Original Research Article

Effect of Phosphorous and Boron on Growth and Yield of Rice Bean

ABSTRACT

A field experiment was titled “Effect of Phosphorus and Boron on Growth and Yield of Rice Bean” conducted during *Zaid* season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of Phosphorus and Boron on growth and yield of Rice Bean. The treatments consist of Phosphorus 20, 40, 60 kg/ha and Boron (Borax 0.01% 20 DAS, Borax 0.02% 40 DAS, and Borax 0.03% 60 DAS). The experiment was laid down in Randomized Block Design with ten treatments which are replicated thrice. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%). Results obtained that the higher plant height (106.90 cm), higher number of nodules (30.94), higher number of branches (8.84) higher plant dry weight (49.25 g/plant), higher number of pods/plant (26.25), higher number of seeds/pod (7.19), higher 1000 seed weight (58.19 g), higher seed yield (2.10 t/ha) and higher stover yield (4.66 t/ha)were significantly influenced with application of Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS. Higher grossreturn (INR 1,15,500.00 /ha), higher net return (INR 84,155.70/ha) and higher B:C ratio (2.68) were also recorded in treatment-9 (Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS).

Keywords: *Rice Bean, Zaid, Phosphorus, Boron, Growth parameters, Yield, Economics.*

INTRODUCTION

Rice Bean [*Vigna umbellata* (Thumb) Ohwi and Ohashi Syn. *phaseolus calcaratus* Rosb] also known as Climbing Mountain Bean, Mambi Bean, Oriental Bean and Bamboo Bean is a native of south and south east Asia. Countries which grow rice bean include India, Burma, Malaysia, Korea, China, Indonesia and Philippines. Rice bean is now also grown in Fiji, Mauritius, Queensland and East Africa for fodder, green manure, cover crop and food **Thomas *et al.* (1983)**.

Rice Bean belongs to the family Fabaceae, similar to other vigna species. Worldwide the seed yield of rice bean is about 2,250 kg/ha. It is1,300-2,750 kg/ha in Zambia, Brazil and

India. In India, fodder yield was reported to range from 5-7 t DM/ha in May and June and 8-9 t DM /ha in November and December **Singh *et al.* (2020).**

Rice bean is adapted to high temperature and humidity as well as to heavy soils. Like many other legumes it has a capacity of nodulation for biological nitrogen fixation and fits in rice bean wheat (late) rotation in Punjab. It has been reported that this species in completely free from yellow mosaic virus which takes heavy toll of other Vintage species. Its seeds are also free from serious insect Bruchids **Singh *et al.* (1980)**. Several strains of rice bean exhibit photo-thermo-sensitivity in terms of flowering and reproduction. The germination in rice bean is epigeal and generally excellent under field conditions and possess good synchrony in pod maturity in its cultivars, which is of considerable importance and significance in comparison with all other Asian Vigna species (Mung, Urad and Moth bean); lack of synchrony is an important breeding problem and harvesting/picking of pods is a labor-intensive operation.

As a legume crop, it is effective in Nitrogen fixation in the soils, thus improve the soil fertility that has a positive effect in increasing the production of followed crops. Rice bean offers good scope for increasing pulse production. In addition, it is also a valuable fodder crop. In this sense, cultivation of rice bean is considered to be important in contributing towards food and nutritional security and utilize uncultivated marginal land **Gautam (2007).**

Though conventional pulses are being grown in India, the production has not been able to meet the entire demand due to various reasons. Hence, there is a growing need of grain legumes to meet the protein requirements of predominantly vegetarian country like India. In this context, the domestication of under-utilized and under exploited pulses like rice bean which is of better nutritional quality would be a better alternative to meet the nutritional requirements of the existing population. Boron is very important in cell division and in pod and seed formation **(Vitosh *et al.* 1997).** Reproductive growth, especially flowering, fruit and seed set is more sensitive to B deficiency than vegetative growth **(Noppakoonwong *et al.* 1997).** Boron influences the absorption of N, P, K and its deficiency changed the equilibrium of optimum of those three macronutrients. The N and B concentrations of grain for Rice bean were markedly influenced by B treatment indicating that the B had a positive role on protein synthesis **(Iqtidar and Rahman, 1984)** found that essential amino acid increased with increasing B supply. Therefore, applications of micronutrients in addition to essential major elements have gained practical significance.

It is primarily needed to maintain the growth of apical growing point. Boron is important in reproductive growth, especially flowering, fruit and seed set is more sensitive to B deficiency than vegetative growth. Boron influences the absorption of N, P, K nutrients. Micronutrients like boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development **Ahmad *et al.* (2009)**.

Considering the facts and to bridge the research gap highlighted above, the present experiment entitled**, "Effect of phosphorus and boron on growth and yield of Rice Bean"**, was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Zaid* 2023.

Materials and Methods

At the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, the experiment was carried out during Rabi of 2022. Ten treatments, each replicated three times, were used in the experiment's Randomised Block Design. Each treatment's plot was 3m by 3m. The treatments consist of Phosphorus 20, 40, 60 kg/ha and Boron (Borax 0.01% 20 DAS, Borax 0.02% 40 DAS, and Borax 0.03% 60 DAS) are contributing factors. At the time of sowing, N, P and Zn were supplied, and three are used as basal. On March 26, 2023, the Rice bean variety was sowed with a 30 cm 15 cm spacing. All agronomical operations kept accordingly and each plot's 1 m^2 was used for harvesting. And five plants were randomly chosen from it for the purpose of observing the yield and growth metrics. Here are the specifics of the treatment:

T_1 - Phosphorus 20 kg/ha + Boron 0.01 % at 20 DAS, T_2 - Phosphorus 20 kg/ha + Boron 0.02 % at 40 DAS, T_3 - Phosphorus 20 kg/ha + Boron 0.03 % at 60 DAS, T_4 - Phosphorus 40 kg/ha + Boron 0.01 % at 20 DAS, T_5 - Phosphorus 40 kg/ha + Boron 0.02 % at 40 DAS,

T_6 -Phosphorus 40 kg/ha + Boron 0.03 % at 60 DAS, T_7 - Phosphorus 60 kg/ha + Boron 0.01 % at 20 DAS, T_8 - Phosphorus 40 kg/ha + Boron 0.02 % at 40 DAS, T_9 - Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS, T_{10} - N 20 Kg/ha + P 40 kg/ha +K 20 kg/ha. Plant height, nodules per plant, dry weight, grain production, and stover yield were all observed and reported. By using the analysis of variance approach, the data were statistically analysed **(Gomez and Gomez, 1976).**

Results and Discussion

Growth Parameters

Plant height – Treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS produced plants with a considerably higher height (106.90 cm) at 100 DAS. To be statistically comparable to treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS, treatment 8 Phosphorus 60 kg/ha + Boron 0.02% at 40 DAS was used.

With the application of phosphorus at a rate of 60 kg/ha, a noticeably greater plant height (106.90 cm) was seen. The application of phosphorus to the soil may have caused plants to grow significantly taller because it increased the crop's ability to access and absorb soil nutrients. Higher nutrient availability may have improved photosynthetic capacity and metabolite translocation to various regions, which eventually improved root and shoot growth of the crop. These results support those of **Yumnam *et al*. (2018).** A further explanation for the slow rise in plant height is that boron may have a role in a number of physiological processes, including the activation of enzymes, electron transport, chlorophyll synthesis, and stomatal control might be attributed to higher levels of chlorophyll synthesis and photosynthetic activity brought on by boron fertilisation, which in turn improved vegetative development. These observations support the conclusions reached by **Myageri and Dawson (2022)**.

Nodules/plant – The treatment with the highest number of nodules per plant (5.61) at 100 DAS was treatment 9 (phosphorus 60 kg/ha + boron 0.03% at 60 DAS). The statistical comparison between treatment 8 (Phosphorus 60 kg/ha + Boron 0.02% 40 DAS) and treatment 9 (Phosphorus 60 kg/ha + Boron 0.03% 60 DAS) was nonetheless statistically equal.

With the application of phosphorus at a rate of 60 kg/ha, a significant and higher number of nodules/plants were produced. According to **Patel *et al.* (2017)** in green gram phosphorus administration enhanced the number of nodules/plants. Furthermore, as a micronutrient, boron performs crucial roles as an electron transporter, a component of organic structures, an enzyme activator, and in osmoregulation. At various times during the nodule development and nodule function phases of the symbiotic association, micronutrients may also affect N_2 fixation in legumes and nonlegumes. Rhizobium-legume cell-surface interaction and pea nodule development are influenced by boron. **Bolanos *et al*. (1996),** among other things.

Number of branches/plant - At 100 DAS, treatment-9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS had the considerably more branches per plant (7.84). To be statistically comparable to treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS, treatment 8 Phosphorus 60 kg/ha + Boron 0.02% at 40 DAS was applied.

The significantly number of branches per plant (8.84) were observed with the application of Phosphorus 60 kg/ha. The significantly higher number of branches/plant were recorded with the application of phosphorus 50 kg/ha. This might be due to Phosphorus, being the constituent of nucleic acid and different forms of proteins, might have stimulated cell division resulting in increased growth of plants similar results reported by **(Niraj and Ved Prakash 2014),** and also**,** boron might be attributed to the favourable influence on plant metabolism and biological process activity and stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth. The results were in accordance with **Krishna *et al.* (2022).**

Dry weight/plant- Treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS had the considerably greater plant dry weight (49.25 g) at 100 DAS. Treatment 8 Phosphorus 60 kg/ha + Boron 0.02% at 40 DAS was statistically comparable to Treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS.

With the application of phosphorus, a significant and increased dry weight is seen. Increases in dry weight brought on by an improvement in photosynthetic capacity and the distribution of metabolites, which eventually led to an improvement in crop shoot growth, are consistent with the findings of **Unni and Debbarma (2022).** Furthermore, when the amount of boron grew, dry weight increased dramatically. Due to the fact that boron typically affects cell division and nitrogen uptake from the soil may promote plant development, which is reflected in terms of plant dry weight. **Naik *et al.* (2022)** also came to similar conclusions.

Crop Growth Rate (g/m^2/day) - At 60–80 DAS, treatment 9 Phosphorus 60 kg/ha + boron

0.03% at 60 DAS had a significantly higher crop growth rate (40.2 g/m^2/day); however, treatment 8 Phosphorus 60 kg/ha + boron 0.02% at 40 DAS, was discovered to be statistically equal to treatment 9 Phosphorus 60 kg/ha + boron 0.03% at 60 DAS. With the application of phosphorus at a rate of 60 kg/ha, a noticeably greater crop growth rate (40.2 g/m2/day) was seen. Phosphorus, an essential component of nucleic acid, ADP, and ATP, may be the cause of the rise in growth parameters. It increases agricultural produce quality, hastens maturity, and has positive impacts on nodulation, root development, growth, and other factors **Choudary *et al*. (2015).**

YIELD ATTRIBUTES:

Number of pods/plant- The significant and higher number of pods/plant (26.25) were observed in treatment-9 with Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS, which was significantly superior over rest of the treatments. However, treatment-8 Phosphorus 60 kg/ha + Boron 0.02 % at 40 DAS, was found to be statistically at par with treatment-9 Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS.

With 60 kg/ha of phosphorus, a considerable and increased number of pods per plant (30.25) were seen. It's because there was a superior supply of phosphorus, which led to higher photosynthetic activity, less premature flower and young pod loss, and eventually more pods per plant. **Malik *et al.* (2010)** findings back up these findings. Additionally, a plant can produce more pods per plant by using boron (2 kg/ha), which aids in the development of flowers and pollen grains. Similar results were found to be in agreement with **Padbhushan and Kumar (2014).**

Number of seeds/pod - Treatment 9 with Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS, which was much better than the other treatments, had a considerable and greater number of Seeds/pod (7.19). Although it was discovered that treatment-8 Phosphorus 60 kg/ha + Boron 0.02% at 40 DAS) was statistically equivalent to treatment-9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS, this was not the case.

The application of phosphorus at a rate of 60 kg/ha resulted in a considerable and increased number of Seeds/pod (7.19). The highest number of seeds or pods were produced in response to the application of phosphorus (60 kg/ha), which may be explained by the increased availability of other plant nutrients that promoted an increase in carbohydrate development and their re-mobilization to the closest sinks in the plant's reproductive parts. Since phosphorus is known to boost flowering and fruiting, this may have encouraged the plants to create more pods and allowed for higher plant growth, which in turn allowed for increased development of seed/pod numbers. **Shah *et al*. (2000)** reported the same outcomes. Boron's important function in plant metabolism and the creation of nucleic acids may be the cause of its beneficial effects. Similar results were found in **Kumar *et al*., (2013)** conformance study.

Test Weight (g) - The significant and higher test weight (58.19 gm) was observed in treatment-9 with Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS, which was significantly superior over rest of thetreatments. However, treatment-8 Phosphorus 60 kg/ha + Boron 0.02 % at 40 DAS, was found to be statistically at par with treatment-9 Phosphorus 60 kg/ha + Boron 0.03 % at 60 DAS.

With the application of phosphorus at a rate of 60 kg/ha, a substantial and higher test weight (58.19 gm) was seen. The increase in test weight associated with phosphorus application (60 kg/ha) may be due to a boost in the symbiotic nitrogen fixation capacity, which in turn causes an increase in the number of plants, the length of pods, the number of grains per pod, the test weight, and eventually grain production. **Parashar *et al.* (2020**) reported a comparable result.

Seed Yield (t/ha) - Treatment 9 with Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS had the highest and considerably greater seed yield (2.02 t/ha), and it outperformed the other treatments by a wide margin. Treatment 8 Phosphorus 60 kg/ha + Boron 0.02% at 40 DAS, however, was shown to be statistically equivalent to treatment 9 Phosphorus 60 kg/ha + Boron 0.03% at 60 DAS.

With the application of Phosphorus at a rate of 60 kg/ha, a considerable and greater seed production (2.10 t/ha) was noted. According to the number of pods/plant and number of seeds/pod, phosphorus may be accountable for the crop's improved development and yield-attributing qualities through higher photosynthesis and assimilate translocation to various plant sections. The extra assimilates that were first held in the leaves were later transferred to sink development, which eventually helped to increase seed output. The most effective boron application method was determined as soil + foliar boron application but other application methods were more effective than control applications which influenced floral development which led to higher pod setting **Oktem (2022). Yumna *et al*. (2018).** Furthermore, boosting seed output may be caused by the application of boron (2 kg/ha). It plays a crucial role in doing so since phosphorous and boron are involved in many physiological processes of plants, including chlorophyll synthesis, stomatal control, and starch utilisation, all of which increase seed yield. In addition to being essential for numerous physiological processes and plant growth, nutrition is also important for boosting crop yields and quality. These findings corroborate the findings of **Naik *et al*. (2022)** research.

Stover Yield (t/ha) - Treatment 9 with (Phosphorus 60 kg/ha + Boron 0.03% 60 DAS), which was much better than the other treatments, had a considerable and higher stover yield (4.66 t/ha). Although it was discovered that treatment-8 (Phosphorus 60 kg/ha + Boron 0.02% 40 DAS) was statistically equivalent to treatment-9 (Phosphorus 60 kg/ha + Boron 0.03% 60 DAS), this was not the case. With the application of phosphorus (60kg/ha), a significant and greater production of stover was seen. Plants have grown and developed more in terms of height, branches, and dry matter, possibly as a result of the enhanced nutritional environment of the rhizosphere and plant system, which led to greater plant metabolism and photosynthetic activity. Yadav and others, 2017. The improved dry matter yield of straw may be responsible for the additional increase in stover yield. B plays a role in stabilising specific components of cell walls and plasma membranes, promoting cell division, tissue differentiation, and metabolism of nucleic acids, carbohydrates, proteins, auxins, and phenols. According to **Padbhushan and Kumar (2014),** similar results were obtained.

ECONOMIC ANALYSIS:

Economics- The result revealed that Maximum gross return (1,15,500.00 INR/ha), Maximum net return (84,155.70 INR/ha) and highest benefit-cost ratio (2.68) was recorded in treatment-9 (Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS) as compared to other treatments (Table-3). Higher gross Return, net return and benefit cost ratio was recorded with the application of (Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS) it might be due to the higher growth and yield attributes resulting in more seed and stover yield with the recommended dose of Phosphorus and Boron.

CONCLUSION

Based on the mentioned results, it can be stated that Boron 0.03 % 60 DAS combined with Phosphorus applied at a rate of 60 kg per hectare, have improved growth metrics and yield characteristics while also being economically viable.

Table 1. Influence of Phosphorus and Boron on growth parameters of Rice Bean.

S. No.	Treatments	Plant height (cm)	Number of nodules/plants	Number of branches	Plant Dry weight (g)	Crop growth rate (g/m^2/day)
1.	Phosphorus 20 kg/ha + Boron 0.01 % 20 DAS	87.59	4.11	5.48	39.68	35.73
2.	Phosphorus 20 kg/ha + Boron 0.02 % 40 DAS	89.20	4.22	5.71	42.14	35.63
3.	Phosphorus 20 kg/ha + Boron 0.03 % 60 DAS	91.53	4.80	6.07	42.84	36.68
4.	Phosphorus 40 kg/ha + Boron 0.01 % 20 DAS	93.75	4.69	6.35	43.91	36.36
5.	Phosphorus 40 kg/ha + Boron 0.02 % 40 DAS	98.31	4.79	6.77	45.02	36.35
6.	Phosphorus 40 kg/ha + Boron 0.03 % 60 DAS	98.87	5.04	6.75	45.40	36.34
7.	Phosphorus 60 kg/ha + Boron 0.01 % 20 DAS	101.08	5.11	7.11	46.51	37.20
8.	Phosphorus 60 kg/ha + Boron 0.02 % 40 DAS	105.05	5.27	6.94	47.84	39.60
9.	Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS	106.90	5.61	7.84	49.25	40.15
10.	Control (RDF 20:40:20 NPK kg/ha)	87.56	4.66	4.98	38.76	35.75
	F test	S	S	S	S	S
	S Em.(±)	0.63	0.20	0.26	0.68	0.93
	CD (p=0.05)	1.87	0.59	0.84	2.03	2.67

Table 2. Influence of Phosphorus and Boron on yield attributes of Rice Bean.

S. No.	Treatments	Pods/plants	Seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Phosphorus 20 kg/ha + Boron 0.01 % 20 DAS	20.01	5.69	47.18	1.12	3.36	28.90
2.	Phosphorus 20 kg/ha + Boron 0.02 % 40 DAS	21.47	6.07	47.84	1.31	3.85	28.02
3.	Phosphorus 20 kg/ha + Boron 0.03 % 60 DAS	23.17	6.34	49.25	1.41	4.09	28.04
4.	Phosphorus 40 kg/ha + Boron 0.01 % 20 DAS	21.58	6.21	48.21	1.59	4.19	27.86
5.	Phosphorus 40 kg/ha + Boron 0.02 % 40 DAS	22.69	6.75	51.75	1.67	4.29	28.53
6.	Phosphorus 40 kg/ha + Boron 0.03 % 60 DAS	24.06	7.03	54.03	1.77	4.43	28.86
7.	Phosphorus 60 kg/ha + Boron 0.01 % 20 DAS	22.84	6.78	53.11	1.81	4.52	27.91
8.	Phosphorus 60 kg/ha + Boron 0.02 % 40 DAS	24.74	6.91	56.91	1.97	4.52	29.78
9.	Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS	26.25	7.19	58.19	2.10	4.66	30.18
10.	Control (RDF 20:40:20 NPK kg/ha)	22.43	26.43	46.76	1.30	3.83	27.09
	F-Test	S	S	S	S	S	N S
	S Em±	0.54	0.20	0.59	0.03	0.18	0.99
	CD (P=0.05)	1.62	0.60	1.74	0.08	0.54	---

Table 3. Influence of Phosphorus and Boron on Economics of Rice Bean.

S. No.	Treatments	Cost of cultivatio (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1.	Phosphorus 20 kg/ha + Boron 0.01 % 20 DAS	27,137.40	61,600.00	34,462.60	1.27
2.	Phosphorus 20 kg/ha + Boron 0.02 % 40 DAS	28,137.40	72,050.00	43,912.60	1.56
3.	Phosphorus 20 kg/ha + Boron 0.03 % 60 DAS	29,137.40	77,550.00	48,412.60	1.66
4.	Phosphorus 40 kg/ha + Boron 0.01 % 20 DAS	28,240.80	87,450.00	59,209.20	2.10
5.	Phosphorus 40 kg/ha + Boron 0.02 % 40 DAS	29,240.80	91,850.00	62,609.20	2.14
6.	Phosphorus 40 kg/ha + Boron 0.03 % 60 DAS	30,240.80	97,350.00	67,109.20	2.22
7.	Phosphorus 60 kg/ha + Boron 0.01 % 20 DAS	29,344.30	99,550.00	70,205.70	2.39
8.	Phosphorus 60 kg/ha + Boron 0.02 % 40 DAS	30,344.30	1,08,350.00	78,005.70	2.57
9.	Phosphorus 60 kg/ha + Boron 0.03 % 60 DAS	31,344.30	1,15,500.00	84,155.70	2.68
10.	Control (RDF 20:40:20 NPK kg/ha)	27,240.80	71,500.00	44,259.20	1.62

*** Data was not subjected to the statistical analysis**

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