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Bio efficacy of new generation herbicides on weed dynamics, crop growth and yield in *rabi* green gram (*Vigna radiate* L.)

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Abstract
A field experiment was conducted at Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad during *rabi* 2020-21 to assess the bio efficacy of new generation herbicides in green gram (*Vigna radiata*). The experiment was assigned ten treatments, laid out in randomized complete block design with three replications. Lower weed density and higher weed control efficiency was recorded with diclosulam 84% WDG @ 26 g a.i ha^{-1} as PE *fb* imazethapyr 10% SL @ 75 g a.i ha^{-1} as PoE at 20 DAS and diclosulam 84% WDG @ 26 g a.i ha^{-1} as pre-emergence application. However, due to phytotoxicity of herbicide on the crop, it resulted in yield loss. The maximum seed yield was registered with weed free check (1430 kg/ha) and was on par with imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha^{-1} as post emergence at 20 DAS (1375 kg/ha) and pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha^{-1} as pre emergence (1244 kg/ha). Among the herbicide combinations, higher net returns and B:C ratio was recorded with imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha^{-1} as post emergence at 20 DAS (₹ 68368 /ha, 3.39) followed by pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha^{-1} as PE (₹58684/ha, 3.02), respectively.

Keywords: Green gram, weed density, imazethapyr + Quizalofop, economics, yield

Introduction
Pulses own a unique position in every system of Indian farming as main crop, catch crop, cover crop, green manure crop and inter crop. Among the pulses, Green gram (*Vigna radiata* L.) is the most important and extensively cultivated legume crop. It ranks third after chickpea and pigeon pea in respect of production. In India, green gram is cultivated over an area of 4.07 million hectares with a production of 1.90 million tonne giving an average productivity of 467 kg ha^{-1}.

Being a short duration crop and relatively slow initial growth, *rabi* green gram is subjected to heavy infestation of weeds posing a considerable threat to achieve the expected yields**.** Competition with the weeds leads to 70-80% reduction in grain yield of green gram during *rabi* season (Diwash *et al*. 2015) [9]. The weed interference in green gram crop can be effectively managed by using mechanical practices like hand weeding and inter-cultivation. Due to more labor cost and problem in availability, it is not economical. For effective control of all types of weed flora from sowing to critical period, herbicide application is necessary for better growth of green gram. Hence, sequential application of suitable combination of herbicides is essential for effective control of weeds in *rabi* green gram.

In view of the above problems, the present study was undertaken.

Materials and Methods
A field experiment was conducted during *rabi*, 2020-2021 at College farm, Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad Telangana state with ten treatments, laid out in randomized complete block design with three replications. The soil of experimental site was sandy clay loam in texture and slightly alkaline in reaction (pH 7.96), low in organic carbon (0.39%) and available nitrogen (235.8 kg/ha), high in available phosphorous (45.5 kg/ha) and potassium (384.6 kg/ha) with electrical conductivity of 0.41 dS/m. Treatments included were (W_1**)** Diclosulam 84% WDG @ 26 g a.i ha^{-1} as PE, (W_2**)** Pendimethalin 30% EC + Imazethapyr 2% EC combination @ 960 g a.i ha^{-1} as PE, (W_3**)**

Imazethapyr 35% + Imazamox 35% WG combination @ 70 g a.i ha^{-1} as PoE, (W_4**)** Imazethapyr 3.75% + Propaquizafop 2.5% w/w ME @ 125 g a.i ha^{-1} as PoE, (W_5**)** Sodium acifluorphen 16.5% EC + Clodinafop propargyl 8% EC @ 250 g a.i ha^{-1} as PoE, (W_6**)** Diclosulam 84% WDG @ 26 g a.i ha^{-1} as PE *fb* Imazethapyr 10% SL @ 75 g a.i ha^{-1} as PoE, (W_7**)** Imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha^{-1} as PoE, (W_8**)** Intercultivation at 20 DAS with power weeder, (W_9**)** Unweeded check and (W_{10}**)** Weed free check.

Green gram variety 'MGG-347' was sown in the field with a seed rate of 20 kg/ha, maintaining 30 cm × 10 cm as spacing at a depth of 2-3 cm. The crop was fertilized with 20:50:20 kg Nitrogen, Phosphorous and Potassium ha^{-1} respectively in the form of Urea, DAP and MOP. Pre emergence (PE) application of herbicides was done at 2 DAS and post emergence (PoE) at 20 DAS. The data on weed density was recorded using 0.25 m^2 quadrate at various intervals. They are dried in the oven till constant weight was recorded.

Weed control efficiency was calculated as per the following formula (Mani *et al.* 1973) [4].

$$WCE\ (\%) = \frac{DM_C - DM_T}{DM_C}$$

WCE = Weed Control Efficiency (%)
DM_C = Dry matter of weeds in the unweeded check (control)
DM_T = Dry matter of weeds in the treatment imposed plot

Results and Discussions

Effect on weed

The principal weed flora observed was *Cynodon dactylon, Eleusine indica* and *Panicum repens, Cyperus rotundus, Parthenium hysterophorous, Trianthema portulacastrum, Amaranthus viridis, Corchorus acutangulus, Commelina benghalensis, Alternanthera sessilis, Celosia argentea* and *Digera arvensis*.

Among the herbicide combinations, significantly lower weed density was registered with diclosulam 84% WDG @ 26 g a.i ha^{-1} as PE *fb* imazethapyr 10% SL @ 75 g a.i ha^{-1} as PoE at 20 DAS and (W_6) diclosulam 84% WDG @ 26 g a.i/ha as pre-emergence application (W_1) at all intervals of observations (Table 1). But these treatments have shown phytotoxic effect on the crop. So, apart from the diclosulam treated plots (W_1 and W_6), lower weed density was recorded with imazethapyr 10% SL + quizalofop ethyl 5% EC (tank mix) @ 125 g a.i/ha as PoE at 20 DAS and pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha^{-1} as PE at 30, 60 DAS and harvest stage.

Diclosulam has controlled weeds effectively till harvest due to longer half-life period and imazethapyr and quizalofop reduced weed density due to dual mode of action of herbicides. Imazethapyr controlled BLW's by hindering the acetolactate synthase (ALS) and quizalofop ethyl reduced the density of grasses effectively as it inhibits the fatty acid synthesis through ACCase inhibition leading to death of weeds. Similar findings were obtained by Poornima *et al.* (2018) [6] and Kumar *et al.* (2019) [2].

Higher WCE (%) was recorded with diclosualm treated plots (W_1 and W_6) at 30 DAS. Similar trend was followed at 45 DAS and at harvest. This was followed by imazethapyr 10% SL + quizalofop ethyl 5% EC (tank mix) @ 125 g a.i/ha as PoE at 20 DAS and pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i/ha as PE. Pre and post emergence application of herbicide combinations effectively controlled weeds which made the crop weed competition in favour of the crop suppressing the dry matter accumulation in weeds, which has been reflected in higher weed control efficiency when compared to weedy check. Lata Verma and Kushwaha (2020) [3] were of similar opinion.

Effect on crop

Herbicide combinations recorded significantly higher plant height and yield attributes and were comparable to weed free check. Weed free check was superior over all the treatments. Maximum plant height (46.87 cm) together with higher number of pods/plant (18.80), seeds/pod (7.07) and 100 seed weight (3.30 g) were registered with imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha-1 as PoE at 20 DAS (W_7). This was followed by pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha-1 as PE (W_2).

Higher seed yield was observed with weed free check (1430 kg/ha) and was on par with imazethapyr 10% SL + Quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha-1 as PoE at 20 DAS (W_7) (1375 kg/ha). This was followed by pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha-1 as PE (W_2) (1244 kg/ha) (Table 2). This might be due to poor density of weeds and better weed control efficiency in those treatments. Consequently the crop is able to compete with the weeds for all the necessary growth factors. The findings were analogous to those obtained by Manpreet Jaidka and Manoj Sharma (2018) [5] and Singh *et al.* (2021) [8]. Diclosulam treated plots (W1 and W6) recorded lowest yield attributes and yield due to herbicide toxicity on the crop.

Economics

Imazethapyr 10% SL + quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha-1 as PoE at 20 DAS (W7) registered higher net returns and B:C ratio (Table 2). This was followed by pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha-1 at PE (W2). On the flip, least net returns and B: C ratio was observed with diclosulam treated plots over unweeded check due to heavy yield loss. Application of herbicides rendered cost effective weed control when compared to weed free check. The observations confirm the findings of Sakthi *et al.* (2018) [7] and Arvind Verma and Roshan Choudhary, (2020) [1].

Table 1: Effect of new generation herbicides on weed density (m^2) and WCE (%)

Treatment	Total weed density (m^2)				WCE (%)		
	15 DAS	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
W1	3.42 (10.67)	3.46 (11.00)	6.63 (43.00)	6.66 (43.33)	94.74	96.37	90.59
W2	3.51 (11.33)	4.80 (22.00)	6.11 (36.33)	6.76 (44.67)	86.57	83.34	56.98
W3	8.83 (77.00)	7.46 (54.67)	9.20 (83.67)	10.55 (110.33)	73.77	40.06	39.47
W4	8.79 (76.33)	6.48 (41.00)	9.00 (80.00)	9.11 (82.00)	81.65	75.85	44.77
W5	8.68 (74.33)	5.60 (30.33)	7.53 (55.67)	8.64 (73.67)	82.53	81.00	49.98
W6	3.79 (13.33)	2.77 (6.67)	2.27 (9.67)	4.58 (20.00)	95.20	97.68	92.15
W7	8.77 (76.00)	3.65 (12.33)	6.03 (35.33)	6.95 (47.33)	89.67	89.26	59.47
W8	9.6 (91.33)	6.61 (42.67)	9.04 (80.67)	9.61 (91.33)	77.50	73.23	42.71
W9	8.98 (79.67)	13.33 (176.67)	13.22 (173.67)	13.49 (181.00)	0.00	0.00	0.00
W10	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	100.00	100.00	100.00
S.Em±	0.32	0.50	0.51	0.31	-	-	-
CD (0.05)	0.95	1.49	1.50	0.94	-	-	-

*Figures in the parenthesis are original values which were subjected to √x+1 transformation and analyzed statistically

Table 2: Yield and economics of *rabi* green gram as influenced by various herbicide combination

Treatment	Plant height (cm)	Number of pods/plant	Number of seeds/pod	100 seed weight (g)	Seed yield (kg/ha)	Net income (Rs/ha)	B:C ratio
W1	23.00	11.27	3.99	2.64	164	-16495	0.41
W2	38.47	18.00	6.96	3.21	1244	58684	3.02
W3	33.47	15.07	5.80	3.15	852	31878	2.13
W4	35.33	17.07	6.24	3.15	1069	47005	2.66
W5	36.33	17.80	6.93	3.22	1207	56819	3.01
W6	24.80	11.00	3.94	2.71	168	-18917	0.40
W7	46.87	18.80	7.07	3.30	1375	68368	3.39
W8	33.53	16.90	5.86	3.19	987	39769	2.34
W9	31.53	15.93	5.09	2.69	672	20588	1.77
W10	45.00	18.80	7.17	3.39	1430	67053	2.98
S. Em±	2.19	0.64	0.28	0.08	69	6068	0.21
CD (0.05)	6.51	1.91	0.83	0.25	205	18025	0.63

Conclusion

To maintain the field weed free, manual weeding is laborious and costlier. So, application of imazethapyr 10% SL + quizalofop ethyl 5% EC (tank mix) @ 125 g a.i ha-1 as PoE at 20 DAS and pendimethalin 30% EC + imazethapyr 2% EC combination @ 960 g a.i ha-1 at PE (W2) have proved to be effective in controlling the weeds together with higher yields and net returns in rabi green gram.

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