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Bioefficacy evaluation of new generation post emergence herbicides in Urdbean in vertisols under South Eastern Rajasthan

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Abstract
An experiment was conducted at Agricultural Research Station, Ummedganj, Kota, during kharif 2020 to investigate the bio-efficacy evaluation of new generation post emergence herbicides on urdbean. The result revealed that among herbicides the maximum and significantly higher growth characters, yield attributes and yield of urdbean was recorded with the application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha followed by Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha and Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha over rest of herbicidal treatments. Similarly, minimum weed density, weed dry matter and weed control efficiency was also recorded under application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha closely followed by Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha, Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha.

Keywords: Urdbean, propaquizafop, imazethapyr, fomesafen, fluazifop-p-butyl

Introduction
Urdbean [*Vigna mungo* (L.) Hepper] is one of the important pulse crop cultivated worldwide in tropical and subtropical regions of the world. This is resistant to adverse climatic conditions and improves the soil fertility by fixing atmospheric nitrogen in the soil. It can be grown round the year in different agro-ecological regions of the country. Urdbean contains 48.0% carbohydrates, 22.3% protein, 154 mg calcium, 9.1 mg iron, 1.4 g fat, 0.37 g riboflavin and 0.42 mg thiamine in per 100 gm (Asaduzzaman *et al*., 2010) [1]. It is mainly consumed in the form of "dal" (whole or split, husked and un-husked) or perched and in a variety of ways across from north to south in preparation of different regular and popular dishes like *vada, idle, dosa, halwa, imarti* in combination with other food grains. Urdbean differs from other pulses in its peculiarity of attaining a mucilaginous pasty character when soaked in water. Amongst other agronomic factors known to augment crop production, appropriate weed control is considered to be as one of the most important factors. It is mainly cultivated in marginal and rain fed areas generally during *Kharif* where inadequate weed management is a major constraint in harnessing its production potential. Being a rainy season crop, it suffers seriously due to severe competition by diverse weed flora. Uncontrolled weeds have been reported to cause a considerable reduction in the grain yield of urdbean, which in case of summer and *kharif* could be 41.2 and 41.6 per cent, respectively (Singh, 2011) [5]. Although weeds pose problem during entire crop growth period, however initial one month of the crop is especially critical (Kumar *et al.*, 1996) [3].

Materials and Methods
An experiment was conducted at Agricultural Research Station, Ummedganj, Kota, during *kharif* 2020 to investigate the Bio-efficacy evaluation of new generation post emergence herbicides in Urdbean in vertisols under South-Eastern Rajasthan. The soil of the experimental field was clay loam in texture, low in organic carbon and medium in available nitrogen & phosphorus and high in potassium, with a pH that was slightly alkaline.
The total eight treatments *viz.*, weedy check, weed free check, two hand weeding at 20 and 40 DAS, imazethapyr 10% SL @ 55g a.i./ha, fluazifop-p-butyl 13.4% w/w @ 250 g/ha, propaquizafop 2.5% w/w @ 33.3 g a.i./ha + imazethapyr 3.75% w/w ME @ 50 g/ha,

acifluorfen-sodium 16.5% EC @ 140 g a.i. /ha + clodinafop-propargyl 8% EC @ 70 g/ha fomesafen 11.1% w/w @ 220 g a.i./ha + fluazifop-p-butyl 11.1% w/w @ 220 g a.i./ha were evaluated in randomize block design with three replications. The urdbean variety Kota Urd 3 (KPU 524-65) was sown on first fortnight of July. The recommended dose of fertilizers (N, P, and K) was applied as a basal dose of 20:40:00 kg/ha. The seeds were sown with 20 kg/ha at 30 x 10 cm spacing. The herbicides were applied at 20 days after sowing with knap-sack sprayer equipped with a flat-fan nozzle.

Weed density was recorded by using 1.0 m^2 quadrat at 30, 60 DAS and at harvest in all the treatments. The data on total weeds density was subjected to square root transformation $\sqrt{x+0.5}$ to normalize the distribution (Blackman and Roberts 1950). Weed control efficiency was calculated at 30, 60 DAS and at harvest in each treatment on the basis of dry weight of weeds based on adopted formula by Umrani and Boi, 1982 [7].

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} \times 100$$

Where

DMC = Dry matter yield of weeds in weedy check plot

DMT = Dry matter yield of weeds in treated plot

Growth parameters like plant height, branches/plant, pods/plant, seeds/pod, test weight was recorded at harvest. Net returns were calculated using current input and output prices during the crop season. The benefit-cost ratio was calculated by dividing net returns from the cost of cultivation. The data was analyzed using standard ANOVA for randomized block design and the significance of differences in treatment means was compared to critical differences at the 5% level of probability.

Results and Discussion

Effect on crop

Data (Table 1) revealed that maximum and significantly higher number of branches/plant (6.53) and pods/plant (24.37) were recorded under weed free check it was closely followed by two hand weeding. Among the various herbicidal treatments, Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS recorded maximum and significantly higher pods/plant (22.78) being at par with Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS and Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS, respectively over rest of herbicidal treatments. Data further revealed that weed free check recorded maximum and significantly higher grain yield (869 kg/ha) it recorded at par results with two hand weeding, Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS, over rest of treatments with 154, 150 and 123 per cent increase over weedy check, respectively (Table 2). Maximum and significantly higher net returns (Rs 22306/ha) was recorded with the application of Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS being at par with Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS, Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS, weed free check and two hand weeding over rest of treatments. No phytotoxicity effect on the crop was observed by application of herbicides (Table 2). This could be owing to better weed management and minimizing the competition of weeds with crop for resources, *viz.* light, nutrients and moisture with effective weed control treatments. Thus, reduced crop-weed competition resulted into overall improvement of crop growth as measured by plant height and dry matter accumulation, which led to better reproductive structure and translocation of photosynthates to the sink. The results also corroborated with the findings of Yadav *et al.* (2014) [8]. The reduced crop weed competition, with hand weeding twice and all herbicidal weed control methods, resulted in a considerable increase in growth and yield characters ultimately led to higher grain yield of urdbean. In a weedy condition, weeds take a bigger portion of the resources available in the soil and environment for their growth during the early stages of crop growth (Tiwari *et al.*, 2018 and Harisha *et al.*, 2021) [6, 9].

Table 1: Effect of weed management practices on growth and yield attributes of Urdbean

Treatments	Plant stand/m^2 at harvest	Plant height (cm) at harvest	Total Branches/ Plant (Nos)	Pods/ plant (Nos)	Seeds /pod (Nos)	100 seed weight (g)
Unweeded check	29.50	32.80	3.39	15.90	5.63	4.59
Weed free check	35.80	31.53	6.53	24.37	6.63	4.68
Two hand weeding at 20 and 40 DAS	34.80	31.40	6.40	23.97	6.29	4.51
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	33.53	31.60	4.69	18.80	6.07	4.82
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	32.53	31.47	4.63	19.93	6.17	4.77
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	33.90	30.47	6.03	22.38	6.69	4.50
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	33.50	30.43	5.93	21.33	6.53	4.50
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	34.80	30.18	6.20	22.78	6.72	4.93
SEm ±	1.62	1.33	0.34	0.52	0.23	0.14
CD (P=0.05)	NS	NS	1.03	1.58	NS	NS
CV (%)	8.39	7.37	10.75	4.27	6.25	5.36

Table 2: Effect of weed management practices on yield and economics of Urdbean

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net return (Rs./ha)	B: C ratio
Unweeded check	341	441	783	44.17	366	0.02
Weed free check	869	1413	2282	38.09	19246	0.58
Two hand weeding at 20 and 40 DAS	853	1387	2239	38.07	18246	0.55
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	551	901	1452	37.96	10266	0.45
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	545	891	1437	37.95	8356	0.34
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	752	1135	1887	39.86	22306	0.98
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	695	1225	1920	36.19	19106	0.84
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	762	1240	2001	38.05	21386	0.88
SEm ±	37	59	95	1.22	2249	0.09
CD (P=0.05)	114	179	287	3.71	6823	0.28
CV (%)	9.68	9.49	9.38	5.46	26.13	27.73

Sale price of urdbean @ 6000/quintal

Table 3: Effect of weed management practices on weed density and weed dry matter at different growth stages of Urdbean

Treatments	Weed density (Nos/1.0 m^2)			Weed dry matter (g/1.0 m^2)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Unweeded check	16.67 (277.77)	18.65 (347.50)	15.35 (235.21)	132.88	175.55	96.34
Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.00	0.00	0.00
Two hand weeding at 20 and 40 DAS	3.10 (9.13)	4.44 (19.27)	3.14 (9.47)	5.34	24.65	9.69
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	9.02 (81.45)	12.67 (161.31)	9.60 (93.25)	44.54	85.26	37.82
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	9.23 (84.84)	11.48 (131.24)	10.13 (102.13)	38.34	76.41	35.31
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	7.30 (52.84)	7.95 (62.74)	6.32 (39.50)	21.24	44.88	22.05
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	7.70 (58.84)	8.42 (70.48)	5.86 (35.29)	24.30	50.26	22.66
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	6.63 (44.17)	7.60 (57.94)	5.42 (30.30)	16.57	39.83	20.97
SEm ±	0.32	0.41	0.58	2.60	3.47	1.32
CD (P=0.05)	0.98	1.24	1.75	7.88	10.53	4.01
CV (%)	7.44	7.86	14.18	12.71	9.68	7.49

*Square root transformed values. Figures in parenthesis are original values

Table 4: Effect of weed management practices on weed control efficiency (%) at different growth stages of Urdbean

Treatments	Weed control efficiency (%)		
	30 DAS	60 DAS	Harvest
Unweeded check	0.00	0.00	0.00
Weed free check	100.00	100.00	100.00
Two hand weeding at 20 and 40 DAS	95.99	85.85	89.93
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	66.61	51.24	60.64
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	71.15	56.34	63.30
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	83.99	74.27	77.07
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	81.71	71.31	76.46
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	87.43	77.39	78.28
SEm ±	1.47	1.73	1.25
CD (P=0.05)	4.46	5.23	3.79
CV (%)	3.48	4.63	3.17

Effect on weeds

The common weeds at experimental site were *Parthenium hysterophorus, Digera arvensis, Trianthema spp., Celosia argentea, Cyperus rotundus Cynodon dactylon, Echinochloa crus-galli, Eleusine indica* and *Commelina bengalensis* etc. Minimum and significantly lower weed count and weed dry matter was recorded with weed free check followed by two hand weeding. Among herbicides, application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS recorded minimum and significantly lower weed count at 30, 60 DAS and at harvest being at par with Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS and Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS over rest of herbicides treatments (Table 3).

Similarly, maximum weed control efficiency was also recorded in weed free check followed by two hand weeding at 20 and 40 DAS. Among herbicidal treatments, maximum and significantly higher weed control efficiency was recorded with application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS recorded being at par with Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS over rest of herbicidal treatments. The weed population (species as well as density) was not uniform in the experimental field (Table 4).

The application of fomesafen 11.1% w/w @ 220 g/ha +

fluazifop-p-butyl 11.1% w/w @ 220 g/ha (pre-mix) at 20 DAS and acifluorfen-sodium 16.5% EC @ 140 g/ha + clodinafop-propargyl 8% EC @ 70 g/ha (pre-mix) at 20 DAS was found effective in controlling weeds and dry matters as these species are naturally susceptible to this group of herbicides because inactivation of the protopohyrinogen oxidase and Acetyl-CoA carboxylase activity. Therefore, susceptible weeds become bronzing, desiccation, chlorosis and necrosis. Imazethapyr inhibits the plastid enzyme acetolactate synthase (ALS) in plants which catalyses the first step in the biosynthesis of vital branched chain amino acids (Valine, leucine, and isoleucine). The ALS inhibitors thus limit cell division and reduce carbohydrate transport in the vulnerable plants (Das, 2008) [10]. Imazethapyr was also recommended for usage in legumes by Papiernik *et al*. (2003) [4].

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