



Effect of Spacing and Levels of Phosphorus on the Growth and Yield of Green Gram (*Vigna radiata*) under Rainfed Condition of Nagaland

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ABSTRACT

The field experiment conducted in the experimental farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University during *kharif* season (June- September) of 2016 revealed that spacing at 30 x 10 cm recorded significantly the higher plant height (48.10 cm), number of leaves (5.47), shoot dry weight (2.88 g plant⁻¹), LAI (2.88) and yield attributes such as number of pods plant⁻¹ (17.00), length of pods (6.81 cm), seed yield (688.54 kg ha⁻¹) and stover yield (1917.81 kg ha⁻¹) respectively. Application of phosphorus at 40 kg ha⁻¹ recorded significantly the higher plant height (49.37 cm), number of leaves (5.73), shoot dry weight (3.34 g plant⁻¹), LAI (3.34), CGR (6.37 g m⁻² day⁻¹) and yield attributes such as number of pods plant⁻¹ (17.56), length of pods (6.91 cm), seed yield (737.42 kg ha⁻¹) and stover yield (1973.01 kg ha⁻¹) respectively.

Key words: Crop growth, Phosphorus, Soil nutrient status, Spacing, Yield attributes.

INTRODUCTION

Green gram or mungbean [*Vigna radiata* (L.) Wilczek] is one of the important pulse crops in India. It is becoming an important crop, as it is the best alternative to meet the food needs of the large population of developing countries due to its nutritional superiority and nitrogen fixing characters (Raza *et al.*, 2012). India is the largest producer and consumer of green gram in the world. India alone accounts for 65% of the world acreage and 54% of the world production. During 2017-2018, 1.9 Mt of mungbean was produced from 4.07 Mha area (DES, 2018) distributed over different seasons.

During the year 2016-2017, the area and production of green gram in Nagaland was only 450 ha and 460 Mt respectively (Directorate of Economics and Statistics, 2017). This low yield is attributed to several reasons *viz*, cultivated as rain fed crops, as intercrops in marginal lands, poor management practices and low yield potential of varieties. Nutrient and weed management practices play a major role in realizing the potential of a given variety along with other contributing factors. One of the most important factors in influencing the green gram yield is correct spacing. Spacing relates to both the distance between seeds or plants and the distance between rows or hills of plants. Improper spacing reduced the yield of green gram up to 20-40% (ACRDC, 1974) due to competition for light, space, water and nutrition. On the other hand, adequate spacing ensures less competition for sunlight, space, water and nutrition and gives a greater yield under favourable moisture conditions. The optimum spacing favours the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients and thus increase grain yield (Miah *et al.*, 1990). The low productivity is also due to

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inadequate supply of nutrients, as most of the Indian soils are deficient in phosphorus. Farmers have the wrong notion that green gram being a leguminous crop does not need any nutrient and usually grow it on the marginal lands without applying any fertilizer. Contrary to the above notion, Hussain (1983) concluded that application of phosphorus to legumes improves seed yield considerably. Phosphorus is known to play an important role in growth and development of the crop and have direct relation with root proliferation and, straw strength, grain formation, crop maturity and crop quantity. Phosphorus plays a key role in plant physiological processes. It is needed for energy storage and release in the living cells. Adequate amount of phosphorus in soil favours rapid plant growth, early fruiting/maturity and improves the quality of the produce. As green gram is a legume crop, it responds well to added phosphorus (Sarkar and Banik, 1991). Phosphorus deficiency causes yield reduction by limiting the plant growth (Peohlmán, 1991). Hence an experiment was conducted to study the effect of spacing and levels of phosphorus on the growth and yield of green gram (*Vigna radiata*).

MATERIALS AND METHODS

A field study was conducted at the experimental farm of School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus, during *kharif* season (June- September) of 2016. The soil of the experimental site was well drained and sandy loam in texture with pH 4.6, organic carbon 0.63 g/kg, available N 203.56 kg/ha, available P_2O_5 15.17 kg/ha and available K_2O 210.67 kg/ha. The experiment was carried out in split-plot design, comprising of three different spacings: S_1 : 20 x 10 cm, S_2 : 30 x 10 cm and S_3 : 40 x 10 cm, with four levels of phosphorus: P_0 : 0 kg ha⁻¹, P_1 : 20 kg ha⁻¹, P_2 : 40 kg ha⁻¹ and P_3 : 60 kg ha⁻¹. The sowing was done on 20th June, 2016. Healthy seeds @ 25 kg ha⁻¹ were used for sowing in furrows prepared with the help of a furrow maker. The seeds were treated with *Trichoderma* @ 4 g kg⁻¹ seed. The seeds were then sown in lines at a row spacing of 20 cm, 30 cm and 40 cm apart as per treatments at a depth of 1.5 cm - 2 cm and plant spacing of 10 cm. The plant spacing was maintained by thinning out the plants after 15 DAS. The different levels of phosphorus (0 kg ha⁻¹, 20 kg ha⁻¹, 40 kg ha⁻¹ and 60 kg ha⁻¹) with the recommended dose of nitrogenous and potash fertilizer (20 kg ha⁻¹ and 40 kg ha⁻¹) were applied to the respective plots in the form of urea, SSP and MOP. All the fertilizers were applied at the time of sowing in single dose in furrows at 5-7 cm away below the seed. The rainfall received during crop growth period of green gram was 149.9 mm during 2016. The observations on growth attributes were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing character were recorded as per the standard method. Yield attributes were also recorded at physiological maturity stage. The seed and straw yield was recorded from net plot area of each treatment. The data recorded for each character were analysed statistically by applying the techniques of Analysis of Variance and the significant of different sources of variation were tested by F test (Cochran and Cox, 1957).

RESULTS AND DISCUSSION

Effect of spacing and levels of phosphorus on growth parameters

The growth parameters were significantly influenced by spacing (Table 1). Spacing at 30 x 10 cm recorded the tallest plant height (48.10 cm), followed by 40 x 10 cm spacing and the shortest plant height was observed at 20 x 10 cm spacing at harvesting. The probable reason for tallest plant height at 30 x 10 cm spacing could be more utilization of energy properly in branching because there was less competition of light while in case of 20 x 10 cm spacing, there was insufficient utilization of light energy by the plant and due the inter plant shading along the row. The results were similar with the findings of Sonani (2016). The highest value of number of leaves per plant (5.47) was recorded at spacing 30 x 10 cm and the lowest value was recorded at 20 x 10 cm spacing respectively. Significantly highest values of shoot dry weight (2.88 g plant⁻¹) were recorded at spacing 30 x 10 cm. This might be owing due to better utilization of available growth resources viz., nutrient, moisture and solar radiation to a greater extent and accumulation of photosynthates. Similar findings were observed by Mandal (2012). Leaf area index was also influenced significantly by different spacing and the highest value (2.88) was recorded at spacing 30 x 10 cm, followed by 40 x 10 cm spacing and the lowest values were recorded at 20 x 10 cm spacing. The highest value of Leaf are Index at 30 x 10 cm might have been attributed to more branches plant⁻¹ which resulted in more leaves leading to higher LA. Similar findings were observed by Sathyamoorthi *et al.* (2008). The highest value of crop growth rate (5.98 g m⁻² day⁻¹) was recorded at spacing 20 x 10 cm, followed by spacing at 40 x 10 cm and lowest was recorded at spacing 20 x 10 cm. Higher number of plants was accommodated under 20 x 10 cm plant geometry and this could have resulted in higher CGR.

The growth parameters of green gram were also significantly affected due to different levels of phosphorus (Table 1). The highest values of plant height (49.37 cm),

Table 1: Effect of spacing and levels of phosphorus on the growth parameters of green gram.

Treatment	Plant Height (cm)	No of leaves per plant	Shoot dry weight (g plant ⁻¹)	Leaf Area Index (LAI)	Crop growth rate (g m ⁻² day ⁻¹)
S_1 : (20 x 10 cm)	46.44	4.95	2.53	2.51	5.98
S_2 : (30 x 10 cm)	48.10	5.47	2.88	2.88	4.84
S_3 : (40 x 10 cm)	47.09	5.20	2.68	2.72	3.24
SEm±	0.08	0.05	0.02	0.03	0.06
CD (P=0.05)	0.42	0.25	0.10	0.14	0.31
P_0 : (0 kg ha ⁻¹)	45.21	4.60	2.17	2.18	3.35
P_1 : (20 kg ha ⁻¹)	46.43	5.09	2.49	2.48	4.04
P_2 : (40 Kg ha ⁻¹)	49.37	5.73	3.34	3.34	6.37
P_3 : (60 kg ha ⁻¹)	47.82	5.40	2.77	2.80	4.99
SEm±	0.09	0.08	0.02	0.03	0.12
CD (P=0.05)	0.32	0.28	0.09	0.10	0.41

number of leaves per plant (5.73), shoot dry weight (3.34 g plant⁻¹), leaf area index (3.34) and crop growth rate (6.37 g m⁻² day⁻¹) were significantly higher with application of 40 kg P₂O₅ ha⁻¹, followed by application of 60 kg ha⁻¹, 40 kg ha⁻¹ and the lowest values were observed at application of 0 level of phosphorus. The increased in the parameters at 40 kg P₂O₅ ha⁻¹ might have been on account of stimulation of root growth of the crop as phosphorus plays an important role in various physiological process including root development, nodulation and N- fixation, better utilization of available growth resources viz., nutrient, moisture and solar radiation to a greater extent and accumulation of photosynthates. Similar results were also observed by Kadam and Khanvikar (2015), Sathyamoorthi *et al.* (2008) and Sipai *et al.* (2015).

Effect of spacing and levels of phosphorus on yield and yield parameters

The yield and yield attributes of green gram markedly influenced with spacing (Table 2). Spacing at 30 x 10 cm recorded significantly highest values of pods plant⁻¹ (17.00) and length of pods (6.81 cm). The higher values of the parameters may be explained in term of rapid growth, more branching and dry matter production. It corroborated with the findings of Kabir and Sarkar (2008). The highest values of seed yield (688.54 kg ha⁻¹), stover yield (1917.81 kg ha⁻¹) and harvest index (26.36%) was also observed at spacing 30 x 10 cm followed by spacing at 40 x 10 cm and lowest values was recorded at spacing 20 x 10 cm. The highest seed yield at 30 x 10 cm spacing resulted mainly due to higher number of branches plant⁻¹ and number of pods plant⁻¹. Similar findings were also observed by Rasul *et al.* (2012) and Yadav (2004). The number of seeds per pod and test weight were not significantly influenced by spacing.

The yield and yield attributes, viz. number of pods per plant, length of pods, seed yield, stover yield and harvest index were influenced significantly by levels of phosphorus, but number of seeds per pod and test weight showed non-significant effect (Table 2). Application Of 40 kg P₂O₅ kg ha⁻¹ recorded significantly highest values of number of pods

(17.56), length of pods (6.91 cm), seed yield (737.42 kg ha⁻¹) and stover yield (1973.01 kg ha⁻¹) than other levels of phosphorus and all the parameters recorded lowest values at 0 level of phosphorus. The highest values of the parameters at 40 kg P₂O₅ ha⁻¹ might due to the primary role of phosphorus in photosynthesis by way of rapid energy transfer and thereby increased photosynthetic efficiency and thus increased the availability of photosynthesis. This resulted in increase in the total biomass production and there translocation in plant parts. These altogether resulted in to overall increase in the above characters. Similar findings were also observed by Patel *et al.* (2013) and Sipai *et al.* (2015). Harvest index varied significantly due to spacing, where highest value (26.36%) was recorded at 30 x 10 cm spacing which was at par with 20 x 10 cm spacing and the lowest value (25.21%) was observed at 20 x 10 cm spacing.

Available soil NPK (kg ha⁻¹)

Application of different levels of phosphorus showed significant influenced on the available NPK in the soil (Table 3). The highest available N (273.53 kg ha⁻¹), P₂O₅ (29.19 kg ha⁻¹) and K (250.86 kg ha⁻¹) in the soil was observed in the treatment 40 kg P₂O₅ ha⁻¹ and the lowest value was observed at control. These findings are in close conformity with the findings by Sipai *et al.* (2015) where they reported that application of 40 kg P₂O₅ ha⁻¹ resulted in the maximum building up of available N, P₂O₅, K₂O content in soil after harvest of crop, which was significantly superior to the rest of levels of P.

Total Nutrient (NPK) uptake by the plant (kg ha⁻¹)

Application of different levels of phosphorus also showed significant influenced on total N, P and K uptake by green gram (Table 3). The highest total uptake N (46.61 kg ha⁻¹), P₂O₅ (5.26 kg ha⁻¹) and K (20.59 kg ha⁻¹) was observed in the treatment 40 kg P₂O₅ ha⁻¹ and the lowest value was observed at control. The application of phosphorus might have improved the nutritional environment in rhizosphere as well, as in plant system leading to increased uptake and translocation of nutrients especially of N, P and K in the reproductive structures which led to higher content and

Table 2: Effect of spacing and levels of phosphorus on the yield and yield parameters of green gram of green gram.

Treatment	No. of pods per plant	Length of pods (cm)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)
S ₁ : (20 x 10 cm)	16.19	6.50	605.96	1790.13	25.21
S ₂ : (30 x 10 cm)	17.00	6.81	688.54	1917.81	26.36
S ₃ : (40 x 10 cm)	16.50	6.70	642.38	1875.01	25.47
SEm±	0.04	0.02	5.34	4.98	0.18
CD (P=0.05)	0.18	0.12	26.41	24.61	0.09
P ₀ : (0 kg ha ⁻¹)	15.64	6.46	563.63	1743.93	24.39
P ₁ : (20 kg ha ⁻¹)	16.36	6.62	613.61	1830.36	25.10
P ₂ : (40 Kg ha ⁻¹)	17.56	6.91	737.42	1973.01	27.19
P ₃ : (60 kg ha ⁻¹)	16.69	6.70	667.85	1896.63	26.04
SEm±	0.05	0.03	4.93	4.75	0.17
CD (P=0.05)	0.18	0.09	17.03	16.42	0.58

Table 3: Effect of levels of phosphorus on the Available soil NPK (kg ha⁻¹) and total Nutrient (NPK) uptake by the plant (kg ha⁻¹).

Treatment	Available soil			Total Nutrient uptake by the plant		
	N	P	K	N	P	K
P ₀ : (0 kg ha ⁻¹)	219.86	20.43	220.44	26.4	2.5	14.63
P ₁ : (20 kg ha ⁻¹)	232.34	23.09	228.86	32.95	3.38	16.4
P ₂ : (40 Kg ha ⁻¹)	273.53	29.19	250.87	46.61	5.26	20.59
P ₃ : (60 kg ha ⁻¹)	252.81	26.15	236.93	38.71	4.28	18.43
SEm±	1.73	0.21	1.56	0.43	0.05	0.14
CD (P=0.05)	5.96	0.74	5.39	1.47	0.16	0.48

Table 4: Gross Return (₹ ha⁻¹), Cost of Cultivation (₹ ha⁻¹), Net Return (₹ ha⁻¹) and benefit cost ratio.

Treatments	Yield (kg ha ⁻¹)		Return (₹ ha ⁻¹)		Gross	Cost of	Net	B:C
	Seed	Stover	Seed	Stover	Return (₹ ha ⁻¹)	Cultivation (₹ ha ⁻¹)	Return (₹ ha ⁻¹)	Ratio
S ₁ P ₀	506.55	1699.09	25327.5	3398.18	28725.68	8500	20225.68	2.38
S ₁ P ₁	582.53	1729.43	29126.5	3458.86	32585.36	8660	23925.36	2.76
S ₁ P ₂	697.17	1919.63	34858.5	3839.26	38697.76	8820	29877.76	3.39
S ₁ P ₃	637.57	1812.38	31878.5	3624.76	35503.26	8980	26523.26	2.95
S ₂ P ₀	613.56	1799.19	30678.0	3598.38	34276.38	8500	25776.38	3.03
S ₂ P ₁	657.01	1898.16	32850.5	3796.32	36646.82	8660	27986.82	3.23
S ₂ P ₂	789.45	2016.38	39472.5	4032.76	43505.26	8820	34685.26	3.93
S ₂ P ₃	694.15	1957.52	34707.5	3915.04	38622.54	8980	29642.54	3.30
S ₃ P ₀	570.79	1733.52	28539.5	3467.04	32006.54	8500	23506.54	2.77
S ₃ P ₁	601.28	1863.48	30064.0	3726.96	33790.96	8660	25130.96	2.90
S ₃ P ₂	725.63	1983.02	36281.5	3966.04	40247.54	8820	31427.54	3.56
S ₃ P ₃	671.83	1920.00	33591.5	3840.00	37431.50	8980	28451.50	3.17

P rice of green gram seeds = ₹ 150 kg⁻¹

Urea = ₹ 10 kg⁻¹ SSP = ₹ 8 kg⁻¹

MOP = ₹ 20 kg⁻¹

Sale rate of seed = ₹ 50 kg⁻¹

Sale rate of Stover = ₹ 2 kg⁻¹

uptake. Similar findings were observed by Kumawat *et al.* (2009) and Sipai *et al.* (2015).

Economics analysis

The data on the effect of spacing and levels of phosphorus in the economics is presented (Table 4). Among the plots the highest net return (₹ 34685.26 ha⁻¹) and BCR of 3.93 were recorded with treatment combinations of S₂P₂ (spacing of 30 cm x 10 cm with 40 kg P₂O₅ ha⁻¹) followed by S₃P₂ (₹ 31427.54 ha⁻¹) with BCR value of 3.56. The lowest net return (₹ 20225.68 ha⁻¹) with BCR Value of 2.38 was realised in S₁P₀ (spacing of 20 cm x 10 cm with 0 level of P₂O₅). Higher net returns and BCR value of S₂P₂ was due to higher seed and stover yield.

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