EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND DEVELOPMENT OF BARI PANIKACHU-6 (*Colocasia esculenta*)

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND DEVELOPMENT OF BARI PANIKACHU-6 (*Colocasia esculenta*)"** submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **SOIL SCIENCE**, embodies the result of a piece of bonafide research work carried out by **MUSTUCK AHAMED**, Registration No. **19-10222** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

December, 2021
Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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The Author

EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND DEVELOPMENT OF BARI PANIKACHU-6 (*Colocasia esculenta*)

ABSTRACT

Colocasia esculenta is a highly nutritive vegetable which is very important for human health with daily diet. The present study was carried out at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period of February 2021 to July 2021 to study the effect of N and K for the growth and development of BARI panikachu-6 (*Colocasia esculenta*). Eight levels of N and K treatments including control were considered for the experiment *viz*. T_1 (control; $N_0P_0K_0$ kg ha^{-1}), T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}), T_4 ($N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}), T_5 ($N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}), T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}), T_7 ($N_{75}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) laid out in randomized complete block design (RCBD) with three replications. Among the treatments, T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) showed the best performance on plant base diameter (30.87 cm), length of rhizome (73.50 cm), fresh weight of rhizome plant^{-1} (3.39 kg), fresh weight stolon palnt^{-1} (240.00 g), rhizome yield (82.24 t ha^{-1}) and stolon yield (6.12 t ha^{-1}) and next to T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) considering growth and yield performance whereas control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) showed minimum results. In terms of nutrient status in post harvest soil, pH, organic carbon (OC) and available P content was found non-significant among the treatments while the maximum S content (29.43 ppm) was recorded from the treatment T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) compared to control. Considering growth, yield contributing parameters and yield and also nutrient status in soil, the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) can be considered as best for BARI panikachu-6 cultivation followed by T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). So, it can be concluded that recommended doses of fertilizers specially N and K are very effective for higher rhizome and stolon yield of *Colocasia esculenta* at farmers level of cultivation.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan’s Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Colocasia esculenta L. Schott is a stem tuber crop belongs to the monocotyledonous family *Araceae* of the order *Arales*, whose members are known as aroids (Henry, 2001). *Araceae* includes about 100 genera and 1500 widely distributed species (Merlin, 1982; Vinning, 2003). It is a most important tuber vegetable of the world and is known as 'Great leaved Caladium' or 'Elephant ear' in English, 'Dasheen' in USA and "Cocoyam" in West Africa. Commonly it is known as taro, aroid, arvi etc. In Bangladesh it is locally known as Kachu and popularly cultivated tuber crops in the whole country. On the basis of its types, it is also termed as panikachu, mukhi kachu etc.

Colocasia is believed to have originated in South East Asia including India (Chang, 1958) and Malaysia (Keleny, 1962). *Colocasia* is one of the few edible species in the genus *colocasia* and is the most widely cultivated species (Vinning, 2003). Cultivated *colocasia* is classified as *Colocasia esculenta*, but the species is considered to be polymorphic. It ranks the third after cassava and yam, in terms of total production, land area under crop and consumption (Chukwu and Nwosu, 2008). Despite the importance of this crop, its cultivation anywhere in Bangladesh is generally a subsistent to semi-commercial crop.

Taro is used as food, prepared in the same way as potatoes. The main economic parts in taro are the rhizome or corms and cormels or stolon, as well as the leaves. The rhizomes and stolons are usually boiled, baked, roasted or fried and consumed in conjunction with other foods like fish and coconut preparations. The leaves are usually boiled or prepared in various ways mixed with other condiments. *Colocasia* is known for its high nutritive values particularly rich in carbohydrate, protein, vitamin C and certain other constituents. The rhizome is an excellent source of carbohydrate, the majority being starch, of which 17-28% is amylase and the remainder is amylopectin. Various parts of the plant are also used in traditional medicine practice (Tsitsiringos, 2002). It is also used in folklore system of medicine in different tribal areas of the world. Hot tubers are locally applied to painful parts in rheumatism. Although, it is irritating to the human skin, mouth and throat, acridity protect taro against herbivores.

Even though there is no statistical data available on the area and production of taro in Bangladesh, it is a fact that taro commands a higher price than cassava or sweet potato. Taro variety BARI panikachu-6 was developed at Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. It is an early maturing variety (150-160 days) coupled with bold rhizome which is preferred by local consumers. Less amount of stolon also produced with this variety. It can be grown in kharif (irrigated and rainfed) and late rabi or summer. This variety can be grown as pure crop and also as intercrop in plantation crops like banana and coconut in kharif or rabi or summer (BARI, 2019).

Taro requires a fairly good amount of nutrients for high and economic yields. Plants need a wide range of proteins to grow, develop and mature. Nitrogen is the element, most frequently deficient in tropical soils. It plays an important role in plant nutrition, being an essential constituent of many metabolic functions, active compounds like amino acids, proteins, nucleic acids, enzymes and co-enzymes (Markam *et al*., 2018, Zhang-FuChun, 2010, Uwah *et al*., 2011). The main body of protein is amino acids and nitrogen is the major component of amino acids. Nitrogen is also present in chlorophyll. Application of N from inorganic sources is essential to sustain and improve crop yield. Potassium is essential for carbohydrate translocation from tops to roots. It plays a major role in the production of corms. Hence, it is necessary for enhancing the corm yield and yield attributes (Omid *et al*., 2018, Uwah *et al*., 2013).

It is also evident from the literature that taro growth and yield responds positively to nitrogen and potassium. The information regarding nutritional requirement of this crop is very scanty. To improve the yield and quality of taro (*Colocasia esculenta*), there is a need to standardize the optimum dose of nutrients for improving the physicochemical properties of soil as well as yield and quality of produce. Research on nitrogen and potassium requirement of taro in Bangladesh is meager. It is also well known that addition of organic manures has shown considerable increase in crop yield, quality and significant influence on physical, chemical and biological properties of soil (Joshi *et al*. 2018). For sustainable crop production, integrated uses of inorganic and organic source of fertilizers are highly beneficial. Nutrient uptake by plants and crop yield is highly depended on nutrient supply system to soil through different sources (Joshi and Sharma, 2017).

Keeping the above in view, the present investigation entitled 'effect of N and K on the growth and development of BARI panikachu-6 (*Colocasia esculenta*)' was conducted with the following objectives.

1. To observe the effect of N and K on the growth and development of BARI panikachu-6
2. To evaluate the interaction effect of N and K for the growth and yield of BARI panikachu-6
3. To find out the suitable doses of N and K for maximum growth and yield of BARI panikachu-6

CHAPTER II

REVIEW OF LITERATURE

The proper nutrient management accelerate growth and influenced yield of crops. Therefore, available findings of the effect of N and K through nutrient management with inorganic fertilizer and organic fertilizer relevant to the present study have been briefly reviewed under the following heads.

2.1 Effect of different levels of nitrogen and potassium on growth, yield and nutrient uptake of taro

2.1.1 Effect of nitrogen on crop growth

Mohankumar and sadanandan (1989) found that increasing levels of nitrogen had significantly increased the height of the plant upto 120th day after planting. The type of growth pattern in taro suggest that for early vegetative growth, higher levels of nitrogen are required. Maximum LAI was observed at 80 kg N ha^{-1}.

In elephant foot yam, Lee *et al.* (1992) observed that the plant height and leaf width increased with increasing rate of nitrogen fertilizers.

Geetha and Madhavan Nair (1993) reported a significant positive influence on morphological characters like plant height, number of branches, number of leaves of *Coleus parviflorus* upon increased nitrogen application.

Sanjay Kumar *et al.* (2004) investigated the effect of graded levels of nitrogen on growth of colocasia *(Colocasia esculenta* Schott) and reported that the application of nitrogen at 120kg ha$^{\mathbf{-1}}$ in 3 splits ***viz.*** 1/3 at planting, 1/3 at 30 days after planting and 1/3 at 60 days after planting was superior to other combinations.

2.1.2 Effect of nitrogen on yield

Alfred *et al.* (2000) envinced that five levels of fertilizer N (0,100, 200, 300 and 400 kg ha^{-1}) applied in split applications did not affect the yield of marketable taro corms but non-marketable corm yield doubled with high N fertilizer rates. As N rates increased, taro yield and biomass increased but the harvest index decreased.

Investigations on the effect of graded levels of nitrogen on yield of colocasia *(Colocasia esculenta* Schott) found that the application of nitrogen at 120kg/ha in 3 splits ***viz.*** 1/3 at planting , 1/3 at 30 days after planting and 1/3 at 60 days after planting was superior to other levels (Sanjay Kumar *et al.*, 2004).

2.1.3 Effect of potassium on crop growth

In west Bengal highest vine yield (22.12t ha^{-1}) was recorded for sweet potato where 75 kg K_2O ha^{-1} was applied in 2 equal splits (Mukhopadhyay *et al.*, 1990).

Suja (2005) reported in white yam *(Dioscorea rotundata* Poir.) as the potassium nutrition at 120 kg ha^{-1} was beneficial in promoting leaf, vine, and tuber dry matter production and resulted in greater plant biomass (802.15 g plant $^{-1}$).

2.1.4 Effect of potassium on yield

Mohankumar and Sadanandan (1989) reported that tuber yield increased with increase in the level of potassium application from 50 to100 kg K_2O ha^{-1} but 100 and 150 kg K_2O ha^{-1} were less effective for higher tuber yield.

In west Bengal highest tuber yield (8.6 t/ha) was recorded in sweet potato where 75 kg K_2O ha^{-1} was applied in 2 equal splits (Mukhopadhyay *et al.*, 1990).

El-Sharkawy (2007) conducted two field experiments to study the effect of nitrogen sources , nitrogen levels and defoliation on growth and corm yield, as well as some chemical constituents, of the local cv. Balady of taro plant. Three nitrogen sources. i.e. ammonium sulphate , ammonium nitrate and urea with three nitrogen levels (40,80 and 160 Kg N/Fed.) and defoliation (leaving 4,5,6 leaves/plant) , as well as the control (not leaves removing) were used. Results showed that the application of nitrogen in the form of ammonium sulphate increased plant height, fresh weight/plant, total yield/plot, corm length and corm diameter. The results also indicated that plant height, leaf area, chlorophyll content, fresh weight/ plant, total yield/plot, corm length, and corm diameter increased with increasing nitrogen application up to 80 Kg N/Fed. Morever, defoliation of the (6 leaves and the control) gave the highest values in all characters except the chlorophyll leaf content, diameter corm and dry matter percentage. Starch percentage of corms increased with increasing nitrogen level up to 80 Kg N/Fed., in the form of urea in addition to the control, while, nitrogen and protein percentage of corms increased with increasing nitrogen level up to 160 Kg N/Fed. in the form of ammonium nitrate and the control one.

Ahmad *et al*. (2018) conducted a field experiment to evaluate the response of colocasia (*Colocasia esculenta*) to different levels of 0, 60, 90, 120 and 150 kg N ha^{-1} under farmer's field condition. All levels of N in the form of urea along with uniform basal doze of 90 kg P_2O_5 ha^{-1} as Triple Super Phosphate (TSP) were applied to soil at time of seed bed followed by thorough mixing. The results showed that application of N produced significantly higher *colocasia* tuber yield, number of tubers $plant^{-1}$, 1000-tubers weight and size of tubers (mean length and diameter) over control but the differences among levels of N were non-significant. However, some parameters like tuber yield was maximum at 60 kg N ha^{-1} and tuber size especially the length of colocasia tuber was maximum at 150 kg N ha^{-1} suggesting that the response of each parameter was different to N levels. Based on maximum relative yield (100%) and increase over control (46.1%) still at lower N levels of 60 kg N ha^{-1}, this level seems to be appropriate level for *colocasia* under the prevailing soil and climatic conditions.

2.1.5 Interaction effect of nitrogen and potassium on crop growth

Sen and Mukherjee (2002) evaluated the effects of levels of nitrogen and potassium application on corm production of elephant foot yam and reported that the application of N and K in three split doses increased growth.

Chattopadhyay *et al.* (2006) studied the effect of different levels of NPK fertilizers on growth and productivity of elephant foot yam and the results indicated that the maximum plant height (89.5 cm), pseudostem girth (19.2 cm) were recorded with highest NPK level (175:125:175 kg ha^{-1}) but maximum canopy spread (123.1 cm) was observed with NPK level 150:100:150.

Zhang-FuChun (2010) specified that yield and income were positively correlated with the application of 167 kg N, 74 kg P_2O_5 and 179 kg K_2O ha^{-1} in *Colocasia esculenta* cv. Liuyehong of China.

2.1.6 Interaction effects of nitrogen and potassium on yield

Premaj *et al.* (1980) studied that 120 kg N and K with 60 kg phosphorus were found to be optimum for colocasia in Tamil Nadu. Ramaswamy *et al.* (1982) found that among the different fertilizer treatments higher tuber yield in colocasia was obtained for the fertilizer dose 40: 60:120 kg N, P_2O_5 and K_2O ha^{-1}.

Ashokan and Nair (1984) obtained highest cormel and total yield of colocasia at a fertiliser dose of 80:50:80 kg N, P_2O_5 and K_2O ha^{-1} respectively. Similar results were also reported by Sen *et al.* (1988).

Mohankumar *et al.* (1990) investigated the effect of levels of NPK and time of application of N and K on the yield of taro *(Colocasia esculenta* L**.** schott) and revealed that the application of 80 kg N, 25 kg P_2O_5 and 100 kg K_2O ha^{-1} in two split doses increased the corm yields.

Verma *et al.* (1996) conducted the experiment on Colocasia which consisting of different combinations of 0, 40, 80 and 120 kg/ha of N and K respectively. They reported that the increasing levels of N had positive effects on plant height, number of suckers/plant and number of leaves/plant. Increasing level of N up to 80 kg/ha significantly increased tuber yields and increasing levels of K had similar effects. There was also a significant interaction between the 2 nutrients, 80 kg N and 120 kg K_2O /ha recorded the highest yields.

Mehla *et al.* (1997) determined the effect of spacing and fertilizer levels on yield of colocasia *(Colocasia esculenta* L.) and reported that the yield and yield attributes of corms increased significantly with fertilizer dosage of 100 kg N + 50 kg P_2O_5 ha^{-1}.

Halavatau *et al.* (1998) obtained significantly highest yields with the application of fertilizer in split doses in sweet potato and taro as compared to single dose application.

In Olkachu *(Amorphophallus campanulatus* Blume), Kundu *et al.* (1998) recorded the highest corm yield and total yield (63.66 and 75.12 t ha^{-1}, respectively) with 200 kg N ha^{-1} + 100 kg P ha^{-1}.

Rajeshkumar and Jain (1998) observed the response of nitrogen and potassium on growth and tuber yield of taro *(Colocasia esculenta* L. Schott.) in the plateau region of Bihar and indicated that 120kg N + 80kg K_2O ha^{-1} was optimum for taro cultivation.

Awad *et al.* (2001) reported that the increase in the N, P and K fertilization levels had a stimulative effect on increased yield of corms. However, application of 120kg N fed^{-1} and highest levels of phosphorus and potassium fertilizers gave the highest weight of corms and potassium content in corms. Percentage of dry matter in corms decreased with increasing nitrogen-levels and with decreasing phosphorus and/or potassium levels. However, the highest yield and its components ***i.e*** corm quality and nutrient content were obtained when the plants received 120 kg N plus 30 kg P_2O_5 and 96 kg K_2O fed^{-1} and produced the maximum yield of taro corms.

Rajeshkumar and Vijoykumar (2001) work out the effect of nitrogen, potassium and spacing in arvi *(Colocasia esculenta* L. Schott). cv. kadama local. The study revealed that the application of 120 kg N/ha gave highest plant height (70.40 cm), number of leaves (6.50), weight of cormels (235.66 g) per plant and mean cormel yield (10.44 t/ha) while potassium did not influence the plant height, number of leaves and leaf length. Application of potassium significantly increased the mean cormel yield (9.28 t/ha) up to 80 kg K_2O/ha. The higher net profit of Rs. 24,040.00, Rs.19,980.00, and Rs.20,785.00 were obtained by application of 120 kg/ha nitrogen, 80 kg/ha potassium respectively at plant spacing of 60x30 cm, for two year of experimentation.

Sen and Mukherjee (2002) observed the treatment with the highest level of both N and K recorded the highest mean corm yield (51.82 t ha^{-1}). Application of N and K in three equal splits registered the maximum mean corm production (52.51 t ha^{-1}). The combination of the highest N and K rates and the application by three equal splits recorded the highest mean corm production (54.02 t ha^{-1}) in elephant foot yam. Similarly, Sethi *et al.* (2002) reported that increased crop yield with increasing NPK rates.

Sau *et al.* (2002) reported that Petiol length of taro cultivator BCC-1 and CE-**6** showed an increasing trend up to 120 DAP with highest values of each N and K at 150 kg per ha. Dry weights of leaves and cormels were highest with each parameters N and K 150 kg/ha but it was almost at par with N @100 kg and K @150 kg/ha. where as, LAI at was found to be higher with N @ 100 kg and K @ 150 kg but at par with N and K @ 150 kg/ha. Crop growth rate (CGR) increased gradually up to 90-120 DAP and recorded highest value at 150 kg each of N and K but at par with 100 kg N and 150 kg K/ha. Yield attributes like number of cormels and average weight of cormel were higher in cultivar BCC-1 followed by Telia for each of N and K 150 kg/ha which was closely followed by 100 kg and 150 kg/ha N and respectively. Similarly the highest cormel yield (12.25 t/ha) was found to be associated with BCC-1 followed by Telia (10.19t/ha).

Salam *et al.* (2003) concluded that different doses of urea and muriate of potash fertiliser and their time of application had significant influence on yield of Mukhi Kachu. The combination of the highest level of urea and muriate of potash fertiliser (300 kg each of urea and MP ha^{-1}) and application of 1/3 dose each at 60, 100 and 140 DAP gave the highest yield of corms (7.20 t ha^{-1}) and cormels (47.89 t ha^{-1}).

Kumar *et al*. (2004) studied the effects of nitrogen fertilizer levels (40, 80, 120 and 160 kg ha^{-1}) and application methods (2 and 3 splits) on the growth and yield of colocasia (*C. esculenta*). The result revealed that corm yield was increased with nitrogen level up to 120 kg ha^{-1} and it was found higher when nitrogen was applied in 3 splits (1/3 at planting, 1/3 at 30 days after planting and 1/3 at 60 days after planting) as compared with 2 splits (1/2 at planting and 1/2 at 30 days after planting).

Ram Batuk *et al.* (2011) observed that the significantly higher yield of 27.49 tonnes ha^{-1} was recorded under the treatment combination of 80 kg nitrogen and 120 kg potassium ha^{-1}. Optimum levels of nitrogen and potassium fertilization for tuber yield in colocasia were found to be 79.62 kg N and 114.79 kg K_2O ha^{-1}.

Santosa *et al*. (2011) observed that the consisted of four doses of nitrogen (0, 50, 100 and 150 kg ha^{-1} N) and three doses of potassium (0, 50 and 100 kg ha^{-1} K_2O). The results showed that application of N and K fertilizers significantly increased vegetative growth, i.e. number of leaves, number of leaflets and second leaf size, but did not affect harvesting time. Fresh weight and dry matter content of daughter corm were significantly affected by N and K applications. Combination of 50 kg ha^{-1} N and 100 kg ha^{-1} K_2O resulted in higher corm weight than other treatments. It is evident that the application of nitrogen and potassium is important in *Amorphophallus muelleri*.

Ogbonna and Nweze (2012) evinced that the application of NPK @ 300kg ha^{-1} in the ratio of 15:15:15 increased tuber yield of *Colocasia esculenta* in the south eastern Nigeria. The tuber yield significantly increased with increased application of fertilizers.

Uwah *et al*. (2013) reported that application of N at the highest rate increased plant height, produced higher number of leaves and branches plant^{-1}, stem girth, number and weight of tubers plant^{-1} and total fresh tuber yield of Cassava compared with other treatments. The fresh tuber yield at 120 kg N ha^{-1}was higher however, it was comparable with that of 80 kg N ha^{-1}. Cassava growth, fresh tuber yield and all yield attributes peaked at 80 kg K ha^{-1}. The 120 kg N ha^{-1} and 80 kg K ha^{-1} increased fresh tuber weight by 48 and 45 % and total fresh tuber yield by 36 and 27 % respectively, compared with the control plots.

Ariffin *et al*. (2016) conducted a research was to study the effect of nitrogen and potassium (NK) fertilizers and plant density on the growth and yield of taro (*Colocasia esculenta* L.). The experimental treatments consist of three levels of NK fertilizer (62.50 kg N, 81 kg K_2O, 125 kg N, 162 kg K_2O, 187.50 kg N, 243 kg K_2O ha^{-1}). The optimum application rate of NK fertilizers was obtained as 127.04 kg N ha^{-1} and 164.64 kg K_2O ha^{-1} with the tuber yield of 16.72 t ha^{-1}.

Lee *et al*. (2016) carried out an experiment with the objectives of fertilizer recommendation are to prevent the application of excessive fertilization and to produce target yields. Also, optimal fertilization is important because crop quality can be influenced by fertilization. In this study, yields and fertilizer use efficiency of Taro (*Colocasia esculenta* Schott) were evaluated in different level of NPK fertilization. N, P and K fertilizer application rates were 5 levels (0, 50, 100, 150, 200%) by practical fertilization (N-P_2O_5-K_2O=180-100-150 kg ha^{-1}), respectively. In the N treatment, the yields of Taro tuber were about 33 Mg ha^{-1} from 90 to 360 kg ha^{-1} N fertilization. However, the ratio of tuber to total biomass decreased with increasing N fertilization rate. In the P and K treatments, yields of Taro tuber were the highest at 150 kg ha^{-1} fertilization. Fertilizer use efficiency was decreased by increase of N and K fertilization. Crude protein of Taro tuber was the highest at practical fertilization. Sucrose content of tuber was influenced by phosphate application.

Omid *et al*. (2018) conducted an experiment entitled "effect of nitrogen, phosphorus and potassium on growth and yield of Arvi (*Colocasia esculenta* L.)" Total ten treatment *viz*. T_1 - NPK 60:30:80 kg ha^{-1}, T_2 - NPK 60 :60:120 kg ha^{-1}, T_3 -NPK 60 :90:160 kg ha^{-1}, T_4 - NPK 90:30:80 kg ha^{-1}, T_5 -NPK 90:60:120 kg ha^{-1}, T_6 -NPK 90:90:160 kg ha^{-1}, T_7 -NPK 120:30:80 kg ha^{-1}, T_8 -NPK 120:60:120 kg ha^{-1}, T_9 -NPK 120:90:160 kg ha^{-1} and T_{10} - Control were tried to assess the impact of nitrogen, phosphorous and potassium on growth and yield of colocasia during investigation. Out of these, the treatment with NPK 120:30:80 was found significantly superior in terms of plant height (cm.), plant spread (cm), number of leaves plant^{-1}, number of tillers plant^{-1}, girth of pseudostem from ground level (cm), length of leaf (cm), width of leaf (cm), petiole length (cm) and petiole breadth (cm). Similarly, yield and yield attributing parameters i.e., number of corms plant^{-1}, corm length (cm), corm girth (cm), weight of corm (g), corm yield plant^{-1} (g), and corm yield (q ha^{-1}) were found significantly superior with the application of NPK 120:30:80 as compared to control and other treatments. Finally, a dose of NPK @ 120:30:80 kg ha^{-1} gave the highest yield of corm i.e., 289.83 q ha^{-1}, whereas lowest yield of corm i.e., 92.25 q ha^{-1} was observed under control during the cropping period.

Markam *et al*. (2018) conducted an experiment on different fertility levels of *Colocasia esculenta*. The result revealed that maximum yield of corm and net returns and benefit cost ratio was recorded significantly maximum under F_5 (130% NPK) followed by F_4 (115% NPK) and minimum was observed under F_1 (70% NPK) in fertility levels.

Singh *et al*. (2021) carried out an investigation to study the influence of differential levels of inorganic and organic sources of nutrients on growth and yield of Bun. The experiment was laid out in a factorial randomized complete block design with sixteen treatment combinations consisted of four levels of fertilizers ($N_0P_0K_0$, $N_{50}P_{40}K_{50}$, $N_{75}P_{60}K_{75}$ and $N_{100}P_{80}K_{100}$) and four levels of Farm Yard Manure (0, 10, 20 and 30 t ha^{-1}). The result revealed that the plant height, leaf area index, length of corm, width of corm, weight of corm $plant^{-1}$, dry matter (%) of tuber and tuber yield increased significantly at each level of fertilizer. The plant height and leaf area index at 3 month after planting, length of corm, weight of corm $plant^{-1}$, dry matter (%), tuber yield, increased significantly at each level of FYM, however, the plant height and leaf area index at 5 month after planting and width of corm, responded significantly up to FYM @ 20 t ha^{-1}. The weight of corm was not influenced significantly with the FYM levels under $N_0P_0K_0$, and $N_{100}P_{80}K_{100}$ (except FYM @ 10 t ha^{-1}) and it responded to each successive level of FYM under remaining two fertilizer doses. The successive doses of FYM were significantly responded by tuber yield under all the fertilizer doses except FYM @10 t ha^{-1} under $N_0P_0K_0$. It shows that the dose of FYM @10 t ha^{-1} might not be sufficient to improve the tuber yield significantly where no fertilizer was applied. The fertilizer dose @ $N_{100}P_{80}K_{100}$ kg ha^{-1} in conjunction with FYM @ 30 t ha^{-1} was found better in terms of higher tuber yield (35.1 t ha^{-1}) of Bunda (*Colocasia esculenta*).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period February 2021 to July 2021 to investigate the effect of N and K on the growth and development of BARI panikachu-6 (*Colocasia esculenta*). Details of different materials used and methodologies followed to conduct the studies are presented in this chapter.

3.1 Site description

The experiment was conducted at the Sher-e-Bangla Agricultural University research field, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The land area is situated at 23°41' N latitude and 90°22' E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharifseason (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The weather data during the study period of the experimental site is shown in Appendix II.

3.3 Soil

The farm belongs to the general soil type, shallow red brown terrace soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to 20 medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done at Soil Science Laboratory, SAU, Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Treatments

Single factor experiment was considered for the present study which is as follows:

1. $T_1 = N_0P_0K_0$ kg ha^{-1}
2. T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1})
3. $T_3 = N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
4. $T_4 = N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
5. $T_5 = N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
6. $T_6 = N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
7. $T_7 = N_{75}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
8. $T_8 = N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

NB: Cowdung @ 5 t ha^{-1} was added in each treatment except control.

3.5 Plant materials and collection of seeds

BARI panikachu-6 was used as plant materials for the present study collected from BARI, Joydebpur, Gazipur, Bangladesh.

3.6 Preparation of experimental land

The plot selected for the experiment was opened in the first week of February 2021 with a power tiller, and was exposed to the sun for a week. The experimental field was prepared to a fine tilth. The ploughing was done with tractor drawn cultivator followed by one cross harrowing to pulverize the soil. Finally, the field was levelled with planker and layout of the experimental plots was done as per the dimensions mentioned.

3.7 Fertilizer application

The following doses of fertilizer were applied for cultivation of crop.

Nutrient element	Fertilizer	Recommended doses ha^{-1}
N, P, K, S	Cowdung	5 t
N	Urea	As per treatment
P	TSP	150 kg
K	MoP	As per treatment
S	Gypsum	65 kg

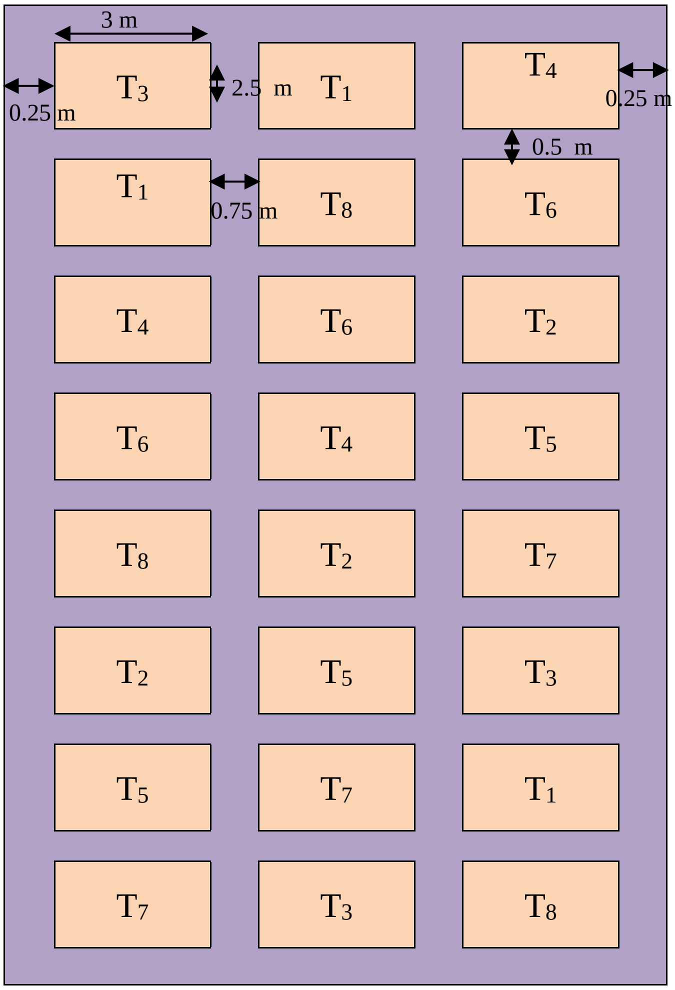
Cowdung @ 5 t ha^{-1} were applied during the final land preparation. The fertilizers N, P, K and S in the form of urea, TSP, MoP and gypsum, respectively were applied. The entire amount of TSP, MoP and gypsum were applied at the final preparation of land. Cowdung was applied at the rate of 5 ton ha^{-1} during 15 days before transplanting. Urea was applied in three equal installments at seedling establishment to harvest.

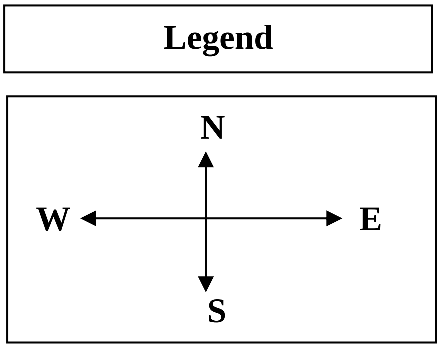
3.8 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications (block). The experiment plot was first divided into three equal blocks. Each block was divided into 8 sub plots where N and K treatments were assigned. Thus the total number of unit plots was 8×3=24. The size of the unit plot was 3 m × 2.5 m. The distance maintained between the row was 0.5 m and between column was 0.5 m. The treatments were randomly assigned to the plots within each block. Layout of the experiment field is presented in Figure 1.

3.9 Transplanting

Cormels were used as planting material. Before planting, the seed material was treated with Bavistin @ 1.0 g/litre of water. The treated seed materials were then transplanted in ridges at a distance of 80 cm × 65 cm spacing and 6 to 8 cm in depth.





Treatments

1. $T_1 = N_0P_0K_0$ kg ha^{-1}
2. T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1})
3. $T_3 = N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
4. $T_4 = N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
5. $T_5 = N_{75}K_{100}$ kg ha^{-1}
6. $T_6 = N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
7. $T_7 = N_{75}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}
8. $T_8 = N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

NB: Cowdung @ 5 t ha^{-1} was added in each treatment except control

Figure 1. Layout of the experiment field

3.10 Intercultural operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the seedlings.

3.10.1 Gap filling

Gap filling was practiced at 15 days after planting. The gaps (unsprouted/failed seeds) were replaced by using treated and sprouted cormels.

3.10.2 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water upto 3 cm at the early stages to enhance vegetative growth. The field was finally dried out at 15 days before harvesting.

3.10.3 Weeding

Weeds under experimental plots were removed timely by hand weeding.

3.10.4 Plant protection

During the copping period, the crop was affected by red mite severely and it was controlled by Vertimek 0.18EC @ 1.25 ml per litre of water, sprayed at 7, 14 and 21 days after planting.

3.11 Harvesting, threshing and cleaning

The crop was harvested when the leaves were partially dried and showed maturity symptoms. Harvesting was done separately for each treatment with the help of spade on July 12, 2021.

3.12 General observation of the experimental field

The field was observed time to time to detect visual difference among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized.

3.13 Recording of data

The following data were recorded during the study period:

3.13.1 Growth parameters

1. Plant height (cm)
2. Petiole length (cm)
3. Leaf breadth (cm)
4. Plant base diameter (cm)

3.13.2 Yield contributing parameters

1. Length of rhizome (cm)
2. Fresh weight of rhizome plant^{-1} (kg)
3. Fresh weight stolon palnt^{-1} (g)

3.13.3 Yield parameters

1. Rhizome yield (t ha^{-1})
2. Stolon yield (t ha^{-1})

3.13.4 Nutrient content of post harvest soil

1. pH
2. Percent organic carbon content (%OC)
3. Percent phosphorus (%P)
4. Percent sulphur (%S)

3.14 Procedures of recording data

A brief outline of the data recording procedure is given below:

3.14.1 Growth, yield contributing parameters and yield

Plant height

Height of the plant was measured from the ground level to tip of the plant in centimeters and mean of five plants was taken.

Petiole length (cm)

Petiole length was measured with the help of a tape for all the leaves of the five plants at final harvest per plot and average values were computed and expressed in cm.

Leaf breadth (cm)

Leaf breadth was measured with the help of a tape for all the leaves of the five plants at final harvest per plot and average values were computed and expressed in cm.

Plant base diameter (cm)

Average diameter of plant base was measured at the time of harvest from five selected plants per plot at the top shoulder and expressed in centimeter.

Length of rhizome (cm)

Average rhizome length of five rhizomes each from five randomly selected plants was measured from base to the tip of the rhizome and expressed in centimeters.

Fresh weight of rhizome plant^{-1} (kg)

After removing the adhering soil and other waste materials (rotten leaves, root etc.) the cleaned rhizome of five randomly selected plants were weighed in physical balance and average was taken. It was expressed in kg.

Fresh weight of stolon palnt^{-1} (g)

Stolon was collected from randomly selected 5 plants of each plot as and when necessary. Collected stolon was weighed at each of collection and all collected totals were recorded in gram.

Rhizome yield (t ha^{-1})

Collected rhizome yield per plot was converted to t ha^{-1}.

Stolon yield of (t ha^{-1})

Collected stolon yield per plot was converted to t ha^{-1}.

3.14.2 Nutrient content of post harvest soil

pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by (Akul *et al.* 1982).

Soil Organic carbon content

Organic carbon in the soil sample was determined by the wet oxidation method. The underlying principle was used to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_3 and titrate the excess $K_2Cr_2O_7$ solution with IN $FeSO_4$. To obtain the content of Organic carbon was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage.

Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions where pH 8.5 was maintained (Olsen *et al.,* 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity was measured calorimetrically at 660 ηm wavelength and readings were calibrated with the standard P curve (Akul *et al.,* 1982).

Available sulphur

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2.H_2O$ (Fox *et al.,* 1964). Sulphur in the extract was determined by the turhidimetric method as described by hunt (1980) using a Spectrophotometer (LKB Novaspce. 4049).

3.15 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of N and K on the growth and development of BARI panikachu-6 (*Colocasia esculenta*). The results have been presented and discussed with the help of table and graphs and possible interpretations have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Different doses of nitrogen (N) and potassium (K) fertilizers showed significant influence on plant height of panikachu (Figure 2 and Appendix IV). Results revealed that the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) gave the highest plant height (119.20 cm) and the result of this treatment showed significant variation to other treatments followed by T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) and T_7 ($N_{75}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). On the other hand, the lowest plant height (67.87 cm) was found from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) that was also varied significantly among the treatments. This result also indicated that the highest doses of N and K showed the maximum plant compared to control and lower doses showed lower plant height which was supported by the findings of Chattopadhyay *et al.* (2006), Uwah *et al*. (2013) and Omid *et al*. (2018); they also found higher plant height with higher doses of NPK.

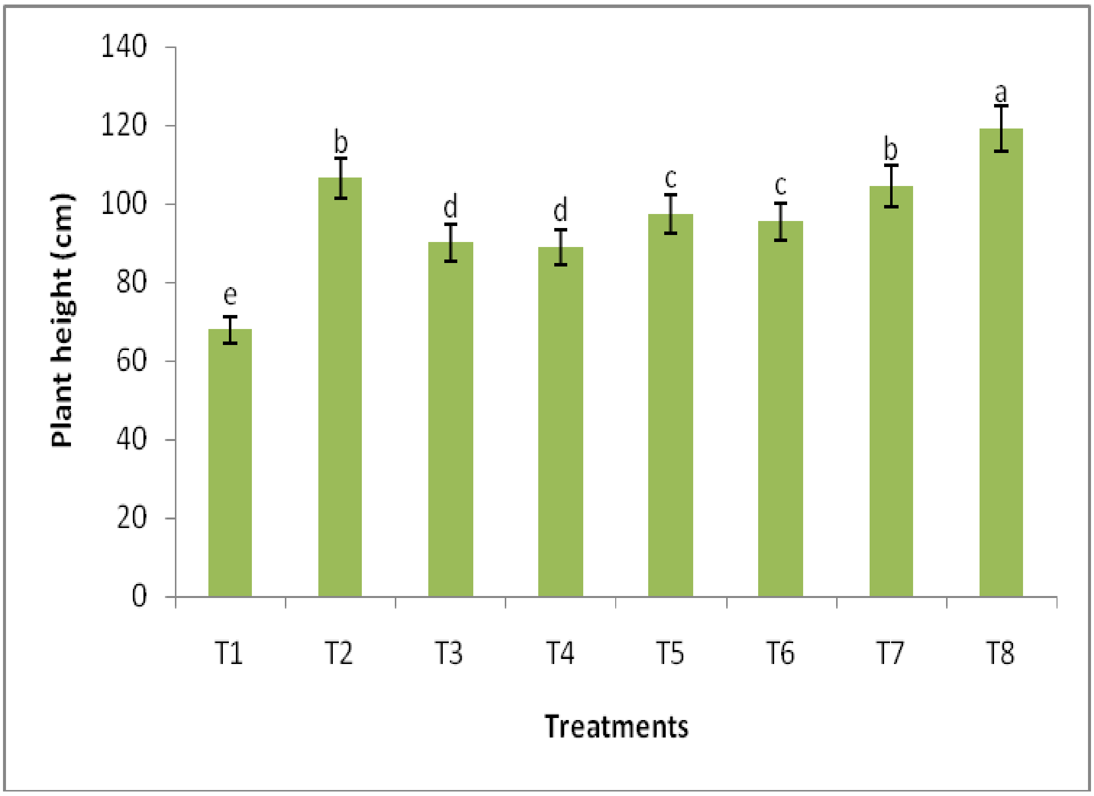


Figure 2. Plant height of BARI panikachu-6 as influenced by different levels of nitrogen and potassium ($LSD_{0.05}$ = 3.705)

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.1.2 Petiole length (cm)

Different treatment levels of N and K showed significant variation for petiole length of panikachu (Figure 3 and Appendix IV). Results indicated that the highest petiole length (35.27 cm) was achieved from the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and this treatment varied significantly to other treatments. The treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) gave the second highest petiole length (33.40 cm) that was similar to T_7 ($N_{75}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). Again, the lowest petiole length (23.47 cm) was found from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) which differed significantly to other treatments.

Generally N is involved in vegetative growth and also N and K have a significant role in photosynthesis, for this reason N and K had significant role in higher vegetative growth with this treatment. Omid *et al*. (2018) also found similar result with the present study and found higher vegetative growth with higher N and K doses which supported the present study.

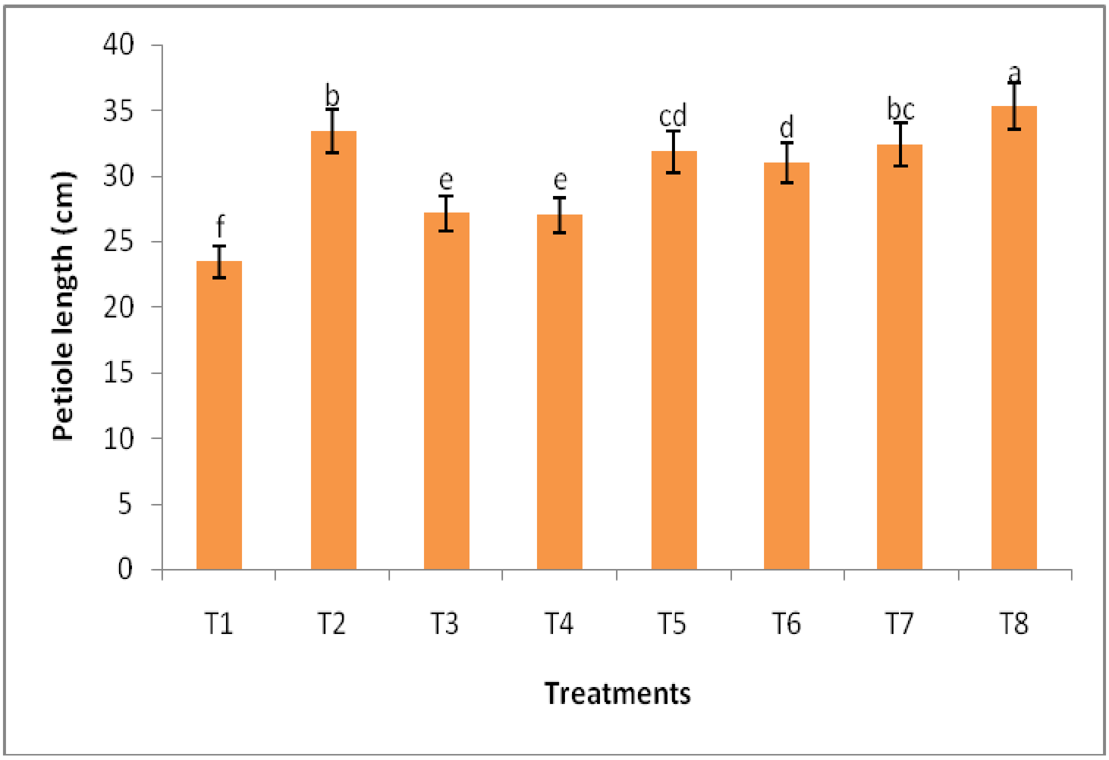


Figure 3. Petiole length of BARI panikachu-6 as influenced by different levels of nitrogen and potassium ($LSD_{0.05}$ = 1.085)

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.1.3 Leaf breadth

Application of different doses of N and K fertilizers in addition with cowdung to panikachu showed significant influence on leaf breadth (Figure 4 and Appendix IV). It was noted that the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) performed the highest leaf breadth (31.57 cm) and next to T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) treatment (29.97 cm) but significantly differed to other treatments. The lowest leaf breadth (19.43 cm) was found from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) which was statistically different to other treatments. The treatment T_4 ($N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also gave lower performance compared to other treatments but significantly same between them which was significant different from T_1 ($N_0P_0K_0$ kg ha^{-1}) treatment. This result was in agreed with the findings of Omid *et al*. (2018); they reported significant effect on leaf breadth with different NPK doses. Supported result was also observed by Singh *et al*. (2021).

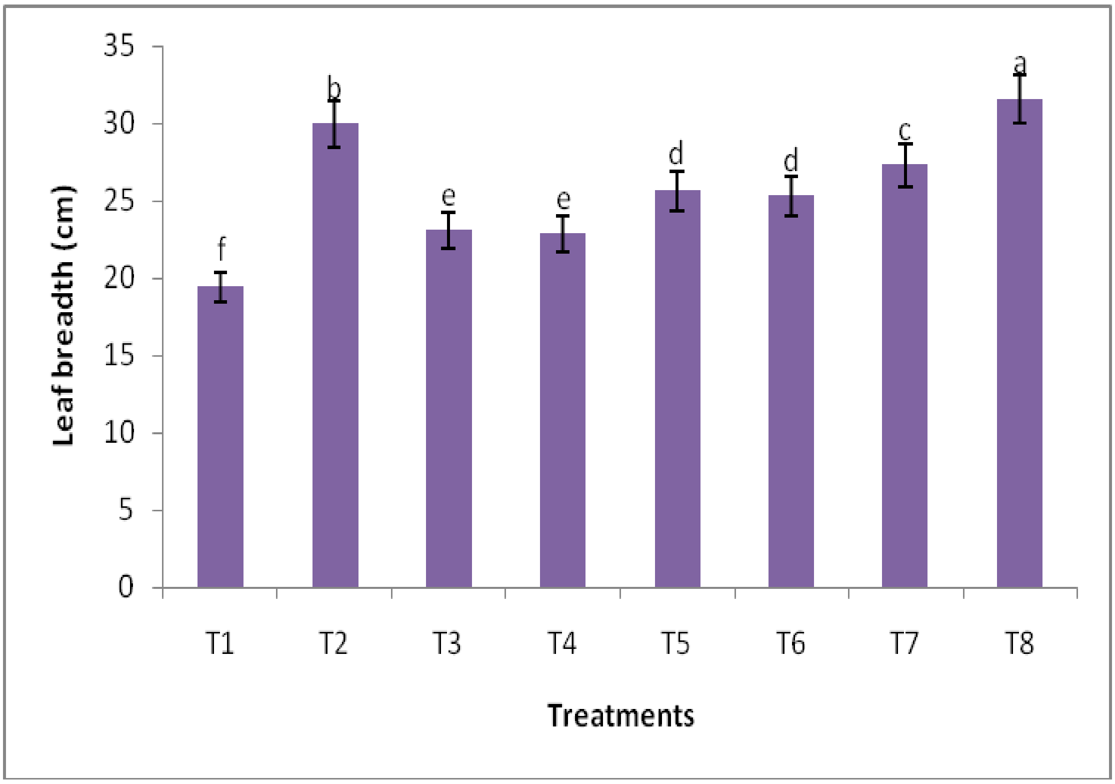


Figure 4. Leaf breadth of BARI panikachu-6 as influenced by different levels of nitrogen and potassium ($LSD_{0.05}$ = 0.988)

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.1.4 Plant base diameter

Different inorganic fertilizer of N and K with cowdung applied to panikachu showed significant variation on plant base diameter (Table 1 and Appendix IV). Results revealed that the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) performed best in gaining maximum plant base diameter (30.87 cm) and this result was similar to T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (29.90 cm). Treatment T_5 ($N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also showed comparatively higher plant base diameter (28.53) that was similar to T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) but significantly different to other treatment.

Table 1. Plant base diameter of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Treatments	Plant base diameter (cm)
T_1	24.87 e
T_2	30.87 a
T_3	28.33 c
T_4	26.43 d
T_5	28.53 bc
T_6	25.70 de
T_7	26.70 d
T_8	29.90 ab
$LSD_{0.05}$	1.524
CV(%)	8.15

In a column, means followed by same letter(s) do not differ significantly at 5% level of probability by LSD. *, ** indicate significant at 5% and 1% levels of probability, respectively

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

The least result on plant base diameter was recorded from control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) that was similar with the treatment of T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). It is well established that N is involved in vegetative growth of plants. This is why this treatment showed higher plant base diameter. Supported result was also observed by El-Sharkawy (2007); they reported that corm diameter increased with increasing nitrogen application to a certain level which supported the present study.

4.2 Yield attributing parameters

4.2.1 Length of rhizome (cm)

Different levels of N and K fertilizers on panikachu showed significant variation on rhizome length (Figure 5 and Appendix V). Results revealed that the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) gave the maximum rhizome length (73.50 cm) that was statistically identical to T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and next to the treatment T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_4 ($N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (66.90 and 65.77 cm, respectively). The minimum rhizome length (52.70 cm) was recorded from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) and this result was differed significantly with other treatments. Treatment T_4 ($N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also showed non-significant variation between them but performed lower rhizome length. This result also suggested that the length of rhizome was increased with the increasing of N and K to a certain level and lower doses showed decreased rhizome which supported the findings of Omid *et al*. (2018) and Singh *et al*. (2021).

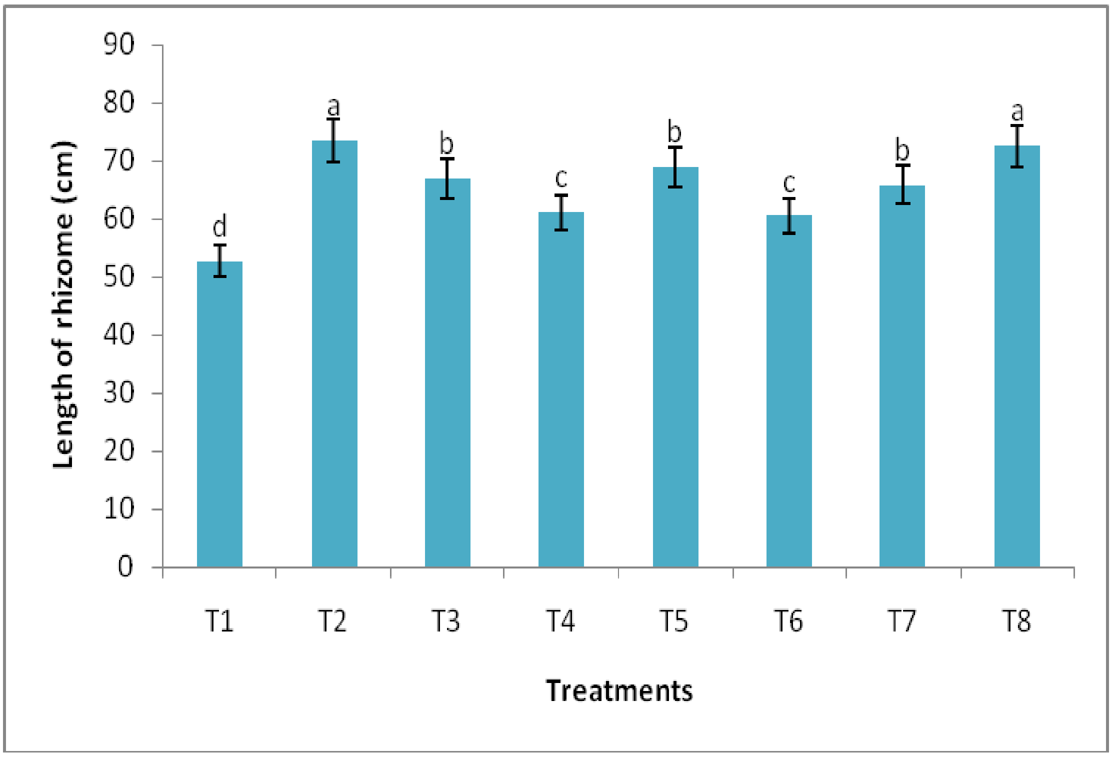


Figure 5. Rhizome length of BARI panikachu-6 as influenced by different levels of nitrogen and potassium ($LSD_{0.05}$ = 3.283)

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.2.2 Fresh weight of rhizome plant^{-1} (kg)

Different N and K fertilizers levels with cowdung on panikachu showed significant influence on fresh weight of rhizome plant^{-1} (Table 2 and Appendix V). Results indicated that the highest fresh weight of rhizome plant^{-1} (3.39 kg) was recorded from the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) and this result was statistically similar to the treatment of T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (3.29 kg). Treatment T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_5 ($N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) showed non-significant variation between them but performed lower rhizome weight and showed significant variation among the treatments. The lowest fresh weight of rhizome plant^{-1} (2.00 kg) was found from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) which was immediate lower than T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) but had significant difference between them. Similar result was also observed by Omid *et al*. (2018); they reported significant variation on plant yield due to variation in N and K application which supported the present findings.

Table 2. Yield attributes of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Treatments	Yield attributing parameters	
	Fresh weight of rhizome plant^{-1} (kg)	Fresh weight stolon palnt^{-1} (g)
T_1	2.00 f	114.40 f
T_2	3.39 a	240.00 a
T_3	3.14 bc	183.80 c
T_4	2.88 d	162.20 de
T_5	3.18 bc	217.00 b
T_6	2.69 e	150.90 e
T_7	3.01 cd	176.70 cd
T_8	3.29 ab	228.80 ab
$LSD_{0.05}$	0.192	20.01
CV(%)	3.66	9.04

In a column, means followed by same letter(s) do not differ significantly at 5% level of probability by LSD. *, ** indicate significant at 5% and 1% levels of probability, respectively

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.2.3 Fresh weight of stolon plant^{-1}

Fresh weight of stolon plant^{-1} of panikachu differed significantly due to different doses of N and K fertilizers (Table 2 and Appendix V). It was observed that the T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) gave the highest fresh weight of stolon plant^{-1} (240.00 g) and next to the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (228.80 g) and it were significantly similar between them. The lowest fresh weight of stolon plant^{-1} (114.40 g) was given by the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) that was significantly varied with other treatments. This result was in agreement with the findings of Sau *et al.* (2002) and Salam *et al.* (2003).

4.3 Yield parameters

4.3.1 Rhizome yield (t ha^{-1})

Rhizome yield ha^{-1} of panikachu differed significantly due to different doses N and K fertilizers with cowdung (Table 3 and Appendix VI). It was observed that the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) gave the highest rhizome yield ha^{-1} (82.24 t ha^{-1}) and this result was similar significantly with T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (80.33 t ha^{-1}). Non-significant variation was found between T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_5 ($N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) on rhizome yield ha^{-1} (76.90 and 77.80 t ha^{-1}, respectively) but it had significant variation with other treatments. The lowest rhizome yield ha^{-1} (52.72 t ha^{-1}) was given by the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) that differed significantly with other treatments. Treatment T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also gave lower rhizome yield ha^{-1} (67.36 t ha^{-1}) but significantly higher from T_1 ($N_0P_0K_0$ kg ha^{-1}). Several authors such as Omid *et al*. (2018), Uwah *et al*. (2013) and Chattopadhyay *et al.* (2006) reported that higher rhizome yield with higher N and K doses but over doses showed lower performance which supported the present findings.

Table 3. Yield parameters of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Treatments	Yield parameters	
	Rhizome yield (t ha^{-1})	Stolon yield (t ha^{-1})
T_1	52.72 f	3.44 d
T_2	82.24 a	6.12 a
T_3	76.90 bc	4.92 bc
T_4	71.48 d	4.46 c
T_5	77.80 bc	5.63 ab
T_6	67.36 e	4.22 cd
T_7	74.28 cd	4.77 bc
T_8	80.33 ab	5.88 a
$LSD_{0.05}$	3.998	0.893
CV(%)	7.63	9.04

In a column, means followed by same letter(s) do not differ significantly at 5% level of probability by LSD. *, ** indicate significant at 5% and 1% levels of probability, respectively

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.3.2 Stolon yield ha^{-1}

Application of N and K fertilizers at different doses with cowdung to panikachu showed significant variation on stolon yield ha^{-1} (Table 3 and Appendix VI). Treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) gave the highest stolon yield ha^{-1} (6.12 t ha^{-1}). The treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also gave higher stolon yield ha^{-1} (5.88 t ha^{-1}) and it was statistically identical to T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) and this was statistically similar with T_5 ($N_{75}K_{100}$ kg ha^{-1}

+ $P_{30}S_{15}$ kg ha^{-1}) (5.63 t ha^{-1}). The control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}) gave the minimum stolon yield ha^{-1} (3.44 t ha^{-1}) that was significantly different to other treatments. Treatment T_4 ($N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) also gave lower performance (4.46 t ha^{-1}) but significantly different with T_1 ($N_0P_0K_0$ kg ha^{-1}). Sau *et al.* (2002) and Salam *et al.* (2003) also found similar result with the present findings and reported that standard doses of N and K showed best results compared to higher or lower doses.

4.4 Nutrient content of post harvest soil

4.4.1 pH

Non-significant variation was found for pH content of post harvest soil due to different levels of N and K fertilizers (Table 4 and Appendix VII). However, the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) showed the highest pH content of post harvest soil (6.23) followed by T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) whereas the lowest pH content (6.08) was recorded from the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}).

4.4.2 Organic carbon content

Organic carbon content of post harvest soil showed non-significant difference due to different doses of N and K fertilizers (Table 4 and Appendix VII). However, it was observed that the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) gave the highest organic carbon content of post harvest soil (0.68%) which was followed by T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) (0.67 and the lowest organic carbon content of post harvest soil (0.59%) was given by the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}).

Table 4. Quality parameters (pH and nutrient content of post harvest soil) of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Treatments	Quality parameters (pH and nutrient content of post harvest soil)			
	pH	Percent organic carbon content (%OC)	Available phosphorus (ppm)	Available sulphur (ppm)
T_1	6.08	0.59	21.81	26.13 d
T_2	6.23	0.67	22.62	28.78 b
T_3	6.12	0.61	23.12	29.43 a
T_4	6.10	0.62	22.05	28.72 b
T_5	6.14	0.64	21.95	27.48 c
T_6	6.10	0.64	22.87	26.04 d
T_7	6.17	0.65	22.18	27.33 c
T_8	6.18	0.68	23.03	29.07 ab
$LSD_{0.05}$	NS	NS	NS	0.387
CV(%)	3.12	3.06	4.50	5.23

In a column, means followed by same letter(s) do not differ significantly at 5% level of probability by LSD. *, ** indicate significant at 5% and 1% levels of probability, respectively

T_1 = Control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}

4.4.3 Phosphorus (P) content

Phosphorus (P) content of post harvest soil was not differed significantly due to different doses of N and K fertilizers (Table 4 and Appendix VII). However, the treatment T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) gave the highest P content (23.12 ppm) followed by T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) whereas the lowest P content of post harvest soil (21.81 ppm) was given by the control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}).

4.4.4 Sulphur (S) content

Different levels of N and K affected sulphur (S) content of post harvest soil significantly (Table 7 and Appendix X). The highest S content (29.43 ppm) was recorded from T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) which was statistically similar to the treatment T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) (29.07 ppm) whereas the lowest S content (26.04 ppm) was given by the treatment T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) that was significantly same to T_1 ($N_0P_0K_0$ kg ha^{-1}) (26.13 ppm).

CHAPTER V

SUMMARY AND CONCLUSION

The present study aims to effect of N and K on the growth and development of BARI panikachu-6 (*Colocasia esculenta*), conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period of February 2021 to July 2021. Eight treatments *viz*. T_1 = control; $N_0P_0K_0$ kg ha^{-1}, T_2 = RFD ($N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 = $N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_4 = $N_{50}K_{75}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_5 = $N_{75}K_{100}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_6 = $N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}, T_7 = $N_{75}K7_5$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1} and T_8 = $N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1} were considered for the present study. The experiment was laid out in randomized complete block design (RCBD) with three replications.

The results of this study showed that the treatment T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) performed the best for maximum studied parameters and gave the highest plant base diameter (30.87 cm), length of rhizome (73.50 cm), fresh weight of rhizome $plant^{-1}$ (3.39 kg), fresh weight of stolon $palnt^{-1}$ (240.00 g), rhizome yield (82.24 t ha^{-1}) and Stolon yield (6.12 t ha^{-1}) followed by T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). Again, the maximum plant height (119.20 cm), petiole length (35.27 cm) and leaf breadth (31.57 cm) were recorded from T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}). On the other hand, the lowest plant height (67.87 cm), petiole length (23.47 cm), leaf breadth (19.43 cm), plant base diameter (24.87cm), length of rhizome (52.70 cm), fresh weight of rhizome $plant^{-1}$ (2.00 kg), fresh weight of stolon $palnt^{-1}$ (114.40 g), rhizome yield (52.72 t ha^{-1}) and stolon yield (3.44 t ha^{-1}) were recorded from control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}).

In terms of nutrient status in post harvest soil, pH, organic carbon content and available phosphorus (P) content was found non-significant among the treatments. However, the maximum pH (6.23), organic carbon content (0.68%) and available P content (23.12 ppm) was recorded from T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$

kg ha^{-1}), T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}), respectively whereas the lowest pH (6.08), organic carbon content (0.59%) and P content (21.81 ppm) were recorded from control treatment T_1 ($N_0P_0K_0$ kg ha^{-1}). Again, available sulphur (S) content was significantly varied among the treatments and the maximum available S content (29.43 ppm) were recorded from the treatment T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) whereas the minimum (26.04 ppm) was recorded from T_6 ($N_{75}K_{50}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}).

From the present study, the following conclusion may be drawn –

1. Different Zn and K treatment in association with cowdung showed significant variation on different parameters.
2. Among 8 treatments, T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) gave better results on different growth parameters except stem base diameter but T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) showed the highest yield contributing parameters and yield followed by T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}).
3. Among the treatments, T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}), T_3 ($N_{50}K_{90}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) and T_8 ($N_{110}K_{110}$ kg ha^{-1} + $P_{30}S_{15}$ kg ha^{-1}) showed comparatively higher pH, OM, available P and S content in post harvest soil compared to control.

So, it can be concluded that the application of T_2 (RFD; $N_{100}P_{30}K_{100}S_{15}$ kg ha^{-1}) treatment was most effective treatment regarding highest rhizome yield (72.24 t ha^{-1}) and stolon yield (5.12 t ha^{-1}) of panikachu-6 compared to other doses including control.

Recommendation

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

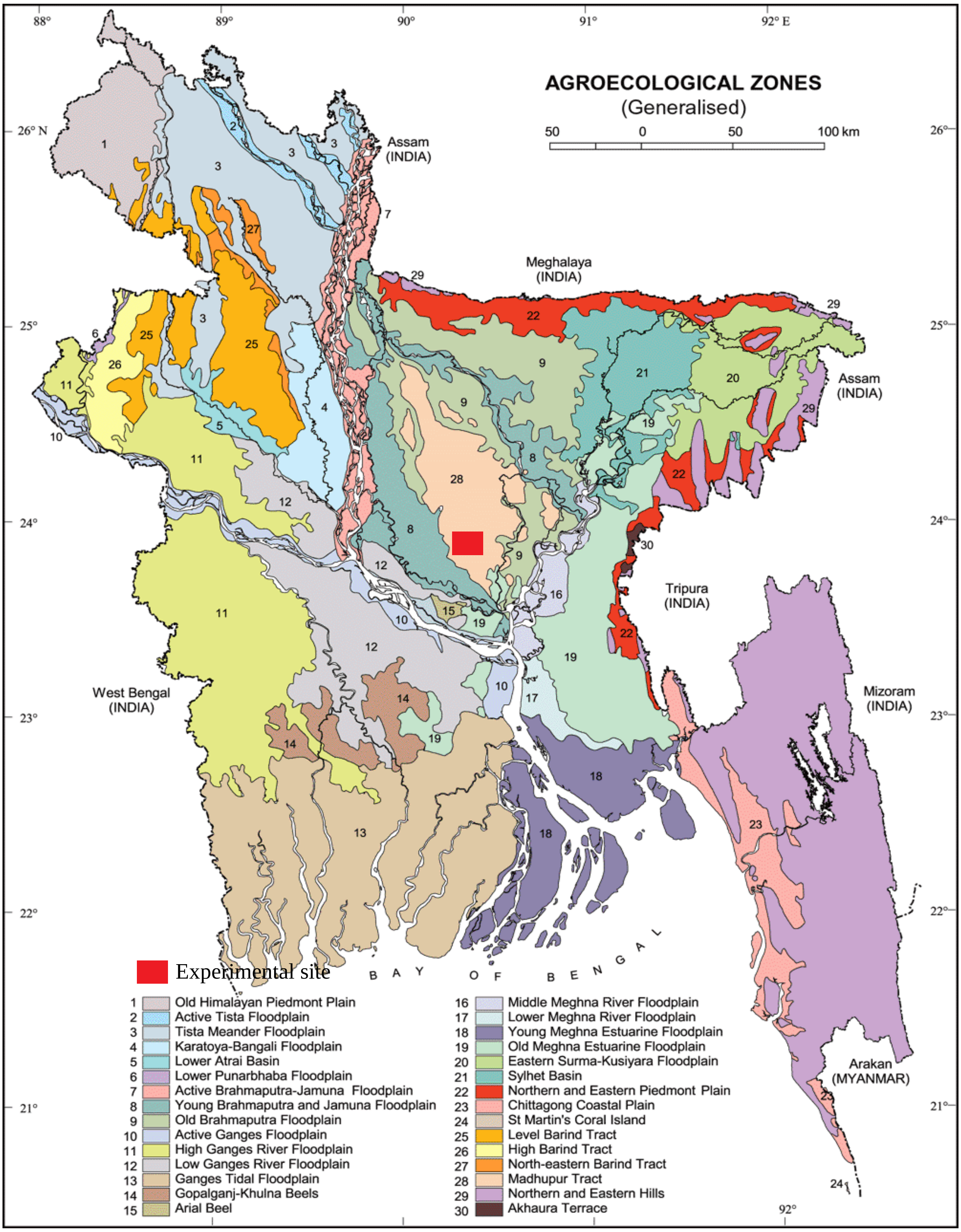

Figure 6. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from February 2021 to July 2021

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2021	February	22.75	14.26	18.51	37.90	0.0
2021	March	35.20	21.00	28.10	52.44	20.4
2021	April	34.70	24.60	29.65	65.40	165.0
2021	May	32.64	23.85	28.25	68.30	182.2
2021	June	27.40	23.44	25.42	71.28	190
2021	July	30.52	24.80	27.66	78.00	536

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Science Laboratory, SAU, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Soil Science Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (USDA)
pH	6.2
Organic carbon (%)	0.62
Organic matter (%)	0.78
Available P (ppm)	20
Exchangeable K (meq/100 g soil)	0.1
Available S (ppm)	30

Appendix IV. Growth parameters of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Sources of variation	Degrees of freedom	Mean square of growth parameters			
		Plant height (cm)	Petiole length (cm)	Leaf breadth (cm)	Plant base diameter (cm)
Replication	2	2.382	0.864	0.153	3.145
Factor A	7	685.05*	46.60*	46.95*	13.11**
Error	14	4.475	0.384	0.318	0.757

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Yield attributes of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Sources of variation	Degrees of freedom	Mean square of yield attributing parameters		
		Length of rhizome (cm)	Fresh weight of rhizome plant^{-1} (kg)	Fresh weight stolon palnt^{-1} (g)
Replication	2	0.406	0.001	1171.069
Factor A	7	143.45*	0.587**	5442.282*
Error	14	3.514	0.012	130.516

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield parameters of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Sources of variation	Degrees of freedom	Mean square of yield parameters	
		Rhizome yield (t ha^{-1})	Stolon yield (t ha^{-1})
Replication	2	0.485	0.533
Factor A	7	267.56*	2.477**
Error	14	5.213	0.260

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Chemical properties of post harvest soil of BARI panikachu-6 as influenced by different levels of nitrogen and potassium

Sources of variation	Degrees of freedom	Mean square of nutrient content of post harvest soil			
		pH	Percent organic carbon (%OC)	Percent phosphorus (P)	Percent sulphur (S)
Replication	2	0.011	0.001	0.024	0.114
Factor A	7	3.612^{NS}	0.008^{NS}	12.147^{NS}	21.403**
Error	14	1.013	0.001	0.106	0.118

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level