The Pharma Innovation Journal 2020; 9(6): 302-305

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(6): 302-305

www.thepharmajournal.com
Received: 04-04-2020
Accepted: 06-05-2020

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Effect of plant geometry and weed management on weed dynamics and yield of green gram

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Abstract
A field experiment was carried out to study the effect of plant geometry and weed management on weed dynamics and yield of green gram at Crop Research Farm of Tirhut College of Agriculture Farm, Dholi, Muzaffarpur, Dr. Rajendra Parsad Central Agricultural University, Bihar ($25^0$39' N latitude and $85^0$40' E longitude). The experimental results revealed that significantly higher grain yield was recorded under hand weeding twice at 15 and 30 DAS over Quizalofop-ethyl and Pendimethalin under closer row spacing of 20 cm × 10 cm. Hand weeding twice at 15 and 30 DAS resulted in the lowest weed count, significant reduction in dry weight of weeds/m^2 and higher weed control efficiency at all the stages while post emergence application of Imazethaypr @ 60 g/ha at 15 DAS resulted in minimum weed density over all other treatments under closer row spacing of 20 cm × 10 cm.

Keywords: Spacing/weed management/green gram/yield/weed dynamics

Introduction
India grows nearly 233.09 lakh hectare of pulse with the annual production is 171.91 lakh tonnes. Green gram stands third after chickpea and pigeon pea among pulses (Tamang *et al.*, 2015) [7]. It occupies 30.53 lakh hectare area and contributes 15.09 lakh tonnes in pulse production in the country (Statistical Year Book, India, 2016). Inspite of being the largest producer in the world, our country has to import pulses to the tune of two million tonnes every year to meet its domestic requirement; the increment in the production being not able to maintain the pace with population growth. Bihar is the major green gram growing state of the country covering an area about 1.76 lakh ha with annual production of 1.18 lakh tonnes and productivity 669 kg/ha. It is an excellent source of protein (25%) with high lysine content (460 mg/g) and tryptophan (60 mg/g). It also has remarkable quantity of ascorbic acid when sprouted and also bears riboflavin and minerals.

Spacing plays an important role in contributing to the high yield because dense plant population will not get proper light for photosynthesis and poses high risk of diseases incidence. On the other hand, very low plant population will also reduce the yield. Hence, the optimum plant population is necessary for obtaining the higher yield. Plant geometry plays an important role in the dominance and suppression of weeds during the process of competition. Various works on spacing of mungbean cultivation showed that optimum plant spacing gave maximum yield (Mansoor *et al.*, 2010) [3]. Weeds cause severe losses in green gram due to its short stature and may causes losses up to 40-68 per cent (Tamang *et al.*, 2015) [7]. The magnitude of loss as a result of crop weed competition depends on type of weed species associated with crop, their densities and duration of competition with crops. In green gram, weeds are normally controlled by hand weeding. However, hand weeding is laborious, time consuming, costly and tedious. With increase in labour cost and constraints in availability on time, manual weed control is no more an economical in green gram. Pendimethalin, a pre-emergence herbicide is used to control initial flush of weeds in moong since last many years. However, sole application of pendimethalin is not sufficient to control the diverse group of weed flora in moong. Hence, there was an urgent need to sort out a broad-spectrum efficient post-emergence herbicide including quizalofop-ethyl and imazethapyr for effective control of weeds in summer green gram to optimize productivity. The present investigation on effect of plant geometry and weed management on yield and weed dynamics in green gram was planned with the objectives to determine the optimum planting geometry and better weed management practices to maximise grain yield at the same environment of row spacing in Bihar condition.

Materials and methods

A field experiment was conducted in *summer* season of 2017 at Research Farm of Tirhut College of Agriculture, Dholi, Muzaffarpur of Dr. Rajendra Parsad Central Agricultural University, Pusa, Bihar ($25^0$39' N latitude and $85^0$40' E longitude) in a randomized block design (RBD) and replicated thrice. The treatment comprised of three plant geometry i.e., 20 cm x 10 cm, 25 cm x 10 cm and 30 cm 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. HUM-16 (Parent- Pusa bold x HUM -8) variety of green gram was used. The field with homogenous fertility and uniform textural make-up was selected for this purpose. The soil of the experimental plot was alluvial and calcareous in nature and is characterised by high content of free calcium carbonate varying from 20 to 40 percent. Observations on weed population/m^2 at 20, 40 and 60 DAS, dry weight of weeds (g/m^2) at 20, 40, 60 DAS and at harvest, weed growth rate (%) at 0-20, 20- 40, 40-60 DAS and 60 DAS-harvest were taken using different methodologies. Weed population was counted from an area enclosed in a quadrate of 0.25 m^2 randomly place at two place in each plot and then converted into per square meter. For taking dry weight of weeds, weeds were removed from quadrate area of the plot, washed, air dried and then kept in the oven at 60^0C till constant weight reached and was expressed on oven dry basis in g/m^2. The dry weights of weeds at two consecutive stages were used to worked out weed growth rate. For this the under mention formula was used:

$$\text{Weed growth rate (\%)} = \frac{W_2 - W_1}{t_2 - t_1} \text{ X } 100$$

Where,

W_1 and W_2 = weed dry matter (g) at the two consecutive stages.

t_1 and t_2 = time interval between two consecutive stage at which observation were recorded. Weed control efficiency was calculated using the following formula (Mani *et al*., 1968) [2].

$$\text{WCE} = \frac{\text{Dry matter of weeds In control plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in control plot}} \text{ X } 100$$

Weed Index is calculated by formula as mentioned below:

$$\text{Weed Index (\%)} = \frac{x - y : - y}{X} \text{ X } 100$$

where, x = Grain yield from weed free treatment and y = Grain yield from treatment

Lastly, at harvest, plot wise weight of grains were taken after threshing, cleaning and sun drying and finally recorded in quintal per hectare. For statistical analysis "Analysis of variance" technique was applied to the data recorded for each character. Data of weed count and dry weight should considerable variation, hence the data were subjected to square root transformation $(X + 0.5)^{1/2}$ before analysis. The treatment means computed from the original values has also been presented along with transformed values parenthesis.

Results and discussion

The predominant weeds found in the experimental plots were *Trianthema portulacastrum, Dactyloctenium aegyptium, Cynodon dactylon, Echinochloa colonum* etc. Both the weed density and dry weight of weeds were significantly reduced in different treatment plots as compared to unweeded check. Plant geometry caused reduction in weed count/m^2 but difference was found to be non-significant at all the stages. The lowest weed count/m^2 was recorded under closest row spacing of 20 cm × 10 cm while the higher number of weeds was observed under widest row spacing of 30 cm × 10 cm at all the stages. Weed management practices caused significant reduction in weed count than weedy check at all the stages of growth. Hand weeding twice resulted in the lowest weed count except at 40 DAS which was found at par with chemical weeding at 40 DAS, however, it was significantly lower than chemical weeding at 60 DAS and at harvest. At later growth stages, the weed count recorded under Imazethaypr and Quizalofop ethyl did not varied significantly. Plant geometry exerted significant effect on weed dry weight at 40, 60 DAS and at harvest. The weed dry weight recorded at closer row spacing of 20 cm × 10 cm was at par and significantly lowers than wider row spacing of 30 cm × 10 cm at all stages except at 20 DAS. Hand weeding twice resulted in significant reduction in dry weight of weed than Quizalofop ethyl and Pendimethalin but was at par with Imazethaypr upto 60 DAS. However, at harvest, the weed dry weight recorded under hand weeding, Imazethaypr, Quizalofop ethyl was at par and significantly lower than Pendimethalin. Results of Rathi *et al*. (2004) [4] also substantiated the present findings. The lowest weed growth rate was recorded under closer row spacing of 20 cm × 10 cm (1.16, 0.59, 0.36 and 0.06 g/m^2/day at 0-20, 20-40, 40-60 DAS and at 60 DAS-harvest, respectively) which was significantly lower over wider row spacing except 20-60 DAS, where it was found at to 25 cm × 10 cm. Among the weed management practices, significantly lower weed growth rate was recorded under hand weeding (0.35 g/m^2/day) at 0-20 DAS. However, at 20-40 DAS, Quizalofop ethyl and Imazethaypr showed negative growth rate. At harvest, lowest weed growth rate was recorded under Pendimethalin (0.03 g/m^2/day) which was found at par with Quizalofop ethyl (0.04 g/m^2/day) and significantly lower than hand weeding (0.15 g/m^2/day) and Imazethaypr (0.08 g/m^2/day).

Higher weed control efficiency was registered under closest row spacing of 20 cm × 10 cm which decreased with widening the row spacing and recorded lower value at wider row spacing of 30 cm × 10 cm at all the stages. Among the weed management practices, highest weed control efficiency was recorded under hand weeding twice, while the lowest value of observation under Pendimethalin. Weed index varied among plant geometry and weed management practices. Closer spacing of 20 cm × 10 cm recorded lowest weed index (20.36) and highest was observed under wider row spacing of 30 cm × 10 cm (22.19). Among the weed management practices, lower value of weed index was obtained under Imazethaypr (6.66) and highest value was recorded under weedy check (48.30).

The highest grain yield was recorded under closest row spacing of 20 cm × 10 cm (12.53 q/ha) which was significantly higher over wider row spacing of 25 cm × 10 cm (11.19 q/ha) and 30 cm × 10 cm (9.17 q/ha). The results are in agreement with the findings of Singh *et al.* (2011) [5]. Grain yield due to weed management practices turned out to be

significant over weedy check (7.19 q/ha). Among the weed control treatments, hand weeding twice produced significantly higher grain yield (13.92) but was found at par with Imazethapyr (12.97 q/ha) and signficantly surpassed over Quizalofop ethyl (11.62 q/ha) and Pendimethalin (9.10 q/ha). Among the chemical weeding, Imazethapyr (12.97 q/ha) and Quizalofop ethyl (11.62 q/ha) being at par and significantly out yielded Pendimethalin (9.10 q/ha). These observations corroborated the findings of Malliswari *et al.* (2008) [1].

Table 1: Effect of plant geometry and weed management on weed count/m^2 in summer green gram

Treatment	Weed count/m^2			
	20 DAS	40 DAS	60 DAS	At harvest
Plant geometry				
20 cm x 10 cm	10.81 (139)	6.32 (57)	6.75 (45)	6.67 (44)
25 cm x 10 cm	12.06 (145)	6.83 (66)	6.69 (48)	6.82 (46)
30 cm x 10 cm	12.27 (150)	7.18 (74)	7.11 (50)	6.96 (48)
SEm±	0.25	0.27	0.28	0.15
CD (P=0.05)	NS	NS	NS	NS
Weed Management				
Weedy check	14.88 (221)	15.61 (243)	10.53 (111)	10.49 (109)
Hand Weeding at 15 and 30 DAS	5.98 (35)	3.96 (15)	4.85 (23)	4.71 (22)
Pendimethalin @ 0.75 kg/ha at pre-emergence	7.29 (52)	6.56 (42)	6.79 (46)	6.58 (43)
Quizalofop-ethyl @ 60 g/ha (15 DAS)	14.56 (211)	4.29 (18)	5.73 (32)	5.55 (30)
Imazethapyr @ 60 g/ha (15 DAS)	14.26 (203)	3.48 (12)	5.36 (28)	5.40 (28)
SEm±	0.32	0.36	0.33	0.19
CD (P=0.05)	0.94	1.04	1.01	0.55

Table 2: Effect of plant geometry and weed management on dry weight of weed in summer green gram

Treatment	Dry weight of weed (g/m^2)			
	20 DAS	40 DAS	60 DAS	At harvest
Plant geometry				
20 cm x 10 cm	4.65 (23.20)	5.64(35.04)	6.24 (42.20)	6.32(43.20)
25 cm x 10 cm	5.05 (27.31)	6.03 (40.06)	6.69 (48.40)	6.84 (50.40)
30 cm x 10 cm	5.27 (29.78)	6.37 (44.80)	7.02 (53.46)	7.18 (56.00)
SEm±	0.10	0.14	0.18	0.18
CD (P=0.05)	0.29	0.40	0.53	0.24
Weed Management				
Weedy check	6.43 (40.87)	9.78 (95.43)	10.53 (110.67)	10.75 (115.33)
Hand Weeding at 15 and 30 DAS	2.72 (6.91)	4.10 (16.40)	4.85 (23.10)	5.11 (25.66)
Pendimethalin @ 0.75 kg /ha at pre-emergence	3.71 (13.36)	6.51 (42.00)	6.79 (45.66)	6.78 (45.67)
Quizalofop-ethyl @ 60 g/ha (15 DAS)	6.19 (38.00)	5.076 (25.33)	5.73 (32.33)	5.78 (33.00)
Imazethapyr @ 60 g/ha (15 DAS)	5.92 (34.67)	4.60 (20.67)	5.36 (28.34)	5.49 (29.66)
SEm±	0.13	0.18	0.23	0.24
CD (P=0.05)	0.38	0.52	0.68	0.69

Table 3: Effect of plant geometry and weed management on weed growth rate in summer green gram

Treatment	Weed growth rate (g/day/m^2)			
	0-20 DAS	20-40 DAS	40-60 DAS	60 DAS-at harvest
Plant geometry				
20 cm x 10 cm	1.16	0.59	0.36	0.06
25 cm x 10 cm	1.36	0.63	0.42	0.12
30 cm x 10 cm	1.49	0.75	0.43	0.15
SEm±	0.03	0.04	0.01	0.005
CD (P=0.05)	0.09	0.12	0.03	0.014
Weed Management				
Weedy check	2.04	2.73	0.76	0.27
Hand Weeding at 15 and 30 DAS	0.35	0.47	0.33	0.15
Pendimethalin @ 0.75 kg/ha at pre-emergence	0.67	1.43	0.18	0.03
Quizalofop-ethyl @ 60 g/ha (15 DAS)	1.90	- 0.63	0.35	0.04
Imazethapyr @ 60 g/ha (15 DAS)	1.73	- 0.70	0.38	0.08
SEm±	0.04	0.05	0.015	0.006
CD (P=0.05)	0.12	0.16	0.042	0.017

Table 4: Effect of plant geometry and weed management on weed control efficiency and weed index in summer green gram

Treatment	Weed control efficiency (%)				Weed Index (%)
	20 DAS	40 DAS	60 DAS	At harvest	
Plant geometry					
20 cm x 10 cm	35.56	58.52	56.89	57.23	20.36
25 cm x 10 cm	34.35	57.96	56.49	56.92	20.91
30 cm x 10 cm	33.82	57.78	56.39	56.17	22.19
SEm±	1.63	1.48	1.97	1.99	0.658
CD (P=0.05)	NS	NS	NS	NS	NS
Weed Management					
Weedy check	-	-	-	-	48.30
Hand Weeding at 15 and 30 DAS	83.10	82.89	79.11	77.73	-
Pendimethalin @ 0.75 kg /ha at pre-emergence	67.41	55.90	58.65	60.43	34.43
Quizalofop-ethyl @ 60 g/ha (15 DAS)	6.95	73.42	70.75	71.42	16.34
Imazethapyr @ 60 g/ha (15 DAS)	15.41	78.23	74.44	74.30	6.66
SEm±	2.100	1.904	2.549	2.568	0.850
CD (P=0.05)	6.114	5.543	7.421	7.478	2.474

Table 5: Effect of plant geometry and weed management on grain yield of summer green gram

Treatment	Grain yield (q/ha)
Plant geometry	
20 cm x 10 cm	12.53
25 cm x 10 cm	11.19
30 cm x 10 cm	9.17
SEm±	0.26
CD (P=0.05)	0.77
Weed Management	
Weedy check	7.19
Hand Weeding at 15 and 30 DAS	13.92
Pendimethalin @ 0.75 kg /ha at pre-emergence	9.10
Quizalofop-ethyl @ 60 g /ha (15 DAS)	11.62
Imazethapyr @ 60 g/ha (15 DAS)	12.97
SEm±	0.34
CD (P=0.05)	0.99

Conclusion

From the experiment it is clear that closer plant spacing of 20 cm × 10 cm and amongst the herbicidal treatments, Imazethapyr as post-emergence can be adopted to control all kinds of weeds in green gram cultivation. Though the highest yield was recorded with hand weeding twice but it depicted low economic benefit due to high labour requirement. So, this herbicide (Imazethaypr @ 60 g/ha) provides us with a great opportunity to overcome uneconomic hand weeding.

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