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Effect of Early Post-Emergence Herbicides on Photosynthetic Pigments and Yield in Greengram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aims: To study the influence of early post-emergence herbicides on photosynthetic pigments and yield in greengram.
Study Design: Randomized Block Design.
Place and Duration of Study: Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore, India during summer 2022.
Methodology: The experiment was laid out with three replications having nine treatments comprising of weedy check, different ready mix early post-emergence herbicides, two hand weedings and weed free. The chlorophyll content mg g^{-1} in the leaf sample was recorded at 30, 45 and 60 DAS. Grain yield and haulm yield was also calculated and expressed in kg ha^{-1}.
Results: Pre-emergence (PE) application of Pendimethalin 30% EC @ 1 kg a.i ha^{-1} on 3 DAS followed by (*fb*) Early post-emergence (EPoE) Imazethapyr 10% SL @ 100 g a.i ha^{-1} + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) on 15 DAS significantly recorded highest value in all photosynthetic pigments viz., Chlorophyll a (1.105 mg g^{-1}**)**, Chlorophyll b (0.402 mg g^{-1}**)**, Total chlorophyll (1.601 mg g^{-1}**)**, Chlorophyll ab ratio and Carotenoids (0.413 mg g^{-1}**)**, whereas higher grain yield (908 kg ha^{-1}) is achieved by the Pre-emergence (PE) application of PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} on 3 DAS followed by (*fb*) Early post-emergence (EPoE) Propaquizafop 2.5% + Imazethapyr 3.75% ME Ready mix (RM) @ 125 g a.i ha^{-1} on 15 DAS.

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Conclusion: Among the early post-emergence herbicides, Imazethapyr 10% SL @ 100 g a.i ha^{-1}+ Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) on 15 DAS shown significant results in all the photosynthetic pigments and Propaquizafop 2.5% + Imazethapyr 3.75% ME Ready mix (RM) @ 125 g a.i ha^{-1} on 15 DAS shown significant results in the yield by suppressing the weeds.

Keywords: Greengram; early post-emergence; chlorophyll; imazethapyr; pendimethalin; ready mix herbicides.

1. INTRODUCTION

Pulses are one of the most widely consumed food in the world. Majority of the pulses have found to be contain 300 to 540 kcal/100 g of energy [1]. Greengram (*Vigna radiata* L., Family : Fabaceae) is a high-protein food legume and third most important pulse crop grown in India due to its versatility as a grain, vegetable, fodder, and green manure crop. It is a healthy food with high protein (20-25%), mineral (4%) and carbohydrate content (46-51 %) [2]. Rajasthan is the leading state in India in terms of both area and production of greengram. The total area under greengram cultivation is 5130.17 thousand ha, with a total production of 3085.35 thousand tonnes and a productivity of 601 kg ha^{-1}. The area under greengram cultivation in Tamil Nadu is 160.56 thousand ha, with a total production of 58.89 thousand tonnes and a productivity of 367 kg ha^{-1} [3].

Greengram yield was reduced due to weeds, which resulted in lower production. Weed emergence in greengram occurs almost simultaneously with crop emergence, resulting in crop-weed competition from the beginning. Because the critical period of crop-weed competition in greengram is 20-40 days after sowing [4], effective herbicide use at these critical stages plays an important role in maintaining productivity by reducing weed interference. Weed-related yield losses in greengram ranged from 30 to 85% [5,6].

Weed emergence is suppressed by pre-emergence herbicide application, which provides a favourable environment for crop growth under weed-free conditions. As hand weeding is laborious and costly besides non availability of labour for weeding, use of suitable early post-emergence herbicides for weed management is the alternate option available with the farmers. There are some difficulties for farmers to mix different herbicides to control various classes of weeds. To avoid this, a ready mixture of herbicides with dual modes of action that controls a broad spectrum of weeds is used. It prevents weed flora shifts, delays weed resistance development, and improves weed control efficiency. In order to investigate the impact of various herbicides on photosynthetic pigments namely chlorophyll a, chlorophyll b, total chlorophyll, chlorophyll ab ratio, carotenoids and yield of greengram, an experiment was carried out during summer 2022.

2. MATERIALS AND METHODS

2.1 Experimental Site

A field study was conducted during summer season of 2022 in Wetlands farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore. The geographical location of the farm is, latitude of $11^0$2'7" N with longitude of $77^0$59'22" E and 426.6 m above mean sea level in Tamil Nadu western agro-climatic zone. The soil in the experimental field was clay loam in texture. The experiment consists of nine treatments and laid out in Randomized Block Design with three replication (Fig.1).

2.2 Sowing and Crop Management

Greengram variety CO 8 (Fig. 2) was sown on 07.03.2022 and harvested on 17.05.2022. The net plot size is 4.8 m × 4.0 m. The seed rate for irrigated greengram is 20 kg ha^{-1} with a spacing of 30 x 10 cm. The recommended fertilizer dose of 25 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5, and 25 kg ha^{-1} K_2O was applied in the form of Urea, SSP and MOP. The entire amount of fertilizers was applied as basal (Fig. 3). Herbicide was applied with the required amount of spray fluid (500 litres ha^{-1}) using knapsack battery operated hand sprayer.

2.3 Observation on Photosynthetic Pigments

The chlorophyll content in the leaf sample was recorded at 30, 45 and 60 DAS using the method proposed by Wellborn et al. [7]. Acetone was used to extract the pigments from the leaves.

Transfer 250 mg of fresh leaf sample to a pestle and mortar, using 10 ml of 80% acetone, macerate the sample and centrifuge the contents for 10 minutes at 3000 rpm then collect the supernatants after centrifuge and make up the volume to 25 ml in volumetric flask with 80 % acetone. Using a spectrophotometer, determine the optical density at 480, 510, 645, 652 and 663 nm for chlorophyll a, chlorophyll b, total chlorophyll and Carotenoids. The chlorophyll content of the samples expressed as mg g^{-1} of fresh leaf. The formula for calculation is,

$$\text{Chlorophyll a} = (12.7 \times \text{OD at } 663) - (2.69 \times \text{OD at } 645) \times \frac{V}{1000 \times W} \quad (1)$$

$$\text{Chlorophyll b} = (22.9 \times \text{OD at } 645) - (4.68 \times \text{OD at } 663) \times \frac{V}{1000 \times W} \quad (2)$$

$$\text{Total chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b} \quad (3)$$

$$\text{Chlorophyll ab ratio} = \frac{\text{Chlorophyll a}}{\text{Chlorophyll b}} \quad (4)$$

$$\text{Carotenoids} = (7.6 \times \text{OD at } 480) - (1.49 \times \text{OD at } 510) \times \frac{V}{1000 \times W} \quad (5)$$

2.4 Yield

The grain yield was calculated by harvesting the pods separately from each plot and dried in the sun. Following that, the pods were threshed, winnowed and the grains were dried separately until the moisture content attains 12%. The cleaned grains were weighed, and the grain yield was calculated and expressed in kg ha^{-1}. The haulm yield was calculated by harvesting the plant portion of five tagged plants from above ground level, pods were removed from the plants and dried in the sun. The dried plants were weighed in each plot, by this the haulm yield was calculated and expressed in kg ha^{-1}.

3. RESULTS AND DISCUSSION

In this study, the effects of different early post-emergence herbicides on photosynthetic pigments and yield of greengram was determined.

3.1 Chlorophyll a

Among the treatments, hand weeding (T_7) 0.595 recorded significantly highest chlorophyll a content at 30 DAS, whereas EPoE Imazethapyr 10% SL @ 100 g a.i ha^{-1} + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) 0.158 (T_6) (Fig.4) recorded lowest. At 45 DAS, T_6 (0.785) recorded highest which was on par with T_7 (0.742). At 60 DAS, T_6 (1.105) recorded highest, whereas T_7 (0.572) recorded lowest chlorophyll a content. Initially, there was a decrease in chlorophyll a content in T6 due to the application of EPoE herbicide, but after a few days, there was an increase in chlorophyll a content in T6 because the effect was reduced. Mahakavi et al. [8] reported that the photosynthetic pigment Chlorophyll a content increased at lower concentration of quizalafop-p-ethyl which touched maximum during the flowering stage followed by pre-flowering and post-flowering stages.

Table 1. Treatment details of Experiment

T_1	PE Pendimethalin + Imazethapyr (32% EC) (RM) @ 1 kg a.i ha^{-1} *fb* Hand weeding on 30 DAS
T_2	PE Pendimethalin (30 % EC) @ 1 kg a.i ha^{-1} *fb* EPoE Imazethapyr 35% + Imazamox 35% WG (RM) @ 100 g a.i ha^{-1}
T_3	PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Propaquizafop 2.5% + Imazethapyr 3.75% ME (RM) @ 125 g a.i ha^{-1}
T_4	PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Clodinafop-propargyl 8% + Sodium acifluorfen 16.5% EC (RM) @ 185 g a.i ha^{-1}
T_5	PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Quizalofop-ethyl 7.5 % + Imazethapyr 15% EC (RM) @ 75 g a.i ha^{-1}
T_6	PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Imazethapyr 10% SL @ 100 g a.i/ha + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix)
T_7	Hand weeding on 20 and 40 DAS
T_8	Weed free
T_9	Weedy check

**RM-Ready mix, *****PE applied on 3 DAS, *EPoE applied on 20 DAS*

3.2 Chlorophyll b

Regarding chlorophyll b content, Weedy check (T_9) 0.366 recorded significantly highest chlorophyll b content at 30 DAS, whereas EPoE Imazethapyr 10% SL @ 100 g a.i ha^{-1} + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) T_6 (0.015) recorded lowest, which was on par with T_8 (0.032). At 45 (0.404) and 60 (0.402) DAS, T_6 recorded highest. According to Maji et al. [9] Imazamox+Imazethapyr in higher dose (60 g a.i. ha^{-1}) recorded maximum decline in (0.90 to 0.95 mg g^{-1}) chlorophyll concentration.

3.3 Total Chlorophyll

The total chlorophyll content varied significantly by the application of EPoE herbicides, hand weeding T_7 (0.848) recorded highest total chlorophyll content at 30 DAS, whereas EPoE Imazethapyr 10% SL @ 100 g a.i/ha + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) T_6 (0.288) recorded lowest. At 45 (1.311) and 60 (1.601) DAS, T_6 recorded highest. According to Amaregouda et al. [10], the amount of total chlorophyll (2.87 mg g^{-1} fr.wt) was noticed in pendimethalin @ 1350.5 (g a.i ha^{-1}) at 40 DAS.

3.4 Chlorophyll ab Ratio

In terms of Chlorophyll ab ratio, at 30 DAS, T_3 (3.573) EPoE Propaquizafop 2.5% + Imazethapyr 3.75% ME (RM) @ 125 g a.i ha^{-1} (Fig.5) recorded significantly highest chlorophyll ab ratio. At 45 DAS, T_8 (2.912) weed free recorded highest. At 60 DAS, T_4 (2.955) EPoE Clodinafop-propargyl 8% + Sodium acifluorfen 16.5% EC (RM) @ 185 g a.i ha^{-1} recorded highest. According to Maji et al. [9] on 55 DAS, Acifluorfen Na + Clodinafop propargyl in either doses recorded significantly higher chlorophyll content (1.80-1.84 mg g^{-1}) among the herbicides, indicating that the crop recovered from the initial herbicidal phytotoxic effect.

3.5 Carotenoids

Carotenoids showed a significant variation among the treatments, at 30 DAS, T_1 (0.297) recorded highest carotenoids. At 45 (0.390) and 60 (0.413) DAS, T_6 - EPoE Imazethapyr 10% SL @ 100 g a.i ha^{-1} + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) recorded highest.

3.6 Grain Yield

Grain yield of greengram was affected by different EPoE herbicides. Among the herbicides combination, PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Propaquizafop 2.5% + Imazethapyr 3.75% ME (RM) @ 125 g a.i ha^{-1} (T_3) significantly produced higher grain yield (908 kg ha^{-1}), whereas T_9 - Weedy Check recorded lowest grain yield. Sapna et al., [11] reported that applying Pendimethalin @ 1.0 kg ha^{-1} (PRE) *fb* imazethapyr @ 50 g ha^{-1} (20 DAS) was successful for weed control as well as enhancing grain yield of greengram. Application of imazethapyr at 100 g ha^{-1} 15-20 DAS recorded similar grain yield with HW at 20 and 40 DAS [12-14].

Table 2. Effect of post-emergence herbicides on chlorophyll a, chlorophyll b and total chlorophyll in greengram

Treatments	Chlorophyll a mg g^{-1}			Chlorophyll b mg g^{-1}			Total Chlorophyll mg g^{-1}		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	0.331	0.554	0.760	0.136	0.229	0.293	0.578	0.820	1.054
T_2	0.397	0.570	0.898	0.140	0.280	0.253	0.499	0.785	0.927
T_3	0.386	0.523	0.766	0.179	0.300	0.277	0.483	0.725	1.043
T_4	0.470	0.539	0.795	0.148	0.257	0.275	0.628	0.708	1.069
T_5	0.406	0.343	0.766	0.136	0.169	0.305	0.499	0.645	1.182
T_6	0.158	0.785	1.105	0.015	0.404	0.402	0.288	1.311	1.601
T_7	0.595	0.742	0.572	0.153	0.285	0.219	0.848	0.929	0.713
T_8	0.428	0.681	0.724	0.032	0.270	0.231	0.241	0.941	0.960
T_9	0.458	0.662	0.713	0.366	0.246	0.284	0.691	0.662	1.092
Mean	0.403	0.600	0.789	0.145	0.271	0.282	0.528	0.836	1.071
SEd	0.038	0.057	0.055	0.012	0.017	0.024	0.046	0.065	0.055
CD(P=0.05)	0.081	0.120	0.117	0.026	0.037	0.051	0.097	0.137	0.117

Table 3. Effect of post-emergence herbicides on chlorophyll ab ratio, carotenoids and yield in greengram

Treatments	Chlorophyll ab ratio mg g^{-1}			Carotenoids mg g^{-1}			Grain yield kg ha^{-1}	Haulm yield kg ha^{-1}
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS		
T_1	3.111	2.454	2.588	0.297	0.221	0.360	710	1926
T_2	2.944	2.703	2.597	0.197	0.227	0.166	555	1556
T_3	3.573	2.616	2.711	0.224	0.268	0.320	908	1456
T_4	3.366	2.326	2.955	0.337	0.226	0.324	620	1509
T_5	3.193	1.132	2.475	0.203	0.149	0.317	585	1727
T_6	3.538	2.653	2.749	0.250	0.390	0.413	766	2491
T_7	2.665	2.502	2.573	0.240	0.275	0.284	655	1262
T_8	3.047	2.912	2.604	0.143	0.292	0.285	812	1332
T_9	1.883	2.455	2.223	0.250	0.239	0.289	484	891
SEd	0.025	0.123	0.132	0.021	0.022	0.018	37.8843	151
CD(P=0.05)	0.530	0.260	0.280	0.045	0.047	0.039	81.3122	320

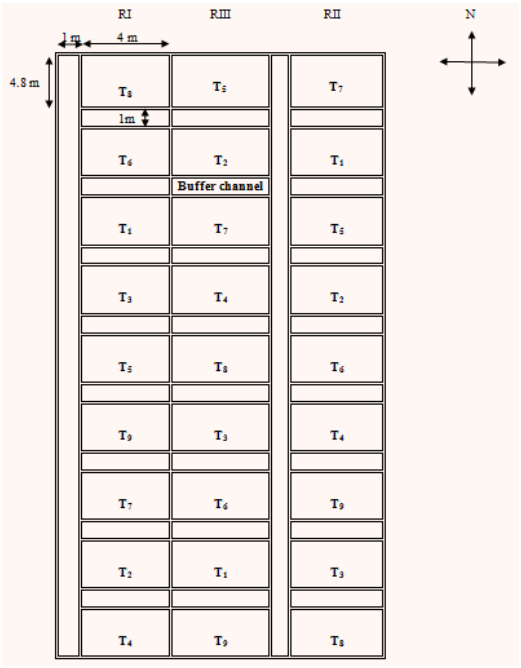

Fig. 1. Layout of field experiment

Fig. 2. Greengram CO 8 seeds

Fig. 3. Fertilizer application

Fig. 4. PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Imazethapyr 10% SL @ 100 g a.i/ha + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) (T_6)

Fig. 5. PE Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Propaquizafop 2.5% + Imazethapyr 3.75% ME (RM) @ 125 g a.i ha^{-1} (T_3)

3.7 Haulm Yield

Following that T_6 - PE Pendimethalin @ 1 kg a.i ha^{-1} *fb* Imazethapyr @ 100 g a.i ha^{-1} + Quizalofop ethyl @ 50 g a.i ha^{-1} (Tank mix) produced higher haulm yield, where as T_9 - Weedy Check recorded lower haulm yield.

4. CONCLUSION

It can be concluded that PE application of Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} on 3 DAS *fb* EPoE Imazethapyr 10% SL @ 100 g a.i/ha + Quizalofop-ethyl 5% EC @ 50 g a.i ha^{-1} (Tank mix) on 15 DAS shown significant results in all the photosynthetic pigments. Regarding yield of greengram, pre-emergence application of Pendimethalin (30% EC) @ 1 kg a.i ha^{-1} *fb* EPoE Propaquizafop 2.5% + Imazethapyr 3.75% ME (RM) @ 125 g a.i ha^{-1} shown significant results in the yield by suppressing the weeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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