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IMPACT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF OKRA *[Abelmoschus esculentus* (L.) Moench] IN HILL SLOPE CONDITION

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Abstract

An experiment was conducted at the Hill Agricultural Research Station, Khagrachari from June to November 2004 to find out the effect of nitrogen (60, 80, 100 and 120 kg/ha) and phosphorus (80, 100 and 120 kg/ha) on the growth and yield of okra in hill slope condition during rainy season. The highest yield (16.73 t/ha) was obtained from 100 kg N/ha, which was statistically identical to 120 kg per hectare. In case of phosphorus, the highest yield of 15.77 t/ha was obtained from 120 kg P_2O_5/ha and was closely followed by the dose of 100 kg P/ha (4.73 t/ha). Considering the treatment combinations, the highest yield (19.22 t/ha) was produced by $N_{100}P_{120}$ and there were no significant variations among $N_{100}P_{100}$, $N_{120}P_{100}$ and $N_{120}P_{120}$. The highest gross return (Tk.193200) and net return (Tk.146l40) were obtained from $N_{100}P_{120}$. The BCR was also higher (4.08) under the same treatment combination.

Key Words: Nitrogen, phosphorus, okra growth and okra yield.

Introduction

Okra *[Abelmoschus esculentus* (L.) Moench] is an annual vegetable crop in tropical and sub-tropical parts of the world (Thakur and Arora, 1986). It is one of the important nutritious vegetable crops grown round the year in Bangladesh. Its every 100 g green pod contains among others, protein 1.8g, carbohydrate 6.4g, fibre 1.2g, vitamin C 18 mg and Ca 90 mg (Rashid, 1999). Okra as a summer/ rainy season vegetable can play a vital role to ameliorate the lower availability of vegetable in rainy season to a certain extent. The total production of okra was about 18,000 metric tons during 1999-2000 and the average yield was 3.0 t/ha which was very low (BBS, 2000) compared to that of other neighbouring country like India (6.12 t/ha) and other developing countries (7.12 t/ha) of the world (Yamaguahi, 1998). So, the yield and total production of okra should be increased.

Chittagong Hill tracts region is about one tenth of the total area of Bangladesh (Anon., 1985). This area has great potentiality for growing okra during rainy season when the whole country goes under water by using high yielding varieties with improved production practices. The yield of different crops in hill is below the national average and in some cases very poor. Low

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fertilizer consumption couple with lack of high yielding variety and improved management practices resulted in low production and productivity in hilly area.

Among the various factors affecting successful cultivation of okra in hill slope, the judicious fertilizer application is one of the vital importance. Nitrogen is an essential element and important determinant in growth and development of crop plants. It plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division, cell elongation. Several workers have reported linear increase in green pod yield of okra with the application of N from 56 to 150 kg/ha (Hooda *et al.*,1980; Mani and Ramanathan, 1980; Majanbu *et al.,* 1985 and Singh, 1995). Phosphorus fertilization can influence fruiting and fruit development of okra. Phosphorus is called the "Key to life" because it is directly involved in most living process. It is a key constituent of ATP has significant role in energy transformation in plants and also in various physiological processes (Shivasankeb *et al*., 1982). Phosphorus helps in nutrients uptake by promoting root growth and thereby ensuring a good pod yield through the increase in total dry matter (Shama and Yadev, 1976; Rao; 1982, 1995). Phosphorus deficiency results in poor root development, poor pod setting and subsequently reduces yield (Jam *et al*., 1990). Many researchers reported the effect of phosphorus application on green pod yield of okra (Gupta *et al.,* 1981; Mohanta, 1998; Sadat, 2000). Therefore, the present experiment was carried out to determine appropriate dose of nitrogen and phosphorus for better yield of okra in hill slope condition.

Materials and Method

The experiment was conducted at the Hill Agricultural Research Station, Khagrachari from June to November 2004. The soil in the area belongs to brown hill soil type series under Northern and Eastern Hills (AEZ-29). It is generally well drained and clay loam in texture. The physio-chemical characteristics of top soil is given in Table 4. Two factors experiment was laid out in RCBD with three replications. The treatments of the experiment were four nitrogen doses viz. 60, 80, 100 and 120 kg/ha and three doses of phosphorus viz. 80, 100 and 120 kg/ha. Thus there were 36 units ($4 \times 3 \times 3$) in total. Moreover, lime at 1.0 t, cowdung 10.0 t, gypsum 100 kg, zinc 10 kg and boron 10 kg per hectare were used to all treatments. The unit plot size was 2.4m × 2.4m. The plot and blocks were separated by 0.5 m and 1.0m, respectively. Seeds of okra were sown on 05 uly 2004 at spacing 60 × 40 cm. Intercultural operations were done as and when necessary. Harvesting of fruits started on 20 August and continued up to 30 October 2004. Data of plant growth and yield contributing characters were recorded from ten randomly selected plants, but yield was recorded on plot basis. Collected data were subjected to statistically analysis by F-test and the difference between the treatments means were judged by Duncan's Multiple Range Test (DMRT).

Table 4. Physio-chemical properties of 0-20 cm topsoil at the experimental plot.

Soil characteristics	Analytical value
Texture class	Clay loam
Soil pH	5.2
Organic matter (%)	1.35
TotalN(%)	0.07
Exchangeable calcium (meq/100 g soil)	1.09
Exchangeable magnesium (meq/l00 soil)	0.50
Exchangeable potassium (meq/l 00 g soil)	0.19
Available P (ppm)	4.2
Available S (ppm)	10.0
Available Cu (ppm)	2.2
Available Iron (ppm)	170.0
Available Zinc (ppm)	1.2
Available boron (ppm)	0.15
Available manganese (ppm)	13.0

Results and Discussion

Plant height

Plant height was recorded at the time of last edible pod harvest. It was observed that different levels of nitrogen exhibited highly significant effect on the plant height (Table 1). Plants grown with minimum dose of N (60 kg N/ha) were found to be significantly shortest (1.30 m) then the plants grown with adequate amount of N fertilizer. Plant height increased with the increasing rate of N upto 120 kg/ha although responses of 100 and 120 kg N/ha was statistically identical and significantly differed with other two doses of nitrogen. There was no significant difference in plant height between 60 and 80 kg N/ha. The higher dose of N might have enhanced cell division and formation of more tissues resulting in luxuriant vegetative growth and thereby increased plant height. Sultana (2002), Meyer and Anderson (1970) reported similar result. Majanbu *et al.* (1985) observed that plant height was enhanced by N fertilizer upto 100 kg N /ha. Singh *et al*. (1998) stated that application of 90 kg N/ha increased plant height by 14.03% compared with control.

Table 1. Main effect of nitrogen and phosphorus on plant and fruit characters of okra during rainy season.

Treatments	Plant height (m)	Branched plant (%)	No. of branches/ plant	Internode length (cm)	No. of fruits/ plant	Individual fruit wt (g)
Nitrogen						
60	1.30b	24.1 b	1.4	7.0 c	14.1 b	15.0 a
80	1.38b	31.lab	1.5	8.3b	15.0b	16.4a
100	1.67 a	35.6 a	1.5	8.4 b	19.3 a	17.3 a
120	1.72 a	40.0 a	1.5	9.4 a	20.6 a	16.0 a
Phosphorus						
80	1.44b	28.8a	1.4	7.8b	14.9b	14.4b
100	1.54 a	33.3 a	1.5	8.6 a	18.0 a	16.6 ab
120	1.57 a	36.3 a	1.6	8.6 a	18.4 a	17.3 a

Higher level of phosphorus tended to increase plant height (Table 1). Application of P_2O_5 at a level of 120 kg/ha produced significantly higherplant height (1.57 m) over P at 60 kg P_2O_5 /ha but produced statistically identical plant height with 100 kg P_2O_5/ha. Sultana (2000) and Sadat (2000) found highest plant height with the application of same dose of phosphorus is in agreement with this finding. Bhai and Singh (1998) stated that phosphorus application significantly increased the plant height. Mohanta (1998) and Gupta *et al.* (1981) observed that plant height of okra increased with the increase upto P 60 kg P_2O_5/ha is a disagreement with this finding. On the other hand, Majanbu *et al.* (1985) did not find any effect of phosphorus application. Interaction effect of N and P was not significant in this regard (Table 2.).

Percentage of branched plant

The percentage of branched plants varied significantly with variation in N dose (Table 1). The percentage of branched plants increased linearly with increased rate of N application thereby producing the maximum plants (40%) under application of 120 kg/ha. The minimum proportion (24%) being recorded at 60 kg N/ha. It is important to note that increased percentage of branched plants had led to increase yield of okra. Effect of phosphorus was found to be non-significant on percentage of branched plants (Table 1), but it ranged from 28.8 to 33.3%. In case of N and P interaction, no significant differences were observed (Table 2). But percentage of branched plants increased with the increase of N and P level.

Table 2. Combined effect of nitrogen and phosphorus on plant ad fruit characters of okra during rainy season

Treatments	Plant height (m)	Branched plant (%)	No. of branches/ plant	Internode length (cm)	No. of fruits/ plant	Individual fruit wt (g)
$N_{60}P_{80}$	1.26	18.3	1.3	6.8 e	12.7 d	14.5
$N_{60}P_{100}$	1.34	21.7	1.4	7.lde	13.9cd	15.0
$N60P_{20}$	1.29	33.3	1.4	7.2 de	13.7 od	15.5
$N_{80}P_{80}$	1.28	26.7	1.3	8.1 ode	13.6 cd	14.9
$N_{80}P_{100}$	1.41	33.3	1.4	8.Scd	15.lcd	17.0
$N_{80}P_{120}$	1.44	33.3	1.6	8.6 c	16.2 bed	18.0
$N_{100}P_{80}$	1.60	31.7	1.4	8.0 ode	15.0 od	16.0
$N_{100}P_{00}$	1.68	36.7	1.5	8.6 c	21.4 ab	17.7
$N_{100}P_{120}$	1.73	38.3	1.6	8.7 bc	21.5 ab	18.3
$N_{120}P_{80}$	1.62	38.3	1.5	8.2 a	18.3 abc	14.1
$N_{120}P_{100}$	1.74	41.1	1.6	10.la	21.6ab	16.7
$N_{120}P_{120}$	1.81	40.0	1.6	10.0 a	22.0 a	17.1
CV (%)	6.96	12.7	14.2	9.80	17.29	13.61

Means followed by same letter or no letter do not differ significantly at 5% level by DMRT

Number of branches per plant

Both main effect of nitrogen and phosphorus and their interaction effect on number of branches per plant were statistically insignificant (Table 1 and 2, respectively). However, application of higher doses of P increased the number of branches per plant and was maximum with 120 kg P_2O_5 /ha. Chauhan and Gupta (1973) and Majanbu *et al.* (1985) also reported that branch production was not influenced by phosphorus.

Internode length

Table 1 indicated that internode length of okra plant was significantly influenced by the application of N fertilizer significant. The longest internode length (9.4 cm) was recorded from the highest dose of N that is 120 kg N/ha. The second highest internode length (8.9 cm) was noted from 100 kg N/ha which was statistically similar to 80 kg N/ha (8.3 cm), while the lowest internode length (7.0 cm) was observed in 60 kg N/ha. Internode length also responded significantly to P application (Table 1). Internode length of okra plants increased upto 120 kg P_2O_5/ha but 120 kg and 100 kg P_2O_5/ha were statistically identical. The interaction effect of N and P application on internode length was significant (Table 2). The highest internode length (10.1 cm) was found from $N_{120}P_{100}$ followed by that of $N_{120}P_{120}$ (10.0 cm) and showed significant variation with all

other treatment combinations. There was no significant difference among $N_{80}P_{80}$ (8.1 cm), $N_{80}P_{100}$ (8.5 cm), $N_{80}P_{120}$ (8.6 cm), $N_{100}P_{80}$ (8.0 cm), $N_{100}P_{100}$ (8.6 cm) and $N_{100}P_{120}$ (8.7 cm). The lowest internode length (6.1 cm) was recorded in $N_{60}P_{80}$, which was at par with $N_{60}P_{100}$ (7.1 cm) and $N_{60}P_{120}$ (7.2 cm).

Number of fruits per plant

It was observed that the significant effect of nitrogen was highly significant of the number of green fruits per plants (Table 1). The highest number of fruits per plant (20.6) was produced by the plant receiving 120 kg/ha N and the lowest (14.1) was given by 60 kg N/ha. Application of N exerted a continuous increasing effect upto 120 kg N/kg and was statistically identical to 100 kg N/ha. Ahmad *et al*. (1999) also found higher number of fruits per plant (24.5) by the application of 120 kg N/ha. Singh (1985) observed that application of N at 90-100 kg/ha gave the higher number of fruits/plant (12.7-14.0). Kurup *et al.* (1997) also stated that N rates upto 100 kg/ha could increase the fruit number of okra.

A similar trend of increase in number of fruits per plant also noticed with the application of higher level of phosphorus (Table 1). The maximum number of fruits per plant (18.4) was obtained from 120 kg P_2O_5 /ha and was at par with 100 kg P_2O_5/ha. This suggested that the optimum rate of P fertilizers for okra was 100 kg/ha. The result is similar to the finding of Sadat (2000). He found that 120 kg P_2O_5/ha significantly increased green pod yield. Sultana (2002) reported that the optimum rate of P plant for okra was 80 kg/ha. But Chauhan and Gupta (1973) reported that increasing level of phosphorus did not show any significant difference for the number of fruits per plant. The number of fruits per plant varied from 12.7 10 22.0 due to different levels of N and P fertilizers application. Interaction effect of N and P fertilizer exerted significant influence on the number of fruits per plant (Table 2). The treatment $N_{120}P_{120}$ produced significantly the highest number of fruits per plant (22.0) followed by $N_{120}P_{100}$ (21.0), $N_{120}P_{80}$ (18.3), $N_{100}P_{120}$ (21.5) and $N_{100}P_{100}$ (21.4). The lowest number of fruits per plant (12.1) was produced by the fertilizer dose of $N_{60}P_{80}$ which was statistically similar to $N_{60}P_{100}$ (13.9), $N_{60}P_{120}$ (15.1), $N_{80}P_{120}$ (16.2) and $N_{100}P_{80}$ (15.0).

Individual fruit weight

Here only single effect of phosphorus showed significant effect on individual fruit weight as presented in Table 1. The highest fruit weight (17.3 g) was attained from P level of 120 kg/ha which was statistically at par with P 100 kg/ha (16.6 g). As the pod size (length and diameter) of 120 kg P_2O_5/ha was highest the increase fruit weight in those plants was justifiable. In Nigeria, Majanbu *et al.* (1985) found no response of phosphorus fertilization to individual pod weight of okra.

Yield (t/ha)

Fruit yield of okra as influenced by different levels of nitrogen is presented in Fig. 1. The highest yield (16.73 t/ha) was obtained from 100 kg N/ha. When N was applied at 120 kg per hectare, yield was decreased, but it was at par with 100 kg N/ha. The differences of yield among four nitrogen levels are attributable to the difference of pods per plant and weight of pods per plant. As the number and weight of fruits were higher in the plant from 100 kg N/ha, the ultimate fruit yield was higher in those plants. This result is similar to the finding of Kurup *et al.* (1997) who reported that N rates upto 100 kg /ha could increase fruit weight per plant of okra cv. Kiran and Pupasawni, respectively, and Sultana (2000) mentioned highest yield from N 100 kg/ha in cv BARI Dherosh-1.

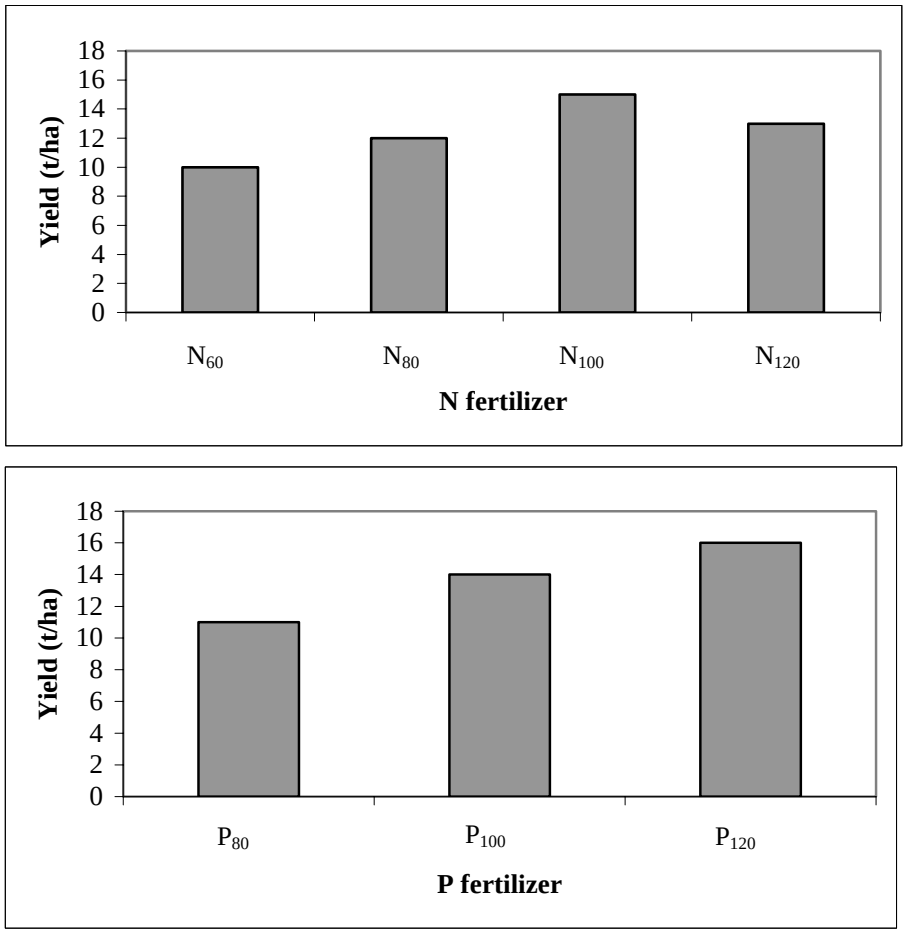

Fig. 1. Main effect of nitrogen and phosphorus on fruit yield of okra in hill slope.

Table 3. Benefit cost ratio analysis of okra as influenced by nitrogen during rainy season and phosphorus.

Treatments	Gross return (Tk./ha)	Cost of production	Net return (Tk./ha)	Benefit cost ratio (BCR)
$N_{60}P_{80}$	101200	45260	55940	2.23
$N_{60}P_{100}$	106400	45900	60500	2.32
$N60P_{20}$	110900	46530	64370	3.38
$N_{80}P_{80}$	103500	45580	57920	2.27
$N_{80}P_{100}$	132700	46530	86170	2.85
$N_{80}P_{120}$	137600	46850	90750	2.93
$N_{100}P_{80}$	122400	45790	76610	2.67
$N_{100}P_{00}$	187400	46420	140980	4.04
$N_{100}P_{120}$	193200	47060	146140	4.08
$N_{120}P_{80}$	128500	47170	81330	2.72
$N_{120}P_{100}$	181600	46750	134850	3.88
$N_{120}P_{120}$	187900	47380	140520	3.97

a. Price of okra: Tk. 10.00

b. BCR: Gross return÷Cost of production

The effect of phosphorus fertilization on fruit yield per hectare was statistically significant (Fig.1). The superior yield of 15.77 t/ha was obtained from 120 kg P_2O_5/ha and was closely followed by the treatment where second highest dose (100 kg P/ha) was applied with the pod yield of 14.73 t/ha. The lowest yield (11.4 t/ha) was recorded in the plot where 80 kg P_2O_5/ha was applied. This result is in disagreement with the findings of Sultana (2000) and Gupta *et al.* (1981) who reported that okra yield increased with the increase of P_2O_5 upto 60 kg/ha. The interaction effect of N and P on pod yield per hectare is given in the Fig. 2. The highest yield (19.22 t/ha) was produced by $N_{100}P_{120}$ and there was no significant variation among $N_{100}P_{100}$, $N_{120}P_{100}$ and $N_{120}P_{120}$. The results indicate that both N and P application had remarkable influence on pod yield per plant. Reddy *et al.* (1984) and Naik and Singh (1999) observed highest yield of okra with N + P at the highest rates.

Economics

Analysis of cost and return revealed that the gross and net returns were higher at higher doses of N and P. The highest gross return (Tk.l93200) and net return (Tk.146140) were obtained from $N_{100}P_{120}$. The BCR was also higher (4.08) under the same treatment combination (Table 3).

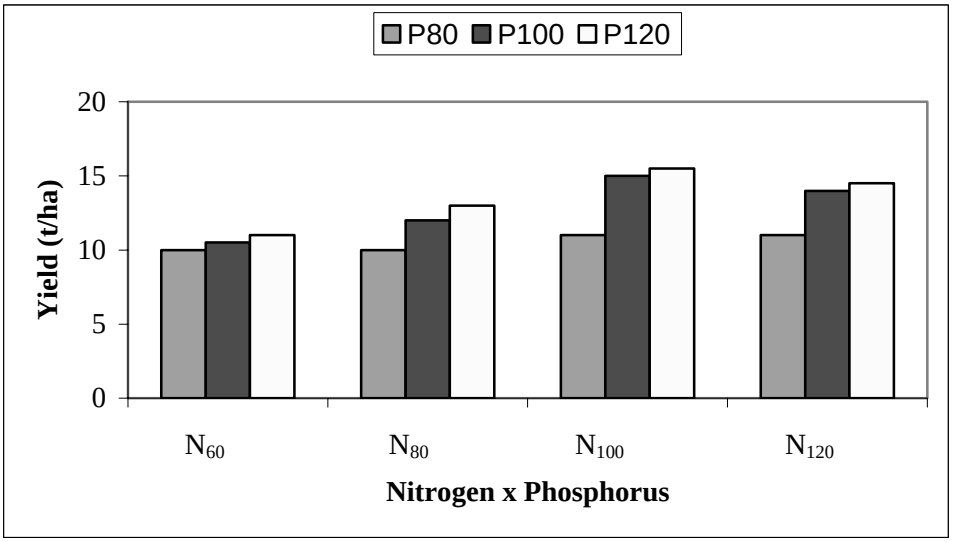

Fig. 2. Combined effect of nitrogen and phosphorus on fruit yield of okra in hill slope.

The above results revealed that $N_{100}P_{120}$ is most suitable for better production of okra in hill slope condition during the rainy season.

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