The Scientific Temper
Vol. 12, No 1-2, January-July, 2021:pp 197-200
ISSN 0976 8653, E-ISSN 2231 6396
A Web of Science Journal
Doc ID: https://connectjournals.com/03960.2021.12.197

Effect of Different Phosphorus and Potassium Levels on a Seed Crop of French Bean (*Phaseolus vulgaris* L.)

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ABSTRACT

A field experiment was conducted during 2017-18 and 2018-19 at Amar Singh College, Lakhaoti, Bulandshahr (Uttar Pradesh) to assess the effect of different levels of phosphorus and potassium on a seed crop of French bean (*Phaseolus vulgaris* L.). The experiment consisted of nine treatment combinations involving three doses of phosphorus (35, 70 and 105 kg P ha^{-1}) and three doses of potassium (30, 60 and 90 kg K ha^{-1}) plus a uniform dose of 70 kg N ha^{-1} (RDN). The nine treatment combinations were evaluated against the control (RDN + 0 kg P + 0 kg K ha^{-1}) in randomized block design with three replications. The effect of different treatments on plant vegetative characters, root characters, and different attributing traits of seed yield and seed quality were appraised. Results indicated that combined application of 70 kg P + 60 kg K ha^{-1} along with RDN resulted in significantly higher plant height (40.8 cm), number of branches per plant (8.1), number of leaves per plant (13.7), primary root length (12.8 cm), number of nodules per plant (10.0), number of mature pods per plant (22.8), number of seeds per pod (8.3), test weight of seed (107.6 g) and seed weight per plant (13.68 g). The same treatment also resulted in significantly higher seed yield (1710.0 kg ha^{-1}) over the control (993.8 kg ha^{-1}), an increment of 172% over the control. Although, application of higher doses of phosphorus @ 105 kg ha^{-1} and potash @ 90 kg ha^{-1} recorded maximum values for these characters, but they were at par with 70 kg P + 60 kg K ha^{-1}, hence the effects of higher dose of phosphorus and potash beyond this level were non-significant. The findings of this study indicated that 70 kg P + 60 kg K along with 70 kg N ha^{-1} may be considered as an optimum dose of fertilizers for better yield and quality of French bean seed in north Indian plain conditions.

Keywords: French bean, phosphorus, potassium, seed quality, seed yield

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is the third most important grain legume crop of the world, after soy bean and peanut. It is widely cultivated in the temperate and subtropical world and also in many parts of the tropics. In India it is grown during the *rabi* season in the plains and during summer season in the lower and mid hills. The tender pods are used as a green vegetable, while the shelled dry seeds, popularly known as *Rajmash* in North India, is used as a grain legume. French bean is quite nutritious and is a rich source of protein, calcium and iron (Salunkhe *et al*., 1987). French bean (bush type) withdraws around 80 kg N, 30 kg P and 100 kg K from the soil for producing 12.0 t ha^{-1} of green pods (AVRDC, 1990); therefore judicious management of these major nutrients is important for growing a healthy crop with high yields.

Favourable response of grain lugume crops to phosphatic and potassic fertilizers is well established. Low phosphorus and potassium in the soil often limits production of grain legumes (Arya *et al*., 1999). Phosphorus is needed by the plant right from its seed germination, root proliferation, vegetative growth upto

the physiological maturation phase (Mitra *et al*., 1990). Phosphorus is essential for growth, proliferation, deeper penetration and nodulation of roots. Beans need P for shoot growth, photosynthesis, nucleus formation and cell division, synthesis of fat and albumen, utilization of sugar and starch, transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction. It also hastens flowering, seed formation and maturity in French bean (Mitra *et al*., 1990; Srinivasan and Naik, 1988).

Potassium is the third key nutrient of commercial fertilizers. It helps strengthen plant's abilities to resist diseases and plays and important role in increasing crop yields and overall quality (Saxena and Verma, 1995). The effect of potassium on French bean is significantly observed in flowering, seed maturity and yield (Arya *et al.,* 1999). There are reports that potassium deficiency symptoms are hard to be observed and the deficiency in bean plants occur without being noticed by the farmers and hence all fertilizer recommendations always include potassium nutrients (Saxena and Verma, 1995).

Keeping in view the gamut of role played by phosphorus and potassium in growth, development and seed yield of French bean, the present field experiment was, therefore, envisaged to study the effect of different levels of phosphorus and potassium in combination on the growth, quality and seed yield in French bean.

MATERIAL AND METHODS

The experiment was conducted at the Horticultural Research Farm of Amar Singh College, Lakhaoti, Bulandshahr (Uttar Pradesh) during 2017-18 and repeated in 2018-19. The experimental field is located at $28^0$31'36"N longitude and $77^0$58'29"E latitude; and at an average altitude of about 200 m above the mean seal level. Lakhaoti falls under the region of semi-arid, sub-tropical climate where hot and dry westerly winds in summers and frost during winters is common. The soil of the experimental field was deep, sandy loam in texture and slightly saline with a pH of 7.8. The soil had 4.1 g organic carbon, 175 kg ha^{-1} available N, 14.0 kg ha^{-1} available P and 155 kg ha^{-1} available K.

Three levels of phosphorus (35, 70 and 105 kg P ha^{-1}) and three levels of potassium (30, 60 and 90 kg K ha^{-1}) in combination were tested on a seed crop of French bean. The ten treatment combinations, thus formulated were *viz*., T_1 Control: RDN (70 kg N) + 0 kg P + 0 kg K ha^{-1}; T_2: RDN + 35 kg P + 30 kg K ha^{-1}; T_3: RDN + 35 kg P + 60 kg K ha^{-1}; T_4: RDN + 35 kg P + 90 kg K ha^{-1}; T_5: RDN + 70 kg P + 30 kg K ha^{-1}; T_6: RDN + 70 kg P + 60 kg K ha^{-1}; T_7: RDN + 70 kg P + 90 kg K ha^{-1}; T_8: RDN + 105 kg P + 30 kg K ha^{-1}; T_9: RDN + 105 kg P + 60 kg K ha^{-1}; and T_{10}: RDN + 105 kg P + 90 kg K ha^{-1}.

The experiment was laid out in randomized block design with three replications. The crop was sown in the first week of November during both the years, and harvested at full maturity in March second week. The seeds of the variety 'Contender' were sown manually in shallow furrows opened by hand hoe, maintaining a spacing of 40 x 20 cm. As per the treatment combinations, the entire dose of phosphorus (in the form of diammonium phosphate) and potash (in the form of muriate of potash) was applied as basal dose to all the plots at the time of field preparation. Nitrogen, applied through DAP and urea, was given uniformly to all plots at the rate of 70 kg ha^{-1}. Half the quantity of nitrogen was applied as basal dose along with phosphorus and potash, and the remaining half as top dressing at 30 days after sowing. The field was kept free from weeds throughout the crop duration. Recommended package of practices were followed to raise the crop.

Table 1: Effect of different phosphorus and potassium levels on vegetative and root characters of French bean

Treatment	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Primary root length (cm)	Number of nodules per plant
T_1 Control: RDN (70 kg N) + 0 kg P + 0 kg K ha^{-1}	27.9	5.5	9.2	8.5	3.0
T_2: RDN + 35 kg P + 30 kg K ha^{-1}	31.5	6.4	10.3	10.4	4.2
T_3: RDN + 35 kg P + 60 kg K ha^{-1}	34.5	7.6	11.5	11.2	5.1
T_4: RDN + 35 kg P + 90 kg K ha^{-1}	35.6	7.9	12.1	11.4	6.4
T_5: RDN + 70 kg P + 30 kg K ha^{-1}	37.4	7.9	12.4	12.3	7.5
T_6: RDN + 70 kg P + 60 kg K ha^{-1}	40.8	8.1	13.7	12.8	10.0
T_7: RDN + 70 kg P + 90 kg K ha^{-1}	41.2	8.1	13.8	12.8	10.5
T_8: RDN + 105 kg P + 30 kg K ha^{-1}	40.3	7.9	12.6	12.9	9.4
T_9: RDN + 105 kg P + 60 kg K ha^{-1}	41.5	8.2	13.8	13.0	10.5
T_{10}: RDN + 105 kg P + 90 kg K ha^{-1}	41.7	8.2	14.0	13.0	10.7
SEm±	2.0	0.2	1.0	0.3	0.3
CD (*P=0.05*)	5.9	0.5	2.7	0.8	0.9

Table 2: Effect of different phosphorus and potassium levels on seed characters and seed yield of French bean

Treatment	Number of mature pods per plant	Number of seeds per pod	Test weight of seed (g)	Seed weight per plant (g)	Seed yield (kg ha^{-1})
T_1 Control: RDN (70 kg N) + 0 kg P + 0 kg K ha^{-1}	13.0	5.3	93.8	7.95	993.8
T_2: RDN + 35 kg P + 30 kg K ha^{-1}	15.3	5.8	98.6	8.84	1105.0
T_3: RDN + 35 kg P + 60 kg K ha^{-1}	18.3	6.6	100.7	10.64	1330.0
T_4: RDN + 35 kg P + 90 kg K ha^{-1}	19.5	6.9	101.8	11.02	1377.5
T_5: RDN + 70 kg P + 30 kg K ha^{-1}	21.4	7.5	105.2	12.23	1528.4
T_6: RDN + 70 kg P + 60 kg K ha^{-1}	22.8	8.2	107.6	13.68	1710.0
T_7: RDN + 70 kg P + 90 kg K ha^{-1}	23.4	8.4	108.7	13.87	1733.8
T_8: RDN + 105 kg P + 30 kg K ha^{-1}	22.0	8.0	105.5	12.13	1516.0
T_9: RDN + 105 kg P + 60 kg K ha^{-1}	23.7	8.5	108.2	13.95	1718.8
T_{10}: RDN + 105 kg P + 90 kg K ha^{-1}	24.0	8.5	109.0	13.84	1743.4
SEm±	0.67	0.29	1.78	0.29	15.47
CD (*P=0.05*)	1.93	0.83	4.14	0.85	67.35

Field observations on nine horticultural traits *viz.*, plant height (cm), number of branches per plant, number of leaves per plant, primary root length (cm), number of nodules per plant, number of mature pods per plant, number of seeds per pod, test weight of seed (g), seed weight per plant (g) and seed yield (kg ha^{-1}) were recorded with standard methods. The pooled data were subjected to analysis of variance and critical difference at 5% level of probability for significance of treatments for comparing the means by the method as advocated by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The data recorded for different vegetative, root and yield attributing characters of French bean var. 'Contender', from both the first year as well as the repeat trial of second year, was analysed statistically and the compiled data is presented in Table 1 and Table 2. A perusal of the data indicated that all the vegetative, root and yield attributing characters of French bean responded significantly and positively to the graded application of phosphorus and potash along with nitrogen.

Vegetative and Root Characters:

The results (Table 1) revealed that every increment in rate of phosphorus and potash brought about marked increase in plant vegetative characters *viz*., plant height, number of branches per plant, number of leaves per plant, as well as root characters *viz*., primary root length and number of nodules per plant. The data revealed that increasing levels of phosphorus and potash improved all the plant vegetative characters at all the stages of crop growth. In the present study, the progressive beneficial effects of P and K have been observed upto 70 kg P + 60 kg K ha^{-1} only. Combined application of 70 kg P + 60 kg K ha^{-1} along with RDN (T_6) resulted in significantly higher plant height (40.8 cm), number of branches per plant (8.1), number of leaves per plant (13.7), primary root length (12.8 cm) and number of nodules per plant (10.0) over the control. The least values for the above vegetative characters were observed in control. Although, application of higher doses of phosphorus @ 105 kg ha^{-1} and potash @ 90 kg ha^{-1} recorded maximum values for these characters, but they were at par with 70 kg P + 60 kg K ha^{-1}. The higher doses of phosphorus and potash beyond 70 kg and 60 kg ha^{-1} respectively, did not result in any significant improvement in plant vegetative and root characters in the present experiment. The increased availability of other essential elements from the soil due to increased root proliferation and enhanced cell division and photosynthetic activity by the combined effect of phosphorus and potassium may be attributed for the increased vegetative growth of French bean plants in the present study. Increased vegetative growth in French bean due to the application of phosphorus and potash have also been recorded by Karim *et al*. (2020); Singh *et al*. (2018); Ali *et al*. (2015); Lad *et al*. (2014); Subhashree *et al*. (2011) and Arya *et al*., (1999).

Seed Characters and Yield:

The compiled data of both the years recorded on different seed characters of French bean is presented in Table 2. It could be noted from the data (Table 2) that a similar trend, as that of vegetative characters, was reflected in the improvement pattern in seed characters and seed yield also. That means, there was significant enhancement in all the seed characters and seed yield with successive increment in the levels of applied phosphorus from 35 kg to 70 kg ha^{-1} and potash from 30 kg to 60 kg ha^{-1}. The effects of higher doses of phosphorus and potash beyond this level were not significant. Application of RDN + 70 kg P + 60 kg K ha^{-1} (T_6) resulted in significantly higher number of mature pods per plant (22.8), number of seeds per pod (8.3), test weight of seed (107.6 g) and seed weight per plant (13.68 g), while the control treatment recorded the least values for the above seed characters. The above respective values of different seed characters increased marginally with higher doses of phosphorus and potash, but remained *at par* with

70 kg P and 60 kg K ha^{-1}, and hence the improvement was non-significant.

The seed yield of any crop is generally based on two important components *viz*., seed weight per plant and plant population per hectare. Further, the seed weight per plant is governed by number of pods per plant, number of seeds per pod and test weight of seed. The data on seed yield (Table 2) showed that application of RDN + 70 kg P + 60 kg K ha^{-1} (T_6) resulted in significantly higher seed yield (1710.0 kg ha^{-1}) over the control (993.8 kg ha^{-1}). The increment in seed yield was to the tune of 172% over the control. Although, the highest seed yield (1743.4 kg ha^{-1}) was obtained with RDN + 105 kg P + 90 kg K ha^{-1} (T_{10}), but the yield increment was non-significant.

The increment in seed yield was obvious because application of phosphorus and potash may have brought about overall nutritional improvement in the rhizosphere as well as in the plant system due to increased root proliferation and nodulation. Phosphorus and potassium is important for greater photosynthesis efficiency and production of assimilates and their efficient portioning into seeds. In a seed crop, phosphorus has greater role to play as it is reported to improve fruiting and increasing the number and size of seed grains; therefore, it directly affects seed quality and quantity. Thus, plants well supplied with adequate quantities of phosphorus and potassium are expected to have efficient photosynthetic mechanism and are better equipped for efficient translocation to sink site, consequently resulting into increased seed yield. Improvement in seed characters and seed yield in French bean with phosphorus and potash application has also been reported by Karim *et al*. (2020); Singh *et al*. (2018); Ali *et al*. (2015); Lad *et al*. (2014); Subhashree *et al*. (2011); Joshi *et al*. (2003); Arya *et al*., (1999) and Kanaujia *et al*. (1999).

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