Direct RESEARCH JOURNALS

Effect of Various Floral Morphometric Characters on the Seed Set in *Linum usitatissimum* (L.) Griesb"

Direct Research Journal of Agriculture and Food Science (DRJAFS) Vol.2 (5), pp. 44-54, June 2014
Available online at directresearchpublisher.org/drjafs
ISSN 2354-4147 ©2014 Direct Research Journals Publisher

Research Paper

Rajesh kumar Jain

Botany Department, D.N College, Meerut,India.

ABSTRACT

This work is unique in that the relationship between floral traits and seed yield has not been previously studied. All characters show high heritability with high genetic advance except the characters like bud breadth, petal breadth and female reproductive organ length. They show moderate heritability with moderate genetic advance. The present finding suggest that these characters are additive in nature and could be improved by direct selection. High heritability estimates also indicates that major portion of genetic variability was owing to additive gene action. Most of the characters under this heading showed high heritability with high genetic advance. The high heritability with moderate genetic advance has been observed for the characters like seed per capsule, vegetative and reproductive phase length, harvest index and fruit breadth. Highly significant positive correlation coefficient has been observed *seed* breadth with fruit length, seed length with flower length, petal breadth, ovary length , breadth and fruit length. Fruit length with bud length, breadth , flower length ,breadth, sepal length , filament length, anther length , female reproductive organ length and ovary length. The female reproductive organ length with bud length, flower breadth, sepal breadth, petal breadth, style and stigma length and ovary length. The bud breadth with bud length. The path coefficient analysis indicated that characters like male reproductive organ length, sepal length, pedicel length and ovary length showed the main contribution towards flower breadth. Hence maximum emphasis should be given for these characters during selecting for improvement in flower breadth , because flower breadth provide more space for insect pollination and helping to get hybrid seeds.

Key Words: *Linum,* Floral parts, variablility correlation, path coefficient.

*Corresponding Author E-mail: rajmeerutcity@gmail.com

Accepted 24 May 2014

INTRODUCTION

Progress in crop production depends to a great extent on the ability of the breeders to select high yielding varieties. Floral traits usually play a key role in rapid diversification, as their modification can easily lead to reproductive isolation and species formation .All things being being equal, species with high potential for rapid response to selection on such traits are likely to differentiate into more incipient species and have a greater number of successful descendants than species with low potentials for rapid evolution. It is universally accepted that the floral morphology of animal-pollinated angiosperms has evolved in close connection with the activity of their pollinating agents (Darwin, 1877; Leppik, 1957; Stebbins, 1970; Faegri and Vander ,1971). Nevertheless, studies directly examining the adaptive significance of floral traits and their influence on plant reproductive success are comparatively scarce (Waser,1983).Testing the adaptiveness of floral traits requires the some variation in the trait, either occurring naturally or induced by experimental manipulation (Waser,1983).Intraspecific variation in floral traits occurring naturally in time or space may be used to ask how variation alters plant reproductive. The floral traits are also a measure of yield and should be considered, during selection in breeding programmes to improve yield.

These are most variable quantitative characters. Variation is a necessary condition for selection programme aimed at improving some desirable traits. Studies of phenotypic variability in plants have favoured vegetative traits (Venable, 1984) over floral traits. Apart from the spectacular and infrequent floral polymorphisms exhibited by some species, flowers have for a long time been regarded as relatively invariant organs with little intraspecific variability (Grant, 1949; Stebbins, 1974), and for many years the only information available on their quantitative variation was the size range of petals, sepals, etc. recorded by systematists from herbarium specimens. More recent studies on intraspecific variation in flowers have focused on character displacement and pollination ecotypes (Armbruster, 1985, 1991; Robertson and Wyatt, 1990; Andersson and Widen, 1993; Johnson, 1997). Studying plant species in which floral variations are marked, easily diagnosable externally, when the goal is evidencing variability and phenotypic selection. With the increasing interest in the evolution of correlated traits and phenotypic integration in plants (Berg, 1960; Conner and Via, 1993; Conner and Sterlin, 1995; Cresswell,1998; Herrera, 1995; Wilson, 1995; Armbruster *et al.,*1999; Wolfe and Krstolic, 1999), new data on intraspecific variation of floral traits have become available. Since the focus of such studies is not documenting phenotypic variability *per se* but the relationships among traits, spectacular variation in floral phenotypes is no longer a prerequisite.

Berg (1960) noted that many plants have specialized relationships with pollinators and have evolved precise correspondence between flower and pollinator morphology. She hypothesized that selection against covariation of floral morphology with vegetative traits would be generated by reduced reproduction in plants with flowers (of unusual shape or size) that place pollen in ‘‘improper’’places on pollinators (that is, places not contacting stigmas) or whose stigmas contact pollinators in places where there is no pollen. Thus the floral morphology of plants with specialized pollination ecology should have evolved to be decoupled from the large phenotypic variation usually exhibited by vegetative traits such as plant stature and leaf size. Berg argued that populations of plants with specialized animal pollination systems have evolved increased phenotypic independence of floral traits from environmentally, developmentally,and genetically generated variation in vegetative traits. This idea has been discussed recently by Andersson (1994), who noted relatively stable flower size and shape in the face of variation in plant size in *Nemophila* (Hydrophyllaceae), and similarly, with regard to pollinator choice, by Møller and Eriksson (1994), who observed apparent buffering of developmental instability (fluctuating asymmetry) in flowers as compared to leaves. Berg also implied that plants with specialized animal pollination systems (in which many floral traits are functionally interrelated) should exhibit tighter phenotypic integration among floral traits than plants with wind or unspecialized pollination systems (in which floral traits have fewer functional relationships). This idea has been more fully developed subsequently (Stebbins, 1974; Conner and Via, 1993; Conner and Sterling, 1995; see also Cheverud, 1996a; Nicotra, Chazdon, and Schlichting,1997; Waitt and Levin, 1998).At the same time, selection should perhaps favor stronger correlations between functionally related floral traits (Stebbins, 1950, 1974; Conner and Via, 1993;Conner and Sterling, 1995; Waitt and Levin, 1998). Thus plants with specialized pollination (that is, precise and consistent fit between flowers and pollinators) should exhibit floral characters that strongly covary with one another but not with vegetative traits. Consequently, this type of research is perhaps more likely to provide an unbiased assessment of floral variation in the angiosperms. In this paper variation and covariation of floral traits are investigated in a set of plants .Information on how patterns of phenotypic correlation are affected by phylogenetic relatedness is scarce in plants (Armbruster, 1988; Mazer and Hultgard, 1993; Armbruster *et al.,* 1994; Torres, 2000).One goal of this study was to attempt to determine whether the pattern of trait integration was consistent . This is of interest because congruence or incongruence of the respective sets of phenotypic correlations can facilitate conclusions on how constrained the evolution of these traits has been during the diversification of this plant group. Ecological and evolutionary studies typically consider variation in single reproductive characters in isolation, without considering how they might be correlated with other reproductive and vegetative characters. The relationships of such variation to measurements of seed yield components and aspects of plant vegetative size. Most of the variation in the sizes of reproductive structure . Measurements of various floral traits in hermaphrodite populations require the analysis of performance through both female and male sex functions. Success, because floral morphology plays an important role in promoting effective cross-pollen transfer in populations . These investigations have often shown that variation in the size of flowers or floral parts translates into differences in seed production and outcrossing rate (Beare and Perkins, 1982; Harder *et al.,* 1985; Thomson and Stratton, 1985; Galen and Newport, 1987; Nilsson, 1988). Floral traits are likely to have been fine tuned by stabilizing selection (Conner and Via, 1993), and thus are expected to have relatively low genetic variation and show significantly high phenotypic and genetic correlations .However, empirical evidence does not support these considerations. In several families morphological diversity of flowers in one genus contrasts with morphological similarity in other genera that occur in a similar range of environments. What is the degree of genetic variation of flower size? Is flower size genetically correlated with other floral traits ?

There is no doubt that phenotypic variation in phenology is the rule in natural populations (Augspurger, 1981, Rathke and Lacey, 1985), and many studies have confirmed a genetic cause to this variation (Pors and Werner, 1989, Dorn and Mitchell-Olds, 1991, Kelly, 1992, Conner and Via, 1993, O'Neil, 1997, Quinn and Weitherington, 2002). Genetic variation in floral traits creates temporal population structure similar to spatial structure . Despite the potential importance of this we know virtually nothing of its strength in natural populations.

The marker-based approach can be powerful in a small, genetically characterized population where paternity of each seed can be established. To achieve this level of resolution in natural populations, however, many pollen donors (thousands?) would have to be characterized at many loci, as would numerous offspring from each seed parent. Difficulties such as like these could be why phenological assortment remains unexplored. Clearly, less cumbersome methods to study assortative mating in natural populations are needed.

Correlations between fitness and traits under selection can be used to study the role of natural selection in local adaptations. Production of a stable quality and quantity of these plants is important to growing world market, which make it necessary to breed varieties with high yield and quality. Seed yield is a quantitative trait and highly affected by environmental factors (Poormohammad et al., 2009). Plant breeders, commonly prefer yield components that indirectly increase seed yield (Yasin and Singh, 2010). Correlation of a particular character with other characters contributing to seed yield is of great importance in indirect selection of genotypes for higher seed yield (Choudhry et al., 1986; Ali et al., 2003). Simple correlation analysis that relates seed yield to a single variable may not provide a complete understanding about the importance of each component in determining seed yield (Dewey and Lu, 1959).

Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated (Wright 1921; Dewey and Lu, 1959).Path coefficient analysis have been widely used in plant breeding programs to determine the nature of the relationships between yield and yield components that are useful as selection criteria to improve crop yield. In most studies involving path analysis, researchers considered the predictor characters as first-order variables in order to analyze their effects over a dependent variable such as yield. This approach might result in multi-colinearity for variables, and possibly make difficulties in interpretation of the actual contribution of each variable (Hair et al., 1995). Recently the sequencial path coefficient analysis has been used by many researchers in different crops (Samonte et al., 1998;Mohammadi et al., 2003; Das et al., 2004; Asghari-Zakaria et al., 2007; Feyzian et al., 2009; Karuppaiah and Senthil, 2010), for complete identification of impact of independent variables on dependent ones. Floral traits are for many reasons suitable for studies of distribution of genetic variation within and between populations. Traditionally floral traits variation have been important components in studies of plant life history evolution (Turesson 1922, Stebbins 1950). The floral traits are also most essential for species survival, shown in many studies to be highly correlated with plant fecundity (e.g., O'Neil 1997, Ollerton & Lack 1998, , Stinson 2004). The objective of present study was to determine the interrelationships among yield and related characteristics for developing selection criteria for improving seed yield using a sequential path model. This paper examines the relationship between quantitative variation in floral morphology and maternal reproductive success.

MATERIALS AND METHODS

The experimental materials consisting of ten genotypes of Linum usitatissimum namely TLP-1,RLC-29,LC-54,LC-185,T-397,Kiran,Nagarkot,Neelum,Shubra and Gaurav.

The certified seeds were procured from Chandershekar Azad University of Agriculture and Technology, Kanpur India. They were sown in the month of November in a randomized block design with four replications spaced 45 cm apart. A distance of 20 cm in between them was maintained by thining some 15-20 days after sowing. A good crop was raised by following the recommended package of practice. The soil of experimental plot was loam and the pH of soil ranges from 5.8 to 7.5.The average annual precipitation of the area about 700 m.m, most of which (above 78%) is received from June to September and the rest from October to May. The hottest month of May and June when the maximum temperature may rise to 45^{o} c. The month of January is the coolest when the minimum temperature of 1.7^{o}c may be reached. The experimental is located at 20.6^{o} N latitude and 77.15^{o}E longitude at an elevation of 230.6 meter above the sea level.

Numerical estimation of various floral parts that is, length and breadth of mature bud, fully expanded flower, pedicel length in flower, sepal and petal length were measured. In petals the length of claw and limb was measured separately. In stamens also, the length of the filament and anther was measured separately. In female reproductive structure (carpel) the length of style , stigma and ovary was also separately measured.

Biometrical Analysis

All the characters were subjected for the analysis of variance given by Panse and Sukhatme (1961).The significance of variance was tested using 'F' test comparing the observed values of variance ratio with its expected G.C.V(genotypic coefficient of variation)and P.C.V(phenotypic coefficient of variation) and heritability were calculated using the formulae as suggested by Burton(1952).The expected genetic advance(G.A) at 5% intensity of selection differential was calculated by Johanson et al;(1955) formulaes. The genetic advance as percentage of mean was calculated by using Allard(1960) formulae. Genotypic and phenotypic correlation coefficient were estimated by Searle(1961) formulae. The significance of phenotypic correlation coefficient was tested against ‘r ‘ value from ‘r ‘ table of Fisher and Yates (1938), for (n-2) degree of freedom. The direct and indirect effect were estimated in path coefficient analysis as suggested by Dewey and Lu (1959).Simmonds (1962) has stated that the range of variability depends upon the selection pressure under domestication that is, upon the system of agriculture. In his later (1979) communication ,he further stated that the imposition of new norms of selection by the plant breeder allowing the survival of only favoured genotypes and variability is destroyed at considerable rate. The rate and magnitude of variability depends upon factors such as breeding system ,reproductive habit, population size and seed and pollen dispersal. So we classified the G.C.V,P.C.V, heritability and genetic advance in to high ,moderate and low magnitude for our convenience for the presentation and analysis of results. However, there is no such particular criteria for the classification of G.C.V,P.C.V and G.A except in case of heritability where Robinson (1966) has given such range. In the present communication we considered the following range for G.C.V,P.C.V, heritability and genetic advance. The magnitude of G.C.V, P.C.V up to 10% as low,10 to 20% as moderate and above the 20% considered as high. The magnitude of heritability in broad sense has been considered as low below the 0.3, between 0.3 to 0.6 as moderate and above 0.6 as high. The magnitude of G.A as in percentage of mean up to 7% as low ,between 7 to 15% as moderate and above 15% as high.

RESULTS AND DISCUSSION

To appreciate better the knowledge of the effect of these floral traits could assist the breeding of linseed. Two aspects of this study should be elaborated. Firstly floral traits were numerically estimated under natural condition (day to day).This may be significant unlikely to be the case for pollination and seed setting. The second point of elaboration is that these traits are statistically analysed and study was confined to one site. Aspects of this regime include both correlation and path coefficient analysis , will influence the economic yield.

The innovations of various biometrical techniques has given encouraging results in various crops in this regards.

The data recorded for various characters and the result obtained in the present investigation have been discussed. The scope of crop improvement for better races depends the magnitude and nature of the variability in the population. A study of variability under the particular stress environment , is of much value in understanding quantitative inheritance in the selection of parents and appropriate breeding techniques.

Variability

A perusal of data (Tables 1 and 2) revealed that there were a significant difference among the varieties of L. usitatisimum for all the floral characters except petal length. The S.E.D.M and C.V values are low and the error variance is less than their respective G.C.V and P.C.V values. The P.C.V values are higher than their respective G.C.V values.

All characters show high heritability with high genetic advance except the characters like bud breadth, petal breadth and female reproductive organ length. They show moderate heritability with moderate genetic advance. The present finding suggest that these characters are additive in nature and could be improved by direct selection. High heritability estimates also indicates that major portion of genetic variability was owing to additive gene action.

. The slight higher value of G.C.V indicate the considerable amount of variability present among the genotypes. Burton (1952) suggested that genotypic coefficient of variation along with heritability estimates would give a better idea about the efficiency of selection. Swroop and Chaugale (1962) suggested that G.C.V alone is not sufficient for the determination of amount of heritable portion. The significance of heritability suggested that there may be higher concentration of dominant alleles in the genotypes which leads to high mean performance. The additive and non- additive gene action assessed through variance were found to be important in the expression of these traits. It indicate that these characters are largely governed by dominant gene action. It would be difficult to improve them through selection.

The present findings shows almost medium to high heritability with low genetic advance, indicating that they were largely influenced by environment and thus require high selection intensity for improving these traits. The heritability estimates provide useful indication of the relative value of selection based on phenotypic expression . Johnson et.al; (1955) suggested that heritability and genetic advance when calculated together are more useful in predicting resultant effect of selection. Swaroop and Chaugale (1962) reported that inspite of high heritability for many characters ,low value of genetic

Table 1. Analysis of variance for various floral parts in linum usitatissimum l.

S.N	CHARACTERS	REPLICATION	TREATMENT	ERROR
	d.f	3	9	27
1	Bud length	0.003094	0.07363**	0.001688
2	Bud Breadth	0.0002560	0.002352**	0.0005539
3	Flower length	0.003545	0.05019**	0.002385
4	Flower Breadth	0.0099963	0.4003**	0.007650
5	Flower pedicel Length	0.03277	1.4818**	0.01147
6	Sepal Length	0.001553	0.03162**	0.0007716
7	Sepal Breadth	0.0001889	0.008863**	0.0005021
8	Claw Length	0.001129	0.005948**	0.0003874
9	Claw Breadth	0.0004833	0.006238**	0.0002944
10	Limb Length	0.002315	0.06731**	0.002286
11	Limb Breadth	0.0002937	0.1798**	0.001963
12	Petal Length	0.01292	0.08951**	0.03240
13	Petal Breadth	0.001949	0.1951**	0.001552
14	Filament Length	0.0005820	0.01704**	0.0006566
15	Anther length	0.0001692	0.001066**	0.0001765
16	Male Reproductive Organ Length	0.0006828	0.02427**	0.0007797
17	Style and Stigma Length	0.0005426	0.01864**	0.0004054
18	Ovary Length	0.0008290	0.01757**	0.0004403
19	Female Reproductive Organ Length	0.01260	0.03686*	0.01278

*Significant at 5% Level,**Significance at 1% Level, df = degree of freedom,3 is the number of replication that is data were recorded on three replication,9 is the number of varieties,27 is the number of plants in three replications.

advance was reported. Thus high heritability does not necessarily mean an increase in genetic advance.In L . usitatissimum we observed four types of flowers in different cultivars. Funnel from LC-54, TLP-1 and RLC-29 , tubular in T-397 and Nagarkot, star shape in LC-185 and Kiran and disk shape in Neelum , Shubra and Gaurav varieties. These findings are in conformity with those reported by Dilman (1938).

Correlation coefficient

During the course of present investigation, phenotypic, genotypic and environmental correlation coefficient have been analysed so as to know the degree of association among the various characters. The significance of genotypic correlation could not be tested as no suitable statistical test is available. (Nasr et al; 1973). However, their magnitude in relation to their corresponding phenotypic estimates formed a sound basis for assessing the magnitude for their practical implication. The genotypic correlation of coefficient, in general has been found to be greater than corresponding phenotypic ones. It indirectly reveals that significant phenotypic association between characters was primarily due to genetic cause. It may be due to pleiotropic effect and due to linkage between genes. The data from the (Table 3) shall now be analysed at phenotypic level.

Highly significant positive correlation coefficient has been observed seed breadth with fruit length ; seed length with flower length, petal breadth, ovary length , breadth and fruit length. Fruit length with bud length, breadth , flower length ,breadth, sepal length , filament length, anther length , female reproductive organ length and ovary length. The female reproductive organ length with bud length, flower breadth, sepal breadth, petal breadth, style and stigma length and ovary length. The ovary length with bud breadth, flower length, breadth, pedicel length, sepal length, breadth, petal breadth and style and stigma length. The style and stigma length with bud breadth, flower breadth petal breadth and male reproductive organ length ; the male reproductive organ length with bud breadth, filament length and anther length ; the anther length with bud length and sepal length ; the filament length with bud length ; the petal breadth with bud breadth, flower length, breadth, sepal length and breadth ; sepal breadth with bud length, pedicel length and sepal length ; the flower length with bud length ; flower breadth with bud length and flower breadth ; the bud breadth with bud length. These findings indicate the highest strength of association among these traits which remain unaltered by environmental effect.

Significant positive correlation has been observed in the seed breadth with bud length, flower length, breadth , pedicel length, petal breadth, filament length, male reproductive organ length ; the seed length with bud

Table 2. Estimation of variability in various floral parts of linum usitatissimum l.

S.N	CHARACTERS	MEAN	S.E.D.M	C.V	G.C.V	P.C.V	HERITABILITY	GENETIC ADVANCE (K=2.06)	G.A % MEAN
1	Bud length	0.86	0.029	4.73	15.46	16.17	0.914	0.26	30.23
2	Bud Breadth	0.36	0.016	6.36	5.73	8.57	0.448	0.03	8.33
3	Flower length	0.97	0.034	5.00	11.21	12.28	0.834	0.21	21.64
4	Flower Breadth	2.29	0.061	3.80	13.63	14.15	0.928	0.62	27.04
5	Flower pedicel Length	2.59	0.075	4.12	23.33	23.69	0.970	1.23	47.49
6	Sepal Length	0.83	0.019	3.32	10.51	11.02	0.909	0.17	20.48
7	Sepal Breadth	0.35	0.015	6.36	12.98	14.45	0.806	0.08	22.85
8	Claw Length	0.20	0.013	9.81	18.60	21.03	0.782	0.07	35.00
9	Claw Breadth	0.20	0.012	8.26	18.58	20.34	0.835	0.07	35.00
10	Limb Length	1.05	0.033	4.53	12.10	12.92	0.877	0.25	23.80
11	Limb Breadth	0.93	0.031	4.75	22.63	23.12	0.958	0.43	46.23
12	Petal Length	1.25	0.012	14.32	16.51	17.19	0.306	0.14	11.20
13	Petal Breadth	0.93	0.027	4.21	23.52	23.90	0.969	0.45	48.38
14	Filament Length	0.61	0.018	4.19	10.47	11.28	0.862	0.12	19.67
15	Anther length	0.18	0.009	7.11	7.99	10.70	0.558	0.02	11.11
16	Male Reproductive Organ Length	0.79	0.019	3.49	9.59	10.20	0.883	0.15	18.98
17	Style and Stigma Length	0.52	0.014	3.85	12.92	13.48	0.918	0.13	25.00
18	Ovary Length	0.30	0.014	6.80	21.23	22.30	0.907	0.13	43.33
19	Female Reproductive Organ Length	0.81	0.07	13.85	16.51	16.80	0.320	0.09	11.11

S.E.D.M=standard error deviation in mean,C.V=Coefficient of Variation,GCV=Genotypic Coefficient of Variation,PCV=Phenotypic Coefficient of Variation.

length, breadth, pedicel length, sepal length, filament length, male reproductive organ length ,style and stigma length and female reproductive organ length ; the fruit breadth with flower breadth ,pedicel length, petal breadth ,ovary length ; fruit length with petal breadth ,style and stigma length ; the female reproductive organ length with bud breadth, flower length, sepal length; the style and stigma length with flower length, filament length, anther length; the male reproductive organ length with bud breadth ,flower length, breadth , sepal length ; anther length with filament length and bud breadth ; filament length with flower length ; petal breadth with pedicel length; petal length with bud length ,flower breadth and sepal length; the sepal length with bud length, breadth ,flower length ; the flower breadth with bud breadth ; the flower length with bud breadth. These findings indicate that the association between different traits differed with environment and hence the correlation coefficient response of different traits to selection might vary with environment. Such alteration in the nature of character association was reported by Roy and Murthy (1969) in wheat and Chauhan and Tandon (1984) in rice. The low positive phenotypic correlation could consult due to the modifying effects of environment on the association of characters at the genetic level. Our correlation coefficient findings are more or less similar to those of reported by Conner and Sterling (1995) in flowering plants. They have stated that the filament and corolla tubes were significantly correlated and the correlation between pistil and corolla tube length were not greater than the other floral correlation.

Path coefficient Analysis

The result of path coefficient analysis of (Table 4) indicated that characters like male reproductive organ length , sepal length, pedicel length and ovary length showed the main contribution towards flower breadth. Hence maximum emphasis should be given for these characters

Table 3. Estimation of correlation coefficient among various floral characters in linum usitatissimum l.

	Bud Breadth	Flower length	Flower Breadth	Flower pedicel Length	Sepal Length	Sepal Breadth	Petal Length	Petal Breadth	Filament Length	Anther length	Male Repro-ductive Organ Length	Style and Stigma Length	Ovary Length	Female Repro-ductive Organ Length	Fruit Length	Fruit Breadth	Seed Length	Seed Breadth	Seedling Vigour
Bud	Rg 0.815	0.801	0.817	0.285	0.698	0.693	0.748	0.682	0.706	0.714	0.777	0.695	0.761	0.744	0.730	0.308	0.601	0.600	-0.101
length	Rp 0.645**	0.713*	0.744**	0.271	0.507*	0.575**	0.506*	0.651**	0.612**	0.600*	0.692**	0.645*	0.700*	0.602**	0.714**	0.286	0.549*	0.519*	-0.097
	Re 0.676	*	-0.107	0.062	-0.019	-0.160	0.021	0.173	-0.128	*	-0.053	*	*	0.377	-0.044	0.209	-0.230	-0.125	-0.028
		-0.175								0.094		0.102	0.083						
Bud	3	0.819	0.732	0.223	0.713	0.472	0.803	0.578	0.661	0.696	0.718	0.652	0.728	0.721	0.706	0.505	0.725	0.731	0.306
Breadth		0.550*	0.470	0.164	0.505*	0.305	0.387	0.379	0.425	0.508*	0.504*	0.436	0.512	0.464*	0.624**	0.353	0.505*	0.413	0.221
		-0.038	-0.010	0.130	-0.064	0.068	0.025	0.125	0.052	0.324	0.206	0.085	0.211	0.312	-0.199	0.161	-0.089	-0.107	0.167
Flower			0.765	0.465	0.536	0.563	0.710	0.679	0.529	0.314	0.541	0.579	0.777	0.723	0.809	0.366	0.704	0.779	0.081
length			0.697**	0.396	0.508	0.532*	0.376	0.609**	0.450*	0.221	0.464*	0.494*	0.699*	0.499*	0.732**	0.235	0.664**	0.456*	0.077
			0.224	-0.254	0.336	0.391	0.052	-0.020	0.010	0.024	0.004	-0.107	*	0.067	0.116	-0.274	-0.160	-0.279	0.063
													0.294						
Flower				0.445	0.748	0.744	0.706	0.776	0.422	0.627	0.511	0.767	0.712	0.781	0.675	0.533	0.691	0.644	-0.412
Breadth				0.424	0.699*	0.692**	0.506*	0.709**	0.371	0.433	0.456*	0.694*	0.669*	0.610**	0.591**	0.445*	0.632**	0.470*	-0.370
				0.031	*	0.412	0.009	-0.128	-0.062	-0.102	-0.066	*	*	-0.178	-0.074	-0.005	-0.104	0.033	0.594
					0.156							-0.186	-0.054						
Flower					0.453	0.705	0.331	0.467	-0.301	-0.090	-0.252	-0.228	0.633	0.582	0.260	0.621	0.565	0.273	-0.104
pedicel					0.420	0.676**	0.179	0.452*	-0.270	-0.082	-0.240	-0.226	0.569*	0.296	0.275	0.531*	0.468*	0.192	-0.009
Length					-0.107	-0.207	-0.008	-0.006	0.075	-0.134	-0.106	-0.213	*	-0.193	0.310	-0.004	-0.178	-0.073	0.092
													-0.462						
Sepal						0.780	0.806	0.644	0.472	0.752	0.579	0.454	0.632	0.728	0.746	0.494	0.632	0.806	-0.223
Length						0.723**	0.537*	0.608**	0.364	0.630*	0.481*	0.428	0.615*	0.557*	0.703**	0.369	0.489*	0.516*	-0.214
						0.418	0.025	0.061	-0.482	*	-0.365	0.146	*	0.445	0.409	-0.085	-0.235	-0.328	-0.082
										0.119			0.451						
Sepal							0.532	0.744	0.008	0.439	0.112	0.282	0.712	0.717	0.490	0.535	0.670	0.577	-0.431
Breadth							0.307	0.678**	-0.051	0.315	0.060	0.240-	0.625*	0.571**	0.403	0.415	0.427	0.282	-0.373
							0.116	0.257	-0.351	0.070	-0.231	0.017	*	0.168	-0.014	-0.010	-0.438	-0.358	0.166
													0.226						
Petal								0.738	0.697	0747	0.754	0.755	0.725	0.775	0.735	0.560	0.802	0.652	-0.083
Length								0.429	0.322	0.333	0.371	0.358	0.378	0.223	0.384	0.117	0.399	0.396	-0.027
								0.188	-0.116	0.045	-0.074	-0.177	-0.016	-0.119	-0.127	-0.369	0.034	0.230	0.160
Petal									0.273	0.541	0.368	0.678	0.741	0.735	0.573	0.643	0.739	0.636	-0.442
Breadth									0.227	0.399	0.325	0.651*	0.688*	0.687**	0.505	0.530*	0.703**	0.447*	-0.433
									-0..342	0.016	-0.251	*	*	0.373	-0.211	-0.224	-0.172	-0.180	-0.095
												0.223	0.097						
Filamet										0.692	0.771	0.621	0.274	0.376	0.725	-0.193	0.469	0.611	0.066
Length										0.467*	0.667**	0.530	0.223	0.138	0.588**	-0.142	0.443*	0.521*	0.055
										-0.054	0.801	-0.213	-0.171	-0.195	-0.223	0.073	0.350	0.391	0.103
Anther											0.783	0.682	0.409	0.636	0.744	0.360	0.433	0.802	-0.328
length											0.667**	0.445*	0.312	0.338	0.583	0.210	0.302	0.386	-0.272
											0.516	-0.225	0.103	0.127	0.275	-0.073	0.065	-0.165	-0.316
Male												0.682	0.345	0.470	0.781	-0.068	0.516	0.694	-0.029
Reprod												0.586*	0.302	0.273	0.662**	-0.062	0.481*	0.555*	-0.020
uctive												*	0.066	-0.048	-0.108	-0.039	0.357	0.295	-0.217
Organ												-0.295							
Length																			
Style													0.587	0.733	0.544	0.061	0.557	0.486	-0.360
and													0.570*	0.574**	0.452	0.061	0.463*	0.340	-0.341
Stigma													*	0.517	-0.253	0.076	-0.006	-0.041	0.029
Length													0.393						

Table 3. Contd.

Ovary Length	0.712 0.638** 0.573	0.701 0.640** -0.093	0.624 0.497* -0.130	0.761 0.635** 0.260	0.649 0.489* 0.134	-0.246 -0.234 -0.061
Female Reproductive Organ Length		0.769 0.362 -0.123	0.610 0.253 -0.113	0.713 0.448* -0.122	0.807 0.271 -0.129	-0.439 -0.267 -0.179
Fruit Length			0.483 0.394 0.040	0.788 0.691** -0.102	0.709 0.632** -0.240	0.146 0.116 0.323
Fruit Breadth				0.628 0.441 -0.136	0.603 0.363 -0.085	-0.051 -0.038 -0.258
Seed Length					0.723 0.652** 0.556	-0.033 -0.027 0.023
Seed Breadth						0.011 0.006 -0.026

*Significant at 5% Level,**Significant at 1% Level

during selecting for improvement in flower breadth , because flower breadth provide more space for insect pollination and helping to get hybrid seeds. The characters like filament length of stamens has highest indirect effect via male reproductive organ length followed by bud length, anther length, fruit length, style and stigma length , seed breadth and bud breadth. The positive direct effect of male reproductive organ length has nullified by the maximum negative indirect effect via filament length. On the other hand it is interesting to note that the filament length of stamen has prime negative direct effect on flower breadth followed by characters like anther length, female reproductive organ length, bud length and fruit length. This direct negative effect compensated mostly through the positive indirect effect through male reproductive organ length which ultimately resulted in the significant positive correlation. Some characters showed positive direct effect with vary low magnitude indicating the neutral behavior of these traits towards the flower breadth. To overcome the problem of nullification characters, special breeding technique may be evolved to break their linkage. The high positive direct effect which was reflected in its positive and significant correlation coefficients might be regarded as the prime character for selection. This might be effective in obtaining superior genotype with wide flower breadth. The residual path has negative value at genotypic level, positive value at phenotypic level and considerably low in magnitude. The negative residual effect indicates that the most of the important attributing characters which enhance flower breadth ratio are taken into account. The positive residual effect indicates that characters or character other than those included in this analysis play an important role in contributing the variability to flower breadth.

Conclusion

Measurements of various floral parts in populations require the analysis of performance through both female and male organs. Here, a factorial design (flower length and breadth) was used to investigate how the pollination environment affects selection on floral morphology via flower breadth. Flower breadth was strongly pollen-limited, with supplemental pollinated plants setting more seeds. Strong positive selection was found on flower breadth, weak positive selection on flower length . By contrast, flowers with relatively wide corollas and low stigma–anther distances were favored in the pollinator exclusion treatment. Floral traits are likely to have been fine tuned by stabilizing selection and thus are expected to have relatively low genetic variation and show significantly high phenotypic and genetic correlations .However, empirical evidence

Table 4.Path coefficient analysis showing direct and indirect effect on flower breadth in linum usitatissimum l.

CHARACTERS			INDIRECT EFFECT													
	CORRELATION WITH FLOWER BREADTH	DIRECT EFFECT	Bud length	Bud Breadth	Flower length	Flower pedicel Length	Sepal Length	Sepal Breadth	Petal Length	Petal Breadth	Filament Length	Anther length	Male Repro-ductive Organ Length	Style and Stigma Length	Ovary Length	Female Reproductive Organ Length	Fruit Lengt
Bud length	rg 0.817	g -0.153		0.051	-0.060	0.049	0.242	0.073	0.015	0.270	-0.756	-0.274	1.119	0.283	0.274	-0.164	-0.095
	rp 0.744	p-0.129	-----	0.050	0.045	0.044	0.239	0.043	0.003	0.297	-0.700	-0.281	1.110	0.211	0.113	-0.154	-0.101
Bud Breadth	0.732	0.055	-0.143		0.066	0.038	0.219	0.049	0.016	0.228	-0.708	-0.234	1.108	0.266	0.236	-0.125	-0.112
	0.470	0.067	-0.096	-----	0.035	0.027	0.148	0.023	0.002	0.181	-0.486	-0.238	0.808	0.142	0.083	-0.119	-0.078
Flower length	0.765	-0.072	-0.128	0.051		0.079	0.145	0.059	0.011	0.269	-0.567	-0.106	0.835	0.236	0.285	-0.160	-0.086
	0.697	0.063	-0.092	0.037	------	0.065	0.149	0.040	0.002	0.278	-0.514	-0.103	0.744	0.161	0.129	-0.128	-0.091
Flower pedicel Length	0.748	0.171	-0.043	0.012	-0.033		0.122	0.084	0.016	0.255	-0.505	-0.286	0.894	0.185	0.205	-0.143	-0.076
	0.699	0.163	-0.035	0.011	0.025	-------	0.123	0.054	0.003	0.277	-0.416	-0.295	0.771	0.140	0.100	-0.143	-0.088
Sepal Length	0.445	0.270	-0.137	0.045	-0.038	0.078		0.082	0.008	0.185	-0.322	0.030	-0.390	0.185	0.205	-0.101	-0.026
	0.424	0.293	-0.105	0.034	0.032	0.069	-----	0.054	0.002	0.206	-0.309	0.038	-0.384	0.140	0.192	-0.076	-0.032
Sepal Breadth	0.744	0.105	-0.106	0.026	-0.040	0.138	0.210		0.016	0.294	-0.008	-0.147	-0.173	0.115	0.264	0.176	-0.050
	0.692	0.075	-0.074	0.021	0.033	0.114	0.212	-------	0.003	0.309	0.058	-0.147	0.096	0.078	0.117	-0.148	-0.050
Petal Length	0.706	0.016	-0.145	0.055	-0.51	0.057	0.271	0.056		0.292	-0.747	-0.251	1.165	0.308	0.236	-0.169	-0.085
	0.506	0.005	-0.065	0.026	0.024	0.029	0.157	0.023	------	0.196	-0.368	-0.156	0.595	0.117	0.061	-0.057	-0.048
Petal Breadth	0.767	0.396	-0.104	0.032	-0.049	0.080	0.174	0.078	0.012		-0.293	-0.182	0.568	0.277	-0.306	-0.197	-0.058
	0.709	0.456	-0.084	0.027	0.038	0.074	0.178	0.051	0.002	------	-0.260	-0.187	0.521	0.213	0.144	-0.176	-0.063
Filament Length	0.422	-1.071	-0.108	0.036	-0.038	-0.051	0.127	0.001	0.011	0.108		0.233	1.153	0.253	0.089	-0.065	-0.074
	0.371	-1.143	-0.079	0.029	0.028	-0.044	0.106	-0.004	0.002	0.104	------	0.219	1.543	0.173	0.036	-0.035	-0.073
Anther length	0.627	-0.336	-0.124	0.038	-0.023	-0.015	0.230	0.046	0.012	0.214	-0.742		1.209	0.278	0.133	-0.110	-0.076
	0.433	-0.468	-0.077	0.034	0.014	-0.013	0.184	0.024	0.002	0.182	-0.533	-----	1.069	0.146	0.050	-0.087	-0.073
Male Reproductive Organ Length	0.511	1.544	-0.118	0.039	-0.039	-0.043	0.156	0.012	0.012	0.146	-1.062	-0.263		0.278	0.112	-0.082	-0.079
	0.456	1.603	-0.089	0.034	0.029	-0.039	0.141	0.004	0.002	0.148	-1.105	-0.312	--------	0.191	0.0490.	-0.061	-0.082
Style and Stigma Length	0.767	0.408	-0.106	0.036	-0.042	-0.039	0.122	0.029	0.012	0.268	-0.666	-0.229	1.054		0.190	-0.144	-0.055
	0.694	0.327	-0.089	0.029	0.031	-0.037	0.125	0.018	0.002	0.297	-0.606	-0.209	0.939	------	0.092	-0.147	-0.056
Ovary Length	0.712	0.325	-0.116	0.040	-0.063	0.108	0.170	0.085	0.012	0.372	-0.293	-0.138	0.533	0.239		-0.191	-0.071
	0.669	0.162	-0.090	0.035	0.050	0.093	0.180	0.054	0.002	0.405	-0.254	-0.146	0.484	0.186	-----	-0.189	-0.075
Female Reproductive Organ Length	0.781	-0.173	-0.144	0.040	-0.066	0.100	0.223	0.106	0.016	0.449	-0.403	-0.214	0.726	0.340	0.358		-0.078
	0.610	-0.257	-0.077	0.031	0.031	0.048	0.163	0.043	0.001	0.313	-0.157	-0.158	0.379	0.187	0.119	---------	-0.045
Fruit Length	0.675	-0.102	-0.142	0.061	-0.061	0.045	0.201	0.051	0.013	0.226	-0.777	-0.250	1.206	0.222	0.228	-0.133	
	0.591	-0.125	-0.105	0.042	0.046	0.042	0.206	0.030	0.002	0.230	-0.672	-0.273	1.060	0.148	0.098	0.093	-------
Fruit Breadth	0.533	0.051	-0.047	-0.028	-0.026	0.106	0.133	0.056	0.009	0.254	0.206	-0.121	-0.105	0.025	0.203	-0.106	-0.049
	0.445	0.054	-0.037	0.024	0.015	0.087	0.116	0.031	0.001	0.242	0.162	-0.098	-0.150	0.020	0.080	-0.065	-0.049
Seed Length	0.691	0.010	-0.125	-0.051	-0.072	0.097	0.170	0.070	0.013	0.332	-0.503	-0.145	0.796	0.227	0.312	-0.176	-0.090
	0.632	-0.025	-0.083	0.034	0.048	0.077	0.143	0.032	0.002	0.321	-0.506	-0.142	0.771	0.151	0.135	-0.115	-0.086
Seed Breadth	0.644	-0.148	-0.137	-0.051	-0.056	0.047	0.230	0.060	0.010	0.251	-0.654	-0.276	1.072	0.189	0.211	-0.140	-0.103
	0.470	-0.075	-0.080	0.028	0.029	0.031	0.151	0.021	0.002	0.204	-0.595	-0.181	0.889	0.111	0.079	-0.069	-0.079
Seedling Vigour	-0.412	0.022	-0.015	-0.017	-0.006	-0.018	-0.060	-0.045	-0.001	-0.175	-0.071	0.110	-0.031	-0.147	-0.080	0.076	-0.015
	-0.370	-0.018	-0.012	0.015	0.005	-0.016	-0.063	-0.028	0.000	-0.195	-0.063	0.127	-0.046	-0.111	-0.038	0.068	-0.014

does not support these considerations. In several families morphological diversity of flowers in one genus contrasts with morphological similarity in other genera that occur in a similar range of environments, because the age of the members of these lineage-pairs is by definition the same, these differences suggest that rate of floral evolution can vary substantially and sometimes may be surprisingly rapid.

ACKNOWLEDGEMENTS

The author wish to acknowledge the principal scientist,Plant Breeding Division, Chandershekar Azad Agricultural and Technological university, Kanpur, India for supply the seeds of Linum usitatissimum varieties. I would like to extend my gratitude Prof.N.P.Saxena and Prof. Harendra Kumar for encouraging me and providing moral support from the very beginning of this study.

They critically read this paper and made many suggestions for improvement.

REFERENCES

Ali N, Javidfar F, Elmira JY, Mirza MY (2003). Relationship among yield components and selection criteria for yield improvement in winter rapeseed (*Brassica napus* L.). Pak. J. Bot., ,35: 167-174.

Allard RW(1960). Principal of Plant Breeding (ed) Jhon Wiley &Sons Inc.London.

Andersson S, Widen B (1993).Pollinator-mediator selection on floral traits in a synthetic population of *Senecio integrifolius* (Asteraceae).*Oikas,* 66: 72-79.

Andersson S (1994). Floral stability, pollination efficiency, and experimental manipulation of the corolla phenotype in *Nemophila menziesii* (Hydrophyllaceae). *American Journal of Botany,* 81: 1397–1402.

Armbruster WS(1985). Patterns of character divergence and the evolution of reproductive ecotypes of *Dalechampia scandens* (Euphorbiaceae). *Evolution,* 39: 733-752.

Armbruster WS (1988). Multilevel comparative analysis of the morphology, function, and evolution of *Dalechampia* blossoms..*Ecology,* 69:1746-1761.

Armbruster WS(1991). Multilevel analysis of morphometric data from natural populations: insights into ontogenetic, genetic, and selective correlations in *Dalechampia scandens. Evolution* 45:1229-1244.

Armbruster WS, Schwaegerle KE (1996). Causes of co-variation of phenotypic traits among populations. *Journal of Evolutionary Biology,* 9: 261-276.

Armbruster WS, Edwards ME, Debevec EM (1994). Floral character displacement generates assemblage structure of western Australian triggerplants *(Stylidium). Ecolog,y* 75: 315-329.

Armbruster WS, Distilio VS, Tuxill JD, Flores TC (1999). Covariance and decoupling of floral and vegetative traits in nine neotropical plants: A re-evaluation of Berg's correlation-pleiades concept. *American Journal of Botany* ,86: 39-55.

Asghari-Zakaria R, Fathi M, Hasan-Panah D (2007).Sequential path analysis of yield compo -nents in potato. J. Potato Res, 49: 273-279.

Augspurger CK (1981). Phenology, flowering synchrony, and fruit set of six neotropical shrubs. *Biotropica* ,15: 257-267

Beare MH and Perkins WE (1982). Effects of variation in floral morphology on pollination mechanisms in *Asclepias luberosa* L., butterflywced (Asclepiadareae). *Ameriran Journal of Botany,* 69: 579-584.

Berg RL (1960). The ecological significance of correlation pleiades. *Evolution* 14: 171–180.

Burton,G.W.(1952). Quantative inheritance in grasses. Proceeding VI. Institute of grassland Congrass. 1,:155-157.

ChauhanVS, Tandon JP (1984) Genetic variability and character association in hill rice.*Oryza*; 21:138-142.

Choudhry AR, Shah AH, Ali L, Bashir M (1986). Path coefficient analysis of yield and yield components in wheat. Pak. J. Agric.Res, 7:71-75.

Conner JK, Sterling A (1995).Testing hypotheses of functional relationships: A comparative survey of correlation patterns among floral traits in five insect-pollinated plants. *American* Journal of Botany, 82:1399-1406.

Conner JS, Via S (1993).Patterns of phenotypic and genetic correlations among morphological and life-histroy traits in wild radish, *Raphanus raphanistrum*. Evolution 7:704-711.

Cresswell JE (1998). Stabilizing selection and the structural variability of flowers within species. *Annals of Botany* 81: 463-473.

Darwin C (1877). *The Various Contriuances 6.r which Orchids are Fertilised 6.r Insects.* 2nd Edn, reprinted 1984, Chicago: *University* of Chicago Press.

Das KM, Fuentes RG, Taliaferro CM (2004). Genetic variability and trait relationships in switchgrass. Crop Sci., 44: 443-448.

Dewey JR, Lu KH (1959). A correlation and path coefficient analysis of components of creasted wheat(Agropyron cristatum) seed production. *Agronomy Journal;51*: 515-518.

Dorn LA, Mitchell-Olds T(1991). Genetics of *Brassica campestris*. 1. Genetic constraints on evolution of life-history characters. Evolution 45:371-379.

Eberhard SA, Russell WA (1966). Stability parameters for comparing varieties. *Crop Science ; 6* : 36-40.

Faegri K, Vander PL, (1971). The Principles of Pollination Ecology. 3rd Edn. Oxford: Pergainon Press.

Feyzian E, Dehghani H, Rezai AM, Jalali M (2009). Correlation and sequential path model for some yield-related traits in melon (*Cucumis melon* L.). *J. Agric. Sci. Technol., 11*: 341-353.

Fisher RA, Yates F (1938).Statistical tables for biological agricultural and medical research (ed.) Longman Group London

Gandhi SM, Sanghi Ak, Nathawat KN, Bhatnagar MP (1964).Genotypic variability and correlation coefficient relating to grain yield and a few other quantative characters in Indian wheats. *Indian . J . Genet; 24* : 1-8.

Grant V(1949).Pollination systems as isolating mechanisms ir angiosperms. *Evolution* 3: 82-97.

Hair JF, Anderson RE, Tatham RL, Black WC (1995). Multivariate data analysis with readings. 4th ed., Englewood Cliffs, NJ:Prentice-Hall.

Harder LD, Thompson JD, Cruzan MB, Unnasch RS (1985). Sexual reproduction and variation in floral morphology in an ephemeral vernal lily, *Erythronium americanum. Oecologia (Berlin), 67*:28629 1.

Herrera CM (1995).Floral traits and plant adaptation to inseci pollinators: a devil's advocate approach. In: Lloyd DG, Barren SCH, eds. *Floral biology: studies on floral evolution in animalpollinated plants*. New York: Chapman and Hall, 65-88.

Johanson HW, Robinson HF, Comstock RE (1955). Estimate of genetic and environmental variability in soyabean. *Agronomy Journal; 47*: 314-318.

Johnson SD (1997).Pollination ecotypes of *Satyrium hallacki,*(Orchidaceae) in South Africa. *Botanical Journal of the Linnear,Society* 123: 225-235.

Kansal KK and Gupta,S.C.(1987).Gene action in linseed.*Indian journal of Agriculture Science;51*:634-637.

Karuppaiah P, Senthil KP (2010).Correlation and path analysis in African marigold (*Tagetes erecta* L.). *Electr. J. Plant Breed., 1*:217-220.

Kelly CA (1992). Spatial and temporal variation in selection on correlated life-history traits and plant size in *Chamaecrista fasciculata*. Evolution 46: 1658-1673.

Leppik EE (1957). Evolutionary relationship between entomophilous plants and anthophilous insects. Evolution, 11:466-481.

Mazer SJ Hultgard UM (1993).Variation and covariation among floral traits within and among four species of northern European Primula (Primulaceae). *American Journal of Botany* 80: 474-485.

Mohammadi SA, Prasanna BM, Singh NN (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop Sci., 43*: 1690-1697.

Nasr,HG Shands HI Forsberg RA (1973) Correlation between kernel, plumpness, lodging and other agronomical char
acteristics in six rowed barley crosses. *Crop Sci; 13* :399-402.

Nilsson,L A(1988). The evolution of flowers with deep corolla tubes. *Nature, 334:* 147-149.

Ollerton,J A Lack J (1992). Flowering phenology, an example of relaxation of natural selection?. *Trends in Ecology and Evolution 7*: 274-276

O'Neil P(1997).Natural selection on genetically correlated phenological characters in *Lythrum salicaria* L. (Lythraceae). Evolution 51:276-274..Panse, V.G (1957).Genetic of quantitative characters in relation to plant breeding. *Indian Genet. Pl. Breed ; 17* : 318-328

Panse, VG PV Sukhatme PV (1961) Statistical method for Agricultural workers

Pathak HC, Dixit SK (1986).Genetic variability ,correlation and path coefficient analysis for component of seed yield in single stemed sesame . *Gujrat. Ag .Uni. Res. J; 12* : 1-5.

Pors BP, Werner A (1989). Individual flowering time in a goldenrod (*Solidago canadensis*): field experiment shows genotype more important than environment. American Journal of Botany 76: 1681-1688.

Poormohammad KS, Maury P, Nouri L, Ykhlef N, Grieu P, Sarrafi A (2009). QTL analysis of yield-related traits in sunflower under different water treatments. Plant Breed., 128: 363-373.

Quinn JA, Weitherington JD (2002).Genetic variability and phenotypic plasticity in flowering phenology in populations of two grasses. Journal of the Torrey Botanical Society 129:96-106.

Rai RSV, Venkateswaran A N Ramchandran T K Srinivasan G (1982).Genetic variability and correlation studies in Sesamum indicum. *Indian J. Ag .Res ; 15* : 119-122.

Ramanujam S Thirumalachar D K (1967).Genetic variability of certain characters in red piper (Capsicum annum).*Mysore .J. Ag. Sci ; 1* : 30-36.

Rao C.R.(1952) Advance statistical method in Biometrical Research. John. Willay & Sons. Inc. N.Y

Rao S K and Singh,S.P.(1985). Relationship of maturity with seed characteristics and their implication in selection of linseed. *Journal of Oil Seed Research;2* : 86-92.

Rao S K and Singh,S.P.(1987) .Additive dominance and epistatic effects in linseed. *Indian .J .Ag Sci; 57* : 208-211.

Rathke B E Lacey P (1985) Phenological patterns of terrestrial plants. *Annual Review of Ecology and Systematics 16*: 179-214

Robertson J L Wyatt R (1990). Evidence for pollination ecotypes in the yellow-fringed orchid, Platanthera ciliaris. *Evolution* 44: 121-133

Robinson,H.F. (1966). Quantitative genetics in relation to breeding on centennial of Mendalism. *Indian Journal of Genetics; 26* :171-187.

Roy N N Murthy B R (1969). Character association under different environment in bread wheat. *Indian .J.Genet*; 29: 233-240.

Samonte S O P B Wilson L T Mcclung A M (1998). Path analyses of yield and yield-related traits of fifteen diverse rice genotypes. *Crop Sci., 38*: 1130-1136.

Searle S R (1961).Phenotypic, genotypic and environmental correlation. *Biometrics; 17* : 474-480.

Simmonds N W (1962).Variability in crop plants, its use and conservation.*Biological Review; 37* : 422-465.

Singh R K (1969) .Undersuchungen Zer linlijhrung der index selection inder Pflazen Zijohtung. Unpublished Ph.D thesis, University of Rostock (Germany).

Singh P (1977).Biometrical analysis of yields and its components in linseed (L. usitatissimum). Ph.D Thesis ,Kanpur Uni,Kanpur.

Singh P Srivastava AN Singh I B (1987).Estimatiom of genetic variance for yield components and oil content in linseed. *Farm Sci. J;2*: 138-143.

St Pierra CA Klinch H R Gauthier FM (1967) .Early generation selection under different environment as it influence adaptation of barley. *Can .J .Pl. Sci ; 47* : 507-517.

Stebbins GL (1950) Variation and evolution in plants, Columbia University Press, New York,USA,

Stebbins GL(1957). Self fertilization and population variability in the higher plants. American Naturalist, 91:337-354.

Stebbins GL (1970). Adaptive radiation in angiosperms. I. Pollination mechanisms. *Annual* Review of Ecology and Systematics, 1:307-326.

Stebbins GL(1974).*Flowering plants: evolution above the species level.*Cambridge, Massachusetts: Belknap

Stinson K A (2004) Natural selection favours rapid reproductive phenology in *Potentilla pulcherrima* (Rosaceae) at opposite end of a subalpine snowmelt gradient. *American Journal of Botany 91(4)*: 531-539.

Swaroop V Chaugle D S(1962) Studies on genetic variability in sorghum. I .Phenotypic variation and inheritance component in some important quantitative characters contributing towards yield. *Indian .J . Genet ; 22* : 31-36.

Thomson J D Startton D A(1985).Floral morphology and cross-pollination in *Erythronium grandgorum* (Liliaceae). *American Journal of Botany, 72:* 433-437.

Torres C (2000) Pollen size evolution: correlation between pollen volume and pistil length in Asteraceae. *Sexual Plant Reproduction* 12: 365-370.

Turesson G (1922). The genotypical response of the plant species to the habitats. *Hereditas 3*: 211-350.

Waitt D E Levin D A (1998). Genetic and phenotypic correlations in plants: a botanical test of Cheverud's conjecture. *Heredity 80*: 310–319.

Waser N M (1983). The adaptive nature of floral traits: ideas and evidence. In L. Real (Ed.), *Pollination Biology:* 241-285. Orlando: Academic Press.

Wilson P (1995).Selection for pollination success and the mechanical fit of *Impatiens* flowers around bumblebee bodies. *Biological Journal of the Linnean Society* 55: 355-383.

Wolfe LM, Krstolic JL(1999).Floral symmetry and its influence on variance in flower size. *American Naturalist* 154: 484-488.

Wright S (1921).Correlation and causation. *J. Agric. Res., 20*: 557- 585.

Venable DL (1984).Using intraspecific variation to study the ecological significance and evolution of plant life-histories. In: Dirzo R, Sarukhan J, eds. *Perspectives on plant population ecology.*Massachusetts, Sinauer, 166—187.

Yasin AB, Singh S (2010).Correlation and path coefficient analyses in sunflower. J. Plant Breed. Sci., 2: 129-133.