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Bhagyashree
Master' Student, Department of
Agronomy College of Agriculture,
Raichur, UASR, Karnataka, India

AS Police Patil
Scientist (Agronomy), AICRP on
Kharif Pulses ZARS, Kalaburagi,
Karnataka, India

SB Reddy
Assistant Professor, Department of
Soil Science and Agricultural
Chemistry, College of Agriculture,
Bheemarayanagudi, Karnataka,
India

BM Dodamani
Associate Director of Research,
ZARS, Kalaburagi, Karnataka,
India

DH Patil
Associate Professor, College of
Agriculture, Kalaburagi,
Karnataka, India

Corresponding Author:
Bhagyashree
Master' Student, Department of
Agronomy College of Agriculture,
Raichur, UASR, Karnataka, India

Influence of post emergent herbicides on growth and yield of greengram (*Vigna radiata* L.) under rainfed condition

Bhagyashree, AS Police Patil, SB Reddy, BM Dodamani and DH Patil

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Abstract

A field experiment was conducted during *kharif* 2023 in Northern dry Zone of Karnataka in medium black soils at Zonal Agricultural Research Station (ZARS) Farm, Kalaburagi. The experiment was laid out in Randomized Complete Block Design with ten treatments and replicated thrice. The results revealed that, significantly higher plant height, number of branches, leaf area, total dry matter production and root nodules at harvest was recorded with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS followed by fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS and hand weeding at 15 and 30 DAS. Further highest seed yield, stover yield, gross returns, net returns and BC ratio was recorded with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS followed by fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS and hand weeding at 15 and 30 DAS.

Keywords: Post emergent, herbicide, greengram, yield and economics

Introduction

Pulses play a major role in meeting the global nutrition security. In view of the significance of pulses and to promote the pulse production across the world, United Nations declared the year 2016 as 'International year of Pulses' and 10th February of every year as 'World Pulses Day'. India ranks first in the world as producer, consumer and importer of pulses and contributes about 25 per cent of global pulse production (Kumar *et al.*, 2022) ^[9]. Pulses are the second most important group of food grain crops after cereals in India. Cultivation of pulses has multiple benefits as these fit well to different cropping system and create crop diversification, being hardy and ecologically sound crops they show climate-resilience, low external input demanding crops and thus, register less carbon footprint in agriculture, fix atmospheric nitrogen biologically with improvement of soil health and provide nutritious food grains (Sahu *et al.*, 2021) ^[20]

After chickpea and pigeonpea, greengram is third most important pulse in India belonging to family leguminosae sub family papilionoideae. It is originated from India and Central Asia. In India it is grown in an area of 5.55 mha with production of 3.68 mt and productivity of 663 kg ha⁻¹ (Anon., 2023) ^[1]. In Karnataka, it is grown in an area of 4.99 lakh hectares with production of 1.91 lakh tonnes and productivity of 383 kg ha⁻¹ (Anon., 2023) ^[1].

Weed infestation is one of the major biotic factor which is limiting growth and productivity of greengram. Weeds grow at the expense of the crop because they compete with crops for precious resources like nutrients, soil moisture and light. As a consequence of competition, the crops suffer in growth and yield. The losses caused by weeds and the cost of weed management are among the most expensive items in crop production (Mishra *et al.*, 2023) ^[12]. Yield reduction in greengram ranges from 35 (Raman and Krishnamoorthy, 2005) ^[19] to 80 per cent (Talnikar *et al.*, 2008) ^[24] depending on the type of weed flora associated with the crop. Besides causing crop losses, weeds are also responsible for reducing crop quality, nutrient status of soil *etc.* Critical period of crop weed competition for *Kharif* (rainy season) greengram is 20-40 DAS (Sheoran *et al.*, 2008) ^[22].

Greengram is most vulnerable for weed interference during its early growth stages. Intermittent rainfall provides congenial atmosphere for abundant population and growth of weeds. Therefore, control of weeds at right time is of great importance to realize its potential yield. In conventional methods, farmers go for controlling of weeds through manual methods either through intercultivation or manual weeding. But in the present scenario, timely availability of labour is a major constraint and continuous or erratic distribution of rainfall during the rainy season obstructs timely manual operations.

Mechanical and manual methods being expensive, tedious and thus making farmers to choose alternative management practices i.e chemical weed control. Pendimethalin is the most widely used pre-emergence herbicide. It's effectiveness for late emerging weeds in *Kharif* greengram is less due to frequent rains of south-west monsoon. Moreover, the late emerged weeds pose severe competition to the crop and infest the land with weed seeds making it less productive in the successive seasons. Application of post-emergence herbicide (PoE) is alternative for effective weed management under modern pulse production strategies (Panda *et al.*, 2021)^[15].

In present days farmers are using majority of single herbicide molecules it controls limited weed flora. But the recent trend to use different two or more herbicides mixture either tank mix or ready mix at the time of application. These combinations of herbicides result into wide spectra to control of weeds. So, if weed growth is controlled during crop weed competition period, crop yield will be equivalent to that of weed free. Therefore, it is essential to control weeds during this period. Due to combinations of different herbicides, their synergistic or additive effect may also increase weed control efficiency. Hence the use of post emergent ready mix herbicides reduces the cost of weed management, prevents herbicide resistance in weeds and facilitates improvement in overall weed management. Therefore in the present study, the effect of different weed management practices on weed dynamics, crop growth, yield and economics were evaluated.

Materials and Methods

A field experiment was conducted during *kharif* season of 2023 at Zonal Agricultural Research Station (ZARS) Farm, Kalaburagi, Karnataka. The soil of the experimental field was clay in texture with slightly alkaline in reaction (pH 7.85), medium in organic carbon (0.49%), available phosphorus (32.62 kg ha⁻¹) and potassium (325.25 kg ha⁻¹) and low in available nitrogen (237.81 kg ha⁻¹). The experiment was laid out in randomized complete block design with 10 treatments and replicated thrice. During the year (2023) of experimentation, average total rainfall of 678.6 mm was received with 32 rainy days. July month received a maximum rainfall of 303 mm. The maximum temperature of 40 °C was recorded in the month of June and minimum temperature of 17.11 °C was noticed in January. The mean relative humidity fluctuated between 50.69 in April to 82.52 in July. The greengram variety 'BGS-9' having duration of 65-68 days was sown at a row-to-row distance of 30 cm and plant-to-plant distance of 10 cm with seed rate of 12.5 kg ha⁻¹. A recommended basal dose of 25 kg N and 50 kg P₂O₅ were applied at the time of sowing. The sources of N and P were urea and diammonium phosphate respectively. A knapsack sprayer fitted with flat fan nozzle was used to apply the post emergent weedicides with a spray volume of 750 l ha⁻¹ as per the treatments at 15-20 DAS. The Fomesafen + Fluazifop-p-butyl is a post emergent broad spectrum herbicide which belongs to chemical family Diphenylether + Aryloxyphenoxy-propionate.

Fomesafen controls broad leaved weeds by inhibiting the protoporphyrinogen oxidase (PPO) enzyme in plants. PPO inhibitors, weedicide site-of-action interfere with an enzyme involved in chlorophyll and heme biosynthesis. Fluazifop-p-butyl which is quickly absorbed into the leaf surface, hydrolyzed to fluazifop-p and translocated through the phloem and xylem, accumulating in the rhizomes and stolons of perennial grasses and the meristems of annual and perennial grasses. It inhibits acetyl CoA carboxylase, an enzyme that catalyzes an early step in fatty acid synthesis presumably blocks the production of phospholipids which are essential components of cell membranes (Hardik, 2020). Suitable plant protection chemicals were sprayed in all the plots to check the incidence of pests and diseases. The observation on weed density and weed dry weight was recorded at 25, 45 DAS and at harvest with the help of quadrat of 0.5 m². Observations on crop growth parameters were recorded at 15, 30, 45 DAS and at harvest, for randomly selected five plants from each plot.

Results and Discussion

Weed flora

The important weed flora found in the experimental plot during the period of experimentation was recorded. Among-the broad-leaved weeds, *Alternanthera sessilis* L., *Amaranthus viridis* L., *Boerhavia erecta* L., *Celosia argentea* L., *Parthenium hysterophorus* L., *Portulaca oleracea* L. and *Tridax procumbens* L. were predominant; among-the grassy weeds, *Cynodon dactylon* L., *Dactyloctenium aegyptium* L. and *Echinochloa crusgalli* L. were noticed and the common sedge observed was *Cyperus rotundus* L (Mishra *et al.*, 2023 and Singh *et al.*, 2023)^[12, 23].

Growth parameters

Plant height

There was a significant difference w.r.t plant height as influenced by different weed management practices (Table 1). At harvest, weed free check recorded significantly higher plant height (50.45 cm) which was found to be on par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS and hand weeding at 15 and 30 DAS. Plant height was high under these treatments, because of better utilization of moisture, nutrients and solar energy during the entire crop growth period in absence of weeds and also less competition hence, the crop plants got a favourable condition for better germination and establishment of good plant stand which lead to higher accumulation of photosynthates and subsequently resulted in taller plant height (Harisha *et al.*, 2021)^[6]. Weedy check recorded minimum plant height (33.50 cm) compared to all other treatments. Significantly lower plant height was observed in weedy check, which is mainly because of high crop weed competition for space, moisture and nutrients (Jadhav and Kashid, 2019)^[7]. Due to smothering effect of weeds, it restricts the availability of sunlight to growing plants which inturn affect the plant growth (Shah and Pramanik, 2020)^[21].

Number of secondary branches per plant

Data related to number of secondary branches per plant is presented in Table 1. Among all the treatments, at harvest, weed free check recorded significantly higher number of secondary branches (8.74 plant⁻¹). This was statistically at par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS and hand weeding at 15 and 30

DAS. The reason for increase in number of secondary branches per plant under these treatments might be due to reduced competition between crop and weed, resulting in almost weed free environment during critical period of crop-weed competition, which led to optimal growth and development of crop plants and ultimately more number of branches were recorded (Osari *et al.*, 2019; Nanda *et al.*, 2022) [14, 13]. Whereas, weedy check registered significantly lower number of secondary branches (5.28 plant^{-1}) (Harisha *et al.*, 2021) [6].

Leaf area

Leaf area which constitutes the major assimilatory surface of the plant differed significantly as influenced by different weed management practices and the data is presented in Table 1. At harvest, significantly higher leaf area was registered with weed free check ($372.34 \text{ cm}^2 \text{ plant}^{-1}$) and it was found to be on par with the treatments fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $225 \text{ g a.i. ha}^{-1}$ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $200 \text{ g a.i. ha}^{-1}$ at 15-20 DAS and hand weeding at 15 and 30 DAS. Significantly higher leaf area in weed free check might be due to optimum availability of space, soil moisture, nutrients and solar radiation because of weed free environment that led to maximum weed control efficiency thereby combating critical period of crop-weed competition in the treatment. Significantly lower leaf area was noticed with weedy check ($121.67 \text{ cm}^2 \text{ plant}^{-1}$). The lower leaf area in weedy check was because of depletion in the nutrients by the weeds to put up their dry weight and density which in turn led to devoid of resources for the crop's growth.

Total dry matter production

The data pertaining to total dry matter production is presented in Table 1. At harvest, weed free check recorded significantly higher total dry matter production ($25.39 \text{ g plant}^{-1}$). It was on par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $225 \text{ g a.i. ha}^{-1}$ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $200 \text{ g a.i. ha}^{-1}$ at 15-20 DAS and hand weeding at 15 and 30 DAS. The increase in total dry matter production in weed free check could be attributed due to enhanced plant height and photosynthetic accumulation as there was minimum competition of weeds with the crop for moisture, light and nutrients. The plants utilized the resources efficiently resulting in higher total dry matter production. (Mahajan *et al.*, 2020 and Anusha *et al.*, 2024) [11, 2]. Minimum total dry matter production was registered with weedy check plot ($10.47 \text{ g plant}^{-1}$). In weedy check due to strong weed competition and nutrient depletion by weeds the plant suffered greatly from the lack of favourable conditions, resulting in lower dry matter accumulation (Poornima *et al.*, 2017 and Panda *et al.*, 2021) [18, 15].

Number of root nodules

The data w.r.t root nodules differed significantly as influenced by different weed management practices (Table 1 and Fig.1). Among the different treatments, significantly maximum number of root nodules (29.13) was observed at harvest under weed free plot. Whereas, it was at par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $225 \text{ g a.i. ha}^{-1}$ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $200 \text{ g a.i. ha}^{-1}$ at 15-20 DAS and hand weeding at 15 and 30 DAS. Higher number of root nodules were found in these treatments, as these

weedicides were safe for nodule formation. The increased number of nodules is probably due to improved aeration of the rhizosphere in disturbed soil conditions (Osari *et al.*, 2019; Gupta *et al.*, 2020) [14, 4]. Weedy check recorded significantly lower number of root nodules at harvest (11.67) (Piragi, 2022 and Nanda *et al.*, 2022) [17, 13].

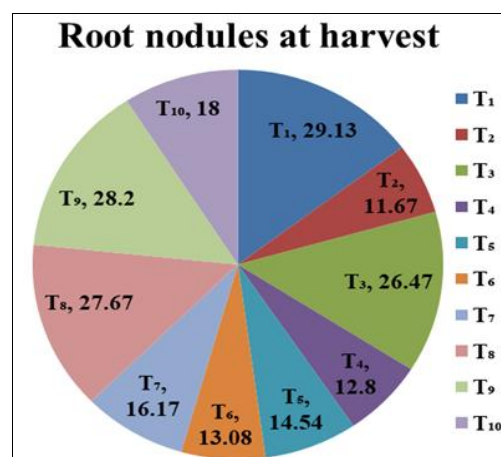


Fig 1: Number of root nodules of greengram at harvest as influenced by different weed management practices

Yield parameters and yield

Among the different weed management practices, significantly higher values of yield parameters like, number of pods plant^{-1} (14.93), number of seeds pod^{-1} (11.52), pod length (12.52 cm) and test weight (5.01 g) were recorded by weed free check. Which was found on par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $225 \text{ g a.i. ha}^{-1}$ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $200 \text{ g a.i. ha}^{-1}$ at 15-20 DAS and hand weeding at 15 and 30 DAS. The lower values of yield parameters were observed in weedy check. Significantly higher seed (1072 kg ha^{-1}) and stover yield (2739 kg ha^{-1}) was achieved from weed free check. Which was found on par with application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $225 \text{ g a.i. ha}^{-1}$ at 15-20 DAS, fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ $200 \text{ g a.i. ha}^{-1}$ at 15-20 DAS and hand weeding at 15 and 30 DAS. Whereas, lower yield was observed in weedy check (Table 1 and Fig.2).

The higher seed yield under these treatments is mainly because of excellent growth and development of greengram plants in a weed free environment during the critical growth period may have resulted in better yield characteristics and also reduction in weed density and weed dry matter, which provided a favourable environmental condition to the crop for better reproductive potential (Harisha *et al.*, 2021 and Nanda *et al.*, 2022) [6, 13]. Further reduced crop weed competition improved growth and yield attributes such as higher total dry matter production and distribution in different parts of the plant. And hence the crop was able to utilize the resources more efficiently compared to weedy check. The higher yield with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL could be due to the effective control of the ready-mix of two weedicides with different modes of action, which controlled the mixed and diverse weed flora at the experimental site (Kadam *et al.*, 2018; Lodha, 2018 and Dhakad *et al.*, 2022) [8, 10, 3].

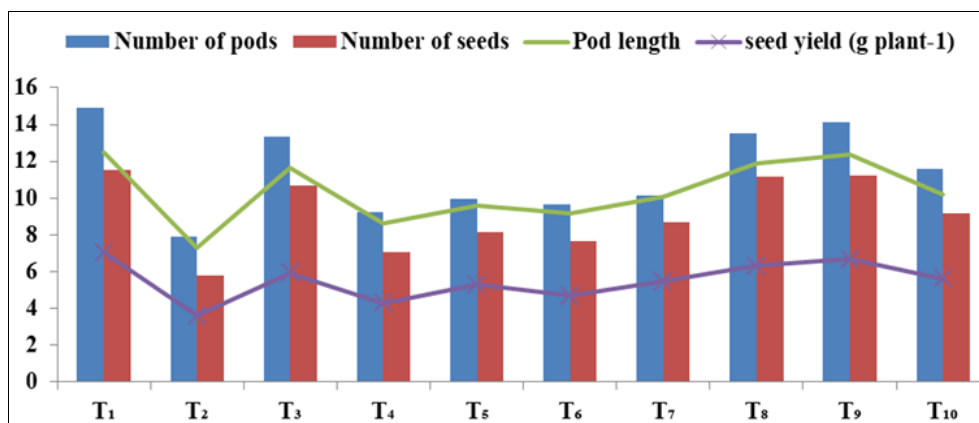


Fig 2: Yield parameters of greengram at harvest as influenced by different weed management practices

Weed index

Weed index is a measure of the crop yield loss in the different treatments compared to the weed free check. The data on weed index differed significantly due to different weed management practices in greengram (Table 2 and Fig.3). Weed free check recorded significantly lower weed index (0%). Whereas, higher weed index was registered from weedy check (49.52%). Among the post emergent weedicides, application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS

recorded lower weed index (3.30%). Which was found on par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS (6.99%). Whereas, application of imazethapyr @ 100 g a.i. ha⁻¹ at 15-20 DAS recorded lower weed index (24.44%). The lower weed index was attributed to the lower weed density and the lower dry weight of the weeds in the weedicide treated plots, which led to good plant growth and intern increased the yield of greengram (Shah and Pramanik, 2020 and Patidar *et al.*, 2023)^[21, 16].

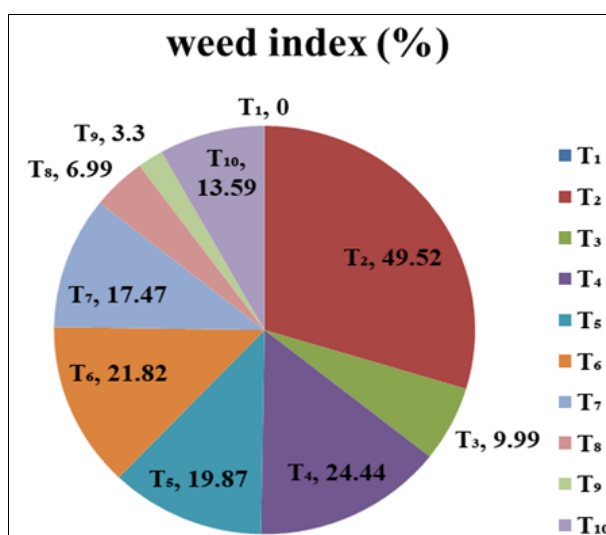


Fig 3: weed index (%) of greengram at harvest as influenced by different weed management practices

Economics

The data pertaining to economics of greengram as influenced by different weed management practices is depicted in Fig. 4. In the present investigation, cost of cultivation, gross returns, net returns and benefit cost ratio differed significantly due to different weed management practices. Application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS recorded significantly higher gross returns, net returns and B:C and it was found on par with fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha⁻¹ at 15-20 DAS. While minimum gross returns, net returns and B:C was obtained from

weedy check plot. The higher B:C with application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS was due to higher seed yield with lesser cost of weeding with weedicide application (Lodha, 2018; Shah and Pramanik, 2020; Harisha *et al.*, 2021 and Nanda *et al.*, 2022)^[10, 21, 6, 13]. It can be concluded that, application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS was found effective in controlling weeds by reducing their density and dry weight which resulted in higher growth, yield, gross returns, net returns and B:C of greengram.

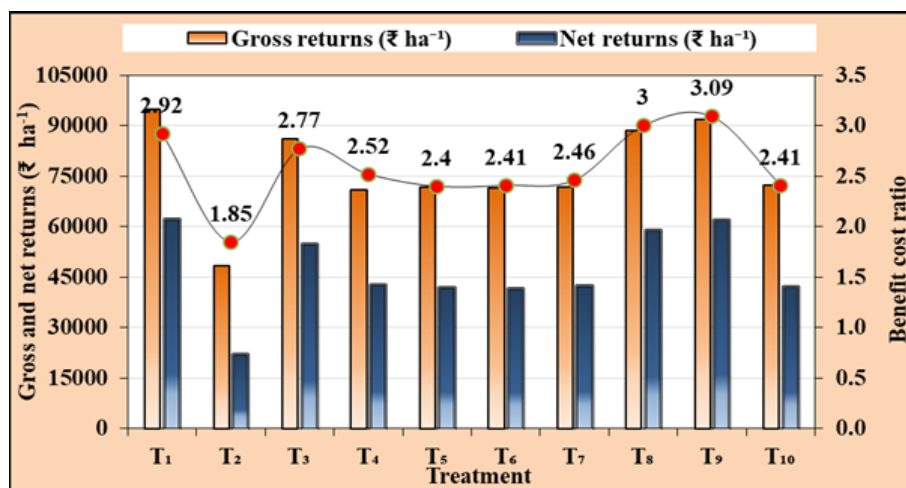


Fig. 4: Economics of greengram as influenced by different weed management practices

Table 1: Growth parameters of greengram at harvest as influenced by different weed management practices

Treatment	Plant height (cm)	Number of secondary branches plant ⁻¹	Leaf area (cm ² plant ⁻¹)	Total dry matter production (g plant ⁻¹)	Number of root nodules
T1: Weed free check	50.45	8.74	372.34	25.39	29.13
T2: Weedy check	33.50	5.28	121.67	10.47	11.67
T3: Hand weeding at 15 and 30 DAS	49.41	8.21	338.79	23.34	26.47
T4: Imazethapyr 10% SL @ 100 g a.i. ha ⁻¹ at 15-20 DAS	41.07	6.77	180.22	15.36	12.80
T5: Propaquizafop 2.5% + Imazethapyr 3.75% @ 125 g a.i. ha ⁻¹ at 15-20 DAS	41.50	7.02	210.24	18.10	14.54
T6: Fomesafen 12% + Quizalofop-ethyl 3% SC @ 180+45 g a.i. ha ⁻¹ at 15-20 DAS	41.27	6.88	192.67	17.10	13.08
T7: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 175 g a.i. ha ⁻¹ at 15-20 DAS	42.34	7.07	249.19	18.91	16.17
T8: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha ⁻¹ at 15-20 DAS	49.95	8.38	356.31	23.94	27.67
T9: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha ⁻¹ at 15-20 DAS	50.15	8.57	364.26	24.83	28.20
T10: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 250 g a.i. ha ⁻¹ at 15-20 DAS	43.67	7.08	262.93	19.66	18.00
S. Em.±	1.83	0.35	12.57	0.95	0.89
CD (P=0.05)	5.86	1.12	40.21	3.05	2.86
CV (%)	7.16	8.17	8.22	8.37	7.83

Table 2: Yield parameter, yield and weed index of greengram as influenced by different weed management practices

Treatment	Number of pods (plant ⁻¹)	Number of seeds (pod ⁻¹)	Pod length (cm)	Test weight (g)	Seed yield (g plant ⁻¹)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index	Weed index (%)
T1: Weed free check	14.93	11.52	12.52	5.01	7.06	1072	2739	0.28	0.00
T2: Weedy check	7.88	5.82	7.30	3.90	3.61	541	1714	0.23	49.52
T3: Hand weeding at 15 and 30 DAS	13.34	10.67	11.65	4.67	5.94	965	2573	0.28	9.99
T4: Imazethapyr 10% SL @ 100 g a.i. ha ⁻¹ at 15-20 DAS	9.24	7.05	8.62	4.08	4.31	810	2314	0.26	24.44
T5: Propaquizafop 2.5% + Imazethapyr 3.75% @ 125 g a.i. ha ⁻¹ at 15-20 DAS	9.93	8.16	9.57	4.14	5.28	859	2362	0.27	19.87
T6: Fomesafen 12% + Quizalofop-ethyl 3% SC @ 180+45 g a.i. ha ⁻¹ at 15-20 DAS	9.68	7.66	9.15	4.11	4.69	838	2354	0.26	21.82
T7: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 175 g a.i. ha ⁻¹ at 15-20 DAS	10.11	8.72	10.09	4.36	5.47	885	2366	0.27	17.47
T8: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 200 g a.i. ha ⁻¹ at 15-20 DAS	13.49	11.17	11.91	4.73	6.33	997	2681	0.27	6.99
T9: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha ⁻¹ at 15-20 DAS	14.10	11.20	12.36	4.82	6.67	1037	2732	0.28	3.30
T10: Fomesafen 11.1% + Fluazifop-p-butyl 11.1% SL @ 250 g a.i. ha ⁻¹ at 15-20 DAS	11.58	9.19	10.17	4.43	5.63	927	2370	0.28	13.59
S. Em.±	0.50	0.43	0.46	0.24	0.27	42	115	0.01	0.86
CD (P=0.05)	1.59	1.38	1.48	NS	0.86	134	367	NS	2.75
CV (%)	7.55	8.18	7.73	9.46	8.41	8	8	8.99	8.93

Conclusion

The experimental findings indicated that there was a significant difference in the productivity of greengram as influenced by different post emergent weedicides. It can be concluded that, application of fomesafen 11.1% + fluazifop-p-butyl 11.1% SL @ 225 g a.i. ha⁻¹ at 15-20 DAS was found effective in controlling weeds by reducing their density and dry weight which resulted in higher growth, yield, gross returns, net returns and B:C of greengram.

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