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Growth and yield of linseed varieties under different establishment methods and foliar nutrition in rice fallow

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Abstract
Field experiment was conducted on "Productivity and resource use efficiency of linseed (*Linum usitatissimum* L.) under conservation tillage and foliar nutrition in rice fallow" during 2018-19 laid out in a split-plot design with three replications. Six combinations of three methods of establishment namely, *paira* cropping, conservation tillage and conventional tillage and two varieties i.e., 'Arpita' and 'Kartika' were allotted to the main-plots and two foliar applications: water spray and 19:19:19 NPK (2%) + B (0.02%) spray before intiation of flowering stage to the sub plots. The soil was loamy sand, slightly acidic low in available N, high in available P_2O_5 and medium in available K_2O. The method of establishment and the variety influenced the growth parameters *viz*; plant height and LAI. Application of foliar spray induced flowering and increased capsules/plant, seeds/capsules as well as the yield of the crop. Linseed variety 'Arpita' under paira cropping supplemented with foliar application of 19:19:19 NPK (2%) + B (0.02%) at flowering produced maximum seed yield of 709 kg/ha and stalk yield of 2232 kg/ha. Variety 'Arpita' produced higher oil yield (259.1 kg/ha) than cv. 'Kartika' (224.8 kg/ha) and paira cropping recorded 253.2 kg/ha oil and 72.8 kg/ha protein.

Keywords: Linseed, paira, conservation tillage, Arpita, foliar nutrition

Introduction
Linseed (*Linum usitatissimum* L.), or flaxseed, occupies a greater importance among oilseeds owing to multiple uses and unique qualities. It is an industrial crop cultivated for its seeds, fibres and oil purpose. Farmers in the state usually fail to undertake timely sowing with conventional tillage after rice harvest, which results in shorter growth period available to late sown linseed coupled with high temperature and hot winds during reproductive growth period, which leads to forced maturity and ultimately poor grain yield. With availability of zero till drill, the crop can be grown immediately after harvest of the previous rice crop in the medium land situation without any turn over period to take advantage of early sowing and better utilization of residual soil moisture Mishra *et al*., (2016) [6]. Linseed is grown as paira crop under residual soil nutrients but the crops under similar farming situation grown in rice fallow have been reported to respond to foliar nutrition Dalei *et al.*, (2014) [1]. Though foliar nutrition did not serve as an effective supplement to or as a substitute for conventional soil fertilization practices, the crops grown in extremely deficient soil may be expected to respond to foliar fertilization. Supplementary foliar fertilization also increases plants' mineral status and improves crop yields Rajasekhar *et al.*, (2017) [9]. Improvement in productivity of the crop is required, particularly in rice fallow with different genotypes, methods of crop establishment and nutrition so as to have better utilization of the limited resources available at the farm level. Thus, a study on Growth and yield of linseed varieties under different establishment methods and foliar nutrition in rice fallow was carried out at the Central Research Station, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar.

Material and Method
The experiment was conducted during 2018-19 at the Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar (20° 26'N, 85°81'E, Odisha. The soil was loamy sand, slightly acidic in reaction (pH 5.67), low in organic carbon (0.45%) and available N (224.9 kg/ha), high in available P_2O_5 (31.4 kg/ha) and medium in available K_2O (54.1 kg/ha).

The experiment was laid out in a split- plot design with three replications. Six treatments with three methods of crop establishment (Paira, conventional and conservation tillage) and two linseed varieties 'Arpita' and 'Kartika' were allotted to the main plots and two nutrient management practices (Control -Water spray and 19-19-19 NPK (2%) + B (0.02%) spray just before initiation of flowering) in the sub-plots.

Linseed crop was sown in rows 30 cm apart behind the plough in the conservation and conventional tilled plots with a seed rate of 25 kg/ha. The *paira* cropped plots were broadcast 10 days before harvesting of the rice crop with 1.5 times of the recommended seed rate. The crop was fertilised with recommended dose of nitrogen (40 kg N/ha), phosphate (20 kg P_2O_5/ha) and potash (20 kg K_2O/ha) at the time of sowing in conservation and conventional tillage and one day before *paira* sowing. Foliar spray of 19-19-19 NPK (2%) + B (0.02%) in form of Borax (0.2%) was sprayed just before initiation of flowering. Quizalofop-p-ethyl (Targa super) was sprayed before flowering to control grassy weeds.

Five plants were selected at random and tagged in each plot to record the growth parameters of the plants at 15 days interval starting from 30 days after sowing (DAS). The plant height was measured in cm from the ground level up to the growing tip of the plant at 15 days interval starting from the 30 DAS. Leaf area index was calculated by dividing the leaf area per sample plant by the land area occupied by the sample plant. The average land area occupied by each plant was taken as 30 cm x 5 cm. Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR) were calculated as per Radford (1967). The yield attributes were studied from the five sample plants tagged before harvesting the crop. Capsules per plant, seeds per capsule (Fifty capsules were drawn randomly from five selected plants and were hand threshed and cleaned. The number of seeds was counted and then the average number of seeds per capsule was calculated), test weight (One thousand seeds were randomly drawn out of net plot produce and were weighed in electronic balance to record 1000-seed weight in gram). The bundle of the net plot produce of linseed was weighed and recorded in kg/ha. The weight of clean grains/seeds obtained from each plot was recorded. Finally, the seed yield per plot was converted into yield/ha by multiplying the hectare. Stalk yield for linseed were obtained plot wise by subtracting grain or seed yield from the biological yield. Harvest index was calculated as per formula given by Donald (1962) [2]. All collected data were analyzed with help of analysis of variance (ANOVA) technique for split plot design. The treatment variations were tested for significance by 'F' test. The standard error of mean SE (m) ± and critical difference (CD) at 5% probability level were calculated.

Result and Discussions

Growth parameters

Plant height

The data on mean plant height at various growth stages of the crop are presented in the Table 1. The plant height increased gradually during the crop growing period but the increment in plant height decreased after 60DAS till maturity. The varieties did not differ in their plant height at different stages of growth which was in line with Kariuki *et al.* (2014) [3] who reported that plant height was not significantly different among the linseed cultivars, while dry matter accumulation was significantly higher in cv. 'Raja' compared to all the other cultivars. The average plant height at harvest was 41.1 cm for variety 'Kartika' and 39.9 cm for 'Arpita'. Different methods of crop establishment also did not influence plant height at all the stages of crop growth except at 30 DAS, where plants were taller in conventional tillage than others. Foliar nutrition did not have any significant effect on the plant height during different crop growing stages.

Leaf Area Index

The mean LAI at various growth stages of crop is presented in Table 1. Variety and method of establishment influenced the LAI at different stages of growth. Linseed variety 'Arpita' exhibited more LAI than 'Kartika' at all the stages and was 0.41 at 60 DAS as compared to 0.37 for 'Kartika'. At all the growth stages, paira cropping registered higher LAI than conventional tillage, but was on a par with conventional tillage except at 75 DAS which was in conformity with the findings of Saha *et al.* (2010) [10] who reported the peak LAI and maximum biomass significantly differed between conventional and zero tillage system in mustard. Foliar nutrition did not render any significant results for LAI at any stage of growth.

Crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR)

Data on crop growth rate reported in Table 2 reveal that linseed attained maximum CGR of 8.46 g/m^2 /day during 60-75 DAS and was not affected by the variety, method of crop establishment or foliar nutrition. Although a significant difference in CGR was seen during 0-30 DAS with respect to different methods of establishment specifically in conventional method i.e., 0.48 g/cm^2 /day which was higher than the other methods and gradually increased up to 60-75 DAS in contrary to RGR which was not affected by the varieties, crop establishment methods and foliar nutrition, whereas significant difference was observed in the initial crop growing period i.e., 0-30 DAS stage in the *paira* cropping (0.12g/g/day). NAR of linseed increased progressively with crop growth and variety 'Arpita' and *paira* cropping registered significant effect on NAR at 30-45 DAS i.e., 0.72 and 0.76 mg/m^2 leaf area/day, respectively. Foliar nutrition also recorded higher CGR and NAR between 60-75 DAS and was superior to water spray. It is in conformity with the findings of Marzoka *et al.* (2018) [5].

Yield attributes

Variety 'Arpita' recorded highest number of capsules/plant than variety 'Kartik' (Table 3). Similar results were reported by Singh *et al.* (2013) [11]. The number of capsules/plant was higher in *paira* cropping, but was at par with conservation tillage and the lowest was in conventional method. Foliar nutrition with NPK and B produced higher number of capsules/plant as compared to control. The linseed varieties 'Arpita' and 'Kartika' did not exhibit any wider difference in the number of seeds/capsule and paira cropping among the other crop establishment methods did render effective results in producing more number of seeds/capsules, which was at par with conventional tillage. NPK and B spray reported to produce higher seeds/capsule (8.6) than water spray. The test weight in the cv. 'Kartika' was higher but was at par with cv 'Arpita'. Paira cropping indicated results with higher test weight (4.62 g), whereas foliar nutrition on the other hand did not show any distinct effect. These findings are in agreement

with findings of Mishra *et al.* (2016) [6] who reported significantly higher pods/plant and seeds/pod with utera as compared to zero tillage.

Crop Yield

Linseed cv. 'Arpita' produced seed yield of 638 kg/ha, which was higher than cv. 'Kartika' by 7.6 percent (Table 3). The stalk yield followed similar trend for cv. variety 'Arpita' (1975 kg/ha) which was 13.5 percent higher than cv. 'Kartika'. Higher yield in variety 'Arpita' may be due to its higher biomass accumulation and its proper partitioning. Such differences in cultivars have been reported earlier by Kumar *et al.* (2019a). Paira cropping registered higher seed yield (651 kg/ha) and was at par with conventional method of establishment (612 kg/ha), but was 11.5 percent higher than conservation tillage also the stalk yield of 1970kg/ha which was at par with conservation tillage, but was 13.2 percent higher than conventional tillage respectively. Higher yield in paira may be attributed to its advanced planting, better availability of residual soil moisture, higher biomass accumulation and its proper partitioning. Foliar spray of NPK and B improved seed yield and stalk yield by 6.2 percent and 7.1 percent over water spray respectively. The results are in the line with the findings of Pareek and Poonia (2011). The crop under conventional tillage registered the higher harvest index of 26.2 percent than paira (24.9%) or conservation tillage (23.9%).

Table 1: Effect of method of establishment and foliar nutrition on plant height (cm) and LAI of linseed varieties at different stages

Particular	Plant height					LAI			
	30 DAS	45 DAS	60 DAS	75 DAS	Harvest	30 DAS	45 DAS	60 DAS	75 DAS
Variety									
'Arpita'	15.9	28.9	37.6	39.8	39.9	0.12	0.22	0.41	0.29
'Kartika'	16.5	30.6	37.7	40.9	41.1	0.08	0.19	0.37	0.25
S.Em(±)	0.33	0.82	0.89	1.36	0.87	0.004	0.006	0.011	0.006
CD(0.05)	NS	NS	NS	NS	NS	0.01	0.02	0.04	0.02
Method of establishment									
Paira cropping	14.8	28.9	36.7	39.8	39.5	0.11	0.21	0.43	0.32
Conservation tillage	14.5	31.1	38.4	40.7	40.7	0.09	0.19	0.33	0.23
Conventional tillage	19.4	29.3	37.7	40.7	41.3	0.11	0.20	0.41	0.27
S.Em(±)	0.41	1.00	1.08	1.67	1.06	0.004	0.008	0.014	0.007
CD(0.05)	1.3	NS	NS	NS	NS	0.01	0.02	0.04	0.02
Foliar nutrition									
Water spray	16.3	29.5	37.4	40.0	40.0	0.10	0.21	0.39	0.27
19:19:19 NPK (2%) + B (0.02%) spray	16.1	30.0	37.8	40.8	40.9	0.10	0.20	0.39	0.28
S.Em(±)	0.15	0.32	0.59	0.64	0.86	0.003	0.004	0.011	0.006
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of method of establishment and foliar nutrition on CGR, RGR and NAR of linseed varieties at different stages

	CGR (g/m^2/day)				RGR (g/g/day)			NAR(mg/m^2 leaf area/day)		
Particular	**0-30 DAS**	**30-45 DAS**	**45-60 DAS**	**60-75 DAS**	**30-45 DAS**	**45-60 DAS**	**60-75 DAS**	**30-45 DAS**	**45-60 DAS**	**60-75 DAS**
Variety										
'Arpita'	0.34	1.05	3.52	8.44	0.07	0.07	0.06	0.72	1.17	2.71
'Kartika'	0.32	1.06	3.34	8.49	0.08	0.07	0.07	0.51	1.06	2.63
S.Em(±)	0.013	0.057	0.164	0.346	0.006	0.003	0.001	0.043	0.046	0.123
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	0.13	NS	NS
Method of establishment										
Paira cropping	0.14	1.31	3.34	8.35	0.12	0.08	0.07	0.76	1.14	2.60
Conservation tillage	0.38	0.92	3.23	7.55	0.06	0.07	0.06	0.58	1.05	2.45
Conventional tillage	0.48	0.94	3.72	9.49	0.05	0.07	0.07	0.51	1.16	2.96
S.Em(±)	0.016	0.070	0.201	0.424	0.007	0.003	0.001	0.052	0.056	0.150
CD(0.05)	0.05	NS	NS	1.34	0.02	NS	NS	0.16	NS	NS
Foliar nutrition										
Water spray	0.33	1.06	3.48	8.78	0.08	0.08	0.07	0.61	1.14	2.83
19:19:19 NPK (2%) + B (0.02%) spray	0.33	1.06	3.39	8.15	0.08	0.07	0.06	0.62	1.10	2.51
S.Em(±)	0.010	0.018	0.125	0.127	0.001	0.002	0.001	0.021	0.048	0.073
CD(0.05)	NS	NS	NS	0.39	NS	NS	NS	NS	NS	0.23

Table 3: Effect of method of establishment and foliar nutrition on yield attributes of linseed varieties

Particular	Capsules/plant	Seeds/capsule	Test weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)	HI (%)
Variety						
'Arpita'	24.2	8.4	4.37	638	1975	24.4
'Kartika'	22.5	8.4	4.45	593	1741	25.5
S.Em(±)	0.50	0.11	0.074	12.5	41.2	0.37
CD(0.05)	1.6	0.3	0.23	39	130	NS
Method of establishment						
Paira cropping	24.7	8.7	4.62	651	1970	24.9
Conservation tillage	23.1	8.2	4.17	584	1866	23.9
Conventional tillage	22.2	8.3	4.45	612	1739	26.2
S.Em(±)	0.61	0.13	0.091	15.3	50.5	0.46
CD(0.05)	1.9	0.4	0.29	48	159	1.4
Foliar nutrition						
Water spray	22.2	8.2	4.40	597	1795	25.1
19:19:19 NPK (2%) + B (0.02%) spray	24.5	8.6	4.43	634	1922	24.9
S.Em(±)	0.47	0.14	0.060	11.4	34.6	0.38
CD(0.05)	1.4	0.4	NS	35	107	NS

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