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IMPORTANCE OF FLOWERING PERFORMANCE AND PATTERN IN LINUM SEED YIELD

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Research Paper

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ABSTRACT

Linum genotype with explorable traits for environment performance remain a major concern to plant breeders. Practical breeding programme require knowledge of gene action explorable for yield improvement. This study aims to analyse the flowering phenology variation, and fitness, for this reason. Additionally, an attempt is made to identify proximate environmental suitability that may cue the flowering, and ultimate causes for the flowering patterns. There were significant differences among all the genotypes for all the characters of flowering performance. The character like branch number at first flower and bud number at first flower showed the high heritability estimates with high predicted genetic advance. Moderate heritability with low genetic advance estimate has been observed for the characters like days to first flower from first bud and average daily flower production. Some 55 days are required for first bud and 69 days for first flower. The whole phase of bud development was completed in 15 days from bud initiation. The single continuous flowering period has been found to be 54 days and 4-5 flowers produced daily on a single plant. Flowers start to bloom at 6 to 6.30 A.M and continue till 8.30 to 9.00 A.M in all the varieties. The maximum anthesis has been observed between 7.30 to 8.00 A.M. The corollas were shed about 5.30 hours after the beginning of anthesis. So the petals drop off between 11.30 A.M to 3.00 P.M on the same day. The shedding of corolla was completed in 3.30 hours and the speedy hours were 1.30 to 2.00 P.M. The characters at maturity are the essence of all the study and also practically interlinked with crop growth and development. 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. The character like biological yield has maximum positive direct effect on economic yield followed by harvest index , the biological yield has highest positive direct effect on seed yield followed by harvest index and single continuous flowering period. The 1000 seed weight has highest positive indirect effect on economic yield via character like biological yield followed by harvest index, flower number per plant, capsule number per plant, reproductive phase length, secondary branch number and plant height at maturity.

Key Words: Linseed, flowering performance, flowering pattern, variability, path analysis.

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INTRODUCTION

Flowering phenology is an important and poorly understood plant trait that may possibly be related to the invasiveness potential of alien species. Plants are particularly sensitive to climate warming because snow melt timing exerts a direct control on their reproduction. Global warming is due to increased Co_2 level and snow melt dates with longer snow-free periods. The timing of flowering within and among individuals is of fundamental biological importance because of its influence on total seed production and, ultimately, fitness. Traditional descriptive parameters of flowering phenology focus on onset and duration of flowering and on synchrony among individuals. These parameters do not adequately account for variability in flowering across the flowering duration at individual and population level. Due to very extensive economic use of the plant *Linum usitatissimum* have attracted the attention of workers from various disciplines of botany and agriculture. There has always been an attempt to increase their yield and productivity to meet their ever increasing demand. The literature has been complied on linseed by Richharia (1962) and Wellwood (1961), concentrated on the morphology of flowers. Dillman (1938) reported that flowers were fully opened between 6.40 to 7.00 A.M and the petals begin to drop around 10:30 AM. Kadam and Patel, (1938) however reported that flowers open fully within 30 minutes after the sunrise. Davidson and Yermanos (1965) discussed periodic blooming which according to them is genetically determined. The timing and duration of flowering is affected by environmental factors. The flowering pattern has been studied by Howard and Khan (1924), Tammes, (1928) ,Kadam and Patel (1938), Davidson and Yermanos (1965),Chopde and Thakre (1969) and Hovland and Dybing (1973).Howard and Khan (1924) discussed the appearance of secondary flowering in India due to deep root system and soil moisture availability.

Tammes, (1928) classified flax flower in to first second and third categories in order of succession depending upon their position in the plant. Davidson and Yermanos (1965), found that under uniform environmental conditions of the green house, flowering and rest periods exhibits a variable timing and duration under field condition , they are more synchronized. They observed that when flowers were continuously removed, they were produced in an uninterrupted continuous periods with no detectable period of rest. Chopde and Thakre, (1969) found a single continuous flowering period between 33rd to 63rd day. Hovland and Dybing (1973), explained the physiological regulation of cyclic flowering in flax.

Varietal performance of linseed has been studied at Kangra hills (Gill and Singh, 1954); Madras (Rao 1962); Malva (Dastur and Bhatt 1965); Bichpuri (Kumar and Singh 1967); in Tarai area (Rai 1969) as also in Narmada valley (Bhatt, 1970). Bhatt (1970) reported that the main reason for lower per hectare yield of Indo-gangetic linseed varieties is their por germination in black clay soil. Hovland and Dybing (1973), has observed that low temperature favours the vegetative growth of the plant. The high temperature on the other hand favours flowering and seed production. Genetic and environmental requirements of varieties are extremely diverse within regions and therefore, make breeding programmes more complex (Singh and Sharma, 1996).To develop high yielding types for specific environment, inheritance pattern in the trait performance is of tremendous assistance to plant breeders. Rao and Singh (1985) found a wide range of genetic variability for days to flowering ,days from flowering to maturity ,seed morphological characters; some work has been done on the aspect like heritability and genetic advance by (Shehata and Comstock 1971;Kumar et al; 1980; Dayal et al., 1975) observed that the genetic coefficient of variation and heritability estimate have been shown the variability for days to flowering ,maturity and plant height. Ingale (1985) studied the days to flowering , days to maturity showed moderate heritability. (Shehata and Comstock, 1971; Dhaker, 1994; and Patel and Gupta, 1997) reported the additive and non-additive genetic variance for characters like days to flower, days to maturity, plant height and primary branch number.Competitive environments for plant performance for variance to separate the effects of other varieties in agricultural systems have been studied by Sakai, (1955, 1961); Donald , (1981); Langton,(1985) and in natural environment interaction on plant fitness (Solbrig and Simpson, 1977; Kelley and Clay, 1987; Goldberg, 1988). However, little is known relative performance of a genotype varies with about how the performance of genotypes competitive regime (Gupta and Lewontin 1982) . The use of heritability estimates complemented by genetic gain (genetic advance) in making superior selection has proved successful (Abou Al-Fadil et al., 2004; De Araujo et al., 2002).

The coefficient of variation (CV) describe the temporal variation in flowering on individual and population levels. Phenotypic plasticity, or the ability of a single genotype in response to environmental variation, has been the subject of intense investigation (Bradshaw, 1965; Schlichting, 1986; Scheiner, 1993;Sultan, 1995, 2000; Via et.al., 1995; Schmitt, 1997). Phenotypic plasticity is considered adaptive if the natural selection differs between environments, and the plastic phenotypic response is in the direction favoured by selection (Schmitt et al., 1995; Dudley and Schmitt, 1996; Dorn et.al., 2000). There have been several observations of adaptive plasticity as well as nonadaptive plasticity (Schmitt et.al., 1995; Warkentin, 1995; Dudley and Schmitt, 1996; Nunney and Cheung, 1997; Schmitt, 1997; Denver et al.,1998; Donohue et al., 2000a,b, 2001; Dorn et al., 2000;Agrawal et al., 2002). In addition, the evolution of phenotypic plasticity is critically dependent on the relative frequency of selective environments (Gomulkiewicz and Kirkpatrick, 1992). Genetic and environmental requirements of *Linum* varieties in the usitatissimum species are extremely diverse within regions and therefore, make breeding programmes more complex . The seed yield of varieties is determined by collective influence of both qualitative and quantitative traits and its progenies depend largely on the additive dominance variance components (Aremu et al., 2003). The seed yield is low due to unfavorable environmental conditions such as high rainfall, high disease incidence, reduced sunshine hour, poor soil fertility level etc. The choice of specific genotypes adaptable to unfavorable environmental condition is determined by careful breeding programmes (Khattack et al., 2002). One of such programmes involves knowledge of the gene actions operative in both qualitative and quantitative traits and formulation of breeding techniques for combining any of such desirable traits into developing high yielding genotypes for specific environment sensitivity should be there. Westerman and Lawrence (1970) provided an early example of selection acting against plasticity in their study of plastic responses to temperature in the model plant, Arabidopsis thaliana. The environmental variability may cause changes in flowering phenology (Molau et al., 2005), pollinator frequency (Tøtland, 2001), predator frequency (Galen, 1990; Freeman et al., 2003) and intensity of plant–plant interactions (Klanderund, 2004), affecting the overall performance of plants .Climatic conditions under which plants have evolved determine flowering phenology, although this trait might change if a plant is transported to a new region (Rathcke and Lacey 1985; Dlugosch and Parke,r 2008). Thuiller et al. 2005, observed that if the climate in the new range is similar to the original range, then alien species will not be expected to change their flowering phenology, and will bloom at the same time as native species. This may lead to different flowering phenology as compared to natives so that invasive alien species can start flowering before and for longer periods than natives (Pysˇek and Richardson, 2007) or later (Celesti-Grapow et al., 2003). So far, it remains unclear whether the flowering phenology pattern observed in invasive plants is due to a species-specific reproductive strategy involving a variable degree of local adaptation and plasticity, or if invaders simply conserve the flowering phenology of their native region.When more variables are included in the correlation studies, the indirect association becomes complex.Under such circumstances, path coefficient analysis provides an effective mean of finding out direct and indirect causes of association among causal variables. The study of the genetic parameters controlling the expression of its yield and components of yield is essential in determining the effect of such genetic parameters in enhancing the seed yield .The study is aimed for analyse the flowering phenology of Linum that has been described as temporally highly variable ('pulsed flowering') and the genetic variations ,relative performance including surviving, growth parameters of a genotype varies with about how the performance of genotypes in competitive regime of landrace and cultivar parents . For developing high yielding types for specific environment, inheritance pattern in the trait performance will be tremendous assistance to plant breeders.

MATERIAL 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.

Flowering Performance

It includes many parameters-days to first bud, days to first flower, days to first flower from first bud, days to 50% flowering, single continuous flowering period, average daily flower production, buds number at first flower, branch number at first flower, plant height at first bud and plant height at first flower.The initiation of first bud was determined in term of days between sowing and initiation of first bud. The opening of first flower was calculated in term of days between sowing and anthesis of first flower. The time lag between the first bud to first flower was recorded in term of days between first bud initiation and opening of first flower.The time period taken for the flowering of 50 % plants was also recorded in days from the date of sowing. The single continuous flowering period was calculated from the opening of the first flower to the time when lowering ceased in almost all the plants. The average daily flower production was also recorded . At the time when 50 % plants produced flowers , some plants were labeled. The preexisting flowers and fruits were removed and the periodicity of flowering was recorded..One sepal of each counted flower was removed for identity. The buds and branch number at the time of first flower was recorded by counting the number of buds and branches at the time of first bloom. The plant height at first bud and first flower was measured from the point of tillering to the top of the tallest shoot.

Flowering Pattern

It is determined by timing ,duration and frequency of flowering. For this purposes ,after the 50 % blooming ,50 fully grown buds were tagged in the evening. On the next morning ,they were examined at an interval of 30 minutes. The observations were repeated for 5 days . For the identity of each counted flower ,one sepal was removed. To study the shedding of corolla, the observations were taken after the initiation of flowers after a gap of 5 hours .The other observations were repeated at an interval of 30 minutes. For the study of anther dehiscence some 50 floral buds which were expected to bloom, were tagged in the evening. On the next morning ,they were observed carefully with hand lens to find out whether the anther has dehisced or not. Every care was taken that anther is not damaged during the process of recording the observations.

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 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.

RESULT AND DISCUSSION

The success of any crop improvement programme primarily depends upon the floral biology of the particular crop and mechanism of fruit production. It has been recognized as a model for understanding the interplay between natural selection and evolution of plants. 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 by hybridization 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

As we know adaptation of species under the natural condition may caused genetic variation among seed sources.These results illustrate the complementary nature of analyses of the net pattern of selection on phenotypic plasticity (over all environments) and the costs of phenotypic plasticity as expressed in individual environments. The measurement of variability in a population is not a simple matter. Phenotypic variability under a given environment can be easily measured but the phenotypes are determined by the joint effect of genotype , environment and their interactions. They reflect genetic as well as non genetic influence on the development. In the present study variability has been studied by the analysis of variance separately for all the characters by estimates of genotypic and phenotypic coefficient of variation, heritability and genetic advances.

Flowering performance

A perusal of data of (Tables 1 and 2), revealed that there were significant differences among all the genotypes for all the characters of flowering performance. The coefficient of variation (CV) defined as the standard deviation relative to the mean number of open flowers per day could provide a measure of temporal variation in flowering. The coefficient of variation at population level has been used widely in mast seeding/mast flowering research to estimate the degree of annual variation in seed output within a population (Silvertown, 1980; Kelly, 1994).The value S.E.D.M and C.V are low for all the characters except for the characters like branch number at first bud ,where S.E.D.M value is very low and C.V value high. The value of error variance is lesser than their respective G.C.V and P.C.V values. The P.C.V values are higher than G.C.V values for all the characters. These findings indicates that these characters , though controlled genetically but are greatly affected by environment. Environmental factors play a major role in their manifestation. The G.C.V helps to measure the range of genetic variability in characters and provides a measurement the genetic variability to

Table1. Analysis of variance for Flowering Performance in *Linum usitatissimum* L.(Mean performance).

S.N	CHARACTER d.f	REPLICATION	TREATMEN	ERROR
1	% Germination(Field)	17.4895	125.1736**	4.2106
2	Hypocotyl length(Field)	0.04472	0.266**	0.0156
3	Days to Ist bud	1.4713	62.4982**	5.5005
4	Days to Ist flower	6.6510	63.9722**	5.4432
5	Days to Ist Flower from Ist bud	0.09960	0.6172**	0.4075
6	Days to 50 % Flowering	14.2343	59.7309**	8.5306
7	Single continuous Flowering period	15.8723	81.8402**	4.6854
8	Average daily flower production	0.1609	0.2213**	0.08535
9	Plant height at Ist bud	1.7343	41.5564**	2.6464
10	Branch number at Ist bud	0.5949	1.0460**	0.2059
11	Branch number at Ist flower	0.2448	3.7243**	0.1490
12	Buds number at Ist flower	1.4739	103.1267**	3.1540

*Significant at 5 % level,** Significant at 1 % level

Table 2. Estimation of variability for Flowering Performance in *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 IN % MEAN
1	% Germination(Field)	88.97	1.45	2.30	6.18	6.60	0.878	10.61	11.92
2	Hypocotyl length(Field)	3.54	0.088	3.52	6.48	7.37	0.772	0.42	11.86
3	Days to Ist bud	55.49	1.65	4.22	6.80	8.01	0.721	6.61	11.91
4	Days to Ist flower	69.72	1.64	3.34	5.49	6.43	0.729	6.73	9.65
5	Days to Ist Flower from Ist bud	14.31	0.45	4.45	1.60	4.74	0.114	0.16	1.11
6	Days to 50 % Flowering	79.77	2.06	3.66	4.49	5.79	0.600	5.71	7.15
7	Single continuous Flowering period	54.32	1.53	3.98	8.08	9.01	0.805	8.12	14.94
8	Average daily flower production	4.94	0.20	5.90	3.73	6.98	0.285	0.20	4.04
9	Plant height at Ist bud	43.6	1.73	5.74	7.15	8.06	0.786	5.70	13.07
10	Branch number at Ist bud	3.29	0.32	13.77	15.91	19.57	0.505	0.67	20.36
11	Branch number at Ist flower	5.97	0.27	6.46	15.84	17.11	0.857	1.80	30.15
12	Buds number at Ist flower	23.09	1.25	7.68	21.65	22.97	0.888	9.70	42.00

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

compare in other characters.

A high CV can be the result of a highly variable and unsynchronized behaviour of the individuals or of a moderate individual variation combined with a high among-individual synchrony. Hence, identical CV values may reflect different biological causes. Therefore it was proposed to dissect the CV into within-individual variability and among individual synchrony to allow for the determination of their relative contributions (Herrera, 1998). The biological importance of the population-level parameter CV is hard to assess. Referring to mast seeding data sets, Herrera (1998) suggested the dissection of the CV into biologically more relevant parameters of within-individual variability and among-individual synchrony. In fact, analysis of mast seeding data showed that temporal variation on population-level reflected both, variation in CV and, to a lesser extent, variation in among-individual synchrony (Herrera, 1998; Koenig et al., 2003).

The character like branch number at first flower and bud number at first flower showed the high heritability estimates with high predicted genetic advance. This is encouraging, since selection based for these characters being additive in nature , is likely to be more efficient for their improvement. Lal et.al. (2007) observed the higher estimates of heritability coupled with the higher genetic advance for number of peduncles/plant, number of days to flower, number of pods/plant and pod yield/plant cowpea (*Vigna unguiculata* (L.) indicated that heritability is mainly due to additive genetic effects. Traits with greater magnitude of additive gene than dominance type are exploitable by standard hybridization and selection procedure. Selection of traits with such genetic variation would lead to meaningful breeding programme. The use of heritability estimates complemented by genetic gain (genetic advance) in making superior selection has proved successful (Abou Al-Fadil et al., 2004; De Araujo et al., 2002). In the contrary, Khattack et al. (2002) discovered high heritability and heterosis >100% over the better parent of a single maize hybrid. According to Dhaliwal et al. (2002), transgressive gene segregation leads to increase in vigor. The resultant generations also produced more branches and carried more pods than the cultivated smaller parent. Inspite of high heritability with moderate to low value of genetic advance has been observed for characters like days to first bud and first flower ,single continuous flowering period and plant height at first bud . These findings indicate that these characters being additive in nature and conclude that improvement could be done by simple selection . Mutry and Hashim (1973) found that characters like days to 50 % flowering and Chaudhary ,et.al., (1977) character like days to first flower were highly heritable in Sesame. Heritability estimates for days to flowering were large in a cowpea [*Vigna unguiculata* (L.)] as recorded by Francis and Ehlers (2008). However, moderate heritability with low genetic advance estimate has been observed for the characters like days to first flower from first bud and average daily flower production indicat -ing that these characters are non-additive in nature and completely controlled by environment.It could only be improved indirectly via other characters and suitable hybridization programme followed by appropriate selection.Chaudhary et.al., (1977) worked out the genetic variability for days to first flowers. This was highly heritable and it is operate by additive type of gene action. Stefan, (1996) observed low to moderate narrow-sense heritabilities for flower number, flowering date, plant height in Saxifraga granulate. The moderately high heritability and genetic advance values for these traits also confirm the reliability in the choice to improve yield for humid environment performance. Knowledge of gene action with quantitative traits is important in enhancing yield improvement for environment sensitive varieties. All the traits exhibited partial dominance by recording additive components to be higher than dominant components. These findings equally agree with the study of Saleh et al. (2002) who reported partial dominance for plant height and pod maturity for mungbean. Tefera (2002) reported additivity to increase amount of genotypic superiority available for future breeding programme.The high additive gene effect for these traits is highly informative and that manipulation of genes controlling would produce appreciable results especially for humid sensitive environment. The genetic variability in L. usitatissimum has been worked out by various workers namely (Gill and Singh 1958; Dyal et.al.,1975; Rao and Singh 1984; Chatterjee and Jha, 1990; Heyland and Hemkar 1991). Comstock et. al. (1958) reported that G. C. V does not give the idea of total variation that is heritable.

The relative amount of heritable portion of variation can be assessed through heritable estimates. Heritability is a standard of measuring the proportion of genetic variability to the phenotypic variability for predicting the resultant effect for selection on the basis of the phenotypic perfor - mance. Most of the characters under study in this heading exhibited the high estimates of heritability in broad sense. Thus the materials under study appear to be promising. High heritability values for characters are always preferred by breeders in generally. The characters with high heritability estimates are comparatively less affected by environment and these estimates thus enable him to base his selection reliable on phenotypic expression of these characters in individual plant. According to Majumdar et al . (1969) a high heritability value may be attributed to the additive gene action whereas, high environmental effect may lead to low heritability.

The expected genetic advanced showed wide range. Inspite of high heritability for many characters, low value of genetic advance has been observed. High heritability estimates was associated with high predicted genetic advance, which is encouraging. Since selection based on these characters being additive in nature, is likely to be more efficient for their improvement. As such phenotypic selection for these traits is likely to be effective for their improvement. Even though heritability estimates provide useful indication on their 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 Chaugle, (1962) advocated that high heritability does not necessarily mean in genetic advance. Gandhi et al. (1964) reported that a high genetic gain along with high heritability shows most effective conditions for selections.In *L. usitatissimum* we observed some 55 days are required for first bud and 69 days for first flower. The whole phase of bud development was completed in 15 days from bud initiation. The single continuous flowering period has been found to be 54 days and 4-5 flowers produced daily on a single plant. These finding more or less similar to those of Chopde and Thakre (1969).They reported a single continuous flowering period of 33-66 days and average daily flower production of 5-7 flowers in linseed. The first flower was bloomed on average 68-70th days after sowing. Bhatt, (1970) also observed the similar results in Narmada valley tract.

Flowering pattern

Flowering pattern is determined by timing ,duration and frequency of flowering. Plants display a wide variety of flowering patterns. The variation in flowering pattern has implications for many aspects of community ecology that is, organization and structure of communities (Janzen 1967, Frankie et al., 1974, Stlies ,1978) and population biology that is, flow in plants as determined by the foraging behavior of pollinators in resource patches varying in time and space (Levin 1979).The phonological studies conducted in tropical lowland ecosystem, particularly in Cost-Rica (Fournier and Sales 1966, Frankie et al.1974 ,Stlies 1978) have contributed much to our understanding of the flowering pattern. In L. usitatissimum, the present study revealed that flowers start to bloom at 6 to 6.30 A.M and continue till 8.30 to 9.00 A.M in all the varieties.

The maximum anthesis has been observed between 7.30 to 8.00 A.M. Thus duration of anthesis was 3- hours that is, anthesis is completes within three hours. The dehiscence of anthers was found to occur between 6.30 to 8.30 A.M and is completed within two hours.The corollas were shed about 5.30 hours after the beginning of anthesis. So the petals drop off between 11.30 A.M to 3.00 P.M on the same day. The shedding of corolla was completed in 3.30 hours and the speedy hours were 1.30 to 2.00 P.M. The periods of corolla shedding from anthesis was 7 to 10 hours.On a clear warm day the flowers are fully open approximately 30 minutes after the sunrise and the anther dehisces approximately 30 minutes after the flower open. The petal falls by early afternoon. So the flowering pattern or behavior is largely depend upon the Sunlight.

When weather is sunny ,abundant pollen grains were available for pollination. At the time of anther dehiscence, the flowers were usually in semi opened condition. A variety of selective factors may of selective factors may act as ultimate causes for the timing of flowering on both population and individual levels. Population flowering phenology is the sum of the flowering behaviour of the individuals. Hence, the main aspects on which potential selection on the schedule of flowering could act are the flowering duration of the individual, the distribution of open flowers within the individuals' flowering duration and the interaction among individuals by means of among-individual synchrony of flowering. For example, synchronous flowering may attract pollinators due to increased floral display and should promote outcrossing by maximizing the number of potential mates. In fact, high flowering synchrony has been shown to increase reproductive output (Augspurger, 1981; Marquis,1988; Mahoro, 2002; but see Primack, 1980; McIntosh,2002; Buide, 2004). However, slight asynchrony has also been described as beneficial for individual fitness if it forces pollinators to move between individuals (Rathke and Lacey, 1985). Tammes (1928) has used the terms as first, second, third etc to classify the flax flower with respect to their anthesis. Dillman (1938) studied the flowering behavior of flax (L. usitatissimum) and observed somewhat similar findings as those of ours in opening, anther dehiscence and corolla shedding. An extensive discussion on the anthesis of flax was presented by Kadam et al. (1938) .This study however, did not include observation on the pattern of flower production. Weevers (1952) reported that floral diversity is correlated in general with morpho - logical behavioural diversity. Davidson and Yermanos (1965) studied the flowering pattern in flax in different manner and reported the different pattern of periodic blooming. The flowers were produced in an interrupted period of bloom with no detectable period of rest.

The flowering pattern of linseed has been studied by Chopde and Thakre (1969) in a different manner. They considered that appearance of distinct flowering period is genetically determined and the timing and duration of these periods are affected by environmental factors. Hovland and Dybing (1973) studied the cyclic flowering pattern in flax and reported that flax produces flower in a cyclic manner with distinct blooming period. Guldberg and Atsatt (1975) also reported the behavioural diversity in flowering plants. We observed that the percentage shedding of corolla in *L. usitatissimum* is highly affected by temperature, cloudiness etc. These findings are in conformity with those reported by Addicott, (1977). He studied the flower behavior of *L.lewissi* and reported that flower opening is primarily a response to light but is slower when temperature is low .Flower close during the afternoon of the day of anthesis. They found that petal absicission is sensitive to temperature and moisture supply. Allies, (1977) observed that flowers open at 7.00 A.M and closed (shed) at 2.00 P.M.We conclude that flowering time obviously is a trait that varies greatly across the geographic range of species and varieties. For most species and varieties this variation can be attributed at least in part to variation in latitude, elevation or other factors that reflect climatic seasonality. Mc. Neilly and Antonovics (1968) examined the *Agrostis tenuis* and *Anthoxanthum odoratum* near the abrupt boundaries between soil type. They found substantial differences in flowering times of individuals. According to Fox (2003) genetic variation in flowering schedules creates temporal population structure similar to spatial structure. Lebon et al. (2008) found that in grapevine, sugars play an important role in flowering.This complex process from inflorescence initiation to fruit maturity. Climatic conditions under which plants have evolved determine flowering phenology, although this trait might change if a plant is transported to a new region (Rathcke and Lacey 1985;Dlugosch and Parker 2008). Plant species native to tropical regions are known to flower either as a response to the tropical wet season, as a consequence of phylogenetic constraints, or both, mainly corresponding to the summer of temperate regions (Wright and Calderon, 1995; Singh and Kushwaha, 2006). In temperate regions, where winter cold is the main limiting environmentalfactor, flowering time can extend from early spring tolate summer (Rathcke and Lacey 1985).

Currently, most of the available data concern the involvement of sugars as energy sources during the formation of reproductive structures from initiation of inflorescences, until flower opening. Sugars devoted to the development of reproductive structures are supplied either by wood reserves or by photosynthesis in leaves or inflorescences, depending on the stage of development. Female meiosis appears to be a key point in the success of flower formation because (i) flowers are vulnerable at this stage and (ii) it corresponds in the whole plant to the transition between reserve mobilization from perennial organs (roots, trunk, and canes) towards efficient leaf photosynthesis. The perturbation of reserve replenishment provokes in the development of inflorescences, whereas altering the photosynthetic sources affects the formation of flowers. In particular, a lack of sugar availability in flowers at female meiosis caused by various environmental or physiological fluctuations may lead to drastic flower abortion. Apart from energy, sugars also play roles as regulators of gene expression and as signal molecules that may be involved in stress responses. Aidyn et al.(2002) suggested that flowering is controlled by environmental conditions and developmental regulation .The plant can produce a coordinated flowering response under conditions in which multiple environmental parameters are changing simultaneously. Also, genetic analysis of *Arabidopsis* varieties showing natural variation in flowering time and how balancing the effects of different environmental stimuli on flowering time is important in plants adapting to growth in different geographical locations.

Overall performance

The characters at maturity are the essence of all the study and also practically interlinked with crop growth and development. This is precisely because, these aspects are of immense significance in realizing the genetic potential fixed by overall performance for evaluation of crop production.As such, overall performance is fundamentally based on sound genetic principles. It renders a desirable permanent (heritable) change in the nature of the plant thus evaluation of its genetic ceiling for productivity and quality. It is responsible for the aquesition of stability by a cultivar over a wide range of edaphoclimatic conditions.Environmental variation in temper -ature can have dramatic effects on plant morphology, phenology, and fitness, and for this reason it is important to understand the evolutionary dynamics of phenotypic plasticity in response to temperature. We investigated constraints on the evolution of phenotypic plasticity in response to a temperature gradient in the model plant Arabidopsis thaliana by applying modern analytical tools to the classic data of Westerman and Lawrence (1970). We found significant evidence for two types of constraints. First, we detected numerous significant genetic correlations between traits across all environments, which differed qualitatively in pattern between the set of ecotypes and the set of mutant lines in the original sample. Secondly, we detected significant costs of flowering time plasticity in two of the three experimental environments, and a net pattern of selection against flowering time plasticity in the experiment.

A breeding programme aimed in developing phenotypically stable varieties require informa -tion on the extent of genotype x environment interaction action for seed yield. Johnson et al. (1955) stated that the capacity of a variety for yielding well in range of environment had an importance equal to that of its yield potential. Borlaugh (1965), Eberhart and Russell, (1966) and St. Pierra et al. (1967) also stressed the advantage of selection for wide adaptability. It is now fairly appreciated that different varieties vary greatly in their response to a wide range of environment. This was demonstrated by Finlay and Wilkinson (1993) in barley and Eberhart and Russell (1966) in maize. Allard and Bradshaw (1964) suggested the use of genetic mixture rather than homogenous or pure line varieties as a means to reduce genotype x environment interaction. A perusal of data of (Tables 3 and 4) revealed that there are significant difference among all the varieties. The S.E.D.M and C.V values are low to very low which indicate high environmental influence. The high C.V values has been observed for the characters like primary branch number and biological yield. The error variance is less than their G.C.V and P.C.V for all the characters except characters like flower number per plant , capsule number per plant, capsule setting and life period , in these cases the error variance is higher than G.C.V and P.C.V. the former result indicate though these characters are controlled genetically but the environmental factor plays a major role in their manifestation and the latter shows that these characters are mostly influenced by environment. In general the P.C.V is marginally higher than G.C.V. The high value of G.C.V and P.C.V have recorded for the characters like primary and secondary branch number, flowers number per plant ,capsule number per plant, biological and economic yield in all the varieties. The 1000 seed weight has also showed the similar result. These indicate that there is scope for improving them through direct selection. However the influence of environment on each trait could be determined by the difference in P.C.V and G.C.V. Low gap between P.C.V and G.C.V indicates the stability of these traits over the environment. Low estimates of G.C.V and P.C.V have been recorded for characters like vegetative and reproductive phase length, life period,

Table 3. Analysis of variance for various maturity characters in linum usitatissimum L.

S.N	CHARACTERS d.f	REPLICATION 3	TREATMENT 9	ERROR 27
1	Vegetative Phase Length	2.5572	77.2569**	5.9971
2	Reproductive Phase Length	2.9427	90.0763**	4.8292
3	Life Period	1.1666	42.0000**	6.6435
4	Plant Height at Maturity	3.5729	409.6527**	7.7662
5	Primary Branch Number	0.7156	2.5182**	0.2180
6	Secondary Branch Number	12.6562	207.0616**	3.0251
7	Flower Number per Plant	26.2916	2617.7778**	43.3981
8	Capsule per Plant	25.0833	2131.6667**	43.9444
9	Seed per Capsule	0.03426	0.8924**	0.1020
10	% Capsule Setting	3.4687	28.3263**	3.9502
11	Biological Yield	1.3216	265.2803**	9.8508
12	Economic Yield	0.1715	35.8019**	0.5160
13	Harvest Index	0.9550	18.7335**	2.3182
14	Fruit Length	0.001476	0.02748**	0.001176
15	Fruit Breadth	0.001441	0.008580**	0.0006463
16	Seed Length	0.0002965	0.009260**	0.0006948
17	Seed Breadth	0.0001025	0.002600**	0.0004284
18	1000 Seed Weight	0.01155	22.1411**	0.0005714

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

seed number per capsule , capsule setting ,harvest index, fruit length and seed length and breadth. However plant height at maturity and fruit breadth also shows the low value of G.C.V and P.C.V. Here the difference between G.C.V and P.C.V is marginal. These findings indicate that these traits least affected by environment. It is well fact that importance of the result is the interaction between genotype and environment and as such the importance of this can not be ignored to arrive at reliable conclusion. The environmental condition has significance effect on characters. The evaluation of genotype under different environment would provide useful informations as the relative magnitude of phenotypic and genotypic variability. The critical examination of result revealed fairly good difference in the phenotypic and genotypic coefficient of variation for most of the characters indicating the scope for further improvement in these characters . The G.C.V values in measure the range of genetic variability in a character and provides a measurement to compare the genetic variability present in other characters. However, it is not responsible to estimate heritable variation with the help of G.C.V alone.Gupta (1975),Murugesan et al.(1979) and Joel and Thangavelu (1997) reported the high P.C.V value than G.C.V for characters like plant height, number of primary and secondary branches , capsule number and seed number per capsule and seed yield in linseed. However, Desai et al.(1982) and Pathak and Dixit (1986) observed low G.C.V value for seed yield and capsule number per plant.

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. It suggest that additive gene effect was predominating the expression of these traits. The moderate heritability and high genetic advance has been observed for seed breadth .The high heritability with low genetic advance for characters like percentage capsule setting , suggests that phenotypic selection for this character could not be reliable. It is because of the fact that in addition to genetic components, this character shows considerable portion of environmental factors. The moderate heritability with low genetic advance for character like life period indicate towards the non-additive gene effect for this trait. Characters with high heritability with high genetic advance indicate the presence of additive gene effect and consequently a high genetic gain from phenotypic selection is effective. selection. High heritability with moderate genetic advance indicate that additive gene effect is predominant in the expression of these traits. It also suggested some kind of simultaneous selection scheme such as selection index based on these characters may be taken up for further improvement. Panse (1957) stated that high heritability with high genetic advance provides a good scope of further improvement by selection. If these characters are subjected to mass progeny or family or modified selection scheme for exploiting additive genetic variance ,these characters can be isolatedin improved forms. Ramanujam and Thirumalachar (1967) also suggested that heritability estimates will be reliable if accompanied by high genetic advance. Gandhi et al. (1964) stated that high genetic gain alongwith high heritability shows more effective conditions for selection model might be adequate to get the desired genetic advance because no additional selection shall be achieved even by employing more sophisticated selection models. Characters with high heritability and low genetic advance might be due to larger contribution of environment variance to total variability. It also suggests that

Table 4. Estimation of variability for various maturity characters in 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 IN % MEAN
1	Vegetative Phase Length	70.09	1.73	3.49	6.02	6.96	0.748	7.52	10.72
2	Reproductive Phase Length	73.38	1.55	2.99	6.29	6.97	0.815	8.59	11.70
3	Life Period	142.43	1.82	1.80	2.09	2.76	0.571	4.63	3.25
4	Plant Height at Maturity	86.88	1.97	3.20	11.54	11.97	0.928	19.89	22.89
5	Primary Branch Number	5.39	0.33	8.65	14.06	16.51	0.725	1.33	24.67
6	Secondary Branch Number	49.25	1.22	3.53	14.50	14.92	0.944	14.29	29.01
7	Flower Number per Plant	199.73	4.65	3.29	12.70	13.12	0.937	50.58	25.32
8	Capsule per Plant	179.41	4.68	3.69	12.73	13.26	0.922	45.20	25.19
9	Seed per Capsule	9.20	0.22	3.47	4.83	5.95	0.660	0.74	8.04
10	% Capsule Setting	89.34	1.40	2.22	2.76	3.55	0.607	3.69	4.43
11	Biological Yield	39.72	2.21	7.90	20.12	21.61	0.866	15.32	38.56
12	Economic Yield	11.10	0.50	6.47	26.75	27.53	0.945	5.95	53.60
13	Harvest Index	27.76	1.07	5.48	7.30	9.13	0.639	3.34	12.03
14	Fruit Length	0.75	0.024	4.55	10.78	11.70	0.848	0.15	20.00
15	Fruit Breadth	0.58	0.017	4.34	7.62	8.77	0.754	0.08	13.79
16	Seed Length	0.48	0.018	5.42	9.53	10.97	0.755	0.08	16.66
17	Seed Breadth	0.25	0.014	7.98	8.99	12.02	0.599	0.04	16.00
18	1000 Seed Weight	7.28	0.032	0.63	32.28	32.30	0.989	4.84	66.48

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

phenotypic selection for these characters could not reliable because in addition to genetic component, this character show considerable portion of environmental factors. Patel et.al., (1974) stated that low estimates of genetic advance further leads to conclude that the improvement is only possible through suitable hybridization programme followed by appropriate selection. Johanson et.al.,(1955) too advocated that heritability values as well as estimates of genetic advance should be considered more useful than heritability alone while making selection.

Rao,(1952) stated that the selection of parents based on a single attribute may not be useful as the performance of any parent. This depends upon the number of important characters collectively, particularly is the aim to bring about improvement in complex quantitative traits. So, the basic information of heritability and genetic advance is a prequsite for planning a sound breeding programme based on selection technique. The magnitude of component is most important aspect of the genetic constitution of a breeding material. Burton (1952) suggested that G.C.V together with heritability estimates would give a best picture of the amount of the advance to be expected from selection.The heritable portion of the variation was thus found with the help of heritability estimates. The genetic advance indicates that capsule per plant and yield per plant can be improved through selection. Rai et.al. (1982) stated that number of branches possesses high value for all the genetic parameters. In L.usitatissimum Rao and Singh (1987) and Singh et.al.(1987) emphasized the importance of both additive and non-additive gene action for all most all the characters. Additive gene action has been reported for character like tiller number by Singh, (1977), Kumar and Chauhan (1982), for capsule number per plant by Kansal and Gupta (1987), Rao and Singh (1985), for seed per capsule by Mishra, (1977), Doucet et al. (1978) reported the additive gene action for vegetative phase length. Reproductive timing strongly influences natural selection and evolutionary potential (Donohue, 2005) and, as Stinson, (2004) points out, the extent to which alpine plants can endure climate change may depend on their potential for adaptive plasticity in flowering phenology under new environmental conditions. In S. ciliata, although earlier flowering improves plant fitness, the flowering start seems to be photoperiodically constrained toward the end of spring, preventing efficient use of the limited water supply. Flexibility to exploit selective pressure towards early flowering in evolutionary terms is limited, especially in marginal populations when faced with rapid warming and frequent extreme heat events. Thus the time scale may not be long enough to allow for local adaptation (Etterson and Shaw, 2001; Jump and Peñuelas,2005).

The disparity in some of the studies may be due to differences in size, diversity and nature of the material under study, the environment in which the experiments were conducted and the method of analysis employed. The estimates of genetic parameter to a large extent, are depending upon the materials under study.

Path coefficient analysis

The path coefficient analysis provide a picture of forces producing a given correlation coefficient and measure the cause and effect relationship in term of direct and indirect contribution of trait to a desired end product. Li (1956) emphasized the great use of path in genetics and plant breeding study and pointed out that it can be successfully used in the estimation of non-additive gene effect, equilibrium within inbreeding environmental influence. Deway and Lu (1959) pointed out that this analysis is very valuable tool in detecting the real merit of characters contributing towards the yield. It helps to separate the individual effects of characters in question rather than evaluating it only on the basis of its correlation with the final and most important of characters.

The result of (Table 5) ,indicated that character like biological yield has maximum positive direct effect on economic yield followed by harvest index , the biological yield has highest positive direct effect on seed yield followed by harvest index and single continuous flowering period. Sukhchain and Sidhu (1994) Path coefficients analysis revealed that panicle number per plant had highest direct effect on seed yield per plant, followed by branch number per panicle, days to flower and 100 seed weight in Guinea grass (Panicum maximum Jacq.) The 1000 seed weight has highest positive indirect effect on economic yield via character like biological yield followed by harvest index ,flower number per plant, capsule number per plant, reproductive phase length , secondary branch number and plant height at maturity. Hondelmann, Strauss (1990) found that the Number of flowers of primary inflorescence' and 'Number of flowers of secondary inflorescences' proved to be of major importance through direct effects on 'Total number of fruits' as indicator of seed yield. Indirect effects generally arc being canalized via the same variables. Selection for seed yield is made possible through the relation between 'Number of secondary branches' and 'Number of flowers of secondary inflorescences in Euphorbia lathyris L. Akinyele and Osekita (2006) found that in okra (Abelmoschus esculentus (L.) number of pods per plant and height at flowering had the highest direct effect on seed yield The existence of a strong relationship between plant size and flower production constitutes a general pattern in most plant species and habitats (Mitchell,1994; Ollerton and Lack, 1998), including the Mediterranean (Herrera, 1991; Albert et al., 2001). However, plant size exerted a constant positive effect on duration which, in turn, had a significant positive effect on flower number and flowering synchrony. Thus, despite the lack of a direct effect as shown in our SEM diagrams, plant size indirectly controls flower production: larger plants have a longer flowering period because of higher resource investment, and this corresponds to higher flower production.

Several previous studies have shown that the performance of genotypes varies significantly among different competitive regimes, suggesting specialization to particular competitive environments. Previous research with other species has shown that the maternal environment can have a large effect on seed size (Winn and Werner, 1987), and larger seeds may produce largerseedlings and adults, especially in competitive environments (Stanton, 1984; Gross, 1984). It has been argued that values of species traits cannot be treated as independent points in comparative analyses (Harvey and Purvis, 1991).

The differences from the previous works may be due to the difference in gene system which has come into play in different seasons. Perhaps the manifestation of some gene under different genetic background is not always the same, and more evidence may be called these assumption. Finlay and Wilkinson (1963), Khera and Sandhu (1978) and Sandhu et al. (1985) reported that parent as well as hybrid progenies showed differential response when grown in different environment. Tøtland (1999) found no evidence of selection acting on flowering time in the alpine Ranunculus acris subjected to experimental warming, but his previous studies in the same area found higher plant fitness in earlyflowering plants, suggesting that selection could differ between seasons depending on temperature conditions (Tøtland,1994, 1997). Stanton et.al. (2000) concluded that phenotypic selection may promote the avoidance of stressful conditions for reproduction through earlier flowering. In an ingeniousexperiment that manipulated the reproductive timing of an annual species, Griffith & Watson (2006) found that evolution to early reproduction would allow plants to reproduce beyond their actual range. It is now fairly well appreciated that different varieties vary greatly in their response to a wide range of environment.

Those characters show direct positive effect with very low magnitude indicating the neutral behavior of these traits towards the yield. The high positive direct effect which has reflected in its positive and significant correlation coefficient might be regarded as the prime characters for selection. This might be effective in obtaining superior genotype. However , the characters which have positive and significant correlation coefficient with seed yield but the direct effect is negligible or negative , the indirect effect seem to be the cause of correlation. Therefore , for improving the seed yield , the

Table 5.Path coefficient analysis of flowering performance characters showing direct and i ndirect effect on economic yield in linum usitatissimum L. INDIRECT EFFECTS

CHARACTERS	Correlation With Economic Yield	Direct Effect	1 Days to Ist Bud	2 Plants heigt at Ist Bud	3 Days to Ist Flower	4 Days to Ist flowr from Ist Bud	5 Days to 50% Flowerig	6 Single continuos Flowering period	7 Average Daily Flower production	8 Plant Height At maturity	9 Primary Branch number	10 Secondary Brach number	11 Flower/ Plant	12 Capsule/ Plant	13 Seed/ Capsule	14 Vegetative Phase length	15 Reprductive Phase length	16 Biologicl yield	17 Harvet index	18 1000 Seed weigt	19 Seedlig vigour
Days toIst Bud	rg 0.027 rp 0.035	G 0.017 P0.019	------	0.004 -0.002	-0.024 0.009	- 0.002 - 0.004	0.012 -0.009	-0.054 -0.001	-0.008 -0.003	-0.002 0.001	0.030 0.010	0.011 -0.002	0.000 0.000	0.021 0.015	0.000 -0.001	0.040 -0.002	-0.017 -0.002	0.079 0.073	-0.035 -0.023	-0.024 -0.002	0.009 -0.003
Plants height at Ist Bud	0.029 0.021	0.010 -0.011	- 0.007 - 0.003	-------	-0.008 0.003	- 0.002 0.000	0.004 -0.002	-0.021 0.000	-0.002 0.000	0.026 0.008	-0.007 -0.003	-0.014 0.002	0.000 0.000	0.002 0.000	0.000 -0.001	0.017 -0.001	0.021 0.002	0.153 0.118	-0.121 -0.082	-0.025 -0.002	-0.005 0.001
Days toIst Flower	-0.038 -0.033	-0.022 0.011	- 0.018 - 0.016	0.003 -0.003	-----	- 0.002 - 0.004	0.011 -0.010	-0.052 -0.001	-0.006 -0.004	0.001 0.000	0.027 0.010	0.013 -0.001	0.000 0.000	0.020 0.013	0.000 -0.002	0.039 -0.002	-0.018 -0.002	0.046 -0.006	-0.065 -0.018	-0.016 - 0.0020	0.006 -0.002
Days to Ist flower from Ist Bud	-0.810 -0.407	-0.003 -0.016	- 0.011 - 0.005	0.007 0.000	-0.019 0.003	------	0.011 -0.002	-0.051 0.000	0.002 -0.004	0.004 0.000	0.013 0.003	0.007 -0.001	-0.00 0.000	0.039 0.012	0.000 -0.001	0.032 -0.001	-0.022 -0.002	-0.881 -0.293	-0.324 -0.103	0.082 0.003	0.005 -0.001
Days to50% Flowering	0.059 0.003	0.017 -0.018	- 0.012 - 0.009	0.002 -0.001	-0.015 0.006	- 0.002 - 0.002	-----	-0.033 0.000	0.002 0.001	0.006 0.002	0.024 0.007	-0.004 0.000	0.000 0.000	0.024 0.013	0.000 -0.001	0.026 -0.001	-0.016 -0.001	0.143 0.084	-0.091 -0.076	-0.010 -0.001	-0.001 0.001
Single continuous Flowering period	0.119 0.099	0.055 0.001	0.016 0.013	0.004 0.004	0.021 0.008	0.003 0.002	-0.010 0.007	------	0.009 0.002	-0.004 -0.002	-0.040 -0.014	-0.018 0.003	0.001 0.000	-0.040 -0.022	0.000 0.003	-0.034 0.002	0.030 0.003	0.084 0.061	0.036 0.040	0.023 0.002	-0.011 0.004
Average Daily Flower production	0.392 0.191	0.012 0.011	0.011 0.005	-0.002 -0.000	0.012 -0.004	- 0.001 0.006	0.002 -0.001	0.040 0.000	------	0.001 0.000	-0.029 -0.007	-0.018 0.002	0.001 0.000	-0.021 -0.011	0.000 0.001	-0.024 0.001	0.015 0.002	0.331 0.200	0.089 -0.019	0.004 0.000	-0.031 0.007
Plant Height At maturity	0.110 0.107	0.027 0.011	- 0.001 - 0.001	0.009 -0.008	-0.001 0.000	0.000 - 0.001	0.004 -0.003	-0.008 0.000	0.000 0.000	------	-0.013 -0.005	-0.028 0.005	0.000 0.000	0.003 0.002	0.000 0.000	0.005 0.000	0.020 0.002	0.207 0.190	0.089 -0.082	-0.026 -0.003	0.002 -0.001
Primary Branch number	0.271 0.243	-0.054 -0.026	0.009 0.007	0.001 -0.002	0.011 -0.004	0.001 0.002	-0.008 0.005	0.041 0.000	0.007 0.0003	0.007 0.002	--------	-0.021 0.003	0.001 0.000	-0.029 -0.015	0.000 0.005	-0.017 0.001	0.033 0.004	0.257 0.214	0.045 0.042	-0.003 0.000	-0.009 0.003
Secondary Branch number	0.179 0.176	-0.054 0.010	0.004 0.004	0.002 -0.003	0.005 -0.002	0.000 0.001	0.001 0.000	0.019 0.000	0.004 0.002	0.014 0.005	-0.021 -0.009	-------	0.001 0.000	-0.032 -0.021	0.000 0.001	-0.008 0.000	0.028 0.004	0.267 0.238	-0.067 -0.053	0.009 0.001	0.005 -0.002
Flower/Plant	0.297 0.290	0.001 0.000	0.008 0.006	0.000 0.000	0.009 -0.004	0.002 0.003	-0.005 0.005	0.040 0.001	0.006 0.003	0.001 0.001	-0.032 -0.014	-0.031 0.005	-------	-0.060 -0.040	0.000 0.003	-0.016 0.001	0.045 0.005	0.344 0.332	-0.010 -0.015	0.011 0.001	-0.016 0.006
Capsule/Plant	0.350 0.322	-0.061 -0.044	0.006 0.006	0.000 0.000	0.007 -0.003	0.002 0.004	-0.007 0.005	0.036 0.000	0.004 0.003	-0.001 0.000	-0.026 -0.009	-0.028 0.005	0.001 0.000	-------	0.000 0.002	-0.013 0.001	0.041 0.005	0.365 0.321	0.030 0.020	0.008 0.001	0.014 0.005
Seed/Capsule	0.209 0.209	0.000 0.008	0.002 0.002	0.000 0.001	0.002 -0.002	0.002 0.002	-0.001 0.001	0.026 0.000	0.000 0.001	0.000 0.000	-0.041 -0.016	-0.010 0.001	0.000 0.000	-0.016 -0.0.11	--------	-0.004 0.000	0.023 0.003	0.218 0.230	0.016 -0.020	-0.010 -0.001	0.001 0.000
Vegetative Phase length	-0.007 -0.001	0.038 -0.002	- 0.018 - 0.015	0.004 -0.003	-0.023 0.009	- 0.002 - 0.005	0.012 -0.007	-0.050 -0.001	-0.008 -0.003	0.003 0.001	0.025 0.007	0.011 -0.002	0.000 0.000	0.022 0.012	0.000 -0.001	--------	-0.017 -0.001	0.057 0.030	-0.049 -0.014	-0.002 -0.002	0.008 -0.003
Reprductive Phase length	0.308 0.261	0.048 0.007	0.006 0.006	0.004 -0.003	0.008 -0.003	0.001 0.005	-0.006 0.004	0.035 0.000	0.004 0.003	0.012 0.004	-0.037 -0.015	-0.032 -0.005	-0.001 0.000	0.053 -0.035	0.000 0.003	0.013 0.000	------	0.397 0.316	-0.032 -0.040	-0.003 0.000	-0.014 0.005
Biological yield	0.779 0.748	0.835 0.818	- 0.002 - 0.002	0.002 -0.002	-0.001 0.000	0.003 0.006	0.003 -0.002	0.006 0.000	0.005 0.003	0.007 0.003	-0.016 -0.077	-0.017 0.003	0.000 0.000	-0.027 -0.017	0.000 0.002	0.003 0.000	0.022 0.003	----	0.238 0.145	-0.071 -0.007	-0.008 0.003
Harvest index	0.765 0.648	0.318 0.344	0.002 0.001	-0.004 0.003	0.005 -0.001	0.003 0.005	-0.005 0.004	0.006 0.000	0.003 -0.001	-0.008 -0.003	-0.006 0.003	0.011 -0.001	0.000 0.000	-0.006 -0.003	0.000 0.000	-0.006 0.000	-0.005 0.001	0.624 0.345	----	-0.067 -0.006	0.000 0.000
1000 Seed weight	0.748 0.722	-0.088 -0.009	- 0.005 - 0.004	0.003 -0.002	-0.004 0.002	0.003 0.005	0.002 0.002	-0.015 -0.000	-0.001 0.000	0.008 0.003	-0.002 -0.001	0.005 -0.001	0.000 -0.000	0.006 0.004	0.000 0.001	0.009 0.001	0.001 0.000	0.680 0.617	0.244 0.211	-----	0.001 0.000
Seedling	-0.188	0.035	-	-0.001	-0.004	0.000	-0.001	-0.017	-0.011	0.002	0.013	-0.008	0.000	0.025	0.000	0.009	-0.019	-0.203	0.002	-0.002	

Residual effect(genotypic)= -0.007,Rresidual effect(phenotypic)= 0.0010 indirect causal factors are to be considered simultaneously for selection. They also indicated that the correlation coefficient are almost equal to its indirect effect and has a time relationship between seed yield and causal factors. Hence, a direct selection through these traits would be effective.

To overcome the nullification problems,Patel et al.(1997) suggested that intermating or random selection in early segregating generations (especially in F_2 or F_3). This can be obtained by crossing these parents. They shall release the hidden genetic variability through breakage of undesirable linkage involved in different characters. It may produce an elite population for selection of high yielding lines in advance generations. The study also disclose that the precocity will reduce the yield and caution the breeder do not reduce the duration beyond the limit.

In the present study ,the biological yield has maximum direct effect on seed yield or economic yield suggested that the greater biological yield will provide more photosynthetic area through more number of leaves which in their turn would produce more flowers resulting in more number of pods per plant and more number of seed which would give more yield per plant. Duarte and Adams (1972) also showed the importance of more photosynthetic area in increasing the yield in field bean and indicated that leaf number was highly associated with pod number per plant and leaf size. But vegetative yield would bring down the harvest index.

It was also interesting to note that some characters showed the positive direct effect at genotypic level and negative direct effect at phenotypic level or vice versa. The residual effect has negative value at genotypic level and positive value at phenotypic level with very low magnitude at both level indicated that most of important characters have been included in the present study. It seems that character or characters other than those included in this analysis played an important role in contributing the variability in yield. Thus residual path makes outstanding contribution in determining various characters other than yield.

Conclusion

These kinds of analyses, once performed for a number of species in different competitive environments, will aid in our understanding of the selective effects of competitive interactions in plants. However, intraspecific variation of such size-dependence among sites and years has been little studied, especially in relation to environmental factors. The analysis of events and a cursory review of flowering pattern and flowering performance of L. usitatissimum faciliates a proper understanding of future processes. It is the flower which provides the site for all the reproductive events to occur for the development of a new generation. Reproductive timing strongly influences natural selection and evolutionary potential and can endure climate change may depend on their potential for adaptive plasticity in flowering phenology under new environmental conditions. Flexibility to exploit selective pressure towards early flowering is limited, especially in marginal populations when faced with rapid warming and frequent extreme heat events.

It is proposed that the selective benefit of this pulsed flowering may arise by at least two facts. First, the risk of reproductive failure due to unfavourable weather conditions for wind-pollination will be reduced by spreading the flowering events across the flowering season.

Secondly, high flower densities due to synchronous flowering pulses increase pollination efficiency and the rate of outcrossing. High heritability with expected high genetic gain suggests wider scope for characters improvement. On the basis direct and indirect effects of component characters it may be concluded that all the characters are in a harmonious time relationship controlled by an unexplored morphogenetic factors.

It is now fairly, well appreciated that the different varieties vary greatly in their response to a wide range of environment. Therefore, in developing phenotypically stable varieties, require information to the extent of varieties and environment interaction. In the light of the above findings it may be concluded that both additive and non-additive component of genetic variation are important in the expression of almost all the traits.The additive component is fixable that is the intensity of the trait expression controlled by gene acting additively, does not change due to the segregation effect. Not only this ,if a trait is controlled by additive genes, the selection of carrier genotype becomes reliable. The flowering pattern and flowering performance of the plant are considered to be the sum of all the genetic, physiological and morphological traits of a species variety. It determine its optimum fitness that is adaptation to the immediate environment or to future change. The crossing system in plants is naturally linked with their floral structure, flowering behavior and gametogenesis. Thus the flowering pattern and flowering performance with the working knowledge for a rapid crop improvement to fulfil the need for evergreen world population.

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REFERENCES

Abou Al-Fadil T, Dechamp GG, Poormohammad KS, Sarrafi (2004).Genetic variability and heritability for resistance to black stem in sunflower Helianthus annuos L. J.Genet .Breed. 58:325-328.

Addicott FT(1977). Flowering behavior in Linum lewisii . Some ecological and physiological factors in opening and abccission of petals. Am. Mid . Nat . 97: 321-332.

Aidyn M , Cremer F, Coupland G (2002).Control of flowering time interacting pathways as a basis for diversity . The Plant Cell . 14:111-130.

Agrawal AA, Janssen A, Bruin J, Posthumus MA, Sabelis MW (2002).An ecological cost of plant defence :attractiveness of bitter cucumber plants to natural enemies of herbivores. Ecol. Lett. 5: 377–385.

Akinyele BO, Osekita OS (2006). Correlation and path coefficient analyses of seed yield attributes in okra (Abelmoschus esculentus (L.) African Journal of Biotechnology. 5(14):1330-1336.

Albert MJ, Escudero A, Iriondo JM (2001).Female reproductive success of narrow endemic Erodium paularense in contrasting microhabitats. Ecology. 82: 1734–1747.

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

Allard RW, Bradshaw AD (1964).Implication of genotype environment interaction in applied plant breeding. Crop Sci . 4: 503-508.

Allies PT (1977).Effect of intra and inter-varietal pollination on the quality and yield of fibre flax sed.. In Mel' nichenko A.N(ed) Pollination of Ag Crops By Bees. 3:223-229,New Delhi.

Aremu CO, Fawole I, Azeez MA (2003).Genetic analysis of branching traits and inheritance pattern in a cross of branching and non branching cowpea. Nig. J. Genet. 18:44-48.

Augspurger CK (1981).Reproductive synchrony of a tropical shrub: experimental studies on effects of pollinators and seed predators on Hybanthus prunifolius (Violaceae). Ecology. 62: 775–788.

Bhatt JG (1970.) A comparison of growth, yield and oil content in indogangetic and peninsular varieties of linseed in Narmada vally tract. Madras . Ag .J .57:415-420.

Borlaugh NE (1965). Wheat rust and people . Phytopathology. 55: 1088-1098.

Bradshaw AD (1965). Evolutionary significance of phenotypic plasticity in plants. Adv. Genet. 13: 115–155.

Buide ML (2004).Intra-inflorescence variation on floral traits and reproductive success of the hermaphrodite Silene acutifolia. Annals of Botany. 94: 441–448.

Burton GW (1952).Quantative inheritance in grasses. Proceeding VI. Institute of grassland Congrass 1 155-157.

Celesti-Grapow L, Di Marzio P, Blasi C (2003). Temporal niche separation of the alien flora of Rome. In: Child LE, Brock JH, Brundu G, Prack P, Pysˇek P, Wade PM, Williamson M (Eds), Plant Invasions: Ecological Threats and Management Solutions. Backhuys, Leiden: pp.101–111.

Chatterjee SD, Jha AR (1990).Response to direct selection for seed yield in linseed. Indian. J. Ag. Sci. 60: 223-224.

Chaudhary PM, Patil GD, Zope RE (1977). Genetic variability and correlation studies in sesame (Sesamum indicum) J . Maharastra . Ag . Uni . 2 30-33.

Chopde PR, Thakre JT (1969). Flowering pattern of linseed. (Linum usitatissimum) Nagpur. Ag .Coll. Mag . 41:36-39.

Comstock RE, Kellehar T, Morrow EB (1958). Genetic variation in asexual species of garden strawberry. Genetics. 64 : 634-646.

Dastur RH, Bhatt JG (1965). Factors affecting the growth and yield of linseed(L. usitatissimum) in Malwa M.P. Indian .J .Ag. Sci . 36:141-152.

Daucet I (1978).Genetic analysis of some flax characters. Probleme de Genetica Theoretica Si Applicata 10:597-609.

Davidson J, Yermanos DM (1965).Flowering pattern of flax(Linum usitatissimum). Crop. Sci . 5: 23-28.

Dayal B,Tikka SBS, Jaimini SN,Goyal SN (1975).Heritability estimates in linseed.(Linum usitatissimum) .Oil .Seed. J . 5: 3-4.

De Araujo MRA, Coulman BE, Rakow G (2002) .Genetic variation, heritability and progeny testing in Meadow brome grass. Plant Breed. 121:417-424.

Dlugosch KM, Parker IM (2008). Invading populations of an ornamental shrub show rapid life history evolution despite genetic bottlenecks. Ecology Letters, 11:701–709.

Denver RJ, Mirhadi N, Phillips M (1998). Adaptive plasticity in amphibian metamorphosis: response of Scaphiopus hammondii tadpoles to habitat desiccation. Ecology .79: 1859–1872.

Desai NM, Shah RM, Kukadia MU (1982).Genetic parameters ,interrelationship and path coefficient analysis in sesame. Oil .Seed . J . 12 : 33-38.

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.

Dhaker JM (1994).Studies on heterosis, combining ability and stability parameters in linseed(Linum usitatissimum) .Unpublished Ph.D thesis, Rajasthan Agricultural University, Udaipur .Rajasthan.

Dhaliwal MS, Kaur A, Singh S (2002).Genetic analysis and correlation involving populations derived from L.esculentum X L.Pim pinellifolium cross of tomato. J .Genet. Breed. 56:345-354.

Dillman A C (1938). Natural crossing in flax. J .Am. Soc. Agron . 279-286.

Donald CM (1981). Competitive plants, communal plants, and yield in wheat crops. In Evans LT and Peacock WJ [eds.], Wheat science-today and tomorrow, Cambridge University Press, New York Pp.223-247.

Donohue K, Hammond Pyle E, Messiqua D, Heschel, MS, Schmitt J (2000a). Evidence of adaptive divergence in plasticity: density- and site-dependent selection on shade avoidance responses in Impatiens capensis. Evolution .54: 1956–1968.

Donohue K, Hammond Pyle E, Messiqua D, Heschel MS, Schmitt J (2000b). Density dependence and population differentiation of genetic architecture in Impatiens capensis in natural environments. Evolution .54:1969–1981.

Donohue K, Hammond Pyle E, Messiqua D, Heschel MS, Schmitt J (2001). Adaptive divergence in plasticity in natural populations of Impatiens capensis and its consequences for performance in novel habitats. Evolution .55: 692–702.

Donohue K (2005). Niche construction through phenological plasticity: life history dynamics and ecological consequences. New Phytologist. 166: 83–92.

Duarte RA, Adams MW (1972).A path coefficient analysis of some yield component interrelation in field beans (Phaseolus vulgaris). Crop Sci 12 579-582.

Dorn LA, Hammond Pyle E, Schmitt J (2000). Plasticity to cues and resources in Arabidopsis thaliana: testing for adaptive value and costs. Evolution. 54: 1982–1994.

Dudley SA, Schmitt J (1996). Testing the adaptive plasticity hypothesis: Density-dependent selection on manipulated stem length in Impatiens capensis. Am. Nat. 147: 445–465.

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

Etterson JR, Shaw RG (2001). Constraint to adaptive evolution in response to global warming. Science. 294: 151–154.

Finlay S, Wilkinson GN (1963). The analysis of adaptation in plant breeding programme. Aust .J. Ag .Sci 14: 742-754.

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

Fournier LA, Salas S (1966). Algunas observaciones sobre la dinamica de la floracion en el bosque tropical humedo de villa colon. Revista . Biol .Trop . 14 : 75-85.

Fox GA (2003).Assortative mating and plant phenology: evolutionary and practical consequences. Evolutionary Ecology Research . 5: 1-18 .

Francis KP, Ehlers JD (2008). Effectiveness of early generation selection in cowpea for grain yield and agronomic characteristics in semiarid west Africa. Crop. Sci. 48: 533-540.

Frankie GW, Baker HG, Opler PA(1974). Comparative phonological studies of trees in tropical wet and dry forest in the lowland of Costa-Rica. J .Ecol. 62: 881-919.

Freeman RS, Brody AK, Neefus CD (2003). Flowering phenology and compensation for herbivory in Ipomopsis aggregata. Oecologia. 136: 394–401.

Galen C (1990). Limits to the distribution of alpine tundra plants,

herbivores and the skypilot, Polemonium viscosum. Oikos .59: 355–358.
Gandhi SM, Sanghi AK, Nathawat KS, 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.
Gill KS, Singh S (1954). A study on some yellow seeded improved strain of linseed for introduction in Kangra hill of Punjab. Indian. Oil. Seed. J. 3: 9-13.
Gill KS, Singh G (1958) .Correlation studies in a cross between K-2 an improved strain of linseed for introduction in Kangra hill of Punjab . Indian .Oil .Seed. J . 3: 9-13.
Goldbergd E (1988). Response of Solidago Canadensis clones to competition. Oecologia. 77: 357-364.
Gomulkiewicz R, Kirkpatrick M (1992). Quantitative genetics and the evolution of reaction norms. Evolution. 46: 390–411.
Griffith TM Watson MA (2006).Is evolution necessary for range expansion? Manipulating reproductive timing of a weedy annual transplanted beyond its range. The American Naturalist .167: 153–164.
Gross KL (1984). Effects of seed size and growth form on seedling establishment of six monocarpic perennial plants. J. Ecol. 72: 369-387.
Gupta AP, Lewontin RC (1982). A study of reaction norms in natural populations of Drosophila pseudoobscura . Evolution . 36: 934-948.
Guldberg LD, Atsatt PR (1975). Frequency of reflection and absorption of ultraviolet light in flowering plants. Am .Midl . Natur. 93: 35-43.
Gupta TR (1975). Estimates of genotypic and environmental variability in some quantitative characters of sesame . Madras . Ag . J. 66 :366-369.
Harvey PH, Purvis A (1991). Comparative methods for explaining adaptations. Nature. 351: 619–624.
Herrera CM (1991). Dissecting factors responsible for individual variation in plant fecundity. Ecology. 72: 1436–1448.
Herrera CM (1998). Population-level estimates of interannual variability in seed production: what do they actually tell us? Oikos .82: 612–616.
Heyland KU, Hemkar, R.(1991).Suitability of vegetative and reproductive traits as selection criteria in breeding for concurrent use of oil and fibre in flax. Boden Bulter. 42:45-56.
Hondelmann W, Strauss DD (1990). Path coefficient analysis of seed yield components in Euphorbia lathvris L. Plant Breeding . 105 (2) 112-116.
Hovland AS, Dybing CD (1973).Cyclic flowering pattern in flax as influenced by environment and plant growth regulators. Crop. Sci . 13: 380-384.
Howard LCG, Khan AR (1924). Studies in Indian oilseed II linseed. Memories Dept Ag India (Bot. Ser) .12: 135-183.
Ingale BV (1985). An analysis association of characters of value in breeding in linseed. J. Maharastra. Ag Uni. 10 :287-289.
Janzen DH (1967). Synchronization of sexual reproduction of trees within the dry season in central America. Evolution .21 : 620-637.
Joel AJ, Thangavelu S (1997).Variability ,heritability and genetic advance in sesame. Madras. Ag .J. 84: 156-158.
Johanson HW, Robinson HF,Comstock RE (1955). Estimate of genetic and environmental variability in soyabean . Agronomy Journal. 47: 314-318.
Jump AS, Peñuelas J (2005.) Running to stand still: adaptation and the response of plants to rapid climate change. Ecology Letters. 8: 1010–1020.
Kadam BS, Kulkarni RK, Patel SM (1938). Natural cross pollination in linseed. Madras .Ag. J. 26: 3-9.
Kansal KK,Gupta SC (1987) .Gene action in linseed. Indian journal of Agriculture Science. 51:634-637.
Kelley SE, Clay K (1987). Interspecific competitive interactions and the maintenance of genotypic variation within two perennial grasses. Evolution . 41:92-103.
Kelly D (1994). The evolutionary ecology of mast seeding. Trends in Ecology & Evolution. 9: 465–470.
Khattack GS, Haq MA, Ashra FM, Hassan S (2002).Detection of epistasis and estimation of additive and dominance component of genetic variation. J.Genet.Breed. 56:1-7.
Khera AS, Sandhu BS (1978). Genotypes environment interaction in cotton. Cotton .Dev . 7: 15-18.
Klanderund K (2004). Climate change effects on species interactions in an alpine plant community. Journal of Ecology. 93: 127–137.
Koenig WD, Kelly D, Sork VL, Duncan RP, Elkinton JS, Peltonen MS,Westfall RD (2003). Dissecting components of population-level variation in seed production and the evolution of masting behavior. Oikos. 102: 581–591.
Kumar S, Singh SP (1967). Studies of American flax. Performance of some American flax strains at Bichpur. Balwant .Vidyapeeth .J .Ag .Sci . Res . 9: 49-56.
Kumar S, Chauhan BPS, Jaimini SS (1980). Diallel analysis of flowering and maturity in linseed. Indian. J. Ag. Sci. 50: 225-230.
Kumar S,Chauhan BPS (1982).Variability and combining ability in F2 population of diallel set in linseed. Indian .J . Ag. Sci. 52 :723-727.
Lal, Rai M, Karan S, Verma A, Ram D (2007). Multivariate hierarchical clustering of cowpea germplasm(Vigna unguiculata (L.) Walp. ISHS Acta Horticulturae 752: I International Conference on Indigenous Vegetables and Legumes. Prospectus for Fighting Poverty, Hunger and Malnutrition.
Langton FA (1985).Effects of intergenotypic competition on selection within Chrysanthemum progenies . Euphytica .34: 489-497.
Lebon G,Wojnarowiez G, Holzapfel B, Fontaine F, Vaillant-Gaveau N, Clement C (2008).Sugars and flowering in the grapevine(Vitis vinifera). Journal of Experimental Botany 59: 2565-2578.
Levin DH (1979). Pollinator foraging behavior : Genetic implication for plants., in Solbrig OT Jain S, Johnson GB, Raven PH (ed.) Topic In plant population biology. Columbia Uni Press N.Y. Pp 131-153.
Li CC (1956). The concept of path coefficient and its impacts on population genetics. Biometrics.12: 190-210.
Mahoro S (2002). Individual flowering schedule, fruit set, and flower and seed predation in Vaccinium hirtum Thunb. (Ericaceae). Canadian Journal of Botany. 80: 82–92.
Majumdar Pk, Prakash R, Haque FM (1960) .Genotypic and phenotypic variability in quantitative characters in groundnut. Indian . J .Genet. 29: 291-296.
Marquis RJ (1988).Phenologcal variation in the Neotropical understory shrub Piper arieianum: causes and consequences. Ecology. 69:1552–1565.
McIntosh ME (2002). Flowering phenology and reproductive output in two sister species of Ferocactus (Cactaceae). Plant Ecology. 159: 1–13.
McNeilly T, Antonovics J (1968).Evolution in closely adjacent plant population IV. Barriers to gene flow. Heredity. 23: 205-218.
Mishra AP (1977).Partial diallel analysis in relation to breeding for yield and its components in linseed (L.usitatissimum) Ph.D thesis, Kanpur University.
Mitchell RJ (1994). Effects of floral traits, pollinator visitation and plant size on Ipomopsis aggregata fruit production. American Naturalist 143:870–889.
Molau U, Nordenhall U, Eriksen B (2005). Onset of flowering and climate variability in an alpine landscape: a 10-year study from Swedish Lapland. American Journal of Botany. 92: 422–431.
Murugesan M, Dhanu KP, Arokiraj A (1979). Genetic variability in some quantitative characters of Sesamum. Madras. Ag. J . 62 : 366-369.
Mutry DS, Hashim M(1973). Inheritance of oil and protein content in a diallel cross of sesame (Sesamum indicum). Can . Genet . Cytol 15 : 177-184.
Nunney L, Cheung W (1997). The effect of temperature on body size and fecundity in female Drosophila melanogaster :evidence for adaptive plasticity. Evolution .51: 1529–1535.
Ollerton J, Lack AJ (1998). Relationships between flowering phenology, plant size and reproduct -ive success in Lotus corniculatus (Fabaceae). Plant Ecology. 139: 35–47.
PanseVG (1957). Genetic of quantitative characters in relation to plant breeding. Indian. Genet.Pl .Breed. 17 :318-328.
Panse VG, Sukhatme PV (1961). Statistical method for Agricultural workers(ed.) .Kalyani Publishers New Delhi.India.
Patel, J .A., Gupta,Y.K.(1997).Genetic analysis in linseed under moisture stress condition. Madras Agriculture Journal . 84 :188-191.
Patel SN, Desai KB, Khatri TJ (1974). Genotypic and phenotypic variabilities in yield and fiber characters in cotton varieties. Cotton Development .4: 6-11.

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.
Primack RB(1980). Variation in the phenology of natural populations of montane shrubs in New Zealand. Journal of Ecology. 68: 849–862.
Pysˇek P, Richardson DM (2007). Traits associated with invasiveness in alien plants: where do we stand? In: Caldwell M.M. (Ed.), Biological Invasions. Springer, Berlin, Heidelberg: 97–125.
Rai B (1969) . Linseed makes in roads in to Tarai. Indian Farmer Digest . 11: 14-15.
Rai RSV, Venkateswaran AN, Ramchandran TK, Srinivasan G (1982). Genetic variability and correlation studies in Sesamum indicum . Indian .J . Ag. Res. 15: 119-122.
Ramanujam S, Thirumalachar DK (1967). Genetic variability of certain characters in red piper (Capsicum annum). Mysore. J . Ag . Sci. 1: 30-36.
Rao RPV (1962). Linseed cultivation in coastal tract of Madras. Madras. J. Ag. 15: 135-136.
Rao CR (1952). Advance statistical method in Biometrical Research. John. Willay & Sons. Inc. N.Y
Rao SK, Singh SP (1984). Breeding behavior and genetic variation for yield and its components in Indian X exotic linseed(L. usitatissimum) crosses. Indian. J. Heredity .14: 37-44.
Rao SK, Singh SP (1985). Relationship of maturity with seed characteristics and their implication in selection of linseed. Journal . Oil .Seed. Research . 2: 86-92.
Rao SK, Singh SP (1987). Additive dominance and epistatic effects in linseed. Indian . J .Ag .Sci .57 :208-211.
Rathke B, Lacey EP (1985). Phenological patterns of terrestrial plants. Annual Review of Ecology and Systematics .16:179–214.
Richharia RH (1962).The Indian Central Oilseed Committee. Hyderabad. Pp.155. .
Robinson HF (1966).Quantitative genetics in relation to breeding on centennial of Mendalism. Indian Journal of Genetics . 26: 171-187.
Saleh GB, Abdulah D, Annur AR (2002).Performance,heterosis and heritability in selected tropical maize single,double and three way cross hybrids. J.Agric.Sci. 138: 21-28.
Sakai KI (1955). Competition in plants and its relation to selection. Cold Spring Harbor Symposium on Quantitative Biology . 20: 137-1 57.
Sakai KI (1961). Competitive ability in plants; its inheritance and some related problems. In F. L. Milthorpe [ed.], Mechanisms in biological competition. Symposium XV. Society for Experimental Biology, 245-263. Academy Press, New York.
Sandhu BS, Singh TH, Negi PS, Singh S (1985). Genotype x environment interaction in desi cotton. Cotton. Dev .15: 11-13.
Scheiner SM (1993). Genetics and evolution of phenotypic plasticity. Annu. Rev. Ecol. Syst. 24: 35–68.
Schlichting CD (1986). The evolution of phenotypic plasticity in plants. Annu. Rev. Ecol. Syst. 17: 667–693.
Schmitt J(1997).Is photomorphogenic shade avoidance adaptive? Perspectives from population biology. Plant Cell Environ. 20: 826–830.
Schmitt J, Mc Cormac AC, Smith H (1995). A test of the adaptive plasticity hypothesis using transgenic and mutant plants disabled in phytochromemediated elongation responses to neighbors. Am. Nat. 146: 937–953.
Silvertown JW (1980). The evolutionary ecology of mast seeding in trees.Biological Journal of the Linnean Society. 14: 235–250.
Searle SR (1961).Phenotypic, genotypic and environmental correlation. Biometrics . 17: 474-480.
Shehata AH,Comstock VE (1971). Heterosis and combining ability estimates in F2 flax population influenced by plant density. Crop Science. 11: 534-536.
Simmonds NW (1962).Variability in crop plants, its use and conservation.Biological Review. 37: 422-465.
Simmonds NW (1979). Principles of Crop improvement. Longman Group London.
Singh P, Srivastava AN, Singh IB (1987).Estimation of genetic variance for yield components and oil content in linseed. Farm. Sci. J . 2: 138-143.
Singh P (1977).Biometrical analysis of yields and its components in linseed (L. usitatissimum). Ph.D Thesis ,Kanpur Uni,Kanpur.
Singh BB, Sharma B (1996).Restructuring cowpea for higher yield. Indian. J. Genet. 56:389-403.
Singh KP, Kushwaha CP (2006). Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. Annals of Botany. 97: 265–276.
Solbrig, Simpson BB (1977). A garden experiment on competition between biotypes of the common dandelion (Taraxacum ominale). J. Ecol. 65: 427-430.
Stinson KA (2004).Natural selection favors rapid reproductive phenology in Potentilla pulcherrima (Rosaceae) at opposite ends of a subalpine snowmelt gradient. American Journal of Botany. 91:531-539.
Stanton ML, Roy BA, Thiede DA (2000).Evolution in stressful environments. I. Pheno -typic variability, phenotypic selection, and response to selection in five distinct environmental stresses. Evolution. 54: 93–111.
Stefan A (1996).Floral variation in Saxifraga granulata: phenotypic selection, quantitative genetics and predicted response to selection .Heredity. 77:217–223.
St. Pierra CA, Klinch HR, Gauthier FM (1967). Early generation selection under different environment as it influence adaptation of barley. Can .J .Pl. Sci. 47: 507-517.
Stlies FG (1978). Temporal organization of flowering among the humming bird food plants of a tropical wet forest. Biotropica. 10 :194-210.
Sultan SE (1995). Phenotypic plasticity and plant adaptation. Acta Botanica Neerlandica. 44: 363-383.
Sultan SE (2000). Phenotypic plasticity for plant development, function and life history. Trends Plant Sci. 5: 537-542.
Swaroop V, Chaugle DS (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.
Tammes T (1928). The genetics of genus Linum. Biblphia. Genet . 4:1-36.
Tefera H (2002).Inheritance of morphological and agronomical traits in tef(Eragrostis tef).Genet.Breed.56: 353-358.
Thuiller W, Lavorel S, Araújo MB, Sykes MT, Prentice C (2005). Climate change threats to plant diversity in Europe. Proceedings of the National Academy of Sciences, USA. 102: 8245–8250.
Tøtland O (1994). Intraseasonal variation in pollination intensity and seed set in an alpine population of Ranunculus acris in southwestern Norway. Ecography .17: 159–165.
Tøtland O (1997). Limitations on reproduction in alpine Ranunculus acris. Canadian Journal of Botany. 75: 137–144.
Tøtland O (1999). Effects of temperature on performance and phenotypic selection on plant traits in alpine Ranunculus acris. Oecologia. 120: 242–252.
Tøtland O (2001). Environment-dependent pollen limitation and selection on floral traits in an alpine species. Ecology. 82: 2233–2244.
Via S, Gomulkiewicz R, Dejong G, Scheiner SM, Schlichting CD, Vantienderen PH (1995). Adaptive phenotypic plasticity: consensus and controversy. Trends Ecol. Evol. 10:212-217..
Warkentin KM (1995). Adaptive plasticity in hatching age: A response to predation risk trade-offs. Proc. Natl. Acad. Sci. U. S. A. 92: 3507–3510.
Weevers TH (1952). Flowers colours and their frequencies. Acta. Bot. Neerl. 1: 81-92.
Wellwood AS (1961) . Floral morphology of Linum species. Am. J. Bot. 48: 537.
Westerman JM, Lawrence MJ (1970).Genotype-environment interaction and development -tal regulation in Arabidopsis thaliana. I. Inbred lines; description. Heredity. 25:609–627.
Winn AA, Werner PA (1987). Regulation of seed yield within and among populations of Prunella vulgaris. Ecology . 68: 1224-1 233.
Wright SJ, Calderon O (1995).Phylogenetic patterns among tropical flowering phenologies. Journal of Ecology . 83: 937–948.