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Performance and Character Association in Maize (*Zea mays* L.) under Normal and Low Nitrogen cCnditions in Different Environments

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Abstract
A set of one-hundred and twenty genotypes including eight parents, their $F_{1's}$, $F_{2's}$ and backcross generation of maize differing in their reaction to low-N conditions were used for estimating relative yield reduction and inter-character correlations between different morphological traits, planted at Pantnagar, Gorakhpur and Dholi. Analysis of variance showed that the genotypes differ significantly for all of the trait except plant height under low-N conditions. Among inbred lines Tarun 83 had the lower per cent yield reduction across all the three environments. This indicates that it is tolerant inbred line for low N condition. This inbred line could be incorporated in the future breeding program of maize for low N tolerance. In both F_1 and F_2 generations, crosses between tolerant and susceptible and tolerant with tolerant were found to be susceptible for low N tolerance, indicating thereby dominance of susceptibility over tolerance. Estimates of genotypic correlation coefficient were generally higher than phenotypic correlations coefficients in all environments. The result revealed those days to 50% tasseling was significantly and negatively correlated with yield under both high and Low-N conditions. It was also found that plant height; ear height and cob diameters were significantly and positively correlated with yield under both high and Low-N conditions. Thus, these three characters can be considered for selection.
Keywords: Maize, grain yield, correlation among yield components, low-N

1. INTRODUCTION

The ultimate aim of a breeding program is to develop superior genotypes by exploiting the available genetic variability from the broad array of breeding material. To evolve superior genotypes, the knowledge of interrelationship of yield and yield related traits in a particular situation is a prerequisite. The extent of relationship between the important traits in given conditions can be studied by correlation coefficients and will aid in developing suitable selection criterion in order to choose suitable breeding procedure for developing cultivars suitable for wide range of environments. After drought, low-N stress is the second most important constraint for maize production and productivity in developing world including sub-Saharan Africa, Asia and Latin America (Zaid and Singh, 2005). In India about 50 per cent loss of maize production occurs every year because of low-N stress ((Logrono and Lothrop, 1997). Therefore, the objective of this research was to estimate yield reduction and to work out the correlations between different morphological traits under high and low N conditions.

2. MATERIALS AND METHODS

2.1 Description of the study area

The experiment was conducted at at G.B. Pant University of Agriculture and Technology, Pantnagar and maize Farm, Belipar, Gorakhpur and Dholi. Different characteristics of the location are presented here under.

Table 1. Different characteristics of the location are as follows

Characteristics	Pantnagar	Gorakhpur	Dholi
Agroclimatic zone	Submontane tarai belt	Indo-Gangetic plain	
Soil type	Clay loam	Sandy loam	Sandy loam
Previous crop	Pigeonpea for *Rabi* trail		
	Wheat for *kharif* trail	Maize	Maize
pH of soil	7.4	8.4	
Altitude	243.8 m	130 m	51.80m
Longitude	29.0 N	27.34 N	85.75'E
Latitude	79.3 E	81.36 E	25.59N

2.2. Experimental Material

The experimental materials consisted of one-hundrand and twenty genotypes of maize which included eight parents (five tolerant and three susceptible), their $F_{1's}$, $F_{2's}$ and backcrosses, grown at G.B. Pant University of Agriculture and Technology, Pantnagar and maize Farm, Belipar, Gorakhpur and Dholi.

2.3. Field Experimental Design, Trail management and Season

At all the three locations, the experiments were laid down in randomized block design with three replications and in two sets (one under normal and the other under low-N conditions). Experiments were sown in one row plots of 5 meter length with row to row spacing of 75 cm and plant to plant distance of 25 cm. In low-N trial, nitrogen fertilizer was not applied at all the growth stage of the crop. The low-N experiments were planted in a field with depleted soil-N. The field was continuously planted with maize after maize (at Gorakpur and Dholi locations) maize after wheat and vice-versa for more than 10 crop cycles. Soil analysis of the fields revealed that available soil N in the top 30.0 cm soil ranges 12.3-30.7 kg ha^{-1} which is less than normal. In normal-N trial 40 kg N ha^{-1} (farmers rate) was applied in all locations.

2.4 Data collected

Observations were recorded on days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, plant height, ear height, cob length, number of ears per plant, leaf senescence, yield, 100-kernel weight and cob diameter for evaluation of genotypes for intercharacter relationship. Plant height was recorded after completion of male flower, as the distance between the ground surface and node bearing flag leaf on 10 plants excluding plants at the boarder. Leaf senescence was scored using a 1-10 scale (1= 10% and 10= 10% dead leaf area) two weeks after 50% female flowering. Days from planting to anthesis and silking, indicated when 50% of plants had extruded anther or produced silk, was recorded by daily visual observations during the flowering period. Antheisis-silking interval (ASI) was calculated as the differences between number of days to 50% silking and 50% anthesis. At maturity, ears were harvested, excluding two plants close to alley from both ends of the rows; ear number per plot was determined and ears per plant were calculated. A cob with at least one fully developed kernel was considered as an ear. Ears were oven-dried to a constant moisture level, and 100-kernel weight and grain yield was recorded on a shelled grain basis.

2.5. Statistical Analysis

Relative yield reduction due to N stress was calculated as 1-$GY_{Low N}$/ $GY_{High N}$ (Banziger and Lafitte, 1997), where $GY_{Low N}$ and $GY_{High N}$ were mean grain yields of the common entries in paired experiments under low and high N. The correlations between all possible pairs of characters under study, at genotypic, phenotypic and environmental levels under normal and low-N was computed using MSTATc ststistical package (MSTAT-c, 1990).

3. RESULTS AND DISCUSSION

Analysis of variance in both in high and low-N conditions showed significant difference in all characters except plant height under low-N condition (Table 1), indicating thereby the existence of sufficient genetic variability. Inconsistent with this finding nNo significant differences were observed among across low N conditions in maize (Makumbi, et al, 2011). This is may be due to differences in the genetic materials studied.

3.1 Relative yield reduction

By and large low-N stress leads to reduction in yield of 10-50 per cent in Asia in general and in India up to 50 per cent in particular (Logrono and Lothrop, 1997). In the present study the per cent yield reduction varied from 16% to 59.67% in inbred lines (Table 2).

Regarding yield reduction in inbred lines, YHP P147 had maximum (**59.67%) and** Tarun 83 had minimum per cent yield reduction (16%) across all the three environments (Table 2) which is lower than the one obtained by Presterl, et al. (2002) who reported that N-deficiency stress reduced grain yields by 34% relative to the high N environment in the lines. This indicates that Taru 83 is tolerant for low N condition. This inbred line could be incorporated in the future breeding program of maize for low N tolerance.

Among single crosses we recorded the lower yield reduction (**17.33%**) from Pop3121/7×Pop3123 and the higher from Pop3121/7×YHP P10 (87%). The single crosses between tolerant x susceptible (Pop 3121/7 x YHP p10, YHP p42-1 x Pop 3123, YHP p10 x Tarun 83) were susceptible to low-N across environments in low-N conditions. It would appear that susceptibility is dominant over tolerance. The crosses Pop 3121/13 x Tarun 83 (tolerant x tolerant) and YHP p147 x Tarun 83 (also tolerant x tolerant) were also susceptible. It would appear to be situation comparable to dominance towards susceptibility.

Among F_2 generations YHPp42-9xTarun 83 gave the lower yield reduction (18.67%) while Pop3121/7xYHPp10 gave the higher yield reduction (**67.33%**). As in single crosses here also the crosses between tolerant x susceptible Pop3121/7xYHPp10 and YHP p42-1xYHP p147 were susceptible to low-N across environments in low-N conditions. It would appear that susceptible is dominant over tolerant. Further, F_2 generations behave almost like F_1 generations in most of the cases.

In case of backcross generations (BC_1) minimum reduction in yield was exhibited by (Pop3121/7xYHP10)/Pop3121/7 (27%) and maximum yield reduction was obtained from (Pop3121/13xYHPp147) POp3121/13 (72.67%). Finally (Pop3121/7xYHP42-9)YHP42-9 which is BC_2 gave the lower yield reduction (16.33%) and (YHPp10xYHPp147)YHPp147 the higher (74.67%). Here most of the BC_1 generations behave like P_1 and BC_2 generations also behave like P_2 in most of the cases. Similar reduction in yield was also observed by Banziger and Lafitte (1997), and Logrono and Lothrop (1997).

Generally the reduction of 27 per cent or more in a particular genotype is categorized as susceptible one. From the results we can sort out the tolerant genotypes as per this scale. Comparison of performance of hybrids and their parents under low-N indicated that, in general most of the hybrids showed relatively more susceptibility to low-N stress than inbred lines (Zaid *et al*., 2004; Presterl *et al.,* 2002; Balko and Russell, 1980; Laffite and Edmeades, 1995). One of the reasons for relatively less susceptibility of inbred lines may be because of their less requirements due to short plant stature and less yield potential in comparison to hybrid progenies, and the required amount of N demand was fulfilled through the amount of N available through N mineralization in soils (Presterl *et al*., 2002).

3.2 Correlations

3.2.1 Phenotypic correlation

The present investigation, character correlation coefficients estimated in normal and low-N trials in three environments are presented in the Tables 3 and and 4, respectively.

Days to 50 per cent tasseling was positively and significantly correlated at phenotypic level with days to 50 per cent silking (r_p = 0.50) in low-N conditions. However, days to 50 per cent tasseling was negatively and significantly correlated with yield (r_p = -0.37) in high-N conditions and (r_p = -0.28) in low-N conditions. Furthermore, the same character was negatively and significantly correlated with plant height (r_p = -0.44 and r_p = -0.34) and ear height (r_p = -0.22 and r_p = -0.20), cob length (r_p = -0.23 and r_p = -0.30), under low and high - N conditions, respectively (Tables 3 and 4). The same character was significantly associated with cob diameter (r_p =-0.18), and number of ears/plant (r_p =-0.22) under low-N condition only.

Anthesis-silking interval displayed no significant and negative relationship with yield under high-N conditions (r_p = -0.07), ear height (r_p = -0.03), cob diameter (r_p = -0.01), cob length (r_p = -0.03) at phenotypic level (Table 3) under high-N condition. However, it showed significant and negative relationship with ear height (r_p = -0.31) and yield (r_p = -0.24) but non significant association for the rest of the traits under low – N condition (Table 4). Ear height showed positive and significant relationship with cob length (r_p = 0.32) and yield (r_p = 0.43) in high-N condition. While it displayed positive and significant association with, cob length, cob diameter, number of ears /plant and yield (r_p = 0.41, r_p = 0..22, r_p = 0.18 and r_p = 0.35 in the mentioned order) in low N-condition. Cob diameter displayed significant and positive correlation with cob length (r_p = 0.35 and r_p =0.45, in that order) and yield (0.29 and r_p = 0.30, in the mentioned order) in high-N and low N- conditions.

Cob length manifested positive and significant correlations with yield (r_p = 0.36) under low-N condition.

Leaf senescence, one of the physiological characters displayed negative and non significant correlation with yield (r_p= -0.01) under low-N condition but under high-N conditions it displayed positive association with yield (r_p = 0.12) at phenotypic level.

3.2.2 Genotypic correlation

Leaf senescence was negatively and non significantly correlated with number of ears per plant (r_g = -0.03 and r_g = -0.02) in low and high – N, respectively and yield (r_g = -0.01) at genotypic level under low-N conditions only (Table 4). However, it was positively correlated with yield (r_g = 0.12) at high-N level only (Table 3).

Number of ears per plant displayed highly significant correlation with yield (r_g = 0.26) at genotypic level in low-N conditions only. In case of low-N trial, an important negative correlation of ASI and yield (r_g = -0.24) was observed, as lower ASI reflects the degree of tolerance to low-N stress. Rathore *et al.* (1998) and Zaidi *et al.* (2004) also reported similar findings for these traits.

Days to 50 percent tasseling showed positive and significant correlation with days to 50 per cent silking under both high and low-N condition (r_g = 0.71 and r_g = 92 in that order). Days to 50 per cent tasseling also showed significant but negative correlation under high –N condition with plant height (r_g = -0.59), ear height (r_g = -0.30), cob diameter (r_g =-0.35), leaf senescence (r_g = -0.26) cob length (r_g = -0.49) and yield (r_g = -0.58). It also displayed significant but negative correlation in low N-condition with plant height (r_g = -0.63), ear height (r_g = -0.31), cob length (r_g = -0.33), number of ears/plant (r_g = -0.44) and yield (r_g = -0.39). Similar finding was showed by Sultan *et al*. (2014) for correlation between yield and days to 50 percent tasseling.

Days to 50 per cent silking showed significant correlation with all characters studied except 100-kernel weight in low-N conditions only. The same character displayed significant association with days to 50% tasseling (r_g = 0.71), anthesis – silking interval (r_g = 0.24), plant height (r_g=-0.30), ear height ($r_{g =}$ -0.20), and leaf senescence (r_g = -0.20) under high N condition only (Table 3).

Plant height was found to be significantly and positively correlated with ear height (r_g = 0.74), cob diameter (r_g = 0.27), cob length (r_g = 0.48), number of ears/plant (r_g = 0.33) under low-N condition. It was also significantly and positively correlated with yield (r_g= 0.43) in low-N conditions only which is consistent with the findings of Lafitte and Edmeades (1994), Lizaso and Ritchie (1997), Mathur *et al.* (1997), Zaidi *et al.* (2003, 2004) and Sultan *et al.* (2014). Plant height showed significant and positive correlation with ear height (r_g = 0.81 and r_g = 74), cob diameter (r_g = 0.35 and r_g = 0.27), cob length (r_g = 48) and yield (r_g = 57) under high - N condition (Table 3).

Ear height was significantly and positively correlated with cob length and yield (r_g= 0.35, and r_g= 0.45, respectively) under high-N. Further, the character had significant and positive correlations with cob diameter (r_g= 0.24), cob length (r_g= 0.0.43), number of ears/plant (r_g = 0.34) and yield (r_g = 36) under low-N. This result is consistent with that obtained by Sultan et al. (2014) considering the association between ear height and yield.

Hundred - kernel weight manifested significant and positive relationship with cob diameter only (r_g =0.19 and r_g = 0.18) at both low and high-N conditions.

Cob diameter had significant and positive association both at low and high- N conditions with cob length (r_g = 0.52 and r $_g$= 0.41,) and with yield (r_g = 0.41 and r_g = 0.33), respectively. Similarly, cob length showed significant and positive correlation with leaf senescence (r_g = 0.31 and r_g = 0.19) and yield (r_g = 0.50 and r_g = 0.38) under high - N and low-N conditions, respectively.

Number of ears per plant was significantly and positively correlated with yield (r_g = 0.296) in low-N condition only. Lafitte and Edmeades (1994) and Zaidi *et al.* (2003, 2004) also reported similar findings. In low-N trials, leaf should stay green more in order to support the plant growth under low-N conditions, by providing photosynthetic assimilates as obtained in this study. Similar, observation was also reported by Lafitte and Edmeades (1994).

Generally, correlation coefficients at genotypic levels were similar in direction but of higher magnitude than phenotypic correlation coefficient for most of the intercharacter associations. This suggested the preponderance of environmental factors which might have suppressed the expression of character association at phenotypic level.

In any breeding program directed to improve the yield under low-N conditions it is necessary to conduct experiments under both the conditions as selection for yield under stress is much less efficient than under non-stress conditions (Blum, 1988).

Under high-N and low N conditions yield had significant and positive association with plant height, ear height and cob diameter. Cob length showed positive and significant relationship at genotypic and phenotypic levels under high N condition but at genotypic level only at low N condition. Similarly, number of ears per plant had significant and positive relationship with yield at genotypic level only under low N. Generally, in those characters in which grain yield exhibited positive and significant association, there were component interactions in which a gene conditioning an increase in one character will also influence another character provided other conditions are kept constant.

Further, due importance is to be given to the parameters like ASI, leaf senescence and number of ears per plant and yield (Edmeades *et al.* 1999; Banziger and Lafitte, 1997).

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Table 1: Analysis of variance for different characters over three environments under low and high - N conditions

Source of variation	d.f.	Days to 50% tasseling	Days to 50% silking	ASI	Plant height	Ear height	No. of ears/ plant	Yield (kg/ha)	100-kernel weight	Cob length	Cob diameter	Leaf senescence
		Mean sum of squares for different observations under low - N										
Replication	2	260.83	369.87	56.08	198.58	35.09	0.27	7441.07	9.41	19.93	1.01	0.11
Genotype	119	33.70**	62.95**	32.25**	2301.12	578.82**	0.37**	3327937**	44.79**	15.75**	0.94**	3.48**
Error	238	4.19	9.23	0.34	81.48	20.06	0.23	8846.78	2.66	0.30	0.50	0.34
		Mean sum of squares for different observations under High - N										
Replication	2	403.75	564.96	73.36	261.27	24.35	0.25	477.87	3.48	17.99	1.48	0.25
Genotype	119	10.81**	10.63**	13.62**	1168.01**	476.97**	0.75**	5078036**	54.10**	12.46**	1.76**	2.53**
Error	238	6.68	6.85	0.94	86.45	22.36	0.34	5874.04	1.69	1.02	0.68	0.27

Envi. : Environment; E_1 = Pantnagar, E_2 = Gorekpur, E_3 = Dholi
* and ** denotes significance at 5 and 1 per cent level of significance

Table 2. Yield reduction in genotypes under low N conditions in all environments

S. No.	Genotypes	Relative yield reduction			
		E_1	E_2	E_3	Mean
	Parents (Inbreds)				
1.	Pop3121/7	50	40	22	**37.33**
2.	YHP P42-1	93	50	33	**58.67**
3.	Pop 3121/13	88	50	30	**56.00**
4.	YHP P10	33	93	25	**50.33**
5.	Pop 3123	9	82	40	**43.67**
6.	YHP P147	43	93	43	**59.67**
7.	YHP P42-9	33	17	1	**17.00**
8.	Tarun 83	14	17	17	**16.00**
	F_1's				
9.	Pop3121/7×YHP P42-1	7	64	33	**34.67**
10.	Pop3121/7×Pop3121/13	62	25	17	**34.67**
11.	Pop3121/7×YHP P10	93	80	88	**87.00**
12.	Pop3121/7×Pop3123	29	14	9	**17.33**
13.	Pop3121/7×YHP P147	9	88	10	**35.67**
14.	Pop3121/7×YHP P42-9	36	80	2	**39.33**
15.	Pop3121/7×Tarun 83	50	73	7	**43.33**
16.	YHP p42-1×Pop 3121/13	47	30	7	**28.00**
17.	YHP p42-1×YHP P10	30	68	26	**41.33**
18.	YHP p42-1×Pop3123	50	75	65	**63.33**
19.	YHP p42-1×YHP P147	50	14	7	**23.67**
20.	YHP p42-1×YHP P42-9	80	53	16	**49.67**
21.	YHP p42-1×Tarun 83	92	33	14	**46.33**
22.	Pop 3121/13×YHP P10	93	29	8	**43.33**
23.	Pop 3121/13×Pop3123	68	33	8	**36.33**
24.	Pop 3121/13×YHP P147	20	33	38	**30.33**
25.	Pop 3121/13×YHP P42-9	40	80	11	**43.67**
26.	Pop 3121/13×Tarun 83	53	73	50	**58.67**
27.	YHP p10×Pop 3123	17	76	2	**31.67**
28.	YHP p10×YHP P147	25	94	25	**48.00**
29.	YHPp10×YHP P42-9	47	42	13	**34.00**
30.	YHP p10×Tarun	29	33	60	**40.67**

Table 4.8.4 : Contd….

S. No.	Genotypes	Relative yield reduction			
		E_1	E_2	E_3	
31.	Pop3123×YHP P147	30	71	13	**38.00**
32.	Pop 3123×YHP P42-9	4	67	18	**29.67**
33.	Pop3123×Tarun	50	50	11	**37.00**
34.	YHPp147×YHP P42-9	17	85	24	**42. 00**
35.	YHPp147×Tarun 83	68	94	3	**55. 00**
36.	YHPp42-9×Tarun 83	60	88	17	**55. 00**
	F_2's				
37.	Pop3121/7xYHP p42-1	47	40	44	**43.67**
38.	Pop3121/7xPop3121/13	25	90	40	**51.67**
39.	Pop3121/7xYHPp10	87	82	33	**67.33**
40.	Pop3121/7xPop3123	33	90	14	**45.67**
41.	Pop3121/7xYHP p147	93	82	33	**69.33**
42.	Pop3121/7xYHP p42-9	67	90	14	**57.00**
43.	Pop3121/7xTarun 83	60	9	47	**38.67**
44.	YHP p42-1xPop 3121/13	1	20	54	**25.00**
45.	YHP p42-1xYHP p10	67	33	40	**46.67**
46.	YHP p42-1xPop3123	25	14	47	**28.67**
47.	YHP p42-1xYHP p147	80	80	3	**54.33**
48.	YHP p42-1xYHP p42-9	92	25	56	**57.67**
49.	YHP p42-1xTarun 83	87	75	27	**63.00**
50.	Pop 3121/13xYHP p10	17	67	44	**42.67**
51.	Pop 3121/13xPop3123	85	67	22	**58.00**
52.	Pop 3121/13xYHP p147	1	92	22	**38.33**
53.	Pop 3121/13xYHPp42-9	20	88	73	**60.33**
54.	Pop 3121/13xTarun 83	1	87	86	**58.00**
55.	YHP p10xPop 3123	40	77	4	**40.33**
56.	YHP p10xYHPp147	86	50	14	**50. 00**
57.	YHPp10xYHPp42-9	60	83	29	**57.33**
58.	YHP p10xTarun 83	25	11	50	**28.67**
59.	Pop3123xYHPp147	20	2	50	**24. 00**
60.	Pop 3123xYHPp42-9	87	2	53	**47.33**
61.	Pop3123xTarun 83	60	50	47	**52.33**
62.	YHPp147xYHPp42-9	80	50	28	**52.67**
63.	YHPp147xTarun 83	50	17	75	**47.33**
64.	YHPp42-9xTarun 83	3	7	46	**18.67**

Table 2 Contd….

S. No.	Genotypes	Relative yield reduction			
		E_1	E_2	E_3	
	BC_1's				
65.	(Pop.3121/7xYHPp42-1)Po3121/7	20	60	37	**39. 00**
66.	(Pop 3121/7xPop3121/13)Pop3121/7	82	25	11	**39.33**
67.	(Pop3121/7xYHP10)/Pop3121/7	57	20	4	**27. 00**
68.	(Pop3121/7xPop3123)Pop3121/7	75	80	64	**73. 00**
69.	(YHP147xPop3121/7)Pop3121/7	5	50	65	**40. 00**
70.	(Pop3121/7xYHP42-9)Pop3121/7	33	20	67	**40. 00**
71.	(Pop3121/7xTarun)Pop3121/7	7	58	94	**53. 00**
72.	(YHP42-1XPop3121/13)YHPp42-1	86	14	43	**47.67**
73.	(YHPp42-1xYHPp10)YHPp42-1	1	75	33	**36.33**
74.	(YHPp42-1xPop3123)YHPp42-1	25	87	47	**53. 00**
75.	(YHP42-1XYHP147)YHPp42-1	50	63	5	**39.33**
76.	(YHPp42-1xYHPp42-9)YHPp42-1	80	53	61	**64.67**
77.	(YHPp42-1xTarun83)YHPp42-1	85	23	60	**56. 00**
78.	(Pop3121/13xYHPp10)Pop3121/13	60	52	38	**50. 00**
79.	(Pop3121/13xPop3123/3)Pop3121/13	47	66	60	**57.67**
80.	(Pop3121/13xYHPp147)POp3121/13	84	67	67	**72.67**
81.	9Pop3121/13xYHP p42-9)Pop3121/13	12	65	20	**32.33**
82.	(Pop3121/13xTarun 83)Pop3121/13	1	67	93	**53.67**
83.	(YHP p10xPop3123)YHPp10	75	40	73	**62.67**
84.	(YHPp10xYHPp147)YHPp10	60	75	24	**53. 00**
85.	(YHP42-9xYHPp10)YHPp10	50	93	58	**6700.**
86.	(YHPp10xTarun 83)YHPp10	50	75	33	**52.67**
87.	(Pop3123xYHPp147)Pop3123	91	38	20	**49.67**
88.	(Pop3123xYHPp42-9)Pop3123	60	53	5	**39.33**
89.	(Pop3123xTarun 83)Pop3123	50	50	6	**35.33**
90.	(YHPp147xYHP p42-9)YHPp147	67	80	25	**57.33**
91.	(YHPp147xTarun 83)YHPp147	67	85	1	**51. 00**
92.	(YHP42-9xTarun 83)Tarun 83	17	83	14	**38. 00**

Table 2 Contd….

S. No.	Genotypes	Relative yield reduction			
		E_1	E_2	E_3	
	BC_2's				
93.	(Pop.3121/7xYHPp42-1)YHPp42-1	40	95	12	**49. 00**
94.	(Pop 3121/7xPop3121/13)Pop3121/13	55	97	15	**55.67**
95.	(Pop3121/7xYHPp10)YHPp10	7	50	6	**21. 00**
96.	(Pop3121/7xPop3123)Pop3123	50	95	6	**50.33**
97.	(YHP147xPop3121/7)Pop3121/7	1	38	38	**25.67**
98.	(Pop3121/7xYHP42-9)YHP42-9	10	33	6	**16.33**
99.	(Pop3121/7xTarun 83)Tarun 83	67	25	6	**32.67**
100.	(YHP42-1XPop3121/13)Pop3121/13	67	75	6	**49.33**
101.	(YHPp42-1xYHPp10)YHPp10	17	88	6	**37. 00**
102.	(YHPp42-1xPop3123)Pop3123	1	75	9	**28.33**
103.	(YHP42-1XYHP147)YHP147	7	75	5	**29. 00**
104.	(YHPp42-1xYHPp42-9)YHPp42-9	40	93	61	**64.67**
105.	(YHPp42-1xTarun 83)Tarun 83	17	88	12	**39. 00**
106.	(Pop3121/13xYHPp10)YHPp10	1	92	10	**34.33**
107.	(Pop3121/13xPop3123/3)Pop3123/3	60	17	40	**3900.**
108.	(Pop3121/13xYHPp147)YHPp147	40	90	6	**45.33**
109.	9Pop3121/13xYHP p42-9)YHP p42-9	90	64	55	**69.67**
110.	(Pop3121/13xTarun 83)Tarun 83	67	71	30	**56. 00**
111.	(YHP p10xPop3123)Pop3123	14	70	33	**39. 00**
112.	(YHPp10xYHPp147)YHPp147	97	67	60	**74.67**
113.	(YHP42-9xYHPp10)YHPp10	88	67	22	**59. 00**
114.	(YHPp10xTarun 83)Tarun 83	47	70	6	**41. 00**
115.	(Pop3123xYHPp147)YHPp147	1	83	35	**39.67**
116.	(Pop3123xYHPp42-9)YHPp42-9	27	88	7	**40.67**
117.	(Pop3123xTarun 83)Tarun 83	38	50	6	**31.33**
118.	(YHPp147xYHP p42-9)YHP p42-9	70	33	22	**41.67**
119.	(YHPp147xTarun 83)Tarun 83	80	50	15	**48.33**
120.	(YHP42-9xTarun 83)Tarun83	78	33	44	**51.67**

Table 3. Genotypic (G), phenotypic (P) and environmental (E) correlation coefficients among different characters under high-N conditions in three environments

Character		Days to 50% tasseling	ASI	Plant height	Ear height	100-kernel weight	Cob diameter	Cob length	Leaf senescence	No. of ears/ plant	Yield
Days to 50% silking	G	0.71**	0.24**	-0.30**	-0.21*	0.01	-0.04	-0.17	-0.20*	-0.10	-0.18
	P	0.32**	0.12	-0.14	-0.15	-0.04	-0.01	-0.92	-0.11	-0.01	-0.11
	E	0.07	-0.02	0.14	-0.12	-0.17	0.04	0.01	0.01	0.05	-0.02
Days to 50% taseeling	G		0.15	-0.59**	-0.30**	0.05	-0.35**	-0.49**	-0.26**	0.02	-0.58**
	P		0.10	-0.34**	-0.20*	0.01	-0.13	-0.30**	-0.15	0.08	-0.37**
	E		0.04	0.07	-0.03	-0.07	0.18*	-0.03	0.05	0.13	-0.04
ASI	G			-0.01	-0.04	0.07	0.012	-0.03	0.05	0.02	-0.08
	P			0.01	-0.03	0.07	0.01	-0.03	0.05	0.02	-0.07
	E			0.07	0.03	0.09	-0.05	-0.04	0.09	0.14	-0.03
Plant height	G				0.81**	0.11	0.35**	0.48**	0.14	0.14	0.57**
	P				0.73**	0.11	0.30**	0.43**	0.30	-0.08	0.53**
	E				-0.08	0.04	0.06	0.01	-0.04	-0.01	-0.33**
Ear height	G					0.11	0.13	0.35**	0.12	-0.15	0.45**
	P					0.11	0.11	0.32**	0.11	-0.09	0.43**
	E					0.06	0.03	0.02	-0.01	-0.02	0.04
100-kernel weight	G						0.18*	0.18	-0.02	-0.13	0.11
	P						0.15	0.16	-0.01	-0.08	0.10
	E						-0.01	-0.01	0.12	-0.01	0.02
Cob diameter	G							0.41**	-0.01	-0.08	0.33**
	P							0.35**	-0.01	-0.06	0.29**
	E							0.04	0.01	-0.03	0.08
Cob length	G								0.31**	0.08	0.50**
	P								0.28	0.06	0.47**
	E								-0.02	0.04	-0.01
Leaf senescence	G									-0.06	0.12
	P									-0.02	0.12
	E									0.08	0.07
Number of ears per plant	G										-0.03
	P										-0.02
	E										-0.02

* and ** denotes significance at 5 and 1 per cent level of significance

Table 4. Genotypic (G), phenotypic (P) and environmental (E) correlation coefficients among different characters under low-N conditions in three environments

Character		Days to 50% tasseling	ASI	Plant height	Ear height	100-kernel weight	Cob diameter	Cob length	Leaf senescence	No. of ears/ plant	Yield
Days to 50% silking	G	0.92**	0.48**	-0.58**	-0.42**	-0.06	-0.38**	-0.50**	-0.22*	-0.40**	-0.47**
	P	0.50**	0.34**	-0.41**	-0.28**	-0.04	-0.24**	-0.33**	-0.14	-0.09	-0.35**
	E	0.02	-0.01	0.13	0.01	0.01	0.08	0.11	0.14	0.12	-0.
Days to 50% taseeling	G		0.04	-0.63**	-0.31**	-0.06	-0.22	-0.33**	-0.07	-0.44**	-0.39**
	P		0.04	-0.44**	-0.22*	-0.04	-0.18*	-0.23*	-0.069	-0.22*	-0.28**
	E		0.07	0.046	-0.01	-0.01	-0.14	-0.01	-0.09	-0.07	0.04
ASI	G			-0.19*	-0.32**	0.05	-0.17	-0.18	-0.13	-0.27**	-0.24**
	P			-0.18	-0.31**	0.04	-0.15	-0.17	-0.13	-0.14	-0.24**
	E			-0.03	-0.06	-0.02	-0.01	0.01	-0.09	0.01	-0.02
Plant height	G				0.74**	0.05	0.27**	0.48**	0.21	0.33**	0.43**
	P				0.70**	0.06	0.26**	0.45**	0.20*	0.18*	0.41**
	E				0.01	0.12	0.15	0.04	-0.04	0.03	0.04
Ear height	G					0.02	0.24**	0.43**	0.18	0.34**	0.36**
	P					0.02	0.22*	0.41**	0.18	0.18*	0.35**
	E					0.03	0.08	0.22*	0.6	-0.01	-0.23**
100-kernel weight	G						0.19*	-0.01	-0.05	0.05	0.06
	P						0.17	0.01	-0.05	0.01	0.05
	E						-0.03	0.01	-0.07	-0.06	-0.04
Cob diameter	G							0.52**	0.10	0.06	0.33**
	P							0.45**	0.05	0.03	0.30**
	E							-0.05	-0.01	-0.03	-0.20*
Cob length	G								0.19*	0.08	0.38
	P								0.18	0.03	0.36**
	E								0.01	-0.06	0.05
Leaf senescence	G									-0.03	-0.01
	P									-0.02	-0.01
	E									0.05	-0.02
Number of ears per plant	G										0.26**
	P										0.14
	E										-0.02

* and ** denotes significance at 5 and 1 per cent level of significance