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Effect of planting methods and weed management practices on yield of green gram {*Vigna radiata* (L.) R. Wilczek}, weed dynamics *vis a vis* phytotoxicity in green gram

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ABSTRACT

An experiment was carried out to find out suitable method of planting and weed management in green gram grown during the *kharif* season of 2014 and 2015. The density of *E. colona* and *C. rotundus* was significantly reduced in raised bed planting method. Significant reduction in total dry weight of weeds was obtained in raised bed planting method as compared to conventional and zero till planting method. Maximum weed control efficiency was found in raised bed planting method. Significantly more number of seeds pod^{-1} were observed in raised bed planting method as compared to conventional and zero till planting method. Seed yield and straw yield were found maximum in raised bed planting method during both years of study and were statistically at par in conventional and zero till planting method. Harvest index was not influenced by planting methods. Phytotoxicity on crop due to different herbicides was similar under different planting methods. Among different weed management treatments, HW at 15 and 30 DAS was found most effective in reducing density and dry weight of weeds during crop growing period except at 15 DAS (where weeding was done after taking observation). Maximum weed control efficiency was observed in HW (15 & 30 DAS). Weedy check treatment resulted in minimum while weed free treatment resulted in maximum number of seeds pod^{-1}. Among the treatments having herbicide application, post emergence application of Imazethapyr @ 100 g ha^{-1} resulted in maximum seed and stover yield.

Key words: Density, Dry weight, Green gram, Phytotoxicity, Planting methods, Weed control efficiency, Weed management practices.

INTRODUCTION

Green gram {*Vigna radiata* (L.) R. Wilczek} is one of the major *kharif* pulse crop. In India, the crop is cultivated in arid and semi arid regions. It occupies 3.38 million hectare area and contributes to 1.61 million tonnes (DES, 2015). The green gram is a fast growing, warm season legume. It reaches maturity very quickly under tropical and subtropical conditions where optimal temperatures are about 28-30^{o}C and always above 15^{o}C. In *kharif* season, weeds are serious problem due to favourable conditions for their growth. Adequate tillage checks and delays the emergence of weeds and provides a more favourable environment for early crop establishment.The dominating weed flora found in Haryana consisted of *Trianthema portulacastrum*, *Echinochloa colona*, *Digera arvensis*, *Dactyloctenium aegyptium*, *Cyperus rotundus*, *Cyperus compressus*, *Cleome viscosa*, *Cucumis callosus*, *Tribulus terresteris*, *Corchorus tridens*, *Chorchorus aestuans* (Anonymous, 2011). Cultural as well as mechanical practices such as hand weeding and interculture are effective but unavailability of labour and continuous rainfall in rainy season does not permit to remove weeds timely. Chemical weed control is other option which is cheaper and provides effective control of weeds.

MATERIALS AND METHODS

The experiment was conducted at research farm, Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana during *kharif* season of 2014 and 2015. The soil of experimental field was sandy loam in texture having pH of 7.8. The soil was medium in organic carbon (0.28 %), available nitrogen (160 kg ha^{-1}), phosphorus (16 kg ha^{-1}) and potassium (342 kg ha^{-1}). Three planting methods were taken as main plot treatment (raised bed, conventional and zero till) and nine weed management practices [Weedy check , Hand weeding (15 & 30 DAS) , Weed free ,Pendimethalin PRE @ 1000 g ha^{-1}, Imazethapyr PRE @ 70 g ha^{-1}, Imazethapyr PRE @ 100 g ha^{-1}, Imazethapyr 3-4 leaf stage @ 70 g ha^{-1}, Imazethapyr 3-4 leaf stage @ 100 g ha^{-1}, Imazethapyr + Imazamox(RM) 3-4 leaf stage @ 70 g ha^{-1}] were taken as sub plot treatment using split plot design. During 2014, field was prepared in last week of June by cross harrowing followed by cultivator in plots where conventional tillage and raised bed method of planting was to be practiced and raised beds were prepared by bed planter machine, then planking was done to bring fine tilth and no soil disturbance was done in plots where zero till method of planting was practiced. Previously

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growing weeds present in plots where zero tillage was practiced were killed by application of glyphosate. During 2015, plots of conventional till planting method were prepared with same operations as done in previous year in the last week of June while raised beds were kept as such and only their reshaping was done and no disturbance was done in plots where zero till planting method was practiced.Sowing was done on 30 June and 2 July during 2014 and 2015, respectively using seed rate 20 kg ha^{-1} (Variety MH-421)with recommended dose of fertilizer by seed cum fertilizer drill and by bed planter on raised beds with two rows of green gram on the bed (75 cm wide). Pendimethalin and Imazethapyr were applied as pre-emergence (PRE) spray to the soil surface as per treatment on the day of sowing and Imazethapyr and Imazethapyr + Imazamox (RM) were applied at 3-4 leaf stage during both years of experimentation as per treatment. Herbicides were applied through knapsack sprayer. Hand weeding was done manually with the help of *kasola* to keep the field free from weeds in weed free treatment and two hand weeding were done at 15 and 30 DAS in the plots where it was required as per treatment. *Echinochloa colona* and *Cyperus rotundus* were the two most abundant weeds present in the experimental field. Weeds present within two randomly selected (0.5 m x 0.5 m) quadrate in each net plot area were counted separately at 15, 45 DAS and at maturity and converted to represent number of weeds m^{-2}.Weed samples from two randomly selected spots for each plot taken for weed density of individual weed at 15, 45 DAS and before maturity with the help of quadrate measuring 0.5 m x 0.5 m were collectively put for oven drying at 70°C till constant weight was achieved. Then dried weed samples were weighed and the weight was expressed in terms of g m^{-2} before subjecting to statistical analysis. The weed control efficiency was calculated by the following formula and expressed in percentage:

$$WCE\ (\%) = \frac{\text{Dry weight of weeds in weedy check - Dry weight of weeds in treatment}}{\text{Dry weight of weeds in weedy check}} \text{ X } 100$$

For calculating number of seeds pod^{-1} all the pods were taken from three tagged plants. Pods were removed carefully by hand. Seeds were separated from straw and then they were counted and an average was worked out. A random sample from each plot was taken from the threshed grains. Later on counting of 100 seed was carried out for each treatment separately and was weighed on an electric balance. From the recorded data of seed yield kg per plot, seed yield were computed kg per hectare on multiplying the yield per plot by conversion factor. From the recorded data of biological yield kg per plot, seed yield kg per plot was subtracted and then computed kg per hectare on multiplying the yield per plot by conversion factor. Harvest index was calculated using the following formula:

$$\text{Harvest index } (\%) = \frac{\text{Economic yield (seed)}}{\text{Biological yield (seed+ straw)}} \text{ X } 100$$

Phytotoxicity on crop due to different herbicides was observed visually at 30 DAS (0-100 scale).

RESULTS AND DISCUSSION

Effect of planting methods on

a) Density, dry weight of weeds and weed control efficiency: Planting methods did not influence density and dry weight of weeds at 15 DAS during both years. Density of weeds, dry weight of weeds, efficiency to control weeds (Table 1,2,3 & 4) was significantly influenced by planting methods during both years.

Table 1: Effect of planting methods and weed management on density of *E. colona* (no. m^{-2}).

Treatments	15 DAS		45 DAS		Before maturity (60 DAS)	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	2.5 (6.8)	2.8 (8.5)	3.6 (15.8)	3.9 (17.4)	2.7 (8.2)	2.9 (9.5)
Conventional	2.6 (6.9)	2.8 (9.1)	4.1 (20.0)	4.5 (24.6)	3.1 (10.8)	3.4 (12.9)
Zero till	2.6 (7.2)	2.9 (8.8)	4.0 (19.1)	4.4 (21.7)	3.0 (10.4)	3.3 (12.1)
SEm±	0.04	0.05	0.05	0.07	0.06	0.10
CD at 5%	NS	NS	0.14	0.21	0.19	0.28
B. Weed management						
Weed free	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)
Pendimethalin PRE (1000 g ha^{-1})	1.6 (1.8)	1.6 (1.7)	4.7 (22.1)	5.2 (26.5)	3.5 (12.0)	3.9 (14.5)
Imazethapyr PRE (70 g ha^{-1})	1.7 (2.0)	1.7 (1.8)	5.4 (29.1)	5.6 (30.2)	4.1 (16.0)	4.1 (16.2)
Imazethapyr PRE (100 g ha^{-1})	1.6 (1.8)	1.6 (1.6)	5.0 (25.0)	5.3 (27.5)	3.8 (13.6)	3.9 (14.4)
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	3.5 (11.5)	3.9 (14.6)	2.9 (7.7)	3.3 (9.8)	2.3 (4.6)	2.6 (6.2)
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	3.5(11.5)	4.0 (15.1)	2.8 (7.3)	3.2 (9.3)	1.7 (2.0)	2.1 (3.5)
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	3.6 (11.6)	3.9 (14.3)	3.5 (11.7)	3.8 (13.8)	3.1 (9.1)	3.4 (10.8)
Hand weeding (15 & 30 DAS)	3.5 (11.5)	4.0 (15.3)	2.4 (4.8)	3.0 (8.2)	1.6 (1.7)	1.9 (2.5)
Weedy check	3.4 (11.0)	3.9 (15)	7.6 (57.2)	8.1 (65.6)	5.5 (29.4)	6.0 (35.2)
SEm±	0.07	0.06	0.08	0.09	0.06	0.06
CD at 5%	0.21	0.19	0.24	0.25	0.19	0.18

*Original data given in parenthesis were subjected to square root $\sqrt{(x + 1)}$ transformation before analysis.

Observations taken at 45 DAS and before maturity (Table 1) showed that density of *E. colona* was significantly lower in bed planting method which may be due to more foliage growth of bed planted green gram which caused hindrance in germination of weeds and deeper burial of weed seeds during formation of raised beds. As results presented in Table 2 showed that density of *C. rotundus* increased at a very fast rate from 15 DAS to 45 DAS, however, the increase was slow from 45 DAS- maturity. Except at 15 DAS, bed planting method resulted in significantly lower density of *C. rotundus* during both years of study. Similar results where decrease in weed infestation in bed planted crop was observed were reported by Singh *et al*.(2004), Kumar *et al*. (2006), Mishra and Singh (2009), Jha and Soni (2013). Significantly lower dry weight of weeds at 45 DAS and before maturity (Table 3) was observed in bed planting method that may be due to better crop growth in bed planting which did not allow weeds to get optimum sunlight, moisture and nutrient supply for accumulation of more dry matter in them and thus checked their growth. Similar were the findings of Kumar *et al*. (2006) in blackgram where raised bed planting resulted in minimum total weed count and dry matter

Table 2: Effect of planting methods and weed management on density of *C. rotundus* (no. m^{-2}).

Treatments	15 DAS		45 DAS		Before maturity	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	2.6 (6.5)	2.7 (7.4)	5.4 (33.0)	5.6 (34.1)	6.6 (49.1)	6.9 (52.9)
Conventional	2.7 (7.3)	2.8 (7.7)	5.7 (36.6)	6.0 (39.8)	7.0 (55.1)	7.3 (59.7)
Zero till	2.6 (6.9)	2.7 (7.6)	5.6 (35.6)	6.2 (42.7)	6.9 (53.8)	7.3 (58.5)
SEm±	0.04	0.06	0.03	0.07	0.05	0.06
CD at 5%	NS	NS	0.10	0.20	0.15	0.19
B. Weed management						
Weed free	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)
Pendimethalin PRE (1000 g ha^{-1})	3.2 (9.7)	3.4 (10.7)	7.9 (62.0)	8.2 (66.7)	9.2 (84.5)	9.4 (87.4)
Imazethapyr PRE (70 g ha^{-1})	1.8 (2.3)	1.7 (2.0)	6.8(45.5)	7.0 (48.8)	8.2 (66.6)	8.6 (73.0)
Imazethapyr PRE (100 g ha^{-1})	1.5 (1.3)	1.5 (1.4)	6.5 (42.3)	6.7 (45.3)	8.0 (63.3)	8.3 (68.5)
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	3.3 (10.2)	3.3(10.4)	5.6 (31.3)	6.0 (36.2)	7.2 (51.7)	7.7 (58.4)
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	3.3 (10.1)	3.4 (11.0)	5.3 (27.4)	5.9 (34.0)	6.8 (45.5)	7.2 (50.6)
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	3.2 (9.8)	3.4 (10.8)	5.8 (33.1)	6.2 (37.5)	7.5(55.5)	7.9 (61.7)
Hand weeding (15 & 30 DAS)	3.2 (9.5)	3.5 (11.0)	3.5 (11.4)	3.7 (13.0)	4.5 (19.8)	5.0 (24.4)
Weedy check	3.2 (9.3)	3.4 (10.7)	7.9 (62.8)	8.2 (68.2)	9.3 (87.0)	9.5 (89.3)
SEm±	0.05	0.05	0.09	0.07	0.06	0.07
CD at 5%	0.14	0.15	0.28	0.20	0.19	0.20

*Original data given in parenthesis were subjected to square root $\sqrt{(x + 1)}$ transformation before analysis.

Table 3: Effect of planting methods and weed management on dry weight of weeds (g m^{-2}).

Treatments	15 DAS		45 DAS		Before maturity	
	2014	2015	2014	2015	2014	2015
A. Planting methods						
Raised bed	1.7 (2.16)	1.6 (1.80)	5.5 (36.10)	4.7 (27.10)	9.4 (10.60)	8.9 (96.70)
Conventional	1.7 (2.17)	1.6 (1.90)	6.4 (49.70)	6.0 (43.40)	10.3 (124.80)	10.0 (117.70)
Zero till	1.7 (2.17)	1.6 (1.80)	6.2 (45.80)	5.6 (37.80)	10.1 (121.10)	9.8 (113.90)
SEm±	0.01	0.01	0.15	0.14	0.17	0.10
CD at 5%	NS	NS	0.45	0.41	0.49	0.30
B. Weed management						
Weed free	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)
Pendimethalin PRE (1000 g ha^{-1})	1.4 (0.97)	1.3 (0.77)	7.5 (56.30)	6.7 (45.30)	13 (169.5.00)	12.6 (158.60)
Imazethapyr PRE (70 g ha^{-1})	1.3 (0.63)	1.2 (0.50)	7.1 (50.10)	6.4 (40.70)	11.9 (142.20)	11.5 (132.00)
Imazethapyr PRE (100 g ha^{-1})	1.2 (0.50)	1.2 (0.48)	6.7 (45.00)	5.9 (35.30)	11.7 (136.00)	11.3 (127.80)
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	2.1 (3.30)	1.9 (2.90)	5.7 (32.00)	5.4 (28.20)	8.9 (80.00)	8.7 (74.80)
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	2.1 (3.40)	1.9 (2.90)	4.6 (21.00)	4.3 (18.30)	7.6 (58.00)	7.4 (54.50)
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	2.0 (3.40)	2.0 (3.00)	6.3 (40.00)	5.5 (30.00)	9.9 (99.00)	9.7 (94.80)
Hand weeding (15 & 30 DAS)	2.1 (3.60)	2.0 (3.00)	3.8 (13.80)	3.2 (9.30)	7 (48.00)	6.8 (46.50)
Weedy check	2.1 (3.60)	2.0 (3.00)	11.6 (136.00)	10.8 (117.00)	17.9 (321.00)	17.2 (295.80)
SEm±	0.07	0.03	0.15	0.11	0.07	0.06
CD at 5%	0.20	0.10	0.45	0.32	0.20	0.17

*Original data given in parenthesis were subjected to square root $\sqrt{(x + 1)}$ transformation before analysis.

Table 4: Weed control efficiency (%) of different treatment combinations to control weeds before maturity.

Weed Management	Weed free	Pendimethalin PRE (1000 g ha^{-1})	Imazethapyr PRE (70 g ha^{-1})	Imazethapyr PRE (100 g ha^{-1})	Imazethapyr 3-4 leaf stage (70 g ha^{-1})	Imazethapyr 3-4 leaf stage (100 g ha^{-1})	Imazethapyr + Imazamox (RM) 3-4 leaf stage (70 g ha^{-1})	Hand weeding (15 & 30 DAS)	Weedy check	Mean
Planting methods										
					2014					
Raised bed	100	47.5	57.1	60.1	78.4	86.5	73.4	86.9	0	65.5
Conventional	100	46.1	53.6	55.4	72.0	78.5	65.4	83.2	0	61.5
Zero till	100	47.2	56.1	56.5	74.4	80.9	68.7	84.3	0	63.1
Mean	100	46.9	55.6	57.3	74.9	82.0	69.1	84.8	0	
					2015					
Raised bed	100	48.8	59.4	59.1	74.9	84.8	68.8	86.4	0	64.6
Conventional	100	46.3	52.8	56.6	71.8	80.1	67.6	82.9	0	62.0
Zero till	100	47.2	58.1	58.5	74.0	82.2	68.7	86.1	0	63.8
Mean	100	47.4	56.7	58.0	73.6	82.3	68.3	85.1	0	

while in soybean crop Jha and Soni (2013) also reported lowest weed density of monocot and dicot weeds under broad bed and furrow method of sowing. During second year of study, less dry weight of weeds was observed as compared to dry weight of weeds during first year although weed density was more in second year as compared to first year, which might be due to higher rainfall received during second year which favoured better growth of green gram which did not allow weeds to accumulate more dry weight by causing hindrance in their photosynthesis.

Mean weed control efficiency (Table 4) was minimum in conventional planting method during both years of study and maximum in bed planting method. Similarly, Jha and Soni (2013) found higher weed control efficiency under broad bed and furrow method of sowing in soybean crop.

b) Yield: Bed planting method resulted in significantly more number of seeds pod^{-1} (Table 5) during both years of study as growth parameters were improved in bed planting method due to better growing condition and lesser competition by weeds. However, 100 seed weight was not affected by planting methods. Seed yield being a function of yield attributes was also significantly more in bed planting method. Similar results were reported by Shivakumar *et al*. (2001), Dhindwal *et al*. (2006), Yadav and Singh (2014) in green gram and Kang *et al*. (2012) in soybean. Straw yield (Table 5) were also significantly more in bed planting method as compared to conventional and zero till planting method during both years. However, harvest index (Table 5) was found to be non significant among different planting methods.

Effect of weed management practices on

a) Density, dry weight of weeds and weed control efficiency: Density of *E. colona* (Table 1) at 15 DAS was significantly reduced in treatments receiving pre emergence application of Pendimethalin @ 1000 g ha^{-1}, Imazethapyr @ 70 g ha^{-1}, Imazethapyr @ 100 g ha^{-1} as compared to weedy check during both years of study. As no post emergence herbicide was applied at this stage, so density of *E. colona* in these treatments was similar to weedy check and hand weeding was also done after taking observation. Observations taken at 45 DAS showed good control of *E. colona* in all weed management treatments compared to weedy check.

There was no weed in weed free treatment. After this treatment, next best treatment in reducing the density of *E. colona* was HW (15 & 30 DAS) followed by treatment having post emergence application of Imazethapyr @ 100 g ha^{-1} and Imazethapyr @ 70 g ha^{-1}.At 15 DAS, pre emergence application of Imazethapyr @ 100 g ha^{-1} and Imazethapyr @ 70 g ha^{-1} provided good control of *C. rotundus* (Table 2) compared to weedy check. Pre emergence application of Pendimethalin @ 1000 g ha^{-1} was not effective in controlling *C. rotundus* at any stage. Hand weeding was also done after taking observation, so density in this treatment was also

Table 5: Effect of planting methods and weed management on yield attributes and yield of green gram.

Treatments	Seeds pod^{-1}(no.)		100 seed weight(g)		Seed yield (kg ha^{-1})		Straw yield(kg ha^{-1})		Harvest index(%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A. Planting methods										
Raised bed	9.1	9.7	4.0	4.1	835	857	2400	2476	25.1	25.0
Conventional	8.0	8.6	4.0	3.9	734	796	2266	2381	23.8	24.3
Zero till	7.6	9.0	3.9	3.9	716	810	2254	2389	23.4	24.6
SEm±	0.30	0.20	0.01	0.01	7.6	7.9	8.0	6.6	0.14	0.12
CD at 5%	0.9	0.6	NS	NS	22	23	23	20	NS	NS
B. Weed management										
Weed free	9.6	10.5	4.0	4.0	1094	1130	2715	2783	28.6	28.8
Pendimethalin PRE (1000 g ha^{-1})	7.3	8.4	4.0	4.0	457	475	1725	1868	20.9	20.3
Imazethapyr PRE (70 g ha^{-1})	7.7	8.8	3.9	4.0	659	713	2307	2497	22.2	22.2
Imazethapyr PRE (100 g ha^{-1})	8.2	9.0	4.0	4.0	712	746	2409	2575	22.8	22.5
Imazethapyr 3-4 leaf stage (70 g ha^{-1})	8.5	9.5	4.0	3.9	873	978	2570	2649	25.2	26.9
Imazethapyr 3-4 leaf stage (100 g ha^{-1})	8.9	9.7	3.9	4.0	917	1022	2633	2747	25.7	27.1
Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	8.2	9.4	4.0	4.0	842	952	2548	2639	24.7	26.5
Hand weeding (15 & 30 DAS)	9.1	9.7	4.0	3.9	1033	1070	2765	2799	27.1	27.6
Weedy check	6.1	7.2	3.9	3.9	265	300	1085	1180	19.6	20.2
SEm±	0.37	0.32	0.02	0.02	10.4	8.1	19.0	21.2	0.27	0.22
CD at 5%	1.1	1.0	NS	NS	29	23	55	61	0.7	0.6

Table 6: Phytotoxicity (%) in green gram (0-100 scale) due to different weed management practices under different planting methods at 30 DAS.

Weed Management	Weed free	Pendimethalin PRE (1000 g ha^{-1})	Imazethapyr PRE (70 g ha^{-1})	Imazethapyr PRE (100 g ha^{-1})	Imazethapyr 3-4 leaf stage (70 g ha^{-1})	Imazethapyr 3-4 leaf stage (100 g ha^{-1})	Imazethapyr + Imazamox(RM) 3-4 leaf stage (70 g ha^{-1})	Hand weeding (15 & 30 DAS)	Weedy check
Planting methods				**2014**					
Raised bed	0	0	0	0	12.6	20.3	10.0	0	0
Conventional	0	0	0	0	12.3	20.0	9.3	0	0
Zero till	0	0	0	0	13.0	20.6	10.3	0	0
Mean	0	0	0	0	12.6	20.3	9.8	0	0
				2015					
Raised bed	0	0	0	0	13.0	22.6	10.6	0	0
Conventional	0	0	0	0	13.0	22.3	11.3	0	0
Zero till	0	0	0	0	13.3	21.6	11.0	0	0
Mean	0	0	0	0	13.1	22.2	11.0	0	0

similar to weedy check. At 45 DAS all herbicides provided good control of *C. rotundus* compared to weedy check except Pendimethalin @ 1000 g ha^{-1}. Observations taken before maturity showed that after weed free treatment, HW (15 & 30 DAS) was best treatment in reducing density of *C. rotundus* and among treatments having herbicides application, post emergence application of Imazethapyr @ 100 g ha^{-1} proved best. Similar were findings of Meena *et al*. (2011) in soybean and Kumar *et al*. (2016) in mungbean.

Dry weight of weeds (Table 3) at 15 DAS showed that application of all the three pre emergence herbicides (Pendimethalin @1000 g ha^{-1}, Imazethapyr @ 70 g ha^{-1}, Imazethapyr @ 100 g ha^{-1}) proved very effective in reducing dry weight of weeds as compared to weedy check. At 45 DAS all weed management treatments proved effective in reducing the dry weight of weeds compared to weedy check. Observations taken before maturity revealed that weedy check treatment resulted in maximum dry weight of weeds as there was no control of weeds. After weed free treatment, HW (15 & 30 DAS) was best in reducing dry weight of weeds as compared to weedy check. All herbicides were effective in significantly reducing dry weight of weeds as compared to weedy check but post emergence application of Imazethapyr @ 100 g ha^{-1} was best in reducing dry weight of weeds. Similar were the findings of Veeraputhiran *et al*. (2008) in blackgram, Ram and Singh (2011) in soybean, Singh *et al*. (2014a), Khairnar *et al*. (2014), Kumar *et al*. (2016) in mungbean.

Mean weed control efficiency (Table 4) was found to be maximum in HW (15 & 30 DAS) followed by treatment having post emergence application of Imazethapyr @ 100 g ha^{-1} during both years of study. Results were in conformity with the findings of Khairnar *et al*. (2014), Singh *et al*. (2014a), Kumar *et al*. (2016) in green gram. Higher weed control efficacy and long lasting effects of Imazethapyr in reducing weed dry matter might be due to broad spectrum activity of herbicide particularly on established plants and its greater efficacy to retard cell division of meristem as a result of which weeds died rapidly. Lower weed control efficiency was observed in treatment having pre emergence application of Pendimethalin @ 1000 g ha^{-1} due to no control of *C. rotundus* which was one of the major weed in the field during both years and decrease in efficiency of Pendimethalin to control later flushes of weeds which appeared with advancement of crop age.

b) Yield: Seeds pod^{-1} varied among different weed management treatments; however, there was no effect on 100 seed weight (Table 5). Similar effect on 100 seed weight by weed management practices was observed by Tamang *et al*. (2015) in green gram. The maximum number of seeds pod^{-1} was found in weed free treatment followed by HW (15 & 30 DAS) as there was no competition with weeds and better availability of nutrients and moisture which resulted in higher crop growth rate and finally better results in terms of yield attributes. Post emergence application of Imazethapyr @ 100 g ha^{-1} resulted in maximum number of seeds pod^{-1} among treatments having application of herbicides. Lower weed dry weight and high weed control efficiency which resulted in lesser crop-weed competition showed better results in the form of higher yield attributes in crop. Similar were the findings of Godara and Singh (2014).

As yield attributes were improved in all weed management practices compared to weedy check, thus seed yield, straw yield and harvest index in green gram (Table 5) get improved with adoption of weed management practices as compared to weedy check during both years of study. Weed free treatment provided maximum seed yield and harvest index during both years of study. HW (15 & 30 DAS) was next best treatment after weed free treatment. Among treatments having herbicide application, post emergence application of Imazethapyr @ 100 g ha^{-1} resulted in maximum seed yield, straw yield and harvest index in green gram during both years. Similar results were reported by Singh *et al*. (2014a) and Kumar *et al*. (2016) in green gram. Pre emergence application of Pendimethalin @ 1000 g ha^{-1} resulted in lower values of yield attributes and yield as compared to post emergence application of Imazethapyr @ 70 g ha^{-1}, Imazethapyr @ 100 g ha^{-1} and Imazethapyr + Imazamox @ 70 g ha^{-1} because *C. rotundus* is not controlled with the application of Pendimethalin. Similar were the findings of Kaur *et al*. (2016) in green gram.

Phytotoxicity on green gram due to weed management practices: Application of Imazethapyr @ 70 g ha^{-1}, Imazethapyr @ 100 g ha^{-1} and Imazethapyr + imazamox @ 70 g ha^{-1} at 3-4 leaf stage resulted in reduced plant height of green gram and phytotoxicity which caused leaf chlorosis (Table 6). Similarly, phytotoxic effect of imazethapyr was also reported by Gousia (2005), Naidu *et al*. (2012) on blackgram and Punia (2014) in green gram.

CONCLUSION

Imazethapyr @ 100 g ha^{-1} applied at 3-4 leaf stage was most effective in controlling weeds among different herbicidal treatments. Among pre-emergence herbicides, Imazethapyr @ 100 g ha^{-1} was most effective. Higher dose of Imazethapyr (100 g ha^{-1}) was found more effective in controlling weeds as compared to its lower dose (70 g ha^{-1}). Based on two years study, raised bed planting (75 cm bed) method was found superior to conventional and zero till planting methods. Raised bed planting produced 10.5 % and 10.8 % higher seed yield of green gram as compared to conventional and zero till planting methods, respectively. Yield attributes of green gram were also found superior in raised bed planting.

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