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Effective weed management for profitable Mungbean [*Vigna radiata* (L.) Hepper] production in rainy season in South Eastern Rajasthan

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Abstract
In an experiment at Agricultural Research Station, Ummedganj, Kota, during *kharif* 2020 to find the effective weed management for profitable Mungbean [*Vigna radiata* (L.) Hepper] production in rainy season in South Eastern Rajasthan. Application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha recorded maximum and significantly higher growth characters, yield attributes and yield of mungbean among herbicides 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 due to 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: Mungbean, fomesafen, fluazifop-p-butyl, clodinafop-propargyl, propaquizafop

Introduction
Mungbean is an important *kharif* pulse crop of Rajasthan for rainfed conditions. In *kharif* season, weeds cause great losses than either insects or diseases. Weeds compete for water, nutrients and space and cause up to 45 percent loss in mungbean. Intermittent rains, unavailability of timely labour during rainy season has caused the problem of weed competition in crops up to 30-40 days after sowing (DAS), being the critical period for crop weed competition. It is imperative to develop cheaper methods of weed control with effective herbicides helps in reducing the weed population without much adverse effect on the crop productivity.

Materials and Methods
The field experiment was conducted during *kharif* 2020 at Agricultural Research Station, Ummedganj, Kota, Agriculture University, Kota, Rajasthan to investigate the effect of various herbicides in controlling weeds in mungbean. The soil of the experimental field was clay loam in texture, low in organic carbon and available nitrogen, medium in phosphorus and high in potassium, with a pH that was slightly alkaline.
The experiment was laid out in randomize block design and with three replications with eight treatments *viz*., weedy check, weed free check, two hand weeding at 20 and 40 DAS, imazethapyr 10% SL @ 55g/ha, fluazifop-p-butyl 13.4% w/w @ 250 g/ha, propaquizafop 2.5% w/w @ 33.3 g/ha + imazethapyr 3.75% w/w ME @ 50 g/ha, acifluorfen-sodium 16.5% EC @ 140 g/ha + clodinafop-propargyl 8% EC @ 70 g/ha, fomesafen 11.1% w/w @ 220 g/ha + fluazifop-p-butyl 11.1% w/w @ 220 g/ha. The experiment was laid out in randomize block design and replicated thrice. The mungbean, variety IPM 02-03 was sown on 10th of July. The fertilizer dose of N, P, and K was applied as a basal dose of 20:40:00 kg ha^{-1}. The seeds were sown @ 20 kg ha^{-1} 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 0.5 m^2 quadrat at 30, 60 DAS and at harvest in all the treatments and then converted into number of weeds per m^2. The data on total weeds density was subjected to square root transformation $\sqrt{x+0.5}$ to normalize the distribution (Blackman and Roberts 1950) [1]. 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 [2].

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

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

Result revealed that maximum and significantly higher number of branches/plant (3.64), pods/plant (41.87) and seeds/pod (12.04) was recorded under weed free check closely 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 maximum and significantly higher pods/plant (36.29) 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 (Table 1).

Weed free check recorded maximum and significantly higher grain yield (904 kg/ha) being at par with two hand weeding, Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS, 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 treatments with 160, 158, 145, 132 and 115 percent increase over weedy check, respectively (Table 2). Maximum and significantly higher net returns (Rs 36784/ha) was recorded with the application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS being at par with Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 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 with 686, 647, 561, 582 and 569 percent increase over weedy check. 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 main crop for resources, *viz*. light, nutrients and moisture with those 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 corroborated with the findings of Yadav *et al.* (2014) [6]. 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 mungbean. 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) [5, 8].

Effect on weeds

The common weeds at the experimental site were *Cynodon dactylon*, *Echinochloa crus-galli*, *Eleusine indica*, *Commelina bengalensis*, *Parthenium hysterophorus*, *Digera arvensis*, *Trianthema spp.*, *Celosia argentea*, *Cyperus rotundus*. Result revealed that 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 herbicides application of Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS recorded maximum and significantly higher weed control efficiency 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. 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, isoleucine). The ALS inhibitors thus limit cell division and reduce carbohydrate transport in the vulnerable plants (Das 2008). Imazethapyr was also recommended for usage in legumes by Papiernik *et al*. (2003) [4].

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

Treatments	Plant stand/m^2 at harvest	Plant height (cm) at harvest	Total Branches/ Plant (Nos)	Pods/ plant (Nos)	Seeds/pod (Nos)	Test weight (g)
Unweeded check	27.20	57.33	1.82	16.59	8.99	3.09
Weed free check	30.93	55.10	3.64	41.87	12.04	3.32
Two hand weeding at 20 and 40 DAS	31.27	50.03	3.26	40.18	10.88	3.31
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	31.27	53.87	2.74	25.67	11.56	3.21
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	31.60	54.13	2.95	27.75	11.51	3.20
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	31.93	53.00	3.16	35.89	11.81	3.29
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	30.93	53.00	3.06	33.50	11.30	3.29
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	31.27	52.17	3.16	36.29	11.99	3.22
SEm ±	1.19	2.36	0.18	1.60	0.37	0.05
CD (P=0.05)	NS	NS	0.54	4.86	1.13	NS
CV (%)	6.68	7.64	10.33	8.61	5.73	2.59

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

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Net return (Rs./ha)	B: C ratio
Unweeded check	347	530	877	39.59	4680	0.23
Weed free check	904	1448	2352	38.43	31923	0.96
Two hand weeding at 20 and 40 DAS	895	1434	2329	38.44	31300	0.95
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	625	988	1613	38.74	21965	0.95
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	673	1067	1740	38.67	23865	0.97
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	806	1261	2067	38.98	34967	1.52
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	747	1165	1912	39.08	30940	1.36
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	852	1338	2189	38.92	36784	1.50
SEm ±	40	66	105	0.05	2860	0.11
CD (P=0.05)	121	199	319	0.16	8674	0.32
CV (%)	9.41	9.84	9.68	0.24	18.31	17.55

Sale price of mungbean @ 7196/quintal

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

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	15.55* (241.40)	18.14 (328.85)	14.51 (210.16)	126.10	166.58	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	3.70 (13.33)	3.97 (15.33)	3.28 (10.60)	7.33	20.86	9.48
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	9.58 (92.00)	11.94 (143.33)	8.75 (77.26)	46.53	78.87	37.82
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	9.00 (80.67)	10.66 (113.27)	8.83 (77.49)	40.33	66.38	37.17
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	7.01 (48.67)	8.31 (68.74)	6.77 (45.33)	23.23	49.78	21.31
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	7.43 (54.67)	8.77 (76.48)	6.44 (41.91)	26.30	53.40	22.44
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	6.30 (40.00)	7.91 (62.67)	6.46 (41.60)	18.57	46.95	20.23
SEm ±	0.37	0.40	0.45	2.60	2.48	1.37
CD (P=0.05)	1.11	1.22	1.38	7.88	7.53	4.14
CV (%)	8.56	7.90	11.31	12.48	7.13	7.73

*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 mungbean

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	94.19	87.51	90.15
Imazethapyr 10% SL @ 55 g/ha at 20 DAS	63.23	52.55	60.64
Fluazifop-p-butyl 13.4% w/w @ 250 g/ha (Ready mix) at 20 DAS	68.01	60.09	61.44
Propaquizafop 2.5% @ 33.3 g/ha + Imazethapyr 3.75% ME @ 50 g/ha (Ready mix) at 20 DAS	81.54	70.03	77.84
Acifluorfen-sodium 16.5% EC @ 140 g/ha + Clodinafop-propargyl 8% EC @ 70 g/ha (Ready mix) at 20 DAS	79.14	67.90	76.68
Fomesafen 11.1% @ 220 g/ha + Fluazifop-p-butyl 11.1% @ 220 g/ha (Ready mix) at 20 DAS	85.16	71.89	79.05
SEm ±	1.55	1.37	1.27
CD (P=0.05)	4.69	4.17	3.84
CV (%)	3.75	3.73	3.21

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