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Effect of plant geometry and weed management on growth and quality of summer mungbean (*Vigna radiata* L.)

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Abstract
A field experiment was carried out during *kharif* season of 2017 at research farm of TCA Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) to study the "Effect of plant geometry and weed management on growth and quality of summer mungbean (*Vigna radiata* L.)" The experiment was laid out in randomised block design and replicated thrice. The treatment comprised of three plant geometry *i.e.,* 20 x 10 cm, 25 x 10 cm and 30 x 10 cm and five weed management practices *i.e.,* weedy check, hand weeding at 15 and 30 DAS, Pendimethalin 0.75 kg/ha as pre-emergence, Quizalofop-ethyl 60 g/ha at 15 DAS and Imazethapyr 60 g/ha at 15 DAS. Significantly higher plant height and crop growth rate were recorded at closer row spacing of 20 × 10 cm than wider row spacing at harvest. However, higher dry matter accumulation/plant and number and dry weight of nodules per plant were significantly higher at wider row spacing of 30 × 10 cm over closer row spacings. Among the weed management practices, hand weeding twice recorded significantly higher plant height, dry matter production/plant, crop growth rate and number and dry weight of nodules/plant than Quizalofop-ethyl and Pendimethalin. Protein content in grain was not significantly influenced by planting geometry and weed management practices.

Keywords: Mungbean, plant geometry, weed management practices, growth and quality

Introduction

Greengram (*Vigna radiata* L. Wilczek) is the third most important pulse crop in India. It is an excellent source of protein (24.5%) with high quality lysine (460 mg/g N) and tryptophan (60 mg/g N). It also contains remarkable quantity of ascorbic acid and riboflavin (0.21 mg/100 g) and minerals (3.84 g/100g). Mungbean, being a short duration crop, fits well in various multiple and intercropping systems. After picking of pods, mungbean plants can be used as green fodder or green manure. Besides these, the crop also enriches soil by fixing atmospheric nitrogen and leaves 30- 50 kg N/ha as residual N, which increases yield of succeeding crops. It is cultivated in an area of 30.53 lakh hectare area with production of 15.09 lakh tonnes in the country (Statistical year book India, 2016) [11]. Plant geometry plays an important role in the dominance and suppression of weed 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. Weeds pose a serious threat to greengram cultivation during the early phase of crop growth. Weeds in greengram fields reduce production efficiency by competing with crop plants for space, water, nutrients and light interception. Weed control is of prime importance to save the wasteful loss and to harvest higher yield. This could be possible by either frequent mechanical weed control or by herbicidal treatments. Manual weeding is expensive and time consuming and therefore, less practiced and often gets delayed. Under such situation, chemical weed control may prove to be economical and effective alternative to tilt the crop-weed competition in favour of crop by providing season long weed control.

Material and methods

The field experiment was conduct during summer season of 2017 at research farm of Tirhut College of Agriculture Farm, Dholi (Muzaffarpur), Dr. Rajendra Parsad Central Agricultural University, Pusa (Samastipur) Bihar. Farm is situated between $25^0$39' N latitude and $85^0$40' E longitude. The soil of the experimental plot was low in organic carbon, available nitrogen, available P_2O_5 and medium in available K_2O which indicate that the soil was low in fertility.

The treatment consists of three plant geometry *i.e.*, 20 x 10 cm, 25 x 10 cm and 30 x 10 cm and five weed management practices *i.e.*, weedy check, hand weeding at 15 and 30 DAS, Pendimethalin 0.75 kg/ha (pre-emergence), Quizalofop-ethyl 60 g/ha at 15 DAS and Imazethapyr 60 g/ha at 15 DAS. These treatment combinations were replicated thrice in Randomized Block Design.

A plot having uniform fertility and even topography was selected for experimental trial. The field was given a pre sowing irrigation before field preparation to obtained proper germination and establishment of the crop. The land was ploughed by soil turning plough followed by two disking. Sowing was done using the seed rate of 25 kg/ha in rows, furrows opened by hand plough to a depth of 5 cm at row distance of 20, 25 and 30 cm. Seeds were treated with Thiram @ 2 g/kg of seed before sowing against fungal diseases. Plant to plant distance of 10 cm was maintained by thinning after 15 days of sowing. One irrigation was given at 20 DAS and this was found sufficient for the crop growth and development. Application of recommended dose of fertilizer (20:40:0 kg N: P_2O_5: K_2O/ha) was done. Plant spacing within the row was maintained by thinning out extra plants at 15 days after sowing when all the plants were emerged out. As per treatment, pendimethailn was applied one day after sowing of crop while imazethapyr and quizalofop ethyl were applied at 15 days after sowing. These herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 600 litres of water per hectare. Care was taken to avoid the drift hazard. Hand weeding operations was performed at 15 and 30 DAS.

Plant height was measured at regular interval of 20 days commencing from 20 days after sowing till harvest. The height of five randomly selected and tagged plants in second row of each plot was measured from ground surface to apex leaf and then average was taken. Five random plant samples from second row of each plot were uprooted and washed thoroughly at 20 days interval starting from 20 days after sowing to harvest. The samples so obtained were sun dried and then oven-dried at 70 °C temperature till constant weight was obtained. Thereafter final dry weight was recorded. The crop growth rate of a unit area of canopy at any instant time (t) is defined as the increase of plant material per unit time. The CGR is calculated by the formula:-

$$CGR = \frac{w_2 - w_1}{t_2 - t_1}$$

Where,

W_2 = Dry weight of plant at successive stage

W_1 = Dry weight of plant at preceding stage

t_2-t_1 = Time interval between two stages of observations.

Five plants were randomly selected from each plot at 20 and 40 DAS and uprooted carefully such that nodules were not lost by detaching in the soil. After washing the roots carefully, total number of nodules present on the roots were detached from the roots and counted and then averaged. The nodules so detached were freshly weighed in the weighing balance after which the nodules were dried in sun for 2 days and then dried in oven at 70 °C temperature. After complete drying of the nodules, dry weight was taken. The sample of grains taken from different treatment was dried and crushed in to powder form and nitrogen content was estimated by micro Kjeldhal's method. The protein content of grain was calculated by multiplying the percent nitrogen in grains with constant factor 6.25 (assuming 16 percent N in protein).

Result and Discussion

Plant height

Plant height of mungbean increased with the advancement of crop age and reached the maximum at harvest. No perceptible variation in plant height was observed due to row spacings at 20 DAS but significant variation was observed at 40, 60 DAS and at harvest. Maximum plant height was obtained at closest row spacing of 20 × 10 cm *viz.*, 24.75, 40.42 and 42.77 cm at 40, 60 DAS and at harvest, respectively which was significantly higher over wider row spacing of 25 × 10 cm and 30 × 10 cm. It might be due to more number of plants per unit area and also due to the reason that the sparsely sown crop spreads more than closely spaced one which lead to grown in upward direction on other hand when the plant are sown closely together their stems are shaded from the light resulting in accumulation of auxin which is a major growth hormone that stimulates cell division and elongation. In sparsely spaced plant auxin destruction by light occur resulting in plant being shorter. This result is in accordance with the findings of Kachare *et al.* (2001) [4] in green gram and Nimje *et al.* (2003) [7].

The effect of weed management practices on plant height was well pronounced at every successive growth stages except at 20 DAS. At 20 DAS, weed management practices produced non-significant effect on plant height. Among the weed management practices, hand weeding twice found significantly superior over chemical weeding and recorded plant height *viz.*, 25.13, 41.84 and 44.60 cm at 40, 60 DAS and at harvest, respectively. Among the chemical weeding, Imazethaypr recorded altough higher plant height of 23.40, 39.24 and 42.00 cm at 40, 60 DAS and at harvest respectively, but was found at par with Quizalofop ethyl at all the growth stages. It might be due to reduced crop-weed competition for better utilisation of nutrients, moisture and solar radiation are known to improve of the plant vigour significantly. This trend was fully reflected in hand weeding and chemical weeding practices. Chhodavadia *et al*. (2014) [2] also observed higher values of plant height.

Plant dry weight (g/plant)

Plant dry weight differed significantly among row spacing at all the stages of crop growth except at 20 DAS. Significantly higher plant dry weight was recorded under widest row spacing of 30 × 10 cm *viz.*, 4.72, 11.10 and 13.96 g/plant at 40, 60 DAS and at harvest, respectively than closer row spacing of 25 × 10 cm and 20 × 10 cm. This might be due to less competition for space, moisture and nutrients which accelerate normal photosynthetic activity and provided sufficient photosynthates for development of root system, branches and leaf number per plant, flowers and fruits which lead to an increase in total dry matter production.

Significant effect of weed management practices on plant dry weight was noticed at all the stages of crop growth. At 20 DAS, plant dry weight did not varied significantly among the weed control treatments. However, at later growth stages, hand weeding recorded higher plant dry weight 5.27, 11.43 and 15.13 g/plant at 40, 60 DAS and at harvest, respectively which was found at par with Imazethaypr and significantly higher over Quizalofop ethyl and Pendimethalin. Increase in plant dry matter accumulation may be attributed to better utilisation of growth factors and higher photosynthetic efficiency resulting in increased plant height, number of trifoliate leaves and more leaf area which contributed towards increased dry matter yield. Kaur *et al*. (2010) [6] and Chhodavadia *et al*. (2014) [2] also observed higher values of all the growth parameters with the use of cultural and herbicidal treatments on mungbean.

Crop growth rate (g/ m^2/day)

Significant variation was recorded on crop growth rate due to plant geometry. Crop growth rate was significantly higher under closest spacing of 20 × 10 cm *i.e.*, 1.09, 9.70, 11.20 and 7.82 g/m^2/day at 20, 40, 60 DAS and at harvest, respectively as compared to wider row spacing of 25 × 10 cm and 30 × 10 cm.

Among the weed management practices, maximum crop growth rate was observed under hand weeding twice *viz.*, 1.00, 9.77, 12.38 and 8.94 g/m^2/day at 0-20, 20-40 40-60 DAS and at 60 DAS - harvest which was found at par with Imazethaypr at all the growth stages and Quizalofop ethyl at 40-60 DAS and at 60 DAS- harvest.

Number of nodules per plant

The highest number of nodules per plant was observed under wider row spacing of 30 × 10 cm *i.e.*, 11.74 and 23.96 nodules/plant at 20 and 40 DAS respectively which was significantly higher than closer spacings of 20 × 10 cm (9.99 and 20.75 nodules/plant) and 25 × 10 cm (10.74 and 21.95 nodules/plant) at 20 and 40 DAS, respectively. Weed control treatments exerted significant effect on number of nodules/plant than weedy check. This might be due to the plants grown with wider spacing got better opportunity for development of root in rhizosphere and available maximum space, light and nutrients leading to maximum plant growth, due to less competition among the plant for nutrient space and moisture. The plant grown stress less competition and produce healthy plant with more number of nodules. The above findings are in complete agreement with earlier work of Kalsariya *et al*. (2017) [5] and Gohil *et al.* (2017) [3].

Among the weed management practices, highest number of nodules per plant was observed under hand weeding twice (11.68 nodules/plant) than chemical weeding at 20 DAS. Among the herbicidal treatments, Pendimethalin altough recorded higher number of nodules per plant which was found at par with Imazethapyr (10.88 nodules/plant) and Quizalofop ethyl (10.58 nodules/plant) at 20 DAS. While, at 40 DAS, the number of nodules per plant did not varied significantly among the weed control treatments. Higher number of nodules under weed control treatments might be due to less crop weed competition for nutrient, water, space which provide congenial environment for proper growth and development of root in rhizosphere and their proliferation and nodulation. Their results are in close conformity with Raman and Krishnamoorthy (2005) [8] and Chatta *et al.* (2007) [1].

Dry weight of nodules per plant

Dry weight of nodules per plant was recorded significantly higher at wider plant spacing of 30 × 10 cm *i.e.*, 26.08 and 73.00 g/plant at 20 and 40 DAS, respectively which was significantly higher over closer plant spacings of 25 × 10 cm and 20 × 10 cm. This might be due to the plants grown with wider spacing got better opportunity for development of root in rhizosphere and available maximum space, light and nutrients leading to maximum plant growth, due to less competition among the plant for nutrient space and moisture. It produced higher weight of nodules per plant. The above findings are in complete agreement with earlier work of Sathe and Patil (2012) [9], Kalsariya *et al*. (2017) [5] and Gohil *et al.* (2017) [3].

Weed management practices significantly influenced dry weight of nodules per plant than weedy check. Among weed management practices, highest dry weight of nodules per plant was observed under hand weeding twice *viz.*, 26.55 and 73.41 g/plant which was found at par with Pendimethalin *i.e.*, 25.42 and 70.47 g/plant and significantly higher over Imazethaypr and Quizalofop ethyl at 20 and 40 DAS, respectively. Among the herbicidal treatments, the dry weight of nodules did not varied significantly. It might be due to less crop weed competition for nutrient, water, space which provide congenial environment for proper growth and development nodulation give higher dry weight of nodules per plant. Their results are in close conformity with Raman and Krishnamoorthy (2005) [8] and Chatta *et al.* (2007) [1].

Protein content in grains (%)

Protein content of grain was not significantly influenced by different plant geometry and weed management treatments. However, the maximum protein content was recorded under wider row spacing of 30 × 10 cm (24.12) and the minimum protein content was recorded under closer row spacing of 20 × 10 cm (23.27). This might be due to wider row spacing provided optimum condition for plant growth because of minimum inter plant competition which accelerate the uptake of nitrogen by plant resulted in higher nitrogen content in seed. Among the weed management practices, the maximum protein content was recorded under twice hand weeding (24.00) and the minimum protein content was recorded under weedy check (23.37). It is obvious that control of weeds minimised the competition for essential inputs resulting in better crop growth and higher yield. The reduced weed growth owing to weed control saved substantial amount of nutrients, particularly N which resulted in improved growth and consequently increased protein content. This finding is in agreement with the finding of Singh *et al.* (1999) [10].

Table 1: Effect of plant geometry and weed management on plant height and plant dry weight of summer mungbean

Treatment	Plant height (cm)				Plant dry weight (g/plant)			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
Plant geometry								
20 x 10 cm	7.32	24.75	40.42	42.77	0.44	4.32	8.80	11.46
25 x 10 cm	7.04	22.54	38.17	40.57	0.46	4.42	9.70	12.36
30 x 10 cm	6.42	19.83	36.48	38.82	0.47	4.72	11.10	13.96
SEm±	0.25	0.35	0.59	0.63	0.01	0.08	0.17	0.22
CD (P=0.05)	NS	1.01	1.72	1.83	NS	0.23	0.50	0.65
Weed Management								
Weedy check	6.40	19.30	34.14	34.90	0.41	3.07	7.00	8.03
Hand Weeding 15 and 30 DAS	7.50	25.13	41.84	44.60	0.49	5.27	11.43	15.13
Pendimethalin 0.75 kg /ha at pre-emergence	6.63	21.70	37.84	40.60	0.45	4.27	9.23	10.83
Quizalofop-ethyl 60 g /ha (15 DAS)	6.90	22.33	38.74	41.50	0.46	4.77	10.63	14.23
Imazethapyr 60 g /ha (15 DAS)	7.20	23.40	39.24	42.00	0.47	5.07	11.03	14.73
SEm±	0.33	0.45	0.76	0.81	0.02	0.10	0.22	0.29
CD (P=0.05)	NS	1.31	2.21	1.83	0.04	0.29	0.65	0.84

Table 2: Effect of plant geometry and weed management on crop growth rate and protein content in grain of summer mungbean

Treatment	Crop growth rate (g /m²/day)				Protein content in grain (%)
	0-20 DAS	20-40 DAS	40-60 DAS	60 DAS -at harvest	
Plant geometry					
20 x 10 cm	1.09	9.70	11.20	7.82	23.27
25 x 10 cm	0.91	7.92	10.56	6.25	23.69
30 x 10 cm	0.79	7.07	10.63	5.60	24.12
SEm±	0.01	0.13	0.17	0.12	0.281
CD (P=0.05)	0.04	0.39	0.50	0.34	NS
Weed Management					
Weedy check	0.83	5.41	7.92	2.34	23.37
Hand Weeding 15 and 30 DAS	1.00	9.77	12.38	8.94	24.00
Pendimethalin 0.75 kg /ha at pre-emergence	0.92	7.79	9.92	3.86	23.63
Quizalofop-ethyl 60 g /ha (15 DAS)	0.94	8.80	11.77	8.70	23.71
Imazethapyr 60 g /ha (15 DAS)	0.96	9.40	11.97	8.94	23.75
SEm±	0.02	0.17	0.22	0.15	0.362
CD (P=0.05)	0.05	0.50	0.65	0.44	NS

Table 3: Effect of plant geometry and weed management on number and dry weight of nodules per plant of summer mungbean

Treatment	Number of nodules per plant		Dry weight of nodules per plant	
	20 DAS	40 DAS	20 DAS	40 DAS
Plant geometry				
20 x 10 cm	9.99	20.75	22.10	63.56
25 x 10 cm	10.74	21.95	23.81	67.08
30 x 10 cm	11.74	23.96	26.08	73.00
SEm±	0.18	0.57	0.39	1.07
CD (P=0.05)	0.52	1.67	1.12	3.11
Weed Management				
Weedy check	9.78	15.96	19.23	59.59
Hand Weeding 15 and 30 DAS	11.68	24.96	26.55	73.41
Pendimethalin 0.75 kg /ha at pre-emergence	11.18	23.96	25.42	70.47
Quizalofop-ethyl 60 g /ha (15 DAS)	10.58	22.86	24.05	67.23
Imazethapyr 60 g /ha (15 DAS)	10.88	23.36	24.73	68.71
SEm±	0.23	0.74	0.50	1.38
CD (P=0.05)	0.67	2.16	1.44	4.01

Conclusion
The experimental evidences warrant the following specific conclusion Closest plant spacing of 20 × 10 cm was found effective for enhanced plant height than wider row of 25 × 10 cm and 30 × 10 cm, However dry matter accumulation/plant and number and dry weight of nodules per plant were significantly higher at wider row spacing of 30 × 10 cm over closer row spacings. Among weed management practices, hand weeding twice recorded significantly higher in respect to all plant growth parameters.

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