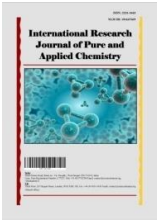

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Effect of Weed Management Practices on Weed Growth and Yield of Greengram (*Vigna radiata* (L.) Wilczek) in Southern Rajasthan

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A Field experiment was conducted at Agronomy instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) during 2016-17 to find out the impact of new generation herbicides in green gram. The results revealed that all growth and yield characters of blackgram were significantly affected by distinct weed control practices. A similar trend was also observed in weed parameters. Higher seed yield (13.8 qha^{-1}) and higher weed control efficiency (88.97%) were recorded under application of acifluorfen sodium + clodinafop propargyl (370 g a.i. ha^{-1}) at 3-4 leaf stage and which comparable with pre-emergence application of pyroxasulfone +pendimethalin (TM) 127.5+1000 g a.i/ha, imazethapyr+ quizalofop (TM) use at 70 + 60 g a.i/ha at 3-4 leaf stage, imazethapyr 70 g a.i/ha 3-4 leaf stage, imazethapyr + imazamox (RM) use at 70 g a.i/ha at 3-4 leaf stage, pendimethalin *fb* quizalofop 1000 + 60 at pre-emergence & 3- 4 leaf stage, imazethapyr + pendimethalin (RM) 1000 g a.i/ha as pre-emergence, propaquizfop 75 g a.i/ha at 3-4 leaf stage, weedy check and two hand weeding twice at 20 & 40 DAS. They also recorded improvement in yields and net returns by 65.22% over weedy check. These herbicide ready-mixes may be a promising weed management strategy for the green gram grown in the Southern Rajasthan.

Keywords: Herbicide; greengram; phytotoxicity; ready mix; weed control efficiency.

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1. INTRODUCTION

Food legumes are often acknowledged as poor man's meat. They are reasonably cheaper source of dietary protein in India, which ranks 102 on the global hunger index [1]. The expected food legume requirement of the country by 2030 is 32 million tonnes [2]. Among the major food legumes, green gram (*Vigna radiata* (L.) Wilczek) enjoys significant consumer preference due to its palatability and nutritious levels [3]. It is a warm-season food legume and is usually grown as a *Kharif* (monsoons) or spring summer crop across India, and also as a rabi (winter) crop in the warmer southern and central tracts of the country. Fresh weight weeds after every rainfall spell and poor crop competitiveness against weeds due to slow growth in the early stages severely limit monsoon green gram growth and productivity. Moreover, the short duration of the prevalent varieties (~ 60-65 days) leaves no room for recovery from the setbacks in crop performance due to late weed removal. The critical crop weed competition period for green gram spans around 20 to 30 days post sowing. Reports suggest that the magnitude of weed induced losses largely depend on the intensity and the spectrum of weed infestation and lack of judicious management within stipulated time may incur severe yield losses in the range 30 to 85% [4]. The growing labour crisis, high wage rates, and frequent rainfall during the monsoon season make manual weeding a difficult proposition. During the kharif season, weeding operation schedule largely depends on the rainfall forecast. Under such circumstances, the application of herbicide is a feasible and effective management option over manual weeding [1], more so when there is a rainfall spell forecast during the critical crop weed competition period. Less labour-intensive herbicidal management allows effective weed control over large area within a short span of time, thereby broadening the time window for taking up adequate weeding operation. Although selective herbicides leave the crop unharmed while killing the target weeds, their long-term indiscriminate use only adds to the problem of herbicide resistance in weed. Ready-mix application of Clodinafop-propargyl and Acifluorfen sodium with doses ranging from 245 to 370 g ha^{-1} ensured effective control of both dicot and monocot weeds in black gram [5] and [6]. Clodinafop propargyl controls grassy weeds by inhibiting acetyl-CoA carboxylase while Acifluorfen controls both grassy and broad-leaves by inhibiting protoporphyrinogen oxidase [5]. Presently, imazethapyr is a very effective post emergence herbicide for controlling broad leaf and some grassy weeds in green gram. But its efficacy has not been tested in combination with other herbicides for wide spectrum weed control in green gram. Therefore, the present investigation was carried out to assess the efficacy of different ready mix and tank mix herbicides when applied alone or in combination with other herbicides to provide weed free environment during the entire growing period of green gram through easy, efficient and economically viable weed management practices.

2. MATERIALS AND METHODS

The experiments were conducted at the Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan under natural weed infestations in green gram. The cumulative rainfall during the experimental period was 865.3 mm in 2017-18. Thirteen weed control treatments in green gram, including both pre-emergence (PE) and post-emergence (PoE) applied herbicides were laid out in a randomized block design with three replications in a gross experimental plot area of 5 m × 3.6 m. The treatments consisting of Aciflourfen 16.5% + clodinafop 8% EC 245 g a.i/ha at 3-4 leaf stage (RM), Aciflourfen 16.5% + clodinafop 8% EC 305 g a.i/ha 3-4 leaf stage, aciflourfen 16.5% + clodinafop 8% EC 370 g a.i/ha 3-4 leaf stage, pyroxasulfone +pendimethalin (TM) 127.5+1000 g a.i/ha, PRE, Imazethapyr+ quizalofop(TM) 70 + 60 g a.i/ha 3-4 leaf stage, Imazethapyr 70 g a.i/ha 3-4 leaf stage, imazethapyr + imazamox (RM) 70, 3-4 leaf stage, pendimethalin *fb* quizalofop 1000 + 60 at PE & 3- 4 leaf stage, Imazethapyr + pendimethalin (RM) 1000 g a.i/ha, PE, Propaquizfop 75 g a.i/ha at 3-4 leaf stage, Weedy check and Two hand weeding at 20 & 40 DAS. Herbicidal application in green gram was carried out using a flat fan nozzle fitted knapsack sprayer having a volume rate of 500 L water ha^{-1}. The experimental field was shallow cultivated using a tractor-drawn disc harrow. Post harrowing, the land was levelled with a wooden plank. Green gram (MM-4) seeds treated with recommended Rhizobium strain (supplied by Department of Agriculture & Soil Science, RCA, Udaipur) were sown at a row to row distance of 30 cm and plant to plant distance of 10 cm on 10th July. A recommended basal dose of 20 kg N and 40 kg P_2O_5 were applied at the time of sowing & sources of N & P_2O_5, was Di ammonium phosphate. Observations on individual weed count, total weed flora and weed

biomass were taken at 25 DAS and at harvest and also the final yield was taken at the time of harvest. The sampled weeds were then categorized into grasses, broad-leaves and sedges. Category wise weed density was first determined by counting and then weed dry weight was measured after sun-drying for two days followed by oven-drying at 70 ± 5°C for 48 hours. Weed control efficiency (WCE) was computed using the equation as follows:

$$Weed\ control\ efficiency\ (\%) = \frac{WDMc - WDMt}{WDMc} x\ 100$$

where WDMc is the weed dry matter (g m^{-2}) in control plot, i.e. the weedy check and WDMt are the weed dry matter (g m^{-2}) in the treated plot.

Data on crop and weeds were analyzed statistically by applying the analysis of variance (ANOVA) techniques for randomized block design as laid down by Gomez and Gomez [7]. ANOVA was performed with the square root transformed data ($\sqrt{x + 0.5}$) on weed density [8].

3. RESULTS AND DISCUSSION

3.1 Weed Dynamics and Population

The experimental plot was infested with grassy, broadleaf and sedges. The prominent weed species are *Echinochloa colona* (29.8%), *Commelina bengalensis* (5.8%), *Trianthama portalacastrum* (11.3%), *Digera arvensis* (6.2%), *Parthanium hysterophorus* (17.0%) and *Cyperus rotundus* (29.8%). The occurrence of above weeds at varying population significantly differs under different treatments of various times of observations. The total weed population recorded at 25 DAS and harvest was classified under three broad groups viz., grasses, sedges and broad-leaved weeds. Weed control efficiency indicated the magnitude of effective reduction of weed population and their competition by weed control practices over weedy check. This was highly influenced by different weed control treatments. Among the different weed control treatments ready mix application of acifluorfen 16.5% + clodinafop propargyl 8% EC 370 g a.i. ha^{-1} as post-emergence at 3-4 leaf stage was found more effective (Tables 1&2). This might be due broad-spectrum activity of application of this post emergence herbicide on weed and their greater efficiency to retard cell division of meristems as a result of which weeds died rapidly [9]. Herbicide reduced the total dry weight of weeds at harvest, ultimately the rapid growth of green gram crop, dense crop canopy might be suppressed weed growth as indicated by plant height and a greater number of branches per plant, which did not allow weeds to grow vigorously due to smothering effect. These results confirm the finding of [7].

3.2 Growth Parameters

Among the various weed management methods, growth and yield attributes viz., number of branches $plant^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1} were significantly increased with the application of acifluorfen 16.5% + clodinafop propargyl 8% EC 370 g a.i. ha^{-1} at 3-4 leaf stage (Table 3). The above promising weed management practices were responsible for not only the reduction of weed growth but also to reduce the nutrient depletion by weeds and thereby increasing the nutrient uptake by crop throughout its life period. This type of congenial atmosphere created by the promising weed management practices helped the crop to obtain more number of branches $plant^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1} of green gram. The results are analogous to those reported by [10].

3.3 Weed Control Efficiency

The highest weed control efficiency was noticed with Acifluorfen 16.5% + Clodinafop propargyl 8% EC use at 370 g a.i. ha^{-1} at 3-4 leaf stage was found superior to the rest of herbicide treatments in respect of weed control efficiency (Table 4). This was due to greater reduction in weed biomass in this treatment which might have increased the weed control efficiency. Similar result was reported by [5]. This was followed by the acifluorfen 16.5% + clodinafop propargyl 8% EC use at 370 g a.i. ha^{-1}. The lowest weed control efficiency was recorded over the weedy check plot. Similar findings were reported by [2]. The maximum weed control efficiency observed by the above promising weed management practices were due to greater reduction of grasses, sedges and broad-leaved weeds in all the stages of crop growth which increases the weed control efficiency. These results were in line with the findings of Marimuthu et al. [11]. The finding on WCE is collaborate the result of Sultan and Baigh [12] and [13] in green gram.

Table 1. Effect of treatments on weed density at 25 DAS

Treatment	Weed density (No./m^2)					
	Echinochloa colona	***Digera arvensis***	***Trianthema portulacastrum***	***Commelina benghalensis***	***Parthenium hysterophorus***	***Cyperus rotundus***
Aciflourfen 16.5% + clodinafop 8% EC 245 g a.i/ha at 3-4 leaf stage (RM)	3.53 (12.00)	1.00 (0.50)	1.76 (2.60)	2.29 (4.77)	(3.90)2.10	1.05 (0.60)
Aciflourfen 16.5% + clodinafop 8% EC 305 g a.i/ha 3-4 leaf stage	3.81 (14.00)	1.00 (0.50)	1.58 (2.00)	1.87 (5.20)	1.87 (3.00)	1.05 (0.60)
Aciflourfen 16.5% + clodinafop 8% EC 370 g a.i/ha 3-4 leaf stage	1.58 (2.00)	0.84 (0.20)	1.45 (1.60)	1.70 (3.52)	1.70 (2.40)	1.22 (1.00)
Pyroxasulfone 127.5 g a.i/ha, PE	2.12 (4.00)	1.22 (1.00)	1.34 (1.30)	1.57 (4.70)	1.57 (1.95)	1.22 (1.00)
Pyroxasulfone +pendimethalin (TM) 127.5+1000 g a.i/ha, PRE	1.58 (2.00)	1.22 (1.00)	1.34 (1.30)	1.56 (3.67)	1.56 (1.95)	1.22 (1.00)
Imazethapyr+ quizalofop(TM) 70 + 60 g a.i/ha 3-4 leaf stage	3.94 (15.00)	1.221.00)	1.34 (1.30)	1.57 (4.26)	1.57 (1.95)	1.22 (1.00)
Imazethapyr 70 g a.i/ha 3-4 leaf stage	(2.12) 4.00	1.22 (1.00)	1.58 (2.00)	1.87 (4.82)	1.87 (3.00)	1.22 (1.00)
Imazethapyr + imazamox (RM) 70, 3-4 leaf stage	3.08 (9.00)	0.71 (1.00)	1.67 (2.30)	1.99 (4.75)	1.99 (3.45)	0.71 (0.00)
Pendimethalin *fb* quizalofop 1000 + 60 at PE & 3-4 leaf stage	2.12 (4.00)	1.22 (1.00)	1.78 (2.66)	2.12 (5.24)	2.12 (3.99)	0.71 (0.00)
Imazethapyr + pendimethalin (RM) 1000 g a.i/ha, PE	1.58 (2.00)	1.22 (1.00)	2.12 (4.00)	2.55 (5.61)	2.55 (6.00)	0.71 (0.00)
Propaquizfop 75 g a.i/ha at 3-4 leaf stage	4.85 (23.00)	1.22 (1.00)	1.58 (2.00)	1.87 (5.61)	1.87 (3.00)	0.71 (0.00)
Weedy check	5.43 (29.00)	2.55 (6.00)	3.39 (11.00)	4.12 (5.67)	4.12 (16.50)	5.43 (29.00)
Two hand weeding at 20 & 40 DAS	2.12 (4.00)	1.22 (1.00)	1.22 (1.00)	1.41 (3.37)	1.41 (1.50)	2.12 (4.00)
SEm ±	0.48	0.07	0.14	0.45	0.21	0.33
LSD (P = 0.05)	1.40	0.21	0.41	1.30	0.61	0.97

Data subjected to $\sqrt{x+0.5}$ transformation and figures in parenthesis are original weed count per sq.m

Table 2. Effect of treatments on weed density at harvest

Treatment	Weed density (No./m^2)					
	Echinochloa colona	***Digera arvensis***	***Trianthema portulacastrum***	***Commelina benghalensis***	***Parthenium hysterophorus***	***Cyperus rotundus***
Aciflourfen 16.5% + clodinafop 8% EC 245 g a.i/ha at 3-4 leaf stage (RM)	3.85 (14.36)	1.05 (0.60)	1.90 (3.11)	2.49 (5.71)	2.27 (4.67)	1.10 (0.72)
Aciflourfen 16.5% + clodinafop 8% EC 305 g a.i/ha 3-4 leaf stage	4.15 (16.76)	1.05 (0.60)	1.70 (2.39)	2.59 (6.22)	2.02 (3.59)	1.10 (0.72)
Aciflourfen 16.5% + clodinafop 8% EC 370 g a.i/ha 3-4 leaf stage	1.70 (2.39)	0.86 (0.24)	1.55 (1.91)	2.15 (4.21)	1.84 (2.87)	1.30 (1.20)
Pyroxasulfone 127.5 g a.i/ha, PE	2.30 (4.79)	1.30 (1.20)	1.43 (1.56)	2.47 (5.63)	1.68 (2.33)	1.30 (1.20)
Pyroxasulfone +pendimethalin (TM) 127.5+1000g a.i/ha, PRE	1.70 (2.39)	1.30 (1.20)	1.43 (1.56)	2.21 (4.39)	1.68 (2.33)	1.30 (1.20)
Imazethapyr+ quizalofop(TM) 70 + 60 g a.i/ha 3-4 leaf stage	4.30 (17.95)	1.30 (1.20)	1.43 (1.56)	2.37 (5.10)	1.68 (2.33)	1.30 (1.20)
Imazethapyr 70 g a.i/ha 3-4 leaf stage	2.30 (4.79)	1.30 (1.20)	1.70 (2.39)	2.49 (5.76)	2.02 (3.59)	1.30 (1.20)
Imazethapyr + imazamox (RM) 70, 3-4 leaf stage	3.36 (10.77)	1.30 (1.20)	1.80 (2.75)	2.48 (5.68)	2.15 (4.13)	0.71 (0.00)
Pendimethalin *fb* quizalofop 1000 + 60 at PE & 3-4 leaf stage	2.30 (4.79)	1.30 (1.20)	1.92 (3.18)	2.59 (6.27)	2.30 (4.78)	0.71 (0.00)
Imazethapyr + pendimethalin (RM) 1000 g a.i/ha, PE	1.70 (2.39)	1.30 (1.20)	2.30 (4.79)	2.68 (6.71)	2.77 (7.18)	0.71 (0.00)
Propaquizfop 75 g a.i/ha at 3-4 leaf stage	5.29 (27.53)	1.30 (1.20)	1.70 (2.39)	2.68 (6.71)	2.02 (3.59)	0.71 (0.00)
Weedy check	5.93 (34.71)	2.77 (7.18)	3.70 (13.17)	2.70 (6.78)	4.50 (19.75)	5.93 (34.71)
Two hand weeding at 20 & 40 DAS	2.30 (4.79)	1.30 (1.20)	1.30 (1.20)	2.13 (4.03)	1.51 (1.80)	2.30 (4.79)
SEm ±	0.57	0.09	0.17	0.53	0.25	0.40
LSD (P = 0.05)	1.68	0.26	0.49	1.56	0.73	1.16

Data subjected to $\sqrt{x+0.5}$ transformation and figures in parenthesis are original weed count per sq.m

Table 3. Total weed dry matter and growth parameters

Treatment	Weed dry matter(g/m^2)	Branches per plant	Seeds per pod	Pods per plant
Aciflourfen 16.5% + clodinafop 8% EC 245 g a.i/ha at 3-4 leaf stage (RM)	4.24 (17.47)	4.70	4.70	34.25
Aciflourfen 16.5% + clodinafop 8% EC 305 g a.i/ha at 3-4 leaf stage (RM)	4.32 (18.13)	5.20	5.70	35.00
fop 8% EC 370 g a.i/ha 3-4 leaf stage (RM)	2.86 (7.68)	4.60	5.96	35.98
a, PRE	3.24 (10.00)	4.70	4.20	32.00
alin (TM) 27.5+1000g a.i/ha, PRE	2.88 (7.83)	4.90	5.00	35.20
+ 60 g a.i/ha 3-4 leaf stage (TM)	4.25 (17.57)	4.20	5.60	30.40
leaf stage	2.44 (11.34)	5.20	4.90	32.00
RM) 70, 3-4 leaf stage	3.90 (14.69)	4.70	4.70	32.20
1000 + 60 at PE & 3-4 leaf stage	3.55 (12.11)	4.80	3.60	31.60
in 1000 g a.i/ha, PRE (RM)	3.72 (13.34)	5.60	4.50	34.90
3-4 leaf stage	5.03 (24.81)	4.60	4.30	30.10
	8.37 (69.65)	1.50	1.50	20.00
40 DAS	3.34 (10.66)	3.30	4.70	23.00
SEm ±	0.08	0.13	0.21	0.95
LSD (P = 0.05)	0.25	0.39	0.61	2.79

Table 4. Total weed dry matter, weed control efficiency, yield and economics

Treatment	Weed control efficiency at harvest (%)	Seed yield (q/ha)	Haulm yield (q/ha)	Net returns (Rs/ha)	B C Ratio
Aciflourfen 16.5% + clodinafop 8% EC 245 g a.i/ha at 3-4 leaf stage (RM)	74.76	7.6	11.2	37930	2.03
Aciflourfen 16.5% + clodinafop 8% EC 305 g a.i/ha at 3-4 leaf stage (RM)	73.83	7.5	11.2	36922	1.96
Aciflourfen 16.5% + clodinafop 8% EC 370 g a.i/ha 3-4 leaf stage (RM)	88.97	9.3	13.8	50140	2.69
Pyroxasulfone 127.5 g a.i/ha, PRE	85.55	8.6	12.4	44906	2.38
Pyroxasulfone +pendimethalin (TM) 27.5+1000g a.i/ha, PRE	88.77	8.9	13.5	46381	2.39
Imazethapyr+ quizalofop 70 + 60 g a.i/ha 3-4 leaf stage (TM)	74.65	8.4	11.7	42396	2.16
Imazethapyr 70 g a.i/ha 3-4 leaf stage	83.70	8.1	11.8	40886	2.11
Imazethapyr + imazamox (RM) 70, 3-4 leaf stage	78.80	7.9	12.2	39148	1.99
Pendimethalin *fb* quizalofop 1000 + 60 at PE & 3-4 leaf stage	82.50	7.4	10.7	35108	1.78
Imazethapyr + pendimethalin 1000 g a.i/ha, PRE (RM)	80.78	8.6	12.2	43868	2.23
Propaquizfop 75 g a.i/ha at 3-4 leaf stage	64.28	8.6	13.1	41154	1.79
Weedy check	0.00	4.6	9.4	15659	0.80
Two hand weeding at 20 & 40 DAS	84.65	8.3	12.0	44621	2.63
SEm ±	0.92	0.03	0.06		
LSD (P = 0.05)	2.68	0.10	0.16		

3.4 Yield

Results of the study revealed that all the weed control treatments have a salutary effect on yield of green gram over weedy check. Among different treatments, acifluorfen 16.5% + clodinafop propargyl 8% EC use at 370 g a.i. ha^{-1} registered the maximum seed and haulm yields and was 65.22 and 16.66 per cent higher over weedy check (Table 4). This might be due to better control of all categories of weeds which reduced the crop-weed competition by providing no weed situation in green gram field [6] and [14]. Thus, the crop plants being vigorous by efficiently utilization of nutrients, moisture, sunlight with space and gave better yield [15] and [16]. The weedy check plot gave significantly lowest yield due to heavy competition for nutrient, moisture and light between the crops and weeds. Similar grain yield losses due to weeds was reported by [17].

3.5 Economics

The highest benefit cost ratio was recorded with acifluorfen 16.5% + clodinafop propargyl 8% EC @ 370 g a.i. ha^{-1} and this was closely followed by acifluorfen 16.5% + clodinafop propargyl 8% EC @ 305 g a.i. ha^{-1} and pre emergence application of pyroxasulfone + pendimethalin (TM) 127.5+100 g a.i. ha^{-1} indicating the cost effectiveness of herbicides, whereas weed free treatment involved highest labour cost and cost of cultivation, which leads to decreased net returns (Table 4). The findings confirm the result of Velayudham [18] also reported significantly higher net return in weed management practice.

4. CONCLUSION

Application of acifluorfen 16.5% + clodinafop propargyl 8% EC @ 370 g a.i. ha^{-1} at 3-4 leaf stages was found superior in respect of decreasing the density and biomass of weeds and recorded higher seed yield as compared to other treatments. It can be considered as appropriate option for broad spectrum weed suppression as well as higher B: C ratio in greengram.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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