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Assessment of Inter-Characters Associations in the Germplasm of Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] Over Five Years in Hot Arid Climate of Rajasthan, India

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A B S T R A C T

Forty accessions of pearl millet were evaluated for five consecutive years (environments) to assess the magnitude of presence of genetic variability, heritability in broad sense, genetic advance, inter characters correlation and path coefficients for yield and yield contributing characters. All the accessions showed considerable amount of variation in their mean performance with respect to studied characters. The phenotypic co-efficient of variation (PCV) was greater than genotypic co-efficient of variation (GCV) for all the studied characters this shows the influence of environmental factors on the expression of characters. High GCV and PCV estimates were observed for plant height, total number of tillers per plant, number of productive tillers per plant, number of leaves per plant, spike girth, ear exertion distance, test weight, and yield per plant in all the environments. High heritability coupled with high genetic advance was observed for plant height, total number of tiller per plant, number of productive tillers per plant, number of leaves per plant, spike length, spike girth, ear exertion distance, test weight, yield per plant, stover yield per plant and harvest index in all the environments. Seed yield per plant was positively and significantly correlated with number of productive tillers per plant, number of leaves per plant, spike length, spike girth, test weight, stover yield and harvest index in all the environments and in pooled environment. Genotypic path coefficient analysis revealed highest positive direct effect registered by spike girth, spike length, number of productive tillers per plant, plant height and test weight in all the environments. Hence, these characters have to be given importance during the selection programme to improve the seed yield potential of the crop.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is an outstanding dual purpose cereal crop with enormous variability for agronomically important characters adapted to diverse agro-climatic conditions. Due to its potential to with stand drought and adverse agro climatic conditions, it is mainly grown under marginal lands with low rainfall during *Kharif* season (Vidyadhar *et al.*, 2007) and (Bhoite *et al.*, 2008). Estimation of genetic parameters is an essential component of future targeted trait based crop improvement. The measurement and evaluation of variability are essential in drawing essential steps and meaningful conclusion from a given set of phenotypic observations (Mehdi and Khan., 1994; Marwede *et al.*, 2004). Hence, to have a thorough comprehensive idea it is necessary to have an analytical assessment of yield components. Since heritability is also influenced by environment thus, information on heritability alone may not help in pin pointing characters enforcing selection. Nevertheless the heritability estimates in conjunction with the predicted genetic advance will be more reliable (Johnson *et al.*, 1955). Heritability gives the information on the magnitude of inheritance of quantitative characters while genetic advance will be helpful in formulating suitable breeding procedures.

Grain yield in pearl millet is a complex character controlled by many factors and is the final product of actions and interactions of various yield contributing characters hence, understanding association between yield and its components is of paramount importance. In order to develop promising accessions with high yield it is essential to know the associations among different traits especially with seed yield. The correlation and path analysis are usually taken up to measure the relative magnitude and direction of each independent variable on a dependent variable like seed yield. Therefore, the present research work was attempted to understand presence of nature and magnitude of genetic variability, heritability and genetic advance under selection of different yield and yield contributing characters and also pattern of character associations of yield and yield contributing traits in germplasm of pearl millet.

Materials and Methods

Forty pearl millet [*Pennisetum glaucum* (L.) R. Br.] accessions, collected from diverse geographical regions of country and conserved at Regional Seed Gene Bank at ICAR-NBPGR, Regional Station, Jodhpur, along with checks were evaluated at the research farm of NBPGR Regional Station, Jodhpur, which is situated at about 28^0 35' N, longitude of $70^0$18' E and an altitude of 226 m above mean sea level. These accessions *viz.*, IC 285152, IC 285200, IC 323995, IC 324035, IC 325176, IC 325739, IC 325804, IC 329029, IC 329070, IC 329909,IC 333121,IC 333179,IC 333240,IC 369836,IC 370487, IC 370507, IC 373424, IC 373504IC 373558, IC 420330, IC 420367, IC 426704, IC 426811, IC 426892, IC 426907, IC 449439, IC 449474, IC 537957, IC 537996, IC 538001, IC 541018, IC 541900, NIC 17769, NIC 17795, NIC 17819, JBV-2, CZP-9802, Pusa-383, Raj-171) represented diverse geographic regions of India. The trials were conducted in a Randomized Complete Block Design (RBD) with three replications for five consecutive years (environments) *viz.*, *Kharif* 2012 (E1), *Kharif* 2013 (E2), *Kahrif* 2014 (E3), *Kharif* 2015 (E4) and *Kharif* 2016 (E5). The line to line and plant to plant distances were kept 45 and 15 cm, respectively. The recommended agronomic packages of practices were followed to raise good crop during the experimental period. Fourteen morphological traits (days to fifty percent flowering, days to maturity, days for reproductive period, plant height (cm), total number of tillers per plant, number of productive tillers per plant, number of leaves per plant, ear exertion distance (cm), spike length (cm), spike girth (cm), test weight (g), stover yield per plant(g), seed yield per plant (g) and harvest index (%) were recorded on five randomly taken plants of each plot as per the standard descriptors, developed for pearl millet. The mean of all the traits of plants in each replication was subjected to analysis of variance as per the method suggested by Panse and Sukhathme (1967). The estimate of genotypic variance and phenotypic variance were worked out according to the method suggested by Johnson *et al.,* (1955) using mean square values from the ANOVA table. Phenotypic and genotypic coefficients of variance were calculated based on the method given by Burton (1952). Heritability in broad sense was estimated as per the method described by Lush (1940) and traits were classified as having high, moderate and low heritability as per the method of Robinson *et al.*, (1949). Genetic advance was estimated according to the method suggested by Johnson *et al.*, (1955) and expressed as percentage of mean. Traits were classified as having high, moderate or low genetic advance as per the method suggested by Johnson *et al.*, (1955), while correlation coefficients and path coefficient analysis were calculated using the formulae suggested by Falconer (1964) and Dewey and Lu (1959) respectively.

Results and Discussion

Mean performance of the accessions in different locations

The analysis of variance revealed the significant difference among the accessions for some of the major traits. Among the five environments (Table 1), E3 (51.58 days) had taken minimum days to 50 % flowering followed by E1 (51.69 days), Pooled (52.24 days), E4 (52.44 days), E5 (52.59 days) and E2 (52.91 days). E1 (82.35 days) had taken minimum days to maturity followed by E3 (82.63 days), E5 (82.86 days), pooled (83.08 days), E2 (83.43 days) and E4 (84.15 days) while reproductive period was minimum in E4 (30.12 days) followed by E5 (30.75 days), pooled (30.78 days), E2 (30.88), E3 (30.90 days) and E1 (31.23 days). E4 (192.33 cm) was more favourable for higher plant height followed by E2 (187.70 cm), pooled (183.03 cm), E5 (181.01 cm), E3 (178.47 cm) and E1 (175.67 cm). Considering the performance over four environments, E3 (2.84) was more favourable for better expression of the total number of tillers per plant followed by E4, (2.81), E1 (2.79), pooled (2.79), E2 (2.77) and E5 (2.71) whereas number of productive tillers was maximum in E5 (2.45) followed by E3 (2.45), E2 (2.40), pooled (2.40), E1 (2.36) and E4 (2.35). Number of leaves per plant was highest in E5 (8.50) followed by E3 (8.46), pooled (8.43), E2 (8.42), E1 (8.41) and E4 (8.38), Spike length in E3 (27.54 cm) followed by E5 (27.23 cm), pooled (26.83 cm), E1 (26.75 cm), E4 (26.57 cm) and E2 (26.06 cm), Spike girth in E4 (1.85 cm) followed by E2 (1.85 cm), pooled (1.84 cm), E5 (1.84 cm), E3 (1.82 cm) and E1 (1.82 cm), Ear exertion distance in E2 (6.18 cm) followed by E5 (6.15 cm), E1 (6.13 cm), pooled (6.09 cm), E3 (6.02 cm) and E4 (5.98 cm), test weight in E1 (8.16 g) followed by E5 (8.09 g), E4 (8.09 g), pooled (8.08), E3 (8.07 g) and E2 (8.01 g). Yield per plant was maximum in E4 (114.34 g)followed by E3 (113.72 g), E2 (110.77 g), pooled (109.98 g), E5 (109.32 g) and E1 (101.77 g), stover yield per plant in E1 (490.09 g) followed by E4 (473.27 g), pooled (18.39 g), E2 (468.70 g), E5 (463.68 g) and E3 (452.23 g), harvest index in E3 (19.30 %) followed by E4 (19.14 %), E5 (18.51 %), E2 (18.45 %), pooled (18.39 %) and E1 (16.55 %).

Variability

The estimates of genotypic and phenotypic coefficient of variation are necessary to understand the role of environmental influence on different traits. The differences between the GCV and PCV indicate the level of environmental variations that contributes a major part in the expression of traits (Majumdar *et al.*, 1974). Accessions exhibited considerable amount of variability for all the fourteen studied traits over five years. The estimates of genotypic coefficients of variation were lesser than the estimates of phenotypic coefficients of variation for all the traits in all the environments indicating the environmental influence over the studied traits. High GCV and PCV estimates were observed for plant height, total number of tillers per plant, number of productive tillers per plant, number of leaves per plant, spike girth, ear exertion distance, test weight, and yield per plant in all the environments (Table 1 and Fig. 1). This indicated that there is greater diversity for these characters in pearl millet. Hence direct selection based on these traits would be effective. The high PCV and GCV were earlier reported in pearl millet by Kumar *et al.,* (2014) for productive tillers per plant, grain yield per plant and panicle length traits, similarly Bhuri singh *et al.,* (2014) reported high PCV and GCV for grain yield per plant and 1000 seed weight. These results are in conformity with the report of Vetriventhan and Nirmalakumari (2007), Dapke *et al.,* (2014), Singh *et al.,* (2014) and Harinarayan *et al.,* (2015) in pearl millet. High GCV and PCV for total number of leaves were also reported by Suthamathi and Stephen Dorairaj (1995), Vidyadhar *et al.,* (2007) and Bhoite *et al.,* (2008).

PCV and GCV values were estimated medium for days to fifty per cent flowering, spike length and harvest index in E1, for reproductive period in E4 and for stover yield per plant in E2. Low PCV and GCV were reported for days to maturity in E2, for days to fifty per cent flowering and stover yield per plant in E4. While high PCV and medium GCV was observed in E2, E3, and E5 for reproductive period and in E5 for stover yield per plant. Medium PCV and low GCV was observed in E1, E3 and E5 for days to fifty per cent flowering and for stover yield per plant in E1 and E3. The low GCV estimates were observed for days to maturity is in confirmation with the earlier findings of Deb Choudhary and Das (1998), Saraswathi *et al.,* (1995), Kumari and Nagarajan (2008), Lakshmana *et al.,*(2009), Lakshmana *et al.,* (2010) and Chaudhary *et al.,* (2012) in pearl millet.

Heritability and genetic advance

High heritability coupled with high genetic advance was observed for plant height, total number of tiller per plant, number of productive tillers per plant, number of leaves per plant, spike length, spike girth, ear exertion distance, test weight, yield per plant, stover yield per plant and harvest index in all the environments (Table 1). For reproductive period medium heritability and medium genetic advance was observed in E4, for plant height medium heritability and high genetic advance was observed in E5 and for the trait harvest index high heritability coupled with medium genetic advance was recorded in E3, E4 and E5, while for the trait stover yield per plant high heritability coupled with medium genetic advance was recorded in E2, E3, E4 and medium heritability and medium genetic advance was observed in E1 for these traits. High heritability coupled with high genetic advance values were reported in pearl millet by Lakshmana *et al.,* (2009) for plant height, productive tillers per plant, ear head length and grain yield per plant. Singh *et al.,* (2013) reported high heritability along with high genetic advance for number of tillers per plant and fodder yield per plant in sorghum. Salih *et al.,* (2014) reported high heritability along with high genetic advance for 1000 seed weight. Govindaraj *et al.,* (2011) reported high heritability along with high genetic advance for grain yield per plant and panicle length. Sharma *et al.,* (2003) reported heritability along with high genetic advance for number of leaves per plant.

Characters having high heritability and high genetic advance generally indicates that heritability is more due to the additive gene effects. Yadav *et al.,* (2001) and Singh *et al.,* (2009) reported that high estimate of heritability along with high magnitude of genetic advance is useful for genetic improvement of any trait through selection.

Table.1 Variability parameters of different traits in different environments (E1, E2, E3, E4, E5, and pooled environments)

Traits	Environment	Mean	Min.	Max.	PCV (%)	GCV (%)	h^2 (%)	Genetic advance % of mean
Days to 50% flowering (DF)	E1	51.69	44.33	58.00	11.51	9.65	70.30	16.67
	E2	52.91	44.67	58.00	10.24	9.45	85.07	17.95
	E3	51.58	45.00	57.33	11.45	9.87	74.32	17.53
	E4	52.44	44.00	58.67	9.90	7.74	61.13	12.47
	E5	52.59	42.00	58.67	10.38	9.82	89.50	19.14
	Pooled	52.24	44.33	57.73	10.51	8.96	72.64	15.73
Days to Maturity (DM)	E1	82.35	75.33	89.00	7.58	6.28	68.56	10.71
	E2	83.43	75.33	89.67	7.71	7.21	87.43	13.89
	E3	82.63	73.00	92.00	7.75	6.57	71.85	11.47
	E4	84.15	75.33	92.00	7.45	7.13	91.63	14.05
	E5	82.86	73.67	92.00	7.79	6.62	72.19	11.58
	Pooled	83.08	75.27	90.60	7.83	7.66	95.91	15.46
Reproductive period (Days)	E1	31.23	28.33	34.33	17.48	14.32	67.10	24.16
	E2	30.88	28.00	34.00	21.52	18.50	73.90	32.76
	E3	30.90	26.33	35.00	21.15	18.99	80.64	35.13
	E4	30.12	26.00	37.33	17.26	12.86	55.48	19.73
	E5	30.75	27.67	35.67	21.28	19.14	80.91	35.47
	Pooled	30.78	28.00	33.87	21.33	19.21	81.16	35.65
Plant height (Cm)	E1	175.67	67.32	259.55	73.99	58.09	61.64	93.95
	E2	187.70	72.68	259.96	60.62	50.58	69.62	86.94
	E3	178.47	84.27	249.92	69.94	56.84	66.05	95.16
	E4	192.33	73.67	264.32	63.02	49.92	62.75	81.46
	E5	181.01	84.86	266.40	70.26	52.16	55.11	79.76
	Pooled	183.03	76.56	257.68	70.75	54.65	59.67	86.97
Total number of tillers per plant (TP)	E1	2.79	1.87	5.20	33.59	30.00	79.77	55.19
	E2	2.77	1.47	5.40	41.25	35.25	73.02	62.05
	E3	2.84	1.80	4.27	32.25	28.37	77.39	51.41
	E4	2.81	1.47	4.73	36.47	34.79	91.00	68.37
	E5	2.71	1.27	4.33	32.57	28.69	77.59	52.05
	Pooled	2.79	1.75	4.73	33.06	29.18	77.91	53.06
No. of Productive tillers per plant (PT)	E1	2.36	1.40	3.80	32.50	28.74	78.20	52.35
	E2	2.40	1.20	3.93	29.93	26.79	80.12	49.40
	E3	2.45	1.53	3.67	26.67	25.20	89.28	49.05
	E4	2.35	1.20	3.93	26.56	21.89	67.93	37.16
	E5	2.45	1.27	3.80	26.99	25.52	89.40	49.70
	Pooled	2.40	1.41	3.81	27.48	26.01	89.59	50.72
No. of leaves per plant (LP)	E1	8.41	5.67	12.20	22.61	21.46	90.09	41.96
	E2	8.42	5.93	12.07	25.25	23.77	88.62	46.10
	E3	8.46	5.60	12.53	21.89	20.61	88.65	39.97
	E4	8.38	5.73	12.23	23.82	21.32	80.11	39.31

	E5	8.50	5.60	11.33	26.21	24.66	88.52	47.80
	Pooled	8.43	5.72	12.01	26.71	25.16	88.73	48.82
Spike length (SL) (cm)	**E1**	26.75	19.54	40.37	11.77	11.09	88.78	21.53
	E2	26.06	18.42	37.09	13.46	13.02	93.57	25.94
	E3	27.54	20.07	37.36	14.36	13.24	85.01	25.15
	E4	26.57	18.17	41.43	12.89	11.63	81.41	21.62
	E5	27.23	19.04	41.20	14.68	13.56	85.32	25.79
	Pooled	26.83	20.06	39.49	15.17	14.05	85.78	26.81
Spike girth (SG) (cm)	**E1**	1.82	1.21	2.53	31.79	30.51	92.11	60.32
	E2	1.85	1.28	2.77	31.70	29.55	86.90	56.74
	E3	1.82	1.19	2.61	30.09	29.75	97.75	60.59
	E4	1.85	1.19	2.75	31.05	30.93	99.23	63.47
	E5	1.84	1.19	2.54	30.41	30.07	97.78	61.24
	Pooled	1.84	1.21	2.60	30.90	30.56	97.81	62.27
Ear exertion distance (EED) (cm)	**E1**	6.13	1.47	11.33	23.27	22.96	97.35	46.67
	E2	6.18	1.71	11.00	25.51	25.18	97.43	51.20
	E3	6.02	1.49	11.54	24.02	23.71	97.44	48.21
	E4	5.98	1.57	10.70	24.09	23.96	98.92	49.09
	E5	6.15	1.57	11.59	24.34	24.03	97.47	48.86
	Pooled	6.09	1.56	11.04	24.83	24.52	97.52	49.89
Test weight (TW) (g)	**E1**	8.16	5.93	10.09	21.04	20.06	90.90	39.40
	E2	8.01	5.80	10.15	32.54	29.52	82.30	55.17
	E3	8.07	5.83	10.02	34.93	32.55	86.84	62.48
	E4	8.09	4.86	10.04	32.29	29.43	83.07	55.26
	E5	8.09	5.87	9.96	35.25	32.87	86.95	63.13
	Pooled	8.08	5.84	9.90	35.74	33.36	87.13	64.15
Yield per plant (YP) (cm)	**E1**	101.77	25.82	220.79	26.17	25.37	93.98	50.66
	E2	110.77	25.97	255.47	26.31	24.81	88.92	48.19
	E3	113.72	32.89	275.29	25.15	24.37	93.89	48.65
	E4	114.34	32.57	265.56	25.17	24.95	98.26	50.95
	E5	109.32	31.36	272.40	25.47	24.69	93.97	49.29
	Pooled	109.98	31.24	256.27	25.96	25.18	94.08	50.32
Stover yield per plant (SY) (g)	**E1**	490.09	291.95	772.06	11.08	9.91	80.00	18.26
	E2	468.70	232.65	741.33	13.46	10.04	55.64	15.43
	E3	452.23	248.25	694.31	10.74	9.58	79.57	17.60
	E4	473.27	242.00	768.24	9.17	8.95	95.26	17.99
	E5	463.68	237.48	769.33	10.06	9.40	87.30	18.08
	Pooled	469.59	281.54	708.38	10.55	10.39	96.99	21.09
Harvest index (HI) (%)	**E1**	16.55	7.22	34.89	11.08	10.72	93.61	21.37
	E2	18.45	6.08	38.93	11.81	11.36	92.52	22.51
	E3	19.30	8.24	37.50	12.74	10.35	66.00	17.32
	E4	19.14	9.55	46.71	11.81	9.48	64.43	15.68
	E5	18.51	7.15	37.34	12.06	10.67	78.27	19.44
	Pooled	18.39	8.86	39.07	11.55	11.16	93.36	22.22

Table.2 Genotypic (above diagonal) and phenotypic (below diagonal) correlation of different traits in E1 (*kharif* 2012) and E2 (*kharif* 2013)

E1 (*kharif* 2012)													
Traits	**DF**	**DM**	**RP**	**PH**	**PT**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**YP**
DF	**1.00**	0.84**	0.75**	-0.25*	-0.48**	-0.24*	-0.11	-0.17	-0.13	-0.31*	-0.67**	-0.64**	-0.63**
DM	0.78**	**1.00**	0.58**	-0.16	-0.24*	0.15	-0.21	-0.14	-0.18	-0.06	-0.44**	-0.34*	-0.25*
RP	0.72**	0.46**	**1.00**	0.20	-0.14	0.41**	-0.19	-0.24*	-0.32*	-0.28*	-0.31*	-	-0.30*
PH	-0.20*	-0.15	0.16	**1.00**	-0.18	0.30*	0.31*	0.18	0.21	-0.30*	0.34*	0.09	-0.28*
TP	-	-0.21	-0.10	-0.17	**1.00**	0.42**	-0.34*	-0.08	-0.03	0.64**	0.42**	0.83**	0.75**
LP	-0.19	0.13	0.35*	0.26*	0.36**	**1.00**	-0.20	-0.06	-0.08	0.29*	0.51**	0.58**	0.38**
EED	-0.10	-0.18	-0.13	0.28*	-0.33*	-0.18	**1.00**	-0.20	-0.18	0.14	0.32 *	-	0.49**
SL	-0.15	-0.11	-0.20	0.15	-0.06	-0.05	-0.16	**1.00**	-0.25*	0.30*	0.25*	0.37**	0.44**
SG	-0.12	-0.16	-0.31*	0.20	-0.03	- 0.05	-0.15	-0.21	**1.00**	0.28*	0.19	0.20	0.34*
TW	-0.28*	-0.05	-0.22*	-0.25*	0.58**	0.25*	0.11	0.24*	-0.26*	**1.00**	-0.30*	0.86**	0.83**
SY	-	-	-0.25*	0.38**	0.40**	0.47**	0.26*	0.23*	0.17	0.26*	**1.00**	0.58**	0.46**
HI	-	-0.27*	-0.32*	0.06	0.82**	0.53**	-0.34*	0.32*	0.18	0.78**	0.45**	**1.00**	0.72*
YP	-	-0.19	-0.26*	-0.24*	0.65**	0.27*	0.42**	0.41**	0.32*	0.80**	0.42**	0.68**	**1.00**
E2 (*kharif* 2013)													
Traits	**DF**	**DM**	**RP**	**PH**	**PT**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**YP**
DF	**1.00**	0.72**	0.88**	-	-0.69**	-0.30*	-0.13	-0.12	-0.14	-0.34*	-0.55**	-0.61**	-0.52**
DM	0.68**	**1.00**	0.45**	-0.28*	-0.43**	0.18	-0.20	-0.17	-0.20	-0.09	-0.59**	-0.55**	-0.38**
RP	0.83**	0.42**	**1.00**	0.21	-0.10	0.51**	-0.13	-	-0.52**	-0.19	-0.25*	-0.43**	-0.34*
PH	-0.35*	-0.26*	0.18	**1.00**	-0.16	0.27*	0.35*	0.20	0.14	-0.36**	0.33*	0.11	-0.24*
TP	-	-	-0.08	0.14	**1.00**	0.61**	-0.35*	-0.10	-0.06	0.54**	0.73**	0.80**	0.81**
LP	-0.27*	0.15	0.46**	0.26*	0.58**	**1.00**	-0.21	-0.13	-0.10	0.32*	0.57**	0.62**	0.43**
EED	-0.11	-0.16	-0.11	0.32*	-0.32*	-0.18	**1.00**	-0.19	-0.20	0.15	0.32 *	-0.45**	0.58**
SL	-0.11	-0.15	-	0.17	-0.09	-0.12	-0.16	**1.00**	-0.28*	0.34*	0.22*	0.38**	0.43**
SG	-0.10	-0.18	-	0.12	-0.05	-0.10	-0.18	-0.26*	**1.00**	0.32*	0.21	0.18	0.27*
TW	-0.28*	-0.06	-0.16	-0.34*	0.50**	0.28*	0.13	0.31*	0.26*	**1.00**	-0.34*	0.63**	0.58**
SY	-	-	-0.23*	0.30*	0.68**	0.55**	0.31*	0.20	0.17	-0.31*	**1.00**	0.81**	0.83**
HI	-	-	-	0.10	0.77**	0.60**	-	0.35*	0.15	0.58**	0.75**	**1.00**	0.79*
YP	-	-	-0.33*	0.22*	0.80**	0.41**	0.55**	0.42**	0.22*	0.53**	0.80**	0.75**	**1.00**
*** Significant at 5 percent, ** Significant at 1 percent**													

Table.3 Genotypic (above diagonal) and phenotypic (below diagonal) correlation of different traits in E3 (*kharif* 2014) and E4 (*kharif* 2015)

E3 (*kharif* 2014)

Traits	DF	DM	RP	PH	TP	LP	EED	SL	SG	TW	SY	HI	YP
DF	**1.00**	0.63**	0.78**	-0.30*	-0.50**	-0.28*	-0.20	-0.12	-0.14	-0.36**	-0.73**	-0.80**	-0.78**
DM	0.61**	**1.00**	0.53**	-0.21	-0.23*	0.09	-0.18	-0.13	-0.11	-0.12	-0.58**	-0.49**	-0.37**
RP	0.74**	0.51**	**1.00**	0.14	-0.20	0.40**	-0.19	-0.23*	-0.35*	-0.32*	-0.25*	-0.47**	-0.25*
PH	-0.25*	-0.18	0.13	**1.00**	-0.21	0.25*	0.35*	0.14	0.18	-0.24*	0.31*	0.10	-0.33*
TP	-0.46**	-0.22*	-0.18	0.20	**1.00**	0.45**	-0.37**	-0.13	-0.09	0.68**	0.49**	0.75**	0.71**
LP	-0.25*	0.08	0.36**	-0.24*	0.41**	**1.00**	0.14	-0.10	-0.08	0.30*	0.52**	0.61**	0.44**
EED	-0.18	-0.15	-0.16	0.33*	-0.35*	0.13	**1.00**	-0.21	-0.16	0.15	-0.35*	-0.43 **	0.52**
SL	-0.11	-0.13	-0.22*	0.12	-0.12	-0.08	-0.20	**1.00**	-0.25*	0.30*	0.25*	0.37**	0.43**
SG	-0.13	-0.09	-0.30*	0.15	-0.08	-0.06	-0.13	-0.22*	**1.00**	0.30*	0.15	0.13	0.32*
TW	-0.32*	-0.11	-0.28*	-0.22*	0.61**	0.27*	0.14	0.27*	0.28*	**1.00**	-0.34*	0.75**	0.72**
SY	-0.69**	-0.57**	-0.24*	0.30*	0.43**	0.50**	-0.32*	0.24*	0.11	-0.33*	**1.00**	0.68**	0.70**
HI	-0.75**	-0.43**	-0.45**	0.09	0.74**	0.57**	-0.38**	0.35*	0.12	0.72**	0.65**	**1.00**	0.76*
YP	-0.73**	-0.34*	-0.24*	-0.31*	0.68**	0.39**	0.50**	0.39**	0.28*	0.68**	0.67**	0.74**	**1.00**

E4 (*kharif* 2015)

Traits	DF	DM	RP	PH	TP	LP	EED	SL	SG	TW	SY	HI	YP
DF	**1.00**	0.53**	0.62**	-0.34*	-0.53**	-0.23*	-0.16	-0.11	-0.15	-0.38**	-0.65**	-0.73**	-0.75**
DM	0.51**	**1.00**	0.51**	-0.23*	-0.20	0.14	-0.13	-0.15	-0.10	-0.15	-0.54**	-0.52**	-0.41*
RP	0.58**	0.48**	**1.00**	0.15	-0.21	0.36**	-0.24*	-0.26*	-0.33*	-0.35*	-0.28*	-0.57**	-0.26*
PH	-0.32*	-0.20	0.14	**1.00**	-0.16	0.27*	0.30*	0.16	0.20	-0.22*	0.36**	0.18	-0.45**
TP	-0.48**	-0.18	0.20	-0.14	**1.00**	0.58**	-0.35*	-0.06	-0.08	0.73**	0.58**	0.83**	0.82**
LP	-0.21	0.13	0.34*	0.24*	0.55**	**1.00**	0.18	-0.04	-0.02	0.38**	0.61**	0.65**	0.53**
EED	-0.14	-0.11	0.22*	0.28*	-0.32*	0.16	**1.00**	-0.20	-0.15	0.13	0.32*	-0.47**	0.52**
SL	-0.10	-0.14	0.23*	0.13	-0.06	-0.03	-0.17	**1.00**	-0.24*	0.35*	0.36**	0.49**	0.55**
SG	-0.13	-0.08	0.30*	0.17	-0.05	-0.02	-0.13	-0.21	**1.00**	0.38**	0.21	0.12	0.34*
TW	-0.27*	-0.14	0.31*	-0.21*	0.71**	0.35*	0.11	0.33*	0.36**	**1.00**	-0.36**	0.65**	0.70**
SY	-0.63**	-0.51**	0.25*	0.33*	0.54**	0.57**	0.28*	0.32*	0.20	-0.31*	**1.00**	0.63**	0.65**
HI	-0.72**	-0.47**	0.53**	0.16	0.80**	0.60**	-0.45**	0.40**	0.11	0.58**	0.57**	**1.00**	0.80**
YP	-0.73**	-0.36**	0.23**	-	0.78**	0.48**	0.50**	0.52**	0.33*	0.67**	0.60**	0.78**	**1.00**

*** Significant at 5 percent, ** Significant at 1 percent**

Table.4 Genotypic (above diagonal) and phenotypic (below diagonal) correlation of different traits in E5 (*kharif* 2016) and pooled environments

E5 (*kharif* 2016)													
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**YP**
DF	**1.00**	0.53**	0.48**	-0.26*	-	-0.34*	-0.13	-0.12	-0.16	-0.54*	-0.54**	-0.62**	-0.65**
DM	0.51**	**1.00**	0.57**	-0.20	-0.26*	0.20	-0.15	-0.18	-0.13	-0.14	-0.51**	-0.57*	-0.41*
RP	0.45**	0.53**	**1.00**	-0.18	-0.20	0.41**	-0.20	-0.34*	-0.28*	-0.38**	-0.30*	-0.55**	-0.28
PH	-0.22*	-0.17	-0.16	**1.00**	-0.15	0.25*	0.31*	0.19	0.11	-0.29*	0.42**	0.20	-0.45**
TP	-0.56**	-0.23*	-0.19	-0.11	**1.00**	0.51**	-0.32*	-0.10	-0.10	0.65**	-0.61**	0.78**	0.80**
LP	-0.27*	0.18	0.35*	0.23*	0.43**	**1.00**	-0.28*	-0.09	-0.09	0.51**	0.73**	0.57**	0.68**
EED	-0.11	-0.13	-0.15	0.26*	-0.28*	-0.23*	**1.00**	-0.21	-0.20	0.21	0.36**	-0.52**	0.49**
SL	-0.10	-0.15	-0.29*	0.16	-0.09	-0.06	-0.20	**1.00**	-0.34*	0.30*	0.45**	0.58**	0.62**
SG	-0.13	-0.12	-0.23*	0.10	-0.08	-0.05	-0.17	-0.32*	**1.00**	0.40**	0.18	0.14	0.32*
TW	-0.48**	-0.11	-0.34*	-0.23*	0.50**	0.43**	0.18	0.21	0.31*	**1.00**	-	0.55**	0.62**
SY	-	-	-0.27*	0.40**	-	0.65**	0.31*	0.35*	0.15	-0.33*	**1.00**	0.58**	0.57**
HI	-0.57**	-	-	0.17	0.63**	0.51**	-	0.43**	0.11	0.46**	0.42**	**1.00**	0.68**
YP	-0.61**	-	-0.22*	-	0.72**	0.62**	0.38**	0.55**	0.30*	0.54**	0.53**	0.58**	**1.00**
Pooled													
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**YP**
DF	**1.00**	0.64**	0.57**	-0.32*	-	-0.32*	-0.21	-0.18	-0.13	-0.34*	-0.54**	-0.59**	-0.62**
DM	0.57**	**1.00**	0.54**	-0.18	-0.29*	0.20	-0.17	-0.16	-0.20	-0.13	-0.48**	-0.42**	-0.28*
RP	0.49**	0.45**	**1.00**	-0.21	-0.25*	0.53**	-0.20	-0.31*	-0.35*	-0.25*	-0.30*	-0.53**	-0.35*
PH	-0.30*	-0.15	-0.17	**1.00**	-0.14	0.34*	0.32*	0.15	0.20	-0.34*	0.38**	0.18	-0.36**
TP	-0.48**	-0.23*	-0.23*	-0.11	**1.00**	0.61**	-0.34*	-0.18	-0.13	0.57**	-0.45**	0.75**	0.72**
LP	-0.25*	0.18	0.48**	0.32*	0.57**	**1.00**	-0.14	-0.10	-0.11	0.40**	0.67**	0.64**	0.56**
EED	-0.18	-0.15	-0.16	0.29*	-0.31*	-0.11	**1.00**	-0.20	-0.21	0.18	0.34*	-0.58**	0.67**
SL	-0.16	-0.13	-0.23*	0.13	-0.16	-0.08	-0.18	**1.00**	-0.31*	0.35*	0.22*	0.54**	0.51**
SG	-0.11	-0.18	-0.28*	0.19	-0.12	-0.09	-0.20	-0.27*	**1.00**	0.24*	0.15	0.18	0.32*
TW	-0.29*	-0.11	-0.21	-0.28*	0.53**	0.32*	0.15	0.31*	0.22*	**1.00**	-0.33*	0.75**	0.78**
SY	-0.47**	-	-0.29*	0.34*	-	0.63**	0.32*	0.19	0.13	-0.28*	**1.00**	0.63**	0.70**
HI	-0.53**	-	-	0.15	0.68**	0.61**	-	0.51**	0.14	0.71**	0.61**	**1.00**	0.68*
YP	-0.59**	-0.25*	-0.32*	-0.33*	0.70**	0.54**	0.63**	0.49**	0.30*	0.68**	0.65**	0.62**	**1.00**

*** Significant at 5 percent, ** Significant at 1 percent**

Table.5 The direct (diagonal values in bold) and indirect effects of component traits on yield per plant in E1 and E2

E1 (*kharif* 2012)												
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**Corr. with YP**
DF	**-0.163**	-0.018	-0.015	-0.013	-	0.026	-0.022	0.027	0.021	-	0.024	-0.023	-0.63**
DM	0.129	**-0.116**	-0.014	-0.022	-	0.011	-0.025	0.023	0.023	-	0.022	-0.026	-0.25*
RP	0.052	-0.095	**-0.135**	-0.001	-	0.023	-0.027	0.018	0.025	-	0.017	0.025	-0.30*
PH	-0.013	-0.014	-0.009	**0.685**	-	0.027	-0.071	0.032	0.027	-	0.035	0.077	-0.28*
TP	-0.017	-0.026	-0.021	0.021	**0.458**	0.032	-0.022	0.095	0.074	0.054	0.062	0.035	0.75**
LP	-0.092	-0.012	-0.013	-0.007	0.345	**0.061**	-0.061	0.037	0.065	0.028	0.050	0.016	0.38**
EED	-0.015	-0.015	-0.006	-0.008	-	0.041	**-0.092**	0.055	0.045	-	0.044	0.063	0.49**
SL	-0.036	-0.015	-0.021	-0.013	0.138	0.037	0.011	**0.531**	0.018	-	0.058	0.011	0.44**
SG	-0.045	-0.016	-0.009	-0.021	0.130	0.018	-0.060	0.031	**0.735**	0.036	0.042	0.028	0.34*
TW	-0.015	-0.008	-0.010	-0.006	0.115	-0.023	0.082	0.062	0.013	**0.104**	0.033	0.019	0.83**
SY	-0.017	-0.096	-0.011	-0.002	0.153	0.016	-0.063	0.035	0.015	0.073	**0.082**	0.027	0.46**
HI	-0.032	-0.011	-0.103	-0.023	0.074	0.039	-0.075	0.067	0.032	0.085	0.056	**0.091**	0.72*
E2 (*kharif* 2013)													
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**Corr. with YP**
DF	**-0.157**	-0.013	-0.011	-0.012	-	0.031	-0.025	0.028	0.023	-	0.026	-0.018	-0.52**
DM	0.137	**-0.132**	-0.098	-0.023	-	0.023	-0.022	0.023	0.020	-	0.029	-0.024	-0.38**
RP	0.049	-0.043	**-0.106**	-0.006	-	0.030	-0.031	0.031	0.022	-	0.028	0.021	-0.34*
PH	-0.011	-0.023	-0.006	**0.632**	-	0.025	-0.068	0.045	0.025	-	0.032	0.063	-0.24*
TP	-0.014	-0.025	-0.026	0.019	**0.763**	0.018	-0.055	0.095	0.075	0.073	0.075	0.052	0.81**
LP	-0.075	-0.018	-0.021	-0.005	0.238	**0.032**	-0.063	0.032	0.063	0.035	0.073	0.035	0.43**
EED	-0.019	-0.011	-0.010	-0.010	-	0.025	**-0.079**	0.059	0.048	-	0.044	0.063	0.58**
SL	-0.043	-0.011	-0.025	-0.009	0.152	0.031	0.054	**0.732**	0.014	-	0.064	0.036	0.43**
SG	-0.053	-0.022	-0.006	-0.015	0.184	0.020	-0.057	0.025	**0.709**	0.052	0.052	0.045	0.27*
TW	-0.024	-0.010	-0.015	-0.011	0.135	-0.022	0.064	0.071	0.023	**0.635**	0.038	0.023	0.58**
SY	-0.010	-0.065	-0.021	-0.009	0.173	0.031	-0.072	0.062	0.034	0.072	**0.132**	0.043	0.83**
HI	-0.043	-0.013	-0.232	-0.018	0.112	0.032	-0.075	0.059	0.038	0.095	0.058	**0.082**	0.79*
Residual effect E1 = 0.35, Residual effect E1 = 0.32, * Significant at 5 percent, ** Significant at 1 percent													

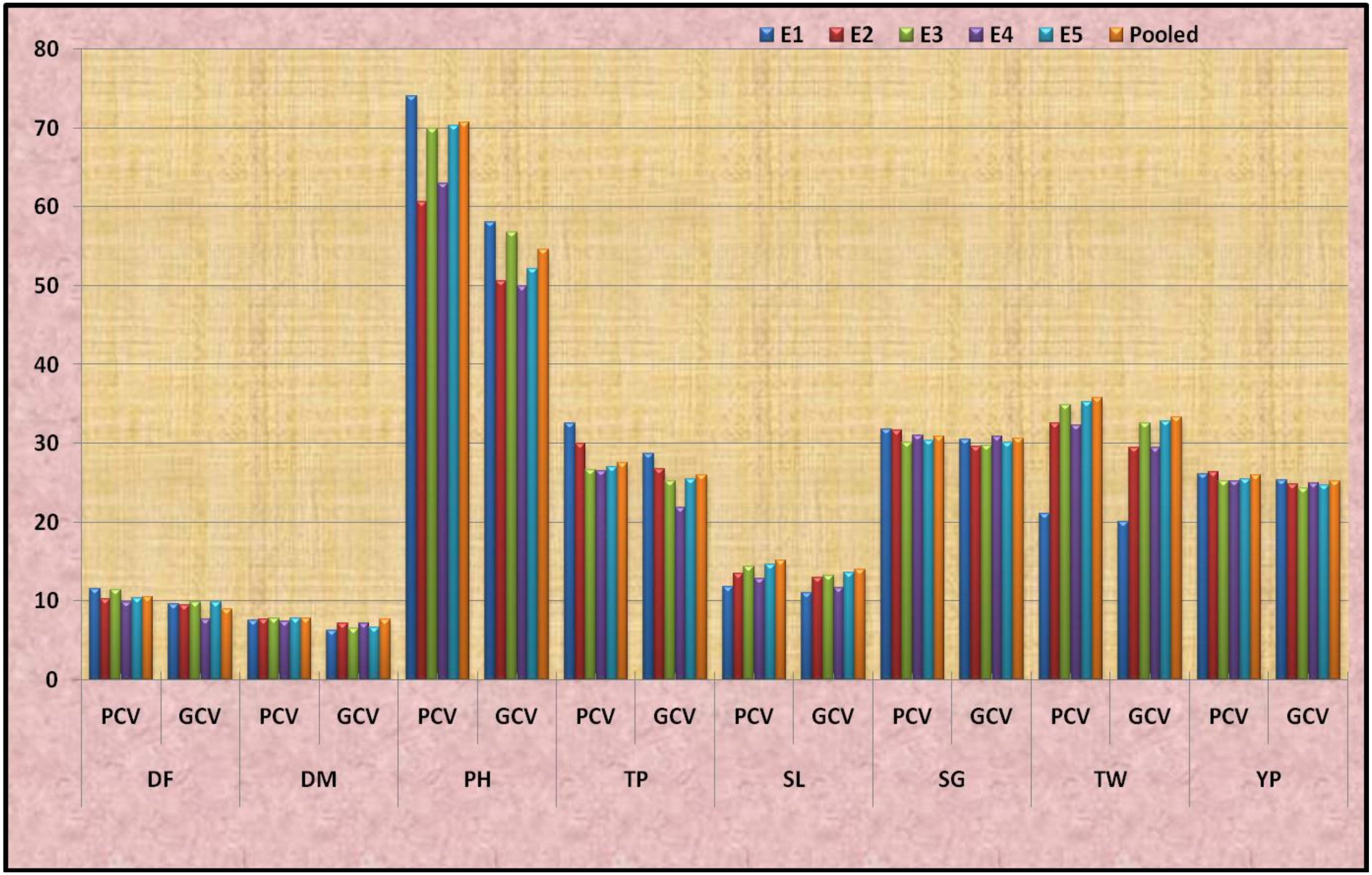
Table.6 The direct (diagonal values in bold) and indirect effects of component traits on yield per plant in E3 and E4

E3 (*kharif* 2013)													
Traits	DF	DM	RP	PH	TP	LP	EED	SL	SG	TW	SY	HI	Corr. with YP
DF	**-0.244**	-0.012	-0.022	-0.011	-	0.018	-0.023	0.033	0.025	-	0.023	-0.025	-0.78**
DM	0.154	**-0.213**	-0.022	-0.023	-	0.013	-0.021	0.026	0.029	-	0.032	-0.028	-0.37**
RP	0.112	-0.063	**-0.152**	-0.012	-	0.022	-0.032	0.021	0.023	-	0.021	0.026	-0.25*
PH	-0.016	-0.022	-0.032	**0.425**	-	0.025	-0.063	0.035	0.025	-	0.042	0.048	-0.33*
TP	-0.015	-0.032	-0.025	0.035	**0.538**	0.036	-0.035	0.083	0.072	0.050	0.032	0.037	0.71**
LP	-0.102	-0.018	-0.011	-0.012	0.286	**0.125**	-0.064	0.058	0.054	0.032	0.037	0.049	0.44**
EED	-0.011	-0.012	-0.013	-0.010	-	0.045	**-0.065**	0.083	0.061	-	0.043	0.036	0.52**
SL	-0.054	-0.011	-0.022	-0.019	0.210	0.032	0.034	**0.643**	0.016	-	0.038	0.045	0.43**
SG	-0.032	-0.022	-0.015	-0.032	0.152	0.021	-0.061	0.057	**0.685**	0.035	0.035	0.033	0.32*
TW	-0.026	-0.010	-0.010	-0.013	0.113	-0.018	0.055	0.065	-	**0.355**	0.036	0.029	0.72**
SY	-0.021	-0.062	-0.026	-0.011	0.162	0.015	-0.054	0.048	0.034	0.056	**0.046**	0.023	0.70**
HI	-0.042	-0.042	-0.182	-0.032	0.043	0.033	-0.045	0.083	0.031	0.064	-	**0.051**	0.76*
E4 (*kharif* 2016)													
Traits	DF	DM	RP	PH	TP	LP	EED	SL	SG	TW	SY	HI	Corr. with YP
DF	**-0.252**	-0.011	-0.021	-0.013	-	0.013	-0.021	-	0.030	-	0.023	-0.013	-0.75**
DM	0.154	**-0.193**	-0.025	-0.025	-	0.016	-0.025	-	0.031	-	0.027	-0.024	-0.41*
RP	0.032	-0.032	**-0.204**	-0.032	-	0.030	-0.023	-	0.023	-	0.023	0.022	-0.26*
PH	-0.013	-0.028	-0.045	**0.536**	-	0.025	-0.048	-	0.032	-	0.064	0.075	-0.45**
TP	-0.011	-0.032	-0.029	0.032	**0.613**	0.023	-0.043	-	0.098	0.069	0.062	0.081	0.82**
LP	-0.082	-0.021	-0.032	-0.023	0.211	**0.042**	-0.043	-	0.076	0.042	0.071	0.063	0.53**
EED	-0.032	-0.017	-0.045	-0.017	-	0.034	**-0.052**	-	0.073	-	0.058	0.057	0.52**
SL	-0.057	-0.009	-0.036	-0.015	0.134	0.054	0.038	**0.598**	0.055	-	0.069	0.048	0.55**
SG	-0.062	-0.028	-0.013	-0.023	0.215	0.032	-0.033	0.043	**0.674**	0.064	0.073	0.067	0.34*
TW	-0.044	-0.015	-0.019	-0.018	0.164	-0.013	0.050	0.087	0.048	**0.393**	0.059	0.032	0.70**
SY	-0.021	-0.084	-0.016	-0.012	0.214	0.034	-0.047	0.074	0.061	0.081	**-**	0.055	0.65**
HI	-0.058	-0.053	-0.120	-0.025	0.164	0.040	-0.032	0.079	0.058	0.074	0.065	**-0.087**	0.80**
Residual effect = 0.36, Residual effect = 0.33, * Significant at 5 percent, ** Significant at 1 percent													

Table.7 The direct (diagonal values in bold) and indirect effects of component traits on yield per plant in E5 and pooled environments

E5 (*kharif* 2016)													
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**Corr. with YP**
DF	**0.143**	-0.015	-0.013	-0.021	-0.024	0.026	-	0.02	0.031	-	0.034	-	-0.65**
DM	0.125	**-0.142**	-0.034	-0.033	-0.021	0.025	-	0.02	0.026	-	0.023	-	-0.41*
RP	0.037	-0.035	**-0.128**	-0.013	-0.027	0.030	-	0.02	0.030	-	0.028	0.019	-0.28
PH	-	-0.021	-0.032	**0.645**	-0.045	0.031	-	0.06	0.058	-	0.067	0.058	-0.45**
TP	-	-0.034	-0.025	0.022	**0.735**	0.028	-	0.09	0.066	0.073	0.075	0.063	0.80**
LP	-	-0.020	-0.032	-0.010	0.205	**0.057**	-	0.07	0.054	0.035	0.079	0.054	0.68**
EED	-	-0.021	-0.013	-0.015	-0.028	0.027	**-**	0.06	0.057	-	0.068	0.053	0.49**
SL	-	-0.015	-0.024	-0.018	0.210	0.031	0.062	**0.71**	0.048	-	0.066	0.032	0.62**
SG	-	-0.024	-0.012	-0.023	0.225	0.020	-	0.05	**0.698**	0.052	0.054	0.035	0.32*
TW	-	-0.023	-0.011	-0.021	0.159	-0.021	0.072	0.08	0.032	**0.658**	0.046	0.024	0.62**
SY	-	-0.045	-0.021	-0.013	0.136	0.029	-	0.07	0.027	0.072	**0.157**	0.047	0.57**
HI	-	-0.031	-0.122	-0.026	0.108	0.023	-	0.06	0.031	0.095	0.032	**0.091**	0.68**
Pooled Environment													
Traits	**DF**	**DM**	**RP**	**PH**	**TP**	**LP**	**EED**	**SL**	**SG**	**TW**	**SY**	**HI**	**Corr. with YP**
DF	**0.148**	-0.011	-0.024	-0.018	-0.022	0.019	-	0.02	0.020	-	0.023	-	-0.62**
DM	0.120	**-0.163**	-0.027	-0.026	-0.024	0.013	-	0.02	0.024	-	0.032	-	-0.28*
RP	0.104	-0.054	**-0.147**	-0.025	-0.027	0.022	-	0.03	0.019	-	0.021	0.026	-0.35*
PH	-	-0.038	-0.037	**0.463**	-0.035	0.024	-	0.03	0.023	-	0.049	0.076	-0.36**
TP	-	-0.035	-0.021	0.034	**0.620**	0.036	-	0.06	0.062	0.033	0.064	0.064	0.72**
LP	-	-0.017	-0.018	-0.028	0.237	**0.125**	-	0.05	0.054	0.035	0.065	0.057	0.56**
EED	-	-0.022	-0.014	-0.019	-0.048	0.035	**-**	0.05	0.063	-	0.081	0.068	0.67**
SL	-	-0.015	-0.027	-0.025	0.176	0.031	0.061	**0.63**	0.023	-	0.078	0.063	0.51**
SG	-	-0.034	-0.035	-0.035	0.135	0.028	-	0.05	**0.654**	0.035	0.065	0.058	0.32*
TW	-	-0.013	-0.018	-0.017	0.128	-0.020	0.059	0.06	-	**0.383**	0.063	0.049	0.78**
SY	-	-0.043	-0.023	-0.015	0.122	0.017	-	0.05	0.057	0.033	**0.183**	0.053	0.70**
HI	-	-0.031	-0.093	-0.023	0.065	0.032	-	0.04	0.035	0.024	-	**0.085**	0.68*
Residual effect (E5) = 0.34, Residual effect (pooled Envi.) = 0.35, * Significant at 5 percent, ** Significant at 1 percent													

Fig.1 Components of variance seed yield per plant and its components traits for five environments in pearl millet



Thus, it indicates that phenotype was fairly good indication of genotype under particular environment and selection on the basis of phenotype should be useful for the attributes under selection (Gupta and Mishra, 2005 and Salini *et al.,* 2010).

High heritability coupled with moderate genetic advance was observed for days to flowering and days to maturity that implies equal importance of additive and non – additive gene actions. The estimates of heritability in broad sense and genetic advance for the studied characters were slightly fluctuating at the different seasons. The differences in the magnitude of heritability would be attributed to the effect of the environment. Robinson *et al.,* (1949) attributed the change in heritability estimates in maize (*Zea mays* L.) to differential response of genotype to the environment.

Correlation and path analysis

Estimation of correlation coefficients between different pair of traits under study revealed that not all traits are correlated to each other or with seed yield per plant. Considering the correlation between seed yield per plant and other characters, it was found that seed yield was positively and significantly correlated with number of productive tillers per plant, number of leaves per plant, spike length, spike girth, test weight, stover yield and harvest index in all the environments and in pooled environment (Table 2, 3 and 4). Hence, these characters have to be given importance during the selection programme to improve the yield potential of the crop. From the aforesaid facts, it was clear that all the yield component traits *viz.,* days to 50 per cent flowering, days to maturity, reproductive period, plant height, number of productive tillers per plant, number of leaves per plant, ear exertion distance, spike length, spike girth, test weight, stover yield and harvest index were inter correlated among themselves. Kumar *et al.,* (2013) observed significant and positive correlation of grain yield per plant with plant height, number of tillers per plant and test weight in wheat. Similar kind of association was revealed by Aruselvi *et al.,* (2008) and Meena kumara *et al.,* (2008) for 1000-grain weight and Dhakar *et al.,* (2012) reported for panicle diameter.

Among the other traits positive and significant phenotypic and genotypic correlation coefficients were observed for days to fifty percent flowering with days to maturity and reproductive period; days to maturity with reproductive period; reproductive period with number of leaves per plant; plant height with number of leaves per plant, ear exertion distance and stover yield per plant; number of productive tillers per plant with number of leaves per plant, test weight, stover yield per plant and harvest index; number of leaves per plant with test weight, stover yield per plant and harvest index; ear exertion distance trait with stover yield; spike length with test weight, stover yield per plant and harvest index; spike girth with test weight; test weight and stover yield per plant with harvest index.

Path co efficient analysis

The correlation coefficients between any two characters would not give a complete picture of a complex situation like yield of plant which is jointly determined by a number of traits either directly or indirectly. In such situation, path coefficient analysis would be useful, as it permits the separation of direct effect from indirect effects through other related traits by partitioning the genotypic correlation coefficient (Dewey and Lu, 1959).

The values of path coefficients are presented in Table 5, 6 and 7. The highest positive direct effect registered by spike girth (0.735) followed by plant height (0.685), spike length (0.531) and plant height (0.458) in E1, number of productive tiller per plant (0.763) followed by spike length (0.732), spike girth (0.709), test weight (0.635) and plant height (0.632) in E2; spike girth (0.685) followed by spike length (0.643), number of productive tillers per plant (0.538), plant height (0.425) and test weight (0.355) in E3; spike girth (0.673) followed by number of productive tillers per plant (0.613), spike length (0.598), plant height (0.536) and test weight (0.393) in E4; number of productive tillers per plant (0.735) followed by spike length (0.712), spike girth (0.698), plant height (0.645) and test weight (0.658), while in pooled environment highest positive direct effect was recorded by spike girth (0.654) followed by spike length (0.631), number of productive tillers per plant (0.620), plant height (0.463) and test weight (0.383).

These results are in accordance with Vetriventhan and Nirmala kumari (2007), Aruselvi *et al.,* (2008) and Dhakar *et al.,* (2012) for panicle girth; Poornima *et al.,* (2004), Salunke *et al.,* (2006), Vetriventhan and Nirmala kumari (2007), Aruselvi *et al.,* (2008) and Meena kumara *et al.,* (2008). For positive direct effect of panicle length on grain yield per plant; Hepziba *et al.,* (1993), Salunke *et al.,* (2006) and Vetriventhan and Nirmala kumari (2007) produce tiller per plant in pearl millet; Mohan Lal and Maloo (2006) in barnyard millet for positive direct effect of plant height on grain yield per plant; Salunke *et al.,* (2006), Vetriventhan and Nirmala kumari (2007), Aruselvi *et al.,* (2008) and Kumari and Nagarajan (2008) for positive direct effect of 1000-grain weight on grain yield per plant. The negative direct effects on grain yield were exerted by days to fifty percent flowering, days to maturity, reproductive period and ear exertion distance. These results are in agreement with the reports of Salunke *et al.,* (2006), Aruselvi *et al.,* (2008) and Dhakar *et al.,* (2012) for days to 50% flowering, Salunke *et al.,* (2006) for days to maturity, and days to 50% flowering. The present study of genotypic path coefficient analysis revealed highest positive direct effect registered by spike girth, spike length, number of productive tillers per plant, plant height and test weight.

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