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Weed growth and productivity of green gram (*Vigna radiata* L.) under integrated weed management practices

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Abstract

Green gram is a short-duration crop that requires initial control of weeds for better crop establishment. The growth and productivity of green gram under integrated weed management was studied at the Agricultural farm of Faculty of Agricultural Sciences, Siksha 'O' Anusandhan, deemed to be University, Bhubaneswar, in the summer 2022. Ten treatments comprised of recommended herbicides, the stale seedbed technique, an aqueous extract of *Calotropis gigantea* and their combination were designed in the RBD with 3 replications. Results showed that the minimum density and biomass of weeds and maximum growth of green gram were found in twice hand weeding, which was statistically significant with the pre-emergence application of pendimethalin *fb* imazethapyr as post-emergence and the stale seedbed technique *fb* imazethapyr as post-emergence. The maximum yield (10.70 q/ha) was documented under two-hand weeding at 15 and 30 DAS, which was statistically comparable with the yield levels of sequential application of pendimethalin *fb* imazethapyr (10.17 q/ha) and stale seedbed technique *fb* imazethapyr as post-emergence (9.92 q/ha). Thus, pendimethalin at 750 g/ha at 1 DAS or stale seedbed at 15 days before sowing (DBS), followed by imazethapyr at 75 g/ha at 20 DAS, appeared to be effective in reducing the diverse weed flora significantly and achieving higher growth and yield in summer green gram.

Keywords

Aqueous leaf extract; *Calotropis;* summer green gram; stale seedbed; weed management

Introduction

Green gram (*Vigna radiata* L.) is the most widely cultivated pulse crop in India. It is one of the most important sources of protein for nutrition. In India, pulses are grown in 28.78 M ha with an overall production of 25.46 million tonnes during 2020-21 (1). In Odisha, green gram is mainly cultivated after the harvesting of rice crop in the rainy season. The irrigated area is also suitable for growing green gram in the summer. Weeds are one of the most critical constraints on yield reduction in short-duration pulses like green gram. The weed infestation in green gram can significantly reduce the yield to 30–80 % during the summer and *kharif* seasons (2, 3).

The control of weeds during the critical period of crop-weed competition is very important so as to avoid yield loss. The initial growth is very slow and the crop suffers from severe weed competition up to 35-40 days after sowing (DAS), which causes a significant yield reduction in green gram. Hand weeding is safe and environment friendly, but escalates the cost of cultivation and is a tedious job to carry out in a large area. Therefore,

the use of chemical means of weed control has gradually increased among farmers. The recent development of herbicides with broad-spectrum weed control creates a new avenue to control weeds in green gram. However, it is essential to apply appropriate herbicides at the recommended dose to control the composite weed flora in green gram. A higher rate of herbicides leaves residues in succeeding crops, whereas a sub-optimal dose may not kill the weeds properly. Thus, herbicides may be recommended based on the nature and intensity of the weed flora in a particular area. In view of the level of weed infestation in summer green gram, the pre and/or post-emergence herbicides are recommended. Application of pendimethalin *fb* imazethapyr significantly reduced weed population and biomass (2). But the application of herbicides alone is not a feasible choice from a sustainable point of view. Thus, the integration of different approaches to weed control may be brought together to reduce the weed infestation below ETL.

As a preventive measure, it is important to reduce the weed pressure in the weed seed bank. In the stale seedbed technique, the weeds are stimulated to emerge by preparing a false seedbed and controlled by either giving shallow tillage or applying a non-selective herbicide before sowing. The stale seedbed resulted in lower down the total weed density then the standard seedbed prepared for normal sowing (4). The stale seedbed technique is a cultural practice that shows great potential as a viable component for integrated weed management by lowering herbicide applications and overall production costs (5). Whereas, plant extracts with allelopathic potential may be involved in reducing weeds in crops and cropping systems. The aqueous extract of *Calotropis* sp. had a retarding effect on different plants due to the phytotoxic effect in it (6, 7).

Chemical weed control methods should be judiciously combined with any feasible method of weed management to achieve safer results. The integration can also reduce the load of chemicals in modern agriculture. Therefore, the present study was conducted based on the objective of evaluating the efficacy of herbicides, stale seedbed techniques, botanicals and their integration on weed density and biomass, crop growth and productivity of summer green gram.

Materials and Methods

The Agricultural farm of the Faculty of Agricultural Sciences, Siksha 'O' Anusandhan, Deemed to be University, Bhubaneswar, Odisha, is located at 20˚15′N latitude and 85˚40′E longitude and 58 m altitude above the mean sea level (MSL), where the investigation was carried out in the summer, 2022. During the green gram cultivation, 41.1 mm rainfall was received, with minimum and maximum rainfall of 1.1 mm and 40.0 mm in the 7th and 8th meteorological standard week respectively. The maximum temperature ranging from 28.7 ˚C to 40.7 ˚C was observed in the 6th and 17th meteorological standard week during 2022. The minimum temperature fluctuated from 15.3˚C to 27.5 ˚C for the same week. The maximum relative humidity of 95.3 % was observed in the 6th meteorological week of 2022. The texture of the soil was sandy loam in nature, with an acidic pH of 5.86. The soil was low in organic carbon (0.47 %), available nitrogen (205.6 kg/ha) and potash (106.6 kg/ha), whereas, medium in phosphorous (18.4 kg/ha). The investigation was undertaken in RBD with 10 treatments in 3 replications. The green gram variety *Virat* (IPM 205-07) was sown at the rate of 25 kg/ha on 15th February, 2022 followed the recommended spacing of 25 cm row to row in the north-south direction. Fertilizers were given at the rate of 20-40-20, N-P_2O_5-K_2O kg/ha through urea, SSP and MOP, respectively.

Herbicides were sprayed as per the respective doses using the knapsack sprayer with a flat fan nozzle at appropriate stages. In the stale seedbed, one irrigation was given 15 days before seed sowing to encourage the weeds to germinate and the flush of weeds were controlled by shallow harrowing. Fresh, disease-free leaves of *Calotropis gigantea* were washed thoroughly and allowed to dry under the shade at room temperature. The air-dried sample was further oven-dried. Then the oven-dried samples were crushed to make powder by using a clean mortar and pestle. The powder was used to prepare 10 and 20 % w/v by soaking 100 g and 200 g of powered *C. gigantea* in 1000 mL of distilled water separately for 48 h at room temperature, respectively. The solution was then filtered through the Whatman No.1 and stored below 4 ˚C in a refrigerator until used. An oxygenated diterpenes phytol was a significant compound in *Calotropis* sp. responsible for the phytotoxicity effect in different plants. Two hand weeding was done at 15 and 30 days after sowing in the summer green gram.

The crop growth parameters of green gram were recorded at 30 DAS during the summer. The height and branch number of randomly selected plants in the net plot area were determined and the average was taken for analysis. The weed density was recorded by placing a 50 cm × 50 cm quadrate in the ear-marked sampling area in each plot at 30 DAS. For dry matter accumulation of plant and weed biomass observation, the plant and weed specimens were oven dried at a temperature of 70 ± 2 °C until a constant weight was reached. Seed and stover yield were taken from the undisturbed net plot area in the center of each plot and expressed in q/ha.

The significance of different sources of variation was tested by the "Error Mean Square Method" of Fisher Snedecor's "F" test at a probability level of 0.05. In the tables, the standard error of means (S.Em ±) and the value of critical differences (C.D.) between means have been provided. Data showing wide variation and having the value zero in weed density and biomass, were subjected to square root transformation [√ (x + 0.5)] before statistical analysis to normalize their distribution (8).

Results and Discussion

The field was infested with 8 weeds, such as *Poa annua* and *Digitaria sanguinalis* among the grasses and *Melochia*

corchorifolia, Aeschynomene afraspera, Cassia tora, Croton sparsiflorus, Mitracarpus hirtus and *Coldenia procumbens* among the broadleaved weeds. Out of which *Poa annua*, *Digitaria sanguinalis* and *Melochia corchorifolia* were found to be predominant during the crop-growing period. The dominance of *Digitaria sanguinalis* was also observed in pulse crops (9, 10).

Results revealed that integrated weed management, along with sole weed control practices had a significant effect on reducing, the population and biomass of weeds. Two hand weeding effectively minimized the density and biomass of weeds during the critical period of crop weed competition, which was closely followed by the application of pendimethalin *fb* imazethapyr (T_6) and the stale seedbed technique *fb* imazethapyr (T_5) (Table 1). This could be due to the effective suppression of all categories of weeds either by the application of pre-emergence herbicide or by implementing the stale seedbed technique to reduce the initial flush of weeds, whereas the late emerging weeds were managed by the post-emergence application of imazethapyr. The stale seedbed by shallow tillage, in combination with the recommended herbicide, had the minimum weed population and biomass and had the highest productivity (11). The next best treatment was the sole application of imazethapyr at 75 g/ha at 20 DAS (T_3), which was significantly followed by the sequential application of the stale seedbed technique at 15 DBS *fb* pendimethalin at 750 g/ha at 1 DAS (T_4) in reducing the densities of all categories and total weeds (Table 1). Application of imazethapyr at 50 and 70 g/ha at 20 DAS (12) and at 50 and 75 g/ha at 15 or 25 DAS (13) significantly reduced the growth of weeds. Among the weed control practices, the application of an herbicide, i.e., imazethapyr, was found to be statistically similar to total weed-free treatment (14). The application of an aqueous extract of *C. gigantea* was effective in suppressing the germination of grassy weeds, which was followed by the pre-emergence herbicide application and stale seedbed technique (Table 1). The higher concentration of *Calotropis* leaf extract was very effective in lowering the grassy weed population in summer green gram. High concentrations of *Calotropis* extract significantly reduced the germination and growth of radicles and plumules in different solanaceous plants (6).

It was concluded from Table 1 that the maximum plant height, no. of branches/plant and dry matter accumulation were documented in twice hand weeding treatment, which was remained at par with the T_6 and T_5 treatments in green gram. Application of *Calotropis* leaf extract reduced the weed growth but the allelochemical had some phytotoxic effect on the overall growth and development of green gram plant. Similarly, the suppressing effects of *Calotropis* in all growth parameters of lentil at its highest leaf extract concentration (15). Plants did not prosper much with respect to their stature under weedy check at any stage of crop growth. This might be due to severe competition exerted by the weeds in green gram by shading or overcrowding in the crop-weed ecosystem and competing with the beneficial crop for essential nutrients, moisture and space. In the present study, all the growth parameters were significantly less in weedy check (T_{10}) plots at all the stages of crop growth and development during summer season (Table 1). The plant height and branches per plant were the lowest in weedy check as compared with two hand weeding along with hoeing at 20 and 40 DAS (16).

The highest productivity of seed (10.70 q/ha) and stover (29.23 q/ha) was recorded under two-hand weeding treatment, which, maintained statistically similar yield levels with pendimethalin at 750 g/ha *fb* imazethapyr at 75 g/ha (10.17 q seed/ha and 27.66 q stover/ha) and stale seedbed technique *fb* imazethapyr at 75 g/ha (9.92 q seed/ha and 26.81 q stover/ha) (Fig. 1). The stale seedbed technique had an effective way to exhaust the weed seed bank, which would create a weed-free environment during the sowing time and reduce the weed intensity afterwards. Similarly, pendimethalin application during pre-emergence lessens weed growth (density and biomass) during the initial crop growing period. These early reductions in weed flora, either as stale seedbeds or as pendimethalin

Table 1. Weed management practices on weed growth and growth of summer greengram

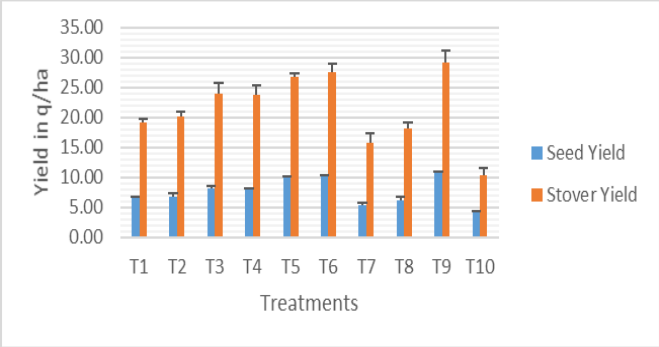
Treatments	Weed density (no./m²) at 30 DAS	Weed biomass (g/m²) at 30 DAS	Plant height (cm) at 30 DAS	Branch (No./ plant) at 30 DAS	Dry matter accumulation (g/m²) at 30 DAS
T_1- Stale seedbed technique at 15 days before sowing (DBS)	6.02 (35.91)	5.33 (27.96)	17.14	3.34	26.11
T_2- Pendimethalin at 750 g/ha at 1 DAS	5.67 (31.75)	5.09 (25.46)	17.17	3.48	26.17
T_3- Imazethapyr at 75 g/ha at 20 DAS	3.41 (11.22)	2.69 (6.76)	18.68	4.20	32.85
T_4- Stale seedbed technique at 15 DBS *fb* pendimethalin at 750 g/ha at 1 DAS	3.70 (13.26)	3.11 (9.23)	18.55	4.09	31.41
T_5- Stale seedbed technique at 15 DBS *fb* imazethapyr at 75 g/ha at 20 DAS	2.41 (5.31)	1.71 (2.44)	19.43	4.95	40.44
T_6- Pendimethalin at 750 g/ha at 1 DAS *fb* imazethapyr at 75 g/ha at 20 DAS	2.21 (4.39)	1.63 (2.17)	19.93	5.10	39.07
T_7- Aqueous leaf extract of *Calotropis gigantea* at 10 % concentration at 1 DAS	6.61 (43.25)	6.35 (39.89)	15.15	2.93	23.95
T_8- Aqueous leaf extract of *Calotropis gigantea* at 20 % concentration at 1 DAS	5.87 (34.05)	5.31 (27.73)	16.95	3.32	25.72
T_9- Two hand weeding at 15 and 30 DAS	1.91 (3.18)	1.23 (1.01)	20.49	5.33	40.56
T_{10}- Weedy check	8.23 (67.41)	8.12 (65.52)	12.92	2.23	19.24
SEm (±)	0.17	0.15	0.59	0.22	1.29
CD(P= 0.05)	0.50	0.44	1.77	0.64	3.83

Figures in parentheses are the original values. The data was transformed to SQRT (x + 0.5) before analysis.

applications integrated with the application of imazethapyr as post-emergence, ultimately improved green gram productivity. The similar results of sequential application of pendimethalin *fb* imazethapyr enhanced the productivity of green gram was corroborated during the summer (2). The sequential application of pendimethalin at 0.75 kg/ha (PE) + imazethapyr at 40 g/ha at 20 DAS recorded lower weed density and biomass and higher weed control efficiency for the significant increment in seed yield (17).

The subsequent best treatments *viz.* imazethapyr at 75 g/ha (8.04 q seed/ha and 23.95 q stover/ha), which was comparable with the sequential integration of stale seedbed technique *fb* pendimethalin (7.84 q seed/ha and 23.76 q stover/ha). Adopting stale seedbed techniques either for 7 or 14 days significantly reduced the population of grassy and broad-leaved weeds (18). Application of imazethapyr at 75 g/ha effectively controlled the diverse weed flora and increased the yield (1093 and 1059 kg/ha for the years 2014 and 2015 respectively), which was comparable with 2 hand weeding (1128 and 1078 kg/ha for the years 2014 and 2015 respectively) in black gram (19). Compared with the weedy check plot, the yield enhancement was ranged from 57.26 to 60.37 % and 61.13 to 64.35 %, on seed and stover yield respectively (Fig. 1).

The relationship between seed yield and weed growth was negatively affected, whereas a positive relationship was found with the growth parameters of green gram. The R^2 values of the plant height, no. of branches/ plant and dry matter accumulation were 0.953, 0.981 and 0.969 with seed yield of summer green gram respectively (Fig. 2 C, D and E). The results showed the positive impact of the decrease in weed population and biomass on the productivity of green gram during the summer season (Fig. 2 A and B). The nature and characteristics of weeds are dynamic and they can respond quickly to the changing environment (20).



T_1- Stale seed bed technique at 15 days before sowing (DBS), T_2- Pendimethalin at 750 g/ha at 1 DAS, T_3- Imazethapyr at 75 g/ha at 20 DAS, T_4- Stale seed bed technique at 15 DBS *fb* pendimethalin at 750 g/ha at 1 DAS, T_5- Stale seed bed technique at 15 DBS *fb* imazethapyr at 75 g/ha at 20 DAS, T_6- Pendimethalin at 750 g/ha at 1 DAS *fb* imazethapyr at 75 g/ha at 20 DAS, T_7- Aqueous leaf extract of *Calotropis gigantea* at 10 % concentration at 1 DAS, T_8- Aqueous leaf extract of *Calotropis gigantea* at 20 % concentration at 1 DAS, T_9- Two hand weeding at 15 and 30 DAS, T_{10}- Weedy check

Fig. 1. Seed and stover yield of summer greengram under different weed management practices.

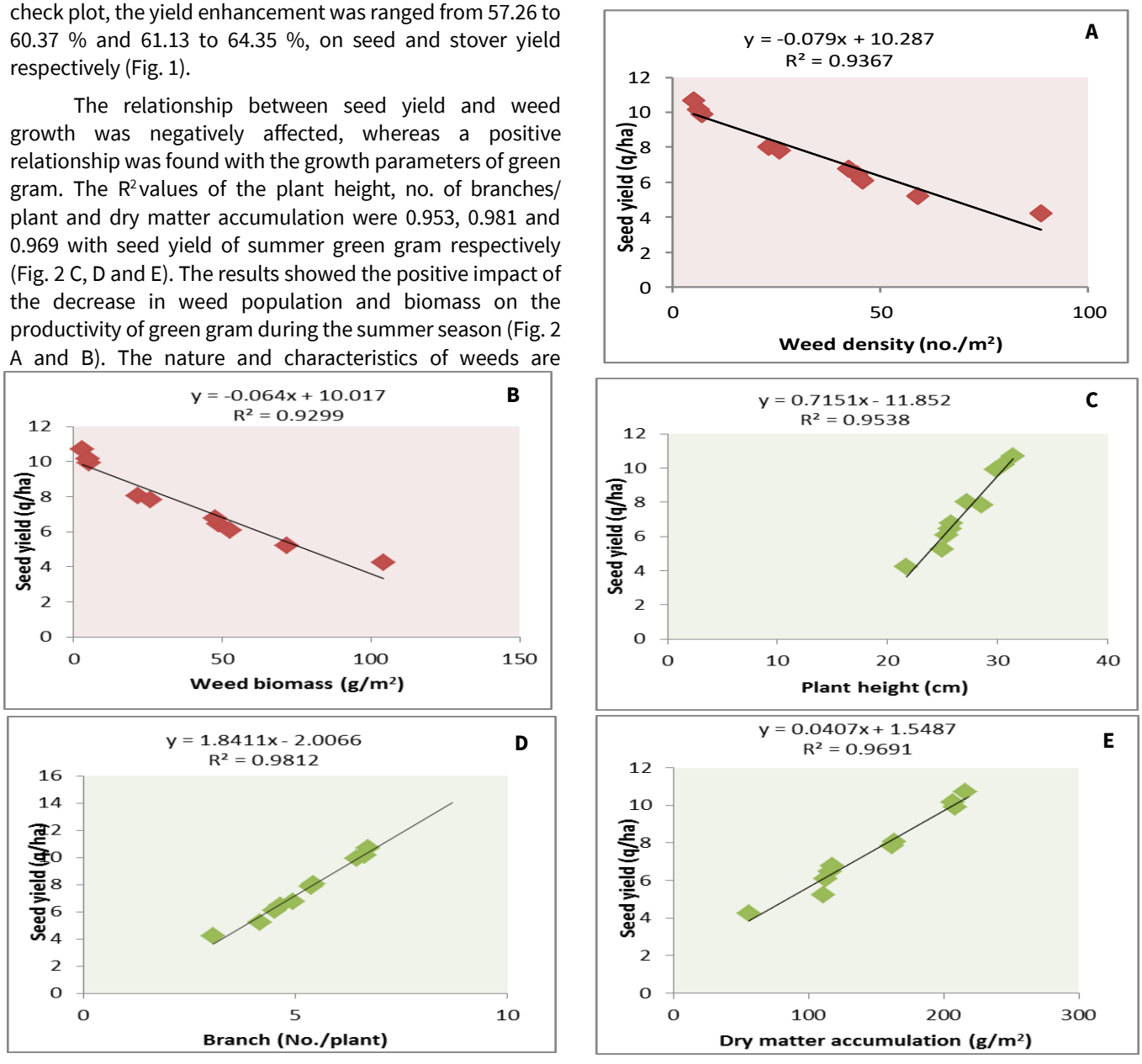


Fig. 2. Showing relationship between (A & B) seed yield and weed growth; (C, D & E) seed yield and plant growth parameters in summer green gram.

Conclusion

Grasses constituted the major proportion of total weed density and dry weight, followed by broadleaved weeds in green gram during the summer season. Hand weeding twice at 15 and 30 DAS recorded the lowest density, dry weight of weeds and maximum growth attributes and yield of green gram, which was at par with the sequential application of pendimethalin at 750 g/ha at 1 DAS *fb* imazethapyr at 75 g/ha at 20 DAS and stale seed bed at 15 DBS *fb* imazethapyr at 75 g/ha at 20 DAS treatments. Thus, the pre-emergence application of pendimethalin at 750 g/ha or stale seedbed at 15 DBS followed by the post-emergence application of imazethapyr at 75 g/ha were found to be effectively manage the diverse weed flora, obtaining maximum growth and productivity in green gram cultivation during the summer season.

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Authors' contributions

RD executed the experiment and collected the data. SD conceptualised and supervised the experiment and analysed the data. AP prepared the manuscript. JJ participated in its design and coordination. SS collected and analysed the data. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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