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Effect of Nitrogen and Potassium on the Growth, Yield and Yield Contributing Traits of French Bean

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In the present study, effects of nitrogen and potassium on the growth, yield and yield contributing traits of French bean was investigated. Two-factor experiment was conducted in the Randomized Complete Block Design (RCBD) with three replications. These two factors with four level of each nutrient were nitrogen (0 kg/ha, 50 kg/ha, 100 kg/ha and 150 kg/ha) and potassium (0 kg/ha, 40 kg/ha, 80 kg/ha and 120 kg/ha). Results revealed that nitrogen had significant effect on most of the yield contributing traits of French bean exceptdiameter of green pod of French bean. The maximum green pod yield (6.53 t/ha) was obtained from the plot where 150kg N/ha was applied. Also, most of the parameters studied were significantly influenced by different potassium levels. The highest pod yield (6.10 t/ha) was obtained from the plot where 120kg K_2O/ha was used. Interaction effect of nitrogen and potassium exhibited significant variation on most of the characters studied, but showed insignificant influence on leaf length, length of green pod, diameter of green pod, number of seeds per plant. The highest pod yield (6.69 t/ha) was obtained when 150kg N/ha with 120kg K_2O/ha was applied. This information will help the farmer to grow French bean with better yield.

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I. Introduction

French bean (*Phaseolus vulgaris*) is a member of the family Leguminosae and sub-family Papilionaceae, which originated in the central and south America (Swiader *et al.* 1992). It is also known as bush bean, basic bean, haricot bean, navy bean, pole bean, wax bean, string bean and binchi (Duke, 1983; Salunkhe *et al.* 1987; Tindall, 1988). French beans are grown intensively in the areas of Eastern Africa, North and Central America, South America, Eastern Asia, Western and South Eastern Europe. Brazilis the largest French bean producer. French bean, including other related species of the genus *phaseolus,*occupied 27.73 million hectares of the world's cropped area, and the production of green pods was about 20.06 million tons with an average yield of 714kg/ha (FAO, 1999). In Bangladesh there is no statistics about the area and production of French bean. However, it is not entirely new crop in this country and is grown in Sylhet, Cox's Bazar, Chittagong, Chittagong Hill Tracts and some other parts of this country on very small scale in winter season.

French bean is an important source of protein in human diet in many countries. Its edible pods supply protein, carbohydrate, fat, fibre, thiamine, riboflavin, Ca and Fe (Shamugavelu, 1989), and the seeds contain significant amount of thiamin, niacin, folic acid as well as fibre (Rashid, 1999). It is also used in different ways such as boiled, baked, canned in sauce, brine and syrup, soups either alone or with fish, meat and other vegetables, fresh salad or curry (Tindall, 1988; Mitra *et al.*, 1990). Although this crop is not widely grown in Bangladesh, it has a great export potential.Because, thefresh green pod has recently been taken a place in the list of fresh vegetables exported from Bangladesh.

Production of French bean depends on many factors such as quality of seed, variety, fertilizers, mulch materials and proper management practices.Various problems hamper French bean production in Bangladesh. Fertilizers, especially nitrogenous and potassic are most critical inputs for increasing crop production (Arya *et al.*, 1999). French bean can fix atmospheric nitrogen in its root zone, but fixing capacity is relatively poor as compared to other leguminous crops (Habbish and Ishaq, 1974).Nitrogen is considered to be the most important nutrient, and plants absorb more nitrogen than any other element. Increasing nitrogen (N) augmented plant growth, number of leaves/plant, spike length, and number of florets, spike (shah *et al.*, 1984).

Potassium is the third key nutrient of commercial fertilizers. It helps strengthen plants' abilities to resist disease and plays and important role in increasing crop yields and overall quality. Potassium found in French beans is an important component of cell and body fluids that help control the heart rate and blood pressure. The effect of potassium on French bean is significantly observed in flowering, seed maturity and yield (Arya *et al.*, 1999). The vegetative growth and yield of French bean were reported to be increased with the dose of nitrogen (Chandra *et al.,* 1987) but may be varied with the contribution of potassium dose (Arya *et al.*, 1999).Although, nitrogen is necessary for its vegetative growth and development however, excessive or under dose of nitrogen can affect the growth and yield of French bean. An optimum amount of nitrogen is necessary to produce maximum yield and good quality of French bean. A plant deficient in potassium shows deformed plant parts. Only a few studies have been made dealing with the fertilizer management for the production of French bean.

Research on the effect of plant nutrients like nitrogen and potassium on growth and yield of French bean is very limited. A detailed and systematic study is therefore needed to find out the optimum requirement of nutrients, particularly N and K for growth and better yield of French bean. Therefore, the present investigation was taken to study the effect of different levels of nitrogen and potassium on growth and yield of French bean.

II. Materials and Methods

Location and collection of French bean seed

The research work was conducted at the Horticulture Farms of the Department of Horticulture, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. The experimental plot was under the agro ecological zone of Old Himalayan Piedmont soil (AEZ- 1). The selected experimental site was well drained medium high land with soil pH 5.85. The percent organic carbon, nitrogen, total available phosphorus and potassium were 1.29%, 0.07%, 18.35 ppm and 0.24 mg /100gm soil, respectively (Soil Testing Laboratory, SRDI, Dinajpur). The varieties of French bean used in the experiment were BARI Zhar Sheem 1. The seeds were collected from the Horticultural Research center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

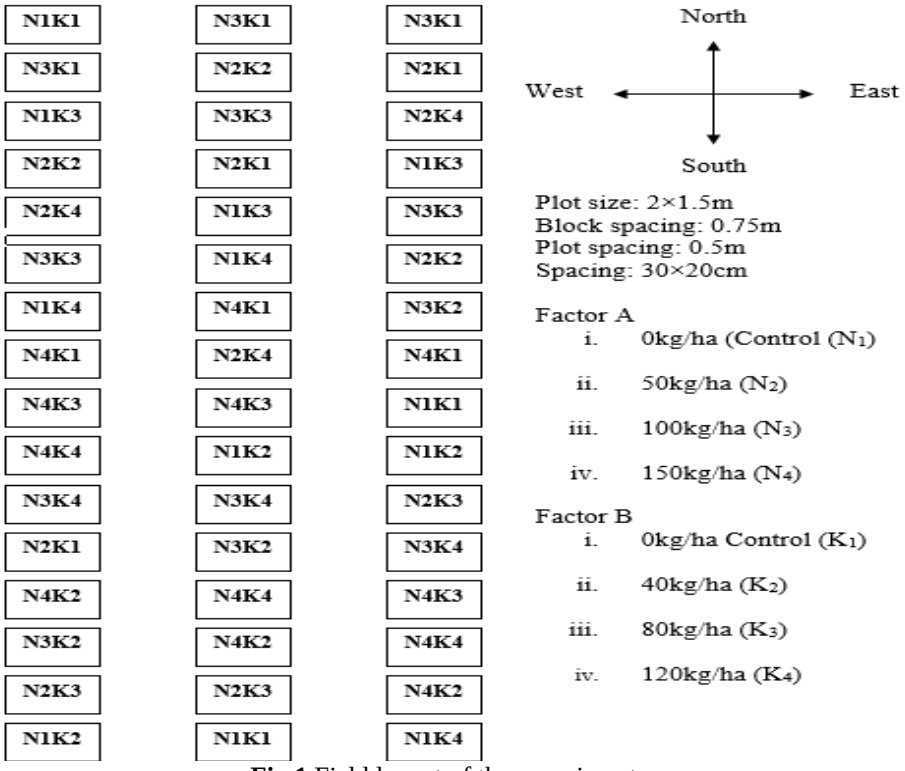

Fig.1 Field layout of the experiment

Design and layout of the experiment

The two-factor experiment was conducted in the Randomized Complete Block Design (RCBD) with three replications. There were 2 (two) factors with four level of each nutrient *viz*. nitrogen (0 kg/ha, 50 kg/ha, 100 kg/ha and 150 kg/ha) and potassium (0 kg/ha, 40 kg/ha, 80 kg/ha and 120 kg/ha). The total number of plots was 48. The size of each plot was 2×1.5m. Distance between two blocks was 0.75 and plot was 0.5m. Treatments were randomly assigned to each block. Each unit plot had 5 (five) rows of 30cm distance and having 20cm distance in plant to plant. Total number of plants per plot was 50(fifty).

Land preparation

At first the land was ploughed with a power-tiller and kept open to sunlight. After wards, the experimental plot was prepared by several ploughings and cross ploughings followed by laddering to break the clods and to level the soil. The weeds and stubble of previous crops were collected and removed from the plot. These operations were done to bring the land under good tilth for sowing of seeds. The experimental plots were laid out in accordance with the experimental design.

Manure and fertilizer

The entire quantity of well decomposed cowdung (10t/ha) was applied at the time of initial land preparation. The whole amount of TSP (as per treatment) and cowdung were applied during the final land preparation. Urea and M_op were applied as the sources of Nitrogen and Potassium, respectively. Doses of Nitrogen and MoP were applied as per treatments of the experiment. Urea and MoP were applied in two equal installments at 15 and 30 days after sowing (DAS) of seed. The fertilizers were mixed thoroughly with the soil by hand.

Sowing of seeds

Two seed was sown in each hill at a depth of 3 cm. The seeds were covered with pulverized soil just after sowing, and gently pressed with hands. The sowing was done on 29 November, 2016 in rows and at a spacing of 30cm x 15cm. The seeds were covered with loose soil. French bean seeds were also sown as border crop to reduce border effects.

Intercultural operations

Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedlings of about 15cm height were transplanted from border rows with roots plunged 5cm below the soil in hills in the evening, and watering was done to protect the seedlings from wilting. All gaps were filled up within two weeks after germination of seeds.

Thinning

When the plants got established, one healthy plant per hill was kept and remaining one was plucked.

Weeding

The experimental plots were kept weed free by hand weeding. Weeding and mulching were done three times as and when necessary.

Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation, was given four times at an interval of 10 days depending on soil moisture content.

Plant protection

Insect pests

At the early stage of growth, some plants were attacked by insect pests (mainly aphids), and malathion 57 EC was sprayed at the rate of 2ml/L at 15 days' interval.

Diseases

Seedlings were attacked by damping off, and Dithane M-45 was sprayed at the rate of 2 ml/L at an interval 15 days. Some plants were attacked by bean common mosaic virus (BCMV) which is an important disease of French bean. These plants were removed from the plots and destroyed.

Harvesting

Immature green pods were harvested at tender stage through hand picking and weighed to estimate the yield of fresh pod. At harvest, pods were nearly full size, with the seeds still small (about one-quarter developed) with firm flesh (Swiader *et al.,* 1992) and the pods were soft and smooth.

Collection of data

Plant height

The plant height was recorded at 20, 30 and 40 days after sowing (DAS). The plant height was taken from the ground level to the tip of the largest leaf of the plants. Plant height was recorded from 10 randomly sampled plants, and the mean was calculated and recorded in centimeter (cm).

Number of compound leaves per plant

The number of compound leaves of 5 randomly selected plants was counted from each unit plot at 10 days' interval from 20 to 40 DAS and the means were calculated.

Leaf length

Leaf length (cm) and breadth (cm) of 5 randomly selected plants from each unit plot were measured by using a measuring scale at 10 days' interval from 20 to 40 DAS and the means were found out.

Number of branches per plant
Average number of branches per plant was found from 5 randomly selected plants per unit plot at 5 days' interval from 20 to 40 DAS, and the means were found out.
Number of pods per plant
Number of pods from 5 randomly selected plants was counted, and their mean values were found out.
Length of green pod
Ten pods from each randomly selected plant were measured using a centimeter scale, and the mean value, were calculated and expressed in centimeter.
Diameter of green pod
Diameter of green pod of 5 randomly selected plants per unit plot was measured in mm with the help of slide calipers, and the average was taken and expressed in mm.
Number of seeds per green pod
Number of seeds per green pod was recorded from 5 randomly selected plants, and the mean value was calculated out.
Weight of fresh pods per plant
Pods from 5 randomly selected plants were weighed, and their average was recorded in gram (g).
Pod yield
Green pods were harvested at regular interval from each unit plot and their weight was recorded. As harvesting was done at different interval, the total weight of pods was recorded for each for each unit plot, and was expressed in Kilogram (kg). The green pod yield per plot was finally converted to yield per hectare, and was expressed in ton (t).
Statistical analysis
The statistical analysis was done by using MSTATC statistical package program. The analyses of variance for the characters under study were performed by F variance test. The difference between the pairs of treatment means was compared using the Least Significant Difference (LSD) test.

III. Results and Discussion

Main effect of nitrogen on the growth and yield of French bean
Plant height
From the result it was found that different levels of nitrogen had significant effect on plant height of French bean at 20, 30 and 40 DAS (Fig. 2). The largest plant (43.67 cm) was recorded at 40 DAS when 150kg N/ha was applied followed by 100kg N/ha (31.97 cm) and the shortest plant (15.86 cm) was found in the control plot. It was probably due to the fact that plant received more nitrogen which encouraged more vegetative growth. Similar results were reported by Srinivas and Naik (1988) and Chandra *et al.* (1987).

Number of compound leaves per plant
The results of different levels of nitrogen showed significant effect at different growth stage. It was observed that the number of leaves per plant was gradually increased with increasing levels of nitrogen and at 40 DAS. The maximum number of leaves per plant (11.78 cm) was recorded from the highest level of nitrogen 150kg N/ha, whereas the minimum (2.65 cm) was observed at control (Table 1). Similar results were reported in an experiment conducted by Meyer (1984).

Leaf length
The main effect of nitrogen revealed that different levels of nitrogen significantly influenced the leaf breadth (Table 1) and not significant effect on leaf length. The larger leaf (17.86 cm) was obtained from 150kg N/ha and smaller leaf length (9.48 cm) was recorded from the control treatment.
Number of branches per plant
Effect of nitrogen was significant on number of branches per plant (Table 1). The highest (7.23) and the lowest (2.23) number of branches per plant were found in the nitrogen levels of 150kg/ha and 0kg/ha, respectively. Nitrogen enhanced vegetative growth and development of plants, which ultimately may have increased the number of branches per plant.

Number of pods per plant
Nitrogen displayed significant effect on the number of pods per plant (Table 2). The highest number of pods per plant (62.95) was obtained when the plants were supplied with 150kg N/ha and the lowest number of pods per plant (56.70) was recorded in control. It might be due to the sufficient supply of nitrogen for the development of higher number of pod bearing branches. The present observation was in full agreement with that of Edris*et al.* (1979), Sa*et al.* (1982) and Calvache*et al.* (1992) who reported significant difference in pod number per plant with different nitrogen levels.

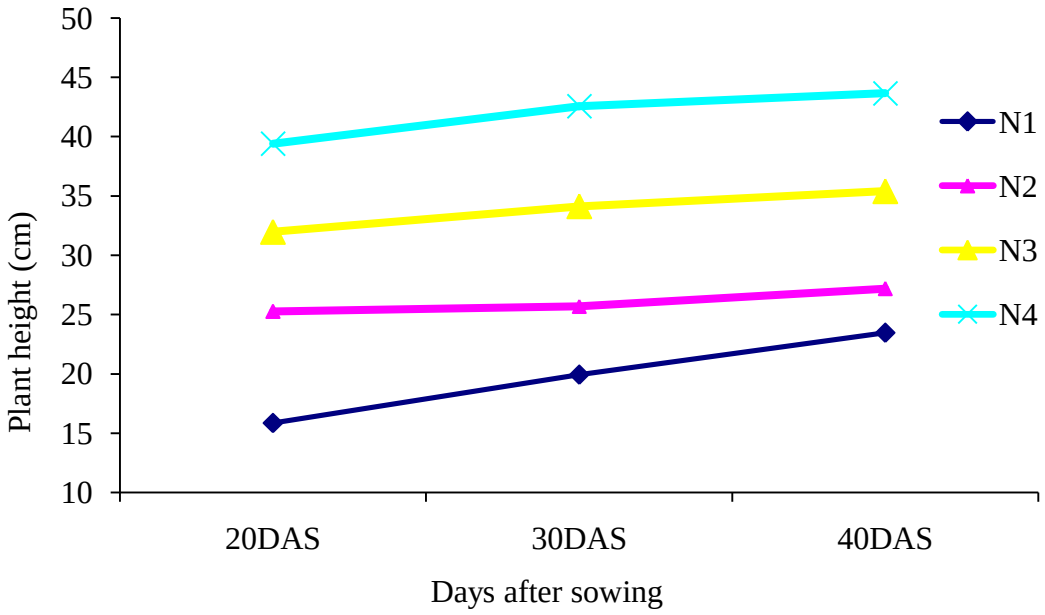

Fig. 2 Effect of different doses of nitrogen on the plant height of French bean.

Table 1. Effect of nitrogen on growth and yield of French bean

Nitrogen	No. of compound Leaf			Leaf length(cm)			No. of branches		
	20DAS	30DAS	40DAS	20DAS	30DAS	40DAS	20DAS	30DAS	40DAS
N_1	2.65d	5.45d	7.67d	9.48d	12.29d	12.83d	2.23d	2.52d	4.63d
N_2	3.51c	5.72c	9.31c	12.53c	12.87c	13.02c	2.62c	2.21c	5.63c
N_3	4.44b	5.82b	10.47b	14.67b	14.43b	14.63b	3.54b	3.33b	6.42b
N_4	5.47a	6.25a	11.78a	17.80a	17.58a	17.86a	4.41a	3.29a	7.23a
LSD 0.05	0.41	0.94	1.77	0.71	0.98	1.51	0.57	0.89	1.31
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	5.92	2.84	2.81	2.36	0.94	0.65	1.82	5.16	3.01

N_1 = 0kg, N2 =50 kg/ha, N_3 =100 kg/ha, N_4 = 150kg/ha; ** Significant at 0.5 level of significance

Length of green pod

The effect of nitrogen on length of green pod was found to be significant effect. The highest length of green pod of French bean (19.13 cm) was observed in 150kg N/ha and the lowest (15.9 cm) was found to control treatment. The application of nitrogen more than 75kg/ha might increase the vegetative growth of plant except pod length (Table 2).

Diameter of green pod

Nitrogen had non-significant influence on pod diameter of French bean. The highest pod diameter (1.73 cm) was found from the crop receiving 150kg/ha and the lowest (1.51 cm) was noticed in control (0kg N/ha) treatment (Table 2).

Number of seeds per green pod

Different levels of nitrogen significantly influenced the number of seeds per green pod (Table 2). The maximum number of seeds per green pod 7.34) was recorded while the crop was given 150kg N/ha and the lowest (5.43) was obtained from control treatment. Tewari and Singh (2000) also reported that higher number of seeds per green pod was found by the application of nitrogen.

Table 2. The effect of nitrogen on growth and yield of French bean

Nitrogen	Number of pods/plant	length of green pod (cm)	Green pod diameter (cm)	Number of seeds/pod	Weight of fresh pod/plant (kg)
N_1	56.70 c	15.9 d	1.51 a	5.42 c	0.85 d
N_2	58.41 bc	15.87 c	1.59 a	6.13 b	0.98 c
N_3	60.38 ab	16.34 b	1.62 a	7.18 a	1.12 b
N_4	62.95 a	19.13 a	1.73 a	7.34 a	1.24 a
LSD 0.05	2.94	0.94	0.99	1.05	2.85
Level of significance	**	**	NS	**	**
CV (%)	1.83	2.79	3.54	1.44	2.46

N_1 = 0kg, N2 =50 kg/ha, N_3 =100 kg/ha, N_4 = 150kg/ha; ** Significant at 0.5 level of significance

Weight of fresh pod/plant

Different level of nitrogen fertilization showed highly significant effect on the pod weight per plant (Table 2). Application of nitrogen at the rate of 150kg/ha gave the maximum pod yield (1.24 kg), whereas the minimum pod weight per plant (0.85 kg) was obtained from 0kg N/ha. There was a gradual increase in the seed yield per plant with the application of increasing levels of nitrogen.

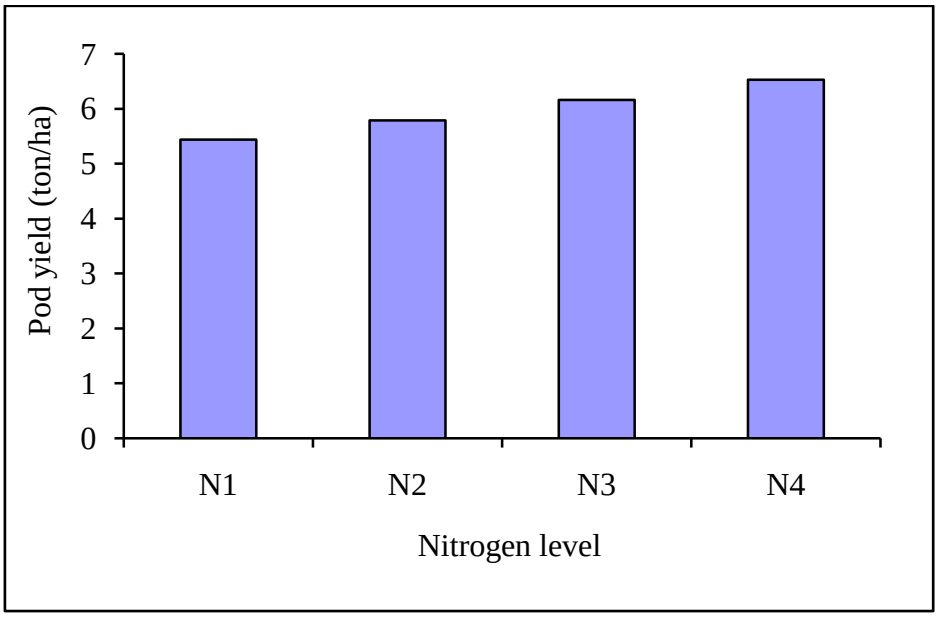

Fig. 3 Effect of nitrogen on the yield of French bean

Pod yield per hectare

Different levels of applied nitrogen showed highly significant variation in the pod yield/plot (Fig. 3). The highest seed yield per plot (6.53 ton/ha) was recorded from the nitrogen dose of 150kg/ha, whereas the lowest (5.44 ton/ha) was obtained from the control treatment (0kg N/ha).

Main effect of Potassium on the growth and yield of French bean

Plant height

Data on plant height were recorded at 20, 30 and 40 days after sowing (DAS). The plant height was significantly influenced due to different doses of potassium fertilizer. The minimum plant height (25.91 cm at 40 DAS) was revealed at control (0kg K_2O/ha) treatment, with the increased potassium dose, plant height also found to increase (Fig. 4) and the maximum plant height (35.11 cm at 40 DAS) was noticed at the highest potassium dose (150kg K_2O/ha). The tallest plant at the highest dose of potassium was recorded due to the fact that plant received higher amount of potassium, which might have encouraged more vegetative growth. Similar result was also found by Kanaujia *et al.* (1999).

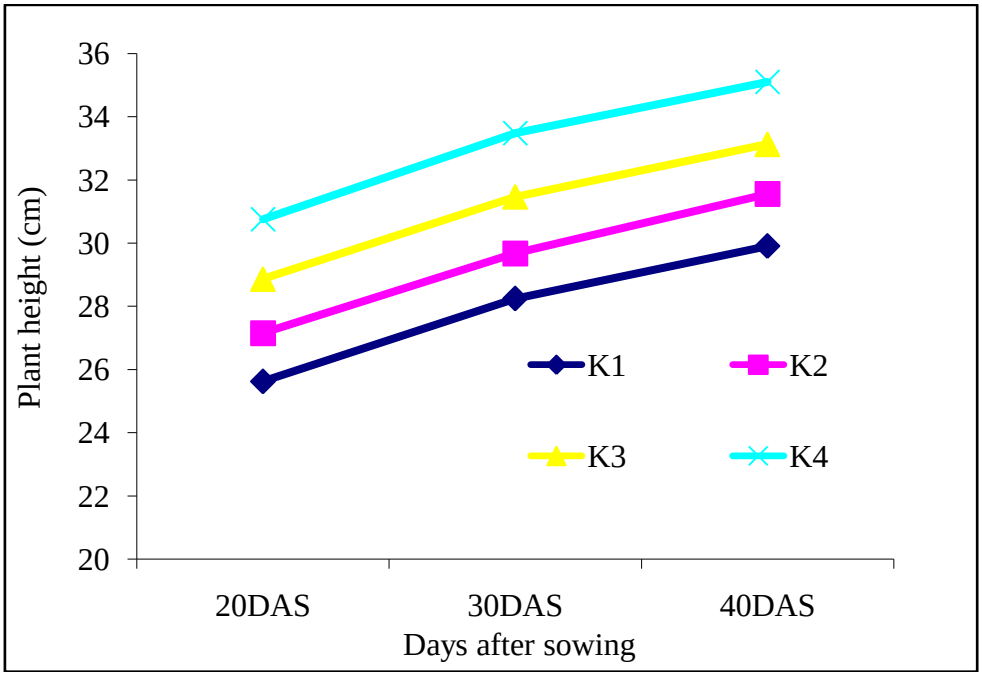

Fig. 4 Effect of different doses of potassium on the plant height of French bean.

Number of compound leaves

The variation in number of compound leaves per plant was found statistically significant. The maximum compound leaves were produced by (10.26) the plants grown with the maximum dose of potassium (120kg K_2O/ha), which was statistically identical with those of plants receiving (80kg K/ha). The minimum compound leaves (3.88) was produced by control (0kg K_2O/ha) treatment (Table 3). The number of compound leaves per plant increased with the increase in potassium dose. Probably, the application of potassium increased the height of plants and ultimately the compound leaves number was also increased due to the influence of this nutrient.

Leaf length

The main effect of potassium revealed that different levels of potassium significantly influenced the leaf length (Table 2). The leaf size increased with the increase in rate of potassium. The larger leaf (15.11 cm) was obtained from 120kg K_2O/ha and the smaller leaf (12.65 cm) was recorded from the control plot (Table 3).

Number of branches per plant

Potassium had significant effect on number of branches per plant (Table 3). The highest number of branches (6.35) per plant were found with the application of 120kg K_2O/ha and the lowest number of branches (2.97) per plant with the doses of 0kg K_2O/ha. But Kanaujia *et al.* (1999) observed that number of branches increased with increasing K rates up to 60kg K_2O/ha.

Number of pods per plant

Potassium had significant effect on number of pods per plant (Table 4). The highest number of pods per plant (60.283) was obtained K_4 (80kg K_2O/ha) treatment and the lowest number of pods per plant (59.049) was recorded from K_o (0kg K_2O/ha) treatment. Similar results were found by Kanaujia*et al.* (1999).

Length of green pod

Length of green pod significantly influenced by potassium doses. The highest length of green pod (17.00 cm) was obtained from K_4 (120kg K_2O/ha) treatment, which were statistically similar with those of plant receiving 80kg K_2O/ha (Table 4). The lowest length of green pod (15.13 cm) obtained from control plot.

Diameter of green pod

Diameter of green pod was influenced by different levels of potassium. Diameter of green pod was gradually increased with the increasing potassium levels. The highest diameter of pod (1.78 cm) was obtained from K_4 treatment (120kg K_2O/ha) and the lowest diameter of pod (1.53 cm) was obtained from control plot (0kg K_2O/ha) (Table 4).

Table 3. The effect of Potassium on growth and yield of French bean

Potassium	No. compound leaf			leaf length(cm)			No. of branches		
	20DAS	30DAS	40DAS	20DAS	30DAS	40DAS	20DAS	30DAS	40DAS
K_1	3.88d	5.62d	9.37d	12.65d	13.55d	13.87d	2.97d	2.75d	5.49d
K_2	4.03c	5.61c	9.76c	13.60c	13.98c	14.37c	3.08c	2.92c	5.95c
K_3	3.93b	5.94b	9.75b	13.81b	14.71b	14.99b	3.23b	2.95b	6.21b
K_4	4.14a	6.07a	10.26a	14.53a	14.94a	15.11a	3.43a	2.73a	6.35a
LSD 0.05	0.41	0.94	1.77	0.71	0.98	1.51	0.57	0.89	1.31
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	5.92	2.84	2.81	2.36	0.94	0.65	1.82	5.16	3.01

K_1 = 0kg, K_2 =40 kg/ha, K_3 =80 kg/ha, K_4 = 120kg/ha; ** Significant at 0.5 level of significance

Number of seeds per green pod

The result on the main effect of potassium revealed that the number of seeds per green pod was significantly influenced by the potassium levels of French bean (Table 4). The maximum number of seeds per green pod (7.99) was recorded from the treatment K_4 (120kg K_2O/ha) and the lowest (5.53) was found in control plot (0kg K_2O/ha).

Table 4.The effect of potassium on growth and yield of fresh bean

Potassium	Number of pods/plant	length of green pod (cm)	Green pod diameter (cm)	Number of seeds/pod	Weight of fresh pod/plant (kg)
K_1	59.049 c	15.13d	1.53 d	5.53c	1.01 d
K_2	59.540 b	15.94 c	1.58 c	6.09 b	1.03 c
K_3	59.552 b	16.67 b	1.69 b	6.68 b	1.15 b
K_4	60.283 a	17.00 a	1.78 a	7.99a	1.18 a
LSD 0.05	2.94	0.94	0.99	1.21	2.85
Level of significance	**	**	**	**	**
CV (%)	1.83	2.79	3.54	1.44	2.46

K_1 = 0kg, K_2 =40 kg/ha, K_3 =80 kg/ha, K_4 = 120kg/ha; **Significant at 0.5 level of significance

Weight of fresh pod/plant

The present study revealed that were was a highly significant effect of potassium on the pod weight per plant of French bean. The highest (1.18 kg) and the lowest (1.01 kg) pod weight per plant were found from the potassium levels of 120kg K_2O/ha and 0kg K_2O/ha respectively.

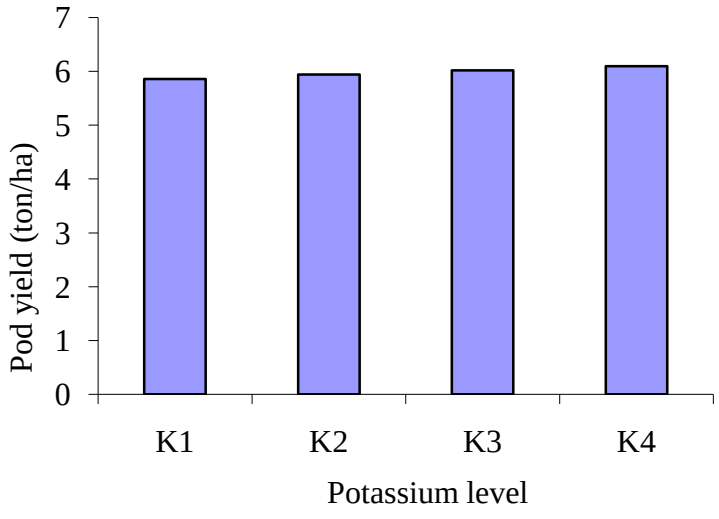

Fig. 5 Effect of potassium on the yield of French bean.

Pod yield per hectare

A highly significant differences was found at different levels of potassium in respect of pod yield per plot of French bean. It was found that the maximum (6.10 ton/ha) and the minimum (5.86 ton/ha) pod yield per plot were obtained from 120kg K_2O/ha and 0kg K_2O/ha respectively.

Combined effect of nitrogen and potassium on the growth and yield of French bean

Plant height

The interaction effect between nitrogen and potassium on plant height was found to be not significant at 20 and 30 DAS but significant at 40 DAS (Table 5) but their combined effect was significant. The maximum plant height (35.74cm) was obtained at 40 DAS from the treatment combination of 100kg N/ha with 120kg K_2O/ha and the lowest (13.56cm) was found in the treatment of no nitrogen with no potassium at same DAS.

Table 5. The combined effect of nitrogen and potassium on growth characters of French bean

NxK	Plant height(cm)			No. compound leaf			leaf length(cm)			No. of branches		
	20DAS	30DAS	40 DAS	20 DAS	30 DAS	0 DAS	20 DAS	30 DAS	40 DAS	20 DAS	30 DAS	40 DAS
N_1K_1	13.56ij	14.37ij	25.47h	2.33g	5.27efg	7.30i	8.30k	12.07k	12.79i	2.10l	2.47de	3.60k
N_1K_2	13.70ij	14.70i	26.50gh	2.70g	5.40efg	7.63i	9.43j	12.20jk	12.84hi	2.17l	2.63cd	4.63j
N_1K_3	14.50i	15.10hi	27.43fg	2.47g	5.47cd	7.38i	9.34j	12.37ij	12.84hi	2.30k	2.87c	5.00i
N_1K_4	14.86hi	15.57h	28.43g	3.20f	5.67bc	8.37h	10.50i	12.53hi	12.84hi	2.37k	2.11f	5.27hi
N_2K_1	14.96h	15.67gh	29.10f	3.50ef	5.70j	8.62h	11.37h	12.70h	12.85hi	2.53j	2.15f	5.50gh
N_2K_2	15.66g	15.85g	29.30efg	3.73e	5.73gh	9.27g	12.60g	12.37ij	12.87hi	2.53j	2.19f	5.63g
N_2K_3	16.01f	16.38f	30.14ef	3.37ef	5.80fg	9.53fg	12.77g	12.94g	12.98h	2.60j	2.24ef	5.80fg
N_2K_4	17.71e	17.24e	30.48e	3.48ef	5.64efg	9.80ef	13.37f	13.48f	13.39g	2.80i	2.28ef	5.60g
N_3K_1	17.63de	17.76de	31.52de	4.13d	5.12def	10.23de	13.43f	13.29f	13.58f	3.13h	3.17b	6.10ef
N_3K_2	17.93d	17.94d	31.74d	4.33cd	5.16def	10.50cd	14.50e	14.17e	14.34e	3.37g	3.60a	6.30de
N_3K_3	18.21cd	18.32cd	32.58cd	4.60c	6.30cde	10.73c	14.87e	15.05d	15.28d	3.53f	3.38ab	6.53cd
N_3K_4	18.63c	18.76c	32.77c	4.34cd	6.70efg	10.39cd	15.53d	15.21d	15.31d	3.77e	3.16b	6.73c
N_4K_1	18.76bc	18.89bc	33.56bc	5.20b	6.38i	11.33b	16.37c	16.14c	16.27c	4.10d	3.21b	6.38de
N_4K_2	19.73b	19.93b	34.68b	5.33ab	6.16hi	11.63b	17.87b	17.18b	17.42b	4.23c	3.27b	7.23b
N_4K_3	20.01ab	20.17ab	34.69ab	5.46ab	6.21b	11.35b	18.27ab	18.46a	18.84a	4.50b	3.33b	7.50ab
N_4K_4	20.66a	20.82a	35.74a	5.63a	6.26a	12.47a	18.70a	18.54a	18.91a	4.80a	3.36ab	7.80a
LSD 0.05	0.92	1.94	2.90	0.82	1.88	3.54	1.42	1.96	3.02	1.14	1.78	2.62
Level of significance	Ns	**	**	*	**	**	**	**	**	**	**	**
CV (%)	1.42	0.43	0.56	5.92	2.84	2.81	2.36	0.94	0.65	1.82	5.16	3.01

K_1 = 0kg, K_2 =40 kg/ha, K_3 =80 kg/ha, K_4 = 120kg/ha, N_1 = 0kg, N2 =50 kg/ha, N_3 =100 kg/ha, N_4 = 150kg/ha; **Significant at 0.5 level of significance

Number of compound leaves per plant

The interaction and combined effect of nitrogen and potassium in respect of number of leaves per plant was statistically significant and their interaction effect was significant except 20 and 30 DAS. The number of leaves was increased with increasing nitrogen and potassium levels. The treatment combination of (N_4K_4 150kg N/ha with 120kg K_2O/ha) produced maximum leaves (12.47) followed by N_3K_4, N_2K_4, N_1K_4 at 40 DAS and the minimum number of leaves per plant (2.33) was found from N_0K_0 (Table 5) which was statistically similar with the treatment combination of N_4K_0.

Leaf length (cm)

There was no significant interaction between nitrogen and potassium in respect of leaf size but their combined effect was significant. The maximum of leaf length (18.91cm) was recorded from the treatment combination N_0K_4 (0kg N/ha with 120kg K_2O/ha), which was statistically similar with the treatment combination of N_2K_2. Whereas the minimum leaf length was (8.30cm) obtained from control treatment combination which was statistically identical with N_4K_0 (Table 5).

Number of branches per plant

Both nitrogen and potassium had significant combined and interaction effect on the number of branches per plant and (Table 5). The highest number of branches per plant (7.80) recorded in the treatment combination of 150kg N/ha with 120kg K_2O/ha, which was statistically similar with the treatment combination of N_1K_2 and the lowest from N_0K_0 (0kg N/ha and 0kg K_2O/ha).

Table 6. The combined effect of nitrogen and potassium on yield contributing characters of French bean

NxK	Number of pods/plant	length of green pod (cm)	Green pod diameter (cm)	Number of seeds/pod	Weight of fresh pod/plant (kg)	Pod yield (ton/ha)
N_1K_1	56.417 j	15.23 ij	1.31 h	5.90 hi	0.82 hi	5.35 hi
N_1K_2	56.593 j	15.24 l	1.33 hg	6.15 h	0.83 h	5.42 h
N_1K_3	56.680 j	15.39 hi	1.37 g	6.64 gh	0.85 gh	5.53 gh
N_1K_4	57.093 ij	15.94 h	1.41 gf	6.677 g	0.89 g	5.54 g
N_2K_1	57.963 hi	16.03 gh	1.44 f	6.71 fg	0.95 fg	5.76 fg
N_2K_2	58.660 h	16.13 g	1.47 ef	6.73 f	0.97 f	5.78 f
N_2K_3	57.863 gh	16.25 fg	1.49 e	6.82 ef	0.99 ef	5.84 ef
N_2K_4	59.137 fg	16.49 f	1.53 de	7.21 e	1.03 e	5.91 e
N_3K_1	59.757 ef	16.81 e	1.57 d	7.26 de	1.16 de	6.01 de
N_3K_2	60.227 de	16.98 d	1.59 cd	7.58 d	1.19 d	6.11 d
N_3K_3	60.543 de	17.14 cde	1.63 c	7.63 cd	1.12 cd	6.20 cd
N_3K_4	60.973 d	17.22cd	1.68 bc	7.56 c	1.16 c	6.38 c
N_4K_1	62.060 c	17.28 c	1.72 b	7.59 bc	1.21 bc	6.41 bc
N_4K_2	62.680 bc	17.31 b	1.76 ba	7.917 b	1.23 b	6.59 b
N_4K_3	63.120 ab	17.34ab	1.79ab	8.31ab	1.25 ab	6.66 ab
N_4K_4	63.930 a	17.37 a	1.81 a	8.48 a	1.27 a	6.69 a
LSD 0.05	5.88	1.88	0.23	0.31	0.22	0.89
Level of significance	**	NS	**	**	**	**
CV (%)	1.83	2.79	3.54	1.44	2.46	4.29

K_1 = 0kg, K_2 =40 kg/ha, K_3 =80 kg/ha, K_4 = 120kg/ha, N_1 = 0kg, N2 =50 kg/ha, N_3 =100 kg/ha, N_4 = 150kg/ha; ** Significant at 0.5 level of significance

Number of pods per plant

Number of pods per plant significantly varied due to combined effect of different nitrogen and potassium levels (Table 6). The interaction effect of nitrogen and potassium was also significant in respect of number of pods per plant. The maximum number of pods per plant (63.930) was obtained from the treatment combination of 150kg N/ha with 120kg K_2O/ha. The minimum number of pods per plant (56.417) was found in N_0K_0.

Length of green pod (cm)

The interaction effects of different levels of nitrogen and potassium was found to non-significant and their combined effect was also significant, and (Table 6). The highest length of pod (17.37 cm) was recorded from the treatment combination of 150kg N/ha with 120kg K_2O/ha and the lowest (15.23 cm) was found in control plot.

Diameter of green pod(cm)

The interaction effect of nitrogen and potassium in respect of pod diameter was found to be statistically non-significant but their combined effect was found to be significant. The treatment combination of N_4K_4 (150kg N/ha with 120kg K_2O/ha) produced the highest pod diameter (1.81 cm) which was statistically identical with N_4K_4 whereas the lowest (1.31 cm) was measured from the treatment combination of N_0K_0 (Table 6).

Number of seeds per green pod

The interaction effect of nitrogen with potassium on the number of seeds per plant was statistically non-significant and their combined effect was found to be significant (Table 6). The maximum number of seeds per green pod (8.48) was obtained from the treatment of 100kg N/ha with 120kg K_2O/ha and the minimum value (5.90) was found in the control plot (0kg N/ha with 0kg K_2O/ha).

Weight of fresh pod/plant

The interaction effect of different levels of nitrogen and potassium on pod weight per plant was statistically significant. The maximum pod weight per plant (1.27 kg) was obtained from the treatment combination of

N_4K_4(150kg N/ha with 120kg K_2O/ha) which was statistically similar with N_4K_1 and the lowest (0.82 kg) was obtained from N_0K_0 which was statistically similar with N_0K_1 (Table 6).

Pod yield per plot

The interaction and combined effect of different levels of nitrogen and potassium on green pod yield per plot was significant. The maximum green pod yield (6.69 ton/ha) was obtained from treatment combination of N_4K_4 (150kg N/ha with 120kg K_2O/ha) which was statistically similar to the treatment combination of N_4K_1, N_1K_4. The lowest green pod yield per plot (5.35 ton/ha) was recorded from N_0K_0 and it was also similar to N_0K_1 and N_0K_2 (Table 6).

IV. Conclusion

A field experiment was conducted to evaluate the effect of nitrogen and potassium on the growth and yield of French bean.From the results of the experiment it was found that the main effect of nitrogen had significant effect on the plant height, number of compound leaves per plant, leaf length, number of branches per plant, length of green pod, diameter of green pod and number of pods per plant. But there was no significant effect onthe diameter of green pod of French bean. The maximum green pod yield (6.53 t/ha) was obtained from the plot where 150kg N/ha was used.The result of experiment revealed that most of the parameters studied were significantly influenced by different potassium levels. It significantly increased all the parameters. The highest pod yield (6.10 t/ha) was obtained from the plot where 120kg K_2O/ha was used.Interaction effect of nitrogen and potassium exhibited significant variation on most of the characters studied, but showed insignificant influence on leaf length, length of green pod, diameter of green pod, number of seeds per plant. Application of 150kg N/ha with 120kg K_2O/ha gave the highest branches and compound leaves per plant, no. of flowers per plant weight of pods per plant and pod yield (6.69 t/ha). This information will help the farmer to grow French bean with better yield.

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