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Review on impact of sowing methods and varieties combination on yield and yield attributes of linseed (*Linum usitatissimum*)

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Abstract
This review paper analyses the various impacts of sowing methods along with varieties combination in Linseed (*Linum usitatissimum*) on the yield and yield attributes. Linseed being an important oilseed crop, belongs to the family Linaceae and is a self-pollinated species of Rabi season. It has an oil content of 33-45 per cent and is also harvested for its fibre called 'linen'. The various experiments which have been conducted shows how the amount of yield produced changes along with change in sowing methods and used varieties which has been a recent interest due to the blooming market of functional food and fibre crop.

Keywords: Linseed, linen, yield

Introduction

The genotypes express variety under various conditions, especially with yield and yield crediting characters in linseed. In this manner, climate assumes a significant part in its creation. The low yield of linseed is portrayed primarily because of absence of high yielding genotypes, further absence of reaction to better conditions and the unsteadiness in yield of linseed because of fluctuating climate are likewise of extraordinary concern. Steadiness in execution is most attractive character of a genotype to be delivered as an assortment for wide appropriation. Data on strength of linseed genotypes before their proposal for development is exceptionally fundamental.

Linseed is exceptional among oilseeds and has acquired new interest in late past in a rising market of utilitarian food because of the presence of high substance of omega-3 for example alpha linolenic corrosive (36-57%), a fundamental polyunsaturated unsaturated fat alongside omega-6 for example linoleic corrosive (18-24%) (Ganorkar and Jain 2013). The restorative properties of linseed help in decreasing blood cholesterol, heart illnesses, rheumatoid joint pain alongside a few cancer prevention agent properties due to lignans. Linseed oil assumes a significant part in the assembling of paints, stains, printing ink, cushion ink, and so on, because of the quick drying properties it confers.

Internationally linseed covers a space of 3.26 million ha with the creation of about 3.18 million tons and usefulness of 1011.20 kg/ha. India positions fifth on the planet with the region, creation and usefulness of 0.32 million ha, 0.17 million tons and 543.8 kg/ha, separately (FAOSTAT 2018). While in Himachal Pradesh, 0.80 thousand ha is under linseed development with the creation of 0.24 thousand ha and normal usefulness of 243 kg/ha (Statistical year book of H.P 2018).

Linseed is developed after rice on minor and sub-negligible terrains with low or no-manures, generally under rainfed both as hand-off trimming "utera" in paddy decrepit and as upland in unbunded fields. In utera development, the vast majority of the ranchers use broadcasting strategy for planting without manure application, bringing about helpless soil seed dampness substance and seed may not get legitimate germination with diminishes plant development. In this way, there is pressing need to discover proficient strategy for planting for ideal stand foundation and higher creation and efficiency of the yield.

Materials and Methods

Environment Conditions

The environment area is sub sticky with warm and dry summer and gentle winter. It goes under agro-climatic sub zone of seventh agro climatic district of India for example eastern level and slopes. The normal yearly precipitation is around 1320 mm of which around 88 % is gotten during a range of four months for example between June to September. The precipitation is to a great extent contributed by south-west storm. The greatest temperature raises up to 45°C during summer and least temperature tumbles to 5-6 °C during winter season. The general moistness arrives at greatest 93 % and least 41 % in August and March, separately.

Treatment Details

The trial was separated into horizontal plots and vertical plots in split plot plan with three replications. It contained four planting strategies *viz*., zero tillage (T_0), harrowing once (T_1), rotavator once (T_2) and conventional tillage (T_3). Also, vertical plots were isolated into four irrigation schedule plans *viz*. one irrigation after seeding (I_0), one irrigation at 35 DAS (I_1), two irrigation at 35 and 75 DAS (I_2) and three irrigation at 0, 35 and 75 DAS (I_3).

Bulk density (mg m^{-3})

The core sampler technique (Black and Hartge, 1986) was accustomed to deciding the bulk density cores of 0.06 m diameter and 0.07 m height were utilized for taking the undisturbed soil center from 0-0.07 m and 0.15-0.22 m profundity. The soil examples were drawn at beginning stage and at reap of linseed during both the years. These sample cores drawn from the soil were oven dried at 105^{0}C for 48 hours and bulk density was determined by utilizing the accompanying formula:

$$BD\ (mg\ m^{-3}) = \frac{\text{Oven dry weight of soil (mg)}}{\text{Volume of soil } (m^3)}$$

Infiltration rate (cm hr^{-1})

Infiltration rate was estimated in-situ according to the technique portrayed by Bouwer (1986). Estimation of infiltration was made at harvest of linseed crop by utilizing a double ring infiltrometer. The two concentric rings of 0.30 and 0.50 m distance across and 0.30 m height were utilized. The rings were headed to a profundity of 0.10 m into soil by pounding delicately by wooden piece set on the highest point of rings. The fall in water level in the internal ring at various time spans was estimated with the assistance of hook guage at 20, 40 and hour long till the consistent perusing was acquired. Water head of 0.10 m was kept up in both the rings during estimation.

Number of capsules plant^{-1}

Complete number of containers were recorded from five arbitrarily labeled plants and mean was worked out by isolating the absolute number of capsules by five and utilized for measurable investigation.

Number of seeds capsule^{-1}

Ten containers were chosen from the bundle of five labeled plants, number of seeds were excluded and normal was worked.

1000-seed weight (g)

Same amount of the harvested grains from each net plot was dried in a oven at 60°C for 20-24 hours to get consistent weight. 1,000 seeds were taken from produce of every treatment, gauge and communicated as 1000 - seed weight in grams. The seeds were burdened electronic equilibrium.

Seed yield (q ha^{-1})

At physiological development, the yield harvested from each net plot. The gathered harvest was air dried, sifting, winnowing and gauged. Seed yield ha^{-1} was figured from yield per plot, which was showed in q ha^{-1}.

Stalk yield (q ha^{-1})

Subsequent to collecting of the harvest, sun dried in the field and the produce was tied in to groups. Stalk yield of plot was noted down after deduction of seed yield from group weight. Then, at that point the group weight of the tail (kg plot-1) was taken and stalk yield is communicated in q ha^{-1}.

Biological yield (q ha^{-1})

The harvested produce of each net plot was tied in groups independently. Stalk yield of plot was noted down after deduction of seed yield from group weight. Pack weight was recorded with the assistance of spring balance.

Harvest Index (%)

It is the proportion of monetary respect natural yield of the harvest. It was figures by utilizing following formula:

$$HI\ (\%) = \frac{\text{Grain Yield, q ha}^{-1}}{\text{Biological Yield, q ha}^{-1}} \times 100$$

Organic Carbon

Soil samples were gathered from each plot adhering to the standard soil inspecting at first and after harvest of linseed crops. Investigation of organic carbon (Walkley and Blacks rapid titration method: Black, 1965), available N (Alkaline permanganate method: Subbiah and Asija, 1956), P (Olsens NAHCO^3; Olsen, 1954) and K (Flame photometer method: Jackson, 1973) were done.

Table 1: Yield attributes of linseed as influenced by sowing methods x varieties and fertilizer levels

Treatment	Number of seeds capsule $^{-1}$	Number of capsules plant $^{-1}$	1000 - seeds wt. (g)
Sowing methods x Varieties			
S_0V_1: Broadcast x RLC-92	6.97	47.78	6.21
S_1V_1: Line sowing x RLC-92	9.09	66.18	8.43
S_2V_1: Criss-cross x RLC-92	7.90	49.61	7.34
S_0V_2: Broadcast x Deepika	7.66	47.14	6.06
S_1V_2: Line sowing x Deepika	8.86	65.04	8.29
S_2V_2: Criss-cross x Deepika	7.76	49.33	6.41
SEm±	0.23	0.65	0.14
CD (P=0.05)	0.92	2.05	0.45
F_0 : RDF	6.93	46.51	6.33
F_1 : RDF + S	8.39	57.41	7.39
F_2 : 50 % more RDF	8.79	58.63	7.65

SEm±	0.16	0.76	0.15
CD (P=0.05)	0.47	2.21	0.45

Table 2: Seed yield, stalk yield, biological yield and harvest index of linseed as influenced by sowing methods x varieties and fertilizer levels

Treatment	Seed yield (q ha^{-1})	Stalk yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Sowing methods x Varieties				
S_0V_1: Broadcast x RLC-92	9.13	22.67	31.71	28.78
S_1V_1: Line sowing x RLC-92	11.71	22.94	34.38	34.07
S_2V_1: Criss-cross x RLC-92	10.68	22.92	33.60	31.59
S_0V_2: Broadcast x Deepika	8.85	22.58	31.79	27.51
S_1V_2: Line sowing x Deepika	10.58	21.47	32.05	32.91
S_2V_2: Criss-cross x Deepika	9.16	21.83	31.99	31.69
SEm±	0.44	0.36	0.41	0.81
CD (P=0.05)	1.39	1.13	1.30	2.56
F_0 : RDF	8.03	19.97	28.02	29.16
F_1 : RDF + S	10.59	23.09	34.40	31.62
F_2 : 50 % more RDF	11.44	24.15	35.34	32.41
SEm±	0.31	0.40	0.38	0.57
CD (P=0.05)	0.91	1.17	1.13	1.68

Result and discussion

Yield attributes and yield

Number of seeds capsule^{-1}

The information on number of seeds capsule^{-1} as affected by sowing methods x varieties and fertilizer levels are given in Table 1. The quantity of seeds capsule^{-1} was altogether impacted by sowing methods x varieties and fertilizer levels. Number of seeds capsule^{-1} was recorded fundamentally higher under line sowing x RLC-92 (S_1V_1) when contrasted with different treatments, yet it was at standard to line sowing x Deepika (S_1V_2) during both the years and on mean basis.

The quantity of seeds case 1 was fundamentally higher under half more RDF (F2) when contrasted with RDF (F0) notwithstanding, it was found similar with RDF + S (F1) during both the years and on mean basis.

Number of capsules plant^{-1}

The information on number of capsules plant^{-1} as impacted by sowing methods x varieties and fertilizer levels are given in Table 1. The quantity of capsules plant^{-1} was essentially affected by sowing methods x varieties and fertilizer levels. Essentially higher number of capsules plant^{-1} was seen under line sowing x RLC-92 (S_1V_1) when contrasted with different treatments, however it was at standard to line sowing x Deepika (S_1V_2) during both the years and on mean basis.

In fertilizer levels, altogether higher capsules plant^{-1} was noted under half more RDF (F_2) than RDF (F_0) however it was at standard to RDF +S (F_1) during both the years and on mean basis.

Number of capsules plant^{-1} of linseed has been changed significantly because of the interaction of strategies of sowing x varieties and fertilizer levels (Table 4.41). The interaction between line sowing x RLC-92 (S_1V_1) and half more RDF (F_2) enlisted fundamentally higher number of capsules plant^{-1} when contrasted with other interactions, however it was at par to interactions between Deepika planted in lines x 50 % more RDF (S_1V_2 x F_2), Deepika planted in lines x RDF + S (S_1V_2 x F_1) and RLC-92 planted in lines x RDF + S (S_1V_1 x F_1) during both the years and on the mean basis.

Altogether higher number of capsules plant^{-1} was noted under line planting method than broadcasting. It could be because of the way that more number of branches permitted in bearing more number of capsules plant^{-1}. The development of more capsules plant^{-1} under normal planting in line was additionally detailed by Khare *et al.* (1999) [4] and most elevated number of panicle m^{-2} under drilling when contrasted with broadcasting technique in wheat was additionally detailed by Dhiman *et al.* (1997) [2].

1000-seed weight (g)

The information on 1000-seed weight of linseed as influenced by planting methods x varieties and fertilizer levels are introduced in Table 1. The outcomes uncovered that fundamentally higher 1000-seed weight (S_1V_1) when contrasted with different treatments, was at par to line planting x Deepika (S_1V_2) during both the years and on mean basis.

Among the fertilizer levels, treatment 50 % more RDF (F_2) enrolled altogether higher 1000-seed weight over RDF (F_0), however it was at par to RDF + S (F_1) during both the years and on mean basis.

Seed yield (q ha^{-1})

The data on seed yield of linseed as influenced by sowing methods x varieties and fertilizer levels are given in Table 2. The results revealed that among sowing methods x varieties significantly higher seed yield of linseed was observed under line sowing x RLC-92 (S_1V_1) as compared to other treatments, however, it was at par to criss-cross x RLC-92 (S_2V_1) and line sowing x Deepika (S_1V_2) during both the years and on mean basis. Linseed seeded under fertilizer levels showed significant variation in seed yield. The 50% more RDF (F_2) produced significantly higher seed yield (11.53, 11.34 and 11.44 q ha^{-1} in 2009-10, 2010-11 and on mean basis, respectively) than RDF (F_0), but it was comparable to RDF + S (F_1) during both the years and on mean basis.

The seed yield of linseed varied significantly due to the interactions between sowing methods x varieties and fertilizer levels (Table 4.43). The interaction between line sowing x RLC-92 (S_1V_1) and 50% more RDF (F_2) registered significantly higher seed yield as compared to other interactions, but it was at par to interactions between RLC-92 sown in criss-cross x 50 % more RDF (S_2V_1 x F_2), Deepika sown in lines x 50 % more RDF (S_1V_2 x F_2), RLC-92 sown in lines x RDF + S (S_1V_1 x F_1), RLC-92 sown in criss-cross x RDF + S (S_2V_1 x F_1) and Deepika sown in lines x RDF + S (S_1V_2 x F_1) during both the years and on mean basis.

The data on seed yield of linseed reveal that significantly highest seed yield of 11.71 q ha^{-1} on mean basis was noted under line sowing x RLC -92 (S_1V_1) followed by criss-cross x RLC -92 (S_2V_1) and line sowing x Deepika (S_1V_2). Increase in seed yield was also contributed due to corresponding increase in growth parameters *viz*., plant height, number of branches plant^{-1}, leaf area index and dry matter accumulation and yield components *viz*. number of seeds capsule^{-1}, number of capsules plant^{-1} and 1000-seed weight. It is well known fact that nitrogen, phosphorus and potassium play a major role in photosynthesis, development of capsules plant^{-1}, 1000-seed weight consequently helping in increased yield. This observation is in close conformity with the findings of Sharma and Thakur (1989) [9], Sood and Kumar (1993) [11], Dhiman *et al.* (1997) [2], Singh *et al.* (1997) [10] and Khare *et al.* (1999) [4].

The treatment line sowing produced higher yield followed by broadcast. Higher seed yield may be because of proper placement of seed and fertilizer through seed-cum-fertilizer drill and availability of nutrient for longer period. Whereas, in broadcast some of the applied nitrogen might have been lost due to volatilization from surface application as the soil reaction was conducive for such a loss. Similar results were reported by Bhati *et al.* (1989) [1].

The higher yield of linseed under 50% more RDF treatment can be ascribed due to higher value for growth parameters like plant height, dry biomass of plant, number of branches plant^{-1}, LAI and CGR during both the years. The above findings clearly suggest that higher nutrient doses enhanced the growth parameters, which ultimately increase seed yield. The higher yield obtained was also due to higher yield attributes *viz*., number of seeds capsule^{-1}, number of capsules plant^{-1} and 1000-seed weight. The similar findings were also obtained by Mahmud *et al*. (1997) [6] and Ramamoorthy *et al.* (1997) [7].

Stalk yield (q ha^{-1})

The data presented in Table 2 reveals that among sowing methods x varieties, the stalk yield of linseed was significantly higher under line sowing x RLC-92 (S_2V_1) as compared to other treatments, however, it was at par to criss-cross x RLC-92 (S_2V_1), broadcast x RLC-92 (S_0V_1) and broadcast x Deepika (S_0V_2) during 2009-10 and on mean basis. During 2010-11, treatment criss-cross x RLC-92 (S_2V_1) registered significantly higher stalk yield of linseed as compared to other treatments, but it was comparable to line sowing x RLC-92 (S_1V_1) and broadcast x Deepika (S_0V_2).

Linseed seeded under fertilizer levels showed significant variation in stalk yield. The 50% more RDF (F_2) produced significantly higher stalk yield (25.11, 23.19 and 24.15 q ha^{-1} during 2009-10, 2010-11 and on mean basis, respectively) than RDF (F_0), however, it was comparable to RDF + S (F_1) treatment during both the years and on mean basis. Similar findings have been also reported by Subbain and Ramaih (1981) [12].

The different sowing methods x varieties influenced the stalk yield and maximum stalk yield was obtained under line sowing x RLC-92 (S_1V_1) in 2009-10 and on mean basis and under criss-cross sowing x RLC-92 (S_2V_1) during 2010-11 as compared to other sowing methods x varieties. This treatment may be attributed to better performance of plant growth parameters (plant height, primary and secondary branches) through optimum utilization of resources which had direct bearing on the production of higher dry matter. This might also because of favourable physical environment that might have increased the mineralization mobility of fertilizer resulting higher nutrient uptake and crop growth thus, leading to higher dry matter production. The results are in conformity with the findings of Kondazatowicz (1970) [5] and Jaiswal and Singh (2001) [3].

Biological yield (q ha^{-1})

The data presented in Table 2 reveal that among sowing methods x varieties, the biological yield was significantly higher under line sowing x RLC-92 (S_1V_1) as compared to other treatments, however, it was at par to criss-cross x RLC-92 (S_2V_1) during both the years and on mean basis. Treatment line sowing x Deepika (S_1V_2) was also found comparable during 2010-11.

The biological yield was significantly affected due to fertilizer levels. Significantly higher biological yield of linseed was observed under 50% more RDF (F_2) than RDF (F_0), however, it was statistically at par to RDF + S (F_1) during both the years and on mean basis.

Harvest index (%)

The data presented in Table 2 reveal that among sowing methods x varieties, the harvest index was significantly higher under line sowing x RLC-92 (S_1V_1) as compared to other treatments, however, it was at par to criss-cross x RLC-92 (S_2V_1) and line sowing x Deepika (S_1V_2) during both the years and on mean basis. Treatment criss-cross x Deepika (S_2V_2) was also comparable on mean basis.

Harvest index was significantly affected due to fertilizer levels. Significantly higher harvest index was noted under 50% more RDF (F_2) as compared to RDF (F_0), however, it was statistically at par with RDF + S (F_1) during both the years and on mean basis. The similar findings were also reported by George *et al.* (1981) and Saxena *et al.* (1996) [8].

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