



Evaluation of Pre and Post Emergence Herbicides in Greengram (*Vigna radiata* L.) during *Kharif* and *Rabi* Seasons in the Uplands of Krishna Zone of Andhra Pradesh

B. Pramila Rani, E. Venkateswarlu

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ABSTRACT

Background: Greengram crop is grown round the year as a catch crop in different cropping systems of the uplands of the Krishna Zone of Andhra Pradesh. The practice of application of pre emergence herbicide like pendimethalin is very popular with the farmers for the control of weeds in the uplands, both in *kharif* and *rabi* seasons. Further spraying of a selective post emergence herbicide is also practiced by farmers. However, some of the weeds of *kharif* viz., *Phyllanthus maderaspatensis* and *rabi* viz., *Chrozophora rotleri* could not be controlled with these herbicides due to their late emergence or due to development of partial resistance to these herbicides. Certain new pre (PE) and post emergence (PoE) herbicides viz., pendimethalin 30% + imazethapyr 2%, acifluorfen sodium 16.5% + clodinafop propargyl 8%, fomesafen 11.1% + fluazifop -p-butyl 11.1%, are recommended in crops like soybean and groundnut. However, there is need to test these herbicides available in market for their suitability to control the weeds in greengram.

Methods: A field experiment was carried out at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, with an objective to evaluate selected PE and PoE herbicide mixtures in greengram managing the major weeds of greengram grown in vertisols of Krishna Zone of Andhra Pradesh during *kharif* and *rabi* seasons of 2018 under upland conditions.

Result: Among the two PE herbicides tested on greengram, pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg/ha was found to be more effective in reducing the weed density and dry matter compared with pendimethalin 30% @ 0.75 kg/ha. The PoE herbicide mixtures tested viz., fomesafen 11.1% + fluazifop -p-butyl 11.1% @111g/ha, propaquizafop 2.5% + imazethapyr 3.75% @ 50+75 g/ha were on par with imazethapyr 10% @ 50g/ha in controlling the weed population without having any adverse affect on the growth and yield of greengram during *kharif* and *rabi*.

Key words: Greengram, Herbicides, Pre emergence, Post emergence, Weed control efficiency.

INTRODUCTION

Greengram is mostly grown as a *kharif* crop in Andhra Pradesh in the upland areas, prior to the sowing of the main crop. Because of its short duration, moderate drought resistance, it is taken up as a catch crop in both *Kharif* and *rabi* seasons. Initial weed free situation is essential for this crop as the critical period of weed competition is up to 20-30 days after sowing (DAS) and the yield losses due to weed infestation during this period ranges from 30-85 per cent (Singh *et al.*, 2015). Due to shortage of human labour, weed control through manual means is not feasible and also uneconomical. In spite of, pre and post emergence herbicide recommendations for control of weeds in greengram there is large variation in the weed intensity and species grown in *Kharif* and *rabi* greengram and that may be due to the rainfall pattern or irrigation schedules or cropping sequence. Significantly lower weed intensity and dry weight in greengram with pre emergence application of pendimethalin 30% + imazethapyr 2% @ 1.0 kg/ha and higher benefit cost ratio as compared to hand weeding treatment was reported by several workers (Tamang *et al.*, 2015, Kumar *et al.*, 2019).

However, some of the weed species like *Phyllanthus* spp. during *kharif*, *Chrozophora* spp. and *Phyllanthus* spp. in *rabi* season are not controlled even after the application

Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Lam, Guntur-522 034, Andhra Pradesh, India.

Corresponding Author: B. Pramila Rani, Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Lam, Guntur-522 034, Andhra Pradesh, India.
Email: pramilarani_b@yahoo.co.in

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of the already available herbicides. This might be due to late emergence of weeds or may be due to development of certain resistance in the weeds to these herbicides. Some ready or tank mixes of compatible pre and post emergence herbicides with varying modes of action may ensure effective control of different weed species and may check the development of herbicide resistance and hence, some of the pre and post emergence herbicides mixtures available in the market need to be tested for both *kharif* and *rabi* seasons for effective control of weeds in greengram.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* and *rabi* seasons of 2018 at Regional Agricultural Research Station, Lam, Guntur under natural weed infestations in greengram. The soil type of the experimental field was clay loam with pH 7.8, low in available nitrogen, medium in available phosphorous and high in available potassium. The experiment consisted of nine treatments i.e. pendimethalin 30% + imazethapyr 2% as PE @ 0.75+0.05 kg a.i./ha, pendimethalin 30% as PE @ 0.75 kg a.i./ha, acifluorfen sodium 16.5% +clodinafop propargyl 8.0% as PoE @165+80 g a.i./ha, fomesafen 11.1%+fluazifop –p-butyl 11.1% as PoE @ 0.111kg a.i./ha, imazethapyr 35%+imazamox 35% as PoE @ 35 g/ha, propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g a.i./ha as PoE at 20 DAS, imazethapyr 10% as PoE @ 50 g a.i./ha, two hand weedings at 20 and 40 DAS along with inter cultivation at 30 DAS and unweeded check.

The experiment was laid in randomized block design with three replications with gross experimental plot area of 6.0 x 3.6 m. The recommended basal dose of 20 kg nitrogen and 50 kg phosphorous per ha were applied at the time of sowing in the form of urea and single super phosphate, respectively. In both the seasons the crop was raised under rainfed conditions. Greengram, variety, IPM 2-14 was sown at a spacing of 30 x10 cm, on 25th June and 22nd October, respectively during *kharif* and *rabi* seasons of 2018. An amount of 562.7 mm rainfall was received from June to October months and there was no rain after the sowing of *rabi* crop. All the recommended packages of practices were followed for the proper establishment of crop except weed management practices. All the PE and PoE herbicides were sprayed with knapsack sprayer fitted with flood jet nozzle as per schedule using a spray volume of 500 l ha⁻¹. The weed species were recorded by placing the quadrat of 50 cm x 50 cm in the sampling area at 20, 45 DAS and at harvest. The weed samples for dry weight were collected from the area used for weed count. The crop was harvested on 28.8.2018 and on 25.12.2018 during *kharif* and *rabi* seasons, respectively. The data on density of different weed species and their dry weight per square meter were recorded at 20, 45 DAS and at harvest stages of crop growth. The weed dry weight was taken after sun drying for 2-3 days followed by oven drying at 70°C for 48 hours. The weed control efficiency (WCE) was calculated at 45 DAS using the formula

$$WCE (\%) = \frac{x - y}{x} \times 100$$

Where,

WCE = weed control efficiency in percentage.

x = weed dry weight per unit area in weedy check.

y = weed dry weight per unit area in treatment plot for which WCE is to be calculated.

The data of weed density and dry weight were subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis to normalize their distribution (Panse and Sukhatme, 1978).

Table 1: Total weed density (per m²), weed dry matter (g/m²) at different stages and WCE as influenced by herbicide application during *kharif*, 2018.

Treatment	Total weed density/m ²			Total weed dry matter g/ m ²			Weed Control efficiency at 45 DAS
	20 DAS	45 DAS	Harvest	20 DAS	45 DAS	Harvest	
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	4.8(23)	8.6(80)	6.1(37)	0.75(0.07)	1.68(2.4)	4.56(25.9)	98.5
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	6.3(39)	11.1(143)	7.2(60)	0.85(0.23)	2.30(5.7)	4.85(28.3)	96.5
T ₃ : Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	10.7(116)	14.1(212)	8.1(65)	2.09(3.92)	9.67(104.4)	10.65(126.8)	41.5
T ₄ : Fomesafen 11.1%+fluazifop–p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	9.5(93)	7.6(63)	6.0(37)	1.60(2.15)	5.62(41.1)	7.23(67.9)	74.4
T ₅ : Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	11.0(124)	7.5(57)	5.4(31)	1.90(3.22)	5.38(29.2)	5.65(35.7)	81.2
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	10.3(107)	5.8(36)	6.5(43)	1.75(2.60)	4.82(22.9)	3.82(15.5)	85.1
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	10.3(113)	9.9(109)	7.4(60)	1.53(2.00)	3.97(19.9)	6.16(37.9)	85.3
T ₈ : Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	10.2(109)	2.4(5)	5.0(25)	1.85(3.11)	0.91(0.33)	5.44(33.2)	99.8
T ₉ : Unweeded	8.3(69)	15.2(236)	8.4(70)	1.93(3.33)	12.66(164.3)	14.94(228.1)	-
SEM.±	1.044	2.026	1.011	0.196	1.403	1.708	10.09
CD(0.05)	3.1	6.1	NS	0.59	4.21	5.12	30.6
CV (%)	20.0	38.4	26.2	21.4	46.5	42.0	21.1

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values.

DAS: days after sowing; PE: pre emergence; PoE: post emergence at 20 DAS.

Yield and yield attributes of crop were recorded at the time of harvest of crop.

RESULTS AND DISCUSSION

Weed growth and weed control efficiency

The weed flora observed during *kharif* in the experimental plots were *Phyllanthus madaraspatanense*, *Trianthema portulacastrum*, *Digera arvensis*, *Cynotis cucullata*, and *Commelina benghalensis* among broad leaf weeds and *Echinichloa colona* and *Panicum ramosum* were among grassy weeds. In addition to these species, during *rabi*,

Chrozophora rottleri was the dominant dicot weed observed. The experimental plot was dominated by broad leaved weeds as compared with grasses or sedges.

Pre emergence application of pendimethalin 30% + imazethapyr 2% at 0.75+ 0.05 kg ha⁻¹ and pendimethalin 30% at 0.75 kg ha⁻¹ significantly reduced both weed density and dry matter at 20 DAS during *kharif* season (Table 1). Similar reduction due to PE application of pre-mix pendimethalin + imazethapyr at 1.0 and 0.75 kg/ha was reported by Singh *et al.*, 2017. At 45 DAS, weed density and dry matter of all the PE and PoE herbicide applications

Table 2: Mean density of broad leaved weeds (BLW) and grassy weeds per m² as influenced by herbicide application at different stages during *Kharif*, 2018.

Treatment	Density of BLW/ m ²			Density of Grass weeds/ m ²		
	20 DAS	45 DAS	Harvest	20 DAS	45 DAS	Harvest
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	4.836 (22.7)	8.416 (77.3)	5.361 (30.7)	1.000 (0.0)	1.667 (2.7)	2.194 (6.7)
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	6.296 (38.7)	11.072 (140.0)	6.836 (54.7)	1.000 (0.0)	1.667 (2.7)	2.333 (5.3)
T ₃ : Acifluorfen sodium 16.5% + clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	10.426 (109.3)	13.786 (200.0)	8.039 (64.0)	2.535 (6.7)	2.694 (12.0)	1.412 (1.3)
T ₄ : Fomesafen 11.1%+fluazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	8.674 (76.0)	7.429 (58.7)	4.068 (17.3)	4.028 (17.3)	1.869 (4.0)	4.028 (20.0)
T ₅ : Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	10.423 (110.7)	6.754 (45.3)	4.582 (21.3)	3.106 (13.3)	3.128 (12.0)	3.157 (10.7)
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	10.258 (105.3)	5.684 (34.7)	4.836 (22.7)	1.412 (1.3)	1.412 (1.3)	4.535 (20.0)
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	9.81 (101.3)	8.809 (90.7)	4.429 (18.7)	2.994 (12.0)	4.415 (18.7)	5.724 (41.3)
T ₈ : Hand weeded at 20 and 40 DAS + intercultivation at 30 DAS	9.935 (104.0)	1.824 (2.7)	1.667 (2.7)	2.281 (5.3)	1.824 (2.7)	4.836 (22.7)
T ₉ : Unweeded	8.193 (66.7)	13.552 (193.3)	7.848(61.3)	1.667(2.7)	6.004 (42.7)	2.861 (9.3)
SEm.+	0.863	2.037	0.898	0.921	1.079	1.182
CD(0.05)	2.609	6.158	2.717	NS	NS	NS
CV (%)	17.1	41.1	29.4	71.7	68.2	59.3

Data were subjected to square root transformation $\sqrt{x + 0.5}$. Figures in parenthesis are original values.

DAS: days after sowing; PE: pre emergence; PoE: post emergence at 20 DAS.

Table 3: Mean density of *Phyllanthus madaraspatanense*/m² at different stages as influenced by herbicide application during *Kharif*, 2018.

Treatment	Density of <i>Phyllanthus madaraspatanense</i> /m ²		
	20 DAS	45 DAS	Harvest
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	2.57 (22.7)	7.679 (61.3)	4.356 (21.3)
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	3.051 (33.3)	10.782 (116.0)	6.521 (49.3)
T ₃ : Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	4.343 (72.0)	10.126 (103.0)	5.505 (32.0)
T ₄ : Fomesafen 11.1% + fluazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	3.827 (56.0)	5.049 (26.7)	3.063 (10.7)
T ₅ : Imazethapyr 35% + imazamox 35% @ 35 g ha ⁻¹ as PoE	4.345 (72.0)	1.869 (4.0)	1.000 (0.0)
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	3.979 (60.0)	4.117 (17.3)	3.235 (12.0)
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	4.503 (78.7)	5.631 (34.7)	3.404 (10.7)
T ₈ : Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	4.261 (70.7)	1.412 (1.3)	1.412 (1.3)
T ₉ : Unweeded	3.74 (52.0)	10.783 (117.3)	5.000 (24.0)
SEm.±	0.261	1.023	1.018
CD(0.05)	0.79	3.093	3.077
CV (%)	11.8	27.8	47.4

Data were subjected to square root transformation $\sqrt{x + 0.5}$. Figures in parenthesis are original values.

DAS: days after sowing; PE: pre emergence; PoE: post emergence at 20 DAS.

was significantly lower than that of unweeded treatment. Among the PoE herbicides imazethapyr 10% at 50 g ha⁻¹ and propaquizafop 2.5% + imazethapyr 3.75% at 50 + 75 g ha⁻¹ were effective in controlling both density and dry matter of weeds and on par with that of hand weeding treatment. In greengram weed density and dry weight was also observed to be low with PoE application of imazethapyr by Kumar *et al.*, 2016. The WCE of all the PE and PoE treatments except acifluorfen sodium 16.5% + clodinafop propargyl 8.0% at 165+80 g ha⁻¹ (ranging between 74.4 to 98.5%) was on par with hand weeding treatment at 45 days stage indicating that any one of the PE or PoE treatments can effectively control the weeds in *kharif* season. The weed control efficiency was highest in hand weeding treatment with intercultivation (99.8%). Aktar *et al.*, 2015 reported similar results in greengram. Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% was not effective in *kharif* in controlling the weed population in greengram.

Post emergence application of imazethapyr 35%+ imazamox 35% at 35 g ha⁻¹, fomesafen 11.1%+fluazifop-p-butyl 11.1% at 0.111 kg ha⁻¹ and propaquizafop 2.5% + imazethapyr 3.75% at 50 + 75 g ha⁻¹ were able to check the density of broad leaved weeds of greengram up to 45 DAS and fomesafen 11.1%+fluazifop-p-butyl 11.1% controlled the BLW population even up to harvest stage during *kharif* (Table 2) which may be due to the two herbicide combination of the product. However, the grass weed density was not significantly influenced by both pre and post emergence treatments at all stages of crop growth.

During *kharif*, among the dicot weeds, the density of *Phyllanthus* (Table 3) was significantly low with pre emergence treatments at 20 DAS. But later at 45 and at harvest stages, the post emergence herbicide imazethapyr 35%+ imazamox 35% recorded lesser density of *Phyllanthus* and was on par with hand weeding. Pre emergence pendimethalin 30% + imazethapyr 2% recorded a *Phyllanthus* population which was significantly lower than unweeded treatment at 45 DAS indicating that pendimethalin 30% is not effective for the control of *Phyllanthus* weed which may be due to the late emergence of the weeds in the season.

During *rabi*, the PE herbicides significantly reduced the dry matter of weeds but not the weed density, at 20 DAS as compared to unsprayed treatment (Table 4). At 45 DAS, weed density and dry weight of PE application of pendimethalin 30% + imazethapyr 2% was on par with that of hand weeded treatment indicating the superiority of this treatment as compared with spray of pendimethalin 30% in controlling the weed density and dry weight. All the PoE herbicides are comparable to hand weeding in both density and dry matter of weeds with no significant difference in the WCE recorded at 45 days after sowing.

Among the PE herbicides, pendimethalin 30% + imazethapyr 2% reduced the density and dry matter of *Phyllanthus* as compared to the pendimethalin 30% and both the PE herbicides were not effective for the control of *Chrozophora* during *rabi* season (Table 5). All the PoE

Table 4: Total weed density (per m²) and total weed dry matter (g/m²) as influenced by herbicide application at different stages during *rabi*, 2018

Treatment	Total weed density per m ²				Total weed dry matter g/ m ²				Weed Control Efficiency (%) at 45 DAS
	20 DAS		45 DAS		20 DAS		45 DAS		
	Harvest	45 DAS	Harvest	45 DAS	Harvest	45 DAS	Harvest	45 DAS	
T ₁ :Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	4.90 (24)	3.45 (12)	5.40 (32)	1.85 (3.7)	1.14 (0.80)	1.85 (3.7)	2.88 (11.2)	93.5	
T ₂ :Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	5.70 (32)	6.50 (44)	5.56 (31)	4.42 (21.9)	1.70 (2.43)	4.42 (21.9)	4.54 (25.7)	68.8	
T ₃ :Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	8.23 (71)	5.62 (35)	5.45 (33)	3.62 (15.9)	3.31 (10.51)	3.62 (15.9)	2.78 (7.2)	74.9	
T ₄ :Fomesafen 11.1%+fluazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	8.43 (72)	4.90 (24)	6.63 (44)	3.32 (11.7)	3.36 (10.77)	3.32 (11.7)	4.35 (18.0)	81.4	
T ₅ :Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	7.56 (63)	3.89(15)	4.70 (23)	3.68 (14.1)	3.30 (10.92)	3.68 (14.1)	3.61 (13.5)	77.6	
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	7.98 (71)	4.91 (29)	6.52 (44)	4.20 (17.2)	3.44 (12.00)	4.20 (17.2)	3.75 (15.2)	72.8	
T ₇ :Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	8.96 (89)	5.12 (32)	5.78 (37)	4.04 (17.1)	3.05 (10.24)	4.04 (17.1)	3.00(9.7)	73.0	
T ₈ :Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	9.26 (85)	2.65 (7)	6.08 (39)	1.78 (2.8)	3.40 (11.89)	1.78 (2.8)	2.45 (5.6)	95.6	
T ₉ :Unweeded	9.307 (87)	7.99 (64)	5.42 (29)	7.94 (63.1)	3.63 (12.72)	7.94 (63.1)	6.43 (41.2)		
SEM.±	1.111	0.965	0.801	0.787	0.418	0.787	0.957	9.523	
CD(0.05)	NS	2.89	NS	2.358	1.25	2.358	NS	NS	
CV (%)	24.6	33.4	24.2	35.2	24.7	35.2	44.5	20.8	

Data were subjected to square root transformation $\sqrt{x + 0.5}$. Figures in parenthesis are original values.

DAS: days after sowing; PE: pre emergence; PoE: post emergence at 20 DAS.

Table 5: Mean density of *Phyllanthus* and *Chrozophora*/ m² and dry matter (g/m²) as influenced by herbicide application at different stages during *rabi*, 2018.

Treatment	Density of <i>Phyllanthus</i> m ²			Density of <i>Chrozophora</i> m ²			Dry weight of <i>Phyllanthus</i> (g/m ²)			Dry weight of <i>Chrozophora</i> (g/m ²)		
	20 DAS	45DAS	Harvest	20 DAS	45 DAS	Harvest	20 DAS	45 DAS	Harvest	20 DAS	45 DAS	Harvest
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	2.693 (6.7)	2.865 (8.0)	2.745 (9.3)	3.273 (10.7)	1.824 (2.7)	3.902 (14.7)	1.074 (0.16)	1.885 (3.33)	2.547 (9.73)	1.052 (0.11)	1.122 (0.27)	1.432 (1.07)
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	3.12 (9.3)	4.956 (24.0)	4.243 (17.3)	4.043 (20.0)	3.374 (10.7)	3.322 (10.7)	1.175 (0.40)	3.178 (10.27)	3.174 (11.87)	1.074 (0.16)	1.336 (0.80)	1.201 (0.45)
T ₃ : Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	4.697 (21.3)	3.931 (14.7)	3.569 (17.3)	3.862 (16.0)	2.708 (8.0)	2.535 (6.7)	1.114 (0.27)	1.781 (2.93)	1.792 (3.20)	1.165 (0.37)	1.222 (0.53)	1.305 (0.80)
T ₄ : Fomesafen 11.1%+fluzazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	.008 (36.0)	3.869 (14.7)	4.429 (18.7)	1.667 (2.7)	1.869 (4.0)	1.000 (0.0)	1.647 (1.73)	1.903 (3.07)	2.605 (6.00)	1.114 (0.27)	1.061 (0.13)	1 (0.00)
T ₅ : Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	4.872 (30.7)	2.281 (5.3)	1.869 (4.0)	2.535 (6.7)	1.412 (1.3)	1.667 (2.7)	1.544 (1.76)	1.441 (1.47)	1.812 (3.60)	1.175 (0.40)	1.114 (0.27)	1.114 (0.27)
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	3.315 (16.0)	2.079 (4.0)	4.183 (20.0)	4.535 (22.7)	2.453 (6.7)	1.667 (2.7)	1.174 (0.43)	1.792 (3.47)	1.692 (2.13)	1.472 (1.20)	1.175 (0.40)	1.061 (0.13)
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	5.424 (30.7)	2.281 (5.3)	4.356 (21.3)	4.491 (20.0)	2.737 (8.0)	1.412 (1.3)	1.392 (1.04)	1.771 (3.07)	2.651 (7.47)	1.379 (0.93)	1.305 (0.80)	1.061 (0.13)
T ₈ : Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	3.656 (16.0)	2.236 (4.0)	2.708 (8.0)	3.902 (14.7)	1.000 (0.0)	1.824 (2.7)	1.442 (1.20)	1.697 (2.13)	1.443 (1.33)	1.33 (0.80)	1.000 (0.00)	1.122 (0.27)
T ₉ : Unweeded	4.169 (17.3)	4.442 (20.0)	5.105 (26.7)	4.644 (21.3)	2.947 (8.0)	2.079 (4.0)	1.122 (0.27)	2.46 (0)	2.279 (6.00)	1.14 (0.32)	1.499 (1.52)	1.175 (0.40)
SEM.#/-	1.056	0.618	1.001	0.89	0.633	1.702	0.195	0.587	0.911	0.107	0.168	0.105
CD(0.05)	NS	1.869	NS	NS	NS	0.563	NS	NS	NS	NS	NS	NS
CV (%)	43.4	33.3	47.0	42.1	48.5	45.2	26.1	51.1	71.0	15.3	24.2	15.6

 Data were subjected to square root transformation $\sqrt{x} + 0.5$. Figures in parenthesis are original values.

herbicides tested were able to reduce the *Phyllanthus* density at 45 DAS on par with that of hand weeded treatment indicating that PoE herbicide application is essential for control of *Phyllanthus* weed in greengram. However, the *Chrozophora*, the problem weed in *rabi* greengram could not be controlled by any of the post emergence herbicides tested during *rabi*.

During *kharif*, the seed yield of greengram recorded with application of all the PE and PoE herbicides (1098 to 1326 kg ha⁻¹) was significantly superior over that of unweeded control (730 kg ha⁻¹) and on par with two times hand weeding control with inter cultivation (1407 kg ha⁻¹) (Table 6). The yield increase was mainly due to increased number of pods per plant which was lowest in unweeded

treatment (17.9) and ranged from 27.5 to 32.9 in other treatments. kumar *et al.*, 2019 reported higher yield of greengram due to pre emergence herbicide pendimethalin 30 EC + imazethapyr 2 EC at 1.0 kg ha⁻¹ followed by one hand weeding.

Similarly, during *rabi* also increase in yield in all the herbicide treatments was recorded except imazethapyr 35%+imazamox 35% (Table 7) and the yield increase was mainly due to higher pod number. The yield reduction in imazethapyr 35%+imazamox 35% application treatment might be due to reduced plant height and no. of pods per plant indicating certain toxicity on plant growth during *rabi* season. Sprays of some herbicides despite of selectivity mechanisms in crops may induce oxidative stress effecting

Table 6: Yield and yield attributing characters of greengram as influenced by different pre and post emergence herbicide application during *kharif*, 2018.

Treatment	Plant height (cm)	No. of pods per plant	No. of seeds per pod	100 seed weight (g)	Seed yield (kg/ha)
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	43.8	31.5	8.0	4.1	1250
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	44.4	31.3	7.7	3.5	1098
T ₃ : Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	49.9	27.5	7.9	3.5	1170
T ₄ : Fomesafen 11.1%+fluazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	44.5	31.8	8.1	3.8	1191
T ₅ : Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	39.8	28.6	7.8	3.3	1148
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	49.3	32.9	8.3	3.2	1326
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	38.4	29.1	7.9	3.4	1147
T ₈ : Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	47.1	32.6	8.8	3.6	1407
T ₉ : Unweeded	41.5	17.9	8.3	3.3	730
SEm.±	2.74	1.86	0.36	0.28	112
CD(0.05)	NS	5.6	NS	NS	335
CV (%)	10.7	11.0	7.8	13.7	16.6

Table 7: Yield and yield attributing characters of greengram as influenced by different pre and post emergence herbicide application during *rabi*, 2018.

Treatment	Plant height (cm)	No. of pods per plant	No. of seeds per pod	100 seed weight (g)	Seed yield (kg/ha)
T ₁ : Pendimethalin 30% + imazethapyr 2% @ 0.75 + 0.05 kg ha ⁻¹ as PE	51.0	17.1	9.5	4.1	968
T ₂ : Pendimethalin 30% @ 0.75 kg ha ⁻¹ as PE	50.7	14.8	9.7	4.4	824
T ₃ : Acifluorfen sodium 16.5% +clodinafop propargyl 8.0% @ 165+80 g ha ⁻¹ as PoE	54.2	17.3	9.7	4.5	1176
T ₄ : Fomesafen 11.1%+fluazifop-p-butyl 11.1% @ 0.111 kg ha ⁻¹ as PoE	53.3	14.9	10.1	4.6	875
T ₅ : Imazethapyr 35%+ imazamox 35% @ 35 g ha ⁻¹ as PoE	47.1	13.3	11.0	4.1	810
T ₆ : Propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g ha ⁻¹ as PoE	49.7	15.5	10.3	3.9	958
T ₇ : Imazethapyr 10% @ 50 g ha ⁻¹ as PoE	53.5	17.9	10.4	4.5	1035
T ₈ : Hand weeded at 20 and 40 DAS + inter cultivation at 30 DAS	53.9	17.4	10.6	3.9	1072
T ₉ : Unweeded	56.6	13.3	10.8	4.4	532
SEm.±	1.610	0.667	0.624	0.227	82.397
CD(0.05)	4.826	1.999	NS	NS	247
CV (%)	5.3	7.3	10.6	9.2	15.5

leaf expansion and biomass accumulation (Cobb and Reade, 2010).

CONCLUSION

Among the two PE herbicides tested on greengram during *kharif* and *rabi* seasons, pendimethalin 30% + imazethapyr 2% at 0.75 + 0.05 kg ha⁻¹ was found to be more effective in reducing the weed density and dry matter and recorded higher yield as compared with pendimethalin 30%. The PoE herbicides mixtures tested viz., fomesafen 11.1%+fluazifop-p-butyl 11.1% at 0.111 kg ha⁻¹, propaquizafop 2.5% + imazethapyr 3.75% at 50 + 75 g ha⁻¹ were effective in reducing weed density and weed dry matter and recorded seed yield on par with imazethapyr 10% at 50 g ha⁻¹ in both the seasons in greengram in the uplands of Krishna zone of Andhra Pradesh.

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