Correlation and Path Coefficient Analysis of Yield and Yield Associated Traits in Linseed (Linum usitatissimum L.)

O. Shyam Sundar, Soni Singh and Shama Parveen

Department of Genetics and Plant Breeding, School of Agriculture, ITM University, Gwalior, M.P, India

(Received 20 July, 2023; Accepted 26 September, 2023)

ABSTRACT
Linseed (Linum usitatissimum L.) is an oil seed crop, mainly grown in the Rabi season. It is grown for its oil content in the seeds and for the flax purpose. It contains lignans and dietary fibre, both of which are beneficial for healthy digestion. Fifteen genotypes including one local check (RLC-81) evaluated to study the correlation and path analysis in the present research work. The experiment conducted in crop research center-II, ITM University, Gwalior M.P. in Rabi season 2022. Seed yield per plant had significant positive association with biological yield and number of primary branches per plant at genotypic level. At phenotypic level biological yield and plant had positive and highly significant. In path analysis, the positive and direct effect reported by the biological yield and harvest index at both genotypic and phenotypic level. Negative and direct effect reported by no of seeds per capsule and days to 50% flowering in genotypic level. At phenotypic level oil content reported the negative and direct effect. This indicates at genotypic and phenotypic levels these characters had a high significant association with seed yield and selection for these characters would lead to improve in yield.

Key words: Direct effects, Indirect effects, Correlation and path analysis.

Introduction
Linseed (Linum usitatissimum L.) is an annual, self-pollinated, diploid (2x=2n=30) oilseed crop belongs to the family Linaceae (Ragupathy et al., 2011). The species is thought to have originated in either the Middle East or India. There are 4.14 million hectares of land worldwide that are used for the cultivation of linseed. 3.34 million Tonnes of linseed are produced worldwide (Knoema.com). In India major linseed producing states are Rajasthan (1.27 tonnes/ ha), Bihar (0.84t/ha), Madhya Pradesh (0.7t/ha), Assam (0.8t/ha). In this Rajasthan ranks first in terms of yield (agricoop.nic.in). India contributes about 10.81 % and 5.30% to world area and production respectively for Linseed. In India linseed occupies an area of 1.7lakh ha with a production and productivity of about 1 lakh tonnes and 574 kg/ha, respectively (aicrp.icar.gov.in). In the period of 2021–2022, the yield increased by about 0.97% in India. The nutritional value of Linseed, which has a protein content of 18 - 25 percent by weight, is a rich source of plant-based protein. It offers all nine necessary amino acids, making it an excellent source of protein for vegans and vegetarians. Omega-3 Fatty Acids: Alpha-linolenic acid (ALA), an important omega-3 fatty acid, is one of the most abundant plant sources found in linseed. The body transforms ALA into additional omega-3 fatty acids including EPA and DHA. Omega-3 fatty acids contain anti-in-
flammatory characteristics and are crucial for heart function. Both soluble and insoluble dietary fibres are abundant in linseed. The presence of soluble fibre supports good digestion and stable blood sugar levels. Insoluble fibre gives the stool weight and might ease constipation. Linseed includes lignans, which are antioxidant substances with possible health advantages. Lignans may be able to fight cancer and lower the risk of developing some chronic illnesses, like heart disease. Vitamins and minerals like, Vitamin E, thiamine (vitamin B1), magnesium, and manganese are all present in linseed in good amounts. These nutrients are crucial for maintaining bone health, neuron health, and energy production.

The present study goes around the correlation between the yield related traits and path coefficient anlaysis. Total 15 germplasms including one check (RLC-81) variety used in the investigation for evaluating the characters like days to 50% flowering, days to maturity, no of primary branches, no of secondary branches and no of capsules per plant etc., assists the direct and indirect selection with in the germplasms. Correlation is a statistical technique which helps in analysing the association between two or more variables. It helps us in determining the degree of relationship between two or more variables. The direction of correlation is either positive or negative. Positive correlation, if two related variables are such that when one increases (decreases), the other also increases (decreases). Negative correlation, if two variables are such that when one increases (decreases), the other decreases (increases). The Path analysis is a method of splitting correlations into different components of effects.

Material and Methods

The research site is situated in the Grid zone at 26.13’ north scope and 76.14’ east longitude, at a rise of 211.52 meters above mean ocean level. The climate in the locale is semi-dry sub-tropical, with blistering and dry summer and freezing winters. The field at Crop Research Centre -2, School of Agriculture, ITM University, Gwalior, located at in northern Madhya Pradesh. The region mostly falls under Chambal area. The soil was sandy loam in the field. The experiment was conducted in Randomized Block Design (RBD) with three replications during Rabi 2022-23. Each genotype was accommodated in three blocks, each replication having 16 plots and each plot has three rows. Plant to pant distance was 25cm and row to row distance is about 30cm. Total area was 216 square meters with forty eight plots were allotted to sixteen genotypes in three replications in the field. I have performed the intercultural operations in the field throughout the crop duration at certain time. Before sowing the seeds basal dose of fertilizers (1kg urea + ½ kg SSP + ½ kg MOP) are applied and 42 days after sowing. Provided irrigation to the field about five times at critical stages like immediately after sowing (rinsed with water cans at the rows), two to three leaves stage of crop, pre-emergence of flower or post vegetative growth stage, at the time of flowering stage and final irrigation after pod formation, followed by weeding for three times at the time of crop duration. Observations on the following characteristics were recorded on the basis of five plants randomly selected and tagged from each row except for days to 50% flowering, days to maturity, which were recorded on the line basis.

Oil content (%)

Find out the oil percentage in each variety by using a Soxhlet extractor unit.

Soxhlet extraction is an advanced technique that involves repeatedly circulating the same solvent through extractor. In 1879, Franz Ritter von Soxhlet, professor of agricultural chemistry developed this extraction technique.

Working principle: Soxhlet extraction is an exhaustive extraction technique widely applied to analytes that are sufficiently thermally stable. The extraction solvent is continuously cycled though the matrix, by boiling and condensation, with the sample being collected in the hot solvent.

\[
\text{Oil percentage} = \frac{\text{Final jar weight} - \text{Initial jar weight}}{\text{Sample weight}} \times 100
\]

Results and Discussion

Correlation coefficient analysis

Correlation estimates provide better understanding of yield components which helps plant breeder during selection. The phenotype of a plant is a result of interaction between many contributing factors, so the final yield is the sum total of the effects of several component characters. Yield is the complex phenotypic performance of the plant, which get influenced
by many factors such as genetic, environment and their interactions. This complex quantitative character is under the control of polygene. Polygenes are highly sensitive to the environment. Hence, the selection of a superior genotype based on yield alone may not be effective. For the rational approach towards the improvement of yield, selection should be operated through associated characters. Genotypic and phenotypic correlation coefficients of different traits are presented in have been presented in Table 1. In general, the estimates of genotypic correlation are higher than phenotypic correlation and the magnitudes are in the same direction (+/-). The results obtained in this investigation for genotypic correlation coefficient are mentioned below.

In genotypic correlation, days to 50% flowering showed positive and significant association with days to maturity (0.367*), while negative and highly significant association with no of secondary branches per plant (-0.867**) and no of capsules per plant (-0.785**). While negative and significant association showed with the characters like test weight (-0.303*) and harvest index (-0.287*). In phenotypic correlation, days to 50% flowering showed negative and highly significant association with biological yield (-0.570**) and no of capsules per plant (-0.565**). While positive and significant association with days to maturity (0.287*) was recorded. While negative and non significant association shown with the characters like test weight (-0.138) and harvest index (-0.037). In genotypic correlation, plant height showed positive and highly significant association with biological yield (0.903**) and no of primary branches per plant (0.831**). The character plant height showed positive and significant association with oil content (0.329*). While negative and highly significant association with the character like days to 50% flowering (-0.524**) was recorded. Positive and non significant association with harvest index (0.04). Negative and non significant association with days to maturity (-0.072) was recorded.

In phenotypic correlation, plant height showed positive and highly significant association with no of primary branches per plant (0.564**) and biological yield (0.541**). While negative and highly significant association showed with days to 50% flowering (-0.420**) was recorded. While positive and non significant association showed with test weight (0.236) and oil content (0.214) was recorded. In genotypic correlation, days to maturity showed positive and significant association with days to 50% flowering (0.367*). While negative and highly significant association with the characters like test weight (-0.428**) and no of seeds per capsule (-0.423**) was recorded. While negative and non significant association with harvest index (-0.25) and no of secondary branches per plant (-0.231).

In phenotypic correlation, days to maturity showed positive and significant association with days to 50% flowering (0.287*). While negative and significant association with test weight (-0.301*) was observed. While positive and non significant association showed with biological yield (0.053) and plant height (0.016). While negative and non significant association showed with no of capsules per plant (-0.154) and oil content (-0.141). In genotypic correlation, no of primary branches showed positive and highly significant association with the characters like seed yield per plant (0.944**) and biological yield (0.908**). While negative and highly significant association with days to 50% flowering (-0.762**) was observed. While positive and non significant association with test weight (0.19), while negative and non significant association with days to maturity (-0.214) was recorded.

In phenotypic correlation, number of primary branches showed positive and highly significant association with no of secondary branches per plant (0.721**) and plant height (0.564**). While negative and highly significant association with days to 50% flowering (-0.466**) was recorded. Positive and significant association showed with oil content (0.305*) and no of seeds per capsule (0.289*). Positive and non significant association showed with harvest index (0.106). Negative and non significant association with days to maturity (-0.129) and test weight (-0.035).

In genotypic correlation, number of secondary branches per plant showed positive and highly significant association with no of capsules per plant (0.955**) and oil percentage (0.844**). While negative and highly significant association showed with days to 50% flowering (-0.867**) was recorded. While positive and non significant association showed with test weight (0.058) and negative association showed with days to maturity (-0.231). In phenotypic correlation, no of secondary branches per plant showed positive and highly significant association with no of capsules per plant (0.757*) and no of primary branches per plant (0.721**). While negative and highly significant association with no of secondary branches per plant (-0.526) was recorded.
positive and non significant association showed with number of seeds per capsule (0.283). Negative association showed with days to maturity (-0.079) and test weight (-0.133). In genotypic correlation, number of capsules per plant showed positive and highly significant association with biological yield (0.783**) and plant height (0.687**). While negative and highly significant association showed with days to 50% flowering (-0.785**) and just significant with days to maturity (-0.297*) was recorded. While positive and non significant association with test weight (0.264) and harvest index (0.103) was recorded. In phenotypic correlation, number of capsules per plant showed positive and highly significant association with number of secondary branches per plant (0.757**) and number of primary branches per plant (0.532**). While positive and significant association with test weight (0.342*) and number of seeds per capsule (0.332**) was recorded. While positive and non significant association with test weight (0.029) was recorded. Negative and non significant association with days to maturity (-0.154) and harvest index (-0.001) was recorded.

In genotypic correlation, showed positive and highly significant association with plant height (0.687**) and showed just significant association with test weight (0.497*). While negative and highly significant association with days to 50% flowering (-0.741**) and days to maturity (-0.423**) was recorded. And non significant association with oil content (0.196) was recorded. In phenotypic correlation, number of seeds per capsule recorded positive and highly significant association with seed yield per plant (0.536**) and biological yield (0.394**). While positive and significant association with no of capsules per plant (0.332*) and no of primary branches per plant (0.289*) was recorded. While positive and non significant association showed

<table>
<thead>
<tr>
<th></th>
<th>DFF</th>
<th>PH</th>
<th>DM</th>
<th>NPB</th>
<th>NSB</th>
<th>NCP</th>
<th>NSC</th>
<th>TW</th>
<th>OC</th>
<th>BY</th>
<th>HI</th>
<th>SYPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFF</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>-0.524**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>0.367*</td>
<td>-0.072</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPB</td>
<td>-0.762**</td>
<td>0.831*</td>
<td>0.214</td>
<td>1</td>
<td>0.564*</td>
<td>0.129</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSB</td>
<td>-0.867**</td>
<td>0.663*</td>
<td>-0.231</td>
<td>0.709**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCP</td>
<td>-0.785**</td>
<td>0.764*</td>
<td>-0.297</td>
<td>0.403*</td>
<td>0.955**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSC</td>
<td>-0.741**</td>
<td>0.687*</td>
<td>-0.423**</td>
<td>0.676**</td>
<td>0.545**</td>
<td>0.497**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW</td>
<td>-0.303*</td>
<td>0.401*</td>
<td>0.428**</td>
<td>0.19</td>
<td>0.058</td>
<td>0.264</td>
<td>0.289**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OC</td>
<td>-0.624**</td>
<td>0.329*</td>
<td>-0.128</td>
<td>0.648**</td>
<td>0.844**</td>
<td>0.601**</td>
<td>0.196</td>
<td>0.460**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BY</td>
<td>-0.473**</td>
<td>0.214*</td>
<td>-0.141</td>
<td>0.305**</td>
<td>0.377**</td>
<td>0.342**</td>
<td>0.161</td>
<td>0.335** 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HI</td>
<td>-0.694**</td>
<td>0.903**</td>
<td>0.061</td>
<td>0.908**</td>
<td>0.743**</td>
<td>0.783**</td>
<td>0.536**</td>
<td>0.468**</td>
<td>0.674**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYPP</td>
<td>-0.570**</td>
<td>0.541**</td>
<td>0.053</td>
<td>0.106</td>
<td>-0.007</td>
<td>-0.001</td>
<td>0.254</td>
<td>-0.099</td>
<td>0.055</td>
<td>-0.304**</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

(* and ** Significant at 0.05 and 0.01 levels of probability, DFF: Days to 50% flowering, PH: Plant height, DM: Days to maturity, NPB: Number of primary branches, NSB: Number of secondary branches, NCP: Number of capsules per plant, NSC: Number of seeds per capsules, TW: 1000 seed weight, OC: Oil content, BY: Biological yield, HI: Harvest index, SYPP: Seed yield per plant. $r_g =$ genotypic correlation and $r_p =$ phenotypic correlation.)
with no of secondary branches per plant (0.283) and harvest index (0.254). While negative and non significant association with days to maturity (-0.097) was recorded.

In genotypic correlation, test weight showed positive and highly significant association with biological yield (0.468**) and oil percentage (0.460**), while negative and highly significant association showed with harvest index (-0.456**) and just significant association showed with days to 50% flowering (-0.303*). And non significant association with the characters like no of seeds per capsule (0.289) and number of capsules per plant (0.264). In phenotypic correlation, test weight showed positive and significant association with oil content (0.335*) while negative and non significant association with days to maturity (-0.301*) was recorded. While positive and non significant association showed with plant height (0.236) and biological yield (0.22). While negative and non significant association showed with days to 50% flowering (-0.138) and no of secondary branches per plant (-0.133). In genotypic correlation, oil percentage showed positive and highly significant association with no of secondary branches (0.844**) and biological yield (0.674**). While negative and highly significant association showed with days to 50% flowering (-0.694**) was recorded. While negative and highly significant association showed with no of seeds per capsule (0.196) and harvest index (-0.11) was recorded.

In phenotypic correlation, oil percentage showed positive and highly significant association with seed yield per plant (0.406**) and biological yield (0.377**). While negative and highly significant association showed with days to 50% flowering (-0.473**) was recorded. While positive and non significant association with test weight (0.283) and number of capsules per plant (0.264). In genotypic correlation, oil percentage showed positive and highly significant association with seed yield per plant (0.988**) and no of primary branches (0.908**) was recorded. While negative and highly significant association showed with days to maturity (-0.694**) was recorded. While negative and highly significant association showed with no of seeds per capsule (0.161) was recorded.

### Table 2. Genotypic and Phenotypic pathcoefficient analysis among yield and yield contributing traits in Linseed

<table>
<thead>
<tr>
<th></th>
<th>DFF</th>
<th>PH</th>
<th>DM</th>
<th>NBP</th>
<th>NSB</th>
<th>NCP</th>
<th>NSC</th>
<th>TW</th>
<th>OC</th>
<th>BYPP</th>
<th>HI</th>
<th>SYPP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G</strong></td>
<td>-0.26044</td>
<td>-0.0402</td>
<td>0.00938</td>
<td>-0.1679</td>
<td>-0.0421</td>
<td>-0.0175</td>
<td>0.02689</td>
<td>-0.0199</td>
<td>0.14646</td>
<td>-0.4444</td>
<td>-0.0945</td>
<td>-0.663**</td>
</tr>
<tr>
<td>P</td>
<td>0.00376</td>
<td>0.01591</td>
<td>0.00894</td>
<td>-0.0345</td>
<td>0.03945</td>
<td>0.0461</td>
<td>0.00504</td>
<td>0.0064</td>
<td>0.01328</td>
<td>-0.5188</td>
<td>-0.0262</td>
<td>-0.546**</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>0.13632</td>
<td>0.07722</td>
<td>-0.0018</td>
<td>0.18263</td>
<td>0.03224</td>
<td>0.01705</td>
<td>0.03823</td>
<td>0.0055</td>
<td>0.01052</td>
<td>-0.06</td>
<td>0.49271</td>
<td>0.04941</td>
</tr>
<tr>
<td>P</td>
<td>-0.00158</td>
<td>-0.0358</td>
<td>0.00553</td>
<td>0.04139</td>
<td>-0.0303</td>
<td>0.03823</td>
<td>0.0055</td>
<td>0.01052</td>
<td>-0.06</td>
<td>0.49271</td>
<td>0.04941</td>
<td></td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>-0.09572</td>
<td>-0.0055</td>
<td>0.02551</td>
<td>-0.4724</td>
<td>-0.0111</td>
<td>0.0066</td>
<td>0.15085</td>
<td>-0.02</td>
<td>0.03033</td>
<td>-0.0373</td>
<td>-0.0821</td>
<td>-0.108NS</td>
</tr>
<tr>
<td>P</td>
<td>0.00108</td>
<td>0.00007</td>
<td>0.03116</td>
<td>-0.0096</td>
<td>0.00582</td>
<td>0.1252</td>
<td>0.00117</td>
<td>0.00393</td>
<td>0.04967</td>
<td>-0.0964</td>
<td>-0.041NS</td>
<td></td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>0.22557</td>
<td>0.05124</td>
<td>0.0058</td>
<td>0.1565</td>
<td>0.04859</td>
<td>0.02134</td>
<td>0.0186</td>
<td>-0.0016</td>
<td>0.14194</td>
<td>0.57986</td>
<td>0.22769</td>
<td>0.944**</td>
</tr>
<tr>
<td>P</td>
<td>-0.00213</td>
<td>-0.0042</td>
<td>0.05311</td>
<td>0.0749</td>
<td>0.06175</td>
<td>0.0038</td>
<td>0.0059</td>
<td>0.0059</td>
<td>0.0067</td>
<td>0.40312</td>
<td>0.07184</td>
<td>0.497**</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>0.07969</td>
<td>0.03086</td>
<td>0.0075</td>
<td>0.08936</td>
<td>0.0464</td>
<td>0.02235</td>
<td>0.1787</td>
<td>0.01734</td>
<td>0.1414</td>
<td>0.50054</td>
<td>0.03456</td>
<td>0.647**</td>
</tr>
<tr>
<td>P</td>
<td>-0.00153</td>
<td>-0.0048</td>
<td>0.03923</td>
<td>0.0567</td>
<td>0.08158</td>
<td>0.0041</td>
<td>0.0014</td>
<td>0.0097</td>
<td>0.46601</td>
<td>0.0005</td>
<td>0.493**</td>
<td></td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>0.18094</td>
<td>0.06968</td>
<td>0.0015</td>
<td>0.1455</td>
<td>0.0409</td>
<td>0.01344</td>
<td>0.0689</td>
<td>0.03001</td>
<td>0.2352</td>
<td>0.42957</td>
<td>0.0346</td>
<td>0.504**</td>
</tr>
<tr>
<td>P</td>
<td>-0.00214</td>
<td>-0.0081</td>
<td>0.0043</td>
<td>0.02228</td>
<td>0.0283</td>
<td>0.2796</td>
<td>0.002</td>
<td>0.01515</td>
<td>0.2819</td>
<td>0.3745</td>
<td>0.03862</td>
<td>0.406**</td>
</tr>
<tr>
<td><strong>G</strong></td>
<td>0.18094</td>
<td>0.06968</td>
<td>0.0015</td>
<td>0.1455</td>
<td>0.0409</td>
<td>0.01344</td>
<td>0.0689</td>
<td>0.03001</td>
<td>0.2352</td>
<td>0.42957</td>
<td>0.0346</td>
<td>0.504**</td>
</tr>
<tr>
<td>P</td>
<td>-0.00214</td>
<td>-0.0081</td>
<td>0.0043</td>
<td>0.02228</td>
<td>0.0283</td>
<td>0.2796</td>
<td>0.002</td>
<td>0.01515</td>
<td>0.2819</td>
<td>0.3745</td>
<td>0.03862</td>
<td>0.406**</td>
</tr>
</tbody>
</table>

Residual effect for genotypic path = -0.0172
Residual effect for phenotypic path = 0.0444
tive and non significant association with days to maturity (-0.061) was recorded. In phenotypic correlation, biological yield showed positive and highly significant association with seed yield per plant (0.706**) and plant height (0.541**). While negative and highly significant association showed with days to 50% flowering (-0.570**) and just significant association with harvest index (-0.304*) was recorded. While positive and non significant association showed with test weight (0.22) and days to maturity (0.053) was recorded.

In genotypic correlation, harvest index showed positive and highly significant association with number of primary branches (0.690**) and seed yield per plant (0.662**). While negative and highly significant association with test weight (-0.456 **) and just significant with (-0.2287*) was recorded. While positive and non significant association showed with no of capsules per plant (0.103) and plant height (0.44) was recorded. While negative and non significant association showed with days to maturity (-0.25) and oil content (-0.11) was recorded. In phenotypic correlation, harvest index showed positive and highly significant association with seed yield per plant (0.425**). While negative and significant association showed with biological yield (-0.304*) was recorded. While positive and non significant association showed with no of seeds per capsule (0.254) and test weight (0.106). While negative and non significant association showed with days to maturity (-0.007) and test weight (-0.099).

In genotypic correlation, seed yield per plant showed positive and highly significant association with biological yield (0.988**) and no of primary branches (0.944**). While negative and highly significant association with days to 50% flowering (-0.663**) was recorded. While positive and non significant association with test weight (0.150) was recorded. While negative and non significant association with days to maturity (-0.108) was recorded. In phenotypic correlation, seed yield per plant showed positive and highly significant association with biological yield per plant (0.706**) and plant height (0.552**). While negative and significant association showed with days to 50% flowering (-0.546**) was recorded. While positive and non significant association showed with test weight (0.154). Negative and non significant association showed with days to maturity (-0.041) was recorded.

Path coefficient analysis
Path coefficient analysis helps in partitioning of correlation coefficients into direct finding out direct and indirect causes of association and presence a critical examination of the specific courses acting to produce a given correlation and measures the relative importance of each causal factor. The association of different component characters among themselves and with yield is quit important for planning an efficient selection criterion for yield. Such inter dependence often affects the relationship of component characters with yield, their by making correlation coefficient to be ineffective. So, there is need to partitioning the correlation into direct and indirect effects to get the information on actual contribution of each character to yield. Thus, correlation in conjunction with path analysis to give a better insight into a cause – and – effects relationship between different pairs of characters along with seed yield in breeding program.

In the present study, the genotypic and phenotypic correlation coefficient between seed yield per plant and yield components were partitioned to the corresponding direct and indirect effects through path analysis in linseed are depicted in Table-2 (genotypic and phenotypic path analysis).

Direct effects of various characters on seed yield per plant
In genotypic path analysis out of 12 characters 7 characters showed positive and direct effect on seed yield per plant viz., biological yield (0.639), harvest index (0.329), no of primary branches (0.219), plant height (0.077), test weight (0.064), no of secondary branches per plant (0.048) and days to maturity (0.025). The reaming 3 characters showed negative and direct effect on seed yield viz., no of seeds per capsule (-0.344), days to 50% flowering (-0.260) and oil content (-0.235).In phenotypic path analysis out of 12 characters 6 characters reported positive and direct effect on seed yield per plant viz., biological yield (0.911), harvest index (0.709), no of capsules per plant (0.081), no of primary branches (0.073), test weight (0.044) and days to 50% flowering (0.003). And the remaining characters showed negative and direct effect on seed yield per plant viz., oil content (-0.281), no of secondary branches per plant (-0.074), plant height (-0.037), days to maturity (-0.031) and no of seeds per capsule (-0.012).
Indirect effects of various characters on seed yield per plant

In genotypic path analysis the days to 50% flowering reported the positive indirect effect on the seed yield per plant via., oil content (0.146) and no of seeds per capsule (0.026). The remaining characters showed negative and indirect effect on the seed yield per plant via., biological yield (-0.444) and no of primary branches (-0.167). In phenotypic path analysis the days to 50% flowering reported the positive indirect effect on the seed yield per plant via., no of secondary branches per plant (0.039) and plant height (0.015). The remaining characters showed negative and indirect effect on the seed yield per plant via., biological yield (-0.518) and no of capsules per plant (-0.046). In genotypic path analysis the plant height character reported the positive and indirect effect on seed yield per plant via., biological yield (0.577) and no of primary branches per plant (0.182). The remaining characters in the analysis showed negative and indirect effect on the seed yield per plant via., oil content (-0.077) and no of seeds per capsule (-0.025).

In phenotypic path analysis the plant height reported the positive indirect effect on the seed yield per plant via., biological yield (0.492) and harvest index (0.049). The remaining characters showed negative and indirect effect on the seed yield per plant via., oil content (-0.518) and no of capsules per plant (-0.046) and days to 50% flowering (-0.095). In phenotypic path analysis the days to maturity reported the positive indirect effect on the seed yield per plant via., biological yield (0.049) and no of secondary branches per plant (0.005). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of capsules per plant (-0.009) and harvest index (-0.096).

In genotypic path analysis the no of primary branches per plant showed positive and indirect effect on the seed yield per plant via., biological yield (0.579) and harvest index (0.227). The remaining characters showed negative and indirect effect on the seed yield per plant via., no seeds per capsule (-0.245) and oil content (-0.151). In phenotypic path analysis the no of primary branches per plant reported the positive indirect effect on the seed yield per plant via., biological yield (0.403) and harvest index (0.071). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of secondary branches per plant (-0.054) and plant height (-0.021).

In the genotypic path analysis the no of branches per plant character showed positive and indirect effect on the seed yield per plant via., biological yield (0.474) and days to 50% flowering (0.225). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of seeds per capsule (-0.198) and oil content (-0.197). In phenotypic path analysis the no of secondary branches per plant reported the positive indirect effect on the seed yield per plant via., biological yield (0.466) and no of capsules per plant (0.061). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of seeds per capsule (0.500) and days to 50% flowering (0.204). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of secondary branches per plant (-0.178) and oil content (-0.141). In phenotypic path analysis the no of capsules per plant reported the positive indirect effect on the seed yield per plant via., biological yield (0.466) and no of primary branches per plant (0.039). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of secondary branches per plant (-0.056) and plant height (-0.017).

In the genotypic path analysis the no of seeds per capsule character showed positive and indirect effect on the seed yield per plant via., biological yield (0.337) and harvest index (0.203). And the remaining characters in the analysis showed negative and indirect effect on the seed yield per plant via., oil content (-0.044) and days to maturity (-0.0105). In phenotypic path analysis the no of seeds per capsule reported the positive indirect effect on the seed yield per plant via., biological yield (0.359) and harvest index (0.177). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of secondary branches per plant (-0.020) and plant height (-0.016). In the genotypic path analysis the test weight character showed posi-
tive and indirect effect on the seed yield per plant via., biological yield (0.298), days to maturity (0.079) and no of primary branches per plant (0.041). The remaining characters showed negative and indirect effect on the seed yield per plant via., harvest index (-0.151) and oil content (-0.108).

In phenotypic path analysis the test weight reported the positive indirect effect on the seed yield per plant via., biological yield (0.2) and no of secondary branches per plant (0.009). The remaining characters showed negative and indirect effect on the seed yield per plant via., harvest index (-0.070) and no of primary branches per plant (-0.025). In the genotypic path analysis oil content showed positive and indirect effect on the seed yield per plant via., biological yield (0.429) and days to 50% flowering (0.162). The remaining characters showed negative and indirect effects on the seed yield per plant via., no of seeds per capsule (-0.068) and harvest index (-0.034). In phenotypic path analysis the oil content reported the positive indirect effect on the seed yield per plant via., biological yield (0.374) and no of capsules per plant (0.279). The remaining characters showed negative and indirect effect on the seed yield per plant via., no of secondary branches per plant (-0.028) and plant height (-0.008). In the genotypic path analysis the biological yield showed positive and indirect effect on the seed yield per plant via., no of primary branches per plant (0.198) and days to 50% flowering (0.180). The remaining characters showed negative and indirect effect on the seeds yield per plant via., no of capsules per plant (-0.192) and oil content (-0.157).

In phenotypic path analysis the biological yield reported the positive indirect effect on the seed yield per plant via., no of capsules per plant (0.041) and no of primary branches per plant (0.035). The remaining characters showed negative and indirect effect on the seed yield per plant via., harvest index (-0.216) and no of secondary branches per plants (-0.034). In the genotypic path analysis the harvest index showed positive and indirect effect n the seed yield per plant via., biological yield (0.321) and no of primary branches per plant (0.151). The remaining characters showed negative and indirect effect on the seed yield via., test weight (-0.029) and days to maturity (-0.006).

In phenotypic path analysis the harvest index reported the positive indirect effect on the seed yield per plant via., no of primary branches per plant (0.007) and no of secondary branches per plant (0.0004). The remaining characters showed negative and indirect effect on the seed yield per plant via., biological yield (-0.277) and test weight (-0.0044).

**Genotypic and Phenotypic coefficient of correlation**

The resultant genotypic coefficient of correlation for Seed yield per plant showed positive and highly significant association with biological yield (0.988**), no of primary branches (0.944**), plant height (0.733**), harvest index (0.662**), no of capsules per plant (0.647**), no of seeds per capsule (0.573**) and oil percentage (0.504**). While negative and highly significant association with days to 50% flowering (-0.663**) was recorded. The resultant phenotypic coefficient of correlation for seed yield per plant showed positive and highly significant association with biological yield per plant (0.706**), plant height (0.552**), no of seeds per capsule (0.536**), no of primary branches (0.487**), no of capsules per plant (0.443**), harvest index (0.425**), no of secondary branches (0.417**) and oil content (0.406**). While negative and significant association showed with days to 50% flowering (-0.546**) was recorded. In the present investigation the values obtain in the genotypic coefficient of correlation was slightly greater than the phenotypic correlation analysis for all the significant characters except for the oil content values. which was similar to the findings of the researchers like Ashish singh et al., (2015), Ankit et al. (2019). There are some similar characters in the findings of Pali and Mehta (2013), R.B. Sudmewad et al., (2016) like primary and secondary branches per plant. Biological yield and plant height Mohit chaudhary et al., (2016) also mentioned positive and highly significant character in their findings was Harvest index (0.892), while for biological yield (0.71) and harvest index (0.59) got positive and highly significant in the findings of M.E. hussain et al., (2016), Choudhary et al., (2017), G. thakur et al., (2021), while findings of Dansk ibrar et al., (2016), Kaur et al. (2018), Ankit et al. (2019), Gemechu nedi and Guleta nepir (2020) also revealed same but test weight also additionally found positive and significant which was not similar to the present findings of the research work. And also they found the results like positive and highly significant correlation of seed yield with no of seeds per capsule, but this trait was just significant in the present findings.
Conclusion

In the present research work the findings that characters like biological yield and no of primary branches per plant at genotypic level, biological yield and no of seeds per capsule at phenotypic level showed positive and high significant correlation with seed yield per plant. These are helpful in selecting the combination of characters in the genotypes. The characters like biological yield and harvest index reported positive direct effect on seed yield per plant. Additionally, the biological yield exhibited a strong indirect association with the harvest index. Improving the characters mentioned above are useful in the future breeding program.

References


Ragupathy, R., Rathinavellu, R. and Cloutier, S. 2011. Physical mapping and BAC-end sequence analysis provide initial insights into the flax (Linum usitatissimum L.) genome. BMC Genomics 12: 21-27


