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Effect of date of sowing and weed management on nutrient uptake by crop, nutrient depletion by weeds and economics of linseed (*Linum usitattissimum* L.)

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Abstract
The present research "Effect of date of sowing and weed management on nutrient uptake by crop, nutrient depletion by weed and economics of linseed (*Linum usitattissimum* L.) was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab during *Rabi* season of 2019-20. The experiment was laid out in split plot design with fifteen treatment combinations with three main plot treatments of Date of sowing (25th October, 04th November and 15th November) and five sub plot treatment of weed management (weed free, weedy check, pendimethalin @ 1 kg a.i./ha, clodinofop @ 60 g a.i/ha and imazethapyr @75 g a.i./ha) and all the treatments were replicated thrice. The maximum nutrient uptake by crop, gross return (₹/ha), net return (₹/ha) and B:C ratio was recorded under 04th November sowing and this was at par with 25th October sowing. However, the minimum nutrient depletion by weeds was observed under 25th October sowing which was at par with 04th November sowing. In weed management, maximum nutrient uptake by crop, minimum nutrient depletion by weeds, gross return, net return and B:C ratio was recorded under W_4 - Imazethapyr @ 75 g a.i./ha which was at par with W_3 - Clodinofop @ 60 g a.i./ha. However, minimum nutrient uptake by crop, maximum nutrient depletion by weeds, minimum gross return, net return and B:C ratio was observed under 15th November sowing. In weed management, weedy check plot recorded minimum nutrient uptake by crop, economics and maximum nutrient depletion by weed.

Keywords: Date of sowing, economics, linseed, nutrient depletion, and weed management

Introduction
Linseed (*Linum usitatissimum* L.) belongs to family Linaceae is 2nd important oilseed crop of *rabi* season after mustard. The proximate composition of linseed seed is moisture (6.9-7.4%), protein (20-24.8%), fat (37.8-43.2%), mineral/ash (3.9-4.8%), crude fibre (6.8-9.9%), and nitrogen free extract (12.6-16.8%) (Prasad *et al.*, 2012) [16]. The oil due to its quick drying property is used in the preparation of paints, varnishes, printing ink, oil cloth, soap, patent leather and waterproof fabrics (Singh *et al.*, 2008) [18]. It is one of the richest plant sources of omega-3 essential fatty acids (Bloedon *et al.*, 2004) [3]. Omega-3 fatty acid lowers levels of triglycerides in the blood, thereby reducing heart disease and also promise in the battle against rheumatoid arthritis (Amin *et al*., 2014) [2]. Since, the area under linseed is decreasing now days due to low yield, thus production techniques such as sowing time and weed management needs to be perfected. Date of sowing being non- monetary input but significantly affect growth character, yield and its components in linseed (Al-Doori, 2012). The sowing time minimize the negative impact of high temperature and moisture stress during the critical flowering and seed filling periods (Chauhan *et al.*, 2008) [4]. Among different date of sowing, highest nutrient uptake and accrued highest net realization with BCR was recorded in sowing on 1st week of November as compared to sowing on 3rd and 4th week of October and 2nd week of November in Gujarat (Prakash *et al.*, 2015, Ganvit *et al*., 2019) [15, 8].
An initial growth period of 20-45 days is very crucial and season long weed competition has been found to decrease linseed yield to the extent of 30-40% (Chhokar *et al*., 2012) [5]. However, hand weeding is most common but is slow as well as labour intensive and costly accordingly use of herbicide may be a suitable alternative for controlling the weed for higher returns (Husain *et al*., 2015) [9]. The effect of herbicide application on soil health make it imperative the choice of suitable herbicide, proper time of application of herbicide and proper dose is an important consideration.

Clodinofop either 60 g/ha or 80 g/ha at 30-35 DAS could be an alternative to isoproturon where Phalaris minor have shown resistance for isoproturon (Husain *et al.*, 2015) [9]. Pre mixed pre emergence application of pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg a.i./ha was on par with twice hand weeding (Siddesh *et al.*, 2016) [17]. Herbicide pendimethalin 30 EC @ 1000 g a.i./ha recorded lowest weed biomass with highest weed control efficacy (91.5%) (Acharya *et al.*, 2017) [1].

Materials and Methods

The research was conducted at Experiment farm of Mata Gujri College, Sri Fatehgarh Sahib, Punjab, India during the rabi season of 2019-20. The experiment was laid out in split plot design with three date of sowing and five weed management practices. The total treatment combinations are fifteen and replicated three times. The main plot are subjected to date of sowing, D_1- 25th October, D_2- 04th November and D_3- 15th November and sub plot are weed management practices, W_0- weed free, W_1- weedy check, W_2- pendimethalin @ 1kg a.i.ha^{-1}, W_3- clodinofop @ 60g a.i. ha^{-1}, W_4- imazethapyr @ 75 g a.i. ha-^{1}. The soil of the experiment field was clay loam in texture with pH 7.1. It was moderately fertile with available nitrogen (392 kg/ha), available phosphorous (10.304 kg/ha), available potassium (168.5 kg/ha), Organic carbon (0.69%), and electrical conductivity (0.32 dS/m). The sowing of linseed variety LC- 2063 was done with seed rate 35kg/ha at row to row spacing of 22.5 cm. Crop was sown according to treatments on 25th October, 04th November and 15th November, 2019. Recommended dose of fertilizer for linseed crop is 60, 40 and 30 kg/ha N, P_2O_5 and K_2O respectively. Full dose of P_2O_5, K_2O and half of N was applied as basal dose and remaining half dose of nitrogen at 30 DAS. After pre sowing irrigation, three irrigations were applied to crop. For effective weed control, herbicides were sprayed as per treatments. Weed free plot were given hand weeding throughout the crop season. Pendimethalin @ 1kg/ha were sprayed as pre emergence, Clodinofop @ 60 g/ha sprayed as post emergence at 30 DAS and imazethapyr @ 75 g/ha as Early post emergence at 22 DAS. The crop was harvested manually with the help of sickle on 12th April, 2020 at ripening, when the stem becomes woody and capsules turn hard. This can be known when the leaves are dry, capsules turn brown and the seeds become shiny. Then, harvested produced of net plot was kept in the field for sun drying then tied into labeled bundles. Regular biometric observations were recorded at periodic intervals of 30, 60, 90 DAS and at harvest stage from five randomly selected plants. Yield parameters were observed just before the harvesting of crop from five randomly tagged plants. Economic analysis was carried out using the prevailing market price. Statistical analysis was done as per the procedures given by Snedecor and Cochran (1968) [20]. The significance difference between the treatments was compared with the critical difference at ±5%.

Results and Discussions

Effect of date of sowing and weed management on nutrient content

The result showed that nutrient content of seed and stover did not affect significantly due to date of sowing and weed management practices (Table 1). The maximum nutrient content of N, P and K in seed and stover were recorded under date of sowing D_2 - 04 November followed by date of sowing D_1- 25 October and minimum nutrient content was reported in date of sowing D_3- 15 November. This is because delays in sowing might results the seeds face a more dry soil environment in later growing period and hence affected the growth and biomass production. Also, higher weed density was recorded which show nutrient deficiency. Certain weeds cause depletion of soil nitrogen by their absorption, and also induced the nitrification. Prakash *et al.*, 2015 [15] reported that nutrient uptake by the crop was highest in 14th November sown crop while it was lowest in crop which was sown on 14th December. Further, results showed that the highest nutrient content of N, P and K was observed under W_4-Imazethapyr @ 75 g/ha followed by W_3- Clodinofop @ 60 g/ha. This may be due to the low density and dry weight of weed, which reduced the dilution of nutrients. The minimum nutrient content in linseed was recorded under weedy check followed by W_2-Pendimethalin @ 1 kg/ha. Similar findings were reported by Pal *et al.* (2018) [13]. They reported that combination of fenoxyprop-p-ethyl with isoproturon at 30 DAS proved effective in highest uptake of N, P and K by crop.

Table 1: Effect of date of sowing and weed management on nutrient content (%) in seed and stover

Treatment	Seed (%)			Stover (%)		
	N	P	K	N	P	K
Date of sowing						
D_1 - 25 October	3.22	0.80	0.71	0.71	0.17	0.84
D_2 - 04 November	3.22	0.81	0.72	0.72	0.18	0.86
D_3 - 15 November	3.06	0.78	0.70	0.70	0.15	0.83
S.Em±	0.07	0.00	0.01	0.00	0.01	0.01
CD (5%)	NS	NS	NS	NS	NS	NS
Weed management NS						
W_0 - Weed free	3.24	0.81	0.73	0.73	0.18	0.85
W_1 - Weedy check	3.12	0.78	0.69	0.69	0.15	0.81
W_2-Pendimethalin @1 kg a.i./ha	3.16	0.79	0.70	0.70	0.16	0.84
W_3 - Clodinofob @ 60 g a.i./ha	3.16	0.80	0.71	0.72	0.17	0.85
W_4 - Imazethapyr @ 75 g a.i./ha	3.16	0.80	0.72	0.72	0.17	0.85
S.Em±	0.03	0.01	0.01	0.01	0.01	0.02
CD (5%)	NS	NS	NS	NS	NS	NS

Effect of date of sowing and weed management on nutrient uptake

The result of the present study revealed that the nutrient uptake by seed, stover and total uptake was significantly affected by date of sowing and weeds management practices (Table 2). Among date of sowing, the maximum nutrient uptake of N, P and K was recorded in D_2- 5th November sowing which was at par with crop sown on D_1- 25th October and minimum nutrient uptake was recorded in D_3- 15th November sown crop. This was due to prevailing favourable weather conditions. Therefore crop will perform better growth and development and ultimately higher crop yield under these treatments. With the delay of sowing, the growth and yield of crop decreased resulting low uptake of nutrients. Similar results were found by Prakash *et al.* (2015) [15]. However, in weed management, the maximum uptake of nutrients of N, P and K was recorded with the W_4-Imazethapyr @ 75 g/ha which was at par with W_3- Clodinofop @ 60 g/ha and minimum was observed in W_0 - weedy check plot**.** This is due to lower weed competition in terms of dry matter of weeds which provide better environment for more availability of nutrients and moisture and also restrict removal of nutrient by weeds which in turn encouraged better growth, healthy seed and resulted high seed yield which led to higher uptake of N, P and K.

Table 2: Effect of date of sowing and weed management on nutrient uptake by crop (kg/ha)

Treatment	Nutrient uptake by seed (kg/ha)			Nutrient uptake by stover (kg/ha)			Total uptake of nutrient (kg/ha)		
	N	P	K	N	P	K	N	P	K
Date of sowing									
D_1 - 25 October	48.60	11.90	10.82	21.96	5.29	26.01	70.28	17.13	36.99
D_2 - 04 November	51.13	12.53	11.44	22.89	5.64	26.99	73.51	18.15	38.59
D_3 - 15 November	33.23	8.00	7.60	15.88	3.68	18.76	46.49	11.40	24.66
S.Em±	1.35	0.17	0.21	0.36	0.21	0.42	0.92	0.26	0.59
CD (5%)	5.37	0.66	0.83	1.43	0.81	1.65	3.63	1.03	2.32
Weed management									
W_0 - Weed free	58.60	14.33	13.18	26.04	6.48	30.32	83.38	20.70	43.08
W_1 - Weedy check	31.87	7.60	7.05	15.05	3.30	17.77	44.28	10.66	24.81
W_2-Pendimethalin @1 kg a.i./ha	35.41	8.56	7.85	16.13	3.65	19.33	49.84	12.13	26.81
W_3 - Clodinofob @ 60 g a.i./ha	46.71	11.40	10.52	21.38	5.16	25.24	67.73	16.63	35.26
W_4 - Imazethapyr @ 75 g a.i./ha	49.11	12.17	11.17	22.63	5.77	26.94	71.91	17.68	37.11
S.Em±	1.21	0.32	0.26	0.61	0.28	0.89	1.43	0.36	0.79
CD (5%)	3.54	0.92	0.77	1.79	0.81	2.60	4.17	1.05	2.31

Effect of date of sowing and weed management on nutrient depletion by weeds

Nutrient depletion by weeds is known to be positively correlated with weed dry matter accumulation. Nutrient depletion by weeds was recorded non- significantly influenced by different sowing dates presented in (Table 3). Meanwhile, minimum nutrient depletion by weeds was recorded in D_1- 25th October sowing which was at par with D_2- 5th November sowing due to lower dry matter accumulation by weeds. Singh *et al.* (2014) [19] revealed that early sowing record the lowest nutrient depletion by weeds due to lesser weed density and dry matter of weeds. Similar results were also given by Neenu *et al.* (2017) [12] and Kumari *et al.* (2020) [10].

Among weed management, nutrient depletion by weeds was found to be significantly influenced by different weed management treatment presented in (Table 3). The minimum nutrient depletion by weed was recorded in W_4-Imazethapyr @ 75 g/ha which was at par with W_3- Clodinofop @ 60 g/ha and maximum nutrient depletion was in weedy check plot. Due to application of herbicide the weed density and dry matter is reduced thus reduced the nutrient uptake by weeds and crop growth is good therefore the depletion of nutrient is less. Weeds under uninterrupted growth remove more nutrients compared with the weed control treatments. It might be assigned for higher dry weight of weed recorded in weedy check treatment. Also similar results were reported by Acharya *et al.* (2017) [1], and Dwivedi (2018) [7].

Table 3: Effect of date of sowing and weed management on NPK depletion by weeds

Treatment	NPK depletion by weeds			Economics		
	N	P	K	Gross return	Net return	B:C ratio
D_1 - 25 October	9.48	7.89	8.95	98236.67	51002.09	1.08
D_2 - 04 November	9.84	8.92	9.67	103090.00	55855.42	1.18
D_3 - 15 November	16.13	12.45	13.26	70282.33	23047.75	0.47
S.Em±	1.47	0.93	0.01	1480.05	1480.05	0.03
CD (5%)	NS	NS	NS	5811.41	5811.41	0.13
Weed management						
W_0 - Weed free	0.00	0.00	0.00	117433.33	60171.80	1.05
W_1 - Weedy check	30.51	17.18	24.16	66292.78	22531.25	0.51
W_2-Pendimethalin @1 kg a.i./ha	11.24	12.18	12.35	72511.11	27034.33	0.59
W_3 - Clodinofob @ 60 g a.i./ha	9.22	10.06	8.61	95550.00	50688.47	1.13
W_4 - Imazethapyr @ 75 g a.i./ha	8.13	9.36	8.00	100894.44	56082.92	1.25
S.Em±	1.01	0.64	0.61	2469.91	2469.91	0.05
CD (5%)	2.96	1.88	1.79	7209.15	7209.15	0.16

Effect of date of sowing and weed management on economics of crop

The data pertaining to economics of crop analysis are influenced significantly due to date of sowing and weed management (Table 3). The further data indicates that the maximum gross return (103090.00₹/ha), net return (55855.42₹/ha) and benefit cost ratio (1.18) were recorded with D_2- 04 November which was at par with D_1- 25 October sowing and significantly superior over D_3- 15 November sowing. This is due to early sowing resulted better development of the seed and stover due to longer growing period than the late sowing. Similar results were showed by Devendra *et al.* (2016) [6], Maurya *et al.* (2017) [11]. However, in case of weed management, the maximum gross return (100894.44 ₹/ha), net return (56082.92 ₹/ha) and benefit cost ratio (1.25) were recorded with W_4- Imazethapyr @ 75 g/ha followed by W_3- Clodinofop @ 60 g/ha and significantly superior over rest of treatments. This might be due to the entire yield attributes and ultimately seed yield and stover yield found significantly maximum in the treatment which leads to the maximum gross returns, net returns and B:C ratio. Parwaiz *et al.* (2021) [14] reported that gross return was found statistically maximum in two hand weeding at 30 and 60 DAS which was significantly superior over other treatment and was at par with T_5-Imazethapyr 75 g/ha and T_8-Clodinafop 60 g/ha.

Conclusion

It can be concluded that higher nutrient content and their uptake as well as economics were recorded in D_2- 04 November followed by D_1- 25 October sowing. However, nutrient depletion by weeds is lower in D_1 - 25 October followed by D_2 - 04 November. Among weed management, the higher nutrient content and uptake i.e. N, P, K content and uptake in seed and stover was recorded in W_4- Imazethapyr @ 75 g/ha followed by W_3- Clodinofop @ 60 g/ha. However, amongst treatment combinations D_2W_4 - D_2 - 04 November with W_4- Imazethapyr @ 75 g/ha was found to be the best treatment in nutrient content, uptake and economic analysis followed by D_2W_3 - D_2- 04 November with W_3 - Clodinofop @ 60 g/ha.

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