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Effect of nitrogen and potassium on growth parameters of banana

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ABSTRACT

Banana (Musa spp.) is a vigorously growing, monocotyledonous herbaceous plant. Though Bangladesh is more suitable for production of banana but its productivity is very low due to a lack of improve variety, sustainable production & protection technology, soil fertility and fertilizer management. Fertilizers i.e. nitrogen and potassium are one of the most important elements that can play vital role to increase productivity of banana. Hence, the present research investigation was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from November, 2016 to December, 2017 to evaluate the effect of nitrogen & potassium fertilizers on growth and yield and also find out the best combination of N & K fertilizers for economic production of banana. Four levels of Nitrogen (N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant and N_4=600g Urea/plant) and four potassium (K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant) were studied in a randomized complete block design (RCBD) with three replications. The results revealed that the single application of N_3=500g Urea/plant, K_3=450g MOP/plant and their combination ($N_3 \times K_3$=500g urea/plant×450g MOP/plant) showed more significant increase in morpho-physiological characteristics namely pseudo-stem height (m), pseudo-stem girth (cm), number of functional leaves, total number of leaves per plant, minimum days to bunch maturity & crop duration (days) and increase in yield contributing characters viz. total number of fingers per bunch, total number of hands per bunch, bunch weight (kg/plant), yield (t/ha) and benefit cost ratio in this study. The application of these two fertilizers as single or their interaction would be the most appropriate level for getting the superior growth and yield performance of banana.

Key words: *Nitrogen, Potassium, Morpho-physiological traits, Yield attributes and Banana*

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I. Introduction

Banana (*Musa spp.*) is an important commercial fruit crop in Bangladesh. It is one of the most ancient fruits of the world and known as "Apple of the paradise" (Hossain and Haque, 2013). It is the cheapest and plentiful fruit in Bangladesh because it can grow throughout the year. That's' why it can get available and the most important fruit. The country is the largest producer of banana in the world. Its consumption rate is higher among all fruits but it is increasing popularity among farmers as an economic crop. The financial return of the crop is very high (Baruah and Mohan, 2010). Banana is comparatively easy digestible and enrich in carbohydrate (27%), vitamins (B-carotene, riboflavin, niacin, ascorbic acid) and minerals (K, P, Mg, Ca, Fe) (INIBAP, 1987). So, banana can play vital role to fulfill the nutrient of people through consuming it. Though Bangladesh is more suitable for production of banana but its productivity (18.23t/ha) is very low compare to other countries where they produce 35.41 t/ha in India, 34 t/ha in Argentina, 33 t/ha in Costa Rica, 32 t/ha in Paraguay and 32 t/ha in Senegal (FAO, 2012). High yielding variety, sustainable production & protection technology, soil fertility and fertilizer management can play an important role to increase the banana yield. Banana responds greatly to major essential nutrient elements like nitrogen, potassium and phosphorus in respect of its yield. Banana takes up more nutrients per unit area than almost any other crop (Chandrakumar et al., 2011). Deficient and imbalance of these nutrients result in poor growth and reduction in yield (Chattopadhyay et al., 2018). A different dose of N along with uniform doses of P_2O_5 and K_2O per plant, increasing N levels resulted in increased vegetative growth, greatest plant height and pseudo-stem girth (Hossain and Haque, 2013) and higher yield (Jagirdar and Ansari, 2016). The application of different fertilizers especially nitrogen and potassium gave better results compared with the application of only N fertilizer (Jambulingum et al., 2011). The increase in the N and K fertilization levels improved the growth parameter of plant and had a positive response to higher K application after flowering (Chandrakumar et al., 2011). Therefore, taking into consideration of proper application of nitrogen & potassium and return higher yield of banana, the present research investigation was undertaken to the evaluating the effect of nitrogen (N) & potassium (K) fertilizers on growth and yield and also find out the best combination of N & K fertilizers for economic production of banana.

II. Materials and Methods

Experimental location and soil characteristics

A research experiment was conducted at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from November, 2016 to December, 2017 to know the effect of different levels of nitrogen and potassium fertilizers on growth and yield of banana. Geographically the experimental plots were located at 24°43'19.4'' N latitude and 90°25'23.8'' E longitudes at an elevation of 18 m above the sea level. The site belongs to the non-calcareous dark grey floodplain soil under the series of Sonatola i.e. Agro-ecological Zone Old Brahmaputra Floodplain (AEZ-9) (Alam et al., 2020). The soil of the experimental field was silty loam in texture having pH 6.8 with 1.29% organic matter, nitrogen (0.087 µg/ml), K (37.33 ppm) and P (9.8 ppm) (Alam et al., 2020).

Weather conditions

The location was situated in sub-tropical climate zone which is characterized by heavy rainfall, high humidity and low temperature during kharif season (April-September) and scarce rainfall, low humidity, low temperature and short day period during Rabi season (October-March).

Planting materials and treatments

Sword suckers (age of 3-4 months) of the commercial variety Amritasagar were used as planting materials. Four levels of nitrogen *viz.* N_1=300g urea/plant, N_2=400g urea/plant, N_3=500g urea/plant, N_4=600g urea/plant and four levels of potassium such as K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant were used as treatments in this study.

Experimental layout and design

The field was designed according to the randomized complete block design (RCBD) with three replications. The unit plot size was 4m×2m with spacing of 2m×1.73m maintained by planting sword suckers of healthy banana plant. Finally, the total numbers of unit plots were 48. Sword suckers of

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banana were planted on 15th November, 2016 following hexagonal system where the plots were placed 1m apart and the spacing between unit plots was 0.70m.

Crop husbandry and treatment application

Before planting, the land was prepared well with a power tiller followed by laddering and leveling the surface of the soil to get good tilth. Three weeks before planting, pits of 60cm×60cm×60cm were prepared by digging the soil with spade. All recommend fertilizers were applied in each pit before 10 days of planting except urea and potassium. The fertilizer of Urea and MOP was applied as per treatment. Half of the MOP was applied in the pit during pit preparation. Half of the MOP of rest half and one-third of urea was applied by making ring around the plant after 120 days of planting. The rest amount of MOP and one third of urea were applied after 160 days of planting. The rest of urea was applied at the commencement of flowering. Ten days after the pits were filled in with manure and fertilizers, selected sword suckers were planted on 15th November, 2016. Weeding, irrigation and other intercultural operation were done properly as and when necessary for better growth and development of banana plants. The bunches were harvested when the fingers were fully rounded and matured. The harvesting was started in August, 2017 and continued till December, 2017.

Data Collection

Data were collected from three (3) plants selected at random from the unit plot in respect of morpho-physiological and yield contributing characters under each of the treatments. Data were recorded on morpho-physiological *namely* pseudo-stem height (m), pseudo-stem girth (cm), number of functional leaves, total number of leaves per plant, days to bunch maturity and crop duration (days) and yield contributing characters such as total number of fingers per bunch, total number of hands per bunch, bunch weight (kg/plant), yield (t/ha) and benefit cost ratio. The benefit cost ratio (BCR) was calculated as follows (Alam et al., 2020):

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package R statistical software version 3.5.3. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test according to Gomez and Gomez (1984) when necessary.

III. Results and Discussion

Effect of N and K fertilizers on pseudo-stem height

Pseudo-stem heights of banana were directly influenced by the single and combined application of N and K fertilizers and significant data variation depicted in Table 02 and Figure 01. The maximum pseudo-stem height (2.28m) was observed with N_3=500g urea/plant at 210 days after planting which was statistically different from other N treatments while the minimum pseudo-stem height (1.86m) was recorded from N_1 (300g urea/plant). Similarly, data revealed that the application of K_3 (450g MOP/plant) had the maximum pseudo-stem height (2.24m) which was statistically significantly different from other K treatment and the minimum pseudo-stem height (1.94m) were noted in K_1 (250g MOP/plant) (Figure 01). Among the interactions, the level of the most effective interaction of N_3×K_3 (500g urea×450g MOP/plant) for pseudo-stem height (2.87m) than other interactions where the highest increase of pseudo-stem at 210 days after planting (Table 02). In contrast, the lowest pseudo-stem height (1.45m) were found from the interaction of N_1×K_1 (300g urea×250g MOP/plant) treatment. However, N and K fertilization levels improved the growth parameters of plant (Chandrakumar et al., 2011). Pseudo-stem i.e. growth stages of banana was significantly changed from one growth stage to another growth stage in this study. Similar trends were also observed by Naresh et al. (2004) in banana and Jambulingum et al., 2011.

Effect of N and K fertilizers on pseudo-stem girth of banana

The different levels of nitrogen and potassium had a marked influence on pseudo-stem girth of banana at different days after planting i.e. statistically significant at all days after planting (DAP). The pseudo-stem heights increased gradually up to 210 DAP. In case of single effect of nitrogen, the result revealed

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that, 500g urea/plant (N_3) showed the highest pseudo-stem girth (52.64 cm) where 300 g urea per plant (N_1) showed the minimum height of pseudo-stem (1.86 m) (Figure 02). These results indicate that nitrogen increases the girth of pseudo-stem of banana which ensured the greatest pseudo-stem girth than other treatments. The same types of results were observed by Saleh (2001) and Shailendra *et al*. (2015) where they are applied 200g N/plant in their field. On the other hand, pseudo-stem girth had differed significantly to the application of different levels of potassium at 120, 150, 180 and 210 DAP and gradually increased up to 210 DAP. At 210 DAP, the greatest girth of pseudo-stem (53.00cm) of banana was recorded from K_3 (450g MOP/plant) treatment and the lowest pseudo-stem girth (45.83cm) was occurred due to the application of potassium where the rate of 250g MOP per plant (Figure 02). Chandrakumar et al. (2011) reported the increase in N and K fertilization levels improved the growth of pseudo-stem girth. A significant variation was observed due to combined effect of nitrogen and potassium in terms of pseudo-stem girth of banana at different days after planting. The maximum pseudo-stem girth of banana (57.55cm) was recorded from the combined effect of $N_3 \times K_3$ (500g urea×450g MOP/plant) treatment and $N_1 \times K_1$ (300g urea×250g MOP/plant) treatment gave the minimum girth of pseudo-stem of banana (Table 02). From the results, it was revealed that both nitrogen and phosphorus favored the pseudo-stem girth. Similar findings were reported by Jambulingum et al. (2011).

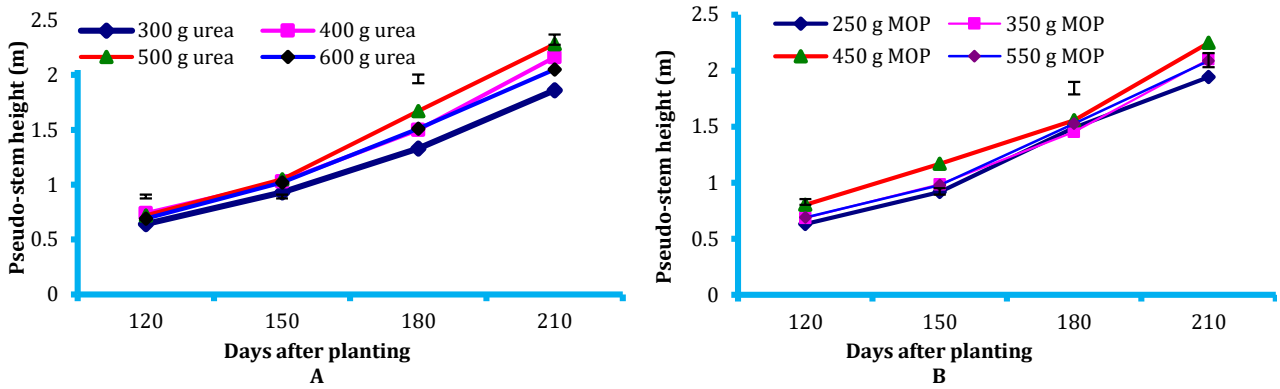

Figure 01. Effect of different levels of nitrogen (A) and potassium (B) fertilizer on pseudo-stem height of banana at different days after planting. Vertical bars represent the LSD values at 5% level of probability.

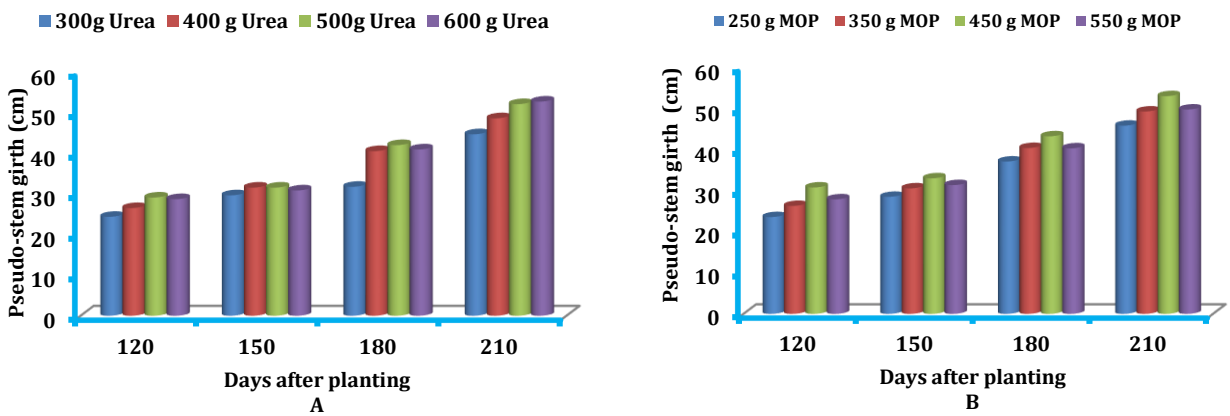

Figure 02. Effect of different levels of nitrogen (A) and potassium (B) fertilizer on pseudo-stem girth of banana at different days after planting

Effect of N and K fertilizers on number of functional leaves of banana

Table 03 and Figure 03 showed the number of functional leaves relationship with N and K fertilizers. Nitrogen and potassium increased the functional leaves of Banana at 120, 150, 180 and 210 DAP. At 210 DAP, the maximum number of functional leaves per plant (14.86) was recorded from N_3 (500g urea/plant) treatment and the lowest number of functional leaves per plant (11.80) was noted in N_1 (300g urea/plant) treatment (Figure 03). The result of this study conforms to Srinivas et al. (2001) who found that the number of functional leave per plant is increased with the increase in N and K fertilization up to 450g per plant. On the contrary, K_3 (450g MOP/plant) treatment produced the

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highest (14.38) number of functional leaves per plant than other applied treatments in this study while K_1 (250g MOP/plant) treatment exhibited the lowest (12.69) number of functional leaves per plant (Figure 03). The result is in agreement with the findings of Naresh et al. (2004). In case of interaction, the highest number of functional leaves per plant was counted from the combined effect of $N_3 \times K_3$ (500g urea×450g MOP/plant) at 210 DAP where the minimum number of functional leaves per plant was observed in $N_1 \times K_1$ (300g urea×250g MOP/plant) treatment (Table 03). The trend of functional leaves of banana was also similar to Srinivas et al. (2001).

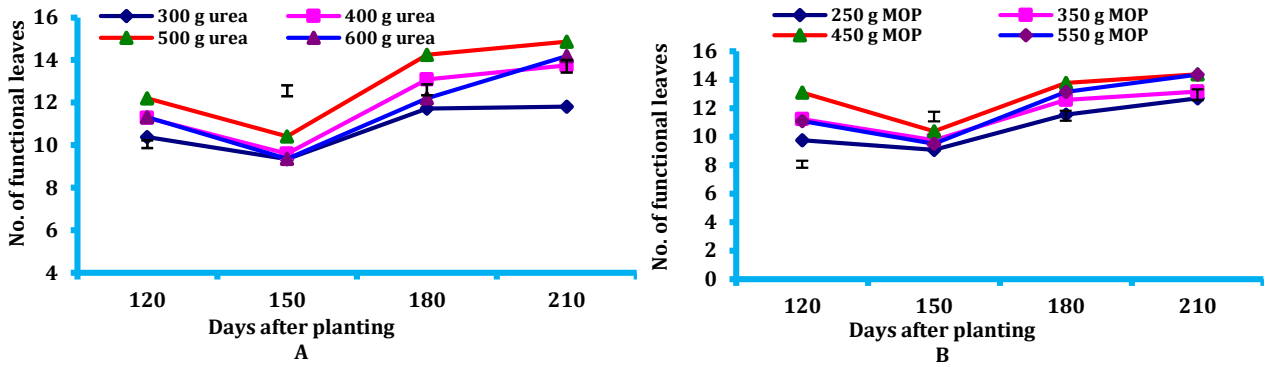

Figure 03. Effect of different levels of nitrogen (A) and potassium (B) fertilizer on number of functional leaves of banana at different days after planting. Vertical bars represent the LSD values at 5% level of probability.

Effect of N and K fertilizers on total number of leaves per plant

Leaves are the photosynthetic main part of plant which plays an important role in the yield. Different levels of nitrogen and potassium fertilizer significantly influenced the total number of leaves per plant and their significant data from the results of this study are presented in Table 03 and Figure 04. The highest number of leaves (34.16) per plant was found with N_3 (500g urea/plant) treatment and the lowest number of leaves (30.33) per plant was found with N_1 (300g urea/plant) treatment (Figure 04). This result is in agreement with Singh and Kashyap, 2010 who reported that the highest number of leaves was found by the application of 450g N per plant in banana tree. Similar findings were also reported by Teixeira et al. (2001). Opposite, the highest number of leaves (34.75) per plant was found with K_3 (450g MOP/plant) treatment and the lowest number of leaves (30.58) per plant was found with K_1 (250g MOP/plant) treatment (Figure 04). Significant variation was found due to combined effect of nitrogen and phosphorus in terms of total number of leaves per plant up to harvesting stage. The highest number of leaves (38.33) per plant was produced with the treatment combination of $N_3 \times K_3$ (500g urea×450g MOP/plant) and the lowest number of leaves (27.33) per plant was obtained from the treatment combination of $N_1 \times K_1$ (300g urea×250g MOP/plant) (Table 03). The application of accurate nitrogen and potassium fertilization with proper irrigation is useful for increasing the life span of banana leaves (Teixeira et al, 2001). Our study also supported these results. The present result of this research was in agreement with the findings of Venkatesam et al. (2017) and Teixeira et al. (2001) who reported the increased number of green leaves with an increasing supply of nitrogen and potassium.

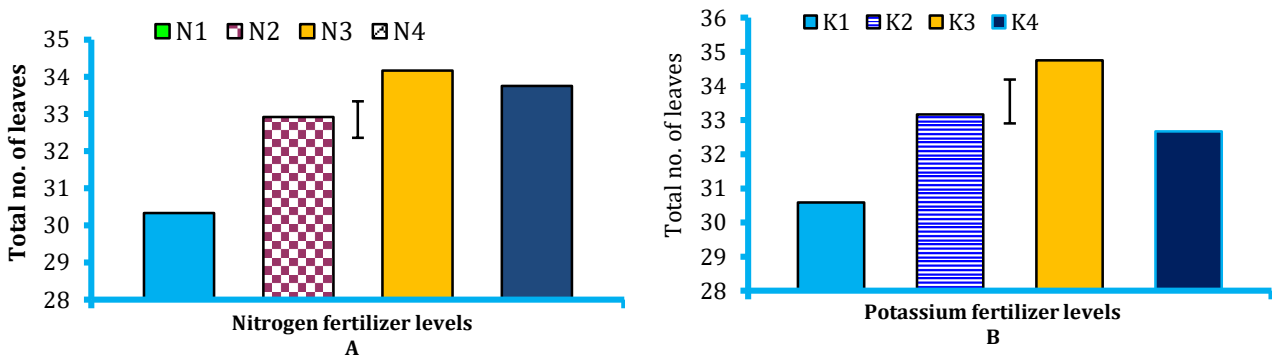

Figure 04. Effect of different levels of nitrogen (A) and potassium (B) fertilizer on total number leaves of banana. Vertical bar represents the LSD value at 5% level of probability

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Effect of N and K fertilizers on days to bunch maturity

Days to bunch maturity had differed significantly due to the application of different levels of nitrogen and potassium. Significant variation showed against days to bunch maturity through the effect of application of different levels of nitrogen and potassium and their results are presented in Table 01, 03. Data revealed that the maximum days to maturity (84.66) were recorded from N_1 (300g urea/plant) treatment and the minimum days to maturity (78.69) were obtained from N_4 (600g urea/plant) treatment (Table 01). It was reported in the literature that application of increased level nitrogen hastens maturity (Chattapadhayay et al., 2018). Likewise tread was found in the effect of potassium on days to bunch maturity. The maximum days to maturity (85.08) were observed from K_1 (250g MOP/plant) treatment and the minimum days to maturity (76.38) were noted from K_3 (450g MOP/plant) treatment (Table 01). The application of increased level potassium enhanced early flowering and maturity which gave the conformity of the findings (Jambulingum et al., 2011). In case of interactions, combined $N_1 \times K_1$ (300g urea×250g MOP/plant) treatment showed the maximum duration of maturity (93.78) and Combined $N_3 \times K_3$ (500g urea×450g MOP/plant) treatment exhibited the minimum duration of maturity (72.66) (Table 03). These results indicate that nitrogen and potassium fertilizer has influenced on days to bunch maturity than other treatments. The result is consistent with that of Hossain and Haque (2013) from their experiment.

Effect of N and K fertilizers on crop duration

The application of different levels of nitrogen and potassium fertilizer had a significant influence on crop duration and their results are shown in Table 01 and 03. The maximum crop duration (375.27) was recorded from N_2 (400g urea/plant) treatment followed by N_4 (600g urea/plant) treatment (374.50 days). The minimum crop duration (366.22) was recorded from N_3 (500g urea/plant) treatment (Table 01). Hossain and Haque (2013) reported that application of an increased level of nitrogen enhanced flowering and shortened crop duration which gave conformity to the findings. On the contrary, the maximum crop duration (382.69 days) was recorded from K_1 (250g MOP/plant) treatment and the minimum crop duration (359.52 days) was recorded from K_3 (450g MOP/plant) treatment (Table 01). This result has got support from Jambulingum et al. (2011) who reported that increased level potassium application enhanced early flowering and maturity and reduced crop duration. In case of combined effect, the combined effect of application of different levels of nitrogen and potassium fertilizers on crop duration was found to be statistically significant. The maximum crop duration (393.33 days) was recorded from $N_1 \times K_1$ (300g urea×250g MOP/plant) treatment combination and the minimum crop duration (345.77 days) was recorded from $N_3 \times K_3$ (500 g urea × 450 g MOP/plant) treatment combination (Table 03). This finding of this experiment is in partial or fully agrees with that of Hossain and Haque (2013).

Table 01. Effect of different level of nitrogen and potassium on morpho-physiological characters of banana

Treatments	Days to bunch maturity	Crop duration (days)	Treatments	Days to bunch maturity	Crop duration (days)
N_1	84.66	371.75	K_1	85.08	382.69
N_2	79.64	375.27	K_2	81.27	373.27
N_3	80.36	366.22	K_3	76.38	359.52
N_4	78.69	374.50	K_4	80.61	372.25
LS	*	**		**	*
CV (%)	6.45	7.12		6.48	7.31
LSD	1.47	6.71		1.47	6.71
SE (±)	1.33	1.21		0.98	1.10

Here, N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant, N_4=600g Urea/plant, K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant and DAP=Days after planting, LS= Level of significance, CV(%)= Co-efficient of variance, LSD=Least significant different, SE(±)= Standard error, In a column means having dissimilar letter(s) are statistically different, *means at 5% level of probability, **means at 1% level of probability

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Table 02. Combine effect of different level of nitrogen and potassium on morpho-physiological characters of banana

Interaction	Pseudo-stem height (m) at different DAP				Pseudo-stem girth (cm) at different DAP			
	120	150	180	210	120	150	180	210
N_1K_1	0.500	0.837	1.517	1.453	21.10	26.557	33.67	42.11
N_1K_2	0.603	0.880	1.257	2.100	23.78	30.110	37.11	43.88
N_1K_3	0.760	1.033	1.247	1.993	25.89	31.557	41.33	47.44
N_1K_4	0. 717	0.973	1.337	1.903	27.63	30.443	38.88	45.11
N_2K_1	0.680	0.927	1.730	2.110	22.89	27.780	37.11	44.22
N_2K_2	0.733	1.037	1.433	2.190	27.11	31.333	40.89	46.88
N_2K_3	0.777	1.093	1.620	2.420	28.66	31.333	42.66	51.66
N_2K_4	0.770	1.063	1.677	2.870	27.44	35.777	41.33	51.44
N_3K_1	0.670	0.940	1.623	2.123	25.33	30.667	37.66	46.33
N_3K_2	0.680	1.020	1.620	2.057	27.55	29.553	41.89	52.33
N_3K_3	0.860	1.375	1.910	2.870	36.00	36.443	46.66	57.55
N_3K_4	0.830	0.910	1.550	2.157	27.55	29.557	41.66	51.89
N_4K_1	0.677	0.960	1.553	2.080	26.11	29.223	40.11	50.66
N_4K_2	0.720	1.003	1.500	2.053	26.88	31.447	41.77	54.00
N_4K_3	0.807	1.190	1.450	1.997	32.78	32.890	42.33	55.33
N_4K_4	0.590	0.963	1.543	2.093	29.11	29.890	39.44	50.55
Maxi. Interaction	0.860	1.375	1.910	2.870	36.00	36.443	46.66	57.55
Mini. Interaction	0.500	0.837	1.247	1.453	21.10	26.557	33.67	42.11
LS	**	**	*	*	*	**	*	**
CV (%)	6.66	7.12	5.48	7.04	5.56	6.07	6.73	6.54
LSD	0.105	0.117	0.235	0.268	2.666	2.590	2.031	1.723
SE (±)	1.26	1.12	1.10	0.98	1.25	1.14	1.27	1.22

Here, N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant, N_4=600g Urea/plant, K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant and DAP=Days after planting, LS= Level of significance, CV(%)= Co-efficient of variance, LSD=Least significant different, SE(±)= Standard error, In a column means having dissimilar letter(s) are statistically different, *means at 5% level of probability, **means at 1% level of probability

Effect of N and K fertilizers on different yield and yield attributes

Total number of fingers per bunch: Table 04 and 05 showed the number of fingers per bunches relationship with N and K fertilizers. Nitrogen and potassium significantly increased the fingers per bunch. The highest number of fingers (67.45) per bunch was found with N_3 (500g urea/plant) treatment and the lowest number of fingers (55.61) per bunch was found with N_1 (300g urea/plant) treatment (Table 04). The result is in agreement with Naresh et al. (2004) who found highest number of fingers per bunch with 240g N/plant and from another study, Chattapadhayay et al. (2018) also observed the increase in levels of nitrogen doses from 0-240g/plant increased the fingers per bunch on Cavendish banana *cv.* Giant Governor. Similar type of result was found in potassium application. K_3 (450g MOP/plant) treatment produced the maximum number of fingers (67.22) per bunch where K_1 (250g MOP/plant) treatment produced the minimum number of fingers (57.16) per bunch (Table 04). The number of fingers per bunch increased with increasing rates of K_2O up to 300g (Jambulingum et al., 2011; Singh and Kashyap, 2010). On the contrary, the highest number of fingers (79.55) per bunch was found with N_3×K_3 (500g urea×450g MOP/plant) treatment combination and the lowest number of fingers (50.33) per bunch was found with N_1×K_1 (300g urea×250g MOP/plant) treatment combination (Table 05). The result of this study is in agreement with Chandrakumar et al. (2011) who reported that the increase in the N and K fertilization levels and ratios influenced the yield and yield parameters. However, the positive response of banana to higher potassium application after flower was also observed.

Total number of hands per bunch: Numbers of hand per bunch are vital elements of plant which plays an important role in the yield. Different levels of nitrogen and potassium fertilizer significantly influenced the total number of hands per bunch and their significant data is shown in Table 04 and 05.

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Table 03. Combine effect of different level of nitrogen and potassium on morpho-physiological characters of banana (continued)

Interaction	No. of functional leaves at different DAP				Total no. of leaves/plant	Days to bunch maturity	Crop duration (days)
	120	150	180	210			
N_1K_1	8.530	8.000	9.890	10.33	27.33	93.78	393.33
N_1K_2	10.22	10.00	11.66	11.33	32.00	87.55	374.00
N_1K_3	11.88	9.890	12.89	11.77	31.00	76.76	361.11
N_1K_4	10.89	9.487	12.44	13.77	31.00	80.55	358.55
N_2K_1	9.568	8.957	10.44	14.33	33.33	75.33	385.00
N_2K_2	11.62	10.00	13.88	12.33	32.66	80.33	375.77
N_2K_3	12.40	10.00	14.11	14.33	34.00	82.00	367.44
N_2K_4	11.55	9.443	13.89	14.00	31.66	80.89	372.89
N_3K_1	10.41	10.00	13.78	13.33	30.66	88.22	361.33
N_3K_2	11.75	9.223	13.44	14.55	33.66	79.44	374.89
N_3K_3	14.55	12.66	15.66	16.22	38.33	72.66	345.77
N_3K_4	12.07	9.770	14.11	15.44	34.00	81.11	382.89
N_4K_1	10.43	9.344	12.11	12.88	31.00	83.00	391.11
N_4K_2	11.34	9.780	12.11	14.44	34.33	77.77	368.44
N_4K_3	13.55	9.000	12.44	15.22	35.66	74.11	363.77
N_4K_4	9.887	9.280	12.11	14.22	34.00	79.88	374.67
Maxi. Interaction	14.55	12.66	15.66	16.22	38.33	93.78	393.33
Mini. Interaction	8.530	8.000	9.890	10.33	27.33	72.66	345.77
LS	**	*	*	*	*	**	*
CV (%)	8.09	3.48	7.0	6.14	6.45	6.64	7.14
LSD	1.009	1.427	1.434	1.619	2.773	2.969	13.420
SE (±)	1.11	1.09	1.07	1.18	1.10	1.07	1.17

Here, N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant, N_4=600g Urea/plant, K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant and DAP=Days after planting, LS= Level of significance, CV(%)= Co-efficient of variance, LSD=Least significant different, SE(±)= Standard error, In a column means having dissimilar letter(s) are statistically different, *means at 5% level of probability, **means at 1% level of probability

Table 04. Effect of different level of nitrogen and potassium fertilizers on yield and yield attributes of banana

Treatments	Total no. of fingers/bunch	Total no. of hands/bunch	Bunch wt. (Kg/plant)	Yield (t/ha)
Effect of Nitrogen				
N_1	55.61	5.02	8.87	24.49
N_2	64.67	5.61	10.44	28.73
N_3	67.45	5.91	10.56	29.11
N_4	62.97	5.36	9.24	25.68
Level of significance	*	**	*	*
CV (%)	6.47	7.01	6.18	5.48
LSD	3.43	0.30	0.46	
SE (±)	1.04	0.98	1.10	1.12
Effect of potassium				
K_1	57.16	5.13	9.51	26.02
K_2	62.91	5.47	9.56	26.55
K_3	67.22	6.00	10.27	28.58
K_4	63.38	5.30	9.77	26.87
Level of significance	**	*	*	*
CV (%)	5.18	6.57	6.63	7.14
LSD	3.43	0.30	0.46	0.19
SE (±)	0.87	1.01	1.14	1.27

Here, N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant, N_4=600g Urea/plant, K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant and DAP=Days after planting, CV(%)= Co-efficient of variance, LSD=Least significant different, SE(±)= Standard error, In a column means having dissimilar letter(s) are statistically different, *means at 5% level of probability, **means at 1% level of probability

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Application of N_3 (500g urea/plant) treatment produced the maximum number of hands (5.91) per bunch and the minimum number of hands (5.02) per bunch was found from N_1 (300g urea/plant) treatment (Table 04). This result is in agreement with Chattapadhayay et al. (2018). The highest number of hands (6.0) per bunch was recorded in the treatment of K_3 (450g MOP/plant) and the minimum number of hands (5.13) per bunch was found from K_1 (250g MOP/plant) treatment (Table 04). Total number of hands per bunch increased with increasing rates of K_2O up to 300g (Baruah and Mohan, 2010). Similar results were reported by Chandrakumar et al. (2011) and Jagirdar and Ansari (2016). After there, among the interaction, the maximum number of hands (7.55) per bunch was found in the combined treatment of $N_3 \times K_3$ (500g urea × 450g MOP/plant) whereas, the minimum number of hands (4.33) per bunch was obtained from the combined treatment of $N_1 \times K_1$ (300g urea×250g MOP/plant) (Table 05). The increase in the N and K fertilization levels and ratios influenced the yield and yield parameters. However, the positive response of banana to higher potassium and nitrogen application after flower was also observed (Chandrakumar et al., 2011).

Bunch weight (kg/plant): Bunch weight had varied significantly due to application of different levels of nitrogen and potassium fertilizer and significant variation data are presented in Table 04 and 05. The highest bunch weight (10.56kg) was observed with N_3 (500g urea/plant) treatment and the lowest bunch weight (8.87kg) was found with N_1 (300g urea/plant) treatment (Table 04). Singh and Kashyap (2010) obtained best bunch weight by the application of 450g N/plant. Similar results were observed by Chandrakumar et al. (2011) and Sahilendra et al. (2015). In case of K fertilizer, the maximum bunch weight (10.27 kg) per plant was found from K_3 (450 g MOP/plant) treatment and the minimum bunch weight (9.51 kg) was recorded from K_1 (250 g MOP/plant) treatment (Table 04). The previous study (Jagirdar and Ansari, 2016; Jambulingum et al., 2011) supported the findings. On the other hand, based on interaction, the maximum bunch weight (12.33 kg) per plant was obtained from $N_3 \times K_3$ (500g urea × 450 g MOP/plant) and the minimum bunch weight (8.44 kg) was per plant obtained from $N_1 \times K_1$ (300g urea × 250 g MOP/plant) treatment combine (Table 05). Similar findings were also reported where application of 300 g nitrogen and 300 g potassium gave the highest bunch weight (Sahilendra et al., 2015).

Table 05. Combined effect of nitrogen and potassium fertilizers on yield and yield attributes of banana

Interaction	Total no. of fingers/bunch	Total no. of hands/bunch	Bunch wt. (Kg/plant)	Yield (t/ha)	Benefit cost ratio
N_1K_1	50.33	4.333	8.541	23.82	1.56
N_1K_2	57.11	5.447	9.341	25.69	1.68
N_1K_3	57.44	5.333	9.179	25.23	1.65
N_1K_4	57.55	5.000	8.440	23.23	1.53
N_2K_1	59.55	5.777	10.27	28.27	1.77
N_2K_2	67.55	5.553	10.50	28.90	1.81
N_2K_3	67.66	5.667	10.44	28.71	1.80
N_2K_4	63.88	5.443	10.56	29.05	1.82
N_3K_1	57.33	5.333	9.610	26.42	1.60
N_3K_2	63.77	5.443	9.500	26.13	1.58
N_3K_3	79.55	7.557	12.33	34.22	2.04
N_3K_4	69.11	5.333	10.80	29.70	1.78
N_4K_1	61.44	5.110	9.630	25.57	1.49
N_4K_2	63.22	5.443	8.929	25.48	1.49
N_4K_3	64.22	5.443	9.152	26.16	1.53
N_4K_4	63.00	5.447	9.280	25.52	1.46
LS	**	*	*	*	
CV (%)	6.58	4.62	7.14	5.48	
LSD	6.86	0.80	0.93	1.81	
SE (±)	1.10	1.05	0.98	1.22	

Here, N_1=300g Urea/plant, N_2=400g Urea/plant, N_3=500g Urea/plant, N_4=600g Urea/plant, K_1=250g MOP/plant, K_2=350g MOP/plant, K_3=450g MOP/plant, K_4=550g MOP/plant and DAP=Days after planting, LS= Level of significance, CV(%)= Co-efficient of variance, LSD=Least significant different, SE(±)= Standard error, In a column means having dissimilar letter(s) are statistically different, *means at 5% level of probability, **means at 1% level of probability

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Yield (t/ha): Yield is the final output of crop production. There were significant variations in yield among the application of different levels of nitrogen and potassium fertilizers in banana production. Single and combined effects of N and K on yield are presented in Table 04 and 05. The maximum yield (29.11 t/ha) was obtained from N_3 (500g urea/plant) treatment and the minimum yield (24.49 t/ha) was obtained from N_1 (300g urea/plant) treatment (Table 04). Data revealed that yield of Amritasagar banana variety increased with the increase of N level up to 240 g/plant (Naresh et al., 2004 and Chattopadhayay et al., 2018). Application of different levels of potassium had exhibited significant influence on yield of banana per hectare. The maximum yield (28.58 t/ha) was obtained from K_3 (450g MOP/plant) treatment and the minimum yield (26.02 t/ha) was obtained from K_1 (250g MOP/plant) treatment (Table 04). These findings support the results of Saleh (2001) and Baruah and Mohan (2010) in banana. In case of interaction, the maximum yield (34.22 t/ha) was found from $N_3 \times K_3$ (500g urea×450g MOP/plant) treatment and the minimum yield (23.23 t/ha) was obtained in $N_1 \times K_1$ (300g urea×250g MOP/plant) (Table 05). The result is in agreement with Chandrakumar et al. (2011) who found that both levels and ratios of N and K fertilization influenced the yield of banana.

Benefit cost ratio: The combination of nitrogen and phosphorus for benefit cost ratio was different in all treatment combinations. The highest (2.04) benefit cost ratio was performed from the treatment combination of $N_3 \times K_3$ (500g urea×450g MOP/plant) and the lowest benefit cost ratio (1.46) was obtained from $N_4 \times K_4$ (600g urea×550g MOP/plant). From an economic point of view, it is apparent from the above results that the treatment combination of $N_3 \times K_3$ was more profitable than the rest of the treatment combination (Table 05).

IV. Conclusion

The results of the current research indicate that the application of nitrogen (N) and potassium (K) fertilizers regarding various morpho-physiological characters, yield attributes and yield of banana were significantly influenced by N_3 (500g urea/plant) and K_3 (450g MOP/plant) singly or their interactions were more effective for obtaining the greater results comparatively than that of other application of N and K. Therefore, it could be concluded that the application of N_3 (500g urea/plant) or K_3 (450g MOP/plant) or their interaction, $N_3 \times K_3$ (500g urea×450g MOP/plant) effect would be optimum level for maximizing the morpho-physiological and yield contributing characters of banana.

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V. References

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