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Effect of Pre and Post-Emergence Herbicides on Yield, Economics and Weed Control in Linseed (*Linum usitatissimum* L.) Under Irrigated Medium Land Condition of Jharkhand

Md. Parwaiz Alam[1] and Swati Shabnam[1*]

[1]Department of Agronomy, Ranchi Agriculture College, Birsa Agricultural University, Jharkhand-834006, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Linseed (*Linum usitatissimum* L.) production is affected by several factors, out of which weed is one of the most important factors responsible for causing tremendous loss in yield. An experiment was conducted during *rabi* season of 2018-2019 and 2019-2020 at Research Farm of Birsa Agricultural University, Kanke, Ranchi, Jharkhand to study the effect of pre and post-emergence herbicide on yield, economics, weed count, weed dry matter and weed control efficiency in linseed. The treatments comprised of weed management practices *viz*., T_1-Weedy Check, T_2-Hand weeding twice at 30 and 60 DAS, T_3-Metribuzin 250 g/ha + Oxyflourfen 125g/ha (Pre.), T_4-Pendimethalin 1 kg/ha (Pre.) *fb*. metsulfuron methyl 4 g/ha (Post.), T_5-Imazethapyr 75 g/ha (Post.), T_6-Oxyflourfen125 g/ha (Pre.), T_7-Metsulfuron methyl 4 g/ha (Post.), T_8-Clodinafop 60 g/ha (Post.), T_9-Clodinafop 60 g/ha + metsulfuron methyl 4 g/ha (Post.) and T_{10}-Oxadiargyl 80 g/ha (Pre.), and were replicated thrice. The research outcomes revealed that Hand Weeding twice at 30 and 60 DAS resulted in maximum seed yield (14.26, 15.66 and 14.96 q/ha), net return (Rs. 41635, 45907 and 43771/ha), in 2018-19, 2019-20 and pooled data respectively while among weed parameters hand weeding recorded minimum total weed count at 30 DAS (1.19 and 1.22 /m^2) and 60 DAS

**Corresponding author: E-mail: swatishbnam282@gmail.com;*

(3.04 and 3.19 /m^2), minimum total weed dry matter at 30 DAS (1.17 and 1.18 g/m^2) and at 60 DAS (3.43 and 3.57 g/m^2) and maximum weed control efficiency at 30 DAS (97.08 and 96.97%) and at 60 DAS (80.66 and 79.24%) in 2018-19 and 2019-20 respectively.

Keywords: Growth parameters; herbicide; linseed; yield; economics.

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an important *rabi* oilseed crop next to rapeseed and mustard in India [1]. India holds first position in terms of area under linseed cultivation and third in terms of production in the world. In India, it is cultivated in about 4.68 lakh ha with a total production of 1.63 lakh tons [2]. In Jharkhand it is cultivated in over 0.26 lakh ha with production of 0.16 lakh MT and its average yield is 6.12 q/ha [3].

Linseed (*Linum usitatissimum* L.) belongs to Linaceae family and is commonly known by different names viz. a*lsi*, *teesi*, *chikna* or Linseed in India. It is a great source of nutrients and contains 33 to 47% of oil. Linseed oil is used in cooking as well as for industrial uses. Out of total oil produced, about 20% is used at farmer's level and the rest 80% oil goes to industries in various purposes such as borated oil, boiled oil, urethane oil, aluminates oil, eposidized oil, isomerizes oil etc. The oil is rich in linolenic acid (>66%) and it is a perfect drying oil. Linseed contains high levels of dietary fiber as well as lignin, an abundance of micronutrient and omega-3 fatty acids. It tastes good and contains 36% protein, 85% of which is digestible. It is also used as organic manure and contains about 5% N, 1.4% P_2O_5 and 1.8% K_2O [4]. Linseed's essential fatty acids have anti-inflammatory properties, offering health benefits to a number of chronic diseases such as Heart disease, Diabetes and Arthritis [5].

Out of several factors affecting the production of linseed, weed is one of the most important factors responsible for causing tremendous loss in yield. Weeds are unwanted plants competing for water, light, space and nutrients and affect the crop growth. Owing to poor initial growth and lower canopy spread with small sized leaves, weed infestation imposes serious constraints in realizing higher yields causing 30-40% loss in seed yield [6]. Heavy infestations may even cause complete crop failures. In this context, several scientific researches show that reduction or elimination of weed interference can increase linseed seed and oil yield. Conventionally, weeds are controlled by hand weeding and inter-culturing between the rows, but it involves more cost which reduces profit gain. Therefore, the use of herbicides may be a suitable alternative for managing the weeds for higher returns [7]. Some herbicides are extensively used as pre-emergence herbicide and some herbicides are used as post-emergence for weed management in linseed field, but the efficacy of herbicides fluctuates according to the soil type, moisture regime, and types of weed flora. Therefore, for effective control of weeds in linseed, selected herbicide is needed with the integration of interculturing and hand weeding [8].

2. MATERIALS AND METHODS

A field experiment was conducted in upland areas of Research Farm of the Birsa Agricultural University, Kanke, Ranchi ($23^0$17' N latitude, $85^0$10' E longitude and 625 m above MSL (mean sea level), India during *rabi* seasons of 2018-19 (sowing date: 15th November 2018 and harvesting date: 23 March 2019) and 2019-20 (sowing date: 17th November 2019 and harvesting date: 27th March 2020), respectively, to evaluate the "effect of pre and post-herbicide on growth parameters, yield, economics, weed count, weed dry matter and weed control efficiency in linseed". Variety of linseed taken for experimentation was "Divya". The experiment was laid out in Randomized Block Design with ten treatments comprising of weed management practices *viz*., T_1-Weedy Check, T_2-Hand weeding twice at 30 and 60 days after sowing (DAS), T_3-Metribuzin 250 g/ha + Oxyflourfen 125g/ha (Pre.), T_4-Pendimethalin 1 kg/ha (Pre.) *fb*. Metsulfuron methyl 4 g/ha (Post.), T_5-Imazethapyr 75 g/ha (Post.), T_6-Oxyflourfen125 g/ha (Pre.), T_7-Metsulfuron methyl 4 g/ha (Post.), T_8-Clodinafop 60 g/ha (Post.), T_9-Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) and T_{10}-Oxadiargyl 80 g/ha (Pre.). Treatments were replicated thrice. Soil of the experimental plot was sandy loam in texture having low carbon (0.34 %) and nitrogen (178.6 Kg/ha), and medium in phosphorous (15.23 Kg/ha) and potassium (184.64 Kg/ha). pH of the soil 5.6 which was slightly acidic. Plot size taken was 5 m X 3 m. The mean minimum and maximum temperature throughout the cropping season ranged from 2.2 ^{0}C to 38.1^{0}C during 2018-19 and

total rainfall recorded during crop period was 66.80 mm, while during 2019-20, the mean minimum and maximum temperature ranged from 2.0 ^{0}C to 37.6 ^{0}C and total rainfall recorded during crop period was 393.90 mm. The recommended fertilizer dose applied was 40 kg N: 40 kg P_2O_5: 30 kg K_2O /ha (as per general recommendation by Birsa Agricultural University, Ranchi, Jharkhand) for this region, supplied through urea, single super phosphate and muriate of potash, respectively. The linseed was sown manually in rows at using 30 kg/ha seed rate with 30 cm row spacing. The recommended package of practices were applied same in all the treatments. All observation on yield (seed yield and stalk yield), economics, total weed count, total weed dry matter and weed control efficiency were recorded from the marked area of net plot. All the data obtained from the experiment were put to statistical analysis by ANOVA has been adopted for the statistical analysis of the data of the experiment as suggested [9]. Critical difference (CD) at 5% level of significance was worked out to determine the difference between treatments.

3. RESULTS AND DISCUSSION

3.1 Effect of Pre and Post-Emergence Herbicide in Controlling Weed on Yield

Yield is the result of synchronized interplay of various yield attributes like no. of capsules per plant, no. of seed per capsule and test weight. Seed and stover yield were significantly influenced by different weed control treatments (Table 1 and Fig 1). An appraisal of data revealed that the treatment T_2 *i.e.* Hand Weeding twice recorded higher seed (14.26, 15.56 and 14.96 q/ha in 2018-19, 2019-20 and pooled data respectively) and stover yield (29.61, 31.25 and 30.43 q/ha in 2018-19, 2019-20 and pooled data respectively) followed by treatment T_9 *i.e.* Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) but was statistically at par with all the treatment except T_1-Weedy Check. Treatment T_9 *i.e.* Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) recorded seed yield 13.51, 14.91 and 14.21 q/ha and stover yield 28.55, 30.19 and 29.37 q/ha in 2018-19, 2019-20 and pooled data respectively) and stover yield which was statistically superior over T_1- Weedy check.

The analysis of data revealed that the harvest index was not influenced by weed management practices. The highest harvest index was obtained from T_2-Hand Weeding twice which was statistically at par with all the treatments. The lowest harvest index was observed in T_1-Weedy check.

This result can be attributed due to marked improvement in yield attributes and better weed control. The treatment, which had higher yield attributing characters and better weed control, produced higher grain and straw yield. The minimum seed yield was recorded under Weedy check, which was attributed due to more weed growth and poor yield attributing characters. These results were in accordance with the findings of [6,10,11].

3.2 Effect of Pre and Post-Herbicide in Controlling Weed on Economics

Economics of linseed cultivation as affected by different herbicide treatments is presented in Table 2. The gross return obtained by yield of crop varied markedly in different treatments, which ultimately influenced the net return and benefit: cost ratio.

The magnitude of increase in gross return and net return in the treatment T_2, *i.e.* Hand Weeding twice were to the tune of 49.69% and 63.69% respectively in 2018-19, and 49.78% and 63.49% in 2019-20 over weedy check (T_1). However, all the herbicide combinations and treatments were found to be more profitable than Weedy check.

The maximum benefit cost ratio of 2.34, 2.41 and 2.21 2018-19, 2019-20 and pooled data respectively, was recorded in treatment T_9-Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) followed by T_4-Pendimethalin 1 kg/ha (Pre.) *fb*. Metsulfuron methyl 4 g/ha (Post.), T_8-Clodinafop 60 g/ha (Post.), T_3-Metribuzin 250 g/ha + Oxyflourfen 125g/ha (Pre.), T_5-Imazethapyr 75 g/ha (Post.), T_2-Hand Weeding twice, T_7-Metsulfuron methyl 4 g/ha (Post.), T_6-Oxyflourfen125 g/ha (Pre.), T_{10}-Oxadiargyl 80 g/ha (Pre.) and T_1-Weedy check. The lowest benefit cost ratio was obtained with weedy check in both the years. This higher benefit cost ratio obtained with Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) inspite of higher seed yield in hand weeding was due to higher cost of cultivation in hand weeding treatment. These finding are in the close vicinity with those reported by [7,12,13].

Table 1. Effect of pre and post-emergence herbicide on seed yield, stalk yield and harvest index of linseed

Treatments	Seed yield (q/ha)			Stover yield (q/ha)			Harvest Index (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Weedy check	7.12	7.76	7.44	15.82	17.53	16.68	31.03	30.48	30.76
Hand weeding twice	14.26	15.66	14.96	29.61	31.25	30.43	32.38	33.30	32.84
Metribuzin 250 g/ha + Oxyflourfen 125 g/ha (Pre.)	12.92	14.19	13.55	28.06	29.72	28.89	31.57	32.36	31.97
Pendimethalin 1 kg/ha (Pre.) *fb.* Metsulfuron methyl 4 g/ha (Post.)	13.33	14.60	13.97	28.23	29.96	29.10	32.07	32.76	32.42
Imazethapyr 75 g/ha (Post.)	12.51	13.94	13.23	27.60	29.34	28.47	31.19	32.22	31.71
Oxyflourfen125 g/ha (Pre.)	11.58	12.99	12.29	27.13	28.77	27.95	29.88	31.08	30.48
Metsulfuron methyl 4 g/ha (Post.)	11.83	13.10	12.47	27.16	28.87	28.02	30.45	31.29	30.87
Clodinafop 60 g/ha (Post.)	12.71	14.03	13.37	27.84	29.55	28.70	31.47	32.33	31.90
Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.)	13.51	14.91	14.21	28.55	30.19	29.37	32.13	33.08	32.61
Oxadiargyl 80 g/ha (Pre.)	11.20	12.47	11.84	26.32	28.04	27.18	29.86	30.81	30.34
SE(m)±	0.74	0.77	0.76	1.44	1.44	1.44	1.41	1.03	1.22
CD at 5%	2.31	2.40	2.31	4.47	4.49	4.48	NS	NS	NS
CV%	10.64	9.98		9.35	8.83		7.85	5.58	

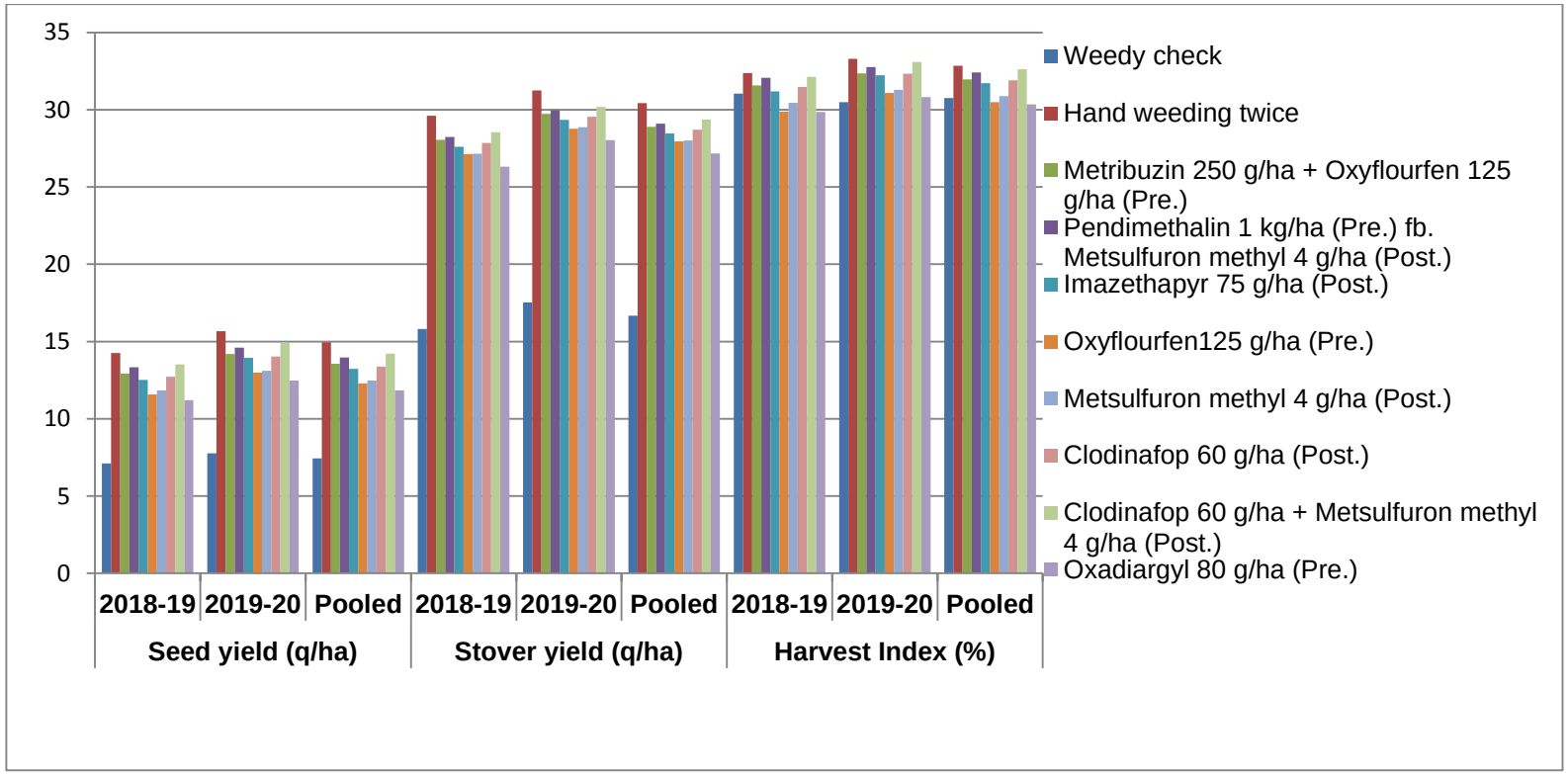

Fig. 1. Effect of pre and post-emergence herbicide on seed yield, stalk yield and harvest index of linseed

Table 2. Effect of pre and post-emergence herbicide on economics of linseed

Treatments	Cost of cultivation (Rs./ha)			Gross Monetary Return (Rs./ha)			Net Monetary Return (Rs./ha)			B:C ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Weedy check	15419	16580	16000	30537	33339	31938	15118	16759	15939	0.98	1.01	1.00
Hand weeding twice	19057	20492	19775	60692	66398	63545	41635	45907	43771	2.18	2.24	2.21
Metribuzin 250 g/ha + Oxyflourfen 125 g/ha (Pre.)	17043	18035	17539	55256	60446	57851	38212	42120	40166	2.24	2.30	2.27
Pendimethalin 1 kg/ha (Pre.) *fb.* Metsulfuron methyl 4 g/ha (Post.)	17051	18334	17693	56853	62061	59457	39803	43727	41765	2.33	2.38	2.36
Imazethapyr 75 g/ha (Post.)	16678	17655	17167	53600	59443	56522	36923	41510	39217	2.21	2.31	2.26
Oxyflourfen125 g/ha (Pre.)	16419	17752	17086	49990	55696	52843	33571	38041	35806	2.04	2.15	2.10
Metsulfuron methyl 4 g/ha (Post.)	16509	17484	16997	50919	56122	53521	34409	38370	36390	2.08	2.16	2.12
Clodinafop 60 g/ha (Post.)	16772	18326	17549	54406	59825	57116	37634	41790	39712	2.24	2.32	2.28
Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.)	17248	18546	17897	57602	63308	60455	40354	44762	42558	2.34	2.41	2.38
Oxadiargyl 80 g/ha (Pre.)	16261	17933	17097	48352	53555	50954	32092	36071	34082	1.97	2.06	2.02
SE(m)±	-	-		2926	3042	2984	2927	3042	2985	0.16	0.14	0.15
CD at 5%	-	-		9110	9470	9445	9110	9470	9419	0.51	0.43	0.48
CV%	-	-		9.78	9.00		14.49	13.54		13.77	11.21	

Note: Selling price of linseed- Rs. 3800/- and selling price of linseed stover- Rs. 220/-

Table 3. Effect of pre and post-herbicide in controlling weed on total weed count and total weed dry matter in linseed

Treatments	Total weed count (No./m^2)				Total weed dry matter (g/m^2)			
	30 DAS		60 DAS		30 DAS		60 DAS	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1=Weedy check	5.64 (31.35)	5.79 (33)	6.79 (45.74)	6.9 (47.24)	5.22 (26.87)	5.38 (28.42)	6.84 (46.46)	6.94 (47.89)
T_2=Hand weeding twice	1.19 (0.91)	1.22 (1)	3.04 (8.76)	3.19 (9.72)	1.17 (0.87)	1.18 (0.89)	3.43 (11.32)	3.57 (12.29)
T_3=Metribuzin 250 g/ha + Oxyflourfen 125 g/ha (Pre.)	4.17 (16.93)	4.3 (18)	5.39 (29.06)	5.25 (30.43)	3.96 (15.21)	4.06 (16.01)	5.21 (26.70)	5.33 (27.92)
T_4=Pendimethalin 1 kg/ha (Pre.) fb. Metsulfuron methyl 4 g/ha (Post.)	3.92 (14.83)	4.1 (16.33)	4.69 (22.61)	4.8 (23.54)	3.83 (14.15))	3.99 (15.38)	4.77 (22.84)	4.89 (24)
T_5=Imazethapyr 75 g/ha (Post.)	4.62 (20.98)	4.78 (22.33)	5.79 (33.06)	5.91 (34.45)	4.24 (17.51)	4.36 (18.49)	6.03 (36.54)	6.14 (37.79)
T_6=Oxyflourfen125 g/ha (Pre.)	5.06 (25.23)	5.21 (26.67)	6.24 (38.44)	6.35 (39.79)	4.81 (22.62)	4.94 (23.89)	6.41 (40.76)	6.51 (41.95)
T_7=Metsulfuron methyl 4 g/ha (Post.)	4.66 (21.3)	4.81 (22.67)	6.17 (37.87)	6.27 (39.15)	4.39 (18.93)	4.52 (19.93)	6.22 (38.41)	6.32 (39.68)
T_8=Clodinafop 60 g/ha (Post.)	4.19 (17.08)	4.34 (18.33)	5.53 (30.09)	5.65 (31.43)	4.19 (17.14)	4.29 (17.94)	5.36 (28.94)	5.48 (30.15)
T_9=Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.)	3.66 (12.93)	3.85 (14.33)	4.63 (21.15)	4.78 (22.56)	3.37 (10.93)	3.56 (12.19)	4.59 (20.70)	4.72 (21.93)
T_{10}=Oxadiargyl 80 g/ha (Pre.)	5.32 (27.81)	5.46 (29.33)	6.46 (41.25)	6.55 (42.54)	4.9 (23.67)	5.01 (24.65)	6.57 (43.17)	6.67 (44.48)
SE(m)±	0.16	0.15	0.36	0.36	0.16	0.16	0.34	0.40
CD at 5%	0.49	0.48	1.13	1.11	0.51	0.50	1.04	1.23
CV%	6.48	6.05	11.49	11.00	7.11	6.70	10.47	12.12

Table 4. Effect of pre and post-herbicide on weed control efficiency in linseed

Treatments	Weed Control Efficiency (%)			
	30 DAS		60 DAS	
	2018-19	2019-20	2018-19	2019-20
T_1=Weedy check	0	0	0	0
T_2=Hand weeding twice	97.08	96.97	80.66	79.24
T_3=Metribuzin 250 g/ha + Oxyflourfen 125 g/ha (Pre.)	45.96	45.42	37.45	36.5
T_4=Pendimethalin 1 kg/ha (Pre.) fb. Metsulfuron methyl 4 g/ha (Post.)	52.62	50.44	48.21	47.95
T_5=Imazethapyr 75 g/ha (Post.)	33.12	32.37	26.94	26.33
T_6=Oxyflourfen125 g/ha (Pre.)	19.75	19.39	15.55	15.39
T_7=Metsulfuron methyl 4 g/ha (Post.)	31.89	31.15	16.86	16.8
T_8=Clodinafop 60 g/ha (Post.)	45.47	44.41	33.25	32.55
T_9=Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.)	58.58	56.42	54.17	52.62
T_{10}=Oxadiargyl 80 g/ha (Pre.)	11.19	11.03	9.52	9.68
SE(m)±	3.19	3.61	2.65	2.91
CD at 5%	9.93	11.23	8.24	9.05

3.3 Effect of Herbicide in Controlling Weed on Total Weed Count, Total Weed Dry Matter and Weed Control Efficiency

The experimental plots during the course of investigation were infested with numerous weeds. Total weed count (Table 3) at 30 DAS was recorded lowest in Hand Weeding twice (1.19 and 1.22 in 2018-19 and 2019-20 respectively) followed by Clodinofop @ 60 g/ha + Metsulfuron methyl @ 4 g/ha (post) (3.66 and 3.85 in 2018-19 and 2019-20 respectively) and highest in Weedy check (5.64 and 5.79 in 2018-19 and 2019-20 respectively). Likewise, total weed count at 30 DAS was also found least in Hand Weeding twice (3.04 and 3.19 in both the years respectively) that was comparable to Clodinofop @ 60 g/ha + Metsulfuron methyl @ 4 g/ha (post) 4.63 and 4.78 in both the year respectively) and maximum in Weedy check (6.79 and 6.90 in both the year respectively).

Results of two-year experimentation revealed that total weed dry matter (Table 4) was observed least in hand weeding twice (1.17 and 1.18 g/m^2 at 30 DAS and 3.43 and 3.57 g/m^2 at 60 DAS in both the years) and reported maximum in weedy check (5.22 and 3.38 g/m^2 at 30 DAS and 6.84 and 6.94 g/m^2 at 60 DAS in both the years).

Reduction in dry weight of weed accumulation leads to maximization of weed control efficiency (Table 4). With the application of Hand Weeding twice (interculturing at 30 and 60 DAS) recorded highest weed control efficiency (97.08 and 96.97% at 30 DAS and 80.66 and 79.24% at 60 DAS in both the years), which was followed by treatment Clodinofop @ 60 g/ha + Metsulfuron methyl @ 4 g/ha (post) having weed control efficiency of 58.58 and 56.42% at 30 DAS and 54.17 and 52.62% at 60 DAS in both the years. While, minimum weed index (0.00 at 30 and 60 DAS in both the years) was recorded under treatment Weedy check.

The best control of weeds in hand weeding twice at 30 and 60 DAS was due to less infestation of weed at later stage of crop growth along with cultural practices gave maximum weed control efficiency which was comparable to clodinofop @ 60 g/ha + Metsulfuron methyl @ 4 g/ha (post) [14-16]. Singh et al. [7]. also observed lower weed count, dry weight of weed and maximum weed control efficiency in hand weeding twice treatment compared to chemical weed control and weedy check in linseed.

4. CONCLUSION

Based on the results of the two years field experiment, it can be concluded that highest yield, economics as well as weed control efficiency in linseed can be achieved by maintaining weed free through hand weeding throughout crop growth period, where labours are easily available. In case of labours scarcity, application of Clodinafop 60 g/ha + Metsulfuron methyl 4 g/ha (Post.) was also equally effective.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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