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Response of Green Gram [*Vigna radiata* (L.) Wilczek] to Different Weed Management Practices

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ABSTRACT

Background: Green gram is an important pulse crop known for its nutritive values as a rich source of protein and high culinary application in Indian dietary system. However, like any other crop, it faces the challenge of weed competition, which can significantly reduce its yield and quality. The objective of this study was to determine the best suitable weed management practices for green gram.

Methods: Field experiment was conducted during summer season of 2021 at School of Agricultural Sciences, Nagaland University, Medziphema Campus. There were seven weed management treatments and one treatment kept as control. All treatments were replicated thrice.

Result: Hand weeding at 20 and 40 DAS showed greater weed control and recorded higher values in growth and yield and showed at par values with other weed management practices pre-emergence application of pendimethalin *fb* hand weeding at 20 DAS, Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Rice straw mulching @ 5 t ha^{-1}, Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS and Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS. However, the use of only rice straw could not perform better. This indicates the advantages of integration of weed management practices. With hand weeding a laborious task concerning in large field condition, other integration of weed management will serve a viable option for profitable weed management in green gram.

Key words: Green gram, Growth, Integrated weed management, Yield.

INTRODUCTION

India has crossed a population of 1.3 billion people, making it the second most populous country in the world. The nation's population has been increasing for decades and this trend is anticipated to continue. India's rapid population growth is a significant source of concern due to the obstacles it poses to the country's food security. Despite increasing food production, a significant portion of the population still suffers from hunger and malnutrition. In fact, India ranks 107th out of 121 countries in the global hunger index 2022. In this regard, legumes represent a promising and potential supplementary food source. Grain legumes are an important and cheapest source of dietary protein, due to which they are often acknowledged as poor man's meat. Green gram (*Vigna radiata* L.) is one of the major legumes cultivated in India for its high nutritive values such as protein, vitamins and dietary fibre.

Green gram has wide adaptability and can be grown in all seasons. However, it is mostly grown in *kharif* and summer season as rainfed intercrop or sole crop. With the onset of monsoon, every shower helps in the establishment of weed flushes that threatens the early establishment of the crop. The severity of yield loss due to weed infestation depends on the intensity and diversity of weed flora, but in general, the yield loss is estimated to be about 10-45% (Rao *et al*., 2014). A simple and effective way of controlling weeds is by manual hand weeding but in today's context, with expanding labour shortage, high wages accompanied by extremes of heat and unpredictable rainfall during summer and *Kharif* makes it an impractical option. Due to such conditions, herbicides have gained popularity among farmers for their feasibility and effectiveness. Because weeds vary greatly in type and are highly complex, using just one method is not enough to completely control them. The smothering effect of mulching by depriving weeds of light and space can be employed along with selective herbicides such as pendimethalin (Kumar *et al*., 2017), imazethapyr (Jinger *et al*., 2016), Clodinafop propargyl (Maji *et al*., 2020), for effective control of grasses and broad-leafed weeds (BLWs).

Expanding on the perspective above, the present study has been conducted with the main objective to study the effects of different treatments and find out the possible weed management in green gram.

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MATERIALS AND METHODS

Experimental site

The experiment was conducted at School of Agricultural Sciences, Nagaland University, Medziphema Campus, India in the year 2021. The geographical details of the experimental are 25°45′4″N latitude, 95°53′0″E longitude and 310 meters above mean sea level. The daily mean maximum 30.3-35.6°C and minimum 17.7-24.5°C temperature was witnessed from April to July of 2021 and short rainfall of 200 mm. The soil of the study site was acidic (pH 4.56) and contained 274.67 kg ha^{-1} N, 12.7 kg ha^{-1} and 191.20 kg ha^{-1} of available N, P and K, respectively.

Treatment details

Seven weed control treatments *viz*., Weedy check (T_1), Hand weeding at 20 DAS and 40 DAS (T_2), rice straw mulching @ 5 t ha^{-1} (T_3), Pendimethalin @ 0.75 kg ha^{-1} (Pre-emergence (PE) followed by (*fb*) Hand weeding at 20 DAS (T_4), Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Rice straw mulching @ 5 t ha^{-1} (T_5), Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (Post-emergence (PoE) at 30 DAS (T_6), Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7) were laid out in randomized block design (RBD) with three replications. Each plot had a dimension of 4×3 m^2. For uniform application of herbicide, knap sack sprayer fitted with flood jet deflector nozzle size WFN 0.040 was used. For mulching, rice straw collected and stored from previous harvest of *kharif* was used. Hand weeding as per the treatment was done using *khurpi* (A traditional Indian gardening tool, typically consists of a small, handheld and curved blade attached to a wooden or metal handle. It is commonly used for weeding, digging and cultivating soil in small gardens and agricultural fields. The curved blade is designed for cutting and loosening soil, making it a useful tool for various gardening and farming tasks).

Sowing and crop management

The field was prepared by tractor drawn disc harrow and then levelled and appropriate beds of designated size were made to facilitate sowing. A basal dose of 20-40-40 kg ha^{-1} of N-P_2O_5-K_2O was applied through urea, single superphosphate and muriate of potash. With a spacing of 30×10 cm, seeds of green gram cv. SG-1 at 25 kg ha^{-1} was sown on 10th April 2021. The crop was grown under rainfed condition. Staggered harvesting was done starting from 13th June 2021 when 80% of the pods turned brown and matured.

Observation and data collection on weeds and crop

Weed data was collected on 20 and 60 DAS in an area of 0.5×0.5 m from each plot. weeds were then categorized into broad-leafed, grasses and sedges and the weed density were determined. For dry weight, record was taken after weeds were sun dried for two days, followed by oven dried at 72°C for 48 hr. Weed control efficiency (WCE) and herbicide efficiency index (HEI), was computed using the equation as follows:

$$WCE\ (\%) = \frac{W_C - W_t}{W_C} \times 100$$

Where,
W_c- Weed dry weight in g m^{-2} in weedy check.
W_t- Weed dry weight in treated plot.

$$HEI = \frac{\frac{\text{Yield of treated - Yield of control}}{\text{Yield of control}} \times 100}{\frac{\text{Weed dry weight in treated}}{\text{Weed dry weight in control}} \times 100}$$

Crop data were also recorded at 20, 40 and 60 DAS. Five plants selected randomly were tagged and recorded for growth and yield attributes. Leaf area index (LAI), Crop growth rate (CGR) and relative growth rate (RGR) were worked out using the equation as follows:

$$LAI = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

$$CGR\ (gm^{-2}\ day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,
W_2 and W_1 = Dry weight of plant at time t_2 and t_1, respectively.

$$RGR\ (gg^{-1}\ day^{-1}) = \frac{Log_e\ W_2 - Log_e\ W_2}{t_2 - t_1}$$

Where,
W_2 and W_1 = Dry weight of plant at time t_2 and t_1, respectively.

Statistical analysis

Crop and weed data were subjected to analysis of variance (ANOVA) for RBD as given by Gomez and Gomez (1984) using XLSTAT 2022.5.1 (1386) in Microsoft Excel 16.0.15831 (64 bits). Weed population data was square root transformed ($\sqrt{x + 0.5}$) and ANOVA was performed. Duncan's multiple range test (DMRT) for different treatment was performed to test the significance between treatments at $p \leq 0.05$ using statistical tool for agricultural research (STAR v.2.0.1). Pearson's correlation coefficient was worked to assess the relationship between total weed population at 60 DAS, weed control efficiency and seed yield using Microsoft Excel 16.0.15831 (64 bits).

RESULTS AND DISCUSSION

In the current study, the observed weed flora spectrum consist of grasses: Bermuda grass (*Cynodon dactylon* L.), hairy crabgrass (*Digitaria sanguinalis* L.), Indian goosegrass (*Eleusine indica* L.) and cogon grass (*Imperata cylindrica* L.); sedges: purple nutsedge (*Cyperus rotundus* L.) and flat rice sedge (*Cyperus iria* L.); broad-leafed (in oter places you have : billy goat weed (*Ageratum conyzoides* L.), slender amaranth (*Amaranthus viridis* L.), broadleaf buttonweed (*Borreria latifolia* L.), devil weed (*Chromolaena odorata* L.),

Table 1: Effect of weed management practices on weed density (weeds m^{-2}).

Treatment	Weed density							
	20 DAS			60 DAS			Total	
	Grasses	BLW	Sedges	Grasses	BLW	Sedges	20 DAS	60 DAS
Weedy check (T_1)	5.85a	8.62a	4.34a	6.52a	14.75a	5.94a	11.24a	17.15a
	(33.72)	(73.80)	(18.33)	(42.01)	(217.06)	(34.78)	(125.85)	(293.85)
Hand weeding at 20 DAS and 40 DAS (T_2)	5.81a	8.61a	4.10a	3.86c	8.54d	2.25b	11.12a	9.58b
	(33.25)	(73.63)	(16.31)	(14.39)	(72.43)	(4.56)	(123.19)	(91.38)
Rice straw mulching @ 5 t ha^{-1} (T_3)	3.18b	6.73b	2.08b	4.24b	9.97b	2.85b	7.66b	11.15b
	(9.61)	(44.79)	(3.82)	(17.47)	(98.90)	(7.62)	(58.22)	(123.99)
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb hand weeding at 20 DAS (T_4)	2.74b	5.46c	2.02b	3.92c	8.88cd	2.38b	6.35c	9.94b
	(7)	(29.31)	(3.58)	(14.86)	(78.35)	(5.16)	(39.89)	(98.37)
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb rice straw mulching @ 5 t ha^{-1} (T_5)	2.77b	5.50c	2.08b	4.19b	9.64bc	2.59b	6.33c	10.77b
	(6)	(29.75)	(3.82)	(17.05)	(92.42)	(6.20)	(39.57)	(115.67)
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_6)	2.74b	5.52c	1.99b	3.99c	9.33bcd	2.71b	6.41c	10.45b
	(7.17)	(29.97)	(3.46)	(15.42)	(86.54)	(6.84)	(40.6)	(108.8)
Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7)	2.36b	5.17c	1.88b	3.98c	9.30bcd	2.48b	5.90c	10.36b
	(5.06)	(26.22)	(3.03)	(15.34)	(85.99)	(5.65)	(34.31)	(106.98)

*DAS- Days after sowing; BLW- broad-leaved weeds.

**Square root transformation of weed density ($\sqrt{x + 0.5}$) was calculated before statistical analysis and original value is presented in parentheses.

***Different letters within column indicate significant at $p \leq 0.05$ by Duncan's multiple range test.

asthma plant (*Euphorbia hirta* L.) and sensitive plant (*Mimosa pudica* L.). Throughout the study periods, the density of broad-leafed weeds (BLWs) was higher than grasses and sedges (Table 1).

Among various weed management treatments, hand weeding at 20 and 40 DAS recorded the highest WCE of 75.7% (Table 3), followed by post-emergence application of Imazethapyr at 15 DAS *fb* quizalofop p-ethyl at 30 DAS (72.34%). Gopakumar and Menon (2022) and Verma and Kushwaha (2020) also reported in their finding that hand weeding at 20 and 40 DAS showed the lowest weed dry matter production (Table 2) and highest WCE (Table 3). This could be attributed to the broad-spectrum activity of imazethapyr on grasses, sedges and BLWs by inhibiting the acetolactase synthase which are responsible for the synthesis of essential amino acids such as isoleucine, leucine and valine (Stephenson *et al*., 2006) followed by the inhibitory action of quizalofop on the biosynthesis of lipids and fatty acid on grasses (Lichtenthaler, 1990). The WCE was found non-significant with all combinations of chemical and cultural treatments except when rice straw mulching @ 5 t ha^{-1} was employed in isolation. It indicated that integration of herbicides along with cultural methods was needed for effective weed control. For effective weed management, a higher HEI is desirable and this could be seen in post-emergence application of Imazethapyr at 15 DAS *fb* quizalofop p-ethyl at 30 DAS, suggesting the treatment's greater efficiency in weed control.

Effect of weed management on crop growth and yield

Data on crop reveals that plant heights at 20 DAS were statistically non-significant. This can be attributed to the fact that, at 20 days after sowing (DAS), the crop has grown to just a few centimeters in height. This level of growth may not be sufficient to visibly showcase the effectiveness of weed management techniques (Table 4). At 60 DAS, the highest plant height (32.23 cm) was recorded in hand weeding at 20 and 40 DAS, followed by pre-emergence application of pendimethalin *fb* hand weeding at 20 DAS (32.03 cm). This finding is in accordance with that of Mukherjee (2021), where hand weeding at 20 and 40 DAS, resulted in highest plant height in green gram. The effect of different weed management practices was positively reflected on the dry weight of plant, with highest recorded dry weight (0.62 g) at 20 DAS under PoE of imazethapyr at 15 DAS *fb* quizalofop p-ethyl at 30 DAS and 7.90 g at 60 DAS under hand weeding. The significant increase in growth attributes of green gram due to weed control using Imazethapyr has also been described by Gupta *et al.* (2020). It may be noted that hand weeding at 20 and 40 DAS showed greater crop growth *i.e*., LAI, number of primary branches, CGR and RGR (Table 4), in comparison to other weed management methods. This maybe because the manual removal of weeds, falls within the critical crop weed competition of green gram *i.e*., 15-30 DAS (Singh *et al*., 1991), thereby giving an advantage to the crop to utilize resources to the maximum. This result was closely followed

Table 2: Effect of weed management practices on weed dry weight (g m^{-2}).

Treatment	Weed dry weight								
	20 DAS			60 DAS			Total		
	Grasses	BLW	Sedges	Grasses	BLW	Sedges	20 DAS	60 DAS
Weedy check (T_1)	15.52a	6.15a	4.87a	42.63a	15.95a	19.67a	26.54a	78.25a
Hand weeding at 20 DAS and 40 DAS (T_2)	15.07a	5.89a	4.17a	12.21c	4.41d	2.33b	25.13a	18.95c
Rice straw mulching @ 5 t ha^{-1} (T_3)	6.15b	4.15b	3.43a	20.02b	9.46b	7.17b	13.73b	36.65b
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Hand weeding at 20 DAS (T_4)	2.61c	2.30c	1.20b	13.44c	5.11cd	2.48b	6.12c	21.03c
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Rice straw mulching @ 5 t ha^{-1} (T_5)	2.94c	2.34c	1.24b	15.58c	6.21c	3.01b	6.51c	24.79c
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_6)	2.71c	2.27c	1.20b	14.38c	5.21cd	2.83b	6.18c	22.42c
Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7)	2.29c	1.89c	1.20b	13.85c	5.11cd	2.67b	5.38c	21.63c

*DAS- Days after sowing; BLW- Broad-leaved weeds.

**Different letters within column indicate significant at $p \leq 0.05$ by Duncan's multiple range test.

by pre-emergence application of pendimethalin *fb* hand weeding at 20 DAS. Vyvahare *et al*. (2023) gave similar results. Weedy check displayed least growth attributes in all the recorded data due to uncontrolled weed population resulting in maximum crop-weed competition.

The enhanced resource utilization as a result of reduced competition in hand weeding at 20 and 40 DAS was reflected in the yield and yield attributes, giving highest pods plant^{-1}, pod length, seed yield, stover yield, HI and test weight of 16.34, 7.25, 627.82 kg ha^{-1}, 1520.67 kg ha^{-1}, 29.22% and 20.95 g, respectively. Data on test weight showed no statistical difference among different weed control practices. Pre-emergence application of pendimethalin *fb* hand weeding at 20 DAS, Pendimethalin @ 0.75 kg/ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg/ha^{-1} (PoE) at 30 DAS and Imazethapyr @ 0.5 kg/ha^{-1} (PoE) at 15 DAS *fb* Quizalofop

Table 3: Weed indices of different weed management practices.

Treatment	WCE (%)	HEI
Weedy check (T_1)	0	-
Hand weeding at 20 DAS and 40 DAS (T_2)	75.74a	-
Rice straw mulching @ 5 t ha^{-1} (T_3)	53.29b	-
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Hand weeding at 20 DAS (T_4)	63.87ab	2.17ab
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Rice straw mulching @ 5 t ha^{-1} (T_5)	68.23ab	1.32cd
Pendimethalin @ 0.75 kg ha^{-1} (PE) fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_6)	71.31a	1.52bc
Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS fb Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7)	72.34a	1.87bc

*Different letters within column indicate significant at $p \leq 0.05$ by Duncan's multiple range test.

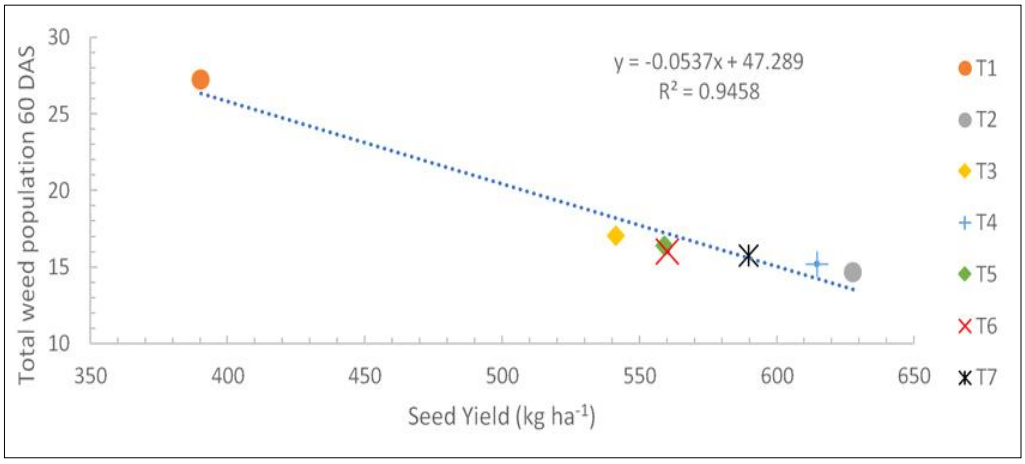

Fig 1: Relation between seed yield and weed population at 60 DAS as affected by weed management practices.

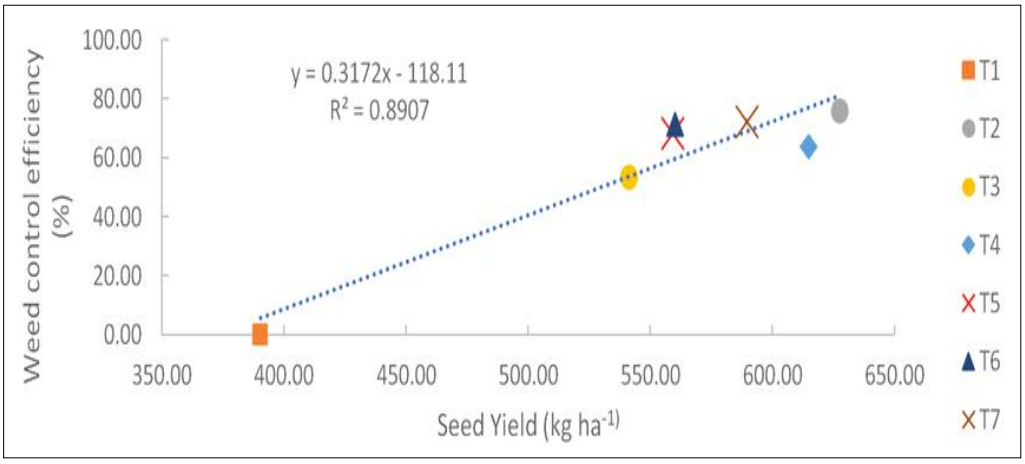

Fig 2: Relation between seed yield and weed control efficiency as affected by weed management practices.

Table 4: Effect of weed management practices on growth parameters of green gram.

Treatment	Plant height (cm)		Plant dry weight (g plant^{-1})		Leaf area index (LAI)		No. of primary branches)		CGR (g m^{-2} day^{-1})		RGR (g g^{-1} day^{-1})	
	20 DAS	60 DAS	20 DAS	60 DAS	40 DAS	60 DAS	40 DAS	60 DAS	20-40 DAS	40-60 DAS	20-40 DAS	40-60 DAS
Weedy check (T_1)	10.89a	21.01	0.56c	4.50f	1.35d	0.63e	3b	3.67d	1.88e	4.68f	0.0239d	0.0210e
Hand weeding at 20 DAS and 40 DAS (T_2)	10.91a	32.23	0.57bc	7.90a	2.28a	1.19a	3.67a	4.56a	3.26a	8.95a	0.0323a	0.0250a
Rice straw mulching @ 5 t ha^{-1} (T_3)	12.06a	27.84	0.59abc	5.59e	1.90c	0.80d	3.22b	4.00cd	2.45d	5.80e	0.0271c	0.0220d
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* hand weeding at 20 DAS (T_4)	11.97a	32.03	0.61a	6.93h	2.32a	1.16ab	3.56a	4.44ab	2.80b	7.73b	0.0286b	0.0240b
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* rice straw mulching @ 5 t ha^{-1} (T_5)	11.83a	28.96	0.60ab	6.13cd	2.09b	1.04abc	3.11b	4.00cd	2.55cd	6.66cd	0.0275c	0.0220d
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_6)	11.67a	29.44	0.59abc	6.00d	1.88c	0.91cd	3.56a	4.33abc	2.45d	6.56d	0.0271c	0.0230c
Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS *fb* quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7)	12.12a	29.92	0.62	6.23c	2.11b	1.02bc	3.07b	4.11bc	2.65c	6.78c	0.0274c	0.0233c

*Different letters within column indicate significant at $p \leq 0.05$ by Duncan's multiple range test.

Table 5: Effect of weed management practices on yield and yield parameters of green gram.

Treatment	Pods per plant	Pod length	Seeds per pod	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Test weight (g)
Weedy check (T_1)	10.97d	6.47c	5.77c	390.37c	1396.67c	21.83g	20.06a
Hand weeding at 20 DAS and 40 DAS (T_2)	16.34a	7.25a	7.66a	627.82a	1520.67a	29.22a	20.95a
Rice straw mulching @ 5 t ha^{-1} (T_3)	14.87c	6.81b	6.66b	541.33b	1480.00b	26.78f	20.29a
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Hand weeding at 20 DAS (T_4)	16.07ab	7.20a	7.66a	614.64a	1523.33a	28.74b	20.86a
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Rice straw mulching @ 5 t ha^{-1} (T_5)	14.96c	7.02ab	6.66b	558.99ab	1483.33b	27.36e	20.34a
Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_6)	15.17c	6.90ab	7.44ab	560.01ab	1496.67ab	27.89d	20.35a
Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS (T_7)	15.22bc	7.06ab	7.66a	589.57ab	1503.33ab	28.16c	20.37a

*Different letters within column indicate significant at $p \leq 0.05$ by Duncan's multiple range test.

Table 6: Correlation between seed yield, weed population at 60 DAS and weed control efficiency (WCE).

	Seed yield	WCE	Weed population 60 DAS
Seed yield	1		
WCE	0.943754	1	
Weed population 60 DAS	-0.97253	-0.97983	1

p-ethyl @ 0.15 kg/ha^{-1} (PoE) at 30 DAS were statistically similar for pod length, seeds pod^{-1}, seed yield and stover yield with hand weeding at 20 and 40 DAS (Table 5). Singh *et al*. (2023) also found similar result where green gram yield was found to be highest in weed free treatment followed by pendimethalin *fb* hand weeding at 20 DAS. Nagender *et al*. (2017) reported similar finding, where weed free treatment and hand weeding at 20 and 40 DAS displayed highest growth and yield attributes in green gram and among herbicide treatments, Imazethapyr fb hand weeding at 20 DAS recorded highest plant height, dry matter accumulation and yield. Lowest yield parameters were observed in the uncontrolled plot.

Relation between weed population, weed control efficiency and seed yield

From Table 6, it is evident that there is negative linear correlation between total weed population at 60 DAS and seed yield and a positive linear correlation between weed control efficiency and seed yield. The correlation coefficient of -0.97 and R^2 value of 0.94 indicates that with increase in weed population, there was reduction in the grain yield and 94% of variation in seed yield was explained by total weed population at 60 DAS. WCE showed correlation coefficient of 0.94 and R^2 (0.89) with seed yield, suggesting a positive relation of seed yield with WCE. A scattered plot on effect of weed management practices on seed yield as influenced by weed population and weed control efficiency is depicted in Fig 1and 2.

CONCLUSION

The study revealed that weed management in summer season grown green gram has resulted in better growth and yield of crop. Based on the data obtained it was found that twice hand weeding at 20 DAS and 40 DAS showed greater weed control and obtained the highest growth and yield. However, taking into consideration its complication in actual field condition as mentioned in the introductory statement, other weed management practices can be opted when large farm areas are considered. Focusing on the data obtained for seed yield and weed control efficiency, integration of herbicide with cultural practice such as pre-emergence application of pendimethalin *fb* hand weeding at 20 DAS, Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Rice straw mulching @ 5 t ha^{-1} and herbicide applications *viz* Imazethapyr @ 0.5 kg ha^{-1} (PoE) at 15 DAS *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS and Pendimethalin @ 0.75 kg ha^{-1} (PE) *fb* Quizalofop p-ethyl @ 0.15 kg ha^{-1} (PoE) at 30 DAS can be opted as it gave at par result with twice hand weeding. This could substantially reduce the time as well as cost of operation involved in twice hand weeding.

Conflict of interest

The authors declare that they have no conflict of interest.

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