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Research Article

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Effect of phosphorus and potassium on the growth and yield of French bean

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh to investigate the yield response of French bean (*Phaseolus vulgaris* L.) as affected by phosphorus and potassium management. The experiment consisted of two factors. Factor A: Phosphorus fertilizer (4 levels) viz. P_1=15Kg P ha^{-1}, P_2=20 Kg P ha^{-1} and P_3=25 Kg P ha^{-1} , P_4=35 Kg P ha^{-1} and factor B: Potassium fertilizer (4 levels) viz. K_1=0 Kg K ha^{-1}, K_2=20 Kg K ha^{-1}, K_3=30 Kg K ha-1 and K_4=40 Kg K ha^{-1}. The variety BARI Jharsheem-3 was used in this experiment as the test crop. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In case of phosphorus @ 25 ha^{-1}, the highest number of pods plant^{-1} (4.96), pod length (13.34 cm), number of seeds pod^{-1} (4.54), weight of 1000-seed (431.21 g), seed yield (1.33 t ha^{-1}), stover yield (1.53 t ha^{-1}), biological yield (2.86 t ha^{-1}) and harvest index (46.50%) were found. In case of potassium @ 40 kg ha^{-1}, the highest number of pods plant^{-1} (5.80), pod length (14.89 cm), number of seeds pod^{-1} (4.24), weight of 1000-seed (430.37 g), seed yield (1.53 t ha^{-1}), stover yield (1.46 t ha^{-1}), biological yield (2.99 t ha^{-1}) and harvest index (51.17%) were found. Interaction effect of phosphorus and potassium the highest number of pods plant^{-1} (5.18), pod length (13.40 cm), number of seeds pod^{-1} (4.30), weight of 1000-seed (430.53 g), seed yield (1.40 t ha^{-1}), stover yield (1.60 t ha^{-1}), biological yield (3.00 t ha^{-1}) and harvest index (46.66%) were recorded from P @ 25 kg ha^{-1} and K @ 40 kg ha^{-1}. However, from the study it can be concluded that application of P @ 25 kg ha^{-1} and K @ 40 kg ha^{-1} was the most suitable combination for better yield of French bean.

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INTRODUCTION

French bean (*Phaseolus vulgaris*) is an important short duration leguminous pod vegetable grown all over the world. French bean (*Phaseolus vulgaris L.)* is one of the five cultivated species from the genus *Phaseolus* and is a major grain legume crop, third in importance after soya bean and peanut [1]. It was originated in the Central America and South America [2]. In our country it is known as Farashi seem [3] or Jharsheem [4]. It is also known as bush bean, kidney bean, snap bean, raj bean, common bean, basic bean, navy bean, haricot bean, pole bean, wax bean, string bean and bonchi [5]. In Bangladesh French bean is being cultivated in areas under greater Sylhet, Chittagong and Comilla district in small scale and has the feasibility throughout the country in winter. According to FAO [6] the production of French Bean in Bangladesh was 94,356 ton in 2011. French bean is valued for its protein rich (23%) seeds. It contains K, Ca, Mg, Fe, P vitamin A, B, D, starch no fat. According to the recent FAO statistics, French beans including other related species of genus *Phaseolus* occupied 25.69 million hectares of the world's cropped area and produced about 17.62 million tons green vegetables with the average yield or 686 kg/ha [6]. It is early donated vegetable crop, it can be grown successfully during winter season after harvest of transplanted Aman paddy and it would allow the growing of *Boro* rice after the harvest of green pods. It can also be intercropped with maize, wheat, sunflower and sugarcane. Recently cultivation of French bean is gaining popularity in Bangladesh because of its high nutritive value, good taste and wide range of use. It has been considered as commodity for export in the ethnic and also in the extreme super market of European countries. Hortex Foundation of Bangladesh exports vegetable French bean and might contribute much to the supply of legume vegetable and bean seeds during winter [7]. Production of French bean depends on many agronomic management factors such as quality seed, variety, sowing date, fertilizer etc. [8,9,10].

Phosphorous (P) fertilization is the major mineral nutrient yield determinant in legume crops. Applied phosphorous significantly influences the yield performance of pulse crop [11]. Phosphorous deficiency reduces the total vegetative growth, secondary branches and leaf development and finally yields of mungbean [12]. Interestingly, application of phosphorus fertilizer is significant for growers for their farming production. Because phosphorus can play a vital role for enrich mungbean mineral composition. It is known that P can promote nodule formation which fixing atmospheric N_2 in root, even it also helps to promote early root formation and the formation of lateral, fibrous and healthy roots [13,14].

Potassium plays a critical role in enzyme activation, water use efficiency, photosynthesis, transport of sugars, protein, and starch synthesis in plants [15,16], is especially important in its interaction with nitrogen throughout the growing period. Adequate potassium in the field results in higher crop yields and higher nitrogen use efficiency as it enhances nodulation and hence N_2 fixation [17]. Crops respond to higher potassium levels when nitrogen is sufficient, and greater yield response to nitrogen occurs when potassium is sufficient, thus a complementary uptake for the plant growth and development. Therefore, contribution of N fixation in K nutrition of legumes is very important.

Phosphorus and potassium play a vital role in the nutrition of plants. Infect these are the nutrients, which are deficient in the soils. Therefore, application of phosphorus and potassium fertilizers becomes important both from quality as well as production point of view. No systematic work has been done on the effect of phosphorus and potassium on yield of French bean particularly in this region. Therefore, the present experiment was undertaken to study the effect of phosphorus and potassium on the growth and yield of French bean. The present study was therefore, undertaken with the objective to assess the optimum level of phosphorus and potassium and their interaction effect for maximizing the growth and yield of French bean.

MATERIALS AND METHODS

Experimental Site

The research work was conducted at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh in order to study the effect of phosphorous and potassium on the growth and yield of French bean during the period from November 2017 to March 2018. The present piece of research work was conducted in the experimental field is located at 24.75°N latitude, 90.50°E longitude and an average altitude of 18 m above the sea level. The experimental site belongs to the Old Brahmaputra Floodplain (AEZ-9) soil. The region occupies a large area of Brahmaputra sediments which are laid down before the river shifted into its present Jamuna channel 200 years ago [18,19]. The texture of the soil in the experimental area was silty loam type and belongs to the Brahmaputra Alluvial Tract. The topography of the experimental field was medium high land. The soil of the experimental field is slightly acidic (pH 6.80) with low organic matter content (1.19 %) and high soil bulk density (1.64 g cm^{-3}). During the winter season average temperature was 8-25°C. The winter season is favorable for French bean cultivation.

Treatments and Design of the Experiment

The experiment was comprised of two factors namely Phosphorus and Potassium level. **Factor A** (4 level of phosphorus): a) P_1 =15 kg P ha^{-1} b) P_2 = 20 kg P ha^{-1} c) P_3 = 25 kg P ha^{-1} d) P4 = 35 kg P ha^{-1} and **Factor B** (4 level of Potassium): a) K_1 = 0 kg K ha^{-1} b) K_2 = 20 kg K ha^{-1} c) K_3 = 30 kg K ha^{-1} d) K_4 = 40 kg K ha^{-1} The experiment was laid out in Randomized Complete Block Design with three replications. There were 16 treatment combinations. Each block consisted of 48-unit plots. The size of each unit plot was 5 m^2 (2.5 m × 2 m). Seeds were sown maintaining the spacing 25 cm × 15 cm. The blocks and unit plots were separated by 1 m and 0.75 m spacing, respectively.

Crop Husbandry

The land was ploughed with a power tiller and afterwards the experimental plot was prepared by several ploughing and cross ploughing followed by laddering to break the clods and to level the soil. The weeds and stubbles were collected and removed from the plot. The half amount of urea (150 kg ha^{-1}) was applied during final land preparation and another half amount of urea was top dressed at 30 days after sowing (DAS) of seeds. The whole amount of TSP (as per treatment) and MoP (as per treatment) were applied during final land preparation. Before seed sowing, Carbendazem @ 5g kg^{-1} seeds were treated with the seed uniformly for controlling soil borne diseases. Two seeds were sown $hill^{-1}$ at a depth of 5.0 cm. Several weeding (20, 35 and 50 DAS) was done to keep the plots free from weeds, which ultimately ensured better growth and development. Over-head irrigation was done as per necessary. The plots were infested by caterpillar, which was successfully controlled by applying Basudin 10 G at the rate of 16.8 kg ha^{-1}. Seedlings were attacked by damping off and anthracnose. Topsin M (Thiophanate methyl) was sprayed at the rate of 2 mL $litre^{-1}$ at an interval of 7 days. The plants attacked by Bean Common Mosaic Virus (BCMV) were removed from the plots except the central portion which was kept for other data collection and destroyed for controlling BCMV. The crop was harvested manually from each plot. Seeds were separated from the plants by beating the bundles with bamboo sticks. The collected seeds were dried in the sun for reducing the moisture content at a constant level (12%). The dried seeds and stover were cleaned and weighed.

Data Collection

Data were recorded on the yield and yield contributing characters presented in tables. The five plants were selected randomly from each plot to record the data. A meter scale was used to measure the height of the plant. Leaves were collected from the selected plant and measured in the Professor Muhammad Hussain Central Laboratory of Bangladesh Agricultural University, Mymensingh. Leaf area $plant^{-1}$ was estimated by Leaf Area Meter (Model no.LI-3100 Area Meter) at 30, 45, 60 days after sowing (DAS). The biological yield and Harvest Index were calculated with the following formula:

I. Biological yield = Grain yield + Stover yield.

II. $HI\ (\%) = \frac{\text{Economic yield(Grain yield)}}{\text{Biological yield}} \times 100$
(Grain yield + Stover yield)

Statistical Analysis

The collected data were compiled and analyzed statistically using the analysis of variance technique with computer package program Minitab statistical software (2010). State college, PA: Minitab, Inc (www.minitab.com).

RESULTS AND DISCUSSION

Effect of Phosphorus on the Yield Contributing Characters and Yield of French Bean

Among the different doses of Phosphorus, the highest pod length (13.34 cm), number of seeds pod^{-1} (4.54), grain yield of French bean (1.33 t ha^{-1}), stover yield (1.53 t ha^{-1}), biological yield (2.86 t ha^{-1}), harvest index (40.81 %) were found 25 kg P ha^{-1} (P_3) application. The lowest pod length (12.27 cm), number of seeds pod^{-1} (4.04), harvest index (37.28%) from 35 kg P ha^{-1} (P_4), The lowest grain yield(1.24 t ha^{-1}), stover yield (1.37 t ha^{-1}), biological yield (2.61 t ha^{-1}) of French bean was recorded in the P_2 (20 kg ha^{-1}). The influence of phosphorus was non-significant on the number of pods plant^{-1} and weight of 1000 seeds. The maximum number of pods plant^{-1} (4.98) was found from 20 kg P ha^{-1} (P_2) and minimum number of pods plant^{-1} (4.95) was found from 35 kg P ha^{-1} (P_4) (Table 1). Numerically the highest weight of 1000 seeds (431.21 g) was observed from 25 kg P ha^{-1} (P_3) and the lowest one (427.85 g) was found from 35 kg P ha^{-1} (P_4) (Table 1). Ahlawat and Sharma [20] reported increased mean seed yield to the tune of 29.6 and 39.5 per cent respectively, with 17.2 and 34.4 kg P ha^{-1}. Saxena and Verma [21] reported that the mean number of grains per pod linearly increased from 5.53 to 7.50 due to increased P fertilization from zero to 120 kg P_2O_5 ha^{-1}. Rahman *et al*., [22] found the maximum pod yield (22.12 t ha$^{-1)}$ of French bean from the application of 60 kg P ha$^{-1.}$ Singh *et al*., [23] observed highest number of pods plant^{-1} (11.20), number of grains pod^{-1} (3.76), seed yield (12.08 q ha^{-1}) and straw yield (18.51q ha$^{-1)}$ of French bean from 60 kg P_2O_5 ha^{-1} application. Zebire and Gelgelo [24] reported higher number of pods plant^{1} (8.0), seeds pod^{-1} (14.0) and seed yield (7.42 quintal ha^{-1}) from this 46 P kg ha^{-1} application. However, the significant influence of Phosphorus in legume crops like mungbean, lentil also proved by many researchers [25,26,27]. Phosphorus by forming nutrient interaction affect other essential nutrient availability in different soils which leading to increase French bean production.

Effect of Potassium on the Yield Contributing Characters and Yield of French Bean

The maximum/highest number of pods plant^{-1} (5.80), length of pod was recorded (14.89 cm), grain yield (1.53 t ha^{-1}), stover yield (1.46 t ha^{-1}), biological yield (2.99 t ha^{-1}), harvest index (51.17 %) were found 40 kg P ha^{-1} (K_4). The shortest/lowest length of pod (12.70), g rain (1.23 t ha^{-1}), harvest index (45.55 %) from 0 kg K ha^{-1} (K_1), number of pods plant^{-1} (4.91), stover yield (1.39 t ha^{-1}), biological yield (2.66 t ha^{-1}) were recorded found from (30 kg P ha^{-1}) (K_3). The effect of potassium had non-significant variation on the number of seeds pod^{-1} and weight of 1000 seeds. The highest number of seeds pod^{-1} (4.24) from (K_4) and lowest number of seeds pod^{-1} (4.02) from 20 kg K ha^{-1} (K_2) (Table 2). Numerically the highest weight of 1000 seeds (430.43 g) was observed from 30 kg K ha^{-1} (K_3) and the lowest one (428.57 g) was found from 0 kg K ha^{-1} (K_1) (Table 2). Yahia *et al.* [28] concluded that application of K significantly increased shoot dry weight, leaf area index, and leaf area duration and crop growth. Application of 50 kg K ha^{-1} proved optimum for growth, and. yield parameters and the seed yield of pigeon pea. Moniruzzaman *et al*. [29] found that the number of green pods plant^{-1}, green pod weight plant^{-1} increased up to potassium level (90 kg K_2O ha^{-1}) and green pod yield increased up to 60 kg K_2O ha^{-1}) in French bean. Similarly, Huda *et al*., [30] observed that increasing the potassium level from 48 to 96 kg K_2O/fed gradually and significantly increased green pod yields of green bean. Akter *et al*., [31] also recorded the highest number of green pods plant^{-1} (27.22), number of seeds pod^{-1} (8.00) and green pod yield (10.66 t ha^{-1}) garden pea from the crop fertilized with 50 kg K_2O ha^{-1}.

Interaction effect of Phosphorus and Potassium on the Yield Contributing Characters and Yield of French Bean

The maximum/highest number of pods plant^{-1} (5.18), length of pod was recorded (14.68 cm), number of seeds pod^{-1} (4.58), seed yield (1.40 t ha^{-1}), biological yield (3.00 t ha^{-1}) was found from the combination of (P_3K_4) and the highest harvest index (47.58 %) was found from the combination of phosphorus @35 kg ha^{-1} and potassium @0 kg ha^{-1} (P_4K_1). The minimum number of pods plant^{-1} (4.78) from the combination of phosphorus @20 kg ha^{-1} and potassium @0 kg ha^{-1} (P_2K_1), length of pod was recorded (11.81 cm) from the combination of (P_4K_4), number of seeds pod^{-1} (3.77) from the combination of phosphorus @35 kg ha^{-1}

Table 1: Effect of phosphorus on the yield contributing characters and yield of French bean

Level of Phosphorus (kg ha^{-1})	No. of pods plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
P_1 = 15	4.96	12.54^{ab}	4.22^{b}	430.19	1.28^{ab}	1.39^{b}	45.94^{b}
P_2 = 20	4.98	13.30^{a}	4.11^{bc}	430.08	1.24^{b}	1.37^{b}	45.50^{c}
P_3 = 25	4.96	13.34^{a}	4.54^{a}	431.21	1.33^{a}	1.53^{a}	46.50^{a}
P_4 = 35	4.95	12.27^{b}	4.04^{c}	427.85	1.25^{b}	1.44^{b}	45.94^{b}
Level of significance	NS	*	*	NS	*	*	*
CV (%)	2.33	5.87	2.13	4.43	6.27	5.21	3.25

Table 2: Effect of potassium on the yield contributing characters and yield of French bean

Level of Potassium (kg ha^{-1})	No. of Pod plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
K_1 = 0	5.18^{b}	12.70^{c}	4.18	428.57	1.23^{b}	1.47^{a}	45.55^{b}
K_2 = 20	4.95^{bc}	12.85^{c}	4.02	429.93	1.26^{b}	1.42^{b}	47.01^{ab}
K_3 = 30	4.91^{c}	13.87^{b}	4.14	430.43	1.27^{ab}	1.39^{b}	47.75^{ab}
K_4 = 40	5.8^{a}	14.89^{a}	4.24	430.37	1.53^{a}	1.46^{a}	51.17^{a}
Level of significance	*	*	NS	NS	*	*	*
CV (%)	5.78	8.32	2.43	3.87	7.21	4.44	10.19

In a column, the mean values with common letter do not differ significantly at 5 % level of probability.* = Significant at 5 % level of probability, NS = Non-significant

Table 3: Interacting effects of phosphorus and potassium on pod number, pod height, no. of seed/pod, Wt. /1000 seed, seed yield, Stover yield, biological yield and harvest index of French bean

Interaction (P×K)	No. of pod plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	1000-seed weight (gm)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$P_1\times k_1$	5.05^{b}	12.51^{c}	4.21^{bc}	420.2	1.37^{ab}	1.56^{ab}	2.93^{abcd}	46.76^{ab}
$P_1\times K_2$	4.66^{bc}	12.03^{c}	4.08^{bc}	430.35	1.31^{abcd}	1.52^{abc}	2.83^{abc}	46.28^{ab}
$P_1\times K_3$	4.85^{cd}	12.43^{c}	4.35^{b}	430.48	1.35^{abc}	1.58^{ab}	2.93^{ab}	46.07^{ab}
$P_1\times K_4$	4.98^{bc}	13.20^{abc}	4.33^{b}	433.45	1.27^{abcd}	1.42^{bcd}	2.69^{bcd}	47.21^{ab}
$P_2\times K_1$	4.78^{d}	12.58^{c}	4.38^{b}	430.29	1.30^{abcd}	1.42^{bcd}	2.72^{abcd}	47.79^{ab}
$P_2\times K_2$	5.05^{b}	14.68^{a}	4.10^{d}	428.85	1.22^{cd}	1.35^{d}	2.57^{cd}	47.47^{ab}
$P_2\times K_3$	5.05^{b}	12.78^{bc}	3.87^{b}	430.62	1.18^{b}	1.33^{d}	2.51^{d}	47.01^{b}
$P_2\times K_4$	5.05^{b}	13.14^{abc}	4.10^{d}	430.55	1.24^{bcd}	1.40^{cd}	2.64^{bcd}	46.96^{ab}
$P_3\times K_1$	5.05^{b}	12.85^{bc}	3.96^{bc}	430.41	1.21^{d}	1.48^{abcd}	2.69^{abc}	44.94^{a}
$P_3\times K_2$	4.85^{cd}	12.83^{bc}	3.97^{c}	430.45	1.28^{abcd}	1.43^{bcd}	2.71^{abcd}	47.23^{ab}
$P_3\times K_3$	4.78^{d}	14.27^{ab}	4.38^{b}	430.30	1.27^{abcd}	1.38^{cd}	2.65^{cd}	47.92^{ab}
$P_3\times K_4$	5.18^{a}	13.40^{abc}	4.58^{a}	430.55	1.40^{a}	1.60^{a}	3.00^{a}	46.66^{ab}
$P_4\times K_1$	5.05^{b}	12.88^{bc}	4.43^{b}	430.22	1.26^{abcd}	1.139^{cd}	2.39^{bcd}	47.58^{b}
$P_4\times K_2$	4.85^{cd}	12.38^{c}	4.03^{d}	430.17	1.23^{cd}	1.37^{cd}	2.6^{cd}	47.30^{ab}
$P_4\times K_3$	4.98^{b}	12.00^{c}	3.77^{f}	430.34	1.30^{abcd}	1.46^{abcd}	2.76^{abcd}	47.10^{ab}
$P_4\times K_4$	4.91^{c}	11.81^{c}	3.92^{de}	430.05	1.21^{d}	1.35^{d}	2.56^{cd}	47.26^{ab}
Level of significance	*	*	*	NS	*	*	*	*
CV (%)	9.76	11.79	8.15	1.09	10.68	13.45	15.36	11.66

In a column, the mean values with common letter do not differ significantly at 5 % level of probability, * = Significant at 5 % level of probability, NS = Non-significant P_1 = 15 kg ha^{-1}, P_2 = 20 kg ha^{-1}, P_3 = 25 kg ha^{-1}, P_4 =35 kg ha^{-1}, K_1 = 00 kg ha^{-1}, K_2 = 20 kg ha^{-1}, K_3 = 30 kg ha^{-1}, K_4 =40 kg ha^{-1}

and potassium @30 kg ha^{-1} (P_4K_3), seed yield (1.18 t ha^{-1}) was found from the combination of phosphorus @20 kg ha^{-1} and potassium @30 kg ha^{-1} (P_2K_3), stover yield (1.60 t ha^{-1}) was found from the combination of (P_1K_1) and lowest stover yield (1.13 t ha^{-1}) was found from the combination of (P_4K_1), biological yield (2.51 t ha^{-1}) was found from the combination of (P_2K_3) and harvest index (46.07 %) from the combination of phosphorus @15 kg ha^{-1} and potassium @30 kg ha^{-1} (P_1K_3) were recorded. Combined effect of phosphorous and potassium showed non-significant variation on the weight of 1000 seed (Table 3). Numerically the highest weight of 1000 seed (433.45 g) was observed from the combination of (P_1K_4) and the lowest one (420.2 g) was found from the combination of (P_3K_4). Phosphorus application @20 kg ha^{-1} and potassium @60 kg ha^{-1} were found to give significant variation on the number of pods plant^{-1} and phosphorus @30 kg ha^{-1} and potassium @40 kg ha^{-1} were found to give optimum seed yield, showed positive correlation with leaf area, dry matter/plant, relative moisture content in leaves, no. of branches, no of pods, seed yield/plant, 1000 seed weight and harvest index of groundnut [32]. The application of P: K at 30:40 kg ha^{-1} was superior in enhancing the yield [33]. Significantly higher plant height (35.8 cm), number of pods plant^{-1}(11.87), seeds pod^{-1}(4.40), 100- seed weight (38.96g) and seed yield plant^{-1} (4.92 g) with 75:30 P_2O_5:K_2O kg ha^{-1} along with 80 kg N ha^{-1} [34]. Chantal *et al.*, [35] also found that P: K at 46:30 kg ha^{-1} along with nitrogen fertilizer produces higher grains pod^{-1}(5), thousand-seed weight (435g) yield (555.2 t ha^{-1}) in bean. The effect of Phosphorus and Potassium is increasing 1000-seed weight and seed yield of bean due to potential of potassium to accelerate enzyme activity which lead to synthesis of protein and assimilate translocation.

CONCLUSION

From the above results of the present study, it was revealed that single application of P and K contributed to improving the yield of BARI Jharsheem-3. The treatments showed the positive effect in most cases and hence may be used for the improvement of yield and quality of BARI Jharsheem-3. From the above findings it can be concluded that the treatment combination of 25 kg ha^{-1}phosphorus and 40 kg ha^{-1} potassium significantly increased the yield of BARI Jharsheem-3 and this treatment combination can be treated as the best treatment considering all other combination in respect of yield and yield contributing characters. However, further investigation is necessary for the other soil types under different AEZ in Bangladesh.

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