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°C and always above 15°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 *Triandema portulacastrum*, *Echinochloa colona*, *Digera arvensis*, *Dactyloctenium aegyptium*, *Cyperus rotundus*, *Cyperus compressus*, *Cleome viscosa*, *Cucumis callosus*, *Tribulus terrestris*, *Corchorus tridens*, *Corchorus aespans* (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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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                     | 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) |
| SE±              | 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)  |
| Pendimethalin PRE | 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  | 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  | 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 | 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 | 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 | 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 (15.5) | 7.6 (57.2) | 8.1 (65.6) | 5.5 (29.4) | 6.0 (35.2) |
| SE±              | 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 |
|------------|--------|--------|-----------------|
| 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 |

**Table 3:** Effect of planting methods and weed management on dry weight of weeds (g m⁻²).

| Treatments | 15 DAS | 45 DAS | Before maturity |
|------------|--------|--------|-----------------|
| 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 |

*Original data given in parenthesis were subjected to square root \((x + 1)\) 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 |           |                                 |                             |                             |                                        |                                        |                                             |                           |             |       |
| 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           | 63.1  |
| 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           | 65.5  |

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. 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.
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               | 20               | 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                           | 12.6                          | 20.3                                   | 10.0                                   | 0                                                           | 0                           |             |
| Conventional    | 0         | 0                               | 0                           | 12.3                          | 20.0                                   | 9.3                                    | 0                                                           | 0                           |             |
| Zero till       | 0         | 0                               | 0                           | 13.0                          | 20.6                                   | 10.3                                   | 0                                                           | 0                           |             |
| Mean            | 0         | 0                               | 0                           | 12.6                          | 20.3                                   | 9.8                                    | 0                                                           | 0                           |             |
| **2015**        |          |                                 |                              |                              |                                        |                                        |                                                             |                              |             |
| Raised bed      | 0         | 0                               | 0                           | 13.0                          | 22.6                                   | 10.6                                   | 0                                                           | 0                           |             |
| Conventional    | 0         | 0                               | 0                           | 13.0                          | 22.3                                   | 11.3                                   | 0                                                           | 0                           |             |
| Zero till       | 0         | 0                               | 0                           | 13.3                          | 21.6                                   | 11.0                                   | 0                                                           | 0                           |             |
| Mean            | 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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