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Effect of spacing and nutrient levels on growth, yield and economics of fodder rice bean [*Vigna umbellata* (Thunb.)]

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Abstract
A field experiment was conducted at College of Agriculture, Vellayani, Trivandrum to standardize the spacing and nutrient levels of fodder rice bean [*Vigna umbellata* (Thunb.)]. The treatments consisted of three spacing (s_1 - 30 cm x 10 cm, s_2 - 30 cm x 20 cm and s_3 - 30 cm x 30 cm), three levels of nitrogen (n_0 - 0 kg N ha^{-1}, n_1 - 20 kg N ha^{-1} and n_2 - 30 kg N ha^{-1}) and three levels of phosphorous (p_0 - 0 kg P_2O_5 ha^{-1}, p_1 - 20 kg P_2O_5 ha^{-1} and p_2 - 40 kg P_2O_5 ha^{-1}). Result showed that sowing of rice bean at spacing of 30 cm x 10 cm (s_1) recorded highest plant height (49.04 cm) at 30 DAS and leaf: stem ratio (0.63) at harvest. The treatment n_1 (20 kg N ha^{-1}) resulted in highest plant height and it was on par with n_2 (30 kg N ha^{-1}), while leaf to stem ratio was the highest at n_2 at harvest. Similarly the highest green (14.57 t ha^{-1}) and dry fodder yield (2.91 t ha^{-1}) were recorded at spacing of 30 cm x 10 cm (s_1) and at n_2 (30 kg N ha^{-1}) resulting in greater net returns (Rs. 35,761 ha^{-1}) and B: C ratio (3.22).

Keywords: Fodder yield, Nutrient levels, Rice bean, Spacing

India supports nearly 20% of the world livestock and 16.8% human population on a land area of only 2.3% of the total. Our country expected to be 30.65% deficient in the supply of forage materials by 2020 (IGFRI, 2013). Now the area under fodder cultivation is only 8.3 m ha (4% of total cropped area) and it is not going to increase in near future (Hazra, 2014). In such a case, leguminous forage can be used as supplement with straw-based diets for ruminants in order to improve digestibility of feed and overall performance of ruminants (Akbar *et al.,* 2003). Rice bean [*Vigna umbellata* (Thunb.)] is a legume crop which belongs to the family Fabaceae. It is a neglected crop and is used for different purposes such as food, fodder, animal feed, green manure, cover crop and to maintain the soil fertility. Rice bean contains high crude protein (25.46%) and low crude fiber (25.33%) which makes it a quality fodder crop (Katoch, 2010).

Spacing levels adopted in the field is found to affect the growth and yield attributes of several fodder crops. Singh *et al.* (2003) observed that the spreading and non-spreading types of fodder cowpea yield less grain and more fodder when planted in closer spaced rows and more grain and less fodder when grown in wider spaced rows. The increasing trend in green forage yield of cowpea in response to increasing level of nitrogen fertilization was observed by Sultana *et al.* (2005). Patidar (2013) observed that in fodder rice bean, the application of 90 kg P_2O_5 ha^{-1} resulted in higher vine length, number of branches per plant, leaf stem ratio and leaf area index and these were significant over the other treatments 0, 30 and 60 kg P_2O_5 ha^{-1}. Since the growth and yield of this crop was found to be good under Kerala conditions, this crop might be recommended as a fodder legume for cultivation in the state and therefore the study was taken up with an objective to standardise the spacing and nutrient levels for fodder rice bean.

The experiment was conducted at College of Agriculture, Vellayani, Kerala during *Kharif* 2017 and was laid out in Randomised Block Design (RBD) with three replications. The soil in the experiment site was red sandy loam, acidic in pH and soil EC in safe range. The soil had high organic carbon content (1.29 %), low available N (124.4 kg ha^{-1}) and medium K (271.94 kg ha^{-1}) content. The treatments consisted of three spacing (s_1 - 30 cm x 10 cm, s_2 - 30 cm x 20 cm and s_3 - 30 cm x 30 cm), three levels of nitrogen (n_0 - 0 kg ha^{-1}, n_1 - 20 kg ha^{-1} and n_2 - 30 kg ha^{-1}) and three levels of phosphorous (p_0 - 0 kg P_2O_5 ha^{-1}, p_1 - 20 kg P_2O_5 ha^{-1} and p_2 - 40 kg P_2O_5 ha^{-1}). FYM @ 5 t ha^{-1} and K_2O @ 30 kg ha^{-1} were applied uniformly to all treatments as basal.

Plant height and L:S ratio of rice bean were significantly affected by treatments except phosphorus levels, however, number of branches were remained statistically similar (Table 1). The closer spacing (30 cm x 10 cm) resulted in a plant height of 49.04 cm and was taller to the other two wider spacing at 30 DAS, however it was

Table 1. Effect of spacing, nitrogen and phosphorus levels on growth and fodder yield of rice bean

Treatments	Plant height (cm)		No. of branches		L: S at harvest	GFY (t ha^{-1})	DFY (t ha^{-1})
	30 DAS	At harvest	30 DAS	At harvest			
Spacing							
s_1 - 30 cm x 10 cm	49.04	121.40	5.37	6.81	0.63	12.95	2.59
s_2 - 30 cm x 20 cm	46.78	118.85	5.74	7.00	0.54	12.26	2.45
s_3 - 30 cm x 30 cm	45.37	116.48	5.77	7.25	0.54	11.35	2.27
SEm±	1.08	3.78	0.22	0.18	0.03	0.63	0.13
CD (P<0.05)	2.18	NS	NS	NS	0.06	1.27	0.26
Nitrogen levels							
n_0 - 0 kg ha^{-1}	42.74	105.29	5.74	7.03	0.51	11.37	2.27
n_1 - 20 kg ha^{-1}	49.47	121.77	5.51	6.81	0.56	12.52	2.50
n_2 - 30 kg ha^{-1}	48.98	129.66	5.62	7.22	0.65	13.66	2.73
SEm±	1.08	3.78	0.22	0.18	0.03	0.63	0.13
CD (P<0.05)	2.18	7.61	NS	NS	0.06	1.27	0.25
Phosphorus levels							
p_0 - 0 kg ha^{-1}	47.61	115.37	5.74	7.14	0.57	12.32	2.46
p_1 - 20 kg ha^{-1}	47.23	123.00	5.51	6.81	0.54	12.75	2.55
p_2 - 40 kg ha^{-1}	46.36	118.37	5.62	7.11	0.61	12.49	2.50
SEm±	1.08	3.78	0.22	0.18	0.03	0.63	0.13
CD (P<0.05)	NS	NS	NS	NS	NS	NS	NS

Table 2. Interaction effect of spacing and nitrogen on green and dry fodder yield of rice bean.

Treatment	Green fodder yield (t/ha)			Dry fodder yield (t/ha)		
	n_0 - 0 kg ha^{-1}	n_1 - 20 kg ha^{-1}	n_2 - 30 kg ha^{-1}	n_0 - 0 kg ha^{-1}	n_1 - 20 kg ha^{-1}	n_2 - 30 kg ha^{-1}
s_1 - 30 cm x 10 cm	10.80	13.46	14.57	2.16	2.69	2.91
s_2 - 30 cm x 20 cm	10.55	11.83	14.40	2.11	2.37	2.88
s_3 - 30 cm x 30 cm	12.77	12.26	12.00	2.55	2.45	2.40
SEm±		1.10			0.22	
CD (P<0.05)		2.21			0.44	

not significant at harvest. This might be because the plants at closer spacing compete to get maximum solar radiation for photosynthesis by growing taller. El Naim and Jabereldar (2010) also reported that increasing plant population increased plant height. Similarly greater L:S ratio (0.63) was recorded in close spacing (30 × 10 cm). At close spacing plant produce thinner stem and more leaves resulting higher L:S ratio. Kurubetta (2006) also observed decrease in the number of leaves when spacing was increased in fodder cowpea. Application of 30 kg N ha^{-1} increased plant height and L:S ratio over control plot. This could be attributed to the beneficial effect of nitrogen in promoting vegetative growth of crops. Balai *et al.* (2017) and Anuradha *et al.* (2017) also observed similar results.

Spacing, N and P levels had significant effect on green and dry fodder yield (Table 1). Close spacing of (30 × 10 cm) recorded the highest GFY (12. 95 t ha^{-1}) and DFY (2.59 t ha^{-1}) and was on par with s_2. This result was in agreement with the finding of Prasad *et al.* (1994) who reported that yield of rice bean decreased with increased spacing. Among the nitrogen levels, application of 30 kg N ha^{-1} recorded highest GFY (13.66 t ha^{-1}) and DFY (2.73 t ha^{-1}) and was found on par with 20 kg N ha^{-1} (Table. 1). The increase in yield with N fertilization might be due to the improved supply of photosynthates and also better uptake of nutrients. Phosphorus failed to exert any significant effect on fodder yield. The interaction effect of spacing and nitrogen was significant on fodder yield (Table 2). Sowing of crop at closer spacing (30 × 10 cm) and fertilized with 30 kg N ha^{-1} recorded highest green (14.57 t ha^{-1}) and dry fodder yield (2.91 t ha^{-1}). This might be because of the presence of more number of plants in the least spacing and the increased vegetative growth due to higher N application. This result was in agreement with the earlier findings of Singh *et al.* (2007), Hasan *et al.* (2010) and Bhavya *et al.* (2014).

The highest net income (Rs. 35,761) and B: C ratio (3.22) were obtained in the treatment combination $s_1 n_2 p_1$ (spacing 30 cm x 10 cm, 30 kg N ha^{-1} and 20 kg P_2O_5 ha^{-1}). This might be because of the closer spacing adopted and the higher fertilizers added increased the yield to maximum levels. It was evident from the data on GFY and DFY that the treatment combination $s_1 n_2 p_1$ was superior in terms of yield.

It was concluded that fodder rice bean can be profitably cultivated at a spacing of 30 cm x 10 cm with application of 30 kg N ha^{-1} in two splits at 15 and 30 DAS and basal application of 20 kg P_2O_5 ha^{-1}, 5 t ha^{-1} of FYM and 30 kg K_2O ha^{-1}.

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