meters above Mean Sea Level. The soil of the experimental field was sandy loam in nature, coarse in texture having poor water holding capacity with low pH (5.23), organic carbon (0.93%), available N (217.21kg/ha), available P (18.24 kg/ha) and available K (111.89 kg/ha). The climatic condition of terai zone is characterized by high rainfall (above 3000 mm annually), high humidity, moderate temperature, prolonged winter with high residual soil moisture. To study the effect of different combinations of NPK on the fruit yield of Plantain cv. Nendran (AAB) under Terai Zone of West Bengal, the investigation was carried out with banana suckers having 2.5 kg average weight with 2m × 2m spacing, which is the popular cultivar of Tamil Nadu. The field experiment was designed in RBD (Randomized Block Design) with 10 treatments and 3 replications (Gamez and Gamez, 1984). Nine different treatment combinations of inorganic fertilizers (urea + single super phosphate + muriate of potash) having 150, 200 and 250 g N/plant; 300, 350 and 400 g K/plant and 80 g P/plant, respectively were compared with control (*i.e.* No N and K applied). Thus, the treatmental combinations were $N_{150}P_{80}K_{300}$ ($\mathbf{T_1}$), $N_{200}P_{80}K_{300}$ ($\mathbf{T_2}$), $N_{250}P_{80}K_{300}$ ($\mathbf{T_3}$), $N_{150}P_{80}K_{350}$ ($\mathbf{T_4}$), $N_{200}P_{80}K_{350}$ ($\mathbf{T_5}$), $N_{250}P_{80}K_{350}$ ($\mathbf{T_6}$), $N_{150}P_{80}K_{400}$ ($\mathbf{T_7}$), $N_{200}P_{80}K_{400}$ ($\mathbf{T_8}$), $N_{250}P_{80}K_{400}$ ($\mathbf{T_9}$) and $N_{Zero}P_{80}K_{Zero}$ ($\mathbf{T_{10}}$) gm/plant. The suckers were planted with FYM at the rate of 10 kg per pits with dose of phosphorus (500 g SSP) were applied for proper growth and development of the crops. After 45 days of transplanting top dressing was done with 1/3 of nitrogen. The 2nd top dressing was done with second one of N and half K_2O on 5th month of transplanting. Again the rest (third of N and rest half K_2O) on 8th month of transplanting. Fertilizers as soil application were taken to evaluate their effects on growth, yield and quality attributes based on the nutritional status of studied soil and on leaf mineral content of Plantain. Observations on growth characters *i.e.* pseudostem height, pseudostem girth, green leaf number, leaf area and total number of suckers per plant were recorded at the time of shooting whereas yield parameters *viz*. length of fingers, diameter of fingers, weight of fingers, number of fingers per hand, number of hands per bunch, weight of bunch and bunch yield (t/ha) were recorded after harvesting of bunches. Total soluble solids (^{0}brix) content of fruit was determined with the use of a hand refractometer calibrated in 0^0 brix at 20°C with the help of a temperature correction correlation chart (Mazumdar and Majumdar, 2003). The total titrable acidity was determined by titrating against N/10, NaOH using phenolphthalein as indicator (Ruck, 1969). The total sugar content of fruits was determined by analyzing the fruits by the method Lane and Eynon (1943). The soluble solids: acid ratio was determined by dividing the total soluble solids with total acidity percentage. The total nitrogen content was determined by the Modified kjeldhal method (Jackson, 1973), phosphorus content was estimated calorimetrically by vanado-molybdate yellow colour method (Jackson, 1973) and total potassium in plant samples was estimated by flame photometer as proposed by Jackson (1973). Available N was determined by the method of alkaline $KMnO_4$ developed by Subbiah and Asija, 1956, available P content of the experimental soils was determined by extracting 2.5g of each soil with a mixture of 25 ml of 0.03 M NH4F and 0.025 M HCl for 5 minutes (Bray and

Kurtz, 1945), followed by colorimetric measurement of P by spectrophotometer and for determination of available potassium the soil samples were treated with neutral normal ammonium acetate solution (pH-7.0) in 1:10 ratio, after one hour shaking, followed by filtration, the leachate was used for the determination of K^+ was measured by using a Flame photometer (Jackson, 1973). For the determination of least significance at 5% level of significance, the statistical table formulated by Fisher and Yates (1963) was consulted.

Results and Discussion

The data presented in reveals that different combination of nitrogen and potassium along with phosphorus significantly affects the most of the vegetative growth parameters of Nendran (table 1). The treatment N_{250} P_{80} K_{350} g/plant recorded significantly maximum pseudostem height (385.83 cm), pseudostem girth (87.12 cm) and number of leaves (19.75), whereas parameters like leaf area (1.563 m^2) and number of suckers (8.33) per plant were prominent under N_{250} P_{80} K_{400} g/plant over control (N_{Zero} P_{80} K_{Zero} g/plant) plot during shooting and higher nitrogen and potassium levels in combination produces maximum number of suckers and leaf area. The present study has been found positive effects of N and K on the growth of Nendran banana and this may be due to the fact that banana crop gives positive response to higher dose of NPK, nutrient application in terms of height, girth and number of leaves of banana (Nalina *et al*., 2006), but it has been observed that maximum pseudostem height, pseudostem girth and leaves number increases as rate of nitrogen increases with increasing rate of potassium but not beyond 350 g/plant. The favourable effect of nitrogen in promoting growth of plant might be due to the fact that being the major constituent of the chlorophyll, proteins and amino acids, N-application increased more transport of metabolites for growth. The highest rate of nitrogen was superior in terms of number of leaves per plant, in agreement with some of previous investigations (Nalina *et al*., 2006). Moreover, the effect of potassium application on leaf number in the present investigation also find supports of Venktesan *et al*. (1965) who opined that effect of potassium seemed to be less reflected on the number of leaves rather than on the size of the leaf.

Significant difference was observed among the different treatments with respect to length of finger, diameter of finger, weight of finger, number of fingers per hand, number hands per bunch, bunch weight and yield (table 2). The treatment having maximum dose of fertilizer N_{250} P_{80} K_{400} g/plant recorded significantly maximum *viz.*, finger length (25.12 cm), finger diameter (4.91cm), finger weight (315.81 g), fingers/hand (10.08), hands/bunch (5.90), bunch weight (15.25 kg) and yield (38.13 tons/ha); while it was minimum in control plots (N_{Zero} P_{80} K_{Zero} g/plant). Yield of banana in the present study had positively affected by various growth parameters like leaf area, no. of hands and weight of hands. Increase in these growth parameters has influence the yield of banana. Banana crop gives positive response to higher dose of NPK, nutrient application in terms of weight of fingers per bunch (Babu and Sharma, 2005) and interaction effects of different NPK doses are significant for bunch weight (Pandey *et al*., 2005). Moreover, potassium catalyzes important reactions such as respiration, photosynthesis, chlorophyll formation and water regulation. The role of K in the transport and accumulation of sugars inside the plant is particularly important since these processes allow fruit fill and yield accumulation. Fruit growth is conspicuously restricted by low potassium supply in two ways-reduction in translocation of carbohydrates from leaves to fruits and their conversion to starch (Martin, 1973). Thus, low potassium supply produces 'thin' fruit and fragile bunches, a phenomenon frequently observed in the field as well as in controlled experiments.

Effect of inorganic fertilizers on fruit quality was significantly influenced by different treatments. The data reveals that maximum TSS (18.25° Brix) and TSS/acid ratio (57.03) recorded under application of highest NPK dose (N_{250} P_{80} K_{400} g/plant). The lowest fruit acidity (0.32%) and maximum total sugar (17.89%) were recorded with higher rate of potassium (400g/plant) and nitrogen (350 g/plant) with phosphorus (80 g/plant). It was observed from the mean values of fruit parameters like acidity and total sugar obtained from (N_{250} P_{80} K_{400} g/plant), $N_{200}P_{80}K_{400}$ g/plant and $N_{150}P_{80}K_{400}$ g/plant are almost in same range indicating the effect of higher potassium application with nitrogen. The treatment (N_{250} $P_{80}K_{400}$ g/plant) recorded significantly maximum TSS and total sugar, but minimum acidity were prominent under control (N_{Zero} P_{80} K_{Zero} g/plant). This may be due to potassium supply, which leads to increase in sugars as well as decrease in acidity (Vadivelu and Shanmugavelu, 1978; Hasan, 1999a; Rumee, 2006).

The results showed that the leaf nitrogen content gets significantly changed among the treatments at shooting. From minimum to maximum mineral contents were recorded and presented in table 3. The total N content was highest (2.94%) in the treatment $N_{250}P_{80}K_{400}$ followed by $N_{250}P_{80}K_{350}$ (2.86%) while the lowest value recorded in (N_{Zero} P_{80} K_{Zero} g/plant) (1.75%).

Table 1 : Effect of N and K application on growth attributes of Plantain cv. Nendran.

Treatment	Pseudostem height (cm)	Pseudostem girth (cm)	Number of leaves	Leaf area (m^2)	Number of suckers
T_1	351.00	76.37	11.42	1.425	7.25
T_2	364.75	79.04	14.38	1.434	7.58
T_3	375.33	82.93	17.50	1.435	7.83
T_4	354.50	77.26	11.83	1.454	7.33
T_5	369.83	79.25	14.77	1.465	7.67
T_6	385.83	87.12	19.75	1.467	7.92
T_7	357.25	77.78	12.12	1.524	7.42
T_8	373.67	80.41	15.25	1.502	7.75
T_9	377.00	83.39	17.50	1.563	8.33
T_{10}	343.18	71.71	7.42	1.337	6.50
SEm (±)	2.389	1.982	0.632	0.009	0.384
CD at 0.05	7.089	5.881	1.328	0.026	1.140

Table 2 : Effect of N and K application on yield attributes of Plantain cv. Nendran.

Treatment	Finger length(cm)	Finger diameter (cm)	Finger weight(g)	Fingers/ hand	Hands/ bunch	Bunch weight(kg)	Yield/ ha (tons)
T_1	15.00	3.32	198.00	9.17	4.83	10.33	25.83
T_2	19.20	3.59	205.31	9.19	5.00	10.74	26.85
T_3	23.63	3.96	210.25	9.25	5.00	11.47	28.68
T_4	15.22	3.37	248.88	9.33	5.08	13.07	32.68
T_5	19.85	3.62	259.04	9.50	5.08	13.28	33.20
T_6	23.69	4.08	273.18	9.55	5.17	13.53	33.83
T_7	15.92	3.38	285.65	9.52	5.25	14.66	35.65
T_8	20.16	3.67	296.08	9.58	5.33	14.84	37.10
T_9	25.12	4.91	315.81	10.08	5.90	15.25	38.13
T_{10}	11.52	2.62	156.57	8.45	3.78	8.49	21.23
SEm (±)	1.647	0.289	1.943	0.202	0.203	0.101	0.247
CD at 0.05	4.893	0.859	5.773	0.600	0.603	0.301	0.734

Phosphorus content in the leaf was positively increased with inorganic fertilizers application and followed the same tread as in nitrogen. The highest leaf phosphorus (0.45%) was recorded in treatment $N_{250}P_{80}K_{400}$ gm/plant. Increasing concentration of phosphorus in banana leaf even with application of constant dose of phosphate fertilizer with higher rate of nitrogen and potassium might be due to the fact that phosphorus uptake increase with increasing rate of potassium (Sheela *et al*., 1990). Relatively lower phosphorus content with low levels of potassium was due to the decreased phosphorus uptake even with high available soil phosphorus as the specific phosphorus ion absorption site requires potassium for activation (Dibbs and Thompson, 1985). Similarly, the highest value of potassium content was observed in $N_{250}P_{80}K_{400}$ (3.39%), while the lowest value was observed in $N_{Zero}P_{80}K_{Zero}$ (2.49%). The highest leaf potassium content was may be due to the fact that increased levels of potassium, which lead to higher content of leaf potassium. Increased potassium content might be also due to better utilization of applied inorganic fertilizer. Where potassium supply is abundant, large amounts of potassium is absorbed during the later half of the vegetative phase (Twyford and Walmsley, 1973) and have a special effect on the maturation process (Fox, 1989).

The nitrogen content in studied soil also varied significantly in among the all treatments (table 4). Maximum nitrogen content (371.71 kg/ha) in soil was recorded under $N_{250}P_{80}K_{400}$ gm/plant while the least nitrogen (246.94 kg/ha) content in soil was observed under control ($N_{Zero}P_{80}K_{Zero}$ g/plant) at shooting. The mineralization might have resulted in the higher nutrient contents as reported by Hasan *et al*. (1999b). Steineck

Table 3: Effect of N and K application on fruit quality of Plantain cv. Nendran.

Treatment	TSS (°Brix)	Titrable Acidity (%)	Total sugar (%)	TSS/ Acid Ratio
T_1	15.31	0.55	15.56	27.84
T_2	15.52	0.53	15.83	29.28
T_3	15.74	0.51	15.96	30.86
T_4	16.43	0.42	16.32	39.12
T_5	16.65	0.41	16.64	40.61
T_6	16.88	0.40	16.66	42.20
T_7	17.24	0.39	17.21	44.21
T_8	17.58	0.37	17.48	47.51
T_9	18.25	0.32	17.89	57.03
T_{10}	14.06	0.61	14.17	23.05
SEm (±)	0.317	0.011	0.048	1.515
CD at 0.05	0.094	0.032	0.146	4.499

(1974) stated the close linking in the physiological functions of nitrogen and potassium in the plant's production and the effect of potassium in increasing the efficiency of the use of nitrogen. Besides, potassium enables the plant to synthesize the organic components linked with the absorption of nitrogen. Phosphorus content in soil was positively increased with inorganic fertilizers application. The soil phosphorus also follows the same treand as in nitrogen. The highest (28.69 kg/ha) phosphorus content was recorded in treatment (N_{250} P_{80} K_{400} g/plant) while the lowest (19.34 kg/ha) value recorded in control (N_{Zero} P_{80} K_{Zero} g/plant). The available phosphorus also showed the increasing trend with increasing dose of fertilizer. It was observed that there was a release of the available 'P' with the progress of time in each of the treatment combination under the addition of nitrogen and potassium fertilizer over control. This may be due to the fact that incorporation of potassium in combination with nitrogen considerably enhanced the available soil phosphorus content (Suresh *et al*., 2002). At shooting, the highest value of potassium content (1271.71 kg/ha) was observed in T9, while the lowest value (730.89 kg/ha) was observed in control (N_{Zero} P_{80} K_{Zero} g/plant). The highest soil potassium content was recorded in treatment (N_{250} P_{80} K_{400} g/plant) and this might be contributed by the application of higher dose of potassium in soil. These results are in agreement with the earlier findings by Hasan (1999b) and Suresh *et al*. (2002).

Conclusion

Low growth parameters were detected in plants from the control treatments (*i.e.* having no nitrogen and potassium). Among the different soil application rates of inorganic fertilizers, treatment (N_{250} P_{80} K_{400} grams/ plant) was recorded significantly prominent growth, yield and quality parameters. The present study has been found positive effects of N and K on the all the attributes of Plantain. The results clearly showed that supply of nutrients through inorganic fertilizers helped significantly out yielded and indicate the beneficial effect of fertilizers when supplemented through inorganic fertilizers. Hence, application of NPK at the rate of 250, 80 and 400 grams/ plant can be recommended for production of plantain (cv. Nendran) with consumable and quality chips for this terai region.

Table 4 : Effect of N and K application on leaf mineral content of Plantain cv. Nendran and on the nutritional status of studied soil.

Treatment	Total NPK content (%) of leaf			Available NPK content (kg/ha) of soil		
	N	P	K	N	P	K
T_1	2.43	0.24	3.13	309.45	23.32	883.62
T_2	2.62	0.27	3.15	318.66	24.42	911.98
T_3	2.75	0.34	3.17	324.78	25.62	934.80
T_4	2.51	0.36	3.22	331.24	23.4	1045.20
T_5	2.66	0.37	3.25	341.23	25.05	1062.85
T_6	2.86	0.40	3.31	349.62	26.28	1083.96
T_7	2.57	0.41	3.34	354.89	23.99	1235.73
T_8	2.71	0.42	3.35	360.24	25.07	1254.41
T_9	2.94	0.45	3.39	371.71	28.69	1271.71
T_{10}	1.75	0.21	2.49	246.94	19.34	730.89
SEm ±	0.0208	0.0094	0.0170	4.9871	1.053	6.6327
CD at 0.05	0.0438	0.0198	0.0358	10.477	2.212	13.934

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