CORRELATION AND PATH STUDY FOR SOME POLLEN CHARACTERS IN *LINUM USITATISSIMUM* L.

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Abstract: The highly significant positive correlation coefficient has been observed among the germinated pollen number after 6 hours with pollen grains number per anther and pollen tube length. The pollen grain number per flower with anther length, pollen grain number per anther, seed length, ovary length female reproductive organ length and economic yield. Character like the female reproductive organ length has maximum positive direct effect on pollen tube length followed by percentage germinated pollen, pollen grain number per flower, total pollen grain on style and stigma and anther length.

Keywords: *Linum*, Pollen, Correlation, Path coefficient

INTRODUCTION

The pollen being haploid carries the hereditary traits. Pollen pistil interaction and pollen ovule ratio is one of the characteristic features of floral biology and biology of sexual reproduction. In angiosperms there is interaction between the male gametophyte (pollen grain) with the massive sporophytic tissue of the pistil. The major event that takes place during this pollen pistil interaction is the recognition and subsequent acceptance or rejection of the male parent by the pistil. If the pollen grain is compatible, all post pollination events i.e., pollen germination and pollen tube entry into stigma and pollen tube growth through the style proceed normally and results in fertilization and seed development. If the pollen is incompatible the pistil effectively arrest one or more of these post pollination events and consequently prevents fertilization. The pollen grain is effectively screened by the pistil before reaching the male gametes to the embryosac. The studies of pollen pistil interaction and pollen ovule ratio are of direct relevance to plant breeding programme. The plant breeder is continuously striving to bring together desirable characters in the progeny through hybridization. A better understanding of both the aspects would obviously enable the plant breeder to manifestate more effectively the pollen screening process by the pistil.

MATERIAL AND METHOD

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.The certified seeds were procured from Chandershekar Azad University of Agriculture and Technology, Kanpur(U.P) India. They were sown in the month of May in a randomized block design with four replications spaced 45 cm apart respectively. 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. Study of pollen biology includes many parameters. They are pollen morphology, size and shape of pollen grains, estimation of pollen production, and estimation of pollen *in vivo*, viability and logivity of fresh and stored pollen grains, pollen viability and longivity through fertilization test, and pollen fertility and tube growth *in vitro*. The pollen morphology of pollen grains has been studied with the help of acetolysed slides.

Table 1. Estimation of correlation coefficient among various characters of pollen biology in *Linum usitatissimum* L.

CHARACTERS	1 Pollen grains /Anther	2 Pollen grain Size	3 Seed Length	4 Ovary Length	5 Fruit Length	6 Seed/ Capsule	7 Female Reproductive Organ Length	8 Pollen Tube length	9 Fresh Pollen Viability	10 % Capsule Setting	11 Germinated Pollen on Style & Stigma	12 Pollen grain Number / Flower	13 Total Pollen Grain on Style & Stigma	14 1000 Seed Weight	15 % Germinated Pollen after 6 hours	16 Seedling Vigour	17 Vigour Index
Anther Length	rg0.807 rp0.651** re0.126	-0.037 0.042 0.199	0.431 0.296 0.060	0.408 0.314 0.114	0.682 0.497* 0.148	0.342 0.266 0.153	0.616 0.426 -0.084	0.748 0.552* 0.082	0.436 0.201 0.038	0.113 0.075 0.023	0.699 0.223 -0.165	0.770 0.639** -0.072	-0.022 -0.045 -0.084	0.646 0.497* -0.242	0.488 0.345 -0.039	-0.328 -0.272 -0.316	-0.115 -0.126 -0.224
Pollen grains /Anther		-0.239 -0.201 0.045	0.637 0.535* -0.017	0.627 0.580** -0.180	0.462 0.418 0.187	0.547 0.417 -0.142	0.659 0.615** -0.158	0.608 0.573** -0.035	0.362 0.169 -0.186	-0.077 -0.074 -0.134	0.766 0.383 -0.204	0.700 0.683** 0.296	-0.098 -0.045 0.336	0.643 0.633** 0.218	0.598 0.576** 0.137	-0.208 -0.205 -0.114	-0.115 -0.102 0.121
Pollen grain size			-0.422 -0.320 -0.028	-0.598 -0.508* -0.080	-0.272 -0.127 0.353	-0.142 -0.172 -0.247	-0.283 -0.239 -0.021	-0.110 -0.050 0.300	-0.161 -0.283 -0.407	0.140 -0.005 -0.320	-0.205 0.042 0.229	-0.275 -0.219 0.311	0.506 0.404 0.149	-0.465 -0.405 -0.145	-0.049 -0.060 -0.147	0.375 0.329 0.092	-0.108 -0.081 0.056
Seed Length				0.772 0.734** 0.263	0.707 0.531* -0.020	-0.073 0.028 0.253	0.761 0.732** 0.135	0.682 0.560* -0.004	0.077 -0.091 -0.295	-0.202 -0.062 0.222	0.648 0.229 0.058	0.659 0.576** 0.252	-0.648 -0.486 -0.082	0.701 0.684** -0.077	0.598 0.510* 0.120	-0.034 -0.032 -0.052	0.369 0.264 -0.254
Ovary Length					0.524 0.420 0.174	0.125 0.090 0.318	0.689 0.684** 0.830	0.635 0.572** -0.136	-0.295 0.114 -0.171	-0.201 -0.139 0.055	0.532 0.228 0.158	0.641 0.600** -0.231	-0.632 -0.533* -0.216	0.711 0.735** -0.303	0.523 0.465* -0.238	-0.246 -0.234 -0.036	0.252 0.221 -0.112
Fruit Length						-0.407 -0.243 0.168	0.546 0.457* -0.059	0.573 0.507 0.144	0.047 0.043 0.103	0.305 0.129 -0.280	0.742 0.127 -0.408	0.493 0.433 -0.001	-0.622 -0.438 0.056	0.736 0.654** 0.243	0.255 0.237 0.154	-0.124 -0.088 0.319	0.221 0.238 0.375
Seed/ Capsule							-0.040 0.015 0.276	0.174 0.164 0.202	0.237 0.159 0.335	-0.559 -0.322 0.073	0.190 0.016 0.072	0.503 0.388 -0.187	0.655 0.403 -0.087	0.110 0.089 -0.063	0.475 0.378 -0.068	0.037 0.023 0.075	-0.032 -0.029 -0.057
Female Reproductive Organ Length								0.730 0.672** -0.021	0.415 0.235 0.060	0.086 0.070 0.031	0.786 0.334 0.227	0.653 0.618** -0.114	-0.630 -0.530* -0.203	0.689 0.661** -0.171	0.516 0.461* -0.245	-0.342 -0.326 -0.020	0.031 0.026 -0.038

Pollen tube Length									**-0.682** **-0.016** **0.320**	**0.290** **0.155** **0.037**	**0.688** **0.149** **-0.003**	**-0.091** **-0.067** **-0.131**	**0.437** **0.224** **0.016**	**-0.568** **-0.340** **0.221**	**0.191** **0.129** **0.087**	**0.323** **0.204** **0.091**	**-0.232** **-0.144** **-0.041**
Fresh Pollen Viability										**0.507** **0.249** **0.058**	**0.722** **0.036** **-0.245**	**0.369** **0.158** **-0.444**	**-0.244** **-0.172** **-0.129**	**0.636** **0.352** **0.020**	**0.217** **-0.074** **0.196**	**-0.134** **-0.088** **-0.125**	**0.034** **0.030** **0.133**
% Capsule Setting											**0.645** **0.090** **-0.158**	**-0.070** **-0.048** **0.081**	**-0.591** **-0.402** **-0.065**	**0.117** **0.089** **-0.116**	**-0.380** **-0.337** **-0.320**	**-0.142** **-0.114** **-0.055**	**-0.470** **-0.403** **-0.290**
Germinated Pollen on Style & Stigma												**0.755** **0.449** **0.280**	**-0.227** **-0.162** **-0.177**	**0.717** **0.318** **-0.026**	**0.751** **0.280** **0.070**	**0.205** **0.063** **-0.083**	**-.099** **0.020** **-0.054**
Pollen grain Number/ Flower													**-0.131** **-0.098** **0.133**	**0.667** **0.662**** **0.145**	**0.568** **0.549*** **0.120**	**-0.176** **-0.173** **0.051**	**-0.083** **-0.075** **0.096**
Total Pollen Grain on Style & Stigma														**-0.566** **-0.466*** **0.008**	**0.106** **0.074** **-0.070**	**0.312** **0.249** **-0.064**	**0.051** **-0.004** **-0.268**
1000 Seed Weight															**0.353** **0.340** **-0.199**	**0.027** **0.026** **0.308**	**0.402** **0.385** **0.442**
% Germinated Pollen after 6 hours																**0.243** **0.234** **0.024**	**0.319** **0.314** **0.383**
Seedling Vigour																	**0.670** **0.650**** **0.384**

Significant at 5% Level
Significant at 1% Level

Table 2. Path coefficient analysis showing driect and indirect effect on pollen tube length in *Linum usitatissimum* L.

CHARACTERS	CORRELATION WITH POLLEN TUBE LENGTH	DIRECT EFFECT	INDIRECT EFFECT															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			Anther Length	Pollen grains /Anther	Pollen grain Size	Seed Length	Ovary Length	Fruit Length	Seed/ Capsule	Female Reproductive Organ Length	Fresh Pollen Viability	% Capsule Setting	Germinated - Pollen on Style & Stigma	Pollen grain Number/ Flower	Total Pollen Grain on Style & Stigma	1000 Seed Weight	% Germinated Pollen after 6 hours	Seedling Vigour	Vigour Index
Anther Length	rg 0.748 rp 0.552	G 0.128 P 0.159	-------	-0.773 -0.518	0.006 -0.008	-0.011 -0.016	-0.378 -0.303	0.119 0.056	0.036 0.036	0.709 0.520	-0.097 -0.072	-0.009 -0.007	-0.046 -0.021	0.473 0.329	-0.004 -0.008	0.189 0.147	0.298 0.194	0.132 0.092	-0.030 -0.031
Pollen grains /Anther	0.608 0.573	-0.852 -0.795	0.116 0.104	--------	0.036 0.040	-0.016 -0.030	-0.581 -0.561	0.081 0.047	0.058 0.056	0.759 0.750	-0.081 -0.061	0.006 0.007	-0.045 -0.036	0.544 0.507	-0.016 -0.008	0.188 0.194	0.360 0.319	0.084 0.007	-0.030 -0.025
Pollen grain size	-0.110 -0.050	-0.151 -0.197	-0.005 0.007	0.204 0.159	-------	0.011 0.018	0.554 0.491	-0.047 -0.014	-0.015 -0.023	-0.326 -0.291	0.036 0.102	-0.012 0.001	0.008 -0.004	-0.150 -0.113	0.081 0.070	-0.136 -0.124	-0.030 -0.034	-0.151 -0.112	-0.028 -0.020
Seed Length	0.682 0.560	-0.026 -0.056	0.055 0.007	-0.543 -0.425	0.064 0.063	--------	-0.900 -0.807	0.123 0.060	-0.008 0.004	0.999 0.893	-0.017 0.033	0.017 0.006	-0.025 -0.021	0.359 0.297	-0.103 -0.084	0.235 0.210	0.366 0.287	0.013 0.011	0.095 0.064
Ovary Length	0.635 0.572	-0.926 -0.967	0.052 0.050	-0.534 -0.461	0.091 0.100	-0.025 -0.046	------	0.092 0.047	0.010 0.017	1.024 1.078	-0.066 -0.041	0.017 0.013	-0.020 -0.021	0.349 0.309	-0.101 -0.093	0.226 0.225	0.320 0.261	0.099 0.079	0.065 0.054
Fruit Length	0.573 0.507	0.175 0.113	0.088 0.079	-0.394 -0.332	0.041 0.025	-0.018 -0.030	-0.485 -0.407	-------	-0.043 -0.033	0.629 0.558	-0.002 -0.016	-0.025 -0.013	-0.036 -0.012	0.268 0.223	-0.099 -0.076	0.215 0.200	0.156 0.133	0.050 0.030	0.057 0.058
Seed/ Capsule	0.174 0.167	0.107 0.134	0.044 0.042	-0.466 -0.332	0.022 0.034	0.002 -0.002	-0.084 -0.121	-0.071 -0.027	-------	-0.046 0.018	-0.035 -0.085	0.046 0.031	-0.007 -0.001	0.274 0.200	0.105 0.070	0.032 0.027	0.290 0.212	-0.015 -0.008	-0.007 0.008
Female Reproductive Organ Length	0.730 0.672	1.152 1.220	0.079 0.068	-0.562 -0.488	0.043 0.047	-0.022 -0.041	-0.823 -0.855	0.095 0.051	-0.004 0.002	--------	-0.092 -0.084	-0.007 -0.007	-0.030 -0.031	0.355 0.319	-0.101 -0.092	0.202 0.203	0.315 0.259	0.137 0.111	0.008 0.006
Fresh Pollen Viability	-0.084 -0.062	-0.223 -0.359	0.056 0.032	-0.309 -0.135	0.024 0.056	-0.024 0.005	-0.274 -0.111	0.001 0.006	0.017 0.032	0.478 0.286	-------	-0.042 -0.024	-0.043 -0.003	0.201 0.081	-0.039 -0.030	0.186 0.108	-0.133 -0.042	0.054 0.030	0.001 0.008
% Capsule	-0.255 -0.232	-0.082 -0.097	0.015 0.012	0.066 0.059	-0.021	0.005 0.003	0.186 0.135	0.053 0.051	-0.060 -0.043	0.099 0.085	-0.113 -0.089	-------	-0.025 -0.008	-0.038 -0.025	-0.094 -0.070	0.034 0.027	-0.232 -0.189	0.057 0.039	-0.121 -0.009

Setting					**0.001**													
Germinated Pollen on Style & Stigma	**0.722 0.252**	**-0.038 -0.094**	**0.154 0.036**	**-0.994 -0.304**	**0.031 - 0.008**	**-0.017 -0.013**	**-0.493 -0.221**	**0.165 0.014**	**0.020 0.002**	**0.906 0.407**	**-0.250 -0.013**	**-0.053 -0.009**	**------**	**0.630 0.231**	**-0.036 -0.028**	**0.257 0.097**	**0.459 0.158**	**-0.082 -0.021**	**0.026 0.006**
Pollen grain Number/ Flower	**0.571 0.557**	**0.544 0.515**	**0.112 0.102**	**-0.852 -0.781**	**0.042 0.043**	**-0.017 -0.032**	**-0.594 -0.581**	**0.086 0.049**	**0.054 0.052**	**0.752 0.755**	**-0.082 -0.057**	**0.006 0.005**	**-0.045 -0.042**	**---------- ---**	**-0.021 -0.017**	**0.195 0.203**	**0.347 0.308**	**0.071 0.059**	**-0.021 -0.018**
Total Pollen Grain on Style & Stigma	**-0.148 -0.079**	**0.160 0.174**	**-0.003 -0.007**	**0.083 0.036**	**- 0.077 - 0.080**	**0.017 0.027**	**0.585 0.515**	**-0.109 -0.049**	**0.070 0.054**	**-0.726 -0.647**	**0.054 0.062**	**0.049 0.039**	**0.009 0.015**	**-0.071 -0.050**	**---------- --**	**-0.166 -0.143**	**0.065 0.042**	**-0.126 -0.085**	**0.013 -0.001**
1000 Seed Weight	**0.461 0.445**	**0.293 0.306**	**0.083 0.079**	**-0.548 -0.503**	**0.070 0.080**	**-0.021 -0.038**	**-0.714 -0.711**	**0.128 0.074**	**0.012 0.012**	**0.794 0.806**	**-0.141 -0.126**	**-0.010 -0.009**	**-0.034 -0.030**	**0.363 0.341**	**-0.090 -0.081**	**------- **	**0.216 0.191**	**-0.011 -0.009**	**0.103 0.094**
% Germinated Pollen after 6 hours	**0.742 0.702**	**0.611 0.562**	**0.063 0.055**	**-0.502 -0.450**	**0.007 0.012**	**-0.015 -0.028**	**-0.484 -0.452**	**0.045 0.027**	**0.051 0.051**	**0.594 0.563**	**0.048 0.027**	**0.031 0.033**	**-0.029 -0.020**	**0.309 0.282**	**0.017 0.013**	**0.103 0.104**	**---------- -**	**-0.098 -0.097**	**0.081 0.078**
Seedling Vigour	**-0.172 -0.154**	**-0.402 -0.339**	**-0.042 -0.043**	**0.177 0.163**	**- 0.057 - 0.065**	**0.001 0.002**	**0.228 0.226**	**-0.022 -0.010**	**0.004 0.003**	**-0.394 -0.398**	**0.030 0.032**	**0.012 0.011**	**-0.008 -0.008**	**-0.096 -0.089**	**0.050 0.044**	**0.008 0.008**	**0.149 0.131**	**------**	**0.172 0.159**
Seed Vigour Index	**0.210 0.197**	**0.275 0.245**	**-0.015 -0.020**	**0.098 0.081**	**0.016 0.016**	**-0.009 -0.015**	**-0.234 -0.214**	**0.039 0.027**	**-0.003 -0.004**	**0.036 0.032**	**-0.001 -0.012**	**0.039 0.039**	**-0.004 -0.002**	**-0.045 -0.039**	**0.008 -0.001**	**0.118 0.118**	**0.192 0.179**	**-0.269 -0.220**	**-----**

Residual Effect (Genotypic) = -0.0275
Residual Effect (Phenotypic) = 0.00689

RESULT AND DISCUSSION

The highly significant positive correlation coefficient has been observed among the germinated pollen number after 6 hours with pollen grains number per anther and pollen tube length. The pollen grain number per flower with anther length, pollen grain number per anther, seed length, ovary length female reproductive organ length and economic yield. The pollen tube length with number of pollen grain per anther, ovary length and male female reproductive organ length. Pollen grain number per anther with economic yield and biological yield. These correlation coefficient indicate the highest strength of association among these traits which unaltered by environmental effect.

The significant and positive correlation coefficient has been found among the germinated pollen grain number after 6 hours with female reproductive organ length and pollen grain number per flower. Pollen grain number per flower with pollen tube length and germinated pollen on style and stigma, biological yield. Pollen tube length with anther length, pollen grain number per anther and pollen grain size with pollen grain number per anther.

The significant negative correlation coefficient has been observed among the number of pollen grains on style and stigma with female reproductive organ length. These findings more or less similar to those reported by Muchay *et al.* (1988) in potato. They have observed the close relationship between pollen size and seed set and reported that small pollen producing more seed than larger pollen grains. Holm (1994) found the positive correlation among pollen size and shape with pollen germination and pollen tube growth in Betula. Sakai (1995) reported that the optimal seed size increase with total resources allocation to reproduction, decreasing out cross pollen availability, and decreasing probability of seedling establishment. De.Leonardis *et al.* (1995) found the positive correlation between pollen grain size and seed size in *Cicer* in cultivated type and negative in wild type, indicating that human selection played an important role in differentiating the latter species from its wild relatives. Diane (1995) observed the positive correlation among pollen quantity, quality and seed setting in Eupatorium (Asteraceae). Yuv and Yurlova (1996) established a positive correlation among pollen number, fruiting variability and early yielding capacity in tomato hybrid. Sayers and Murphy (1966) reported that female reproductive organ length control the pollen tube growth in Alfalfa. They further reported that the large pollen tube increases the frequency of fertilization, fruiting and seed setting. Through study of these association among these characters are therefore it is important to facilitate selection for improvement in other characters .However negatively associated characters indicate that improvements in these characters adversely affect the other and the net economic gain may be adversely affected. So a sort of balance during selection is necessary in order to obtain the maximum effect. The correlated responses of these traits are indeed having an important place in selection experiments.

The aim of correlation studies is primarily to know about the suitability of various characters for indirect selection, because selection for one or more traits should result in correlated response for several other traits (Searle, 1965; Singh, 1972) and pattern of variation would also be changed (Wadington and Robertson 1966). Therefore knowledge of existing at genetic level between yield and its component is essential. The low positive correlation coefficient could be due to the modifying effect of environment on the association of characters at genetic level. The environmental correlation coefficients do not strictly reflect the correlation of environmental deviation. Therefore, it is important for the improvement of the desired characters with sacrificing the gain in the other. The negatively associated characters indicate that the improvement in these characters adversely affects the oyhers and the net economic gain will be adversely affected.

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 . The result of table 2 indicate that character like the female reproductive organ length has maximum positive direct effect on pollen tube length followed by percentage germinated pollen, pollen grain number per flower, total pollen grain on style and stigma and anther length.

The ovary length has highest indirect positive effect on pollen tube length followed by pollen grain number per flower, pollen grain number per anther, number of germinated pollen grains and germinated pollen on style and stigma. The total number of pollen grain on style and stigma, pollen grain size via ovary length. The positive direct effect thus the key characters for use as an index in the selection programme in the present study. Therefore due weightage should be given to these characters during the improvement in pollen tube length resultend more capsule and seed setting ultimately more yield. The indirect positive effects contribute indirectly towards the pollen tube length. Therefore it is desirable to have proper balance with these characters following breeding methodologies.

The ovary length has prominent negative direct effect on pollen tube length followed by characters like pollen grain per anther, fresh pollen viability and pollen grain size. It is interesting to note that this negative direct effect has compensated mostly through positive indirect effect via other characters which ultimately resulted in the significant positive correlation. The negative effect indicated the difficulty to increase the pollen tube length through selection. Thus these characters in a balance proportion have mainly responsible for increased the pollen tube length over the standard check.

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