Journal of Pharmacognosy and Phytochemistry 2018; 7(1): 1154-1157

Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 1154-1157
Received: 04-11-2017
Accepted: 05-12-2017

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Studies on variability, correlation and path coefficient of Asalio (*Lepidium sativum* L.)

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Abstract
Variability present among the eight asalio lines was studied. Phenotypic correlations and their direct and indirect effects were estimated for eleven traits using path analysis. Variability among the morphological, yield and quality traits were assessed. Seed yield per ha, number of siliqua per plant and test seed weight traits showed good variability among the traits. The line MLS-1007 was found as superior line with respect to seed yield. A positive coefficient of phenotypic correlation was found between plant height, days to 50% flowering, days to maturity, number of branches per plant, test seed weight, length of siliqua, oil percentage and oil yield per hectare with seed yield per hectare. However, path analysis revealed that days to 50% flowering, number of branches per plant, test seed weight, length of siliqua, number of siliqua per plant and oil yield per ha exhibited significance at high level in positive direction.

Keywords: Asalio – Variability - Correlation coefficient – Path analysis – Seed yield

1. Introduction

Garden cress / Chandrasur / Asalio (*Lepidium sativum* L.) is an annual herb native to Egypt and West Asia (Zhan *et al*., 2009) [23]. The genus *Lepidium* belongs to the Brassicaceae family, which is rich in health promoting phytochemical constituents. The total phenolic compounds, which are known to be one of the most important groups of natural antioxidants that accumulate in minimally processed vegetables, are responsible for a high antioxidant capacity (Pramod *et al*., 2012) [14]. The leaves are used as salad, cooked with vegetables, curries and also used as fodder for cattle (Moser *et al*., 2009; Patel *et al*., 2009, Rehman *et al*., 2010) [11, 13, 16]. The leaves are stimulant diuretic used in scorbutic disease and hepatic complaints (Raval and Pandya, 2009) [15].

Seeds of *L. sativum* are claimed to possess various medicinal properties like, galactogogue, aperient, diuretic, alterative, tonic, demulcent, aphrodisiac, carminative and emmenagogue. Seeds were largely used for the treatment of hypertension and renal diseases (Patel *et al*., 2009) [13]. Garden-cress seeds are used as a medicine in India in the system of "Ayurveda". Also it has health promoting properties which can be used as a functional food. It is also reported that these seeds contain Glucosinolates, sulphur-containing glycosides found in brassicaceous plants that can be hydrolysed enzymatically by plant myrosinase or non-enzymatically to form primarily isothiocyanates and/or simple nitriles. From a human health perspective, isothiocyanates are quite important because they are major inducers of carcinogen- detoxifying enzymes the most potent inducers are benzyl isothiocyanate (BITC) present in asalio. The seed coat of germinating seeds contains much mucilage, which has an allelopathic substance, lepidimoide. The effects of the germinating seeds were studied to determine the potential for slowing down the hydrolysis of starch to glucose in diabetic persons. The seeds significantly lowered the glycaemic response to a test meal (Williams *et al*., 2009) [21].

To maintain high agricultural productivity, the development of varieties with high yield potential is the ultimate goal of plant breeders in a crop improvement programme. In recent years in asalio breeding, special focus has been placed on developing varieties with improved seed yield, large seed size, and high oil content. By considering these, variability, correlation and path analysis studies are very essential to identify the superior breeding lines for further crop improvement programme; hence this study was undertaken.

2. Material and methods

The experiment consisting of eight breeding lines of Asalio was laid out in a randomized block design with three replications during 2014-15. The entries were sown in plots with the spacing of 30 cm between rows and 10 cm between the plants. Observations were recorded on five randomly selected plants in each lines and replication for different eleven characters.

The statistical mean, range, standard error was calculated using the method suggested by Goulden (1952) [9]. Phenotypic coefficient of variation was computed according to Burton and Devane (1953) [4].

$$\text{Coefficient of variation} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

The correlation coefficients were calculated to determine the degree of association of characters with yield. Phenotypic correlations coefficients were estimated according to the formula given by Al-Jibouri *et al.* (1958) [21].

$$\text{Phenotypic correlation} = r_{xy}\,(g) = \frac{\text{COVxy (p)}}{\sqrt{\text{Vx(p) x Vy(p)}}}$$

Where,
Cov_{xy} (p) = Phenotypic covariance between x and y
V_x (p) = Phenotypic variance of characters x
V_y (p) = Phenotypic variance of characters y
The significance of correlation coefficients was tested against 'r' values given by Fisher and Yates (1963) [61].
Path coefficient analysis as applied by Dewey and Lu (1959) [5] was used to partition the phenotypic correlation into components of direct and indirect effects. By keeping the yield as dependant variable and the other traits as independent variable, simultaneous equations which express the basic relationship between path coefficients were shown to estimate the direct and indirect effects.

3. Results and Discussion

Morphological and yield traits were recorded and presented in Table 1. Good amount of phenotypic variability was found among the traits except number of seeds per siliqua. The plant height showed variation ranging from 82.43 to 102.93 cm with the mean value of 95.81. The coefficient of variation for plant height was 6.09. The number of days taken for 50 % flowering ranges from 42.33 to 57.00 with the mean value of 52.42 and coefficient of variation was 3.39. The coefficient of variation for the trait days to maturity was 1.53 and the range varies from 95.33 to 111.33 with the mean value of 106.47. The number of branches per plant varies from 19.23 to 20.53 with the mean value of 19.48 and the coefficient of variation was 4.97. Seed yield per hectare varies from 1474.67 to 2032.68 kg with the mean value of 1845.18 kg and the coefficient of variation was 10.81.
The mean test seed weight was 1.73 g and this trait ranges from 1.62 to 1.89 g with the coefficient of variation of 9.48. The length of siliqua ranges from 5.40 to 6.45 mm with the mean value of 5.72 and the coefficient of variation was 7.21. The mean number of siliqua per plant was observed as 126.63 which ranges from 2180.10 to 2347.57 with the coefficient of variation of 9.75. The trait number of seed per siliqua was invariably 2 in all the lines selected. The oil percentage of asalio lines varies from 18.63 to 24.67 % with the mean value of 21.51 and the co-efficient of variation was 8.50. The oil yield per hectare ranged from 338.11 to 485.56 kg having the mean value of 398.83 kg and the coefficient of variation for this trait was 16.41 (Table 1). The variability studies results showed that the line MLS-1007 found to be superior for seed yield and it could be utilized further in crop improvement programme. Similar variability studies were conducted in mustard which consonance with our findings (Kumar, 1993; Muhammad Akbar *et al*., 2003 and Yadava *et al*., 2011) [10, 12, 22].

3.1. Phenotypic correlation

The seed yield per hectare was considered as dependant variable and other traits were considered as explicative variable. The number of seeds per siliqua is invariable (2.00 per siliqua) in all the lines hence it showed no correlation with any other traits. The plant height expressed highly significant and positive correlation with days to 50 % flowering (0.675) and days taken for maturity (0.738); showed positive correlation with length of siliqua (0.056), oil yield (0.389) and seed yield per ha (0.561) and it registered negative correlation with number of branched per plant, test seed weight, number of siliqua per plant and oil percentage. The days to 50% flowering showed highly positive correlation with days taken for maturity (0.863) and positive correlation with length of siliqua (0.246) and seed yield per hectare (0.225) with the rest of the traits it showed negative correlation. The trait for days to maturity showed positive correlation with test seed weight (0.325), oil yield (0.168) and seed yield per hectare (0.516) and recorded negative correlation with number of branches per plant, number of siliqua per plant and oil percentage. The number of branches per plant registered positive correlation with length of siliqua (0.228), oil percentage (0.088), oil yield per ha (0.243) and seed yield per ha (0.283) and negative correlation with test seed weight, number of siliqua per plant.
The test seed weight showed positive correlation with length of siliqua (0.128), no of siliqua per plant (0.270) and seed yield per ha (0.064) and negative correlation with oil percentage and oil yield per ha. The length of siliqua showed positive correlation with seed yield per ha (0.113) whereas negative correlation with number of siliqua per plant and oil yield per ha besides showed highly negative correlation with oil percentage. The number of siliqua per plant showed no correlation with seeds per siliqua and oil percentage and showed negative correlation with oil yield per ha and seed yield per ha. Oil percentage revealed highly positive correlation with oil yield per ha (0.715) and positive correlation with seed yield per ha (0.133). The oil yield per ha showed positive correlation with seed yield per hectare (0.786) (Table 2).
In this present investigation, correlation studies made among the characters revealed both positive and negative association with varying levels of significance. The similar finding were also observed in mustard (Shalini, 1998, Bikram Singh, 2004, Tusar *et al*. 2006, Gangapur *et al*., 2009 and Sheweta and Om Praksh, 2014) [17, 3, 20, 8, 18].

3.2. Path analysis

The estimation of correlation coefficient indicates only the event and nature of association between yield and its attributes, but does not show the direct and indirect effects of different yield attributes which are mutually associated. These will in turn impair the true association existing between a component and yield and a change in any one of these component is likely to disturb the whole network of cause and effect. Thus each component has two paths of action *viz.*, direct influence on yield and indirect effects through components which are not revealed from the correlation studies. In this context, the path analysis was analyzed to provide an effective measure of direct and indirect causes of association and depicts the relative importance of each factor involved in contributing to the final product *i.e*., yield (Thondaiman and Rajamani, 2014) [19].

Out of the morphological and yield characters studied, six traits showed positive, direct effects on asalio seed yield. They were days to 50% flowering (0.0401), number of branches per plant (0.0149), test seed weight (0.0122), length of siliqua (0.0181), number of siliqua per plant (0.0165) and oil yield per ha (1.4584). The direct effects of plant height (-0.0098), days to maturity (-0.0741) and oil percentage (-0.9113) were in negative direction. The number of seed per siliqua has no effect on seed yield (0.000) (Table 3). Thus the results of path analysis among asalio lines revealed that greater emphasis should be given to days to 50% flowering, number of branches per plant, test seed weight, length of siliqua, number of siliqua per plant and oil yield per ha for the selection process in crop improvement. The similar studies were conducted in mustard also concord the results (Gangapur *et al*., 2009, Ara *et al*., 2013 and Ejaz-Ul- Hassan *et al*., 2014) [8, 2, 6].

Table 1: Variability studies in asalio

Lines	Plant Height (cm)	Days to 50% flowering	Days to maturity	No. of branches per plant	Seed yield (kg/ha)	Test seed weight (1000 seed)	Length of siliqua (mm)	No. of siliqua per plant	Seeds per siliqua	Oil (%)	Oil yield per hectare
MLS-1007	102.93	56.33	111.00	20.37	2032.68	1.62	5.87	2180.10	2.00	22.67	460.62
HLS-4	98.43	57.00	108.00	19.23	1770.43	1.84	5.57	2301.80	2.00	19.57	346.12
HLS-27	82.43	42.33	95.33	19.80	1474.67	1.74	5.40	2347.57	2.00	22.93	338.11
ULS-15	97.23	50.33	105.33	19.47	1961.19	1.72	5.68	2267.10	2.00	24.67	485.56
ALS-1	102.57	55.67	106.67	19.60	1765.52	1.68	5.57	2207.43	2.00	21.70	384.02
MLS-10-1	94.07	56.33	110.00	19.97	1950.57	1.89	6.45	2260.73	2.00	18.63	361.30
MLS-10-16	92.00	44.67	104.00	20.53	1966.91	1.70	5.75	2184.70	2.00	21.63	429.50
GA-1	96.80	56.67	111.33	19.73	1839.46	1.62	5.45	2242.30	2.00	20.77	385.38
Mean	95.81	52.42	106.47	19.48	1845.18	1.73	5.72	2248.97	2.00	21.57	398.83
CV	3.67	3.39	1.53	4.97	10.81	9.48	7.21	9.75	0.00	8.50	16.41
S.E.	2.0325	1.0274	0.9428	0.5690	115.1366	0.0946	0.2379	126.6322	0.0000	1.0590	37.7891
Minimum	82.43	42.33	95.33	19.23	1474.67	1.62	5.40	2180.10	2.00	18.63	338.11
Maximum	102.93	57.00	111.33	20.53	2032.68	1.89	6.45	2347.57	2.00	24.67	485.56

Table 2: Phenotypic correlation for 11 characters under protected condition in Asalio

Sl. No.	Traits	Plant height (cm)	Days to 50% flowering	Days to maturity	No. of branches per plant	Test seed weight	Length of siliqua (mm)	No. of siliqua/ plant	Seeds per siliqua	Oil percentage (%)	Oil yield per ha (kg)	Seed yield / hectare (kg)
1.	Plant height (cm)	1.000										
2.	Days to 50% flowering	0.675***	1.000									
3.	Days to maturity	0.738***	0.863***	1.000								
4.	No. of branches / plant	-0.001	-0.148	-0.024	1.000							
5.	Test seed weight (g)	-0.021	-0.002	0.019	-0.397	1.000						
6.	Length of siliqua (mm)	0.056	0.246	0.325	0.228	0.128	1.000					
7.	No. of siliqua/plant	-0.118	-0.146	-0.098	-0.083	0.270	-0.182	1.000				
8.	Seeds per siliqua	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000			
9.	Oil percentage (%)	-0.036	-0.343	-0.3441	0.088	-0.246	-0.444*	0.000	0.000	1.000		
10.	Oil yield / ha (kg)	0.389	-0.039	0.168	0.243	-0.117	-0.203	-0.094	0.000	0.715***	1.000	
11.	Seed yield / hectare (kg)	0.561	0.225	0.516	0.283	0.064	0.113	-0.120	0.000	0.133	0.786	1.000

Table 3: Phenotypic Path co-efficient analysis in Asalio for yield

Sl. No.	Traits	Plant height (cm),	Days to 50% flowering	Days to maturity	No. of branches per plant	Test seed weight	Length of siliqua (mm)	No. of siliqua/ plant	Seeds per siliqua	Oil percentage (%)	Oil yield per ha (kg)
1.	Plant height (cm)	-0.0098	-0.0066	-0.0072	0.0001	0.0002	-0.0005	0.0012	0.0000	0.0004	-0.0038
2.	Days to 50% flowering	0.0271	0.0401	0.0347	-0.0059	-0.0001	0.0099	-0.0058	0.0000	-0.0138	-0.0016
3.	Days to maturity	-0.0547	-0.0640	-0.0741	0.0018	-0.0014	-0.0241	0.0073	0.0000	0.0255	-0.0125
4.	No. of branches / plant	-0.0001	-0.0022	-0.0004	0.0149	-0.0059	0.0034	-0.0012	0.0000	0.0013	0.0036
5.	Test seed weight (g)	-0.0003	0.0000	0.0002	-0.0048	0.0122	0.0016	0.0033	0.0000	-0.0030	-0.0014
6.	Length of siliqua (mm)	0.0010	0.0045	0.0059	0.0041	0.0023	0.0181	-0.0033	0.0000	-0.0081	-0.0037
7.	No. of siliqua/plant	-0.0019	-0.0024	-0.0016	-0.0014	0.0045	-0.0030	0.0165	0.0000	0.0000	-0.0016
8.	Seeds per siliqua	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9.	Oil percentage (%)	0.0329	0.3124	0.3136	-0.0803	0.2238	0.4050	-0.0003	0.0000	-0.9113	-0.6514
10.	Oil yield / ha (kg)	0.5673	-0.0563	0.2453	0.3545	-0.1710	-0.2966	-0.1374	0.0000	1.0425	1.4584
11.	Seed yield / hectare (kg)	0.5614	0.2254	0.5164	0.2830	0.0645	0.1138	-0.1198	0.0000	0.1335	0.7861

4. Conclusion

Variability is the important thing that required for any breeding programme. The variability exists in this lines could better utilized for further crop improvement of asalio. The line MLS-1007 was found as superior line as far as yield is concerned. A positive coefficient of phenotypic correlation was found between plant height, days to 50% flowering, days to maturity, number of branches per plant, test seed weight, length of siliqua, oil percentage and oil yield per hectare with seed yield per hectare. The outcome of path analysis showed days to 50% flowering, number of branches per plant, test seed weight, length of siliqua, number of siliqua per plant and oil yield per ha exhibited significance at high level in positive direction. The morphological markers could be utilized for selection of superior lines for crop improvement of asalio.

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