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Standardization of different ready and tank mixed herbicides on weed management in Urdbean (*Vigna mungo* L.)

Shubham Kushwaha, Naveen Kumar Maurya, Ravikesh Kumar Pal, Vineet Dheer, Rajat Yadav and Mahendra Yadav

Abstract
An experiment comprising 8 treatments *viz*., Imazethapyr 70 g ha^{-1} PRE, Imazethapyr 70 g ha^{-1} POE (3-4 leaf weeds stage), Imazethapyr + imazamox (RM) 70 g ha^{-1} POE (3-4 leaf weeds stage), Imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage), Pendimethalin 1000 g ha^{-1} PRE, Imazethapyr + Pendimethalin (RM) 1000 g ha^{-1} PRE, Topramezone 25.80 g ha^{-1} as POE (3-4 leaf weeds stage) and - Hoeing (20 & 40 DAS) along with weedy check were subjected in randomized block design with 3 replications at Research Farm of the University in Urdbean cv. Shekhar 2 during *Kharif* 2022. A wide spectrum of weed flora *viz*., *Echinochloa colona*, *Cynodon dactylon*, *Solanum nigrum*, *Trinthema monogyna*, *Celosia argentea*, *Cyperus rotundus*, *Digera arvensis*, *Phyllanthus niruri*, and *Commelina benghalensis* were observed. The application of pendimethalin 1000 g ha^{-1} (pre emergence) and imazethapyr 70 g ha^{-1} (post emergence at 3-4 leafy stage of weeds) was found to be most effective for minimizing weed density and maximizing its weed control efficiency, yield and its contributing traits. Thus, the combination of these both as pre emergence (Pendimethalin1000 g ha^{-1}) and post emergence (Imazethapyr 70 g ha^{-1}) could be exploited in order to harvest the maximum grain yield (12.48 q ha-1), revenue generation (net return Rs.57586 ha-1) and B: C ratio (2.04) in Urdbean cultivation during *Kharif* season.

Keywords: Urdbean, pre emergence, post emergence, herbicides, weed management

Introduction
Urdbean (*Vigna mungo*), being a major short-duration pulse crop, is grown in tropical and sub-tropical parts of the world. It is mainly cultivated as Khairf, ofnely as Rabi and summer crop where ample facility of water is available. This crop is grown as a sequential crop, catch crop, mixed crop, or sole crop when there is still moisture after rice is harvested and before and after other summer crops are harvested in varied conditions. Seeds are rich in minerals, vitamins, carbohydrates, and protein (25–26%). Urdbean is cultivated in about 4.6 million hectare acreage with a total yield of 24.5 lakh tonnes and productivity of 533 kg/ha (Agricoop.nic.in, 2020-21). However, the extremely low productivity of Urdbean in India, with particular emphasis on Uttar Pradesh, may be attributed due to a varieties of biotic and abiotic causes. One of the most significant causes of concern is the infestation of crops by weeds. In fields of Urdbean, there is a significant increase in the number of weeds. It is the grassy weeds that have the potential to do the most damage, followed closely by the sedges and the BLWS. In addition to directly competing with the crop, the weeds also provide a safe haven for a large number of its pests and pathogens. The most vulnerable time for crop weed competition is between 15 and 45 days after sowing. Weeds are controlled by using a variety of techniques, including cultural, mechanical, biological, and chemical ones (Fand *et al*., 2013) [6]. However Randhawa *et al.* (2002) [15] noted that in some cases this might be 25–35 days after sowing. Weeds can cause up to 50% to 60% of the total damage. To increase the yield of Urdbean, weeds must be removed at the right time and with the right technique. Hand weeding can be used to control weeds (Chand *et al*., 2004) [2], but it is time-consuming, expensive, tedious, and labour-intensive (Dheer and Yadav, 2021) [3]. Additionally, labourers frequently are not accessible during the crucial period of crop-weed competition. Chemical herbicides have thus been investigated as an alternative and are now advised for use in Urdbean to control weeds. The use of pendimethalin and fluchloralin, two herbicides that were proven to be particularly efficient at controlling weeds, is widespread.

Due to the pre-emergence application of both of these herbicides, weeds that later developed produced problems for the crop. Some new generation herbicides, such as imazamox and imazethapyr, have been tested on a variety of pulse crops with compelling results both separately and in ready-mixed combinations. With this context, an experiment was designed to standardize the application of individual and ready-mixed of imazamox and imazethapyr applied at pre and post emergence, along with previously recommended and widely used herbicides for managing the weeds in Urdbean.

Material and Methods

The present experiment comprising 8 treatments *viz*., T_1 - Imazethapyr 70 g ha^{-1} PRE, T_2 -Imazethapyr 70 g ha^{-1} POE (3-4 leaf weeds stage), T_3 -Imazethapyr + imazamox (RM) 70 g ha^{-1} POE (3-4 leaf weeds stage), T_4 -Imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage), T_5 -Pendimethalin 1000 g ha^{-1} PRE, T_6 -Imazethapyr + Pendimethalin (RM) 1000 g ha^{-1} PRE, T_7 -Topramezone 25.80 g ha^{-1} as POE (3-4 leaf weeds stage) and T_8 -Hoeing (20&40 DAS) along with weedy check were subjected in randomized block design with 3 replications at Research Farm of the University in Urdbean cv. Shekhar 2 during *Kharif* 2022 following spacing of 45 cm x 15 cm in plot size of 4.50 m x 4.00 m. The experimental site is located at latitude of about 26.57º North, a longitude of approximately 80.21 º East and an elevation of 126 m above mean sea level. The experimental soil was sandy loam in nature having 7.4 pH, 0.46 dSm^{-1} EC, 0.53 Organic Carbon, 138.2 kg ha^{-1} Available N, 14.7 kg ha^{-1} Available P_2O_5 and 225.7 kg ha^{-1} Available K_2O. Experimental field was prepared well for good germination. Fertilizers @20 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} were applied prior to sowing. Quality seed of variety Shekhar 2 was sown @15 kg ha^{-1} on July 10, 2022. Herbicides were administered by Knapsack sprayer equipped with a flat fan nozzle and 500 litres of water per hectare. Other agronomical and plant protection measures were taken time to time to raise an ideal crop. Three randomly locations were earmarked in weedy plots, and weeds were collected and documented species accordingly. Weed density was measured using a quadrate (0.5 m x 0.5 m) from three randomly selected locations in each plot. Weeds were identified, numbered and expresses in no. m^2.Weed control efficiency (WCE) was computed by using following formula:

WCE (%) =W0-W1/ W0 X 100

Where,
W0 =Weed dry weight in weedy plot
W1= Weed dry weight in treated plot

Ten random plants were selected in order to measure to ancillary characters. Grain yield was measured by adjusting to a moisture content of 12% in q/ha from net plot area of each treatment replication wise. The harvest index was determined by using Donald's (1962) as Economic yield/ Biological yield x 100. The net return was computed by taking the cultivation expenses out of the specific treatment's gross return. Further, the Benefit: cost ratio was calculated by dividing the net return by the cost of cultivating each particular treatment. Data were finally analysed following standard statistical methods.

Results and Discussion

Weed flora

The weed flora observed and documented during the study are presented in table 1. It is apparent that several weed species were perpetuated and damaged the experimental fields. Among them, the grassy ones were *Echinochloa colona* and *Cynodon dactylon.* The *Solanum nigrum*, *Trinthema monogyna*, and *Celosia argentea* were broad leafy weeds. The sedge was *Cyperus rotundus*; and the other weeds were included as *Digera arvensis*, *Phyllanthus niruri*, and *Commelina benghalensis.* Most of the weeds were annual in habitat except *Cynodon dactylon and Cyperus rotundus* which are in perennial. Present findings confirmed the reports of Chand *et al*. (2004) [2], Punia *et al*. (2009) [13] and Fand *et al*. (2013) [6].

Table 1: Weed flora of the experimental field in Urdbean

S. No.	Weed species	English Name/ Common name	Family	Habitat
A.	**Grassy weeds**			
1.	*E. colona*	Wild rice/Dhunia	Graminae	Annual
2.	*Cynodon dactylon* L.	Bermuda grass/ Doob grass	Poaceae	Perennial
B.	**Broad Leafy Weeds**			
1.	*Solanum nigrum*	Makoi	Solanaceae	Annual
2.	*Trianthema monogyna*	Horsepurslane/carpet weed	Azoaceae	Annual
3.	*Celosia argentea*	Cocks comb/Cilmili	Amaranthaceae	Annual
C.	***Sedges***			
1.	*Cyperus rotundus*	Nut sedges/ Motha	Cyperaceae	Perennial
D.	**Other weeds**			
1.	*Digera arvensis*	Lahsua	-	Annual
2.	*Phyllanthus niruri*	Hazardena	Euphorbiaceae	Annual
3.	*Commelina benghalensis*	Day flower	Euphorbiaceae	Annual
4.	*Achyranthes aspara*	Pickly chafflower/Latzira	Amaranthaceae	Annual

Weed density

It is evident that the different weed management measures had a substantial impact on the weed density of particular weed species and overall weeds (Table 2). Among the treatments, application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} PRE recorded significantly lower weed density (69.53) of all the weeds as compared to rest of the herbicides applied in alone or in combination. Reduced weed density (85.41) of different weed flora was recorded with treatment T_5 followed by treatment T_1. As the post-emergence herbicides are concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} at 3-4 leaf weed stage was recorded significantly lower weed density (79.37) of different weed species as compared to rest of the post-emergence herbicides, however,

it was at par with imazethapyr + imazamox (RM) 70 g ha^{-1}. Significantly more weed density (102.58) and (104.13) of different weed flora was recorded with the application of Topramezone 25.80 g ha^{-1} as POE (3-4 leaf weeds stage) and imazethapyr 70 g ha^{-1} POE respectively. The lowest weed density (19.32) was observed by hand hoeing done at 20 and 40 days after sowing. Several researchers have found a significant reduction in weed density in blackgram with the application of herbicides (Sharma *et al*., 2009; Punia *et al*., 2009; Jamin *et al*., 2009; and Dinesh *et al*., 2016) [18, 13, 9, 4].

Table 2: Effect of various treatments on density of different weed species in Urdbean

Treatment	*T. monogyna*	*E. colona*	*C. argentia*	*Solanum nigrum*	*Cyperus rotundus*	Other weed	Total
T_1 -Imazethapyr 70 g ha^{-1} PRE	3.56 (12.18)	3.08 (8.96)	3.12 (9.24)	3.17 (9.52)	7.77 (59.89)	3.56 (12.18)	10.61 (111.97)
T_2 -Imazethapyr 70 g ha^{-1} POE (3-4 leaf weeds stage)	3.15 (9.41)	3.19 (9.70)	2.93 (8.06)	3.21 (9.79)	7.72 (59.14)	3.87 (14.50)	10.54 (110.59)
T_3 -Imazethapyr + imazamox (RM) 70 g ha^{-1} POE (3-4 leaf weeds stage)	2.69 (6.72)	2.83 (7.49)	2.50 (5.76)	2.72 (6.91)	7.44 (54.82)	3.55 (12.10)	9.71 (93.79)
T_4 -Imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage)	2.38 (5.18)	2.79 (7.30)	2.32 (4.90)	2.58 (6.14)	7.11 (50.11)	3.49 (11.71)	9.27 (85.34)
T_5 -Pendimethalin 1000 g ha^{-1} PRE	3.34 (10.64)	2.81 (7.42)	2.86 (7.70)	2.91 (7.98)	6.74 (44.94)	3.70 (13.16)	9.61 (91.84)
T_6 -Imazethapyr + Pendimethalin (RM) 1000 g ha^{-1} PRE	2.63 (6.44)	2.26 (4.62)	2.61 (6.30)	2.79 (7.28)	6.37 (40.04)	3.25 (10.08)	8.68 (74.76)
T_7 -Topramezone 25.80 g ha^{-1} as POE (3-4 leaf weeds stage)	3.34 (10.66)	3.81 (14.02)	3.41 (11.14)	2.70 (6.82)	7.50 (55.78)	3.52 (11.90)	10.53 (110.30)
T_8 -Hoeing (20&40 DAS)	2.02 (3.57)	1.33 (1.26)	1.37 (1.37)	1.48 (1.68)	3.04 (8.72)	1.80 (2.73)	4.45 (19.32)
T_9 -Weedy check	4.58 (20.44)	7.02 (48.72)	4.21 (17.22)	3.44 (11.34)	8.40 (70.14)	4.67 (21.28)	13.77 (189.14)
CD (5%)	0.65	0.76	0.57	0.42	6.65	0.76	9.59

Note: Fig. in parenthesis are the original value, x = $\sqrt{x+0.5}$ transformation

Weed control efficiency (WCE%)

The data given in Fig. No. 1 indicate that different treatments showed their substantial weed control efficiency. Hoeing (20 &40 DAS) gave higher WCE (63.07%) than other treatments. Among the different herbicides, application of Imazethapyr + Pendimethalin (RM) 1000 g ha^{-1} PRE showed its maximum weed control efficiency (61.64%) followed by Pendimethalin 1000 g ha^{-1} PRE (48.81%) and Imazethapyr 70 g ha^{-1} PRE (46.44%). Minimum WCE (38.48%) was recorded with Imazethapyr 70 g ha^{-1} POE (3-4 leaf weeds stage).

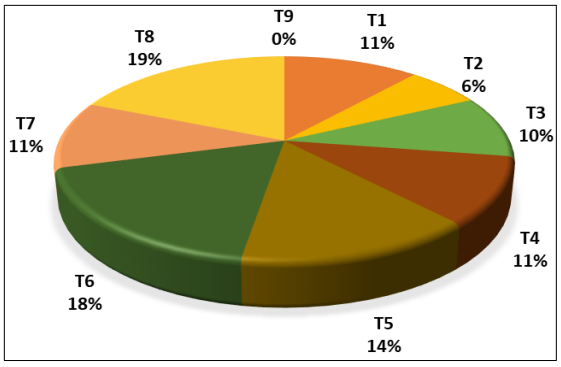

Fig 1: Weed control efficiency of various treatments in Urdbean

Plant height (cm)

In comparison to post-emergence herbicide applications, pre-emergence herbicide applications resulted in taller plants. Significantly higher plant height was obtained with the application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} PRE as compared to rest of the weed control treatments, however, it was at par with T_5 and T_1. As far as post-emergence herbicide treatments are concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stages) recorded significantly higher plant height than T_4, T_7 and T_1. In comparison to conventional weed management methods, hoeing done at 20- and 40-days following sowing resulted in noticeably taller plants. Due to the fact that narrow-leaved weeds escaped to a higher extent, which led to crop competition and subsequently lowered plant height. The weedy check plot recorded the lowest plant height. The findings of Nandan *et al.* (2011) [12], and Meena *et al.* (2011) [11] are closely supported by these findings.

Number of primary branches per plant

The statistics clearly showed that the administration of various herbicide treatments considerably increased the number of primary branches per plant. Application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} recorded significantly more number of primary branches per plant as compared to T_5 and T_1. As far as post-emergence of herbicide treatments are concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} produced significantly more number of primary branches per plant at than T_5 and T_1. Application of Imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage) produced more number of primary branches per plant than Imazethapyr + imazamox (RM) 70 g ha^{-1} POE (3-4 leaf weeds stage) but it did not reach to the level of significance. Hoeing (20 and 40 DAS) produced noticeably more primary branches per plant than the other weed management methods. The weedy check plot reported the smallest number of primary branches per plant. This might occur as a result of the treatments' increased horizontal crop development, which led to a greater number of plant^{-1} branches and enhanced weed control efficacy. Sharma (2009) [18] and Singh *et al.* (2004) [19] both reported similar findings.

Number of secondary branches per plant

Application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} recorded significantly more number of secondary branches per plant as compared to T_5 and T_1. As far as post-emergence herbicide treatments are concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} recorded more number of secondary branches per plant as compared to T_3, T_7 and T_2. When compared to alternative weed control methods, hoeing (20 and 40 DAS) significantly increased the number of

secondary branches per plant. In the weedy check plot, the primary branches per plant were kept to a minimum throughout the whole life cycle of the crop.

Number of pods per plant

The table 3 clearly depicted that the weed control methods had a considerable impact on the number of pods produced by each plant. Application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} increased number of pods per plant (33.27) significantly as compared to rest of the treatments T_5, and T_1. As far as post emergence herbicide treatments was concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} POE produced significantly more number of pods per plant than T_4, T_7 and T_3. The maximum number of pods plant^{-1} (34.21) was obtained with hoeing (20 and 40 days after sowing), while it was minimum in weedy check (26.07). Butter *et al.*, (2008) [1] and Rana (2013) also reported the similar type of response of weed control treatments.

Number of grains per pod

It is evident that various weed management measures considerably altered the number of grains per pod. Significantly higher number of grains per pod (8.42) was recorded with the application of imazethapyr + pendimethalin (RM) 1000 g ha-^{1} as compared to rest of the treatments. However, non-significant differences on number of grains per pod was obtained with T_5 and T_1. As far as post emergence herbicide treatments were concerned, application of imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage) produced significantly more number of grains per pod (7.05) over T_3 and T_3, except T_7. Hoeing (20 and 40 days after planting) produced the highest number of grains per pod (8.70), whereas weedy check (5.42) produced the lowest amount (5.42). Similar types of reactions to weed management methods were also found by Singh *et al.* (2003) [20], Vaishya *et al.* (2005) [17], and Butter *et al.* (2008) [1].

Test weight (g)

The weed control treatments did not influence the test weight significantly. However, the maximum test weight was recorded with hoeing (37.77 g) followed by imazethapyr + pendimethalin (RM) 1000 g ha^{-1} (37.60 g), imazethapyr + imazamox (RM) 80 g ha^{-1} (36.91 g) and imazethapyr + imazamox (RM) 70 g ha^{-1} (36.87 g). The minimum level of test weight (36.13 g) was obtained in weedy check.

Grain yield (q/ ha)

The weed control treatments influenced grain yield of Urdbean significantly (Table 3). Among the different weed control treatments, application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} recorded significantly more grain yield (12.48 g ha^{-1}) as compared to rest of the herbicide application, except T_5 and T_1. Among the different post-emergence herbicides, application of imazethapyr + imazamox (RM) 80 g ha^{-1} POE was recorded significantly more grain yield (9.66 q ha^{-1}) as compared to T_3 but it was at par with T_7 and T_2. The considerable grain yield (12.06 q ha^{-1}) was recorded due to hoeing (20 and 40 DAS) treatment, while the lowest (5.73 q ha^{-1}) in weedy check. The Urdbean increased grain output in response to various weed control measures may have been caused by an increase in the plant's growth and yield-enhancing characteristics as well as a decrease in weed density and dry matter. The findings of Jakhar *et al.* (2015) [8], Shruthi *et al.* (2015) [16], Dinesh *et al.* (2016) [4] and Dheer and Yadav (2021) [3] are closely congruent with similar results.

Harvest index

The different weed control treatments did not influence the harvest index of Urdbean crop appreciably. However, the maximum harvest index (30.15%) was recorded with the application of imazethapyr + pendimethalin (RM) 1000 g ha^{-1} followed by pendimethalin (Table 3).

Net return

The highest net return (Rs. 57586.40 ha^{-1}) was incurred with the application of Imazethaypr + pendimethalin (RM) 1000 g ha^{-1} days after sowing followed (Rs 49252.60 ha^{-1}) by hoeing (20 and 40 DAS) and Pendimethalin 1000 g ha^{-1} PRE (Rs. 43176.60 ha^{-1}). The minimum net return (Rs 14946.60 ha^{-1}) was recorded in weedy check (Table 3). The findings of Meena *et al.* (2011) [11], and Jakhar *et al.* (2015) [8] are in agreement with these findings.

B: C ratio

Among herbicide treatments, the combination of imazethapyr and pendimethalin 1000 g ha^{-1} recorded the highest benefit: cost ratio (2.04) followed by Pendimethalin 1000 g ha^{-1} (1.55) and hoeing done at 20 and 40 days after sowing (1.47), imazethapyr + imazamox (RM) 80 g ha^{-1} POE (3-4 leaf weeds stage) (1.44) and Imazethapyr + imazamox (RM) 70 g ha^{-1} POE (3-4 leaf weeds stage) (1.37). The minimum benefit: cost ratio (0.53) was recorded in weedy check (Table-3). Similar results have also been reported by Ankita *et al.* (2014) [7] and Ram *et al.* 2014) [14].

Table 3: Effects of herbicides on yield and its contributing traits and net return in Urdbean

Treatment	Plant height (cm)	Primary branch/plant	Secondary branch/plant	No. of pod/plant	No. of grain/pod	1000 seed weight (g)	Grain yield (q ha^{-1})	Biological Yield (q ha^{-1})	Harvest index (%)	Net return (Rs. ha-1)	B: C ratio
T 1	36.15	4.41	12.99	30.01	6.97	36.89	9.08	33.86	26.82	36144.6	1.35
T 2	35.33	3.37	10.49	26.58	5.71	36.53	7.80	31.42	24.82	27297.4	1.01
T 3	38.14	3.92	12.30	29.48	6.95	36.87	9.31	35.79	26.02	37411.6	1.37
T 4	38.66	4.30	12.59	30.22	7.05	36.91	9.66	36.43	26.50	39572.6	1.44
T 5	40.10	5.57	13.49	31.59	7.62	37.03	10.26	38.24	26.83	43176.6	1.55
T 6	40.88	6.39	14.23	33.27	8.42	37.60	12.48	41.40	30.15	57586.4	2.04
T 7	39.44	3.74	11.09	28.62	6.43	36.87	8.12	32.09	25.30	24758.4	0.78
T 8	42.62	6.61	15.00	34.21	8.70	37.77	12.02	41.50	28.96	49252.6	1.47
T 9	30.70	3.07	9.97	26.07	5.42	36.13	5.73	28.61	20.02	14946.6	0.58
CD (5%)	4.97	0.40	1.01	2.40	0.18	NS	0.79	3.54	-	-	-

Conclusion

Keeping above findings in view, it is concluded that the application of pendimethalin 1000 g ha^{-1} (pre emergence) and imazethapyr 70 g ha^{-1} (post emergence at 3-4 leafy stage of weeds) could be exploited in order to harvest the maximum grain yield (12.48 q ha^{-1}), revenue generation (net return Rs.57586 ha^{-1}) and (2.04) B:C ratio in Urdbean cultivation during *Kharif* season.

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