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Effect of planting pattern and weed management on linseed equivalent yield and economics in linseed (*Linum usitatissimum* L.) + Chandrasur (*Lepidium sativum* L.) intercropping system

Hema Deshlahare, GK Shrivastava, YK Dewagan and Mahanand Sahu

Abstract
The experiment was carried out in Split plot design with three replications. The findings revealed that planting pattern and weed management had significant influenced on linseed equivalent yield (LEY) and economics. As regards to planting pattern, significantly highest LEY was recorded under T_4-linseed + chandrasur (2:1) row ratio, but it was at par to T_5- linseed + chandrasur (2:2) row ratio during both the years and on mean basis. As regards to weed management practices, significantly maximum LEY was recorded under W_3 -hand weeding (20 and 40 DAS), but it was at par to W_2 -mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) during both the years. Interaction effect between various planting pattern and weed management showed that, significantly maximum linseed equivalent yield was reported under interaction between T_4 -linseed + chandrasur (2:1) row ratio with W_3- hand weeding (20, 40 DAS) during both the years and on mean basis. As regards to planting pattern, the maximum economic returns was recorded under linseed + chandrasur (2:1) followed by linseed + chandrasur (2:2). In case of weed management practices, the maximum net return and B:C ratio was noted under mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) followed by hand weeding (20, 40 DAS) for net return and Oxadiargyl @ 80 g ha^{-1} pre emergence fb one hand weeding (20 DAS) for B:C ratio.

Keywords: Intercropping, linseed equivalent yield, weed management, economics

Introduction
India is an important linseed growing country in the world and it contributes 7% to the world linseed pool (Devendra *et al*., 2016) [3]. Among the oilseeds, linseed or flax (*Linum usitatissimum* L.) is one of the oldest crop, grown in almost all countries of world for oil, fibre and seed purpose. Linseed is unique among oilseeds for its technical grade vegetable oil producing ability and fibre (good quality having high strength and durability) production. It belongs to family Linaceae. Seed contains 33 to 47 percent oil. Seeds of linseed contain high levels of dietary fibers, micronutrients and omega-3 fatty acids. Linseed has two major fatty acids, 57% α linoleic acid (ω-3) and 16% linoleic acid ω-6 (Morris, 2007) [11]. Its oil has a lot of uses apart from human consumption *viz*. Oil paint, varnishes, printing ink, oil cloth, soap, patent leather and waterproof fabrics due to its fast volatility feature (Sharma *et al*., 2015) [14]. Linseed is mainly cultivated in the states like Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Rajasthan, West Bengal, Karnataka, Odisha and Bihar. Chandrasur is widely cultivated in temperate countries for various culinary and medicinal purposes. Nutritive value of its leaves and seeds is very high. Chandrasur seeds contain 18-25% protein, 14-24% lipids, 33-54% carbohydrates and 8% crude fiber (Sharma, 2020) [15]. The seeds are strong antioxidant. In India, a medicinal and aromatic plant grown is spread across the states of Rajasthan, Madhya Pradesh, Uttar Pradesh, Gujarat, and Maharashtra. Both these crops may form a perfect combination for improving their productivity and profitability. Intercropping system has some of the potential benefits such as increased productivity per unit area per unit time, high profitability, improvement in soil fertility, efficient use of resources and reducing damage caused by pests, diseases and weeds (Ghosh *et al*., 2006) [4]. Intercropping offers an excellent opportunity in sustaining their production through the best use of available resources and inputs by minimizing competition and by providing a barrier to the entry of many biotic pests. Intercropping is a technique to increase yield, income of farm and risk management by best utilization of resources.

These crop combinations can also be proved to seek risk coverage under present changing climatic scenario. Different intercrops and their spatial arrangement in intercropping have important effect on competition between component crops and their growth (Sarkar *et al*., 2000) [13]. Keeping in view, the present study was undertaken to select an appropriate row ratio of linseed + chandrasur intercropping system.

Materials and Methods

The experiment was carried out in Split plot design with three replications. In main plots, treatment consisted of five planting pattern *viz*., T_1- Sole linseed, T_2- Sole chandrasur, T_3- Linseed + chandrasur (1:1), T_4- Linseed + chandrasur (2:1), T_5- Linseed + chandrasur (2:2) and four weed management treatment combination *viz*., W_1- Oxadiargyl @ g ha^{-1} pre-emergence fb one hand weeding at 20 DAS, W_2- Mechanical weeding by cycle hoe + hand pulling intra rows at 25 DAS fb one hand weeding at 40 DAS, W3- Hand weeding (20, 40 DAS), W_4- Weedy check were assigned in sub plots. Application of fertilizer in sole linseed was 60:30:30 N, P_2O_5, K_2O kg ha^{-1}, whereas in case sole chandrasur, was 50:40:30 N, P_2O_5, K_2O kg ha^{-1}. Uniform dose of recommended fertilizer (RDF) was applied. Full dose of phosphorus and potassium was applied at the time of sowing, while only half of the recommended dose of nitrogen was applied at the time of sowing. The remaining half dose of nitrogen was top dressed at 25 days after sowing. The crop varieties used during experimentation are 'RLC-161' for linseed and 'GA-1' for chandrasur. Experimental data obtained was compiled and subjected to statistical analysis by adopting Fischer's method of analysis of variance (Gomez and Gomez, 1984) [5]. The critical difference values given in the table at 5% level of significance were used.

Linseed equivalent yield (LEY)

It was given by Willey (1979) [17]. The yield of different intercrops are converted into equivalent yield of anyone crop based on price of the produce. The LEY was calculated as follows LEY (kg ha^{-1}) = Economic yield of chandrasur (kg ha^{-1}) X Price of chandrasur (Rs ha^{-1}) ÷ Price of linseed (Rs ha^{-1})

Cost of cultivation

The cost of cultivation is the total expenditure incurred for raising crop in a cropping system. The cost included for this purpose consists of hired labour, cost of seed, fertilizes, herbicide and irrigation charges etc.

Gross returns

Monetary value of total produce obtained from the crops raised in the cropping system was calculated by using following formula:

Gross return (Rs ha^{-1}) = Crop yield (kg ha -1) x Price of yield (Rs kg-1)

Net returns

Net return of particular treatment was calculated by subtracting the cost of cultivation from gross return of that treatment. It is a good indicator of saitability of cropping system and it represent the actual income of the farmer.

Net return (Rs ha^{-1}) = Gross return (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

Benefit cost ratio

It is ratio of gross return to cost of cultivation. It gives an indicative of the true monetary gains over every rupee of investment under a particular treatment.

Results and Discussion

As regards to planting pattern, significantly highest LEY (1608.44, 1483.88 and 1546.16 kg ha^{-1}) was recorded under T_4-linseed + chandrasur (2:1) row ratio, but it was at par to T_5- linseed + chandrasur (2:2) row ratio (1583.28, 1452.05 and 1517.66 kg ha^{-1}) during both the years and on mean basis, respectively. This might be due to better yields and good prevailing market prices coupled with better utilization of resources by the component crops in the intercropping system. The similar results were found by Bahadur *et al*. (2016) [1] who reported that maximum linseed equivalent yield was recorded from linseed + dwarf field pea (4:1). Biswas *et al*. (2019) [2] noted the maximum wheat equivalent yield under wheat + mustard (3:1). Maheswari *et al*. (2022) [10] recorded the maximum linseed equivalent yield under linseed + chandrasur (3:1) row ratio. As regards to weed management practices, significant variation was reported on LEY. Significantly maximum LEY (1628.62, 1510.28 and 1569.45 kg ha^{-1}) was recorded under W3 -hand weeding (20 and 40 DAS), but it was at par to W2 -mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (1603.24, 1485.40 and 1544.32 kg ha^{-1}) during both the years, respectively. Whereas, minimum LEY (913.66, 849.00 and 881.33 kg ha^{-1}) was recorded under W4- weedy check during both the years and on mean basis, respectively. This might be due to better weed control reduced the crop weed competition for growth and development of crop and it offer better utilization of available resources. Similar results were found by Singh *et al*. (2002) [16], Haque *et al*. (2016) [8], Naher *et al*. (2018) [12] and Kumar *et al*. (2020) [9].

Interaction effect between various planting pattern and weed management showed significant variation on linseed equivalent yield in linseed + chandrasur intercropping system. Significantly, maximum crop equivalent yield (1861.67, 1722.07 and 1791.87 kg ha^{-1}) was reported under interaction between T_4 -linseed + chandrasur (2:1) row ratio with W3-hand weeding (20, 40 DAS), but it was at par to interaction between T_5- linseed + chandrasur (2:2) with W3- hand weeding (20, 40 DAS) recorded (1820.56, 1667.70 and 1744.13 kg ha^{-1}), T_3- linseed + chandrasur (1:1) with W_3-hand weeding (20, 40 DAS) recorded (1826.22, 1684.96 and 1755.59 kg ha^{-1}) and T_4 -linseed + chandrasur (2:1) with W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (1828.56, 1688.19 and 1758.37 kg ha^{-1}) during both the years and on mean basis, respectively as well as T_5- linseed + chandrasur (2:2) with W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (1784.22, 1633.14 kg ha^{-1}) and T_3- linseed + chandrasur (1:1) with W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (1794.44, 165665 kg ha^{-1}) during both the years, respectively. Whereas, minimum linseed equivalent yield (754.66, 727.33 and 741.00 kg ha^{-1}) was recorded under interaction between T_2 - sole chandrasur with W_4-weedy check during both the years and on mean basis, respectively. Similar findings were reported by Haque *et al*. (2016) [8],

Naher *et al*. (2018) [12] and Kumar *et al*. (2020) [9].

Economics

As regards to planting pattern, the highest cost of cultivation (29910, 31441 and 30675 Rs. ha^{-1}) was recorded under T_1-sole linseed during both the years and on mean basis, respectively. Whereas, among the intercropping, T_4- linseed + chandrasur (2:1) had maximum cost of cultivation (29652, 31180 and 30416 Rs. ha^{-1}) during both the years and on mean basis, respectively. As regards to weed management practices, the maximum cost of cultivation (32807, 34662 and 33734 Rs. ha^{-1}) was recorded under W3- hand weeding (20 and 40 DAS) followed by W2-mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (30887, 32562 and 31724 Rs. ha^{-1}) cost of cultivation during both the years and on mean basis, respectively. As regards to planting pattern, significantly the maximum gross return (75143, 71519 and 73331 Rs. ha^{-1}) was obtained under T4-linseed + chandrasur (2:1), but it was at par to T_5-linseed + chandrasur (2:2) recorded (74053, 69928 and 71991 Rs ha^{-1}) during both the years and on mean basis, respectively, as well as T_3 linseed + chandrasur (1:1) recorded (73631 and 69559 Rs ha^{-1}) gross return during both the years only, respectively. Similar findings were reported by Gupta and Singh (2017) [6] in chickpea + linseed (5:1), Gupta *et al*. (2019) [7] and Biswas *et al*. (2019) [2] in wheat + mustard (3:1) row ratio. As regards to weed management practices, the maximum gross return (79956, 76537 and 78246 Rs ha^{-1}) was recorded under W3- hand weeding (20 and 40 DAS), but it was at par to W2-mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) recorded (78744, 75314 and 77029 Rs ha^{-1}) during both the years and on mean basis, respectively. Similar finding was reported by Naher *et al*. (2018) [12]. As regards to planting pattern, significantly the maximum net return (45491, 40338 and 42915 Rs. ha^{-1}) was obtained under T_4-linseed + chandrasur (2:1), but it was at par to T_5-linseed + chandrasur (2:2) recorded (44525, 38704 and 41615 Rs ha^{-1}) and T_3-linseed + chandrasur (1:1) recorded (44103, 38334 and 41219 Rs ha^{-1}) net return during both the years and on mean basis, respectively. Significantly the maximum net return (47857, 42752 and 45304 Rs ha^{-1}) was recorded under W_2-mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS), but it was at par to W_3-hand weeding (20 and 40 DAS) (47148, 41875 and 44512 Rs ha^{-1}) during both the years and on mean basis, respectively. As regards to planting pattern, significantly higher B:C ratio (2.50, 2.26 and 2.38) was obtained under T_4- linseed + chandrasur (2:1) row ratio as compared to other planting pattern, but it was at par to T_5- linseed + chandrasur (2:2) (2.48, 2.21, 2.34) during both the years and on mean basis, respectively. Similar findings were reported by Gupta *et al*. (2017) [6] in chickpea + linseed (5:1), Gupta *et al*. (2019) [7] and Biswas *et al*. (2019) [2] in wheat + mustard (3:1) row proportion. As regards to weed management practices, significantly the maximum B:C ratio (2.55, 2.31 and 2.43) was recorded under W2-mechanical weeding by cycle hoe + hand pulling intra rows (25DAS) fb one hand weeding (40 DAS), but it was at par to W1- Oxadiargyl @ 80 g ha^{-1} pre-emergence fb one hand weeding at 20 DAS (2.49, 2.26 and 2.38) during both the years and on mean basis, respectively. Similar finding was reported by Naher *et al*. (2018) [12].

Table 1: Effect of planting pattern and weed management on linseed equivalent yield in linseed (*Linum usitatissimum* L.) + chandrasur (*Lepidium sativum* L.) intercropping system

Treatment			
Linseed equivalent yield (kg ha^{-1})			
	2020-21	**2021-22**	**Mean**
Planting pattern			
T_1- Sole linseed (30 cm)	1208.92	1132.33	1170.63
T_2- Sole chandrasur (30 cm)	1118.33	1060.35	1089.33
T_3- Linseed + Chandrasur (1:1)	1572.86	1445.16	1509.01
T_4- Linseed + Chandrasur (2:1)	1608.44	1483.88	1546.16
T_5- Linseed + Chandrasur (2:2)	1583.28	1452.05	1517.66
SEm±	11.46	12.58	11.90
CD (P= 0.05)	33.56	36.85	32.12
Weed management			
W_1- Oxadiargyl @ 80 g ha^{-1} pre- emergence fb one hand weeding (20 DAS)	1527.93	1414.34	1471.13
W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS)	1603.24	1485.40	1544.32
W_3 - Hand weeding (20, 40 DAS)	1628.62	1510.28	1569.45
W_4 Weedy check	913.66	849.00	881.33
SEm±	10.09	12.15	6.00
CD (P= 0.05)	29.15	35.10	17.34
T×W	S	S	S

Table 2: Interaction effect of planting pattern and weed management on linseed equivalent yield in linseed (*Linum usitatissimum* L.) + chandrasur (*Lepidium sativum* L.) intercropping system

Linseed equivalent yield (kg ha^{-1})						
Weed management Planting pattern	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	
2020-21						
W_1- Oxadiargyl @ 80 g ha^{-1} pre- emergence fb one hand weeding (20 DAS)	1320.33	1206.67	1699.68	1728.22	1684.78	
W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS)	1359.00	1250.00	1794.44	1828.56	1784.22	
W_3 - Hand weeding (20, 40 DAS)	1372.70	1262.00	1826.22	1861.67	1820.56	
W_4 - Weedy check	783.64	754.66	971.11	1015.33	1043.55	
2021-22						
W_1- Oxadiargyl @ 80 g ha^{-1} pre- emergence fb one hand weeding (20 DAS)	1225.00	1142.00	1557.84	1595.10	1551.72	
W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS)	1270.00	1179.00	1656.65	1688.19	1633.14	
W_3 - Hand weeding (20, 40 DAS)	1283.67	1193.00	1684.96	1722.07	1667.70	
W_4 - Weedy check	750.66	727.33	881.20	930.17	955.62	
Mean						
W_1- Oxadiargyl @ 80 g ha^{-1} pre- emergence fb one hand weeding (20 DAS)	1272.67	1174.33	1628.75	1661.66	1618.25	
W_2 - Mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS)	1314.50	1214.49	1725.55	1758.37	1708.68	
W_3 - Hand weeding (20, 40 DAS)	1328.17	1227.00	1755.59	1791.87	1744.13	
W_4 - Weedy check	767.02	741.00	926.15	972.75	999.58	
	2020-21		**2021-22**		**Mean**	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Factor (B) at same level of A	22.57	65.19	27.18	78.50	13.42	38.78
Factor (A) at same level of B	26.02	79.39	29.76	90.12	16.64	51.25

T_1- Sole linseed (30 cm), T_2- Sole chandrasur (30 cm), T_3- Linseed + Chandrasur (1:1), T_4- Linseed + Chandrasur (2:1), T_5- Linseed + Chandrasur(2:2)

Table 3: Effect of planting pattern and weed management on economics of linseed and chandrasur in linseed

Treatment	Cost of cultivation (Rs ha^{-1})			Gross return (Rs ha^{-1})			Net return (Rs ha^{-1}) B:C ratio					
	2020-21	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**	**2020-21**	**2021-22**	**Mean**
Planting pattern												
T_1: Sole linseed (30 cm)	29910	31441	30675	56208	54603	55406	26298	23162	24730	1.85	1.71	1.78
T_2: Sole chandrasur (30 cm)	29145	30667	29906	69829	68354	69092	40683	37687	39185	2.37	2.21	2.29
T_3: Linseed + Chandrasur (1:1)	29527	31224	30376	73631	69559	71595	44103	38334	41219	2.46	2.19	2.32
T_4: Linseed + Chandrasur (2:1)	29652	31180	30416	75143	71519	73331	45491	40338	42915	2.50	2.26	2.38
T_5: Linseed + Chandrasur (2:2)	29527	31224	30350	74053	69928	71991	44525	38704	41615	2.48	2.21	2.34
SEm±				851	850	585	851	850	585	0.02	0.02	0.01
CD (P= 0.05)				2553	2546	1733	2553	2546	1733	0.06	0.06	0.04
Weed management												
W_1: Oxadiargyl @ 80 g ha^{-1} pre- emergence fb one hand weeding at 20 DAS	30109	31704	30906	75155	71832	73493	45045	40128	42587	2.49	2.26	2.38
W_2: Mechanical weeding by cycle hoe + hand pulling intra rows at 25 DAS fb one hand weeding at 40 DAS	30887	32562	31724	78744	75314	77029	47857	42752	45304	2.55	2.31	2.43
W_3: Hand weeding (20, 40 DAS)	32807	34662	33734	79956	76537	78246	47148	41875	44512	2.43	2.20	2.32
W_4: Weedy check	24407	25662	25034	45238	43487	44362	20830	17825	19328	1.85	1.69	1.77
SEm±				478	613	315	478	613	315	0.01	0.01	0.01
CD (P= 0.05)				1383	1770	911	1383	1770	911	0.06	0.05	0.05
T×W				NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

As regards to planting pattern, significantly highest LEY was recorded under T_4-linseed + chandrasur (2:1) row ratio, but it was at par to T_5- linseed + chandrasur (2:2) row ratio during both the years and on mean basis. As regards to weed management practices, significantly maximum LEY was recorded under W3 -hand weeding (20 and 40 DAS), but it was at par to W2 -mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) during both the years. Interaction effect between various planting pattern and weed management showed that, significantly maximum linseed equivalent yield (LEY) was reported under interaction between T_4 -linseed + chandrasur (2:1) row ratio with W3- hand weeding (20, 40 DAS) during

both the years and on mean basis. As regards to planting pattern, the maximum economic returns was recorded under linseed + chandrasur (2:1) followed by linseed + chandrasur (2:2). In case of weed management practices, the maximum net return and B:C ratio was noted under mechanical weeding by cycle hoe + hand pulling intra rows (25 DAS) fb one hand weeding (40 DAS) followed by hand weeding (20, 40 DAS) for net return and Oxadiargyl @ 80 g ha^{-1} pre emergence fb one hand weeding (20 DAS) for B:C ratio.

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