Original Research Article

Efficacy of some pre- and post-emergenceherbicidesfor weed managementand their effects on yield and yield attributes in*rainy* season green gram (*Vigna radiata* L.) crop

ABSTRACT

Green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated crops in India. The average productivity of this crop is very low and one of the main reasons is competition from weeds. Yield reduction in green gram due to weed infestation ranges between 30-85%. Thus, effective weed management is an important key factor for enhancing the productivity of green gram. In the present study, a fieldexperimentwasconducteddur*ing rainy*seasonof2022atthe G.B.PantUniversityofAgricultureandTechnology,Pantnagar to evaluate the effect of eight different herbicidesfor weed management in green gram genotype Pant mung-6.The experiment was laid out in a randomized block design with three replications.The herbicidetreatmentsconsisted of pendimethalin (30% EC) 750 g.a.i/ha, fenoxprop-p-ethyl (9.3%EC)67.5g.a.i/ha, fluazifop-p-butyl(13.4%EC)125g.a.i/ha, imazethapyr (10%SL)75g.a.i/ha, propaquizafop(10% EC) 100g.a.i/ha, quizalofop-ethyl (5%EC) 50g.a.i/ha, fluazifop-p-butyl (11.1%)150g.a.i/ha+Fomesafen(11.1%EC) 250g.a.i/ha, and sodium acifluorfen (16.5)%+ clodinafoppropargyl (8% EC) 80+165g.a.i./ha. One weedy check and twice hand weeding (at20 and45 DAS) were also included in treatment. Major weed species found infesting the crop were *C.rotundous, Trianthema portulacastrum, Elusine indica, Digitaria sanguinalis, Digeria arvensis, Celosia argentea, Mollugo pentaphylla andP. niruri*. All the herbicide treatments recorded significantly lower weed density than the weedy check. Among the herbicides,pendimethalin (0.75 kg/ha) as pre-emergence, post-emergence application of Imazethapyr (75g/ha) and ready mix product of sodium acifluorfen + clodinafop-propargyl (80+165g/ha) provided excellent weed control with a WCE of more than 85%. Grain yield of mung bean was also highest in these treatments.

Keywords: Green gram, weeds, weed management, herbicides, weed control efficiency

Comment [BK1]: Arrange keywords alphabatically

1. INTRODUCTION

Greengram is the third most important pulse crop in India. It is a short duration (65-90 days) legume crop cultivated on more than six million hectares globally in arid and semi-arid region[1].It is currently cultivated in many parts of the world such as United States of America, South Europe, Pakistan, Bangladesh, Thailand, Indonesia, Malaysia, China and Africa [2]. Asian continent happens to be the largest green gram producer with India producing more than 50 % and China 19 % of total global production. Green gram 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 such as arid and semiarid lands. The grainscontain approximately 25-28% protein, 1.02-1.05% oil, 3.5-4.5% fiber, 4.5-5.5% ash and 60-65%,carbohydrates on dry weight basis.The productivity of green gram is adversely affected by several abiotic and biotic factors such as atmospheric temperature, soil moisture, soil acidity and salinity, drought, water-logging conditions, pestinfestations, weeds infestation and disease infections which affect crop growth and yield.

Weed infestation is one of the major constraints in greengram cultivation(Khan et al., 2023b, Khan et al., 2023c) [3].Weedscompetewith the cropforspace,nutrients,waterandlightandultimatelyreducethegrain yieldofmungbeanby30-85%[4] (Aziz et al., 2022).Besidescausingcroplosses,weedsarealsoresponsibleforreducingseedqualityandnutrient statusofsoil (Khan et al,., 2022b) (Javaid et al. 2022). Hence management of weeds is imperative to sustain mungbean productivity and to ensure food security. The weeds can be managed by adopting various methods like cultural, biological, chemical as well asintegrated weed management (Nadeem et al 2022).Herbicides are commonly used for weed control in high-input crop production systems. Herbicides are the most effective and economic tool among the weed management practices (khan et al., 2022a) Khan et al.,2023a). Use of herbicide is rapidly increasing in the world including India [5].The most commonly used herbicides for controlling weeds in green gram are pendimethalin,propaquizafop, quizalofop-ethyl, imazethapyr, alachlor and fluchloralin. Recently, some ready-mix such as fluazifop-p-butyl +fomesafen, sodium acifluorfen+clodinafop-propargyl have been introduced for the control of complex weed flora in pulse crops like greengram and lentil that reduces the crop weed competition and effectively managethe weed flora in green gram [6]. However, any single herbicide or a ready-mix formulation may not be effective to control all the weed species in a particular area. Therefore, it is imperative to evaluate their efficacy to manage weed flora in any location. This research work was carried out to evaluate the efficacy and find out most suitable herbicide or ready mix formulation for controlling weeds associated with green gramcrop at Pantnagar which lies in the *tarai* belt. The effects of herbicides on yield and yield attributes of green gramwere also evaluated.

2.MATERIALS AND METHODS

A field experiment was conducted during the *rainy* season of 2022 at theN.E Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar to study the effect of different weed management practices on the production of summer mungbean. The experimental site experiences asub-tropical humid climate. The temperature is moderate, ranging from 25 to 38°C and the annual rainfall ranges from 1250 mm to 1500 mm. About 70% of the rainfall is generally received during the months of June to September. The experiment was laid out in a Randomized Block Design (RBD) with 10 different treatmentsreplicatedthree times. Mungbean genotype Pant Mung-6 was grown withrecommended package and practices. The treatments included pendimethalin (30% EC) 750 g.a.i/ha, fenoxprop-p-ethyl (9.3%EC)67.5g.a.i/ha, fluazifop-p-butyl(13.4%EC)125g.a.i/ha, imazethapyr (10%SL)75g.a.i/ha, propaquizafop(10%EC) 100g.a.i/ha, quizalofop-ethyl(5%EC) 50g.a.i/ha, fluazifop-p-butyl (11.1%)150g.a.i/ha+fomesafen(11.1%EC) 250g.a.i/ha, and sodium acifluorfen (16.5)%+ clodinofoppropargyl (8% EC) 80+165g.a.i./ha, two hand weedings(at 20 and 45DAS) and a weedy plot as check. Pendimethalin was applied one day after sowing as pre-emergence whereas other herbicides were appliedpost emergence at 20DAS. All the treatments were applied with knapsack sprayer. Observations were recorded on density of different weed species infesting the crop, weed dry weight and yield and yield attributes of the mung bean crop. The effect of herbicides on individual weed species was also estimated and the weed control efficiency was calculated by using the following formula [7].

$$\text{Weed control efficiency} = \frac{(WPc - WPt)}{WPc} \times 100$$

Where, WPc=Weed population (no./m^2) in untreated plot; WPt=weed population (no./m^2) in treated plot.

3. RESULTS AND DISCUSSION

3.1Major weed flora observed in thecrop field

The crop was found to be infested with a variety of grassy and broad leaved weeds as well as sedges. The weed species observed in crop field are mentioned in table 1.

Table 1 Major weed flora observed inthe experimentalcrop

S. no.	Grassyweed	Broad leaves weed	Sedges
1.	*Echinochloa colona*	*Celosiaargentea*	*Cyperus rotundus*
2.	*Digitaria sanguinalis*	*Phyllanthusniruri*	
3.	*Eleusine indica*	*Digeria arvensis*	
4.		*Trianthema portulacastrum*	
5.		*Mollugo pentaphylla*	

3.1.1 Effect of herbicides on weed density

The density of weeds was significantly affected by the weed management treatments used in the experiment (Table 2). At 45 DAS, weedy check recorded the highest density of *Cyperus rotundus* (38.66/m^2) followed by *Eleusine indica* (26.33/m^2),*Trianthema portulacastrum*(23.0/m^2), *Celosia argentea* (20.33/m^2)*Digera arvensis*(19.66/ m^2), *P. niruri* (18.66/m^2), *Mollugo pentaphylla* (18.0/m^2),and*Digitaria sanguinalis*(13.33/m^2). Population of all the weed species was significantly reduced with two hand weedingsdone at 20 and 45 DAS. Application of pendimethalin 0.75kg/ha(pre emergence)significantly reduced the density of all the weed species which were reduced to 0.33/m^2in case of *Digitaria sanguinalis, P.niruri* to about 0.33/m^2 in *Digera arvensis*5.0/m^2. Pendimethalin prevents emergence of weeds by inhibiting root and shoot growth.Among rest of the ~~herbicides~~herbicide's treatments, the density of*Digera arvensis*was foundto be minimum(4.33/m^2)in thesodium acifluorfen+Clodinafop-propargyl (Ready-mix 80 + 165g/ha at 20 DAS) treatment. Post-emergence application sodium acifluorfen+Clodinafop-propargyl (Ready-mix) has been reported to control broad-leaved and narrowleaved weeds at 3-4 leaf stage [8].

3.1.2 Weed control efficiency of the herbicide treatments

The data on weed control efficiency is given in table 3. The weeds were completely controlled with twohand weedings at 20 and 45 DAS. This was followed by pre-emergence application of pendimethalin(0.75kg/ha).Additionally, post-emergence herbicides such as imazethapyr and sodium acifluorfen+clodinafop-propargyl (Ready-mix) also recorded high WCE valueswhich ranged between 60-85%, indicating their effectiveness in weed control.Similareffectiveness of weed control by these herbicides has been reported by Chhodavadia *et al.*, 2013 [9]. Thespecies wise weed control efficiency of different herbicides was estimated. *Cyperus rotundous* waseffectively controlled by pendimethalin 0.75kg/ha (94.61%) which was at par with hand weeding treatment(100%). The efficiency of pendimethalin in controlling rest of the weed species ranged between 82%to 97% such as *Elusine indica* (87.28%), *Digitaria sanguinalis* (97.22%),*Celosia argentea* (82.87%),*Mollugo pentaphylla* (90.46%) and *P. niruri* (97.78%).Furthermore, the herbicide imazethapyrexhibited the highest weed control efficiency for the weeds*Trianthema portulacastrum* (78.23%) and *Digeria arvensia* (74.96%).For rest of the herbicides, the WCF ranged between 50-65%.Higher weed control efficiency percent of weeds was initially attributed due to root and shoot inhibiting action of pendimethalin on weeds [10] and at later stages due to the higher persistence of imazethapyr also contributed to the control of weeds, as the half-life of imazethapyr varies from 78 to 270 days [11]. Verma and Kushwaha (2020) reported similar findings in green gram [12].

Table.2 Effect of weed management treatments on densityof eight weeds species at 45DASin greengramgenotype Pant mung-6.

		Density(Number/m²)							
S. No	**Treatment details**	***C. rotundous***	***Trianthema portulacastrum***	***Digeria arvensis***	***Elusine indica***	***Digitaria sanguinalis***	***Celosia argentea***	***Mollugo pentaphylla***	***P. niruri***
T_1	Pendimethalin 38.7EC	2.00	4.66	5.00	3.33	0.33	3.33	1.66	0.33
T_2	Fenoxprop-p-ethyl 9.3% EC	13.00	7.0	10.67	11.67	6.33	8.66	8.33	9.00
T_3	Flauzifop-p-butyl 13.4EC	14.66	7.66	9.66	8.33	4.66	10.33	13.00	8.33
T_4	Imazethapyr10%SL	12.66	4.66	4.66	3.66	2.33	5.00	7.33	4.65
T_5	Propaquizafop 10% EC	14.33	12.33	10.00	10.33	2.66	9.33	7.66	8.66
T_6	Quizalofop-ethyl 5%EC	16.33	13.66	9.00	11.00	6.66	8.66	6.33	6.00
T_7	Flauzifop-p-butyl 11.1% + Fomesofen 11.1%EC	19.00	5.00	5.00	6.66	6.00	9.33	6.66	3.66
T_8	Sodium acifluorfen 16.5%+Clodinafop-propargyl 8%EC	16.33	6.66	4.33	5.00	4.00	3.00	6.66	3.33
T_9	Handweeding	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_{10}	Weedy check	38.66	23.0	19.66	26.33	13.33	20.33	18.0	18.66
	S.Em±	1.96	1.67	1.05	1.42	1.03	1.41	1.14	1.65
	CD(*P*=0.05)	5.76	5.00	3.14	4.27	3.10	4.23	3.43	4.95

Table3.Weed controlefficiency of different weed management treatment for individual weeds species at 45 DAS in greengramgenotypePant mung-6.

S.No	Treatment details	*C. rotundous*	*Trianthema portulacastrum*	*Digeria arvensis*	*Elusine indica*	*Digitaria sanguinalis*	*Celosia argentea*	*Mollugo pentaphylla*	*P. niruri*	*Mean*
T_1	Pendimethalin 38.7EC	94.61	78.20	74.69	87.28	97.22	82.87	90.46	97.78	87.89
T_2	Fenoxprop-p-ethyl 9.3% EC	66.91	69.06	46.17	55.76	48.72	56.27	53.15	47.94	55.50
T_3	Flauzifop-p-butyl 13.4EC	62.26	66.06	50.52	68.53	65.26	51.17	26.34	50.09	55.03
T_4	Imazethapyr10%SL	67.79	78.23	76.96	85.97	82.75	76.82	59.40	85.70	76.70
T_5	Propaquizafop 10% EC	61.93	47.10	48.46	60.33	46.76	55.02	57.69	50.00	53.41
T_6	Quizalofop-ethyl 5%EC	56.67	36.18	54.64	58.91	53.64	58.88	63.75	63.16	55.73
T_7	Flauzifop-p-butyl 11.1% + Fomesofen 11.1%EC	49.26	76.04	75.30	74.22	55.60	54.58	61.81	79.86	65.83
T_8	Sodium acifluorfen 16.5%+Clodinafop-propargyl 8%EC	56.68	69.56	78.20	80.68	67.35	75.80	61.67	79.95	71.24
T_9	Handweeding	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00
T_{10}	Weedy check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.Em±	5.10	6.45	5.05	5.41	7.52	6.34	6.24	7.36	
	CD(*P*=0.05)	15.29	19.32	15.14	16.22	22.51	18.99	18.69	22.04	

3.2 Effect on yield and yield attributes

The different weed management treatments had a significant impact on the total dry weight of weeds, pods per plant, seed yield, biological yield, and harvest index (Table 4). Without any management practices (weedy check condition), both the biological yield (2000kg/ha) and seed yield (383kg/ha) were lowest which is obviously due to higher weed density and dry weight of weeds. On the other hand, if weeds were controlled during the critical crop weed competition period, the seed yield of mung bean was highest (1048 kg/ha) (the treatment with two hand weedings). Our study shows that there was a 63.45% reduction in economic yield of mung bean if the weeds are not managed.Application of pendimethalin also recorded similar yield (1025kg/ha) as that in the hand weeding treatment. It was followed by imazethapyr treatment (841kg/ha). Yield attributes like pod/plant were significantly higher in hand weeding treatment (22.73) which was at par with treatment pendimethalin (22.07). This was followed by the treatments imazethapyr and readymix of sodium acifluorfen+clodinofop-propargyl which also recorded relatively high pod counts (20.67 and 21.60, respectively).A perusal of the reduction of weed density species wise (table 2) and total dry weight (table 4) shows that the treatments pendimethalin, imezathypyr and the readymix application of Sodium Acifluorfen and clodinfop-propargyl significantly reduced the density and dry weight of the weeds infesting the crop. The reduction in weed dry weight ranged between 79.10 % in case of pendimethalin to 73 % in case of both Imezathypyr and ready mix formulation of Sodium Acifluorfen and clodinafop-propargyl. The suppression of weeds by these treatments during the

critical competition period led to increase in yield attributes like total biological yield and number of pods per plant thus, higher seed yield. Effective weed management in mung bean by these herbicides, both single and ready mix formulations has been reported by many workers [13, 14,15]. Add more in discusion

Table.4 Effect of different weed management treatments on yield and yield attributes in greengram genotype Pant mung-6

S.No	Treatment details	Yield and yield attributes			
		Total weeddrymatter (g/m^2)	No. ofpods/Plant	Seed yield(kg/ha)	Biologicalyield (kg/ha)
T_1	Pendimethalin 38.7EC	2.61	22.07	1025	3533
T_2	Fenoxprop-p-ethyl 9.3% EC	5.69	16.23	516	2106
T_3	Flauzifop-p-butyl 13.4EC	6.64	17.13	663	3033
T_4	Imazethapyr10%SL	3.26	20.67	841	3266
T_5	Propaquizafop 10% EC	5.67	15.53	608	2800
T_6	Quizalofop-ethyl 5%EC	4.97	16.33	641	2700
T_7	Flauzifop-p-butyl 11.1% + Fomesofen 11.1%EC	3.82	17.67	550	2166
T_8	Sodium acifluorfen 16.5%+Clodinafop-propargyl 8%EC	3.36	21.60	666	2500
T_9	Handweeding	0.00	22.73	1048	3566
T_{10}	Weedy check	12.49	13.60	383	2000
	S.Em±	0.52	1.42	30.23	275.33
	CD(*P*=0.05)	1.55	4.25	90.51	824.39

4. CONCLUSION

The study highlights the weed control efficiency of different herbicides and its effect on yield and yield attributes of rainy season green gram crop.Weedy situation recorded a 63.45%decrease in seed yield of the crop. Among the weed management treatments, hand weeding at 20-45 DAS completely controlled the weeds and recorded higher yield. However, this method is economically unacceptable due to higher cost of manual weeding.Among the herbicides,pendimethalin 0.75kg/ha as pre-emergence and imazethapyr 75g/ha at 20 DASas post-emergence were found most effective in controlling weeds at all stages and thus, recorded higher weed control efficiency and yield parameters. This study shows that with the use of right and efficient herbicides, weeds can be efficiently and economically managed in rainy

season green gram crop. It also highlights the efficacy of the herbicide treatments for managing individual weed species which can be used as reliable information for weed management in green gram under different situations and with the dominance of different weed species.

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