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Patel Yashkumar Bharatbhai
Department of Agronomy, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Veeresh Hatti
Department of Agronomy, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

JK Patel
Department of Agricultural Chemistry and Soil Science, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

DM Patel
Department of Agronomy, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

AK Singh
Bio Science Research Centre, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Vikash Kumar
Department of Agronomy, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Corresponding Author:
Veeresh Hatti
Department of Agronomy, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India

Weed management practices influence productivity and profitability in *kharif* Greengram (*Vigna radiata* L.)

Patel Yashkumar Bharatbhai, Veeresh Hatti, JK Patel, DM Patel, AK Singh and Vikash Kumar

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Abstract
A field experiment with the objectives to understand the effect of weed management practices on *kharif* greengram (*Vigna radiata* L.) during *kharif* season of 2023. Weed free treatment recorded significantly higher seed and stover yield (1545 and 3316 kg/ha, respectively). Further, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS registered significantly higher seed and stover yield (1330 and 2905 kg/ha, respectively) and found at par with stale seedbed *fb* interculture and hand weeding at 40 DAS (1286 and 2828 kg/ha, respectively) as compared to unweeded check (491 and 1297 kg/ha, respectively) owing to the effective suppression of grasses, sedges, broad leaf and total weeds at 50 DAS and at harvest with higher weed control efficiency and lower weed index values. Furthermore, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS recorded higher net neturns (₹ 70670/ha) followed by weed free (₹ 67350/ha) and stale seedbed *fb* interculture and hand weeding at 40 DAS (₹ 64126/ha) as compared to unweeded check.

Keywords: Greengram, soil solarization, stale seedbed, weeds, growth, yield, economics, correlation, regression

Introduction
Greengram [*Vigna radiata* (L.) Wilczek] also known as moong bean is one of the important pulse crop of India, belonging to the family *Leguminosae* and subfamily *Papilionaceae.* It has been reported that greengram has been cultivated in India since ancient times. It is believed that greengram is a native of India and Central Asia and grown in these regions since prehistoric times. Greengram is a fairly good source of some dietary minerals. The total minerals content in greengram is to the tune of 3.5 percent. Greengram seeds contain 22-28% protein, 60-65% carbohydrates, 1.0-1.5% fat, 3.5-4.5% fibre and 4.5-5.5% ash (Anon., 2019) [3]. Among the array of biotic and abiotic factors, weed infestation emerges as the primary biotic factor contributing to the reduced productivity of greengram in India. The potential yield loss in greengram due to weed has been estimated in the range of 10-45% (Rao and Chauhan, 2014) [26]. The critical period of crop-weed competition in greengram has been pinpointed as occurring from 15 to 30 days after sowing, with weed presence beyond this period resulting in significant losses in greengram yield (Mandal *et al.*, 2006) [21]. Competition with the weeds led to 30 to 80% grain yield reduction in greengram during summer and *kharif* seasons, while 70-80% during *rabi* season (Algotar *et al.*, 2015) [1]. Use of herbicides in conjunction with cultural practices or other practices would make complete control of weeds and will be acceptable by the poor farmer (Ayansina *et al.*, 2003) [4]. Application of different straw mulches, soil solarization and stale seedbed have been found efficient in managing weeds. Hence, development of an integrated weed management is economically viable as well as ecologically safe for effective weed control and enhances the productivity of greengram.

Materials and Methods
The field experiment was conducted on Plot No. C-6 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat) to investigate

effect of weed management practices on *kharif* greengram. The soil of experimental field was loamy sand in texture with low in organic carbon (0.25%) and available nitrogen (148.0 kg/ha), medium in available phosphorus (38.6 kg/ha) and available potassium (252.4 kg/ha) having pH value of 7.45. The experiment was laid out in Randomized Block Design with three replications. The treatments comprised of ten methods of weed management *viz*., T_1: Soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_2: Soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_3: Soil solarization *fb* interculture and hand weeding at 40 DAS, T_4: Stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_5: Stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_6: Stale seedbed *fb* interculture and hand weeding at 40 DAS, T_7: Imazethapyr 100 ml/ha as PoE at 15 DAS, T_8: Imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS, T_9: Weed free, T_{10}: Unweeded check. Greengram variety 'GM 4' was sown on 18th July, 2023 and fertilized with 20-40-00 kg N-P_2O_5-K_2O/ha. The crop was grown with recommended package of practices for south Gujarat Agro-climatic Zone and was harvested on 09th October, 2023. The sedges, grasses, broad leaf weeds were uprooted from 0.25 m^2 (50 cm × 50 cm) area in ring area of plots. The protein content in various samples was determined as a percentage using an NIR (Near-Infrared) spectroscopy device made by Dicky John Company (USA). The protein yield (kg/ha) was computed by using following formula,

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in seed (\%) x Seed yield (kg/ha)}}{100}$$

Results and Discussion

Effect on weed parameters

The major weed species found in the experimental field at various stages were: *Cyperus rotundus* L., *Bulbostylis barbata* Rottb. among sedges, *Cynodon dactylon* L., *Dactyloctenium aegyptium* L., *Digitaria sanguinalis* L. among grasses and *Amaranthus viridis*, *Corchorus tridens* L., *Boerhavia erecta* L., *Tribulus terrestris* L., *Digera arvensis* L., *Leucas aspera* L. among broad leaf weeds. At each stage (25, 50 DAS, and at harvest), the dominant species were *Cyperus rotundus* L. among the sedges, *Cynodon dactylon* L. among the grasses, and *Boerhavia erecta* L. among the broadleaf weeds.

The evaluation and analysis of data concerning weed dry weight revealed a consistent trend, mirroring that of weed density at 25 DAS. Among different weed management practices, weed free treatment recorded significantly lower dry weight of sedges, grasses, broad leaf and total weeds. Further, stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS resulted in notably reduced sedge, grasses, broad leaf, and total weed dry weight next to weed-free treatment which was statistically at par with stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS, imazethapyr 100 ml/ha as PoE at 15 DAS, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS, soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS and soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS. Whereas, unweeded check treatment has recorded significantly higher dry weight of sedges, grasses, broad leaf and total weeds. The lower weed dry weight of sedges, grasses, broad leaf weeds and total weeds recorded under weed free treatment was mainly due to frequent and effective removing of standing weeds through mechanical and physical efforts. Singh *et al*. (2015[a]) [32] also supported these findings and claimed that weed free treatment resulted in lowest weed density and dry weight of weeds. Moreover, stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS and stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS have also witnessed significantly lower dry weight of sedges, grasses, broad leaf and total weeds which was due to lower weed count of category wise and total weeds observed in those plots because of effective suppression of weeds by stale seedbed and mulching practices at initial phase. The findings are in conformity with results obtained by Mathukia *et al.* (2017) [22] who recorded that stale seedbed recorded significantly lowest dry weight of weeds, followed by soil solarisation. These findings were also further supported by Joshi *et al.* (2020) [15]. Whereas, at initial stage application of imazethapyr 100 ml/ha as PoE at 15 DAS and imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS treatments damaged the aceto lactate synthase (ALS) enzyme in the targeted weed plants which ultimately stopped amino acids synthesis resulting in suppression of broad leaf, sedges and grasses weeds. Further, Lal *et al.* (2018) [19], Singh *et al.* (2015[a]) [32] and Goud *et al.* (2014) [11] also observed lower dry weight of weeds due to application of imazethapyr. The higher dry weight of weeds observed under the unweeded check treatment was a result of unchecked weed growth due to the absence of any weed control measures. Similar observations have also been reported by Chandolia *et al.* (2010) [5], Meena *et al*. (2011) [23] and Jagadesh *et al.* (2019) [13].

The analysis of data concerning the dry weight of weeds at 50 DAS and at harvest, under the influence of various weed management practices, emphasized that weed free treatment resulted in markedly reduced dry weight of sedges, grasses, broadleaf, and total weeds. Further, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS demonstrated significantly lower weed dry weight of sedges, grasses, broadleaf, and total weeds and was found at par with stale seedbed *fb* interculture and hand weeding at 40 DAS. Whereas, higher weed dry weights noticed in other treatments was because of higher population of weeds recorded under these treatments. Wherein, significantly higher weed dry weight of different categories weeds like sedges, grasses, broadleaf, and total weeds were observed under the unweeded check condition. Effective control of weeds under the above-mentioned treatments might have resulted in less dry weight of weeds. Under weed free treatment significantly lower weed density was reported at 50 DAS and at harvest due to complete control of weeds at these stages resulting in lower weed dry weight. The similar findings were also supported by Ali *et al.* (2011) [2], Goud *et al.* (2014) [11] and Yadav *et al.* (2018). Further, the correlation and regression studies indicated that there was straight positive correlation between total weed density and total weed dry weight at 50 DAS and at harvest with correlation coefficients of 0.9989** and 0.9992**, respectively. In addition, the regression models indicated that every unit ($1/m^2$) increase in weed density shall increase the weed dry weight by 0.65 g/m^2 at 50 DAS and 0.64 g/m^2 at harvest, respectively. Thus, there was perfect positive relationship between weed density and weed dry weight at 50 DAS and at harvest. Jain *et al.* (2022) [14] observed that stale seedbed + hoeing with power weeder at 20 DAS + hoeing once at 40 DAS, stale seedbed + hoeing once at 20 DAS + application of 5 t/ha of straw mulch at 30 DAS recorded significantly lowest mean biomass of broad leaf weeds, grasses and sedges and total weeds at 30 DAS and 50 DAS. The combined effect of herbicide and hand weeding + inter-culturing ultimately resulted in minimum dry weight as observed by Raut *et al.* (2018) [28]. Significantly, lower sedges, grasses, broad leaf and total weed dry weights witnessed under imazethapyr 100 ml/ha as PoE at 15 DAS + inter-culture *fb* hand weeding at 40

DAS may be owing to effective suppression of all the category wise and total weeds up to 40 DAS by inhibition of ace to lactate synthase enzyme involved in protein synthesis in weeds and hence those density and dry weight were reduced. Subsequently, the interculture *fb* hand weeding at 40 DAS was further killed all the standing weeds by physical action resulting in lower weed density at 50 DAS and at harvest. The lower category wise and total weed dry weights witnessed under stale seedbed *fb* interculturing and hand weeding at 40 DAS may be an account of mostly emptying of all the weed seeds present in top 2-3 cm soil layer by stale seedbed effect and further killing of established weeds by interculturing and hand weeding practice at 40 DAS. Whereas, at all the stages significantly higher weed dry weight of category wise and total weeds were recorded under unweeded check because of poor control of weeds like sedges, grasses, broadleaf, and total weeds due to no weed control execution as described above in these treatments. These findings are in close proximity with findings of Singh *et al.* (2009) [30], Godara *et al.* (2014) [10] and Gelot *et al.* (2017) [9].

Effect on growth parameters and yield

At 25 DAS, weed free treatment recorded significantly highest plant height as compared to other treatments. Next to weed free treatment, stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS witnessed significantly higher plant height which was statistically at par with stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS, imazethapyr 100 ml/ha as PoE at 15 DAS, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS, soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS and soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS due to control of weeds by chemical and cultural weed management practices in these treatments resulting in lower weed density and weed dry weight observed in these treatments and hence realized higher plant height. Whereas, unweeded check reported significantly lower plant height which was found statistically at par with soil solarization *fb* interculture and hand weeding at 40 DAS and stale seedbed *fb* interculture and hand weeding at 40 DAS. This was due to higher density of sedges, grasses and broad leaf weeds noticed under these treatments due to lack of any weed management practices at initial stage which caused severe competition with crop.

Significantly higher plant height at 50 DAS and at harvest and number of branches per plant at harvest were realized under weed free which was statistically at par with imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS and stale seedbed *fb* interculture and hand weeding at 40 DAS. Whereas, significantly lower plant height was noticed in unweeded check which was statistically on par with imazethapyr 100 ml/ha as PoE at 15 DAS, soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS, soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS. Furthermore, significantly lower number of branches were recorded under unweeded check.

The significantly greater plant height and number of branches per plant under weed free treatment was mainly attributed to the notably lower weed density and weed dry weight recorded in this treatment due to the effective suppression of various category of weeds. The greater plant height and number of branches per plant observed with imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS and stale seedbed *fb* interculture and hand weeding at 40 DAS chiefly attributed to reduction of sedges, grasses and broad leaf weeds which ultimately reduced dry weight of weeds. The present outcomes were also supported by Patel *et al.* (2016[b]) [25], Singh *et al.* (2015[b]) [33], Verma *et al.* (2017) [34], Mathukia *et al.* (2017) [22], Leva *et al.* (2018) [20], Hajari *et al.* (2020) [12]. Whereas, significantly lower plant height in unweeded check, imazethapyr 100 ml/ha as PoE at 15 DAS, soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS, soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS might be due to poor weed control in these treatments resulting in serious competition between crop and weed for moisture, nutrient, light and space. The results are in conformity with observations of Sharma and Yadava (2006) [29] and Rathi *et al*. (2008) in greengram. Lowest number of branches per plant were observed under unweeded check was mainly due to higher weed densities of sedges, grasses, broad leaf weeds and total weeds resulting in lower weed control efficiency and higher crop-weed competition. The similar consequences were also witnessed by Singh *et al.* (2010) [31], Chhodavadia *et al.* (2013) [7].

Significantly higher seed yield recorded under T_9: weed free, Further, T_8: imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS and T_6: stale seedbed *fb* interculture and hand weeding at 40 DAS were directly attributed to significantly higher growth, yield parameters and stover yield recorded under these treatments *viz.*, pod yield per plant and stover yield. These results are in concurrence with Leva *et al.* (2018) [20] who witnessed higher growth attributes, yield attributes and yield of greengram under weed free treatment but it was at par with imazethapyr 100 g/ha as PoE at 20 DAS + interculture *fb* hand weeding at 40 DAS. This might be due to effective control of weeds resulting in lesser competition from weeds on growth in these treatments. This facilitates the greengram crop to utilize more moisture, nutrients and solar radiation. Higher growth and resource utilization may turned into more number of branches which resulted into more number of pods per plant under these treatments. These improved yield parameters and yield in above treatments are resultant of better weed control which is indicated by perfect negative correlation between seed yield *versus* weed dry weights. The correlation analysis between weed data and seed yield stipulated that there was perfect negative correlation between weed dry weight at 50 DAS and weed dry weight at harvest and seed yield (-0.9928** and - 0.9850**, respectively). In addition, regression equations explored that everyone g/m^2 increase in weed dry weight at 50 DAS and at harvest have reduced the seed yield of greengram by 7.85 and 9.89 kg/ha, respectively. Imazethapyr integrated with hand weeding at 30 DAS resulted in significantly higher seed yield over other treatments (Patel *et al.*, 2016[b]) [25]. Jain *et al.* (2022) [14] also proved that the two years pooled mean data indicated that stale seedbed + hoeing once manually at 20 DAS + straw mulch (5 t/ha) at 30 DAS gave maximum grain yield of maize. Conversely, the unweeded check plot showed a significantly lower number of pods per plant and pod yield per plant, resulting in reduced overall seed and stover yields. This decline was due to the extensive and vigorous growth of weeds compared to all other weed control treatments due to no weed control action made. These findings are in agreement with those of Kushwah and Vyas (2006) [18], Singh *et al.* (2010) [31], Kundu *et al.* (2011[b]) [17], Meena *et al.* (2011) [23], Goud *et al.* (2014) [11], Raut *et al.* (2018) [28] and Kumar and Hiremath. (2018) [16].

The data indicated that weed free treatment recorded lowest weed index. Further, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS witnessed lower weed index which was followed by stale seedbed *fb* interculture and hand weeding at 40 DAS. Whereas, the highest weed index value was observed in the unweeded check. Wherein, imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand

weeding at 40 DAS followed by stale seedbed *fb* interculture and hand weeding at 40 DAS witnessed lower weed index due to integration of different cultural, mechanical and chemical methods which effectively controlled different kinds of weeds and resulted in lower weed dry weight and ultimately higher weed control efficiency. Leva *et al.* (2018) [20] noticed lower weed index under imazethapyr 100 g/ha at 20 DAS + interculturing at 40 DAS which might be due to elimination of weeds by manual weeding and interculturing or by integration with herbicides. Mathukia *et al.* (2017) [22] also opined that weed free treatment recorded lowest weed index followed by hand weeding and interculturing and stale seedbed. The higher weed index in the unweeded check was attributed to the lower crop yield, which was a result of the significantly greater total dry weight of weeds. This increase in weed dry weight was due there was no weed control measure that ultimately resulting in poor yields in the unweeded check causing seed yield loss up to 68.22% in greengram. Similar findings were also reported by Mirjha *et al.* (2013) [24], Godara *et al.* (2014) [10], Datta *et al.* (2017) [8] and Gelot *et al.* (2017) [9].

Effect on quality parameters

The data indicated that different treatments tried in this experiment did not exert their significant impact on protein content. This was due to protein content of seed is essentially the manifestation of N content and as there was uniform application of nitrogen as the dose was common in all the treatments.

The glimpse of data indicated that among different weed management practices protein yield was significantly higher under weed free treatment. Subsequently, significantly higher protein yield was registered with imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS which was statistically on par with stale seedbed *fb* interculture and hand weeding at 40 DAS. Wherein, unweeded check registered significantly lower protein yield. The higher protein yield recorded under above superior treatments was due to relatively higher seed yield reported under these treatments due to proper weed control. Hence, as the seed yield increased, protein yield was also increased and *vice-versa*. Hence, protein yield was direct reflection of seed yield in different treatments. Whereas, under unweeded check treatment protein yield was significantly lower because of lack of weed management practices which led to higher crop-weed competition resulting in poor seed yield resulting in lower protein yield.

Table 1: Effect of different weed management practices on category wise weed dry weight at 25 DAS and 50 DAS in greengram

Treatments	Weed dry weight at 25 DAS (g/m^2)				Weed dry weight at 50 DAS (g/m^2)			
	Sedges	Grasses	Broad leaf weeds	Total	Sedges	Grasses	Broad leaf weeds	Total
T_1	2.00c (3.53)	2.59c (6.23)	2.63c (6.46)	4.09c (16.23)	4.26b (17.69)	5.76b (32.94)	5.79b (33.18)	9.18b (83.81)
T_2	2.05c (3.79)	2.63c (6.60)	2.70c (7.11)	4.21c (17.51)	4.30b (18.08)	5.81b (33.52)	5.83b (33.76)	9.24b (85.36)
T_3	3.32b (10.58)	3.81b (14.08)	3.95b (15.10)	6.34b (39.76)	3.32c (10.79)	4.45c (19.62)	4.58c (20.72)	7.13c (51.13)
T_4	1.72c (2.60)	2.11c (4.04)	2.29c (4.86)	3.42c (11.50)	3.20c (9.80)	4.32c (18.26)	4.44c (19.33)	6.90c (47.39)
T_5	1.86c (2.96)	2.16c (4.24)	2.33c (5.00)	3.55c (12.20)	3.27c (10.32)	4.39c (18.90)	4.49c (20.03)	7.02c (49.24)
T_6	3.21b (9.92)	3.72b (13.50)	3.83b (14.24)	6.16b (37.66)	2.11d (4.05)	2.95d (8.45)	3.10d (9.22)	4.67d (21.72)
T_7	2.12c (4.15)	2.42c (5.46)	2.37c (5.23)	3.87c (14.84)	4.37b (18.71)	5.88b (34.15)	5.85b (33.85)	9.32b (86.71)
T_8	2.23c (4.62)	2.49c (5.96)	2.45c (5.62)	4.03c (16.20)	2.05d (3.78)	2.83d (7.92)	2.49d (5.83)	4.18d (17.53)
T_9	0.71d (0.00)	0.71d (0.00)	0.71d (0.00)	0.71d (0.00)	0.71e (0.00)	0.71e (0.00)	0.71e (0.00)	0.71e (0.00)
T_{10}	4.07a (16.31)	4.77a (22.31)	4.88a (23.40)	7.90a (62.02)	5.35a (28.47)	7.11a (50.34)	7.19a (52.68)	11.49a (131.49)
S.Em.±	0.17	0.22	0.20	0.25	0.21	0.30	0.28	0.29
C.V.%	12.84	13.61	12.24	9.74	10.95	11.93	10.88	7.09

Figures in parentheses are original values and figures outside the parentheses are √x+0.5 transformed values
Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
T_1: Soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_2: Soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_3: Soil solarization *fb* interculture and hand weeding at 40 DAS, T_4: Stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_5: Stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_6: Stale seedbed *fb* interculture and hand weeding at 40 DAS, T_7: Imazethapyr 100 ml/ha as PoE at 15 DAS, T_8: Imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS, T_9: Weed free, T_{10}: Unweeded check

Table 2: Effect of different weed management practices on category wise weed dry weight at 50 DAS and on growth, yield parameter of greengram

Treatments	Weed dry weight at harvest (g/m^2)				Plant height (cm)			Number of branches per plant at harvest	Pod yield per plant (g)
	Sedges	Grasses	Broad leaf weeds	Total	At 25 DAS	At 50 DAS	At harvest		
T_1	4.18b (17.02)	4.75b (22.05)	4.80b (23.16)	7.90b (62.22)	23.03	40.73	43.63	4.60	14.74
T_2	4.24b (17.52)	4.80b (22.61)	4.84b (23.52)	8.00b (63.65)	22.66	39.67	42.83	4.39	14.52
T_3	3.20c (9.76)	3.57c (12.45)	3.70c (13.33)	5.97c (35.54)	17.53	48.34	52.77	5.65	17.57
T_4	3.00c (8.63)	3.47c (11.58)	3.60c (12.54)	5.74c (32.76)	26.30	50.18	54.50	6.03	18.27
T_5	3.07c (9.02)	3.54c (12.25)	3.63c (12.87)	5.84c (34.14)	25.60	49.17	53.33	5.82	17.86
T_6	2.03d (3.87)	2.28d (5.14)	2.60d (6.50)	3.90d (15.50)	18.04	60.79	68.71	7.02	21.10
T_7	4.30b (18.10)	4.95b (24.19)	4.89b (23.47)	8.13b (65.76)	24.40	38.00	41.67	4.20	13.70
T_8	1.92d (3.37)	2.24d (4.87)	2.12d (4.30)	3.52d (12.54)	23.47	61.45	69.80	7.20	21.46
T_9	0.71e (0.00)	0.71e (0.00)	0.71e (0.00)	0.71e (0.00)	31.13	66.37	73.63	7.67	24.32
T_{10}	5.38a (28.54)	6.10a (37.04)	6.16a (38.37)	10.18a (103.95)	15.09	36.33	38.67	3.26	10.04
S.Em.±	0.21	0.25	0.23	0.29	1.44	2.46	2.92	0.30	0.93
C.D. at 5%	-	-	-	-	4.29	7.32	8.69	0.89	2.77
C.V.%	11.29	11.95	10.97	8.44	11.01	8.69	9.39	9.28	9.31

Figures in parentheses are original values and figures outside the parentheses are √x+0.5 transformed values
Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance
T_1: Soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_2: Soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_3: Soil solarization *fb* interculture and hand weeding at 40 DAS, T_4: Stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS, T_5: Stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS, T_6: Stale seedbed *fb* interculture and hand weeding at 40 DAS, T_7: Imazethapyr 100 ml/ha as PoE at 15 DAS, T_8:

Imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS, T_9: Weed free, T_{10}: Unweeded check

Table 3: Effect of weed management practices on yield, protein content, protein yield, weed index and economics of greengram

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)	Weed index (%)	Cost of cultivation (Common cost + Treatment cost) (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B: C ratio
T_1: Soil solarization *fb* castor shell mulch @ 7.5 t/ha at 10 DAS	822	2030	19.10	157.49	46.82	59177	69670	10493	1.18
T_2: Soil solarization *fb* mustard straw mulch @ 5 t/ha at 10 DAS	786	1943	19.33	151.81	49.13	48444	66634	18190	1.38
T_3: Soil solarization *fb* interculture and hand weeding at 40 DAS	1030	2408	21.18	217.43	33.30	45715	86214	40499	1.89
T_4: Stale seedbed *fb* castor shell mulch @ 7.5 t/ha at 10 DAS	1080	2458	21.27	230.56	30.10	55548	89864	34316	1.62
T_5: Stale seedbed *fb* mustard straw mulch @ 5 t/ha at 10 DAS	1048	2415	21.33	224.22	32.12	44815	87440	42625	1.95
T_6: Stale seedbed *fb* interculture and hand weeding at 40 DAS	1286	2828	22.76	291.75	16.75	42085	106214	64129	2.52
T_7: Imazethapyr 100 ml/ha as PoE at 15 DAS	761	1894	19.15	146.09	50.76	36062	64617	28555	1.79
T_8: Imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS	1330	2905	22.54	300.10	13.90	39452	109690	70238	2.78
T_9: Weed free	1545	3316	23.59	362.66	0.00	59585	126953	67368	2.13
T_{10}: Unweeded check	491	1297	17.71	86.49	68.22	33214	42291	9077	1.27
S.Em.+	66.32	123.07	1.25	19.72	-	-	-	-	-
C.D. at 5%	197.03	365.66	NS	58.59	-	-	-	-	-
C.V.%	11.29	9.07	10.43	15.75	-	-	-	-	-

Table 4: Correlation and regression equations for various dependent and independent parameters of greengram

Sr. No.	Independent variable (x)	Dependent variable (y)	Correlation coefficient (r)	Regression equation y	R^2
7	Total weed dry weight at 50 DAS (g/m^2)	Seed yield (kg/ha)	-0.9928**	y=1468.89-7.85x	0.9857
8	Total weed dry weight at harvest (g/m^2)		-0.9850**	y=1439.39-9.89x	0.9702
13	Pod yield per plant (g)		0.9992**	y=-265.87+73.95x	0.9986
14	Stover yield (kg/ha)		0.9982**	y=-242.71+0.54x	0.9964
15	Total weed dry weight at 50 DAS (g/m^2)	Stover yield (kg/ha)	-0.9950**	y=3190.71-14.64x	0.9901
16	Total weed dry weight at harvest (g/m^2)		-0.9900**	y=3137.96-18.50x	0.9801
21	Pod yield per plant (g)		0.9985**	y=-37.04+137.48x	0.9971
22	No. of pods per plant	Pod yield per plant (g)	0.9923**	y=3.98+0.70x	0.9846

** = Significant at 1% * = Significant at 5%

Conclusion

Based on results of one year field experiment, it is concluded that either imazethapyr 100 ml/ha as PoE at 15 DAS + interculture *fb* hand weeding at 40 DAS or stale seedbed *fb* interculture and hand weeding at 40 DAS is suggested for effective control of weeds and achieving higher yield and net returns in *kharif* greengram.

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