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Character association and path analysis for yield and its contributing traits in little millet (*Panicum sumatrance* Roth. ex Roemer and schultes) under different sown conditions in south saurastra conditions

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Abstract
Thirty genotypes of Little millet (*Panicum sumatrance*) at Junagadh, Gujarat during *Kharif* 2017 under Timely (E_1), late (E_2) and vey late (E_3) sown conditions. The characters studied were days to 50 % flowering, days to maturity, number of productive tillers per plant, plant height, panicle length, grain weight per main panicle, grain yield per plant, biological yield per plant, harvest index, 1000 seed weight, chlorophyll content and specific leaf weight. In timely sown condition, the grain yield per plant had highly significant and positive correlations with plant height, number of productive tillers per plant, harvest index and specific leaf weight at both genotypic and phenotypic levels. In late sown condition, grain yield per plant had highly significant and positive correlation at both genotypic and phenotypic levels with number of productive tillers per plant and harvest index. In very late sowing condition plant height, number of productive tillers per plant and harvest index with grain yield per plant at both the levels. Overall in all sowing condition, number of productive tillers per plant and harvest index has significant and positive genotypic and phenotypic correlations.
Path coefficient analysis revealed that harvest index, biological yield per plant, days to 50% flowering and specific leaf weight exhibited high and positive direct effects on grain yield per plant under timely sown condition. While in case of late sown condition, path coefficient analysis revealed that harvest index, biological yield per plant, chlorophyll content, plant height, grain weight per main panicle and panicle length exhibited high and positive direct effects on grain yield per plant. In very late sowing condition, character harvest index, biological yield per plant and days to 50 % flowering shows high and direct positive effect toward grain yield per plant. Among all sowing conditions, biological yield per plant, harvest index and specific leaf weight exhibited high and positive direct effect on grain yield per plant. The residual effect of the present study under timely, late and very late sowing condition was 0.264, 0.829 and 1-1.012, respectively indicating that characters suggested that there might be few more component traits responsible to influence towards grain yield per plant than those studied.

Keywords: Correlation, direct effect, little millet, timely, late and very late sown conditions

Introduction
Little millet (*Panicum sumatrense* Roth. ex. Roem. and Schultz.) is one of the important small grain crops that come up well in dry lands, which are characterized by high temperature, low fertile soil and poor management by resource poor farmers. It is considered to be indigenous to Indian subcontinent due to the luxuriant presence of its wild ancestor Panicum psilopodium throughout India. It is a self pollinated and allotetraploid crop with chromosome number of 2n = 4x = 36 belonging to the family Poaceae and sub family Panicoideae. Besides India, it is widely cultivated as, minor cereal across Nepal, Sri Lanka and western Burma. It is the first food of the year among the tribal farmers and is the staple food for millions in many parts of the world. Little millet is presently grown throughout India in about one million hectares. In India, little millet having cultivated in an area of 291 thousand hectares with annual production of 102 thousand tones and productivity of 349 kg per hectare which is very less as compared to other cereal crops. Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Odisha, Tamil Nadu, Karnataka, Jharkhand and Gujarat are major little millet growing states in the country (Ashwini *et al*., 2017) [3]. In Gujarat, little millet is cultivated in an area of 10,634 hectares with 9,526 tonnes of production having the productivity of 896 kg/ha in 2011 (Anon., 2014) [2]. In Gujarat, it is mainly cultivated as rainfed crop in *Kharif* in the less fertile hilly soil. In Gujarat a number of land races of little millet are grown widely in Dangs, Tapi, Dahod, Panchmahal, Mahisagar, Navsari and Valsad district. It is valued for its drought tolerance, stress tolerance and nutritional value. The great merit of little millet is that it can be stored for a period of up to ten years or more without deterioration.

Consequently, it has traditionally played an important role as reserve food crop. Moreover, it is considered to be free of the major pest and diseases. In spite of these advantages, the national average grain yield of little millet is low, although it has a potential to yield up to 3 t/ha. Its low productivity has been due to lack of improved varieties, frequent drought in rainfed condition and unimproved traditional cultivation practices. Currently most of the farmers are cultivating local varieties (landraces) and so far, five improved varieties have been released in Tamil Nadu for production in place of land races. Replacement of landraces by modern cultivars generally increases the productivity of the crop and income of the farmers. Besides, little millet is being pushed to more marginal areas; so it is believed that, this would aggravate the danger of loss of genetic variation. Therefore investigating and identifying plants for the genetic variation available in the breeding materials is the first step of plant breeding and so vital for successful crop improvement program in future. Hence, this study was undertaken to assess the genetic variability, heritability, genetic advance and inter relationship of different yield and yield contributing traits and to determine the genetic potential of these materials for future use in the breeding programme.

The knowledge of degree of association between yield contributing characters and their relative contribution in yield is very essential for development of high yielding genotypes in little millet. Correlation studies provide an opportunity to study the magnitude and direction of association of yield with its components traits and also among various components. Path coefficient is essential to accumulate optimum combination of yield contributing characters and to know the implication of the interrelationships of various characters in a single genotype. Considering the above points, the present study was undertaken to evaluate the genotypes for yield and its components and to estimate the inter-relationship among the agronomic traits in little millet**.**

Material and methods

The present investigation was carried out in little millet (*Panicum sumatrance*)"at Instructional Farm, Junagadh Agricultural University, Junagadh, Gujarat during *kharif* 2017. In this experiment, genotypes were evaluated in randomized block design with three replications during *kharif* 2017 in randomized block design with three replications under timely, late and very late sown conditions. Geographically Junagadh is situated at 21.5^0 N latitude and 70.5^0 E longitudes with an altitude of 60 meters above the mean sea level. The soil of experimental site was medium black, alluvial in origin with pH 7.8.

The experimental material consisted of 30 diverse genotypes were sown in three blocks in Randomized Block Design. Each genotype was accommodated in a one row plot with a spacing of 30 cm between rows and 10 cm between plants. Observations for all traits (days to 50 % flowering, days to maturity, number of productive tillers per plant, plant height, panicle length, grain weight per main panicle, grain yield per plant, biological yield per plant, harvest index, 1000 seed weight, specific leaf area and chlorophyll content) were recorded on five randomly selected competitive plants of each entry in each replication except for days to 50 % flowering and days to maturity where observations were recorded on plot basis.

The analysis of variance for randomized block design (RBD) was done for each character as per Panse and Sukhatme (1985) [7]. The phenotypic and genotypic correlation coefficients of all the pair of characters were worked out as per Al-Jibouri *et al.* (1958) [1] and path coefficient analysis was suggested by suggested by Dewey and Lu (1959) [5].

Results and discussion

As economic yields are dependent and most complex inherited trait due to their polygenic nature, knowledge of the extent of genetic association between them is useful in isolating the most desirable genotypes. The correlation coefficients were worked-out among 12 characters to find out association of seed yield per plant with its components as well as association among yield components at genotypic and phenotypic levels. Table 1 (timely sowing), Table 2 (late sowing) and Table 3 (very late sowing), In general, the values of genotypic correlation were higher than their corresponding phenotypic correlation in the present investigation. This indicated that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. It is indicative of inherently strong relationship among the traits once the non-heritable of environment was removed. This was also reported by Wolie and Desalegn (2011) [10]. However, in few cases (number of productive tillers per plant for grain yield per plant and plant height, harvest index for days to 50 % flowering and days to maturity in late sowing condition E_1, while in very late sowing condition reported by specific leaf weight on thousand seed weight. the phenotypic correlation was slightly higher than their genotypic counterparts, which implied that the non-genetic cause inflated the value of genotypic correlation because of the influence of the environmental factors.

In timely sowing condition character association study revealed that the grain yield per plant had significant and positive correlation both at genotypic and phenotypic levels with plant height (r_g = 0.685 and r_p = 0.619), number of productive tillers per plant (r_g = 0.786 and r_p = 0.749) and harvest index (r_g = 0.690 and r_p = 0.662) and specific leaf weight (r_g = 0.496 and r_p = 0.300). This character showed significant and negative correlation at both genotypic and phenotypic levels with days to 50 % flowering (r_g = -0.511 and r_p = -0.492) and days to maturity (r_g = -0.538 and r_p = -0.524). In late sowing condition, the grain yield per plant had significant and positive correlation both at genotypic and phenotypic levels with harvest index (r_g = 0.540 and r_p = 0.492) and number of productive tillers per plant (r_g = 0.300 and r_p = 0.348). This character showed significant and negative correlation at both genotypic and phenotypic levels with plant height (r_g = -0.799 and r_p = -0.429) and chlorophyll content (r_g = -0.768 and r_p = -0.479) and specific leaf weight (r_g = -0.340) at only genotypic level. In very late sowing condition correlation studies of these genotypes reported plant height (r_g = 0.483 and r_p = 0.346), number of productive tillers (r_g = 0.391 and r_p = 0.366) and harvest index (r_g = 0.908 and r_p = 0.853) had significant and positive correlations both at genotypic and phenotypic levels with the grain yield per plant. It showed significant and negative correlation at genotypic level with biological yield per plant (r_g = -0.476) at genotypic level.

In timely sowing condition analysis of little millet genotypes revealed that the grain yield per plant had significant and positive correlations both at genotypic and phenotypic levels with plant height, number of productive tillars, harvest index and specific leaf weight. The results are in harmony with Nirmalakumari *et al.* (2010) [10] for plant height. Having analysis of thirty genotypes of little millet for character

association, the grain yield per plant expressed significant negative correlation with traits, days to 50 % flowering and days to maturity at both levels. In late sowing condition the grain yield per plant showed significant and positive correlation both at genotypic and phenotypic levels with number of productive tillers, harvest index; Significant and negative correlation with plant height and chlorophyll content at both levels; grain weight per main panicle and specific leaf area at only genotypic levels. Similar result reported by the Nirmalakumari *et al.* (2010) [6] for yield per panicle. Which indicated increase one character will lead to decrease in another character. In very late sowing condition the grain yield per plant had significant and positive correlations both at genotypic and phenotypic levels with plant height, number of productive tillers and harvest index. Hence, simultaneous selections for these traits will be more reliable to develop high yielding genotypes in very late environments. The result is in harmony with Nirmalakumari *et al.* (2010) [6] for plant height.

Correlation studies alone can't provide a clear cut picture of cause and effect of relationships between yield attributes and their extent of association. In the present investigation, under environment first (E_1) revealed that harvest index reported highest and direct positive effects followed by biological yield per plant, days to 50% flowering and specific leaf area. In late sowing (E_2) path analysis study revealed that characters such as harvest index, biological yield per plant, chlorophyll content and plant height which exhibited very high direct positive influence on grain yield per plant. Under very late sowing condition (E_3) concluded that biological yield per plant, harvest index and days to 50 % flowering contributed high and positive direct effects on grain yield per plant. Thus, these characters turned-out to be the major components of grain yield. For the improvement of grain yield, emphasis should be made on all yield contributing characters which are influencing it directly or indirectly. In the present study, overall picture of path analysis revealed that for improving yield in little millet, weightage in selection should be given to biological yield per plant, harvest index and specific leaf area. Priyadharshini *et al* (2011) [8], Chunilal *et al*. (1996) [4] for harvest index. Wolie and Dessalegn (2011) [10] for biological yield. Singh *et al.* (1990) [9] for biological yield per plant and harvest index. The genotypic residual effect was of low magnitude in early and timely sowing are suggesting that the majority of yield attributes have been included in the study of path analysis and high magnitude of residual effect in late sowing showed that characters are not enough for study.

Conclusion

In timely sown condition, the grain yield per plant had highly significant and positive correlations with plant height, number of productive tillers per plant, harvest index and specific leaf area at both genotypic and phenotypic levels (Fig 1). In late sown condition, grain yield per plant had highly significant and positive correlation at both genotypic and phenotypic levels with number of productive tillers per plant and harvest index (Fig 1). In very late sown condition, the grain yield per plant had highly significant and positive correlations with plant height, number of productive tillers per plant and harvest index (Fig 1). at both genotypic and phenotypic levels.

The path coefficient analysis revealed that the biological yield per plant, harvest index and specific leaf weight exhibited high and positive direct effects on grain yield per plant under all three environmental conditions (Fig 2). While maximum direct and positive effect was due to harvest index, biological yield per plant, days to 50 % flowering and specific leaf weight in early sowing condition (E_1). Whereas, in timely sown condition (E_2), the maximum positive direct effect was observed for harvest index followed by biological yield per plant, chlorophyll content, plant height, yield per panicle and main panicle. In case of late sowing condition (E_3), the maximum positive direct effect was observed harvest index followed by biological yield per plant and days to 50 % flowering. Therefore, these characters are the important characters which could be used in selection for higher yield of little millet.

Table 1: Genotypic and phenotypic correlations coefficient among twelve characters of little millet in timely sown condition

Characters		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle	Biological yield per plant	Harvest index (%)	Thousand seed weight	Specific leaf weight	Chlorophyll Content
Grain yield per plant	r_g	-0.511**	-0.538**	0.685**	0.786**	0.019	0.012	0.044	0.690**	0.145	0.496**	0.116
	r_p	-0.492**	-0.524**	0.619**	0.749**	0.003	0.073	0.066	0.662**	0.121	0.300*	0.106
Days to 50 % flowering	r_g		0.973**	-0.894**	-0.803**	-0.079	0.331*	0.420**	-0.661**	-0.002	-0.860**	-0.459**
	r_p		0.962**	-0.720**	-0.788**	-0.054	0.299*	0.370**	-0.626**	-0.025	-0.617**	-0.411**
Days to maturity	r_g			-0.874**	-0.782**	-0.091	0.280*	0.310*	-0.614**	0.004	-0.770**	-0.478**
	r_p			-0.698**	-0.761**	-0.059	0.242	0.257*	-0.574**	-0.027	-0.560**	-0.422**
Plant height (cm)	r_g				0.941**	0.259*	-0.438**	-0.133	0.654**	-0.038	0.671**	0.513**
	r_p				0.777**	0.230	-0.304*	-0.099	0.553**	-0.034	0.357**	0.424**
No. of productive tillers per plant	r_g					0.099	-0.340**	-0.296*	0.796**	0.053	0.815**	0.267*
	r_p					0.080	-0.316*	-0.267*	0.763**	0.063	0.582**	0.252*
Main panicle length (cm)	r_g						0.033	0.050	-0.068	-0.117	0.148	0.383**
	r_p						0.049	0.056	-0.083	-0.103	0.081	0.356**
Grain weight per main panicle	r_g							0.202	-0.139	0.434**	-0.293*	-0.347**
	r_p							0.194	-0.109	0.333**	-0.251*	-0.285*
Biological yield per plant	r_g								-0.662**	-0.289*	-0.353**	0.011
	r_p								-0.662**	-0.232	-0.266*	0.008
Harvest index (%)	r_g									0.209	0.611**	-0.035
	r_p									0.183	0.411**	-0.006
1000 seed weight	r_g										-0.051	-0.234
	r_p										-0.075	-0.178
Specific leaf weight (g/cm^2)	r_g											0.657**
	r_p											0.347**

*, ** Significant at 5% and 1% level of significance, respectively

Table 2: Genotypic and phenotypic correlations coefficient among twelve characters of little millet in late sown condition

Characters		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle	Biological yield per plant	Harvest index (%)	1000 seed weight	Specific leaf weight	Chlorophyll Content
Grain yield per plant	r_g	-0.207	-0.234	-0.799**	0.300*	0.018	-0.295*	-0.196	0.540**	-0.146	-0.340**	-0.768**
	r_p	-0.083	-0.164	-0.429**	0.348**	0.028	-0.153	-0.027	0.492**	-0.112	-0.196	-0.479**
Days to 50 % flowering	r_g		0.987**	-0.480**	-0.487**	-0.582**	0.618**	-0.288*	0.160	0.104	0.269*	0.784**
	r_p		0.962**	-0.417**	-0.421**	-0.463**	0.424**	-0.275*	0.183	0.072	0.232*	0.665**
Days to maturity	r_g			-0.554**	-0.539**	-0.698**	0.650**	-0.369**	0.228	0.111	0.250*	0.844**
	r_p			-0.459**	-0.500**	-0.543**	0.508**	-0.367**	0.233	0.093	0.223	0.736**
Plant height (cm)	r_g				0.138	0.378**	-0.441**	0.446**	-0.615**	0.097	0.062	-0.193
	r_p				0.145	0.295*	-0.302*	0.398**	-0.515**	0.069	0.056	-0.160
No. of productive tillers per plant	r_g					0.301*	-0.508**	0.166	-0.011	-0.288*	-0.137	-0.653**
	r_p					0.247	-0.421**	0.223	0.003	-0.272*	-0.105	-0.565**
Main panicle length (cm)	r_g						-0.675**	0.523**	-0.490**	-0.320*	0.213	-0.411**
	r_p						-0.503**	0.423**	-0.383**	-0.309*	0.173	-0.366**
Grain weight per main panicle (g)	r_g							-0.091	-0.037	0.268*	0.160	0.645**
	r_p							-0.134	0.021	0.269*	0.120	0.509**
Biological yield per plant	r_g								-0.916**	0.162	-0.085	-0.377**
	r_p								-0.861**	0.144	-0.071	-0.359**
Harvest index (%)	r_g									-0.129	-0.034	0.050
	r_p									-0.131	-0.026	0.064
1000 seed weight	r_g										-0.262*	0.142
	r_p										-0.215	0.124
Specific leaf weight (g/cm^2)	r_g											0.051
	r_p											0.040

*, ** Significant at 5 and 1 % levels, respectively

Table 3: Genotypic and phenotypic correlations coefficient among twelve characters of little millet in very late sown condition

Characters		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle (g)	Biological yield per plant	Harvest index (%)	1000 seed weight	Specific leaf weight	Chlorophyll Content
Grain yield per plant	rg	-0.196	-0.170	0.483**	0.391**	-0.006	-0.222	-0.476**	0.908**	0.125	-0.226	-0.188
	rp	-0.170	-0.150	0.346**	0.366**	0.078	-0.015	-0.244	0.853**	0.086	-0.156	-0.177
Days to 50 % flowering	rg		0.980**	-0.674**	-0.108	-0.608**	0.171	0.299*	-0.263*	0.171	-0.146	0.064
	rp		0.972**	-0.574**	-0.079	-0.419**	0.132	0.229*	-0.229	0.155	-0.102	0.058
Days to maturity	rg			-0.725**	-0.101	-0.679**	0.211	0.369**	-0.288*	0.157	-0.085	0.019
	rp			-0.620**	-0.075	-0.459**	0.158	0.278*	-0.245	0.148	-0.068	0.021
Plant height (cm)	rg				0.004	0.635**	-0.204	-0.250*	0.456**	-0.029	-0.094	0.096
	rp				0.041	0.576**	-0.147	-0.143	0.320*	0.003	-0.021	0.044
No. of productive tillers per plant	rg					-0.025	-0.561**	-0.149	0.377**	0.335*	-0.096	-0.209
	rp					0.044	-0.444**	0.112	0.230	0.223	-0.072	-0.187
Main panicle length (cm)	rg						-0.214	-0.166	0.125	0.152	0.301*	0.078
	rp						-0.143	-0.024	0.101	0.115	0.180	0.044
Grain weight per main panicle (g)	rg							-0.078	-0.142	0.027	-0.316*	0.171
	rp							-0.123	0.038	0.035	-0.167	0.108
Biological yield per plant	rg								-0.799**	-0.042	-0.052	0.220
	rp								-0.705**	-0.042	-0.023	0.142
Harvest index (%)	rg									0.160	-0.055	-0.282*
	rp									0.129	-0.050	-0.241
1000 seed weight	rg										0.109	0.120
	rp										0.116	0.123
Specific leaf weight (g/cm^2)	rg											-0.330*
	rp											-0.297*

Table 4: Genotypic path coefficient analysis Direct (diagonal and bold) and indirect effects of twelve different causal variables on grain yield per plant in 30 genotypes of little millet in timely sowing condition

Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle	Biological yield per plant (g)	Harvest index (%)	1000 seed weight	Specific leaf weight	Chlorophyll Content	Genotypic correlation with grain yield
Days to 50 % flowering	0.733	-0.510	-0.159	0.395	-0.006	-0.058	0.416	-0.929	-0.001	-0.424	0.031	-0.511**
Days to maturity	0.713	-0.524	-0.155	0.384	-0.006	-0.049	0.307	-0.862	0.001	-0.380	0.033	-0.538**
Plant height (cm)	-0.655	0.458	0.177	-0.462	0.018	0.077	-0.132	0.918	-0.010	0.331	-0.035	0.685**
No. of	-0.588	0.410	0.167	-0.491	0.007	0.060	-0.293	1.118	0.014	0.402	-0.018	0.786**

productive tillers per plant												
Main panicle length (cm)	-0.058	0.047	0.046	-0.049	0.069	-0.006	0.049	-0.096	-0.031	0.073	-0.026	0.019
Grain weight per main panicle (g)	0.243	-0.147	-0.078	0.167	0.002	-0.176	0.200	-0.195	0.116	-0.144	0.024	0.012
Biological yield per plant (g)	0.308	-0.163	-0.024	0.145	0.004	-0.035	0.990	-0.929	-0.077	-0.174	-0.001	0.044
Harvest index (%)	-0.485	0.322	0.116	-0.391	-0.005	0.024	-0.655	1.404	0.056	0.301	0.002	0.690**
1000 seed weight (g)	-0.001	-0.002	-0.007	-0.026	-0.008	-0.076	-0.286	0.293	0.267	-0.025	0.016	0.145
Specific leaf weight	-0.631	0.404	0.119	-0.401	0.010	0.051	-0.350	0.858	-0.014	0.493	-0.045	0.496**
Chlorophyll Content	-0.337	0.250	0.091	-0.131	0.027	0.061	0.011	-0.049	-0.063	0.324	-0.068	0.116

*, ** Significant at 5 and 1 % levels, respectively Residual effect: R=0.073

Table 5: Genotypic path coefficient analysis Direct (diagonal and bold) and indirect effects of twelve different causal variables on grain yield per plant in 30 genotypes of little millet in late sowing condition

Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle	Biological yield per plant (g)	Harvest index (%)	1000 seed weight	Specific leaf weight (cm^2g)	Chlorophyll Content	Genotypic correlation with grain yield
Days to 50 % flowering	-0.839	0.194	-0.505	-0.128	-0.235	0.354	-1.980	1.222	-0.053	0.062	1.701	-0.207
Days to maturity	-0.829	0.196	-0.584	-0.142	-0.281	0.373	-2.538	1.738	-0.056	0.057	1.831	-0.234
Plant height (cm)	0.403	-0.109	1.053	0.036	0.152	-0.253	3.068	-4.697	-0.049	0.014	-0.418	-0.799**
No. of productive tillers per plant	0.409	-0.106	0.145	0.263	0.121	-0.291	1.143	-0.083	0.146	-0.032	-1.417	0.300*
Main panicle length (cm)	0.489	-0.137	0.398	0.079	0.403	-0.387	3.600	-3.745	0.163	0.049	-0.892	0.018
Grain weight per main panicle (g)	-0.519	0.128	-0.464	-0.134	-0.272	0.574	-0.623	-0.283	-0.136	0.037	1.398	-0.295*
Biological yield per plant (g)	0.242	-0.073	0.470	0.044	0.211	-0.052	6.880	-6.999	-0.082	-0.020	-0.817	-0.196
Harvest index (%)	-0.134	0.045	-0.648	-0.003	-0.198	-0.021	-6.304	7.638	0.066	-0.008	0.108	0.540**
1000 seed weight (g)	-0.087	0.022	0.102	-0.076	-0.129	0.154	1.114	-0.986	-0.508	-0.060	0.308	-0.146
Specific leaf weight	-0.226	0.049	0.066	-0.036	0.086	0.092	-0.587	-0.256	0.133	0.229	0.110	-0.340**
Chlorophyll Content	-0.658	0.166	-0.203	-0.172	-0.166	0.370	-2.592	0.380	-0.072	0.012	2.169	-0.7688*

*, ** Significant at 5 and 1 % levels, respectively

Table 6: Genotypic path coefficient analysis Direct (diagonal and bold) and indirect effects of twelve different causal variables on grain yield per plant in 30 genotypes of little millet in very late sowing condition

Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Main panicle length (cm)	Grain weight per main panicle	Biological yield per plant	Harvest index (%)	1000 seed weight	Specific leaf weight	Chlorophyll Content	Genotypic correlation with grain yield
Days to 50 % flowering	1.291	-1.743	0.264	0.009	0.135	0.031	0.396	-0.555	-0.014	-0.018	0.008	-0.196
Days to maturity	1.265	-1.777	0.284	0.008	0.151	0.039	0.489	-0.608	-0.013	-0.011	0.002	-0.170
Plant height (cm)	-0.870	1.289	-0.392	0.000	-0.141	-0.037	-0.331	0.963	0.002	-0.012	0.012	0.483**
No. of productive tillers per plant	-0.140	0.179	-0.002	-0.082	0.005	-0.103	-0.198	0.797	-0.028	-0.012	-0.026	0.3918*
Main panicle length (cm)	-0.785	1.207	-0.249	0.002	-0.222	-0.039	-0.220	0.264	-0.012	0.038	0.010	-0.006
Grain weight per main panicle	0.220	-0.376	0.080	0.046	0.048	0.183	-0.103	-0.300	-0.002	-0.040	0.022	-0.222
Biological yield per plant	0.386	-0.656	0.098	0.012	0.037	-0.014	1.324	-1.687	0.003	-0.007	0.028	-0.476**
Harvest index (%)	-0.339	0.511	-0.179	-0.031	-0.028	-0.026	-1.057	2.112	-0.013	-0.007	-0.036	0.908**
1000 seed weight	0.221	-0.280	0.011	-0.028	-0.034	0.005	-0.055	0.338	-0.082	0.014	0.015	0.125

Specific leaf weight	-0.188	0.152	0.037	0.008	-0.067	-0.058	-0.069	-0.115	-0.009	0.126	-0.042	-0.226
Chlorophyll Content	0.083	-0.034	-0.037	0.017	-0.017	0.031	0.291	-0.596	-0.010	-0.042	0.126	-0.188

*, ** Significant at 5 and 1 % levels, respectively

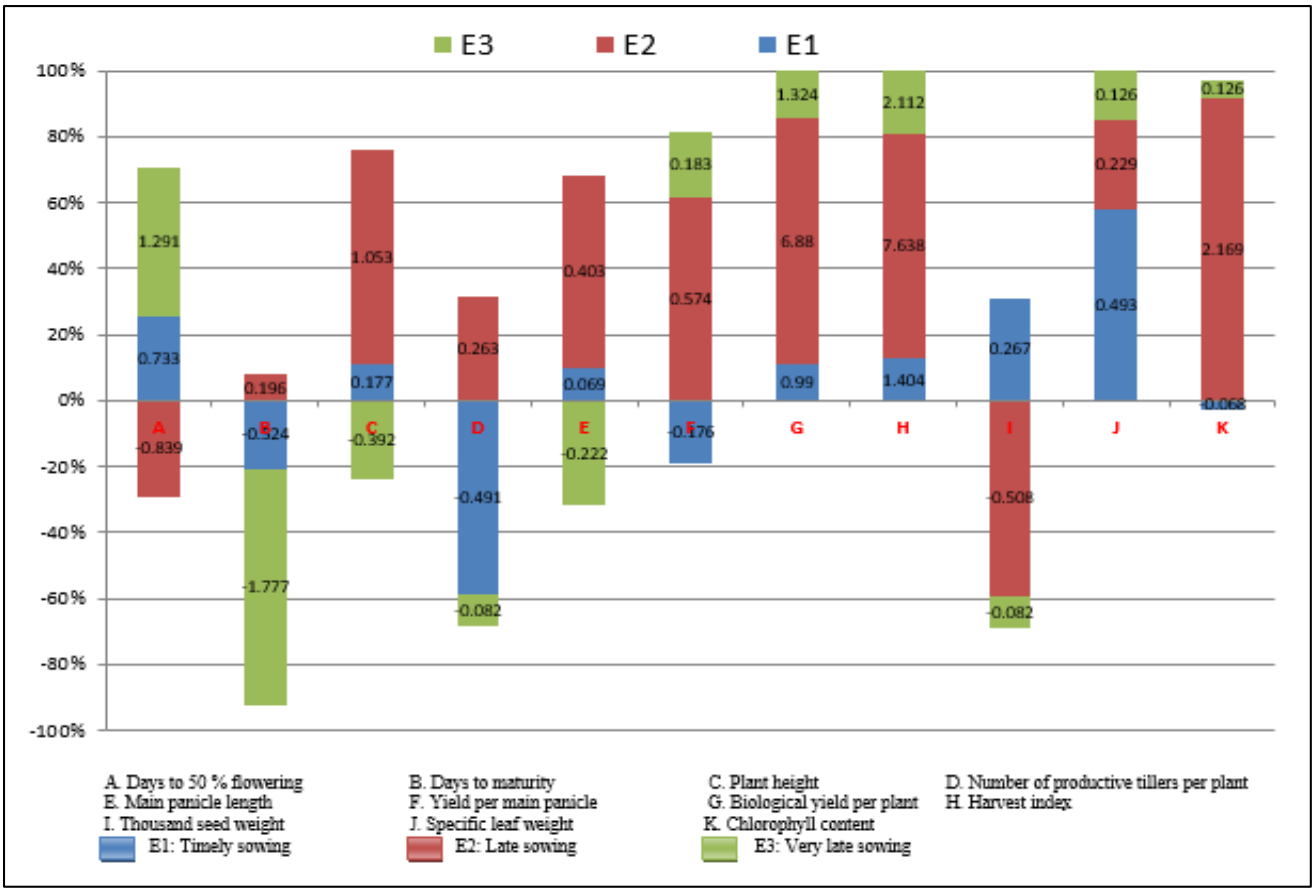

Fig 1: Graph showing direct effect of causal variables on grain yield per plant in three different environments

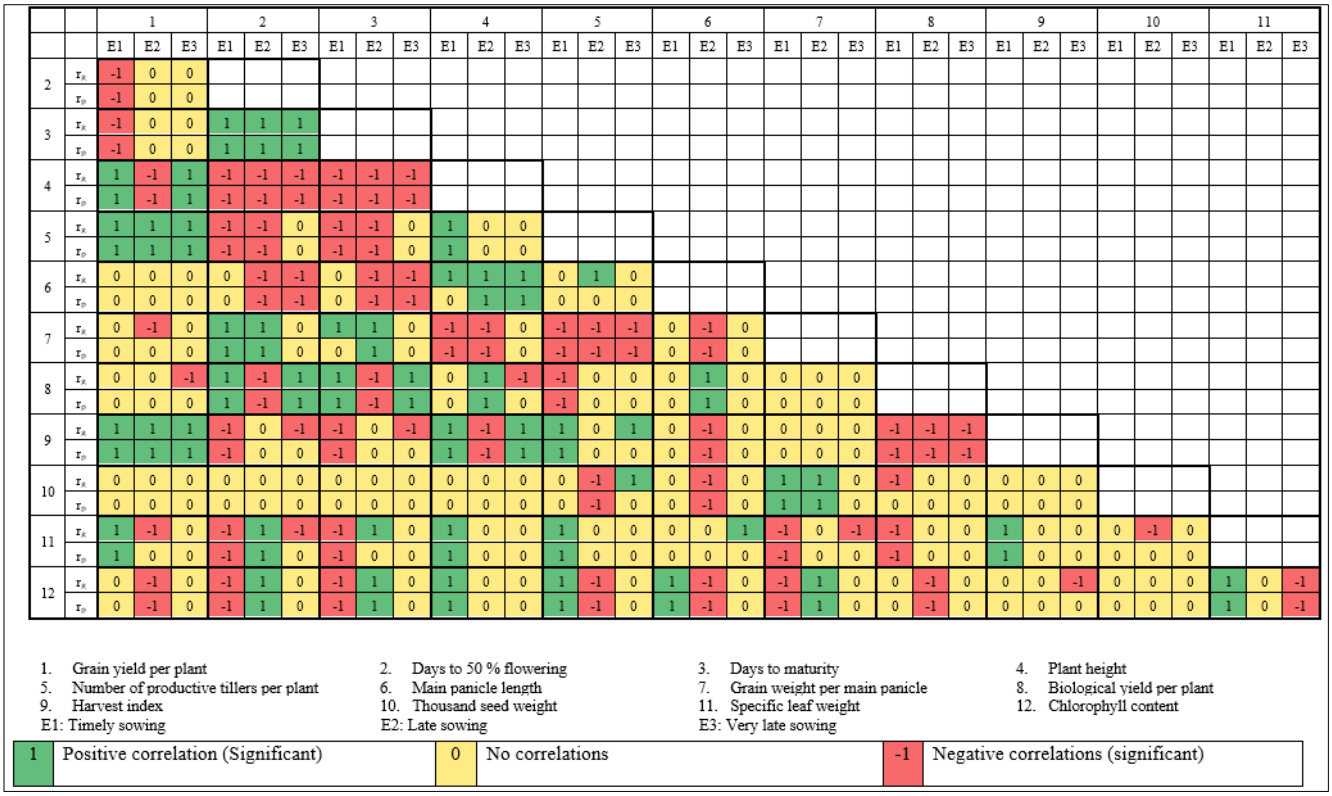

Fig 2: Colored - iconic illustration of genotypic (r_g) and phenotypic (r_p) correlations of twelve different characters for three dates of sowing in little millet

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