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A preliminary study on the time of application of imazethapyr and its ready mix combination with pendimethalin and imazamox against weeds in blackgram

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ABSTRACT

The bio-efficiency of imazethapyr and its ready mix combination products with pendimethalin and imazamox against weeds, their effect on growth, yield and phytotoxic effects on black gram and residual effect on succeeding mustard crop were studied during 2013-14. Significantly lower weed count and dry weight was recorded with application of imazethapyr + pendimethalin (pre-mix) at 800 g/ha, pendimethalin at 1000 g/ha and imazethapyr + pendimethalin (pre-mix) at 900 g/ha. Imazethapyr + pendimethalin (pre-mix) 1000 g/ha and 800 g/ha, pendemethlin 1000 g/ha and imazethapyr 50 and 70 g/ha (pre emergence) behaving statistically similar with pendimethalin 1000 g/ha (pre emergence) and hand weeding at 20 and 40 days after sowing resulted in significantly higher seed yield of black gram. Seed yield of blackgram was negatively associated with total weed count and weed dry weight ($P \leq 0.01$). With every one weed increase per square meter, the blackgram seed yield was expected to reduce by 16.8 kg/ha. Net returns, B:C and net returns over weedy check were highest under imazethapyr + pendimethalin 900 g/ha. The economic threshold levels i.e. No m^{-2} and g m^{-2} with the weed management practices studied varied between 1.7 – 18.0 m^{-2} and 1.0-10.0 g m^{-2}. Imezethapyr + pendimethalin 1000 g/ha and imazethapyr + imazamox 50 g/ha had lowest weed persistence index (WPI). Imazethapyr + pendimethalin 900 g/ha resulted in highest crop resistance index. Weed management index (WMI), Agronomic management index (AMI), and Integrated weed management index (IWMI) were highest following imazethapyr 40 g/ha. Overall impact index (Ii) was highest under imazethapyr 50 g/ha followed by imazethapyr + pendimethalin 900 g/ha, imazethapyr + pendimethalin 1000 g/ha and pendimethalin 1000 g/ha. Weed index (WI) indicated 70.8% loss in yield of blackgram. The residual effects of herbicide treatments on succeeding mustard crop were not observed.

Introduction

Blackgram is grown in an area of nine thousand ha with production of seven thousand tonnes and productivity of 733 kg/ha in Himachal Pradesh. The yield in this state is higher than the

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national average of 585 kg/ha. But to realize its potential yield, weeds so far are the major problem. Weeds are important biological constraints in short and quick growing crops which decrease the crop yield to a greater extent. Weeds compete for water, light and deplete nutrients from the soil resulting in drastic decline in the yield level up to 45 per cent in blackgram (Yadav et al. 2015). During *Kharif* season due to high rainfall, weeds grow luxuriantly and pose a serious threat to short statured blackgram crop. This crop receives low priority as it is grown on poor and marginal soils in Himachal Pradesh. This crop is not very competitive against weeds in early stages of growth. Therefore, weed control is essential to ensure the proper crop growth especially in early stage. In general, weeds absorb as much or more than the crop. Implementation of weed management technology significantly improve nutrient uptake by blackgram and reduce nutrients removal by weeds. Choudhary et al. (2012) reported that blackgram was less competitive against many weeds during early stages of crop especially between 3 to 6 weeks after sowing. If the weeding is delayed beyond this time, the yield losses are reported to be 60-90 per cent. In Himachal Pradesh, pre-emergence pendimethalin is recommended for the control of weeds in blackgram but due to higher soil moisture content, different flushes of weeds come up at later stages which needs to be controlled (Kumar et al. 2013). Therefore a field investigation was undertaken to study the bio efficiency of imazethapyr and its ready- mix combinations against weeds, their effect on growth, yield and phytotoxic effects on blackgram and residual effect on succeeding mustard crop.

Materials and Methods

A field experiment consisting of imazethapyr 50 and 70 g/ha (20 DAS), imazethapyr + pendimethalin (pre-mix) 800, 900 and 1000 g/ha (pre emergence), imazethapyr + imazamox (pre-mix) 40 and 50 g/ha (20 DAS), pendimethalin 1000 g/ha (pre emergence), hand weeding at 20 and 40 DAS and weedy check was conducted in randomized block design with three replications during 2013. The blackgram variety UG-218 was sown on July 5, 2013, with a spacing of 30 x 10 cm and harvested on October 2, 2013. The herbicide treatments were applied with knapsack power sprayer using 600 liters of water per hectare. The crop was fertilized with 20 kg N, 40 kg P_2O_5 and 20 kg K_2O per hectare. Nitrogen, phosphorus and potassium were applied through IFFCO 12:32:16 and urea (46%) at the time of sowing. Observations on weed count at 30, 60 DAS and at harvest were recorded by using a quadrate measuring 25 x 25 cm at two randomly selected spots in each plot and converted into one square meter area. Without disturbing the layout, the residual effect of treatments on succeeding mustard crop was studied. For residual studies the Sarson variety, HPBS-1 was sown immediately after harvest of mash crop. The economic threshold (economic injury levels), the weed density at which the cost of treatment equals the economic benefit obtained from that treatment, was calculated after Stone and Pedigo (1972) as well as those given by Uygur and Mennan (1995) as below.

Stone and Pedigo:

Economic threshold = Gain threshold/Regression coefficient. Where, gain threshold = Cost of weed control (Hc+Ac)/Price of produce (Gp), and regression coefficient (b) is the outcome of simple linear relationship between yield (Y) and weed density/biomass (x), Y = a + bx (where, a is intercept and b is slope/regression coefficient).

Uygur and Mennan:

$$Yield\ loss\ (\%) = \frac{\frac{100}{\text{Herbicide efficiency (He)}} \text{ x Herbicide cost (Hc) + Application cost (Ac)}}{\text{Grain price (Gp)x Yield of weed free (Yg)}} \text{ x } 100$$

The different impact indices were worked out after Walia (2003) and Rana and Kumar (2014) as follow:

Weed control efficiency (WCE)

$$= \frac{Weed\ count\ in\ control\ (unweeded) -\ Weed\ count\ in\ a\ treatment}{Weed\ count\ in\ control\ (unweeded)}$$

Weed control index (WCI)

$$= \frac{Weed\ weight\ in\ control\ (unweeded) -\ Weed\ weight\ in\ a\ treatment}{Weed\ weight\ in\ control\ (unweeded)}$$

$$Weed\ index = \frac{Yield\ from\ weed\ free - Yield\ of\ particular\ treatment}{Yield\ of\ weed\ free}\ x\ 100$$

Weed persistence index (WPI)

$$WPI = \frac{Weed\ weight\ in\ treated\ plot}{Weed\ weight\ in\ control\ plot}\ x\ \frac{Weed\ count\ in\ control\ plot}{Weed\ count\ in\ treated\ plot}$$

Crop resistance index (CRI)

$$CRI = \frac{Crop\ weight\ in\ treated\ plot}{Crop\ weight\ in\ control\ plot}\ x\ \frac{Weed\ weight\ in\ control\ plot}{Weed\ weight\ in\ treated\ plot}$$

Efficiency index (EI)

$$EI = \frac{\frac{Yield\ of\ treatment - Yield\ of\ control}{Yield\ of\ control}\ x\ 100}{\frac{Weed\ weight\ in\ treatment}{Weed\ weight\ in\ control}\ x\ 100}$$

$$Weed\ intensity(\%) = \frac{Weed\ population}{Weed + crop\ population}\ x\ 100$$

$$Crop\ intensity = 100 - weed\ intensity$$

'Overall impact index' was determined, by calculating firstly the 'unit value' where the value under a particular treatment of a parameter was divided by the respective arithmetic mean of treatments for that parameter as given below:

$$U_{ij} = \frac{V_{ij}}{AM_j}$$

Where Uij is the unit value for ith treatment corresponding to jth parameter, Vij is the actual measured value for ith treatment of jth parameter and AMj is the arithmetic mean value for jth parameter.

Secondly, the overall impact index was calculated as an average of unit values (Uij) of all the parameters under consideration:

$$OI_i = \frac{1}{N}\sum_{i=1}^{N} U_{ij}$$

Where, OIi is the overall impact index for ith treatment and N is the number of parameters considered in deriving overall impact index. The data obtained were subjected to statistical analysis by analysis of variance (ANOVA) for the randomized block design to test the significance of the overall differences among the treatments by the "F" test and conclusion was drawn at 5% probability level. Standard error of mean was calculated in each case. When the 'F' value from analysis of variance tables was found to be significant, the critical difference (LSD) was computed to test the significance of the difference between the two treatments.

Results and Discussion

Effect of treatments on weeds

Major weeds of the experimental field were *Cyperus rotundus*, *Datyloctenium* a*egypticum, Echinochloa colona*, *Commelina benghalensis*, *Digitaria sanguinalis, Eleusine indica*, and *Setaria sp*. Weed control treatments brought about significant variation in the count and dry weight of weeds (Table 1). All weed control treatments had significantly lower total weed count and total weed dry weight as compared to unweeded check. At 40 days after sowing, the significantly lower weed count and dry weight was recorded with application of imazethapyr + pendimethalin (pre-mix) at 800 g/ha being similar to pendimethalin at 1000 g/ha and imazethapyr + pendimethalin (pre-mix) at 900 g/ha. Similar trend was observed in respect of total weed count at harvest stage of crop. Chandrakar et al. (2014) also reported effectiveness of early post-emergence application of (15-20 DAS) imazethapyr at 40 g/ha and pendimethalin + imazethapyr (ready mix) at 1.0 kg/ha as pre-emergence being comparable to that under hand weeding twice (20 and 40 DAS). Findings of Patel et al. (2014) were also in conformity with the above results.

Table 1. Effect of treatments on total weed count (No/m²) and total dry weight (g/m²) at 40 DAS and at harvest in mash.

Treatment	Dose (g/ha)	Time (DAS)	Total weed count (No/m²)		Total weed dry weight (g/m²)	
			40 DAS	At harvest	40 DAS	At harvest
Imazethapyr	50	20	8.3	7.49	11.08	3.10
Imazethapyr	70	20	9.7	4.27	13.0	3.10
Imazethapyr + pendimethalin	800	Pre-	3.3	3.92	8.95	2.00
Imazethapyr + pendimethalin	900	Pre-	5.0	1.22	3.05	1.14
Imazethapyr + pendimethalin	1000	Pre-	12.0	6.03	7.61	1.80
Imazethapyr + imazamox	40	20	24.3	9.63	15.05	7.47
Imazethapyr + imazamox	50	20	31.7	14.40	14.28	7.74
Pendimethalin	1000	Pre-	6.0	2.05	11.62	3.57
HW	20 and 40 DAS	20 and 40	4.0	4.75	3.11	2.62
Weedy check	-	-	42.0	61.73	23.82	42.21
SEm±			0.94	0.52	1.91	0.35
LSD (P=0.05)			2.8	1.56	5.68	1.05

Effect of treatments on yield

Pre-mix imazethapyr + pendimethalin 900 g/ha (pre emergence) behaving statistically similar with pendimethalin 1000 g/ha (pre emergence) and hand weeding at 20 and 40 DAS resulted in significantly higher number of pods/plant (Table 2). Weeds in unweeded check reduced the seed yield of blackgram by 70.6% over the best treatment *i.e.* imazethapyr + pendimethalin (pre-mix) 900 g/ha (pre emergence). However, imazethapyr + pendimethalin (pre-mix) 1000 g/ha and 800 g/ha, pendemethlin 1000 g/ha and imazethapyr 50 and 70 g/ha (pre emergence) behaving statistically similar with hand weeding at 20 and 40 DAS resulted in significantly higher seed yield of blackgram (Table 2). Chandrakar et al. (2014) also reported effectiveness of early post-emergence application (15-20 DAS) of imazethapyr at 40 g/ha and pre-emergence pendimethalin + imazethapyr (ready mix) at 1.0 kg/ha equal to hand weeding twice (20 and 40 DAS). Studies conducted by Patel et al. (2014) under Gujarat conditions are also in conformity with above results.

Table 2. Effect of different treatments on plant height, yield attributes of yield of mash.

Treatment	Dose (g/ha)	Time (DAS)	Plant height	Pods/plant	Seed/ pod	Grain yield kg/ha
Imazethapyr	50	20	57.9	44.5	5.85	1215
Imazethapyr	70	20	60.6	50.7	6.23	1132
Imazethapyr + pendimethalin	800	Pre-	60.7	48.2	6.27	1165
Imazethapyr + pendimethalin	900	Pre-	63.0	57.0	5.72	1326
Imazethapyr + pendimethalin	1000	Pre-	58.8	56.3	5.82	1298
Imazethapyr + imazamox	40	20	52.6	41.5	5.95	1201
Imazethapyr + imazamox	50	20	56.5	51.7	5.84	1180
Pendimethalin	1000	Pre-	67.7	43.5	6.64	1256
HW		20 and 40	65.5	50.3	5.91	1333
Weedy check	-	-	65.1	42.7	5.78	389
SEm±			1.98	2.42	0.19	88.5
LSD (P=0.05)			5.9	7.2	0.55	263

The residual effects of herbicide treatments on succeeding mustard crop were not observed (data not shown). Grain yield was negatively associated with total weed and weed dry weight ($P \leq 0.01$). The linear relationship between weed count and dry weight (x) and yield (Y) of blackgram is given here as under: Weed count: $Y = 1369–16.8x$ ($R^2= 0.839$). Weed dry weight: $Y = 1431–30.2x$ ($R^2= 0.943$). These equations explain over 83.9 and 94.3% of the variation in blackgram seed yield due to count and dry weight of weeds, respectively, could be explained by these regression equations. With every one weed increase per square meter, the blackgram seed yield was expected to reduce by 16.8 kg/ha. Similarly with every g/m^2 increase in weed weight, the blackgram yield was subjected to fall by 30.2 kg/ha.

Effect of treatments on Economics

Weed control treatments brought about over three times more gross returns than weedy check necessitating the importance of weed control in this crop (Table 3). Though black gram is a cover crop initial weed free period of 20-40 days may provide economic returns which are very well achieved from the pre-emergence or early post emergence application of herbicides. Net returns, B:C and net returns over weedy check were highest under imazethapyr + pendimethalin 900 g/ha, imazethapyr + pendimethalin 1000 g/ha, imazethapyr 50 g/ha and pendimethalin 1000 g/ha, pendimethalin 1000 g/ha and imazethapyr 70 g/ha. Marginal benefit cost ratio (MBCR) was highest due to imazethapyr 50 g/ha, imazethapyr + imazamox 50 g/ha, imazethapyr + imazamox 40 g/ha, imazethapyr + imazamox 50 g/ha and imazethapyr 70 g/ha. Yadav et al. (2015) found maximum net return and benefit: cost ratio with imazethapyr + imazamox (pre-mix) at 0.05 kg/ha followed by pendimethalin + imazethapyr (pre-mix) at 1.0 kg/ha. Mansoori et al. (2015) found that imazethapyr + imazamox (premix) at 50 g/ha as post-emergence (20 DAS) registered highest net returns and B: C ratio followed by imazethapyr + pendimethalin (premix) at 1000 g/ha as pre-emergence in blackgram. Adpawar et al. (2011) reported maximum net monetary returns and B:C with one hoeing at 15 DAS and one hand weeding at 30 DAS followed by pendimethalin (pre) + one hand weeding at 30 DAS.

Table 3. Economics and threshold of weeds under different treatments.

Treatment	Dose (g/ha)	Time (DAS)	GR	NR	B:C	CWC	NRwc	MBCR	Gt	Et S&P	DW	U&M
Imazethapyr	50	20	77456	53578	2.24	1753	50817	29.0	28.7	1.7	1.0	1.9
Imazethapyr	70	20	72165	47886	1.97	2134	45126	21.2	35.0	2.1	1.2	2.4
Imazethapyr + pendimethalin	800	Pre-	74269	49574	2.01	2530	46814	18.5	41.5	2.5	1.4	2.6
Imazethapyr + pendimethalin	900	Pre-	84533	59610	2.39	2746	56850	20.7	45.0	2.7	1.5	2.4
Imazethapyr + pendimethalin	1000	Pre-	82748	57598	2.29	2963	54838	18.5	48.6	2.9	1.6	3.3
Imazethapyr + imazamox	40	20	76564	52538	2.19	1893	49777	26.3	31.0	1.8	1.0	2.0
Imazethapyr + imazamox	50	20	75225	50912	2.09	2166	48152	22.2	35.5	2.1	1.2	2.5
Pendimethalin	1000	Pre-	80070	54750	2.16	3125	51990	16.6	51.2	3.0	1.7	3.0
HW		20 & 40	84979	43620	1.05	18400	40860	2.2	301.6	18.0	10.0	15.9
Weedy check	-	-	24799	2760	0.13	0	0		0.0	0.0	0.0	0.0
SEm±			5642	-					-		-	
LSD(P=0.05)			16766	-					-		--	

GR, gross return (INR/ha); NR, net return (INR/ha); B:C, benefit cost ratio; CWC, cost of weed control (INR/ha), NRwc, net return due to weed control (INR/ha); MBCR, marginal benefit cost ratio; Gt, gain threshold; Et, economic threshold; S&P, Stone and Pedico; U&M, Uygur and Mennan.

The economic threshold levels of weeds at the current prices of treatment application and the crop production on the basis of weed infestation in blackgram are given in Table 3. The economic threshold levels i.e. No m^{-2} and g m^{-2} with the weed management practices studied varied between 1.7 - 18.0 m^{-2} and 1.0-10.0 g m^{-2} when determined after Stone and Pedigo (1972) and 1.9 to 15.9 after Uygur and Mennan (1995). It is indicated that any increase in cost of weed control would lead to higher values of economic threshold, whereas an increase in price of crop produce would result in lowering the economic threshold. Hand weeding had higher values of economic threshold than the herbicidal treatments due to higher wages. Herbicidal treatments had lower application cost and thus had lower values of economic threshold.

Effect of different treatments on Impact indices

Imezethapyr + pendimethalin 1000 g/ha and imazethapyr + imazamox 50 g/ha had lowest weed persistence index (WPI) both having 0.8. These were followed by imazethapyr + imazethapyr 40 g/ha, HW twice and imazethapyr + pendimethalin 900 g/ha. The later treatment imazethapyr + pendimethalin 900 g/ha resulted in highest crop resistance index followed by HW, imazethapyr + pendimethalin 1000 g/ha, imazethapyr + pendimethalin 800 g/ha and imazethapyr 50 g/ha. Weed management index (WMI), Agronomic management index (AMI), Integrated weed management index (IWMI) were highest following imazethapyr 40 g/ha, imazethapyr + imazamox 50 g/ha, pendimethalin 1000 g/ha and imazethapyr 50 g/ha. Efficiency index (HEI) which indicates weed killing potential and phytotoxicity was highest following imazethapyr + pendimethalin 900 g/ha followed by HW, imazethapyr + pendimethalin 1000 g/ha, imazethapyr + pendimethalin 800 g/ha and imazethapyr 50 g/ha. Weed index (WI) indicated 70.8% loss in yield due to season long uncontrolled growth of weeds. As is indicated by overall impact index (Ii), all treatments were superior in eliminating crop weed competition because of being having higher values than the threshold. However, imazethapyr 50 g/ha was the leading treatment followed by imazethapyr + pendimethalin 900 g/ha, imazethapyr + pendimethalin 1000 g/ha and pendimethalin 1000/ha. Thus in order of preference, imazethapyr 50 g/ha (20 DAS), imazethapyr + pendimethalin 900 g/ha (pre-emergence) and pendimethalin 1000/ha (pre-emergence) may be recommended for effective weed control, productivity and profitability in blackgram.

Table 4. Impact indices under different treatments.

Treatment	Dose (g/ha)	Time (DAS)	WPI	CRI	WMI	AMI	IWMI	HEI	WI	Ii
Imazethapyr	50	20	1.4	14.5	4.0	3.0	3.5	9.9	8.9	1.20
Imazethapyr	70	20	1.8	11.9	3.8	2.8	3.3	7.8	15.1	1.00
Imazethapyr + pendimethalin	800	Pre-	2.4	18.1	3.6	2.6	3.1	12.0	12.6	1.04
Imazethapyr + pendimethalin	900	Pre-	1.1	53.7	3.6	2.6	3.1	38.0	0.5	1.19
Imazethapyr + pendimethalin	1000	Pre-	0.8	23.4	3.9	2.9	3.4	16.4	2.6	1.11
Imazethapyr + imazamox	40	20	1.0	9.1	4.7	3.7	4.2	6.1	9.9	1.06
Imazethapyr + imazamox	50	20	0.8	9.1	4.6	3.6	4.1	6.1	11.5	1.03
Pendimethalin	1000	Pre-	3.0	14.0	4.2	3.2	3.7	9.7	5.8	1.11
HW		20 & 40	1.0	39.5	3.8	2.8	3.3	28.0	0.0	1.05
Weedy check	-	-	1.0	1.0	0.0	0.0	0.0	0.0	70.8	0.21
SEm±										
LSD (P=0.05)										

WPI, Weed persistence index; CRI, Crop resistance index; WMI, Weed management index; AMI, Agronomic management index; IWMI, Integrated Weed management index; HEI, Herbicide efficiency index, WI, Weed index; Wi, Weed intensity; Ci, Crop intensity; Ii, overall impact index

Conflict of Interest

Authors declare no conflict of interest.

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