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Seed yield of linseed varieties grown as '*paira*' crop as influenced by dates of sowing

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Abstract: Linseed is an industrial crop cultivated for its seeds, fibres and oil purpose. Linseed crop can met their requirement *i.e.* moisture and nutritional demand from stored soil moisture and residual fertility status in '*utera*' or '*paira*' system of cropping. On the basis of this fact an experiment was conducted on "Seed yield of linseed varieties grown as *paira* crop as influenced by dates of sowing" in red and laterite zone of West Bengal during *rabi* season of 2012-13 and 2013-14 at Rice Research Station, Bankura, West Bengal, India. Poor in organic matter content, available phosphate and bases, hard structure of iron and aluminium patterned as honeycomb are present in the subsurface regions of the profiles and kaolinite is the predominant clay minerals of red and lateritic zone (western part) of West Bengal. This experiment was laid out in a split-plot design with three replications and compared two factors (dates of sowing and linseed varieties). Objective was identifying the optimum date of sowing and suitable linseed varieties grown as '*paira*' crop under changed climate in red and laterite zone of West Bengal. The experimental results revealed that the highest seed yield (534 kg ha^{-1} as pooled value) was recorded from the treatment D_1 *i.e.* linseed sown on 15th November. The lowest seed yield (489.2 kg ha^{-1} as pooled value) was obtained with treatment D_3 *i.e.* linseed sown on 29th November. Among linseed varieties, T-397 has yielded highest seed yield (573.4 kg ha^{-1} as pooled value). Lowest seed yield (409. 3 kg ha^{-1} as pooled data) was recorded from Neela variety. From the present study it may be concluded that linseed sown on 15th November is the best time and T-397 is the suitable linseed variety grown as '*paira*' crop under changed climate in red and laterite zone of West Bengal.

Keywords: Linseed, *Paira* crop, Sowing dates, Variety and Western zone of West Bengal

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is world old crop and an ancient fibre crop. It is more commonly known as flax in western countries. It is an annual herbaceous plant belonging to lineaceae family, which is native to west Asia and the Mediterranean that has been cultivated since at least 5000 BC (Saghayesh *et al*., 2014). All parts of this plant have extensive and varied uses. It has an industrial value and is also used as proteinaceous feed for livestock as well as for human (Raundal *et al*., 2015). It is one of the most important cultivated plants concerning its high nutritional potential such as protein content, water-soluble fibre fraction, lignin content, mucilage, linamarin, enzymes (El-Nagdy *et al*., 2010) and today is mainly grown for its oil (Oomah, 2001). It is a dual purpose crop for fibres and seeds. The long fibres are spun into linen yarns, moved into towelling, clothing fabrics and textiles. The short fibre are used for twins, paper manufacture and packing. It is an important oilseed cum fibre crop. Every part of the linseed plant is utilized commercially either directly or after processing. It is an important *rabi* oilseed crop in India and occupies 468 thousand ha area with productivity of 349 kg ha^{-1} (DES, Agricultural Statistics at a Glance, Govt. of India, 2010). It is grown under rainfed (63%), utrea (20%) and irrigated (17%) conditions (Rokade *et al*., 2015). It is grown both for its seed as well as fibre, which is used for the manufacture of linen. In addition, the oil obtained from seeds is considered an important source of essential poly unsaturated fatty acids (PUFA) in human diet.

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The seed contain about 30-40% fatty acids with easters of linoleic acid, linolenic acid, stearic acid and oleic acid that α- linolenic acid is the most important fatty acid in it (El-Nagdy *et al*., 2010). Its oil possesses a very healthy fatty acid profile, particularly Omega-3 (Alpha Linolenic Acid), which is richest source only in linseed (58%). The beneficial effects are mostly due to flax lipids. Flax oil is the richest plant source of linoleic (omega-6) and linolenic (omega-3) poly unsaturated fatty acids (PUFA), which are essential fatty acids for human since they can not be synthesized in organism and must be obtained from food and has several human health benefits. Linolenic acid is major compound of PUFA. Delaying in sowing decreased the linoleic and linolenic acid content but increased the palmitic and oleic acids. For the best production and fatty acid contents, it is postulated that the sowing date offers a high economic yield and oil quality. Therefore, it is used as edible oil for human consumption and in some medical industries. ALA (Alpha Linolenic Acid) provides beneficial effects in numerous clinical conditions viz., immune function, cardiovascular disease and inflammatory disorders, cancer etc. [AICRP report on Oilseeds (linseed), College of Agriculture, Nagpur]. It is used in the treatment of symptoms of omega-3 fatty acids deficiency such as neurologic and visual disturbances, hemorrhagic dermatitis, folliculitis and growth retardation. Furthermore, it has anticancer effects on breast, prostate and colon cancers (Jhala and Hall, 2010). Its seed contain about 35-47 percent oil and 11-32 percent protein (Raundal *et al*., 2015). It has quick drying property. So it is also used for the preparation of varnishes, paints, soap, oil cloth, printing ink and water proof fabrics. Straw from seed varieties is used in the manufacture of rugs, twine, upholstery rope and paper (Singh *et al*., 2008). The stem yields fibre of good quality having high strength and durability. The woody matter and short fibres are used as a raw pulp for making paper of quality. In addition, linseed meal is used as feed for livestock (Elayan sohair *et al*., 2015). Linseed is cool season crop and suited to tracts of low rainfall (Singh, 2009). In order to maximize the use of natural resources, the approximate sowing date is very important since it ensure good seed germination as well as the timely appearance of seedling and the optimum development of the root system. It also allows superposing the critical periods for seed yield and its components with the moment of the growth season where more environmental resources are available (Balalic *et al*., 2012). Therefore, attempts have been devoted to maximize linseed productivity per unit area by growing high yielding varieties as '*paira*' or by improving agronomic practices such as sowing date under changed climate in red and laterite zone of West Bengal, India.

MATERIALS AND METHODS

'*Utera*' or '*Paira*' crop may be defined as the crop which is taken with another crop in the same piece of land. When the first crop is at flowering stage, then the seeds of '*paira*' crop are broadcasted on the same land. There is no need for land preparation for '*paira*' or '*utera*' crop. Linseed crop can be included in the '*utera*' or '*paira'* cropping system after rice crop of *kahrif* season. It can meet their requirement from stored soil moisture and residual fertility in the soil under '*utera*' or '*paira*' system of cropping. On the basis of this fact, an experiment was conducted on "Seed yield of linseed varieties grown as *paira* crop as influenced by dates of sowing" in red and laterite zone of West Bengal during *rabi* season of 2012-13 and 2013-14 at Rice Research Station, Bankura, West Bengal, India. This experiment was laid out in a split-plot design with three replications and compared two factors (dates of sowing and linseed varieties) to identify optimum date of sowing with special reference to changed climate and suitable linseed varieties grown as '*paira*' crop regarding yield potentiality in red and laterite zone of West Bengal. Three levels of dates of sowing (D_1 = 15th November, D_2 = 22nd November, D_3 = 29th November] were randomly allotted in the three main plots; while four linseed varieties (V_1 = T-397, V_2 = LW-92-870, V_3 = *Parvati* and V_4 = *Neela*) were randomly allotted in the four sub plots of each main plot. Seven days of time interval is selected in between two date of sowing to avail the sufficient moisture level for germination of linseed seed in the *kharif* paddy field in *paira* system of cropping under changed climate.

The experimental site represents low rainfall area (drought prone) of the West Bengal state with average annual rainfall of 1200-1400 mm. The upland soils are mostly eroded with a very low water holding capacity. Crust formation in the upland soils is serious problem. This experiment was conducted in upland. Physico-chemical properties of the experimental soil up to the depth of 15 cm were studied following Jackson (1973) to know the initial status before conducting the experiment. The texture of experimental soil was sandy loam with slightly acidic in nature (pH: 5.4), 0.13 ds m^{-1} EC, organic carbon 0.43%, available P_2O_5 51 kg ha^{-1} and available K_2O 162 kg ha^{-1}. The soil of experimental field was medium in fertility status. The plot size was 4m x 3m. No fertilizers were applied as basal and split doses in this experiment. Only 2% urea was applied as foliar spray at 45 days after sowing (DAS) to obtain better seed yield and linseed varieties in this experiment were grown mainly by utilizing the stored soil moisture and residual fertility in the soil after harvesting of paddy crop of *kharif* season. One and two light irrigations were applied during flowering and seed development stages, respectively as the critical growth

stages for water of this crop to obtained good seed yield. Statistical analyses of data were carried out by using MSTAT and critical differences at 5% level of significance were calculated following Fisher (1937) and Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Number of capsule per plant: It is an important yield contributing character of linseed crop. The results of experimentation revealed that the levels of dates of sowing significantly influenced the number of capsule per plant at 5% level of significance. The highest number of capsule plant^{-1} was 39, 41 and 40 during both years of experiment and pooled value, respectively obtained from the treatment D_1 *i.e.* 15th November sown crop. It was statistically at par with the treatment D_2 *i.e.* 22nd November sown crop, where number of capsule plant^{-1} was 34.5, 37.1 and 35.8 during 1st, 2nd year and pooled value, respectively. This might be associated with linseed sown in 15th November was exposed to low temperature, more dew formation, higher coldness and resulted in higher growth characteristics, like plant height and number of capsule per plant. The results are in the conformity with those of Abdul EL-Dayem *et al*. (1998). The lowest number of capsule plant $^{-1}$ was 27.7, 30.4 and 29 during both years of experiment and pooled value, respectively recorded with the treatment D_3 *i.e.* 29th November sown crop (Table 1). It was significantly lower than other treatments at 5% level of significance. The lower capsule numbers observed with later flowering may be due to a temperature effect on pollination and ovary survival in delayed sowing dates (Mirshekari *et al*., 2012b). The results are in conformity with the findings of Shaikh *et al*., (2009) and they reported that sowing date has significant effect on some growth characteristics and yield attributes of linseed. This might be due to different sowing dates expose the linseed crop to

Table 1. Seed yield and ancillary characters of linseed varieties grown as '*paira*' as influenced by dates of sowing during *rabi* season of 2012-2013 and 2013-2014.

Treatments	No. of capsules per plant			1000-seed weight (g)			Seed yield (Kg ha^{-1})		
	1st Yr.	2nd Yr.	Pooled	1st Yr.	2nd Yr.	Pooled	1st Yr.	2nd Yr.	Pooled
Levels of dates of sowing									
D_1 (15th November)	39.0	41.0	40.0	5.08	4.98	5.03	531.7	536.4	534.0
D_2 (22nd November)	34.5	37.1	35.8	5.01	4.90	4.95	516.1	520.9	518.5
D_3 (29th November)	27.7	30.4	29.0	4.91	4.88	4.89	486.3	492.1	489.2
S.Em (±)	1.18	1.34	1.13	0.31	0.35	0.32	8.46	8.67	8.32
CD (P = 0.05)	4.65	5.01	4.21	NS	NS	NS	25.22	25.82	25.02
Linseed varieties									
V_1- T 397	42.1	45.0	43.5	5.15	5.10	5.12	571.2	575.6	573.4
V_2- LW-92-870	32.1	34.5	33.3	4.91	4.76	4.83	507.8	512.9	510.3
V_3- Parvati	36.9	39.8	38.3	5.04	5.02	5.03	560.2	564.8	562.5
V_4- Neela	23.9	25.4	24.6	4.89	4.80	4.84	406.1	412.5	409.3
S.Em (±)	4.94	4.52	4.64	0.38	0.41	0.39	15.31	15.68	15.12
CD (P = 0.05)	14.6	13.2	14.1	NS	NS	NS	45.50	46.05	45.21

Table 2. Interaction effects between dates of sowing and linseed varieties grown as '*paira*' on seed yield and ancillary characters during *rabi* season of 2012-2013 and 2013-2014.

Levels of dates of sowing (D)	Linseed varieties (V)	No. of capsules per plant			1000-seed wt. (g)			Seed yield (Kg ha^{-1})		
		1st Yr.	2ndYr.	Pooled	1st Yr.	2nd Yr.	Pooled	1st Yr.	2nd Yr.	Pooled
D_1	V_1	48.5	51.2	49.8	5.25	5.12	5.18	592.6	596.4	594.5
	V_2	37.1	38.5	37.8	5.03	4.89	4.96	528.3	532.1	530.2
	V_3	43.4	45.6	44.5	5.15	5.18	5.16	580.2	584.8	582.5
	V_4	27.3	28.7	28.0	4.89	4.75	4.82	425.7	432.5	429.1
D_2	V_1	43.6	46.4	45.0	5.13	5.16	5.14	575.8	578.3	577.0
	V_2	32.5	35.3	33.9	4.87	4.56	4.71	512.7	517.6	515.1
	V_3	37.3	39.5	38.4	5.05	5.01	5.03	568.4	572.2	570.3
	V_4	24.6	27.2	25.9	4.97	4.87	4.92	407.5	415.7	411.6
D_3	V_1	34.3	37.5	35.9	5.08	5.02	5.05	545.3	552.3	548.8
	V_2	26.7	29.7	28.2	4.82	4.85	4.83	482.6	489.2	485.9
	V_3	30.2	34.3	32.2	4.92	4.89	4.90	532.1	537.4	534.7
	V_4	19.8	20.4	20.1	4.80	4.78	4.79	385.3	389.5	387.4
D at same V										
S.Em (±)		8.5	7.8	7.2	0.66	0.69	0.67	26.52	25.63	24.23
CD (P = 0.05)		25.4	23.5	22.4	NS	NS	NS	78.81	75.09	74.14
V at same of different D										
S.Em (±)		7.51	8.2	7.24	0.65	0.68	0.67	24.48	23.58	22.47
CD (P = 0.05)		22.4	24.9	22.1	NS	NS	NS	75.53	73.52	74.16

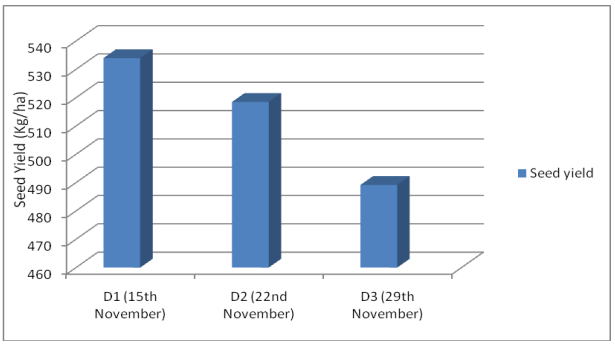

Fig. 1. *Seed yield of linseed as influenced by different dates of sowing.*

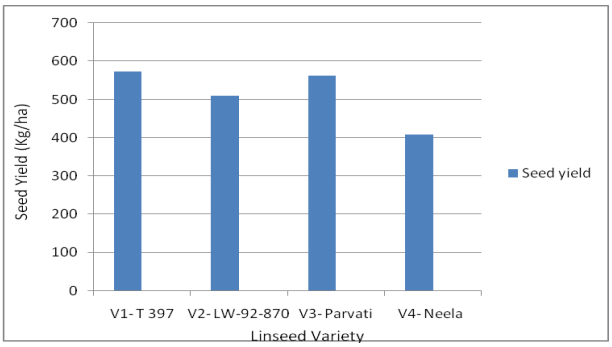

Fig. 2. *Seed yield of linseed as influenced by different varieties.*

climatic condition hence, obstruction in seed filling in capsule of linseed varieties and adversely reflects it in number of seed per capsule. This result is in agreement with the findings of Dixit *et al*. (1992) and Abdul El-Dayem *et al*. (1998).

From the experimental results (Table 1) it was revealed that the levels of linseed varieties significantly influenced the number of capsule plant^{-1} at 5% level of significance. The highest number of capsule plant^{-1} (42.1, 45 and 43.5 during both years of experiment and pooled value, respectively) was obtained from the treatment V_1 *i.e.* T-397 linseed variety. It was statistically at par with the treatment V_3 *i.e.* Parvati, which recorded 36.9, 39.8 and 38.3 capsules plant^{-1} during 1st, 2nd year and pooled value, respectively. The interaction between dates of sowing and linseed varieties significantly influenced the number of capsules per plant in both seasons and pooled value (Table 2).

Test weight: From the results of experimentation it was revealed that the test weight *i.e.* 1000-seed weight was not significantly influenced by the dates of sowing and linseed varieties in both the years and pooled value (Table 1 and 2). The result is in agreement with the findings of Farhadi *et al*. (2013) and they reported that sowing dates had no significant effect on test weight.

Seed yield (Kg ha^{-1}): It was revealed from the experimental results that the levels of date of sowing significantly influenced the seed yield at 5% level of significance. The highest seed yield was 531.7, 536.4 and 534.0 kg ha^{-1} during *rabi* season of 2012-13 and 2013-14 of experimentation and pooled value, respectively recorded from the treatment D_1 *i.e.* 15th November sown crop. It was statistically at par with the treatment D_2 *i.e.* 22nd November sown crop, where seed yield was 516.1, 520.9 and 518.5 *kg ha^{-1}* during 1st, 2nd year and pooled value, respectively. This might be due to sowing date on 15th November was favourable to high seed production because the post anthesis period coincide with the relatively low temperature. The lowest seed yield was 486.3, 492.1and 489.2 kg ha^{-1} during both years of experiment and pooled value, respectively recorded with the treatment D_3 *i.e.* 29th November sown crop (Table 1 and Fig. 1). The seed yield obtained with 29th November sown crop was lower than other treatments of sowing dates. It was significantly lower than other treatments at 5% level of significance. However, late sowing date was unfavourable to seed yield. The results are in conformity with the findings by Kalita *et al*. (1999). Moreover, sowing of flax/ linseed on the 15th November suppressed these sown on 29th November in seed yield per ha. The increase in seed yield ha^{-1} due to sown on the 15th November may be attributed to increase in number of fruiting branches per plant which reflected increases in capsules number as well as seed number per unit area and that in turn reflected increases in seed yield per ha. The inferiority of delaying sowing to last November may be attributed to the short period of vegetative growth and the adverse weather conditions such as temperature, which were beyond the optimum degree for vegetative and reproductive stages that resulted in low photosynthetic products accumulated in the source (leaves) and transplanted to the sink (seeds) (Al-Doori, Saad A.; 2012). This might be due to impact of changed climate on crop production is expected for various latitude limits for all the crop seasons and the linseed crop is most affected during winter season. Linseed crop require cool climate and moderate temperature (not exceeds above 32^{0}C). Increase in temperature affects on flowering and causes low yield. Amongst various agronomic practices, the time of sowing plays an important role in influencing the quality and yield of linseed. Normal sowing have longer growth period which consequently provide an opportunity to accumulate more biomass as compared to late sowing hence manifested in higher seed and biological yield (Dixit *et al*., 1992). Sowing date had no significant effect on seed weight, but it had significant effect on seed yield. It was maximum in first sowing date and decreased with delaying sowing in agreement with the findings of Farhadi *et al*. (2013) which may be due to a high temperature effect on pollination and seed development and long photo period that exist during capsules development. High temperatures during the period of reproductive growth lead to decline of reproductive growth period, failure in the number of crops and finally decreased the number of

seeds and then the decline comes to seed yield (Aldoori, 2012). Ghanem, 1990 reported that increases of seed yield due to increases of dry matter accumulation in the later formed capsules may be attributed to high temperature and long photoperiod that exist during capsules development. The increase in seed yield per ha due to sowing on 15th November may be due to the increase in number of branches per plant and number of capsules per plant which reflects in higher seed yield. Similar conclusions were reported by El-Refaey *et al*., 2010. As sowing dates affected significantly the productivity and seed yield as reported by EL-Deep and Abd EL-Fatah, 2006. They reported that sowing linseed on 15th November recorded the mean of straw and seed yields as well as its components. The results are in conformity with the findings of Shaikh *et al*., (2009) and they reported that sowing date has significant effect on seed yield, oil and protein contents of linseed.

It was revealed from the experimental results that among different linseed varieties, T-397 has yielded highest seed yield of 571.2, 575.6 and 573.4 kg ha^{-1} during *rabi* season of 2012-13, 2013-14 and pooled value, respectively. It was statistically at par with the seed yield obtained from Parvati (560.2, 564.8 and 562.5 kg ha^{-1}) during both years of experimentation and pooled value, respectively under '*paira*' system of cropping and it was statistically significant than other varieties at 5% level of significance (Table 1 and Fig. 2). The lowest seed yield (406.1, 412.5 and 409.3 kg ha^{-1} during *rabi* season of 2012-13, 2013-14 and pooled value, respectively) was recorded from linseed variety Neela. It was significantly lower than other linseed varieties at 5% level of significance. The results in Table 1 and 2 indicated that linseed varieties significantly differed in number of capsules per plant and seed yield per ha in both the years and pooled value. The differences between linseed varieties in seed yield per ha might be attributed to their differences in growth traits such as number of fruiting branches reflected differences in yield components such as number of capsule per plant as well as 1000-seed weight and hence increased seed yield per plant as well as per unit area. The results are in agreement with the findings of El-Shimy *et al*. (2001), El-Shimy *et al*. (2002), Dimmock *et al*. (2005) and Hussein (2007) and they observed that flax genotypes significantly differed in number of capsules per plant and finally seed yield per hectare.

Among the four linseed varieties, T-397 exerted first promising yield attributing characters (mainly capsule per plant) during investigation, which reflected in seed yield. The climatic condition and genetic makeup of variety had better interaction, which could be enhanced growth and development of capsules. The increased in seed yield by the linseed varieties, like T-397 mainly due to overall respective performance in growth and appreciable improvement in the yield attributing characters. Productivity of crop is collectively determined by vegetative growth coupled with higher yield attributes resulting in higher seed yield. Significant variations in seed yield of linseed varieties as '*paira*' crop in western part of West Bengal have also been reported by Jana *et al*. (2013) and they reported that T-397 and Parvati performed better as '*paira*' or '*utera*' crop after harvesting of paddy in red and laterite zone of West Bengal. The interaction between dates of sowing and linseed varieties had a significant effect on seed yield in both years of experiment and pooled value (Table 2). The results indicated that linseed variety T 397 gave the highest seed yield of 594.5 kg ha^{-1}, when sown on 15th November.

Incidence of pests: No pests and diseases were observed during both years of this experimentation in the research field. The result is in agreement with findings of Singh and Singh (2004) and they reported that linseed crop sown on 5th November gave highest yield and less disease intensity. The most widely cited insect of this crop are cutworms, grasshoppers, aster leaf hopper and aphids (Saha, 2003). The serious diseases of flax are fusarium wilt (*Fusarium oxysporum* f. Sp. *lini*) and linseed rust (*Melampsora lini*). Most can be reduced or controlled by using resistant varieties, cultural practices and careful use of crop rotation (Anonymous, 2008).

Conclusion

This '*utera'* or '*paira'* system of cropping of linseed is most important approach for saving water, fertilizer and labour etc. View extrapolated from the results of this experiment that linseed crop can be successfully grown in '*paira*' system of cropping. '*Paira*' cropping of linseed crop is much beneficial for the farmers of West Bengal, particularly in red and laterite zone of the state and it can be grown without manuring the field. Linseed variety T-397 has yielded highest seed yield of 573.4 kg ha^{-1} (pooled value) during *rabi* season. The highest seed yield was 534.0 kg ha^{-1} during *rabi* season (pooled value) recorded from the 15th November sown crop. The T-397 variety has recorded excellent performance and contributed to maximum seed yield in '*paira*' cropping system, when sown on 15th November under changed climate. Performance of parvati variety was also better under red and laterite zone of West Bengal, India. In summary, it is concluded that sowing date was a very important management tool in minimizing the negative impact of high temperature during critical flowering and seed filling periods. From the present study it may be concluded that sowing of linseed cv. T 397 with 15th November was found advantageous in recording more seed yield. Thus, it can be concluded that the date of 15th November was found superior for growth, yield attributes and seed yield of linseed. The linseed variety T 397 was

suitable for '*piara*' or '*utera*' system of cropping with regards to growth, yield attribute and seed yield. The results of the present study may be helpful for recommendation of optimum sowing date for linseed production in similar climatic condition.

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