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Bio-efficacy of Pre- and Post-emergence Herbicides for Weed Management in Linseed (*Linum usitatissimum* L.) under Irrigated Conditions

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A B S T R A C T

The present field experiment was conducted to scrutinize the options available for chemical weed management in irrigated linseed at Agricultural Research Farm, Powerkheda, Madhya Pradesh during two consecutive *Rabi* seasons of 2017 and 2018. The findings of the study reveal that, in linseed crop sown under irrigated condition, pre- emergence application of pendimethalin @ 1 kg/ha *fb* application of metsulfuron methyl @ 4g/ha g responded well in terms of effective weed control and obtaining higher yield. Also, Maximum Net return of Rs.40939/ha with B:C ratio 2.8 was recorded with same mode of weed management.

Introduction

Owing to its various uses and special qualities, Linseed (*Linum usitatissimum* L.) occupies a greater importance among oilseeds. Under Indian agricultural conditions, it is grown mainly for extracting oil. The oil content of the seed varies from 33-47%. Linseed oil is excellent dyeing oil used in manufacturing paints and varnishes, oilcloth, waterproof fabrics and linoleum and as edible oil in some areas. Linseed is also used in making paper and plastics. That is why it is also known as plastic crop. Linseed is more viewed as a health crop and is an excellent vegetarian source of Omega-3 fatty acids. Linseed crop is also grown for its fiber. In India linseed is cultivated in about 293 thousand hectares with a contribution of 142 thousand tones to the annual oilseed production of the country. Its average productivity is 484 kg/ha. Madhya Pradesh has largest growing area (64.5 lakh ha) and production (95 lakh tones) with 147 kg/ha productivity (Anonymous 2019). Among several factors affecting linseed production, weeds infestation is a major factor. Yield losses due to weed infestation in linseed were 36% (Mahajan, 2018). Weeds compete with crop plants for water, nutrients, space and

light. The adverse effect of weeds can be minimized if few weeds are present but heavy infestation may cause complete crop failures. So, the present study was aimed to find out the efficacy of pre and post emergence herbicides for weed management in linseed.

Materials and Methods

The study was conducted during two consecutive *Rabi* seasons of 2017 and 2018 at Agricultural Research Farm, Powerkheda, Madhya Pradesh. The experiment field is situated on the banks of the holy river Narmada at 77^0.42' N Latitude, 22^0.40, E Longitude and 299 m above mean sea level. Total annual rainfall is about 39 inches (980 mm) and more than 75-80% generally occurs during the monsoon season (June-September).The soil of the experimental field was mixed red and black with clay loam in texture and slightly alkaline in reaction with pH 7.7, EC 0.32 dS\m having organic carbon 0.61 per cent and available nitrogen 270 kg\ha, phosphorus 16.4 kg\ha and potassium 352 kg\ha at 0-15 cm soil depth. The experiment was laid out in randomized block design with ten treatments viz: Weedy Check (T_1), Hand Weeding (20 DAS) and 40 DAS (T_2), Metribuzen @ 250g/ha + Oxyflorfen @125 g/ha (Pre emergence) (T_3), Pendimethalin @ 1 kg/ha (Pre emergence) *fb* Metsulfuron methyl @ 4g/ha at 25 DAS (Post emergence) (T_4), Imazethapyr 10EC @ 75g /ha at 2-3 leaf stage of weeds (Post emergence) (T_5), Oxyflourfen @ 125 g/ha at 2-3 leaf stage of weeds (Post emergence) (T_6), Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (Post emergence) (T_7), Isoproturon @ 1 kg/ha at 2-3 leaf stage of weeds (Post emergence) (T_8), Isoproturon @ 1 kg/ha + Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (Post emergence) (T_9) and Oxadiargyl @ 80g/ha at 2-3 leaf stage of weeds (Post emergence) (T_{10}) with three replications. A uniform dose of 40 kg P_2O_5 and 20 kg K_2O was applied through single super phosphate and muriate of potash, respectively. The nitrogen (80 kg) was applied through urea in three split doses. Half dose of nitrogen and full doses of phosphorous and potassium were applied as basal at sowing and remaining half dose of nitrogen was applied in two equal splits i.e. at flowering and grain filling stage of the crop. For weed studies, weed dry weight was recorded (at 20 & 80 days stage) from 0.25 m^{-2} areas by placing a quadrate of 0.5 ×0.5 m randomly at three places in border rows of each plot. Final data was expressed as number of weeds per square meters. The original values were subjected to square root transformation ($Y = \sqrt{x} + 1$) for statistical analysis. The net plot area was harvested manually at the maturity and the seed yield was recorded. Weed control efficiency (WCE) and weed index (WI) were calculated by the following method.

$$WCE\ (\%) = \frac{WCC - WCT}{WCC} \times 100$$

Where,
WCC= Dry weight of weeds in unweeded control plot (g)
WCT= Dry weight of weeds in treated plot (g)

$$Weed\ Index = \frac{X - Y}{X} \times 100$$

Where,
X = Seed yield in weed free check plot (kg ha^{-1})
Y = Seed yield in treated plot (kg ha^{-1})

Results and Discussion

As the present study was aimed to find out the efficacy of pre and post emergence herbicides for weed management in linseed. The results are being discussed on the basis of

performance of chemical treatments applied. The treatments weedy check (T_1) and hand weeding (T_2) were included for comparison and hence not discussed in details.

Effect on crop

The results from the present experiment clearly indicate that apart from mechanical weeding, the chemicals used for weed management had a significant effect on growth and yield attributes of crop during both the years of study (Table 1). Amongst the chemical methods of weed management, T_4 (Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS)) recorded significantly maximum plant height. Whereas, the application of Oxyflourfen @ 125 g/ha at 2-3 leaf stage of weeds (POS) (T_6), recorded the minimum plant height. This might be owing to availability of proper space between plants and less weed competition during initial stages of plant growth. The present findings corroborate with those of Bhatt *et al.,* (2020).

The mean data of two experimental years revealed that among the measures of weed management, T_4 (Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS)) proved significantly superior in terms of all growth and yield attributing characters viz: higher number of branches per plant, number of capsules per plant, number of seed per capsules and test weight of grains at harvest except final plant population (000/ha). It was due to the fact that pre-emergence application of pendimethalin controlled the weeds from the very beginning, reducing crop-weed competition for nutrients, moisture, space and light.

This was followed by application of metsulfuron methyl which controlled the emerging and remaining weeds and created favorable conditions for crop growth by reducing competition further decay of weeds also resulted in improving soil aeration and water holding capacity. The present results agree with those of Tripathi *et al.*, (2016).

Yield is the final expression of all the physiological and biochemical processes going on during the crop life cycle and has a direct relationship with the growth and yield attributing characters of plants. Amongst the weed management practices, application of Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS) (T_4) proved the most beneficial which produced the significantly higher grain (1425.3 kg/ha) next to hand weeding twice. The control (weedy) treatment brought about the significantly lowest productivity parameters.

All these weed management treatments reacted exactly in accordance with the growth and yield-attributing characters brought out by these treatments. The most advantageous factor associated with T_4 treatment was that the Pendimethalin controlled the weeds from the very beginning of the plant growth and thereafter control of further emerging or remaining weeds was monitored by following the post emergence application of metsulfuron methyl, thus providing the almost weed-free condition for the actively growing crop plants. These results are in close agreement with those of Kumar *et al.,* (2017).

Effect on weeds

The major weed species present in the experimental field were *Amaranthus viridis*, *Brachiaria eruciformis*, *Eragrostis* sp., *Pennisetum pedicellatum*, *Cyperus rotundus*, *Cynodon dactylon*, *Cyperus irria*, *Echinochloa crusgalli*, *Euphorbia geniculata*, *Euphorbia hirta*, *Chrozophora rotleri* predominantely.

Table.1 Effect of different herbicides on growth, yield attributes and yield of linseed under irrigated conditions. (Mean of two years)

	Treatment	Plant height (cm) at harvest	Number of branches per plant at harvest	Number of capsules per plant at harvest	Number of seed per capsules	Final plant population (000/ha)	Test weight	Seed yield (kg/ha)
T_1	Weedy Check	46.13	1.00	14.53	6.0	1628	6.9	1087.6
T_2	Hand Weeding 20 DAS and 40 DAS	59.73	1.67	24.07	8.4	1338	8.5	1630.8
T_3	Metribuzen @ 250g/ha + Oxyflorfen @125 g/ha (PRE)	57.60	1.60	22.93	7.3	1546	8.3	1245.3
T_4	Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS)	58.27	1.47	18.00	8.0	1858	7.8	1425.3
T_5	Imazethapyr 10EC @ 75g /ha at 2-3 leaf stage of weeds (POS)	55.93	1.44	17.73	7.0	1835	7.6	1201.6
T_6	Oxyflourfen @ 125 g/ha at 2-3 leaf stage of weeds (POS)	52.67	1.27	15.60	6.8	1705	7.0	1193.8
T_7	Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	54.73	1.33	16.27	6.6	1718	7.6	1055.6
T_8	Isoproturon @ 1 kg/ha at 2-3 leaf stage of weeds (Post emergence)	57.07	1.53	21.53	7.1	1374	8.1	1231.6
T_9	Isoproturon @ 1 kg/ha + Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	55.60	1.47	16.73	7.5	1511	7.7	1309.7
T_{10}	Oxadiargyl @ 80g/ha at 2-3 leaf stage of weeds (POS)	54.30	1.3	15.8	6.3	1420	7.5	1185.6
	SE(m)±	**1.43**	**0.07**	**1.91**	**0.32**	**125.05**	**0.3**	**51.33**
	C.D.(0.05)	**4.18**	**0.21**	**5.60**	**0.79**	**NS**	**0.9**	**150.56**

Table.2 Effect of different herbicides on Weed Density m^{-2}, Weed dry weight m^{-2} (g), Weed control efficiency (%), Weed index of linseed under irrigated conditions. (Mean of two years)

S. No.	Treatment	Weed Density m^{-2}		Weed dry weight m^{-2} (g)		Weed control efficiency (%)		Weed index
		20 DAS	80 DAS	20 DAS	80 DAS	20 DAS	80 DAS	
T_1	Weedy Check	7.34 (53.00)*	11.89 (140.45)	7.10 (49.38)	14.09 (197.53)	0.0	0.0	33.31
T_2	Hand Weeding 20 DAS and 40 DAS	2.52 (5.33)	3.89 (14.13)	2.82 (6.96)	4.34 (17.83)	58.3	66.2	0.00
T_3	Metribuzen @ 250g/ha + Oxyflorfen @125 g/ha (PRE)	5.63 (30.67)	9.07 (81.27)	4.08 (15.66)	7.98 (62.62)	42.5	43.4	23.64
T_4	Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS)	4.60 (23.00)	7.84 (60.95)	3.20 (9.27)	6.17 (37.07)	54.9	56.2	12.60
T_5	Imazethapyr 10EC @ 75g /ha at 2-3 leaf stage of weeds (POS)	6.30 (38.67)	10.17 (102.47)	4.28 (17.33)	8.96 (79.32)	39.7	36.4	26.32
T_6	Oxyflourfen @ 125 g/ha at 2-3 leaf stage of weeds (POS)	6.37 (39.67)	10.29 (105.12)	4.78 (21.88)	9.93 (97.51)	32.7	29.5	26.80
T_7	Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	7.23 (51.33)	11.67 (136.03)	6.45 (40.67)	12.78 (162.67)	9.2	9.3	35.27
T_8	Isoproturon @ 1 kg/ha at 2-3 leaf stage of weeds (Post emergence)	6.83 (45.67)	11.05 (121.02)	5.23 (26.41)	12.31 (150.63)	26.3	12.6	24.48
T_9	Isoproturon @ 1 kg/ha + Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	5.16 (25.67)	8.31 (68.02)	3.33 (10.13)	6.44 (40.53)	53.1	54.3	19.69
T_{10}	Oxadiargyl @ 80g/ha at 2-3 leaf stage of weeds (POS)	6.71 (44.00)	10.84 (116.60)	5.17 (25.73)	10.17 (102.91)	27.2	27.8	27.30
	SE(m)±	3.74	6.26	1.06	5.70	-	-	-
	C.D.(0.05)	10.97	18.35	3.11	16.72	-	-	-

* The values in parenthesis are original values and subjected to $\sqrt{x+1}$ transformation

Table.3 Effect of different herbicides on economics of linseed under irrigated conditions. (Mean of two years)

S. No.	Treatment	Cost of cultivation (Rs /ha.)	GMR (Rs./ha.)	NMR (Rs./ha.)	B:C ratio
T_1	Weedy Check	21800	48942	27142	2.2
T_2	Hand Weeding 20 DAS and 40 DAS	28250	73386	45136	2.6
T_3	Metribuzen @ 250g/ha + Oxyflorfen @125 g/ha (PRE)	24100	56039	31939	2.3
T_4	Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS)	23200	64139	40939	2.8
T_5	Imazethapyr 10EC @ 75g /ha at 2-3 leaf stage of weeds (POS)	22200	54072	31872	2.4
T_6	Oxyflourfen @ 125 g/ha at 2-3 leaf stage of weeds (POS)	22900	53721	30821	2.3
T_7	Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	22500	47502	25002	2.1
T_8	Isoproturon @ 1 kg/ha at 2-3 leaf stage of weeds (Post emergence)	22700	55422	32722	2.4
T_9	Isoproturon @ 1 kg/ha + Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds (POS)	22950	58937	35987	2.6
T_{10}	Oxadiargyl @ 80g/ha at 2-3 leaf stage of weeds (POS)	22100	53355	31255	2.4

The methods of weed management had significant effect on weed density of different species of weeds, weed dry weight, weed control efficiency and weed index. All treatments significantly reduced the weed density of all the species of weed compared to control (Weedy check) (Table 2). Among the herbicide treatments application of Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS) T_4 proved significant and recorded lowest weed density, weed dry weight, weed control efficiency at 20 & 80 DAS. Total weed dry weight and weed control efficiency was in direct proportion to weed density i.e. lesser the weed density, lesser was the total weed dry weight, weed control efficiency and vice-versa. This is due to the effect of pendimethalin in inhibiting cell division and cell elongation which resulted in death of weeds shortly after germination and metsulfuron-methyl is a residual sulfonylurea compound. It is a systemic compound with foliar and soil activity and it works rapidly after it is taken up by the plant which inhibit cell division in the shoots and roots of the plant, and it is biologically active at low use rates.

Weed index indicating yield reduction due to weed competition, was the highest in weedy-check while it was the lowest in weedy check. The highest weed index in weedy-check was due to unchecked weed growth throughout the crop growth period and the consequent competition for growth resources resulted in the lowest yield with the treatment.

Among the herbicide treatments lowest weed index was recorded with Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS) T_4. This showed the efficiency of combined application of these herbicides as pre-emergence for managing weeds in linseed field without much reduction in yield.

Effect on economics

The net income per hectare was directly associated with the productivity of crop under applied resources (Table 3). In the present investigation, the highest net income, next to hand weeding twice, was obtained from T_4 i.e. Pendimethalin @ 1 kg/ha (PRE) + Metsulfuron methyl @ 4g/ha at 25 DAS (POS) up to Rs.40939/ha with B:C ratio 2.8. Similar findings were reported by Mahajan, (2017). Whereas, Despite having high net returns under hand weeding twice T_2 B:C (2.6) ratio was less due to the extra input cost and labours involved in weeding. The lowest income Rs.27142/ha and B:C ratio 1.8 was recorded from the control.

On the basis of present investigation, it is concluded that the pre- emergence application of pendimethalin @ 1 kg/ha *fb* application of metsulfuron methyl @ 4g/ha at 25 DAS in linseed grow under irrigated condition responded well in terms of effective weed control and obtaining higher yield.

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