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STUDIES ON VARIABILITY, CORRELATION AND PATH ANALYSIS IN PEARLMILLET

ABHAY BIKASH, I. S. YADAV* AND R. K. ARYA

Department of Genetics and Plant Breeding
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
**(e-mail : iswaryadav@gmail.com)*
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SUMMARY

A set of 30 elite hybrids of pearlmillet developed at CCS Haryana Agricultural University, Hisar was used in the present study. The purpose of the present investigation was to estimate the variability and association between the grain yield and its component characters and to assess the direct and indirect effects of various characters on grain yield. The results on correlation in the present study revealed that, in general, the genotypic correlation coefficients were higher than their corresponding phenotypic correlations. The grain yield was significantly and positively correlated with harvest index, ear girth, effective tillers, dry fodder and biological yield in all the four environments. The path coefficient analysis suggested the importance of biological yield as it had direct positive effect and indirect effect on grain yield in all four environments. So, the selection for higher yield will be useful if it is based on characters such as biological yield, plant height, dry fodder yield, effective tillers and harvest index as these have significant correlation on grain yield.

Key words : Variability, correlation coefficient, path analysis, pearlmillet

Pearlmillet [*Pennisetum glaucum* (L.) R. Br.] is an important food grain cereal in the arid and semi-arid regions of Africa, India and other Asian countries. India is the largest pearlmillet growing country contributing 42 per cent of production in the world (Arya *et al.*, 2009a). With its wide ability to adapt to diverse agro-ecological conditions, it has unique position in the world agriculture. The potential of pearlmillet as an excellent forage crop is well known, particularly in arid and semi-arid regions of the world. It is a multipurpose cereal grown for grain, stover and green fodder (Yadav *et al.*, 2010). Its plants are highly vigorous, drought and heat tolerant crop and its grains are rich in starch, protein, fat, iron, calcium, magnesium, phosphorus and carotenoids than some of the other important cereals.

The grain yield is a complex character and direct selection for yield is not so much easy. Therefore, improvement in grain yield is made through improvement in contributing characters such as number of tillers/plant, ear length, ear girth, number of grains/ear, 1000-grain weight, etc. along with yield (Arya *et al.*, 2009b). Therefore, considering the above facts in view, the present study was conducted to understand the genetic behaviour of yield and its contributing traits under different environments.

MATERIALS AND METHODS

The experiment was conducted at different Research Farms of CCS Haryana Agricultural University, Hisar to study the stability of 30 hybrids of prearlmillet during **kharif** season at four locations viz., Plant Breeding Research Area (E_1), Regional Research Station, Bawal (E_2), Plant Pathology Research Area, Hisar (E_3) and Dry Land Research Area, Hisar (E_4). These hybrids were developed by Bajra Section, Department of Plant Breeding, CCSHAU, Hisar. All the 30 hybrids were grown in RBD with three replications in five rows per plot of 4 m length with spacing of 50 and 30 cm between and within rows at each location. Observations were recorded on five competitive and randomly selected plants of each genotype for days to 50 per cent flowering, dry fodder yield (g/plant), plant height (cm), total tillers per plant, effective tillers per plant, ear length (cm), ear girth (cm), biological yield (g/plant), grain yield (g/plant), harvest index (%) and 1000-grain weight (g). The variability, correlation coefficient and path analysis were carried out as per standard procedures.

RESULTS AND DISCUSSION

The data presented in Table 1 on mean performance and range in each environment for each character revealed that E_1 was the best environment for the expression of almost all the characters except harvest index and days to 50 per cent flowering, whereas E_2 was found to be the best only for harvest index and E_4 for days to 50 per cent flowering. Grain yield ranged from 19.12 to 40.43 g/plant with mean grain yield of 26.80 g/ plant in E_1, from 12.50 to 28.93 g/plant with mean yield of 19.84 g/plant in E_2, from 15.76 to 30.58 g/plant with mean grain yield of 22.00 g/plant in E_3, and from 4.94 to 13.10 with mean grain yield of 8.28 g/ plant in E_4. Overall mean value ranged from 8.28 g/plant in E_4 to 26.80 g/plant. Overall mean value for dry fodder yield ranged from 47.42 g/plant in E_2 to 101.16 g/plant in E_1, for biological yield ranged from 79.83 g/plant in E_4 to 147.97 g/plant in E_1. Harvest index (%) was found to have highest mean performance (22.64%) and range (16.03-28.74%) in E_2.

Days to 50 per cent flowering ranged from 39.99 to 56.66 days with mean 47.56 days in E_1, from 35.30 to 49.33 days with mean 41.38 days in E_2, from 39.33 to 56.33 days with mean 48.05 days in E_3 and from 34.66 to 49.00 days with mean 41.05 days in E_4. Highest number of total tillers per plant ranged from 4.60 to 7.23 with mean 5.60 in E_1. The plant height (cm) ranged from 159.78 to 233.08 cm in E_1, from 151.25 to 208.75 cm in E_2, from 158.10 to 211.30 cm in E_3 and from 122.36 to 181.19 cm in E_4. The average ear length was 24.47, 23.54, 22.67 and 21.47, and ear girth was 8.74, 8.72, 8.13 and 8.06 cm in E_1, E_2, E_3 and E_4, respectively. 1000-grain weight ranged from 6.61 to 10.47 g with mean 8.56 in E_1, from 6.11 to 9.21 g with mean 7.43 g in E_2, from 6.42 to 9.87 g with mean 8.33 in E_3 and from 5.03 to 9.55 g with mean 6.42 g in E_4. Similar findings were also reported by Arya *et al.* (2010). They reported that in favourable environment more tillers and speedy growth resulted in delayed flowering and more accumulation of biomass. If favourable condition up to grain filling stage, increases both grain as well as fodder yield. On the other hand, if unfavourable conditions prevail then there will be reduction in all yield contributing chatacters.

The selection of superior genotypes based on grain yield as such may not be effective end product of many component traits (Whitehouse *et al.*, 1958). Thus, for rational improvement of yield, the understanding of correlations with its component traits is very useful. However, phenotypic selection may, sometimes, mislead the plant breeder as phenotype is a result of apparent that many of the characters are correlated because of a mutual association, positively or negatively with other characters. As more variables are considered in the correlation tables, the indirect association becomes more complex, less obvious and somewhat perplexing. Under such circumstances, the path coefficient analysis (Wright, 1921; Dewey and Lu, 1959) provides an effective means of separating direct and indirect causes of association and permits critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each casual factor. The yield component characters develop invariably a positive or negative relationship among themselves. An apparent association of a trait to the yield might be appearing, due to balancing of positive and negative contribution.

TABLE 1
Mean performance and range for different characters under four environments

Character	E_1		E_2		E_3		E_4	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Grain yield (g/plant)	26.80	19.12-40.42	19.84	12.51-28.92	22.00	15.76-30.58	8.28	4.94-13.10
Dry fodder yield (g/plant)	101.16	58.38-137.24	47.42	33.44-61.89	92.97	47.96-138.96	51.38	33.87-72.53
Biological yield (g/plant)	147.96	98.48-190.80	87.25	69.19-109.09	134.97	84.63-182.81	79.83	59.68-123.75
Harvest index (%)	18.21	13.58-23.60	22.64	16.03-28.74	16.41	12.58-19.71	10.47	7.45-16.82
Days to 50% flowering	47.56	39.66-56.66	41.38	35.33-49.33	48.05	39.33-56.33	41.05	34.66-49.00
Total tillers/plant	5.60	4.6-7.23	2.43	2.00-3.16	5.24	3.47-7.10	5.30	4.38-6.96
Effective tillers	2.85	2.13-4.04	1.17	1.00-1.50	2.43	1.33-3.24	2.60	1.7-67-3.80
Plant height (cm)	196.94	159.78-233.08	168.98	151.25-208.75	181.22	158.10-211.30	151.39	122.36-181.19
Ear length (cm)	24.47	20.40-32.99	23.54	18.91-31.60	22.67	18.65-29.06	21.47	18.28-29.02
Ear girth (cm)	8.74	7.23-10.22	8.72	6.45-10.06	8.13	5.67-9.59	8.06	6.69-9.58
1000-grain weight	8.56	6.61-1.47	7.43	6.11-9.21	8.33	6.42-9.87	6.42	5.03-9.55

Therefore, path coefficient analysis could be more effective method for use in selection programme, based on component breeding.

A critical examination of the results on correlation of grain yield and its component traits (Table 2) and path analysis (Table 3) depicting the direct and indirect effects of various traits revealed that grain yield had highly significant and positive correlation with biological yield in all four environments. Similar positive association has been reported by Khairwal *et al*. (1990), Kulkarni *et al*. (2000), Pareek (2002) and Arya *et al.* (2009b). Path analysis also revealed positive direct effects of biological yield on grain yield in the four environments. Thus, high grain yield would be possible by having high biological yield. Positive direct effects of biological yield were also reported by Khairwal *et al.* (1990). Further, it was observed that most of the characters like plant height, ear length, ear girth, total tillers, effective tillers and dry fodder yield had contributed towards grain yield per plant mainly via biological yield per plant.

The existence of strong positive association of grain yield with ear girth had also been supported by previous finding in pearlmillet by Manga *et al*. (1985). Path analysis further revealed that positive correlation was due to highest indirect effect through biological yield. Similar results were obtained by Manga *et al.* (1985), Virk (1988) and Karthigeyan *et al.* (1995).

Significant and positive association between dry fodder yield and grain yield is in close agreement with the earlier findings of Savery and Prasad (1994), Navale *et al.* (1995), Harrer and Karad (1998), Kulkarni *et al.* (2000) and Arya *et al.* (2009b). Positive and significant correlation of dry fodder yield with grain yield was found encouraging for the development of dual purpose hybrids. Though dry fodder yield indicated negative direct effect but it contributed through biological yield. This finding is similar to that of Virk (1988).

Positive but low magnitude of correlation of grain yield with 50 per cent flowering as observed in E_1 and E_3 environment is in concordance of the findings of Mukherji *et al.* (1982). Contrary to this negative but low value of correlation coefficient of grain yield with 50 per cent flowering observed in E_2 and E_4 was in agreement to that of Phul *et al.* (1974), Jindla and Gill (1984) and Kamla *et al*. (1986). This may be due to the difference in genetic materials and the environmental conditions. Further path analysis revealed that low correlations were due to the balancing effects of indirect effects of various characters.

Significant and positive correlation of grain yield with effective tillers in the present study is in agreement to the previous workers viz., Phul *et al.* (1974), Murkherji *et al.* (1982), Manga *et al.* (1985), Das and Balakrishnan (1994), Balakrishnan and Das (1995), Harrer and Karad (1998), Kumar *et al.* (2002), Pareek (2002) and Arya *et al.* (2009b) who have reported effective tillers as the principal component of grain yield in prearlmillet. Path analysis revealed that high association was due to indirect effects via biological yield in all the large number of earlier workers viz., Mukherji *et al.* (1982), Manga *et al.* (1985), Das and Balakrishnan (1994), Poongodi and Palanisamy (1995), Karthigeyan *et al.* (1995), Harrer and Karad (1998) and Pareek (2002).

Ear length had non-significant positive correlations with grain yield. This is in close agreement with that of Phul *et al.* (1974), Mukherji *et al.* (1982) and Manga *et al.* (1985). Path analysis revealed that positive association of ear length with grain yield was due to indirect effects via biological yield.

Harvest index is an important component of grain yield owing to its significant positive association with grain yield in E_1, E_2 and E_4 environments, is in agreement with Arya *et al.* (2009b). Path analysis suggested that positive significant association between grain yield and harvest index was mainly due to indirect effects via dry fodder yield.

Positive association of plant height with grain yield in the present study was in close agreement to the previous findings in prearlmillet by Phul *et al.* (1974), Manga *et al.* (1985), Murkherji *et al*. (1982), Rao *et al.* (1987), Poongodi and Palannisamy (1995), Harrer and Karad (1998), Kumar *et al.* (2002) and Pareek (2002). Path analysis revealed that positive association was due to indirect effects via biological yield in all the four environments. Similar results were also reported by Mukherji *et al.* (1982), Manga *et al.* (1985) and Poongodi and Palanisamy (1995).

1000-grain weight had positive correlation with grain yield with significant values in E_1 and E_3 and non-significant values in E_2 and E_4. Positive correlation of 1000-grain weight with grain yield was also reported by Manga *et al.* (1985), Virk (1988), Kulkarni *et al.* (2000) and Arya *et al.* (2009b).

From the foregoing discussion on correlation and path coefficient analysis it could be concluded that for planning any selection criterion for improved grain yield, main emphasis should be given on effective tillers,

TABLE 2

Genotypic (upper diagonal) and phenotypic (below diagonal) correlation coefficients among different characters of pearlmillet

Character	Env.	Day to 50% flowering	Plant height	Ear length	Ear girth	Total tillers	Effective tillers	Dry fodder yield	Grain yield	Biol. yield	Harvest index	1000-grain wt.
Days to 50% flowering	E_1	1.000	0.587	0.414	0.388	0.209	0.1963	0.4942	0.051	0.436	-0.583	-0.239
	E_2	1.000	0.012	0.256	0.049	0.241	0.091	-0.074	-0.236	-0.150	-0.235	-0.195
	E_3	1.000	0.489	0.400	0.337	0.157	0.394	0.525	0.017	0.456	-0.6895	-0.122
	E_4	1.000	0.246	0.011	0.006	0.046	-0.093	0.169	-0.085	0.146	-0.261	-0.217
Plant height	E_1	0.576**	1.000	0.691	0.550	0.422	0.229	0.744	0.303	0.701	-0.635	-0.70
	E_2	-0.029	1.000	0.619	-0.192	0.000	0.089	0.382	0.015	0.295	-0.249	0.016
	E_3	0.484**	1.000	0.650	0.129	0.243	0.160	.724	0.299	0.689	-0.596	-0.24
	E_4	0.240	1.000	0.500	-0.119	0.116	0.233	0.592	0.250	0.595	-0.147	0.304
Ear length	E_1	0.387*	0.664**	1.000	0.437	-0.103	-0.224	0.287	.133	0.218	-0.502	-0.030
	E_2	0.172	0.564**	1.000	0.019	-0.09	-0.310	0.085	0.009	0.059	-0.047	-0.206
	E_3	0.387*	0.634	1.000	0.225	0.110	-0.132	0.475	0.097	0.435	-0.496	-0.033
	E_4	0.001	0.460**	1.000	-0.454	0.458	0.320	0.177	0.143	0.161	-0.156	0.240
Ear girth	E_1	0.341	0.505**	0.421*	1.000	0.029	-0.125	0.360	0.370	0.387	-0.035	-0.240
	E_2	0.051	-0.155	0.063	1.000	-0.071	-0.027	-0.319	0.389	-0.102	0.619	0.131
	E_3	0.312	0.132	0.220	1.000	-0.072	-0.184	0.224	0.426	0.272	0.174	-0.342
	E_4	0.032	-0.084	-0.371	1.000	-0.415	-0.252	0.276	0.383	0.315	0.144	0.037
Total tillers	E_1	0.190	0.386*	-0.085	0.0317	1.000	0.876	0.459	0.407	0.478	-0.144	-0.003
	E_2	0.195	-0.011	-0.108	-0.123	1.000	0.923	-0.037	0.139	0.011	-0.079	0.136
	E_3	0.142	0.214	0.101	-0.058	1.000	0.702	0.344	0.196	0.333	-0.303	0.005
	E_4	0.42	0.093	0.353*	-0.366*	1.000	0.180	0.101	0.014	0.097	0.071	0.168
Effective tillers	E_1	0.170	0.220	-0.183	-0.077	0.760**	1.000	0.397	0.451	0.435	-0.387	-0.072
	E_2	0.069	0.058	-0.1236	0.024	0.544**	1.000	-0.024	0.384	0.003	0.054	0.264
	E_3	.343	0.134	-0.047	-0.154	0.658**	1.000	0.377	.0393	0.453	-0.488	0.003
	E_4	-0.082	0.202	0.274	-0.177	0.705**	1.000	0.387	0.240	0.183	-0.105	0.230
Dry fodder yield	E_1	0.487**	0.744**	0.277	0.357*	0.416*	0.367*	1.000	0.623	0.986	-0.586**	-0.132
	E_2	-0.063	0.361*	0.110	-0.166	-0.034	-0.093	1.000	0.488	0.935	-0.333	-.037
	E_3	0.520**	0.71**	0.462**	0.215	0.366*	0.415**	1.000	0.637	0.991	-0.635	0.253
	E_4	.150	0.534**	0.140	0.230	0.082	0.357*	1.000	0.318	0.990	-0.496	0.502
Grain yield	E_1	0.048	0.300	0.119	0.363*	0.368*	0.399*	0.614**	1.000	0.742	-0.363*	-0.387
	E_2	-0.216	0.014	0.008	0.367*	0.106	0.371*	0.477**	1.000	0.765	0.652	0.189
	E_3	0.17	0.288	0.095	0.403*	0.180	0.372*	0.631**	1.000	0.734	0.1614	0.491
	E_4	-0.076	0.239	0.126	0.364	0.005	0.261	0.285	1.000	0.448	0.651	0.181
Biological yield	E_1	0.428*	0.701**	0.213	0.362*	0.439*	0.390*	0.986**	0.736**	1.000	-0.455	-0.194
	E_2	-0.131	0.295	0.086	-0.006	0.040	-0.65	0.940*	0.748**	1.000	-0.067	0.049
	E_3	0.461**	0.676**	0.423*	0.259	0.310	0.395*	0.0990**	0.730**	1.000	-0.531	0.308
	E_4	0.131	0.541**	0.126	0.268	0.079	0.158	0.989**	0.419*	1.000	-0.369	0.501
Harvest index	E_1	-0.563**	-0.625**	-0.4681	-0.162	-0.037	-0.591	-0.367	-0.381	-0.447	1.000	-0.265
	E_2	-0.204	-0.209	-0.058	0.462**	-0.012	0.088	-0.385*	0.616**	-0.052	1.000	0.222
	E_3	-0.675**	-0.585	-0.478**	0.162	-0.272	-0.412	-0.631*	0.174	-0.525**	1.000	0.193
	E_4	-0.226	-0.212	-0.135	0.135	0.067	0.152	-0.511**	0.655**	-0.387	1.000	-0.188
1000-grain weight	E_1	-0.234	-0.068	-0.023	-0.221	-0.001	-0.061	-0.131	-0.381*	-0.192	-0.257	1.000
	E_2	-0.181	0.017	-0.187	0.111	0.109	0.161	-0.032	0.185	0.047	0.208	1.000
	E_3	-0.120	-0.024	-0.034	0.317	0.003	0.005	0.251	0.482*	0.305	0.183	1.000
	E_4	-0.214	0.289	0.217	0.034	0.152	0.199	0.491**	0.172	0.491	-0.183	1.000

*,**Sigificant at P=0.05 and P=0.01 levels, respectively.

total tillers, ear girth, dry fodder yield, harvest index, biological yield and 1000-grain weight which exhibited high correlation with grain yield. Biological yield not only exhibited direct effect on grain yield but it also contributed towards grain yield indirectly through most of the characters studied. Hence, main emphasis should be given on biological yield in breeding programme.

It was concluded that the grain yield was significantly and positively correlated with harvest index, ear girth, effective tillers, dry fodder and biological yield in all the four environments. The biological yield had direct positive effect and indirect effect on grain yield in all the four environments. So, the selection for higher yield will be useful if it is based on characters such as

TABLE 3

Genotypic path coefficient showing direct (diagonal) and indirect effects of various characters on grain yield

Character	Env.	Day to 50% flowering	Plant height	Ear length	Ear girth	Total tillers	Effective tillers	Dry fodder yield	Biological yield	Harvesting index	1000-grain wt.	Grain yield
Days to 50% flowering	E_1	**-0.00053**	-0.00173	-0.00043	0.00044	0.00016	-0.00003	-2.07644	2.12198	0.00701	0.000067	0.0514
	E_2	**0.000963**	0.00019	-0.00053	0.000003	0.000338	-0.000174	0.13396	-0.36785	-0.002965	-0.000005	-0.2362
	E_3	**0.00138**	-0.00018	0.000021	-0.00027	0.000106	-0.00128	-3.6352	2.65835	-0.00501	-0.00002	0.0178
	E_4	**-0.00002**	-0.0001	0.00000	-0.00000	0.0000	0.00000	-1.07758	0.99204	0.00048	0.00000	-0.085
Plant height	E_1	-0.00032	**-0.00296**	-0.00072	0.00062	0.00032	-0.00003	-3.1099	3.4073	0.00765	0.000020	0.03034
	E_2	0.000012	**0.00518**	-0.0058	-0.00001	0.000001	-0.000171	-0.45828	0.475625	-0.00313	0.00000	0.0158
	E_3	0.000675	**0.000035**	0.000035	-0.000105	0.000163	-0.00052	-2.3861	3.93874	-0.00433	-0.000005	0.2995
	E_4	-0.0004	**-0.00003**	0.00005	0.0000	-0.00000	-0.0000	-3.77564	4.02545	0.00045	-0.00001	0.2502
Ear length	E_1	-0.00022	-0.00205	**-0.00104**	0.00049	-0.0008	0.00004	-1.00108	1.12908	0.00605	0.00009	0.1333
	E_2	0.000247	0.00094	**-0.00207**	0.00001	0.00013	0.00059	-0.15345	0.165130	-0.00060	-0.000005	0.0094
	E_3	0.000552	-0.000232	**0.000053**	-0.00018	0.000074	0.0001	-1.12834	2.4868	-0.00361	-0.00005	0.0974
	E_4	-0.0000	-0.00002	**0.00011**	0.00002	-0.0000	-0.00001	-1.03231	1.1888	0.0002	0.0000	0.1436
Ear girth	E_1	-0.0002	-0.00162	-0.00045	**0.0011**	0.00002	0.0002	-1.46526	1.8353	0.000458	-0.000067	0.3703*
	E_2	0.000005	-0.00029	-0.00004	**0.00007**	-0.0001	0.0005	0.57207	-0.20027	0.00719	0.000003	0.3893*
	E_3	0.000464	-0.000046	0.000012	**-0.00081**	-0.00005	0.0005	-1.71507	1.5537	-0.127	0.0005	0.4264*
	E_4	-0.0000	0.0000	-0.0001	**-0.0001**	0.00000	0.00001	-1.76199	2.1454	-0.0002	-0.0000	0.3830*
Total tillers	E_1	-0.00011	-0.00125	-0.0001	0.000034	**0.00076**	-0.00014	-1.9201	2.3267	0.0019	0.00001	0.4078*
	E_2	0.000023	0.000001	0.00020	-0.000005	**0.00140**	-0.00175	-0.0673	0.038823	-0.000996	0.000004	0.1394
	E_3	0.000217	-0.00087	0.000006	0.00006	**0.00067**	-0.00022	-230568	1.9067	-0.0022	0.000001	0.01901
	E_4	-0.0000	-0.0000	0.0002	0.0001	**-0.00000**	-0.0000	0.6646	-0.6505	-0.0001	-0.0000	0.0142
Effective tillers	E_1	-0.0001	-0.00068	-0.00024	0.00014	0.00067	**-0.00016**	-1.6617	2.1103	0.00044	0.00002	0.4515*
	E_2	0.000088	0.000136	0.000064	-0.000002	0.002295	**-0.00189**	0.08428	0.039133	0.00691	.000007	0.3844*
	E_3	0.000543	-0.00057	-0.000002	0.000149	0.00047	**-0.00032**	-230568	2.691	-0.0035	0.000001	0.3931*
	E_4	0.0000	-0.0000	0.0000	0.0000	-0.0000	**-0.0000**	-1.0964	1.3367	0.0002	-0.00001	0.2406
Dry fodder yield	E_1	-0.00027	-0.00022	-0.0003	0.00039	0.00035	-0.0006	**-4.17559**	4.7933	0.0071	-0.000037	0.6231*
	E_2	-0.000072	0.000414	-0.000178	-0.000022	0.000053	0.000047	**-0.79012**	2.28238	-0.004196	-0.000001	0.4883*
	E_3	0.000724	-0.000258	0.000002	-0.00018	0.00023	-0.00015	**-501868**	5.6598	-0.0047	0.00004	0.6370**
	E_4	-0.0000	-0.0000	0.00002	0.00001	0.0000	-0.0000	**-6.3751**	6.69307	0.0009	-0.00002	0.3189
Biological yield	E_1	-0.00023	-0.00207	-0.00023	0.00043	0.00036	-0.00007	-4.1201	**4.8582**	0.00548	-0.000054	0.7422*
	E_2	-0.000145	0.000296	-0.000124	-0.0000007	0.000017	-0.000007	-0.167481	**2.439528**	0.000224	0.000001	0.7650*
	E_3	0.000641	-0.000246	0.0000023	-0.00022	0.00022	-0.00014	-0.9732	**5.7114**	-0.00386	0.00005	0.7346**
	E_4	-0.0000	-0.0000	0.0000	-0.0000	0.0000	-0.0000	-6.3119	**6.7600**	0.0006	-0.0000	0.4480*
Harvest index	E_1	-0.00031	-0.00189	-0.0005	-0.0004	-0.0001	0.00006	2.3797	-2.0115	**0.0020**	-0.00007	0.3677*
	E_2	-0.000227	-0.000378	0.000099	0.000042	-0.000111	-0.000104	0.59684	0.04336	**0.011258**	0.000006	0.6521*
	E_3	-0.00095	0.000212	-0.00002	-0.00014	-0.0002	0.00015	3.18832	-3.0328	**0.007274**	0.00003	0.1618
	E_4	0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	3.1478	-2.4943	**-0.0018**	0.0000	0.6510*
1000-grain weight	E_1	-0.00013	-0.0002	-0.0003	-0.00023	-0.0002	0.00001	-0.5525	0.9430	-0.0031	**-0.00028**	0.3877*
	E_2	-0.000188	0.00026	0.000429	0.000009	0.0000191	-0.00050	0.06668	0.11960	0.002805	**0.000026**	0.1891
	E_3	-0.00017	0.000009	-0.000002	-0.00027	0.000004	0.000001	-0.2733	1.76359	0.00140	**0.00016**	0.4914*
	E_4	0.0000	-0.0000	0.0000	-0.0000	0.00000	-0.0000	-3.2049	3.3865	0.0003	**-0.0000**	0.1810

biological yield, plant height, dry fodder yield, effective tillers and harvest index as these have significant correlation on grain yield.

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