**Short Research Article**

# Effect of planting geometry and nutrient management on yield, economics and quality of dwarf rice bean (*Vigna umbellata*) under rainfed condition


## ABSTRACT

Rice bean (*Vigna umbellata*) is one of the under-utilized crops which can become a promising pulse crop. A field experiment was conducted during *kharif* season of 2020 at Research Farm, College of Agriculture, Central Agricultural University, Imphal to study the effect of planting geometry and nutrient management on yield, economics and quality of dwarf rice bean under rainfed condition. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. Results indicate that planting geometry at 60 cm × 10 cm ($S_3$) and nutrient management ($F_3$) *i.e.* 60 kg $P_2O_5$/ha with seed treatment of molybdenum + phosphate solubilizing bacteria (PSB) recorded significantly influenced the yield and quality of dwarf rice bean and gave the maximum gross return, net return and B:C ratio. It can be inferred that integration of nutrient management i.e. phosphatic fertilizer with molybdenum and phosphate solubilizing bacteria ($F_3$) coupled with higher planting geometry ($S_3$) *i.e.* 60 cm × 10 cm significantly influenced the yield and quality of dwarf rice bean.



*Keywords*: *Rice bean, planting geometry, nutrient management, yield, quality*


## Introduction

Pulses play a vital part in Indian agriculture. India is a leading pulse growing country and forms an essential part of cropping system of the farmers around the country. The present average per capita consumption of pulses in India was 14 kg per year against the WHO recommendation of 20 kg per year. India with 28 Mha of pulses cultivation area with the annual productivity at 885 kg/ha, has also increased significantly over last 05 year (GOI, 2022). Pulses have the capacity to fix the soil atmospheric nitrogen in their root system, which enables the plants to meet the nitrogen requirement on its own. They are known to render significant impact on soil health and considered to be key component for sustainable agriculture (Laishram *et al.*, 2020). By 2050, the domestic requirements for pulse would be 26.50 M tons, necessitating stepping up production by 81.50%, *i.e.*, 11.9 million tons additional produce at 1.86 % annual growth rates (Singh *et al.*, 2015). Thus, there is need to increase the production and productivity of pulses in the country by more intensive interventions.

Rice bean (*Vigna umbellate)* is one of the under-utilized pulse crops which can become a promising pulse crop. This crop is a native of South and South East Asia from the Himalayas to South China and Indonesia (Chandel and Pant, 1982). In India, as cultigens, rice bean is mainly confined to the tribal regions of the North Eastern Hills, Western and Eastern Ghats in peninsular India (Arora *et al.,* 1980). In the North Eastern Region and also in the hilly regions of both North Bengal and Sikkim, rice bean is grown predominantly under rain fed condition in a mixed farming system, under shifting cultivation or in kitchen gardens and backyards. Despite being a crop that is thought to be underutilised, rice beans are valued for their high nutritional content in Manipur.

Planting geometry and nutrient management are of immense significance which is to be managed properly for higher rice bean production. Inappropriate planting times, high population density, and spatial configuration are some of the major causes of low production (Devi, 2021). Apart from non-existence of economically rational and socially optimum cropping pattern and crop diversification; biotic factors play major role in limiting rice bean production in rain-fed agriculture. Plant geometry plays an important role in the dominance and suppression during the process of competition. Ideal plant geometry is precious and important for better and efficient utilization of available plant growth resources in order to get maximum productivity in crops (Rana, 2011). Increase in yield can be ensured by maintaining appropriate plant population through different planting patterns. The influence of spacing on yield and quality of rice bean is still lacking in most of the rice bean growing areas in our country.

The North Eastern India has more than 80% hilly area of pH less than 5.5 with acid in nature and poor availability of P, Mo, Ca and Mg as well as the toxicity of Al, Fe, and Mn has been blamed for the soil's low productivity. Phosphorus serves a master nutrient for legume crop; it is involved in several plant functions, including energy storage and transfer, photosynthesis, transformation of sugars and starches, etc. Phosphorus application in rice bean promotes seed yield and dry matter production by enhancing root proliferation and nodulation. Yet, in acidic soil conditions, phosphorus is one of the main minerals that are limited for leguminous crops. Molybdenum a trace element found in the soil is required for growth of most biological organisms including plants (Agarwala *et al.,* 1978). Phosphate solubilizing bacteria (PSB) play fundamental roles in biogeochemical phosphorus cycling in agro-ecosystems. It mobilize insoluble form of phosphorus in the rhizosphere into available form. And hence, application of such naturally occurring organic inputs as a whole improved the soil support system and ensured nutrient availability which was ultimately reflected in yield performance of the crop (Zaidi *et al.,* 2017). Keeping the above points in view, a field experiment was conducted to find out suitable planting geometry and nutrient management practices to assess their effect on yield and quality and economics of growing dwarf rice bean under rainfed condition.

## 1. Materials and Methods

A field experiment was conducted during *kharif* season of 2020 at Research Farm, College of Agriculture, Central Agricultural University, Imphal to study the effect of planting geometry and nutrient management on yield, quality and economics of dwarf rice bean (*Vigna umbellata*) under rainfed condition. The experimental site is located at 24.45˚N latitude and 93.56˚E longitudes at an elevation of 790 m above mean sea level. The soil of the experimental site was acidic with pH 5.1, available nitrogen 231.03 kg/ha, available phosphorous 10.95 kg/ha, available potash 150.00 kg/ha, available molybdenum 0.025 mg/kg and organic carbon 1.8 %. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications consisting of three planting geometry treatments *viz.* ($S_1$: 30 cm × 10 cm, $S_2$: 45 cm × 10 cm and $S_3$: 60 cm × 10 cm) and four nutrient management treatments *viz.* ($F_0$: Seed treatment with molybdenum + PSB; $F_1$: 20 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB; $F_2$: 40 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB and $F_3$: 60 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB). The total rainfall received during the crop season was 977.1 mm.

The land was properly prepared by tractor driven cultivator and leveller. Adequate drainage channels were made in the field to drain the excess water as and when required. A uniform dose of 20 kg N/ha through urea and 20 kg $K_2O$/ha through muriate of potash was applied to all the plots. Phosphorus was applied as per treatments through single superphosphate. The required quantity of different fertilizers as per treatments weighted separately and mixed together. After this, all fertilizers of each plot were applied in the rows at the time of sowing nearly 2 cm below the seed.

The rice bean variety used was a local variety and were treated with the mixture of 0.2% sodium molybdate per kg of seed just before sowing and 20 ml of phosphate solubilizing bacteria (PSB) per kg of seed as per treatment. Sowing was done manually using 15 kg seeds/ha in the rows. The crop was infested with several weed species during early growth stage; hence, one hand weeding was done manually in all plots with the help of khurpi at 20 days after sowing (DAS). One spray of Emamectin benzoate 5 % (Proclaim) @ 1 liter/ha was given as a preventive measure at 30 DAS to control aphids and leafhoppers during early vegetative stage. Plant protection measures were provided as and when required.

The crude protein content was determined by multiplying percentage of nitrogen content in seed of rice bean with a factor of 6.25 (Piper, 1966).

- Crude protein % = Nitrogen % x 6.25

The crude protein yield in q/ha under a particular treatment was calculated by multiplying crude protein content with dry matter yield (q/ha) of the respective treatments

- Crude protein yield (kg/ha) $= \frac{\text{Crude protein content (\%) x seed yield (q/ha)}}{100}$

The economics of the experiment was worked out from the cost of inputs and income from the seed yield. The gross and net returns as well as the cost benefit ratio were worked out by using the formulae:

- Gross returns (Rs/ha) = Cost of seed yield of ricebean
- Net returns (Rs/ha) = Gross returns – total cost of cultivation
- Cost bene it ratio $= \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$

All the data obtained were statistically analyzed by the method of analysis of variance to test the significance of the treatment effects as well as result interpretation as given by Gomez and Gomez (1984).

## 2. Results and Discussion

### *Effect of planting geometry and nutrient management on yield (q/ha) of dwarf rice bean*

Perusal of data revealed that the effect of planting geometry and nutrient management significantly influenced the seed yield and stover yield of rice bean (Table 1). Increasing the planting geometry upto 60 cm × 10 cm ($S_3$) gave the highest seed yield (14.66 q/ha), stover yield (89.71 q/ha) and harvest index (33.12%). Planting geometry ($S_1$) *i.e.* 30 cm × 10 cm gave the lowest yield. This might be ascribed to less inter-plant competition and better availability of growth resources, such as light, moisture, nutrients, and space for one another in broader planting geometry, which had improved yield-attributing features and ultimately raised the yield of rice bean. These results are in conformity with the findings of Goud *et al.* (2016) and Ramanjaneyulu *et al.* (2017). Among the different nutrient management practices,

| Treatments | Seed yield (q/ha) | Stover yield (q/ha) | Harvest index (%) | Gross return (Rs/ha) | Net return (Rs/ha) | B:C |
|---|---|---|---|---|---|---|

the highest seed yield (16.01 q/ha), stover yield (105.18 q/ha) and harvest index (33.37%) were recorded in ($F_3$) *i.e.* 60 kg $P_2O_5$/ha + seed treatment with molybdenum+ PSB and it was found lowest in seed treatment with molybdenum + PSB ($F_0$). Such increase in yield might be due to the increase in vegetative growth with the increasing doses of phosphorus. This result is in agreement with those reported by Bhuiyan *et al.* (2016) and Nissa *et al.* (2017).

Integration of phosphatic fertilizer with molybdenum and phosphate solubilizing bacteria significantly influenced the seed yield and stover yield of rice bean. The treatment combination ($S_3F_3$) *i.e.* 60 cm x 10 cm and 60 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB gave the highest seed yield (17.10 q/ha), stover yield (105.84 q/ha) and harvest index (37.70%) while the least was observed in treatment combination of 30 cm x 10 cm and seed treatment with molybdenum + PSB ($S_1F_0$). Such increase in the yield with the application of phosphorus is obvious due to acidic condition of the soil where the availability of phosphorus was limiting and in the medium range. Further, the seed treatment with molybdenum might have enhanced the nitrogen fixation resulting in better growth and yield. The optimum activities of phosphate solubilizing bacteria also increase the availability of phosphorus to the plant which ultimately increases the yield of rice bean. These findings are in line with those obtained by Yadav and Yadav (2011) and Manohar (2014).

***Effect of planting geometry and nutrient management on economics (Rs/ha) of dwarf rice bean***

The data presented in (Table 1) revealed that the planting geometry ($S_3$) *i.e.* 60 cm × 10 cm gave the maximum gross return (117240 Rs/ha), net return (71335 Rs/ha) and B:C (2.55). The lowest was for the planting geometry ($S_1$) *i.e.* 30 cm × 10 cm. Among the different nutrient management practices, the maximum gross return (128054 Rs/ha), net return (80877 Rs/ha) and B:C (2.72) was found in ($F_3$) *i.e.* 60 kg $P_2O_5$/ha + seed treatment with molybdenum+ PSB and it was found lowest in seed treatment with molybdenum + PSB ($F_0$).

| | | | | | | |
|---|---|---|---|---|---|---|
| **Planting geometry** | | | | | | |
| 30 cm × 10 cm ($S_1$) | 13.39 | 78.81 | 29.11 | 106960 | 60305 | 2.29 |
| 45 cm × 10 cm ($S_2$) | 14.07 | 83.72 | 31.81 | 112320 | 66165 | 2.45 |
| 60 cm × 10 cm ($S_3$) | 14.66 | 89.71 | 33.12 | 117240 | 71335 | 2.55 |
| S. Em (±) | 0.29 | 2.55 | 0.73 | - | - | - |
| C.D. (*P* = 0.05) | 0.60 | 5.29 | 1.51 | - | - | - |
| **Nutrient management** | | | | | | |
| Seed treatment with molybdenum + PSB ($F_0$) | 11.71 | 65.91 | 28.91 | 93360 | 48058 | 2.07 |
| 20 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_1$) | 12.71 | 75.45 | 29.31 | 101654 | 55728 | 2.22 |
| 40 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_2$) | 15.71 | 89.79 | 33.80 | 125627 | 79076 | 2.70 |
| 60 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_3$) | 16.01 | 105.18 | 33.37 | 128054 | 80877 | 2.72 |
| S. Em (±) | 0.33 | 2.94 | 0.84 | - | - | - |
| C.D. (*P* = 0.05) | 0.688 | 6.10 | 1.75 | - | - | - |
| **Interaction (Planting geometry ×Nutrient management)** | | | | | | |
| $S_1F_0$ | 11.27 | 59.83 | 28.06 | 90080 | 44361 | 1.9 |
| $S_1F_1$ | 12.65 | 74.07 | 28.62 | 101120 | 54777 | 2.1 |
| $S_1F_2$ | 14.19 | 76.92 | 29.62 | 113440 | 66472 | 2.4 |
| $S_1F_3$ | 15.41 | 104.42 | 30.13 | 123200 | 75607 | 2.5 |
| $S_2F_0$ | 11.53 | 64.10 | 29.30 | 91440 | 45721 | 2.0 |
| $S_2F_1$ | 12.67 | 75.78 | 30.02 | 101280 | 54937 | 2.1 |
| $S_2F_2$ | 16.55 | 89.74 | 35.65 | 132400 | 85432 | 2.8 |
| $S_2F_3$ | 15.53 | 105.27 | 32.29 | 124160 | 76567 | 2.6 |
| $S_3F_0$ | 12.32 | 73.79 | 29.36 | 98560 | 52841 | 2.1 |
| $S_3F_1$ | 12.82 | 76.50 | 29.29 | 102560 | 56217 | 2.2 |
| $S_3F_2$ | 16.38 | 102.71 | 36.13 | 131040 | 84072 | 2.7 |
| $S_3F_3$ | 17.10 | 105.84 | 37.70 | 136800 | 89207 | 2.8 |
| S. Em (±) | 0.57 | 5.10 | 1.46 | - | - | - |
| C.D. (*P* = 0.05) | 1.19 | 10.58 | 3.03 | - | - | - |

**Table 1. Effect of planting geometry and nutrient management on yield and economics of dwarf rice bean**

The treatment combination ($S_3F_3$) *i.e.* 60 cm x 10 cm and 60 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB gave the maximum gross return (136800 Rs/ha), net return (89207 Rs/ha) and benefit cost ratio (2.8) while the least was observed in treatment combination of 30 cm × 10 cm and seed treatment with molybdenum + PSB ($S_1F_0$). The increase in net return might be due to increase in yield of dwarf rice bean and relatively low production cost per unit of yield under the treatment. The higher benefit cost ratio in treatments $S_3$ and $F_3$ (*i.e.* 60 cm × 10 cm and 60 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB) might be due to the higher gross and net return with comparative lower cost of cultivation in compare with other treatments. The result is in conformity with the findings of Rajeshkumar *et al.* (2017) and Vikram *et al.* (2018).

***Effect of planting geometry and nutrient management on quality of dwarf rice bean***

The effect of planting geometry and nutrient management significantly influenced the crude protein content and protein yield of rice bean (Table 2). Increasing the planting geometry upto 60 cm × 10 cm ($S_3$) gave the highest crude protein content (20.32%) and protein yield (42.56 kg/ha) of rice bean. It was found lowest in planting geometry 30 cm × 10 cm ($S_1$). Wider spacing has less plant population than the narrow spacing so the nutrient content in seed is more in the wider spacing as there is less competition among the plants. This result is in conformity with the findings of Rath *et al.* (1997).

Among the nutrient management practices, the highest crude protein content (21.67%) and crude protein yield (49.77 kg/ha) were recorded in 60 kg $P_2O_5$/ha + seed treatment with molybdenum+ PSB ($F_3$) and it was found lowest in seed treatment with molybdenum + PSB ($F_0$). The higher protein content in this treatment may be due to adequate availability of phosphorus besides the contribution from the phosphate solubilizing bacteria which play a major role in protein synthesis. This observation was supported by the findings of Singha and Sarma (2001) and Gupta *et al.* (2012).

Integration of phosphatic fertilizer with molybdenum and phosphate solubilizing bacteria significantly influenced the crude protein content and crude protein yield of rice bean. The treatment combination ($S_3F_3$) *i.e.* 60 cm × 10 cm and 60 kg $P_2O_5$/ha + seed treatment with molybdenum + PSB gave the highest crude protein content (23.26%) and crude protein yield (48.80 kg/ha) while the least was observed in treatment combination of 30 cm × 10 cm and seed treatment with molybdenum + PSB ($S_1F_0$). The results are in agreement with the finding of Gupta *et al.* (2012).

On the basis of findings, it was concluded that a wider crop spacing of 60 cm × 10 cm along with a higher dose of phosphorus 60 kg $P_20_5$/ha application with seed treatment of molybdenum + phospate solubilizing bacteria (PSB) proved to be superior over narrow spacing and low dose phosphorus application by giving best results in terms of yield, economics and quality of growing dwarf rice bean under rainfed conditions of Manipur.

**Table 2. Effect of planting geometry and nutrient management on yield of rice bean**

| Treatments | Crude protein content (%) | Crude protein yield (kg/ha) |
|---|---|---|
| **Planting geometry** | | |
| 30 cm × 10 cm ($S_1$) | 19.32 | 36.58 |
| 45 cm × 10 cm ($S_2$) | 19.91 | 41.87 |
| 60 cm × 10 cm ($S_3$) | 20.32 | 42.56 |
| S. Em (±) | 0.35 | 1.23 |
| C.D. ($P$ = 0.05) | 0.72 | 2.54 |
| **Nutrient management** | | |
| Seed treatment with molybdenum + PSB ($F_0$) | 17.61 | 27.53 |
| 20 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_1$) | 18.92 | 35.35 |
| 40 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_2$) | 21.20 | 48.69 |
| 60 kg P2O5 /ha + seed treatment with molybdenum+ PSB ($F_3$) | 21.67 | 49.77 |
| S. Em (±) | 0.40 | 1.42 |
| C.D. ($P$ = 0.05) | 0.84 | 2.93 |
| **Interaction (Planting geometry ×Nutrient management)** | | |
| $S_1F_0$ | 17.44 | 24.00 |
| $S_1F_1$ | 18.65 | 30.78 |
| $S_1F_2$ | 20.19 | 44.77 |
| $S_1F_3$ | 20.99 | 46.75 |
| $S_2F_0$ | 17.43 | 24.79 |
| $S_2F_1$ | 19.28 | 37.79 |
| $S_2F_2$ | 22.16 | 51.15 |
| $S_2F_3$ | 20.77 | 53.76 |
| $S_3F_0$ | 17.94 | 33.81 |
| $S_3F_1$ | 18.82 | 37.49 |
| $S_3F_2$ | 21.25 | 50.15 |
| $S_3F_3$ | 23.26 | 48.80 |
| S. Em (±) | 0.70 | 2.45 |
| C.D. ($P$ = 0.05) | 1.45 | 5.08 |



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