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Full Length Research Paper

Correlation study of flowering performance and flowering pattern with the yield in *Linum usitatissimum* L.

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Highly significant positive correlation were observed in flax among the 1000 seed weight with biological yield, economic yield and harvest index, the reproductive phase length with primary branch number, flower number per plant and capsule number per plant, the vegetative phase length with days to first bud and days to first flower, the seed number per capsule with primary branch number, the capsule number per plant with flower number per plant, the flower number per plant with single continuous flowering period, the plant height at maturity with plant height at first bud ,the days to first flower with days to first bud. 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, correlation.

INTRODUCTION

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. Flowering performance 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. Flowering pattern is determined by timing, duration and frequency of flowering. Flax, *Linum usitatissimum* L. has attracted the attention of researchers because of its unique oil properties and whole plant utilization. They have always been an attempt to increase yield and productivity to meet ever increasing demand.

Literature compiled on linseed by Wellwood (1961) and Richharia (1962) concentrated on the morphology of flowers. Rao and Singh (1984) reported a positive correlation of seed yield with days to maturity, primary and secondary branches and capsule number. Verma et al. (1994) and Mahto and Mahto (1997) observed the highly significant positive correlation among the seed yield and days to maturity, plant height, number of primary and secondary branches and capsule number per plant in linseed.

MATERIALS AND METHODS

The experimental materials consisting of ten genotypes of *L. 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. The soil of experimental plot was loam and the pH of soil ranges from 5.8 - 7.5. The average annual precipitation of the area was about 700 mm, most of which (above 78%) is received from June - September and the rest from October - May.

The hottest month is May and June when the maximum temperature may rise to 45°C. The month of January is the coolest when the minimum temperature of 1.7ºC may be reached. The experiment is located at 20.6° N latitude and 77.15°E longitude at an elevation of 230.6 m 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 buds to first flower was recorded in term of days between first bud initiation and opening of first flower. The period of time 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 min. 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 h. The other observations were repeated at an interval of 30 min. 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.

RESULTS AND DISCUSSION

During the course of present investigation, phenotypic, genotypic and environmental correlation coefficients have been analyzed for assessment of associations among various characters (Table 1). The significance of genotypic correlation could not be tested as no suitable statistical test is available. However, their magnitude in relation to their corresponding phenotypic estimates, formed a sound basis for assessing the magnitude for their practical implication. The genotypic correlation of coefficient, in general, has been found to be greater than the corresponding phenotypic ones. It is indirectly reveals that significant phenotypic association between characters was primarily due to genetic cause. It may be due to pleiotropic effect and due to linkage between *genes*. The data is analyzed at the phenotypic level.

Highly significant positive correlation coefficient has been observed among the 1000 seed weight with biological yield, economic yield and harvest index, the reproductive phase length with primary branch number, flower number per plant and capsule number per plant, the vegetative phase length with days to first bud and days to first flower, the seed number per capsule with primary branch number, the capsule number per plant with flower number per plant, the flower number per plant with single continuous flowering period, the plant height at maturity with plant height at first bud, the days to first flower with days to first bud . The correlation values show highly significant positive correlation of days to flowering with pods in *Brassica napus, Brassica campestris* and *Brassica juncea* by Sajhidkhan et al. (2008).

Significant positive correlation coefficient has been observed in the reproductive phase length with secondary branch number, the capsule number per plant with single continuous flowering period and secondary branch number, the flower number per plant with primary branch number and secondary branch number, the secondary branch number with plant height at maturity, the primary branch number with single continuous flowering period, the single continuous flowering period with days to first flower from first bud; the days to fifty percent flowering with days to first bud and days to first flower. Sukhchain and Sidhu (1992) observed significant positive correlation coefficients with branch number per panicle, panicle number per plant, panicle length, branch length, 100 seed weight and day to flower in Guinea grass (*Panicum maximum* Jacq.) Akinyele and Osekita (2006) found that okra (*Abelmoschus esculentus* L.). Seed yield per plant showed significant positive correlation with number of pods per plant, height at

flowering, pod width and weight of hundred seeds. Arthur et al. (2004) observed, Flower production was positively

correlated with flowering time in *Brassica rapa.* Muhammad et al. (2008) found that plant height showed a positive correlation with days to flowering in safflower (*Carthamus tinctorius*). Highly significant negative correlation coefficient has been observed among the vegetative phase length with single continuous flowering period and single continuous flowering period with days to first bud and days to first flower.

These results is more or less which is similar with the findings of Daucet (1978), Chandra and Makhija (1979); Singh (1979); Patil et al. (1980); Gupta and Godawat (1981); Singh (1982); Salonen and Suhonen (1995); Fisher et al. (1996) quantifying the relationship between phase of stem elongation and flower initiation in Poinsettia. Nishikawa and Kudo (1995) established a positive correlation between flower number and number of capsule in *Anemone flaccida* (Ranunculaceae). The above discussed results provide the efficiency of exhaustive selection of traits where high correlation exists. Direct selection is ineffective on the basis of phenotypic values alone when negative association between components. It is of paramount importance in formulating selection index when we introducing the complexly inherited traits into superior genotypes

Table 1. Correlation among various characters of flowering performance.

Characters	1 Plants height at Ist bud	2 Days to Ist flower	3 Days to Ist flower from Ist bud	4 Days to 50% flowering	5 Single continuous floweringperiod	6 Average daily flowerproduction	7 Plant height At maturity	8 Primary branch number	9 Secondary branch number	10 Flower/ Plant	11 Capsule/ Plant	12 Seed/ Capsule	13 Vegetative phase length	14 Reproductive phase length	15 Biological yield	16 Economic yield	17 Harvest index	18 1000 seed weight	19 seedling vigour
Days to Ist bud	rg0.396 rp0.168 re-0.237	0.768 0.721** 0.169	0.673 0.270 0.154	0.716 0.491* 0.062	-0.815 -0.694** 0.178	-0.675 -0.262 0.098	0.069 0.053 -0.023	-0.554 -0.381 0.074	-0.211 -0.197 -0.180	-0.453 -0.332 0.304	-0.349 -0.340 -0.376	-0.186 -0.104 -0.010	0.801 0.711** 0.119	-0.363 -0.330 -0.225	0.095 0.090 0.077	0.027 0.035 0.104	-0.111 -0.067 0.025	0.277 0.231 -0.249	0.264 0.206 -0.222
Plants height at Ist bud		0.352 0.276 0.149	0.695 -0.014 -0.302	0.235 0.101 -0.082	-0.386 -0.343 -0.287	-0.153 0.007 0.122	0.761 0.712** 0.118	0.131 0.130 0.141	0.253 0.228 0.283	0.031 0.007 -0.091	-0.034 -0.008 0.088	-0.110 -0.046 -0.212	0.444 0.282 -0.014	0.434 0.285 -0.026	0.183 0.144 0.069	0.029 0.021 0.085	-0.380 -0.239 -0.032	0.288 0.217 0.112	-0.145 -0.084 0.255
Days to Ist flower			0.802 0.280 0.070	0.658 0.546* 0.336	-0.738 -0.728** -0.039	-0.521 -0.345 -0.245	0.042 0.017 -0.123	-0.502 -0.39 -0.093	-0.234 -0.151 0.353	-0.349 -0.379 -0.407	-0.330 -0.290 -0.195	-0.201 -0.109 -0.413	0.745 0.716** 0.282	-0.372 -0.276 0.089	0.055 -0.007 -0.268	-0.038 -0.033 -0.092	-0.203 -0.053 0.272	0.183 0.161 0.288	0.185 0.175 0.251
Days to Ist flower from Ist bud				0.622 0.110 -0.088	-0.727 -0.095 0.446	0.179 -0.348 -0.478	0.139 0.038 -0.031	-0.246 -0.096 -0.050	-0.136 -0.065 -0.092	-0.711 -0.200 0.137	-0.640 -0.265 -0.217	-0.551 -0.131 0.037	0.761 0.331 0.169	-0.471 -0.286 -0.352	0.755 -0.358 -0.077	-0.810 -0.407 -0.196	-0.817 -0.300 -0.044	-0.732 -0.322 -0.348	0.156 0.082 0.226
Days to 50% flowering					-0.603 -0.394 0.091	0.128 0.082 0.056	0.209 0.153 -0.018	-0.456 -0.261 0.119	0.079 0.010 -0.355	-0.294 -0.268 -0.297	-0.389 -0.301 -0.066	-0.084 -0.069 -0.044	0.680 0.421 -0.110	-0.329 -0.199 0.117	0.172 0.103 -0.090	0.059 0.003 -0.275	-0.287 -0.22 -0.114	0.117 0.094 0.156	-0.042 -0.040 -0.095
Single continuous flowering period						0.720 0.146 -0.530	-0.151 -0.142 -0.100	0.736 0.551* -0.045	0.336 0.262 -0.302	0.720 0.609* -0.141	0.643 0.503* -0.412	0.468 0.346 0.018	-0.749 -0.758** -0.289	0.638 0.437 -0.422	0.101 0.074 -0.063	0.119 0.099 -0.051	0.113 0.116 0.132	-0.267 -0.241 -0.161	-0.303 -0.267 0.048
Average daily flower production							0.280 0.036 0.097	0.541 0.259 0.030	0.340 0.200 0.117	0.482 0.296 0.223	0.337 0.250 0.330	0.063 0.029 0.102	-0.631 -0.302 -0.025	0.306 0.234 0.237	0.396 0.244 0.154	0.392 0.191 -0.062	0.280 0.116 -0.346	-0.050 -0.041 0.063	-0.802 -0.495 -0.153

Table 1. Contd.

Plant height at maturity	0.246	0.527	0.053	-0.047	0.014	0.124	0.422	0.248	0.110	-0.279	0.299	0.067
	0.183	0.473*	0.049	-0.040	-0.006	0.093	0.362	0.232	0.107	-0.239	0.290	0.060
	-0.136	-0.100	0.001	0.045	-0.106	-0.079	-0.044	0.096	0.058	-0.147	0.252	-0.100
Primary branch number		0.382	0.597	0.479	0.754	-0.460	0.698	0.307	-0.271	0.140	0.034	-0.249
		0.337	0.526*	0.349	0.597**	-0.268	0.567**	0.262	0.243	0.123	0.025	-0.191
		0.169	0.264	-0.291	0.245	0.269	0.134	0.096	0.148	0.087	-0.222	0.258
Secondary branch number			0.574	0.520	0.191	-0.208	0.589	0.320	0.179	-0.209	-0.101	0.153
			0.542*	0.482*	0.135	-0.156	0.532*	0.291	0.176	-0.155	-0.097	0.165
			0.032	-0.049	-0.116	0.163	0.158	0.020	0.122	0.053	0.149	0.338
Flower/Plant				0.777	0.449	-0.424	0.744	0.412	0.297	-0.045	-0.128	-0.447
				0.716**	0.394	-0.354	0.716**	0.406	0.290	-0.033	-0.126	-0.432
				0.115	0.275	0.009	-0.080	0.376	0.316	-0.131	-0.237	-0.095
Capsule/ Plant					0.260	-0.352	0.761	0.438	0.350	0.095	-0.091	-0.401
					0.241	-0.283	0.706**	0.393	0.322	0.059	-0.085	-0.387
					0.237	0.070	0.332	0.016	-0.064	-0.085	0.307	-0.149
Seed/ Capsule						-0.160	0.480	0.281	0.209	0.050	0.109	0.035
						-0.115	0.389	0.261	0.201	-0.058	0.084	0.024
						-0.272	0.146	0.395	0.260	-0.259	-0.208	-0.089
Vegetative phase length							-0.349	0.069	-0.007	-0.152	0.232	0.233
							-0.204	0.037	-0.001	-0.041	0.200	0.211
							0.302	-0.099	0.004	0.212	-0.045	0.160
Reprductive phase length								0.453	0.308	-0.115	0.031	-0.407
								0.386	0.261	-0.100	0.031	-0.346
								0.029	-0.092	-0.167	0.216	0.285
Biological yield									0.779	0.747	0.814	-0.243
									0.748**	0.422	0.754**	-0.224
									0.727	-0.607	-0.251	0.009
Economic yield										0.765	0.748	-0.188
										0.684**	0.722**	0.187
										0.085	-0.178	-0.238

Table 1. Contd.

Harvest index	0.765 0.614** 0.144	0.005 -0.015 -0.023
1000 seed weight		0.028 0.027 -0.030

*, ** Significant at 5 and 1% level, respectively.

which performance is depend on the phenotypic expression. The magnitude and direction of this association may vary with materials and environmental interactions. The traits with high strength of association and low heritability are of immense value in parametric selection, where direct selection is not much effective.

The above discussed result clearly indicates that the genotypic correlation coefficient has found greater, than the phenotypic and environmental correlation in most the characters. This indicates that though these have a high degree of association between two traits at genotypic level, its phenotypic expression has lessened due to the influence of the environment. The negative correlation might arise in character, favoured over the others in the developing stage when the nutrient supply of the plant is limited. In others words, this is a case of physiological incompatibility which leads to conclusion that intensification of one such character will be at the expense of others. Possible genetic reason for negative correlation among these components could be pleiotropy. The genetic correlation between two characters arising due to pleiotropic *genes* will be negative because pleiotropic *genes* that affect both characters in the desired direction will be strongly acted upon by selection and brought rapidly towards fixation. Such *genes* will contribute little towards variance of the two characters. The pleiotropic *genes* that affects on one character, favourably and other adversely will, however, much less strongly influenced by selection and will remain at intermediate frequencies. Most of the remaining covariance of negatively correlated characters will therefore, be due to these *genes* and the resulting genetic correlation will be negative. The consequence of negative genetic correlation is that, each of the two may show a heritability that is far from zero and yet when selection is applied to them simultaneously neither may respond. Therefore, in this situation selection for these important parameters will be very difficult.

Conclusion

The analysis of events and a cursory review of flowering pattern and flowering performance of *L. usitatissimum* facilitates a proper understanding of future breeding processes. It is remarkable that no breeding procedure or a breeding programmed is expected to be successful, both in term of quality and quantity of the product. Highly significant positive correlation is important in the selection of complex inherited traits in to superior genotypes. A wide genetic base and appropriate genetic principles coupled with an adequate statistical treatment should be employed for desired improvement. It determines its optimum fitness, that is, adaptation to the immediate environment or to future change. The crossing systems in plants are naturally linked with their floral structure, flowering behaviour and gametogenesis. Thus, the flowering pattern and flowering performance with the working knowledge for a rapid crop improvement is to fulfil the need for increasing world population.

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