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Determination of the Critical Period of Crop-weed Competition: Impact on Weed Dynamics, Growth and Yield of Greengram (*Vigna radiata* L.)

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Abstract

A field experiment was conducted during *kharif* (July–September) 2024 at Agronomy Instructional Farm, Department of Agronomy, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (North Gujarat Agro-climatic Zone of Gujarat) to assess the critical period of crop-weed competition in greengram (*Vigna radiata* L.) under North Gujarat condition on loamy sand soil. The experiment was conducted under randomized block design with eight treatments and three replications. Among the different treatments weed free upto harvest treatment recorded significantly higher seed and stover yield (1344 and 3247 kg ha^{-1}, respectively) and was found at par with weed free upto 45 DAS (1235 and 3125 kg ha^{-1}, respectively), weed free upto 30 DAS (1155 and 2956 kg ha^{-1}, respectively) and weedy upto 15 DAS (1122 and 2816 kg ha^{-1}, respectively) as compared to weedy upto harvest (636 and 1462 kg ha^{-1}, respectively) owing to significantly lower dry weight of grasses, sedges, broad leaf and total weeds at 15, 30, 45 DAS and at harvest with higher weed control efficiency and lower weed index values. Furthermore, weed free upto harvest recorded higher net returns followed by weed free upto 45, 30 DAS and weedy upto 15 DAS as compared to weedy upto harvest.

Keywords: Geengram, critical-period of crop-weed competition, yield

1. Introduction

Greengram (*Vigna radiata* L.) is one of the most important and extensively cultivated pulse crop (Udhaya et al., 2023) in arid and semi-arid regions of India. It belongs to the family Fabaceae (Jaswal et al., 2022) subfamily Papilionaceae. It is primarily a native of India and Central Asia may be a secondary centre. It is also referred to as moongbean, moong or goldengram (Udayasri et al., 2022). It is an excellent source of high quality lysine (460 mg g^{-1} N) and tryptophan (60 mg g^{-1} N) and also contains remarkable quantity of ascorbic acid and riboflavin (0.21 mg 100 g^{-1}) which is almost three times that of cereals (Azadi et al., 2013). The grains contain approximately 25% protein (Adhikary and Patra, 2024), 1.02–1.05% oil, 3.5–4.5% fiber, 4.5–5.5% ash and 60–65% carbohydrates on dry weight basis (Guru, 2024). Hence, it supports protein requirement of vegetarian population of the country. It plays an important role as a food security crop because of its nutritional quality as well as its ability to survive in harsh environmental conditions. In India, greengram is cultivated on around 51.87 lakh ha area with of production of 31.03 lakh tonnes (Anonymous, 2025a). In Gujarat, it is grown about 1.38 lakh ha area with a total production of 1.26 lakh tonnes with a productivity of 914.39/kg (Final advance estimates of 2024–25) (Anonymous, 2025b). It is cultivated during *kharif* (July–October) as well as summer (March–June) seasons in India. It is a short duration (65–90 days) (Muchomba et al., 2023), drought tolerant crop that can be grown successfully on drained loamy to sandy loam soil in areas of erratic rainfall. After picking of pods, mungbean plants may be used as green fodder or green manure. Besides these, the crop also enriches soil by fixing atmospheric nitrogen. Amongst the various factors known to augment the crop production, weeds form a single negative factor, which play key role against achieving full yield potential of the crop (Kavad et al., 2016). The weed infestation cause 30 to 80 % of yield loss in greengram (Algotar et al., 2015). It is one of the major constraints in green gram cultivation during the summer and rainy seasons. Dominant weeds associated with greengram were *Dactyloctenium aegyptium*, *Chloris barbata*, *Cynodon dactylon* among grasses, *Cyperus rotundus* among sedges, *Phyllanthus niruri*, *Boerhavia diffusa*, *Cleome viscosa*, *Trianthema portulacastrum, Digera muricata* and *Tridax procumbens* among broad leaved weeds (Natarajan et al., 2003). Among the different growth stages, the period. of crop growth which is most sensitive to weed competition is called as critical period of crop-weed competition. It begins when both competes with each other for same resources such as nutrients, light, space and water at the same time (Singh and Singh, 2020). At initial crop growth of 25–30 days after sowing (DAS), crop-weed competition is more (Singh et al., 2021). Weeds take available resources during competition and suffer the crops from starvation which ultimately affects the crop growth leading to yield loss (Hirani et al., 2024). Singh et al. (2015) stated that when greengram was severely infested with weeds during critical stages there was a yield reduction between 30 and 85%. Hence, identification of critical period of crop-weed competition in greengram is very important, based on which proper weed management strategy can be implemented as effective weed management practices are more important for green gram cultivation. (Rathika et al., 2023). Considering these facts and views, an experiment was conducted to identify critical period of crop weed competition in greengram.

2. Materials and Methods

A field experiment was conducted during *kharif* (July–September) 2024 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (385 506) (North Gujarat Agro-climatic region (AES IV) of Gujarat) at a 24° 19' North latitude and 72° 19' East longitude with an elevation of 154.52 m above the mean sea level. The experiment was laid out in randomized block design with eight treatments and three replications. The experimental field was ploughed by tractor drawn cultivator and was followed by harrowing and planking to obtain fine seedbed. The greengram cultivar "GM 4" was sown manually at a spacing of 45×10 cm^2 on 8th July, 2024 with a seed rate of 17.5 kg ha^{-1}. The gross plot size and net plot size of the experiment were 5.0×4.5 m^2 and 3.6×2.7 m^2, respectively. The crop was fertilized with application of well decomposed FYM at 5 t ha^{-1} at ten days before sowing and 20:40 kg NP_2O_5 ha^{-1} at sowing. The sources of fertilizers used were DAP, and urea which were commonly applied to soil for all treatments just before sowing of seeds in the furrow. The first irrigation was given immediately after sowing of crop and there was rainfall at six days after sowing which was enough for ensuring proper germination and establishment of the seed. Remaining irrigations were given as per requirement of crop.

The weather data indicated that mean maximum temperature ranged between 30.0 to 35.2°C, while mean minimum temperature ranged between 24.8 to 26.9°C during the period of experimentation (July–September, 2024). The mean relative humidity recorded at morning and evening ranged from 74.0 to 98.0 and 42.0 to 89.0%, respectively. During the experimental period i.e., *kharif* season, the weekly rainfall received varied between 0.0 to 161.6 mm. The bright sunshine hours and evaporation ranged between 0.5 to 8.6 h day^{-1} and 2.0 to 5.4 mm day^{-1}, respectively during crop period. All over climatological data indicated that the weather conditions were normal and favourable for the satisfactory growth and development of the greengram crop during *kharif* season of 2024. The experimental field had an even topography with a gentle slope having good drainage. The soil of experimental field was loamy sand in texture with slightly alkaline in reaction and electrical conductivity within safe limit. The soil was low in organic carbon and available nitrogen, medium in available P_2O_5 and K_2O. The crop was harvested on 24th September, 2024 manually at physiological maturity. At first, the border rows (plants from buffer line) were harvested from each plot and taken out from the experimental area. Randomly selected previously tagged five plants from each net plot were harvested separately for recording different biometric observations and later on these five plant yields were added to the seed yield of respective net plots. During the crop season weeding was carried out by manual labour as per treatments.

The sedges, grasses and broad leaf weeds were uprooted from 0.25 m^2 (50×50 cm^2) area in buffer area of plots at 15, 30, 45 DAS and at harvest and were kept in separate brown paper packets for sun drying and later they were kept in hot air oven at 60°C for 72 h till the dry weight reaches constant weight. Later, category wise weed dry weight of sedges, grasses and broad leaf weeds were noted down by weighing in weighing balance and later total weed dry weight of each stage were recorded. Further, the data was multiplied with 4 to convert the data into g m^{-2}. Since the weed count data does not follow normal distribution, the weed count data were analyzed after subjecting to √x+1 transformation as suggested by Gomez and Gomez (1984). All the growth and yield observation of greengram were measured using standard procedures. The statistical analysis of the data collected for different parameters were carried out following the standard procedures.

3. Results and Discussion

3.1. Effect on weed flora, weed dry weight and weed control efficiency

The major weed species found in the experimental field at various stages were: *Cyperus rotundus* L. among sedges, *Eragrostis pilosa* (L.) P. Beauv., *Dactyloctenium aegyptium* L., *Digitaria sanguinalis* L., *Setaria glauca* (L.) P. Beauv. among grasses and *Portulaca oleracea* L., *Boerhavia diffusa* L., *Digera arvensis* L., *Tribulus terrestris* L., *Commelina benghalensis* L., *Euphorbia hirta* L., *Phyllanthus niruri* Hook F., *Mollugo nudicaulis* Lam., *Sida rhombifolia* L., *Leucas aspera*

(Willd.) Link. among broad leaf weeds. Overall, the field was dominated with broad leaf weeds which was followed by grasses and sedges. Among sedges *Cyperus rotundus* L. among grasses *Dactyloctenium aegyptium* L. and among broad leaf weeds *Boerhavia diffusa* L. and *Portulaca oleracea* L. were dominant at all the stages (15, 30, 45 DAS and harvest).

Dry weight of weed was significantly influenced by different treatments in greengram at 15, 30, 45 DAS and at harvest (Table 1 to 2). Among the different treatments, at 15 DAS weed free upto 15, 30, 45 DAS and at harvest treatments showcased the zero weed dry weight with maximum weed control efficiency which could be ascribed to effective weed removal through mechanical and physical control measures. On the other hand a significantly higher weed dry weight of sedges, grasses, broad leaf weeds and total weeds (3.57, 8.84, 14.46 and 26.87 m^{-2}, respectively) with minimum weed control efficiency was found under weedy upto 15 DAS and was on par with weedy upto 30, 45 DAS and at harvest due to the absence of any weed control interventions before or by 15 DAS, allowing unchecked weed growth during the early stages. Significantly lower dry weight of sedges, grasses, broad leaf weeds and total weeds with higher weed control efficiency at 30 DAS were documented under weed free upto 30, 45 DAS, at harvest and weedy upto 15 DAS. Wherein, significantly higher weed dry weight of sedges, grasses, broad leaf weeds and total weeds (19.02, 50.65, 75.66 and 145.33 m^{-2}, respectively) with lower weed control efficiency were recorded with weedy upto 30 DAS and which was statistically at par with weedy upto 45 DAS and at harvest.

The treatments weed free upto 45 DAS, upto harvest, and weedy upto 15 and 30 DAS showed zero dry weight of sedges, grasses, broad leaf weeds, and total weeds with higher weed control efficiency at 45 DAS due to effective weed control in these treatment before 45 DAS. In contrast, significantly higher weed dry weight of sedges, grasses, broad leaf weeds and total weeds (27.62, 64.44, 97.02 and 189.08 m^{-2}, respectively) with minimum weed control efficiency were recorded in weedy upto 45 DAS which were statistically similar to weedy upto harvest. These findings were more or less in line with those of Kumar and Tewari (2004) who reported the highest weed weight under weedy check throughout the crop duration, closely followed by weedy conditions upto 40 days after sowing. Dry weight of sedges, grasses, broad leaf weeds and total weeds noticed 0 g m^{-2} under weed free upto

Table 1: Effect of different treatments on category wise weed dry weight and weed control efficiency at 15 and 30 DAS in greengram

Treatments	At 15 DAS					At 30 DAS				
	Weed dry weight (g m^{-2})				WCE (%)	Weed dry weight (g m^{-2})				WCE (%)
	Sedges	Grasses	Broad leaf weeds	Total		Sedges	Grass-es	Broad leaf weeds	Total	
T_1: Weed free upto 15 DAS	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	100.00	2.60^b (5.83)	5.12^b (25.77)	5.82^b (33.19)	8.07^b (64.79)	52.23
T_2: Weed free upto 30 DAS	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	100.00	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	100.00
T_3: Weed free upto 45 DAS	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	100.00	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	100.00
T_4: Weed free upto harvest	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	1.00^b (0.00)	100.00	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	100.00
T_5: Weedy upto 15 DAS	2.13^a (3.57)	3.14^a (8.84)	3.92^a (14.46)	5.28^a (26.87)	-5.46	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	1.00^c (0.00)	100.00
T_6: Weedy upto 30 DAS	2.18^a (3.83)	2.93^a (7.76)	4.13^a (16.09)	5.35^a (27.68)	-8.65	4.47^a (19.02)	7.17^a (50.65)	8.74^a (75.66)	12.09^a (145.33)	-7.15
T_7: Weedy upto 45 DAS	1.82^a (2.34)	2.64^a (6.01)	4.03^a (15.49)	4.97^a (23.84)	6.42	4.27^a (17.75)	7.26^a (51.96)	8.63^a (74.10)	12.02^a (143.82)	-6.04
T_8: Weedy upto harvest	1.97^a (3.06)	2.90^a (7.69)	3.95^a (14.73)	5.13^a (25.48)	-	3.93^a (14.55)	6.97^a (48.05)	8.57^a (73.03)	11.69^a (135.63)	-
SEm±	0.13	0.18	0.18	0.17	NA	0.22	0.32	0.33	0.28	NA
C.V. %	14.95	15.65	12.52	9.77	NA	15.53	14.58	12.89	8.17	NA

Figures inside and outside the parentheses are original and √x+1.0 transformed values, respectively; Treatment means with the letter(s) in common were not significantly different by DNMRT at p=0.05% level of significance; WCE: Weed control efficiency

Table 2: Effect of different treatments on category wise weed dry weight and weed control efficiency at 45 DAS and at harvest in greengram

Treatments	At 45 DAS					At harvest				
	Weed dry weight (g m^{-2})				WCE (%)	Weed dry weight (g m^{-2})				WCE (%)
	Sedges	Grasses	Broad leaf weeds	Total		Sedges	Grasses	Broad leaf weeds	Total	
T_1: Weed free upto 15 DAS	3.20^b (9.30)	6.02^b (35.81)	6.87^b (46.56)	9.61^b (91.67)	50.58	3.64^b (12.27)	6.12^b (36.90)	6.98^b (48.27)	9.90^b (97.44)	50.42
T_2: Weed free upto 30 DAS	2.61^b (5.99)	3.64^c (12.56)	4.80^c (22.85)	6.49^c (41.40)	77.68	2.98^c (8.03)	3.93^c (14.88)	4.81^c (22.89)	6.83^c (45.80)	76.69
T_3: Weed free upto 45 DAS	1.00^c (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^d (0.00)	100.00	2.21^d (3.97)	3.54^c (11.65)	4.63^c (20.49)	6.07^d (36.10)	81.63
T_4: Weed free upto harvest	1.00^c (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^d (0.00)	100.00	1.00^e (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^e (0.00)	100.00
T_5: Weedy upto 15 DAS	1.00^c (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^d (0.00)	100.00	1.00^e (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^e (0.00)	100.00
T_6: Weedy upto 30 DAS	1.00^c (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^d (0.00)	100.00	1.00^e (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^e (0.00)	100.00
T_7: Weedy upto 45 DAS	5.31^a (27.62)	8.09^a (64.44)	9.89^a (97.02)	13.77^a (189.08)	-1.93	1.00^e (0.00)	1.00^d (0.00)	1.00^d (0.00)	1.00^e (0.00)	100.00
T_8: Weedy upto harvest	5.63^a (30.72)	7.80^a (60.02)	9.77^a (94.75)	13.65^a (185.50)	-	5.65^a (31.45)	8.09^a (64.51)	10.08^a (100.56)	14.05^a (196.52)	-
SEm±	0.21	0.25	0.32	0.25	NA	0.19	0.27	0.31	0.20	NA
C.V. %	13.97	11.90	12.74	7.36		13.87	14.74	14.13	6.81	

Figures inside and outside the parentheses are original and $\sqrt{x+1.0}$ transformed values, respectively; Treatment means with the letter(s) in common were not significantly different by DNMRT at p=0.05% level of significance; WCE: Weed control efficiency

harvest, weedy upto 15, 30, 45 DAS with higher weed control efficiency. However, weedy upto harvest treatment recorded significantly higher dry weight of sedges, grasses, broad leaf weeds and total weeds at harvest (31.45, 64.51, 100.56 and 196.52 m^{-2}, respectively) with minimum lower weed control efficiency which was a direct reflection of higher weed density of sedges, grasses, broad leaf weeds and total weeds. These findings were also supported by Sheoran et al. (2008) and Hirani et al. (2024).

3.2. *Effect on growth parameters*

In greengram, different treatments have significantly varied the plant height at 30, 45 DAS and at harvest (Table 3). An exploration of data stipulated that the data on plant height at harvest revealed that significantly higher plant height at harvest was noticed in weed free upto harvest (71.41 cm) and was at par with weed free upto 45, 30 and weedy upto 15 DAS (67.29, 65.43 and 63.46 cm, respectively). Wherein, significantly lower plant height (44.23 cm) was observed in weedy upto harvest. Reduced competition between crop and weeds led to overall improvement in crop growth as evidenced by increased plant height this in turn promoted better development of reproductive structures and more efficient translocation of photosynthates to the sink in greengram. Outcome of present experiment also corroborated the finding of with Singh et al. (2023), Indra et al. (2024), Singh and Yadav (2015) and Jaswal et al. (2022).

Significantly lower plant height at harvest (44.23 cm) in weedy upto harvest might be reasoned to intense competition from weeds for essential resources such as nutrients, sunlight, water, and growing space throughout its development leading to the shortest plant height. Similar observations have also been reported by Mohanty et al. (2023), Bohara et al. (2022).

The perusal of data asserted that different weed treatments significantly altered the number of branches plant^{-1} at harvest as shown in Table 3. Significantly greater number of branches plant^{-1} at harvest (8.33 plant^{-1}) was recorded under the weed free upto harvest which was statistically comparable to weed free upto 45 DAS (7.80 plant^{-1}), weed free 30 DAS (7.07 plant^{-1}), and weedy upto 15 DAS (6.93 plant^{-1}). In contrast the weedy upto harvest recorded a significantly lower number of branches plant^{-1} at harvest (3.87 plant^{-1}) primarily due to intense competition from weeds for essential resources. This

Table 3: Effect of different treatments on growth parameters in greengram

Treatments	Plant height (cm) at harvest	Number of branches plant^{-1} at harvest	Root nodules at flowering stage		
			Number of root nodules plant^{-1}	Fresh weight (mg plant^{-1})	Dry weight (mg plant^{-1})
T_1: Weed free upto 15 DAS	49.02	5.07	10.80	206.89	54.24
T_2: Weed free upto 30 DAS	65.43	7.07	14.87	278.15	67.63
T_3: Weed free upto 45 DAS	67.29	7.80	15.60	294.71	70.94
T_4: Weed free upto harvest	71.41	8.33	16.93	310.78	74.15
T_5: Weedy upto 15 DAS	63.46	6.93	14.33	265.60	65.12
T_6: Weedy upto 30 DAS	48.84	4.87	8.67	201.13	53.42
T_7: Weedy upto 45 DAS	45.88	4.33	7.80	193.56	51.91
T_8: Weedy upto harvest	44.23	3.87	6.87	187.89	50.77
SEm±	4.11	0.50	0.90	16.93	3.19
CD (p=0.05)	12.48	1.51	2.72	51.36	9.67
C.V. %	12.51	14.32	12.95	12.10	9.05

competition limited the crop's ability to absorb adequate moisture and nutrients leading to reduced carbohydrate production and consequently stunted growth and fewer branches. Similar results were reported by Hirani et al. (2024) who found that weed interference notably reduced the number of branches. The similar consequences were also witnessed by Mirjha et al. (2013) under weedy check in mungbean where lower number of branches plant^{-1} at maturity were observed.

Significant differences in the number of nodules, fresh and dry weight of nodules plant^{-1} at the flowering stage were observed among the various treatments as shown in Table 3. The extent of nitrogen fixation by legume crops was determined by nodule formation. Among various treatments, weed free treatment registered significantly highest number of nodules, fresh and dry weight of nodules (16.93 plant^{-1}, 310.78 mg plant^{-1} and 74.15 mg plant^{-1}, respectively) that was statistically at par with weed free upto 45 DAS (15.60 plant^{-1}, 294.71 mg plant^{-1} and 70.94 mg plant^{-1}, respectively), weed free upto 30 DAS (14.87 plant^{-1}, 278.15 mg plant^{-1} and 67.63 mg plant^{-1}, respectively) and weedy upto 15 DAS (14.33 plant^{-1}, 265.60 mg plant^{-1} and 65.12 mg plant^{-1}, respectively).

Comparatively, weed free treatment recorded significantly highest number of nodule, fresh and dry weight of nodule this was primarily due to the absence of competition from weeds, which better availability of essential resources such as light, water, nutrients, and space. In a weed-free environment, plants experience reduced stress and improved photosynthesis, resulting in greater energy availability for root development and nodule formation. Additionally, the absence of weeds promotes better soil aeration, which was crucial for nodule health. Moreover, improved soil conditions and reduced root-zone competition provided a more favorable environment for the proliferation and activity of *Rhizobium* bacteria, enhancing the symbiotic relationship essential for nitrogen fixation. Together, these factors contributed to enhanced nodulation and overall plant vigour under weed free conditions. Similar outcomes were also expressed by the earlier researchers viz., Mukherjee (2021) who reported that number of nodules plant^{-1} found more with weed free situation, Singh et al. (2023) who witnessed highest nodules number plant^{-1} and nodule dry weight in weed free treatment on the same line, Jakhar et al. (2015) also found weed free treatment attained the highest number of nodules plant^{-1} among all the treatments in urdbean. The significantly lower number of nodules, fresh and dry weight of nodules observed under the treatment weedy upto harvest might be owing to higher density of weeds which caused maximum competition with crop which limited plant growth and reduced the supply of carbohydrates to the roots, resulting in poor nodule formation. The presence of dense weeds could also hinder soil airflow which also affected the nodule formation. Corresponding results were also noticed by Adhikary and Patra (2024).

3.3. Effect on seed yield, stover yield and weed index

The information concerning greengram yield affected by different weed treatments was provided in Tables 4. Grain yield was the ultimate parameter which depended both on the availability of source and sink as well as translocation of the photosynthates from source to sink (Singh and Singh, 2020). In general, seed yield of rainy season greengram showed a declining trend with increasing initial weedy period. Season long weed infestation caused yield reduction to the tune of 52.69% compared to weed free check. Significantly higher seed and straw yield (1344 and 3247 kg ha^{-1}, respectively) of greengram was recorded when the weed free conditions were maintained throughout the crop growth period. However, there was a non-significant variation in seed yield when weed

Table 4: Effect of different treatments on yields, weed index and economics in greengram

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	WI (%)	Economics			
				Total cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BCR
T_1: Weed free upto 15 DAS	871	2249	35.20	40528	74607	34079	1.84
T_2: Weed free upto 30 DAS	1155	2956	14.04	43812	98723	54911	2.25
T_3: Weed free upto 45 DAS	1235	3125	8.06	46274	105275	59001	2.28
T_4: Weed free upto harvest	1344	3247	0.00	51199	113336	62137	2.21
T_5: Weedy upto 15 DAS	1122	2816	16.52	47095	95458	48363	2.03
T_6: Weedy upto 30 DAS	843	2189	37.29	45453	72307	26854	1.59
T_7: Weedy upto 45 DAS	736	2024	45.20	42991	64032	21041	1.49
T_8: Weedy upto harvest	636	1462	52.69	35604	53036	17432	1.49
SEm±	78	184	NA	NA	NA	NA	NA
CD (p=0.05)	236	559	NA	NA	NA	NA	NA
C.V. %	13.59	12.73	NA	NA	NA	NA	NA

free environment were maintained upto 45 DAS (1235 and 3125 kg ha^{-1} respectively), 30 DAS (1155 and 2956 kg ha^{-1}, respectively) and weedy upto 15 DAS (1122 and 2816 kg ha^{-1}, respectively) in comparison to weedy upto harvest.

The higher seed yield observed with these treatments might be attributed to the favourable impact on growth parameters, resulting from more efficient utilization of available resources such as space, nutrients, light and water by the crop. Correspondingly this increase in seed and stover yield was primarily due to the maintenance of a weed free environment, particularly during the critical growth stages of greengram, which reduced crop-weed competition and facilitated better growth and development. Furthermore, the significant increase in seed yield and the corresponding reduction in total density and dry weight of weeds recorded under these treatments clearly indicated that effective weed management also played a crucial role in enhancing the overall productivity of the greengram crop. Thus, it was imperative to eliminate weeds from the crop at proper time and with suitable methods. Comparable outcomes were also noted by Sheoran et al. (2008) who depicted that highest seed yield of greengram was recorded when the weed free conditions were maintained throughout the crop growth period. However, there was a non-significant variation in seed yield when weed free environment were maintained for the initial 40 and 50 days of sowing in comparison to weed free check. These improved yield parameters and yield in above treatments were resultant of better weed control. Jaswal et al. (2022) witnessed that the highest seed yield was recorded in weed free. These findings were also supported by Sobhana et al. (2018), Singh et al. (2023) and Muthuram et al. (2018).

When weedy conditions were maintained upto harvest (636, 1462 kg ha^{-1}, respectively), 45, 30 DAS and weed free upto 15 DAS recorded significantly lower seed and straw yield with a reduction in seed yield to the extent of 52.69, 45.20, 37.29 and 35.19 %, respectively in comparison to weed free situation maintained throughout the crop growth period. Similar outcomes were also achieved by Duary and Hazra (2013) in sesame, Sheoran et al. (2008) and Mandal et al. (2006).

Crop yield tends to decrease as the weed index increases in any type of crop. In the case of greengram, different treatments had a varying impact on the weed index (Table 4). The weed index indicates the reduction in crop yield under various treatments when compared to a completely weed free plot. The weed index of greengram at harvest varied with different treatments. The data indicated that weed free treatment recorded lowest weed index (0.00%). Further, weed free upto 45 (8.06%), 30 DAS (14.04%) and weedy upto 15 DAS (16.52%) witnessed lower weed index. Whereas, the highest weed index value was observed in the weedy upto harvest (52.69%).

3.4. Effect on economics

Variations among the different treatments were observed in terms of economics was provided in Table 4. Among the different treatments, weed free upto harvest treatment recorded higher cost of cultivation (₹ 51199 ha^{-1}) and was followed by weedy upto 15 DAS (₹ 47095 ha^{-1}), weed free upto 45 DAS (₹ 46274 ha^{-1}) and weedy upto 30 DAS (₹ 45453 ha^{-1}). However, lower cost of cultivation was observed under weedy upto harvest (₹ 35604 ha^{-1}). The higher cost of cultivation under the weed free upto harvest treatment was mainly a result of increased labour expenses and the greater number of labour units needed for weeding operations. On the other hand, the lower cost of cultivation in the weedy upto harvest was due to no any expenses associated with treatments.

Further, among various treatments, weed free gave higher gross returns (₹ 113336 ha^{-1}) which was followed by weed free upto 45, 30 DAS and weedy upto 15 DAS (₹ 105275 ha^{-1}, ₹ 98723 ha^{-1} and ₹ 95458 ha^{-1}, respectively). Wherein, lower gross returns was observed under weedy upto harvest (₹ 53036 ha^{-1}). The variations in gross returns were solely due to the seed and stover yields of their respective treatments. Additionally, the net returns from different treatments were determined by taking into account both the gross returns and the cost of cultivation. The data on greengram net returns under various treatments indicated that the highest net returns were achieved with weed free upto harvest (₹ 62137 ha^{-1}) followed by weed free upto 45 DAS (₹ 59001 ha^{-1}), 30 DAS (₹ 54911 ha^{-1}) and weedy upto 15 DAS (₹ 48363 ha^{-1}). The differences in net returns across the different treatments were attributed to variations in gross returns and the cultivation costs associated with each treatment. In contrast, the unweeded control plot recorded the lowest net returns of (₹ 17432 ha^{-1}) reflecting reduced profitability due to lower seed and stover yields observed in the absence of weed management practices.

The data on the benefit cost ratio clearly showed that, among different treatments, a maximum benefit cost ratio of (2.28) was obtained under weed free upto 45 DAS, which was closely followed by weed free upto 30 DAS (2.25), weed free upto harvest (2.21) and weedy upto 15 DAS (2.03). In fact, weedy upto harvest witnessed lowest benefit cost ratio of (1.49). The higher ratio documented under weed free upto 45 DAS than weed free upto harvest was primarily due to comparatively higher gross returns as a resulting of higher seed and stover yield.

4. Conclusion

The study revealed that the critical period of crop-weed competition in greengram was between 15 and 30 DAS and this might be taken into consideration while deciding number and time of weeding and/or any weed control measure.

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