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Bio efficacy of pre and post emergent herbicides on nutrient content, depletion by weeds and Economics of Urdbean (*Vigna mungo* (L.) Hepper)

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Abstract
During the *Kharif* season of 2020, a field study was under taken at the College of Agriculture, AU, Kota, Rajasthan, to investigate the nutrient depletion by weeds and economic parameters of various weed management strategies, including alone and ready-mix herbicides in urdbean [*Vigna mungo* (L.) Hepper]. Two hand weeding at 20 and 40 DAS reduced the nutrient depletion and weed dry matter significantly as compared to weedy check and was almost at par pendimethalin 30% EC @ 1 kg ha^{-1}(PE) propaquizafop fb 2.5%w w^{-1}@ 33.3 g ha^{-1}+ imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS. The two hand weeding at 20 and 40 DAS showed its superiority and reflected in net return ₹ 16030 ha^{-1} and B-C ratio 0.49. Among herbicide management practices, the treatment pendimethalin 30% EC @ 1 kg ha^{-1}(PE) propaquizafop fb 2.5%w w^{-1}@ 33.3 g ha^{-1}+ imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS significantly recorded lowest weed dry matter at harvest and nutrient depletion by weeds, as well as the highest net return and B:C ratio among herbicidal weed control treatments.

Keywords: Urdbean, weed, two hand weeding, nutrient depletion

Introduction
Due to the abundant rainfall received during the monsoons, urdbean is usually accompanied by luxuriant weed growth during the *kharif* season, resulting in significant crop losses. Because the crop is not a good weed competitor (Choudhary *et al*., 2012) [4], weed control initiatives are critical to ensuring proper crop growth, particularly during the early growth period. Weeds can reduce urdbean grain yield by 41.6 to 64.1 per cent depending on their nature, density, and time of occurrence (Singh, 2011) [1]. Urdbean is known as the "King of Pulses" and is one of the most important pulse crops grown in India. Urdbean is a high-protein pulse crop with a protein content of 26%, nearly three times that of cereals. The total pulse production was 22.95 million tonnes from 29.46 million ha area, majority of which fall under rainfed, resource poor and harsh environments frequently prone to drought and other abiotic stress conditions reported by Project Coordenator Report 2016-17.

India at present is importing about 6609.49 thousand tonnes of pulses from other countries to fulfill the domestic needs (Directorate of Economics and Statistics, 2017) [5]. The per capita availability of pulses is 54.4 g $capita^{-1}day^{-1}$ in 2017 (Directorate of Economics and Statistics, 2017) [5] against the requirement of 80 g $capita^{-1}day^{-1}$ as per Indian Council of Medical Research (ICMR) to fulfill the nutritional requirements of an individual (Dietary guidelines for Indians a manual, 2011) [6]. Among the pulses, urdbean is the third most important, accounting for 17% of global production. It is grown throughout India, accounting for 13% of total area and 10% of total pulse production. India produced 3.56 million tonnes of urdbean from 5.44 million hectares of area, with an average productivity of 655 kg/ha. Urdbean requires weed-free conditions for up to 40 – 45 days; however, due to poor weed management practises, urdbean yield is drastically reduced. The critical period of crop-weed competition in urdbean usually occurs between 15 and 45 days after sowing DAS (Vivek *et al*., 2008) [2], and labour is frequently unavailable, especially when the critical period of crop weed completion occurs. Furthermore, monsoon rains make hand weeding impossible due to excess moisture and wet field conditions. In these cases, pre- and post-emergence herbicides provide an alternative for effective weed management in urdbean. The current study was undertaken to find out effective herbicide combinations in rainfed urdbean for performing good weed management and realising potential yields in order to broaden the spectrum of weed control.

Material and Methods

The field experiment was carried out during the *Kharif* season of 2020 at the College of Agriculture, Ummedganj (Kota), Agriculture University, Kota, (Rajasthan), India, to investigate the effect of various herbicides on urdbean. The soil in 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 a randomized block design with ten treatments including pendimethalin 30% EC 1.0 kg ha^{-1} as pre-emergence, and propaquizafop 2.5% w/w 33.3 g ha^{-1} + imazethapyr 3.75% w/w me 50 g ha^{-1} (ready mix), acifluorfen-sodium 16.5% ec 140 g ha^{-1} + clodinafop-propargyl 8% ec 70 g ha^{-1} (ready mix), fomesafen 11.1% w/w 220 g ha^{-1} + fluazifop-p-butyl 11.1% w/w 220 g ha^{-1} (ready mix) and fluazifop-p-butyl 13.4% w/w @ 250 g ha^{-1} as post emergence along and followed by pendimethalin 1.0 kg ha^{-1} with weedy and two hand weeding at 20 and 40 DAS with three replications. Urdbean, *cv*. Mukundra Urd-2 was sown in mid-July. The fertiliser dose of N, P, and K was applied as a basal dose of 20:40:00 kg ha^{-1} and thoroughly mixed with the soil. The seeds were planted at a rate of 40 kg ha^{-1} in furrows with 30 x 10 cm spacing and a depth of 4cm. In 600 L of water/ha, foliar herbicides were sprayed with a knap-sack sprayer equipped with a flat-fan nozzle. Weed nutrient depletion was calculated using the formula provided at the harvest stage. The N, P, and K content of weed dry matter was determined using standard methods and representative samples of weed dry matter collected from each plot at the harvest stage.

$$\text{N/P/K depletion (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%) x Weed dry matter (kg/}ha^{-1})}{100}$$

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 cultivation costs. The data was analysed using standard ANOVA for randomised block design, and the significance of differences in treatment means was compared to critical differences at the 5% level of probability.

Results and Discussion

Nutrient Depletion

A perusal of data revealed that maximum depletion of 17.47, 10.17 and 11.87 kg N, P and K ha^{-1} respectively by weeds at harvest was reported in weedy check plot, it was significantly higher over other treatments (Table 1 and Figure 2). Whereas, the lowest depletion of 1.83, 0.95 and 1.12 kg N, P and K ha^{-1}, respectively were observed with two hand weeding at 20 and 40 DAS that was closely followed by of pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS and pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb fomesafen 11.1% w w^{-1} @ 220 g ha^{-1} + fluazifop-p-butyl 11.1% w w^{-1} @ 220 g ha^{-1} (pre mix) at 20 DAS. The drastic decrease in nutrient depletion by weeds noted under these treatments might be directly related with the consistent reduction in weedy dry matter by weeds due to effective weed control and destruction of weed growth by crop. The above treatments curbed the weeds completely and provide the favourable condition for crop growth and ultimately reduced the weed density of later emergence stage and their lower weed dry matter accumulation during crop growth period resulted in to reduced nutrient depletion by weeds. It can further be substantiated by strong positive correlation values between N (r = 0.438), P (r = 0.456) and K (r = 0.406) depletion by weeds and weed dry matter at harvest (Figure 1). Reduced nutrient depletion by weeds under different weed management practices have also been reported by (Bhimwal *et al.,* 2018) [3] and (Poornima *et al.,* 2018) [9].

Weed dry matter accumulation

The data reveal that the minimum weed dry matter accumulation at harvest (Table 1) was obtained under the treatment two hand weeding at 20 and 40 DAS (9.44 kg ha^{-1}), which was closely followed by treatment pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1}. While, maximum weed dry matter accumulation was under weedy check (27.39 kg ha^{-1}). Data presented in same table further reveal that among the herbicides applied, pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS resulted in the minimum weed dry matter accumulation (14.30 kg ha^{-1}) which was closely followed by treatment of pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb fomesafen 11.1% w w^{-1} @ 220 g ha^{-1} + fluazifop-p-butyl 11.1% w w^{-1} @ 220 g ha^{-1} (pre mix) at 20 DAS (14.60 kg ha^{-1}).

Economics

All the measure adopted for weed management in urdbean fetched significantly higher net return and B: C ratio than weedy check (Table 2, Figure 3,4). Applicaion of pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS provided the maximum net return of ₹ 21171 ha^{-1} with B-C ratio of 0.81. Whereas, pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb fomesafen 11.1% w w^{-1} @ 220 g ha^{-1} + fluazifop-p-butyl 11.1% w w^{-1} @ 220 g ha^{-1} (pre mix) at 20 DAS obsreved to be next superior treatments that enhanced the net return by magnitude of ₹ 16723 ha^{-1} with corresponding B-C ratio of 0.61. The per cent increase in net returns due to application of pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre mix) ME @ 50 g ha^{-1} at 20 DAS was 26.60 and 32.07 respectively over with pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb fomesafen 11.1% w w^{-1} @ 220 g ha^{-1} + fluazifop-p-butyl 11.1% w w^{-1} @ 220 g ha^{-1} (pre mix) at 20 DAS and two hand weeding at 20 and 40 DAS. Results of the present investigation corroborate the finding of (Panda *et al*., 2015) [8]; (Bhimwal *et al*., 2018) [3] and (Sandil *et al*., 2015) [10].

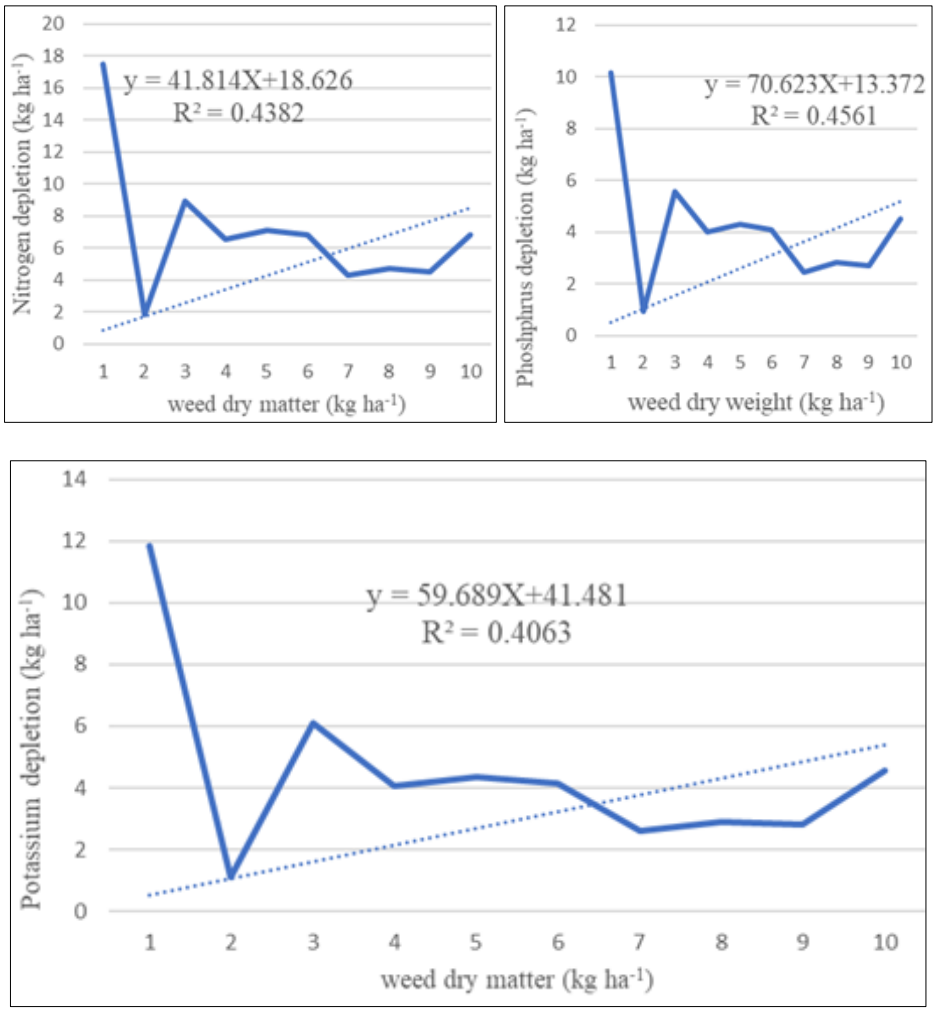

Fig 1: Effect of herbicides on weed dry matter and nutrient depletion by weeds

Table 1: Effect of herbicide on nitrogen, phosphorus and potassium content in weed, nutrient depletion by weeds

Treatment	Nutrient content (%)			Nutrient depletion (Kg ha^{-1})			Weed dry matter accumulation (kg ha^{-1})
	N	P	K	N	P	K	
Weedy check	2.33	1.33	1.56	17.47	10.17	11.87	749.85 (27.39)
Two hand weeding at 20 and 40 DAS	2.07	1.07	1.27	1.83	0.95	1.12	88.73 (9.44)
Pendimethalin 1 kg ha^{-1} (PE)	2.29	1.41	1.55	8.90	5.58	6.12	389.96 (19.76)
Propa 33.3 g ha^{-1} + imaz 50 g ha^{-1} at 20 DAS	2.23	1.34	1.35	6.58	4.02	4.04	294.85 (17.18)
Aciflu-Na 140 g ha^{-1} + clodi prop 70 g ha^{-1} at 20 DAS	2.27	1.38	1.40	7.09	4.31	4.37	312.70 (17.70)
Fomes 220 g ha^{-1} + fluazi 220 g ha^{-1} at 20 DAS	2.25	1.35	1.37	6.85	4.10	4.15	304.29 (17.46)
Pendi fb propa 33.3 g ha^{-1} + imaz 50 g ha^{-1} at 20 DAS	2.10	1.20	1.28	4.28	2.47	2.62	203.98 (14.30)
Pendi fb aciflu-Na 140 g ha^{-1} + clodi prop 70 g ha^{-1} at 20 DAS	2.15	1.29	1.32	4.72	2.84	2.91	219.80 (14.84)
Pendi fb fomes 220 g ha^{-1} + fluazi 220 g ha^{-1} at 20 DAS	2.12	1.25	1.30	4.51	2.71	2.81	212.70 (14.60)
Fluazi 250 g ha^{-1} at 20 DAS	2.30	1.39	1.41	6.86	4.50	4.56	298.33 (17.28)
SEm+	0.09	0.07	0.10	0.29	0.18	0.26	7.16
CD (P=0.05)	NS	NS	NS	0.86	0.54	0.77	21.26
CV (%)	7.33	9.78	12.82	7.30	7.53	10.02	4.03

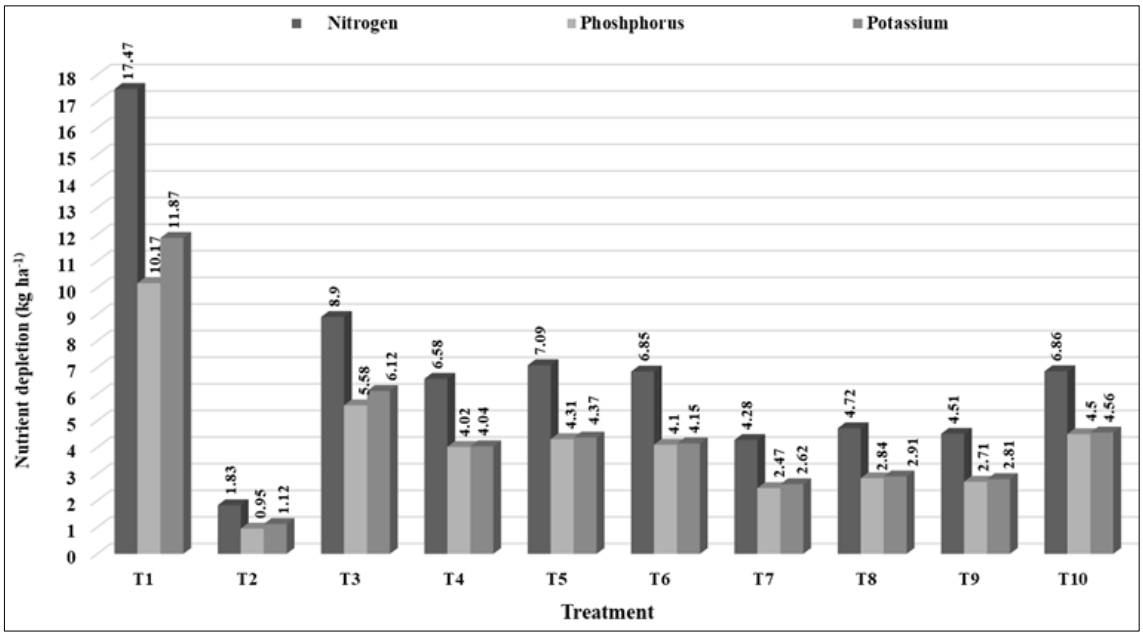

Fig 2: Effect of herbicide on nutrient depletion (kg ha^{-1}) by weeds

Table 2: Effect of herbicides on economics of urdbean

Treatments	Net return (₹ ha^{-1})	B-C ratio
Weedy check	2401	0.12
Two hand weeding at 20 and 40 DAS	16030	0.49
Pendimethalin 1 kg ha^{-1} (PE)	5388	0.23
Propa 33.3 g ha^{-1} + imaz 50 g ha^{-1} at 20 DAS	13088	0.57
Aciflu-Na 140 g ha^{-1} + clodi prop 70 g ha^{-1} at 20 DAS	9610	0.42
Fomes 220 g ha^{-1} + fluazi 220 g ha^{-1} at 20 DAS	10433	0.43
Pendi fb propa 33.3 g ha^{-1} + imaz 50 g ha^{-1} at 20 DAS	21171	0.81
Pendi fb aciflu-Na 140 g ha^{-1} + clodi prop 70 g ha^{-1} at 20 DAS	11917	0.46
Pendi fb fomes 220 g ha^{-1} + fluazi 220 g ha^{-1} at 20 DAS	16723	0.61
Fluazi 250 g ha^{-1} at 20 DAS	3186	0.13
SEm+	1825	0.08
CD (P=0.05)	5422	0.23
CV (%)	8.75	10.86

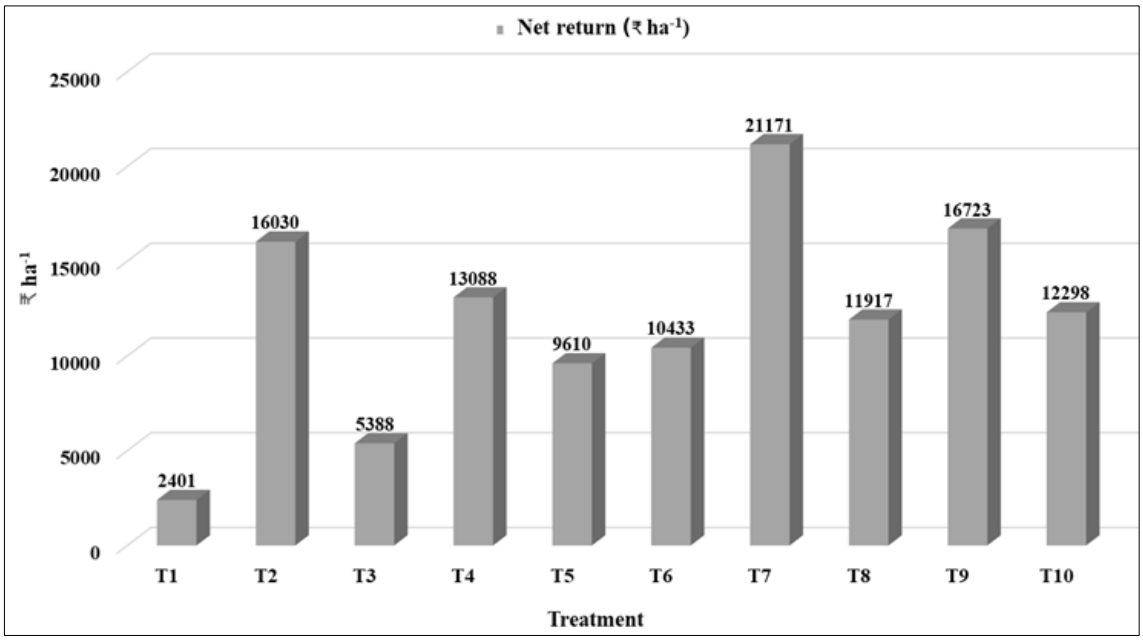

Fig 3: Effect of herbicides on net return (₹ ha^{-1})

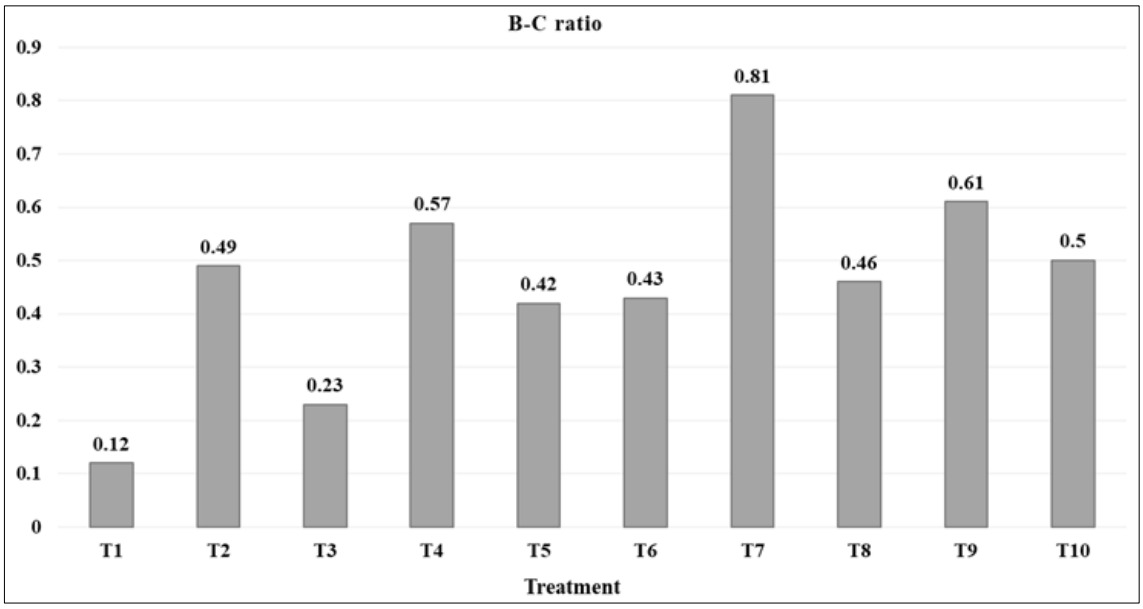

Fig 4: Effect of herbicides on B-C ratio

Conclusion

On the basis of present experiment, it may be concluded that two hand weeding at 20 and 40 DAS results in realization of significantly reduced N, P, K nutrient depletion and weed dry matter by 11.15, 19.54, 18.83 and 65.53 per cent over weedy check, respectively. However, on the basis of B-C ratio and net profit, application of pendimethalin 30% EC @ 1 kg ha^{-1} (PE) fb propaquizafop 2.5% w w^{-1} @ 33.3 g ha^{-1} + imazethapyr 3.75% w w^{-1} (pre-mix) ME @ 50 g ha^{-1} at 20 DAS proved best treatment among herbicides and gave maximum net return of ₹ 21171 ha^{-1} with B-C ratio of 0.81.

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