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Research Note

Per se performance, components of genetic variation and correlation for seed and oil yields in linseed germplasm (*Linum usitatissimum* L.)

Abdul Nizar, M. and R.M. Mulani[1]
ICAR-NBPGR Regional Station , Akola - 444 104, (Maharashtra)
[1] School of Life Science, SRTM University, Nanded (Maharashtra)
E-mail: nbpgrnizar@yahoo.co.in

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Abstract
Field experiments were conducted involving 103 indigenous and exotic accessions of linseed germplasm during rabi 2011-12 and rabi 2012-13 at ICAR-NBPGR Regional Station, Akola with an objective to characterize the germplasm, assess the relative performance, estimate the genetic variability, heritability, genetic advance, correlation among seed and oil yields with other traits. The magnitude of variability for qualitative traits like seed coat colour, petal colour, flower shape, flower size and seed size was relatively higher than that of growth habit, lodging tendency and seed lustre. High GCV was recorded for seed yield per plant and number of capsules per plant and low GCV for days to maturity and oil content. High heritability coupled with high GA was recorded for number of capsules per plant and seed yield per plant and low heritability and GA was recorded for oil content. Significant positive correlation was recorded between seed yield with number of capsules per plant, plant height, days to maturity and 1000 seed weight at genotypic and phenotypic levels. Seed oil content was positively correlated with 1000 seed weight.

Keywords
Linum usitatissimum, germplasm, variability, heritability, correlation, donor.

Linseed or flax (*Linum usitatissimum* L.) belongs to the family *Linaceae*, is an important oil-cum-fibre crop. The seed contains 33-47% edible oil while the stem contains 17-37% bast fibres (Muir and Westcott, 2003). Linseed oil is the oldest vegetable oil in the world. It is distinctive from other oils as it contains a large amount of (52-63%) α-linolenic acid, a form of omega-3 fatty acids which has desirable cholesterol and health effects. Divergent selection for fibre flax and linseed flax during the early human dispersion has resulted in a wide range of infra-specific variability in the crop. The ICAR-National Bureau of Plant Genetic Resources Regional Station, Akola, Maharashtra has been engaged in collection, characterization, evaluation, conservation of linseed germplasm. The Station is maintaining 722 linseed accessions of indigenous and exotic origin. Characterization and evaluation studies were undertaken for two consecutive years with 103 accessions with an objective to identify donor for economically important traits, estimate the components of genetic variation and correlation for seed and oil yield with their component traits.

The germplasm for the study consisted of 75 indigenous accessions of seed flax, 25 exotic accessions and three check varieties *viz.*, H-local, Garima and Kiran. Field experiment was conducted under irrigated condition in black soil during *rabi* 2011-12 and *rabi* 2012-13 at ICAR-NBPGR Regional Station, Akola (Maharashtra) in RBD with two replications. Each accession was sown in three meter long row with spacing of 60 x 10 cm. The package of practices as recommended in the Maharashtra State for linseed was followed to raise good crop. Observations on qualitative traits such as early plant vigour, petal colour and petal shape, flower size, lodging tendency, seed size, seed lustre and seed coat colour were recorded following the procedures outlined in the minimal descriptor (Mahajan *et al.*, 2000). Observations on seven quantitative traits *viz.*, days to 50% flowering, days to maturity, plant height, number of capsules per plant, 1000 seed weight, seed yield per plant and oil content were recorded. Oil content in the dried seed sample was determined using the Nuclear Magnetic Resonance (NMR). The combined analysis of variance for the mean data of two years was performed as per the statistical procedure given by Gomez and Gomez (1984). The various genetic parameters such as genotypic and phenotypic co-efficient of variances (GCV and PCV) were estimated following Burton and Devane (1953), heritability in broad sense by Hanson (1963), genetic advance as percentage of mean following Johnson *et al.* (1955) and genotypic correlation by Singh and Chaudhary (1985).

Variability for qualitative traits:The petal colour varied from white to blue through light blue. Pink and purple petal accessions were not observed. Blue colour was the most common (64 out of 103 accessions) followed by light blue (37 accessions) and white. White petal was rare; only 2 accessions (IC 118888 and IC 249012) exhibited this colour.

Several *Linum* species have the potential to be used as ornamental plants. The red flowered *L. grandiflorum* are often used as ornamental plants. However, pink and purple petal germpalsm was not found in the germplasm studied. White petal was rare in the indigenous collection as only two accessions *viz.*, IC 118888 and IC 249012 showed this colour. Greater variability for petal size was reported in germplasm collection by Nozkova *et al*. (2006) and for petal size shape and petal colour by Brutch *et al.* (2001). In the present study, 20 accessions showed small flowers, 64 showed medium flower and 19 showed large flowers. Three types of petal shape *viz*., funnel, disc and star shape were recorded in the germplasm collection. Seventy seven accessions exhibited funnel shape petal, while 25 accessions bear disc shape petal. Only one accession (IC 249012) showed star shaped flower. Lodging was not observed in 25 accessions whereas 78 accessions showed tendency to lodge. These important non-lodging accessions such as EC 001475, EC 041762, IC 212041, IC 268337, IC 567352, can be utilized as donor for improving the agronomic performance and yield of fibre type flax. The early plant vigour was recorded under three categories *viz*., poor, good and very good. Out of 103 accessions none were poor, 67 accessions were rated as good and 36 as very good. Twenty one accessions exhibited very good early vigour combined with higher seed yield. Some of them were EC 541211, IC 320984, IC 345393, IC 424547. These germplasm may serve as the best parental line in drought resistant breeding programme.

Large size seed was observed in 26 accessions, few important one were EC 001475, EC 041762, EC 541203, IC 118886. Small size seed was observed in 19 accessions and medium size in 58 accessions. These large size seed accessions listed above are the worthwhile germplasm for improving oil type linseed. The surface appearance of seed was shiny in 20 accessions whereas intermediate in 82 accessions. Seed coat colour varied from yellow brown to dark brown. Brown seed coat was found in 63 accessions, dark brown seed coat in 22 accessions, light brown in 17 accessions and yellow brown in one accession (EC 541206). Diederichsen and Fu (2008) reported the positive correlation between seed colour and seed weight with seed oil content. Yellow seeded flax accessions had higher seed weight and oil than brown seeded flax accessions. However, in this study pure yellow seeded accessions could not be seen rather one yellowish brown accession (EC 541206) was found. This accession may be used in the future breeding programme aimed at improving seed size and seed oil content.

Variability for quantitative traits:The range, mean, GCV, PCV, heritability in broad sense (h^2), and genetic advance (GA) as percentage of mean worked out based on the pooled mean of 2011-12 and 2012-13 are given in Table 2. Simple measure of dispersion like range gives an indication on the extent of variability for quantitative traits. The extent of variability was high for plant height, number of capsules per plant, days to 50% flowering and days to maturity and low for 1000 seed weight, oil content and seed yield per plant. Previous reports (VIR, 2000; Brutch *et al.* 2001) indicated high variability for plant height and oil content in Russian germplasm collection. Zimmerman and Klosterman (1959) reported low range for oil content in the germplasm which corroborate with the results of the prese7nt study. Estimates of PCV and GCV obtained for different quantitative traits (Table 2) revealed that the magnitude of PCV was higher than the respective GCV for all the traits suggesting that these traits are influenced by environment. Sivasubramanian and Menon (1973) categorized the GCV and PCV estimates into three categories *viz*., low (0-10%), moderate (10-20%) and high (>20%). The same scale is employed to interpret the results. The values of PCV and GCV were high for seed yield per plant and number of capsules per plant, moderate for number of capsules per plant and plant height and low for days to maturity and oil content. There was close correspondence between PCV and GCV for these traits. The high and moderate GCV is an indication that there is abundant variability in the genotypes with respect to these characters and offer scope for improvement of the traits through selection. The results of the study agrees to previous reports by Singh (2001), Tadesse *et al*. (2010) who observed moderate to high GCV for number of capsules per plant, 1000 seed weight, plant height, and low GCV for days to maturity, plant height and oil content. Savita (2006) also reported low GCV for seed oil content.

The estimate of heritability and genetic advance are often worked out together with GCV and PCV to predict the heritable portion of variation as well as to understand the resultant effect of selection on phenotypic expression (Johnson *et al*. 1955). The estimates of broad sense heritability (Table 1) ranged from 25.6% for oil content to 76.1% for number of capsules per plant. The estimates of genetic advance as percentage of mean ranged from 1.36% for oil content to 96.3% for seed yield per plant. Robinson *et al.* (1949) grouped the h^2 estimates into three categories as low (0-30%), Moderate (30-60%) and high (>60%). Johnson *et al*. (1955) grouped the GA estimates into three categories low (<10%), moderate (0-20%) and high (>20%). The same classification was used to interpret the results. High heritability coupled with high genetic advance was recorded for traits such as number of capsules per plant and seed yield per plant and moderate heritability and genetic advance for plant height. In self pollinated crops like linseed, if the trait shows high heritability and high genetic advance it may be an indication that these traits are more likely to be controlled by additive gene action and could be improved through individual plant selection as mentioned by Falconer (1960). Thus, the traits like number of capsules per plant and seed yield per plant could be easily improved through phenotypic selection. These results are in accordance with the findings of Pali and Mehta (2013). Low heritability and genetic advance was observed for oil content which might be due to presence of non-additive gene effect and high G x E interaction as also observed by Savita (2006).

Correlation studies:At genotypic level, seed yield per plant was positively correlated (Table 3) with number of capsules per plant (r_g=0.94), plant height (0.73), days to maturity (0.63) and 1000 seed weight (0.51). However, there was no significant correlation observed between seed yield and seed oil content, although previous report of Khorgade *et al.* (1992) indicated positive association between the two traits. Significant positive correlation of number of capsules per plant was recorded with plant height, days to maturity and 1000 seed weight both at genotypic and phenotypic levels. Significant positive genotypic correlation was observed between days to 50% flowering and days to maturity and days to maturity and plant height. Hence, it is possible to improve seed yield by improving the positively correlated component traits. Seed oil content was positively associated with 1000 seed weight (r_g=0.51; r_p=0.39). Hence, it is possible to improve the seed oil content indirectly by improving seed weight as reported by Green and Marshall (1981) and Diederichsen and Fu (2008).

Donor for economically important traits: On the basis of pooled mean of 2011-12 and 2012-13 data, elite germplasm lines which are better than or on par with check varieties Garima, H-local and Kiran for economically important traits were identified. Accessions EC 541212, EC 541213 and EC 041762 for early flowering, EC 541207, EC 541218, EC 541216, EC 541208, EC 541202, EC 541211 and EC 541214 for taller stalk length, IC 118887 and IC 567352 for number of capsules per plant, IC 320984, IC 118883, IC 345393 and IC 118878 for 1000 seed weight, EC 541215 for seed yield per plant, IC 118887, EC 541205 and IC 424874 for oil content. Further evaluation will judge the worthiness of these accessions either for direct exploitation as commercial varieties or for use as parents breeding programme.

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