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PERFORMANCE AND PHENOTYPIC STABILITY ESTIMATES OF GRAIN YIELD AND ITS ATTRIBUTES UNDER DIFFERENT ENVIRONMENTAL CONDITIONS OF SOME YELLOW MAIZE (*ZEA MAYS* L.) HYBRIDS

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Abstract

Assessment of yield stability is an important issue for maize hybrids evaluation and recommendation. The main objective of the present investigation was to study the variation, performance and yield stability of seven yellow maize hybrids (S.C.162, S.C.167, S.C.168, S.C.173, S.C.176 T.W.C.352 and T.W.C.353) tested under 18 environments (3 plant density × 3 nitrogen levels × 2 years). A split-split plot design with three replications was used in both years. Plant densities (20, 25, 30 thousand plant fed^{-1}) were randomly arranged to the main plots, N fertilizer (90, 120 and 150 Kg N fed^{-1}) represented the sub plots, while the seven maize hybrids were distributed in the sub-sub plots. Statistical analysis for split-split plot design was separately carried out for each year then the combined analysis over the two years was performed. Results showed that each of the three main factors, plant density, N level, and genotype, has a marked effect on all the studied traits. Increasing N levels from 90 to 150 Kg N fed^{-1} significantly increased all traits of yield and its components. Conversely, increased plant densities significantly decreased most of the studied traits. The highest yielder cross was S.C.162 (33.26 ard. /fed.) followed by S.C.167 (33.01 ard./fed.) and S.C.168 (32.07 ard./fed.) across all the environments while, the least yielder hybrid was S.C. 173 (27.74 ard./fed). The results indicated that there was a wide range for the environmental indices (-2.53 to +1.20), which indicates that there was differences among the different environmental conditions. Mean squares due to genotype × environment (G × E) interaction and their partitions, E (linear), G × E (linear) and pooled deviations (non-linear) were significant for grain yield. The four hybrids SC 162, SC167, SC 168 and TWC 352 showed high relative grain yield, regression coefficient around unity and insignificant deviation from linearity, hence, they considered as an environmentally responsive hybrids. Therefore, these four hybrids would be recommended as stable, high yielding hybrids and/or incorporated as breeding stocks for further use.

Key words : *Zea mays* L., crop breeding, demand, plant height, grain yield.

Introduction

Maize (*Zea mays* L.) is one of the main cereal crops used worldwide for a human food, poultry and livestock feed in addition to many industrial purposes. Recently, it has been used as a biomass for bioenergy purposes. In Egypt, there is need to improve productivity and total production to meet the increasing demand of maize. This could be achieved through enhancing crop breeding and agronomy research.

Growth and yield of maize plants depend on many factors. From the major factors are plant density and nitrogen fertilization. Plant density per unit area is an important factor for the production of maize. Plant density that is too low result in unnecessary sacrificing of yield, but overestimating the required density also lead to unnecessary stress on the plants, which in turn has a detrimental effect on yield. Increasing plant density within certain limits increased plant height (Ahmed, 1999), but decreased number of kernels/ear and number of ears/100 plant (Younis *et al*., 1990). However, increasing plant density up to 27,000 plant/feddan increased number of days to 50% silking, but tended to decrease plant height and grain yield (Galal and El-Zeir, 1990).

Nitrogen is a vital nutrient for maize crop growth. It is the principal raw material required for the plants growth, metabolically active and photosynthesis (Koochekzadeh *et al*., 2009). Its deficiency results in leaf area reduction which causes decreased photosynthesis which in turn leads to suppression of yields and crop quality (Sreewarome *et al.*, 2007). Increasing nitrogen fertilizer rates up to certain levels delayed silking dates and increased plant height, grain yield and its components. Several investigator stated that the grain yield increased as the plant densities or nitrogen level increased (El-Absawy, 2000; Katta and Abd El-Aty, 2002; Muhammad *et al.*, 2012; Al-Naggar *et al.*, 2015).

The development of maize hybrids, which can be adapted to a wide range of diverse environment, is the ultimate goal of plant breeders in a crop improvement program. Genotype × environment interaction (GEI) play an important role in determining yield performance. The GEI interaction could be attributed to predictable and non-predictable effects (Allard and Bradshaw, 1964). Several stability analyses methods have been proposed to handle GEI so as to recommend the genotypes that perform consistently better and yield higher across different environments. The most commonly used method is the joint regression analysis for yield stability (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966). Eberhart and Russell (1966) porposed the use of two statistics, a regression coefficient (b) and the deviation from regression (S^2di) to examine stability. They defined a stable cultivar as one having a regression coefficient close to unity (bi=1) and and the deviation from regression is as small as possible ($S^2di=0$). The objectives of this study were to: 1) Evaluate the grain yield of the seven yellow maize hybrids under three plant densities combined with three nitrogen levels, 2) estimate the phenotypic stability parameters to identify the stable maize hybrids for grain yield under different environments.

Materials and Methods

This study was conducted at the Experimental Farm, Faculty of Agriculture, Kafrelsheikh University during the two seasons, 2014 and 2015. The hybrids included in this study were seven five single crosses ìÔvenynamely S.C.162, S.C.167, S.C.168, S.C.173 and S.C.176 plus two, three-way crosses namely T.W.C352 and T.W.C. 353. In each experiment a split-split plot design with three replications was used in both years, where plant densities were located at the main plots, nitrogen fertilizer levels, represented the sub plots and the hybrids were located in the sub-sub plots. The plot size consisted of 2 rows, 6 meters long and 70 cm apart. Three plant population densities of 20 (D1), 25 (D2) and 30 (D3) thousand plants/fed were used. The distance between plant within row were 30, 25 and 20 cm for D1, D2 and D3, respectively. Three nitrogen levels of 90 (N1), 120 (N2) and 150 (N3) Kg N/fed were randomly arranged to the sub-plots, the nitrogen fertilization were divided into two equal parts, added before the first and second irrigation. The other agronomic field operations were practiced as usual with ordinary field maize cultivation. At harvest, weight of the harvested ears/plot from guarded plants chosen to represent the plot size of each plant density, *i.e.*, 10, 12, 14 guard plant from D1, D2 and D3, respectively where later transferred to ardab/fed (one ardab=140kg) adjusted to 15.5% moisture, which were used in the variance and the needed means. The collected data concerning, days to 50% silking, plant and ear heights, ear length, ear diameter, number of rows/ear, number of kernels/row, 100-kernel weight and grain yield (ardab/fed) were statistically analyzed according to the procedure outlined by Snedecor and Cochran (1989) and the mean values were compared by Duncans multiple range test (Duncan, 1955). Bartlett (1937) test was used to test the homogeneity of error mean squares. In case of homogeneity, combined analysis of variance over the 18 environments was done.

Phenotypic stability analysis for grain yield were performed according to the following Model of Eberhart and Russell (1966)

$$Y_{ij} = m + b_i l_j + S_{ij}$$

Where,

Y_{ij} = Mean of the i^{th} variety at the j^{th} environment.

m = Mean of all the genotypes (hybrids) overall environments.

b_i = Regression coefficient that measures the response of the 1^{st} variety to varying environment.

I_j = Environmental index obtained as the mean of all varieties at the j^{th} environment minus the grand mean

S_{ij} = The deviation from regression of the i^{th} variety at the j^{th} environment .

Results and Discussion

1. Mean performance

1.A. Effect of plant density

Significant effects of plant densities were detected for most studied traits in both seasons (table 1). Number of days to 50% silking as well as plant and ear heights increased as the plant density increased in both seasons and combined data. This may be due to more competition between maize plants for nutrient, moisture and light penetration which induce plants to grow taller, with a thinner stalk at such plant density rate, beside delaying the physiological interaction which push plants to flower (Testa *et al.,* 2016). On the other hand, the higher density rate (30.000 plants/fed) caused significant decreases in

Table 1 : Means of grain yield and other agronomic traits of seven maize hybrids as influenced by plant density and nitrogen levels in 2014, 2015 seasons and combined data.

Main effects and interactions	Silking date (day)			Plant height (cm)			Ear height (cm)			Ear length (cm)			Ear diameter (cm)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Density (D)															
20.000	60.4c	60.3c	60.4c	197.0b	201.0c	199.0c	100.7c	101.0c	100.9c	21.0a	21.3a	21.2a	5.2a	5.3a	5.3a
25.000	61.8b	61.4b	61.6b	214.0 a	217.8b	215.9b	108.3b	103.8b	106.0b	20.4b	19.8b	20.1ab	5.1a	5.1a	5.1a
30.000	63.7a	63.1a	62.4a	224.0 a	224.1a	224.0a	112.4a	108.1a	110.3a	19.9b	19.6b	19.8b	5.0a	5.1a	5.1a
F-test	**	**	**	**	**	**	**	**	**	*	NS	**	**	NS	**
Fertilization (N)															
90 kg N fed^{-1}	60.7c	60.5c	60.6c	205.2c	208.0c	206.6c	100.1c	100.4c	100.2c	19.5b	19.9b	19.7b	4.7c	4.9c	4.8c
120 kg N fed^{-1}	62cb	61.7b	61.8b	210.4b	216.4b	213.9b	109.7b	108.0b	108.9b	20.7b	19.9b	20.3ab	5.2b	5.2b	5.2b
150 kg N fed^{-1}	63.3a	62.8a	63.05a	217 a	220.2a	218.6a	113.7a	114.5a	114.1a	21.2a	20.4a	20.8a	5.4a	5.4a	5.4a
F-test	**	**	*	**	**	**	**	**	**	**	**	**	**	**	**
Varieties (V)															
S.C.162	61.8ab	62.4a	62.1a	218.3a	223.8a	221.0a	106.1a	108.3a	107.2a	21.2a	20.4a	20.8a	5.4a	5.5a	5.5a
S.C.167	63.0a	62.5a	62.7a	213.0b	217.5b	215.3b	103.3ab	104.7ab	104.0b	20.4ab	20.3a	20.4ab	5.2ab	5.3ab	5.3a
S .C.168	61.9bc	61.9ab	61.9ab	212.6b	212.4bc	212.4b	102.1b	103.4bc	102.8c	20.4b	19.7ab	20.05b	5.1ab	5.1bc	5.1bc
S .C.173	61.3c	61.0b	61.15b	206.3c	208.7c	207.5b	100.1b	100.bc	100.0c	20.5ab	19.4b	20.0b	5.1ab	4.9c	5.0c
S.C.176	61.4c	61.2b	61.3b	211.0bc	210.4c	210.7cd	101.2b	101.3bc	103.3bc	20.2b	19.8ab	20 b	5.0b	5.1c	5.1bc
T.W.C352	61.8c	61.2b	61.5b	213.7ab	216.8b	215.2b	103.0ab	104.2bc	103.6bc	20.4ab	19.7ab	20.1 b	5.1b	5.1bc	5.1b
T.W.C353	61.9bc	61.2b	61.55b	209.4bc	212.6bc	211bcd	101.2b	103.4bc	102.3b	20.0b	19.9ab	20.0b	5.2ab	5.2ab	5.2
F-test	**	**	**	**	**	**	*	**	**	*	**	NS	**	**	**
Interaction															
DN	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
DV	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
NV	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DNV	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
YV	-	-	*	-	-	*	-	-	*	-	-	*	-	-	*
YN	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YD	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YDN	-	-	NS	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YDV	-	-	*	-	-	*	-	-	*	-	-	*	-	-	*
YNV	-	-	*	-	-	*	-	-	*	-	-	*	-	-	*
YDNV	-	-	*	-	-	*	-	-	*	-	-	*	-	-	*

Table 1 continued...

Table 1 continued...

Main effects and interactions	No. of rows/ear			No. of kernels/row			100-grain weight (g)			Grain yield (ardab/fed)		
	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.	2014	2015	Comb.
Density (D)												
20.000	16.0a	15.7b	15.9b	38.0b	38.6b	38.3b	36.0b	36.9b	36.5a	30.0b	30.9 a	30.5b
25.000	15.8b	17.0a	16.4a	39.7a	40.0a	40.0a	38.0a	38.4a	38.2a	32.1a	31.8 a	32.0a
30.000	15.7b	15.7b	15.7b	37.2b	39.3b	38.3b	36.3b	36.3b	36.3b	30.8b	29.97b	30.8b
F-test	*	NS	**	*	*	**	NS	*	**	*	*	*
Fertilization (N)												
90 kg N fed^{-1}	15.3c	15.4b	15.4c	37.b	38.0b	37.5b	35.0b	35.6b	35.3b	31.75b	30.01b	30.88b
120 kg N fed^{-1}	15.8b	15.9ab	15.9a	39.7a	40.35a	40.0a	37.1a	37.7a	37.4a	31.82b	32.0a	31.91a
150 kg N fed^{-1}	16.3a	16.1a	16.2a	40.0a	40.6a	40.3a	37.5a	37.9a	37.7a	32.28a	31.28a	31.78a
F-test	**	**	**	**	**	**	**	**	**	*	*	*
Varieties (V)												
S.C.162	16.1a	16.1a	16.1a	39.8a	40.6a	40.2a	37.8a	37.6ab	37.7a	33.39a	33.13a	33.26a
S.C.167	16.00	15.8ab	15.9ab	40.0a	39.4abc	39.7ab	36.6abc	37.3ab	37ab	33.05ab	32.96a	33.01a
S.C.168	15.5b	15.5b	15.5c	38.9a	39.3abc	39.1b	35.1bc	36.6bc	35.9b	32.21c	31.90b	32.07b
S C.173	15.5b	15.7ab	15.6bc	38.4b	39.2bc	38.8b	35.5c	36.6bc	36.1b	28.43d	27.05d	27.74d
S.C.176	15.5b	15.6b	15.5c	39.0ab	39.0c	39.0b	36.4bc	36.1	36.3b	32.50bc	29.77c	31.13c
T.W.C 352	15.9ab	15.9ab	15.9abc	38.2b	39.6abc	38.9b	36.7ab	37.0ab	36.9b	31.95c	31.05bc	31.5c
T.W.C 353	16.2a	15.9ab	16.1a	39.1ab	40.4ab	39.8ab	36.8ab	37.8a	37.3a	32.17c	30.57c	31.4c
F-test	**	*	**	**	**	**	**	**	**	**	*	**
Interaction												
DN	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	*
DV	*	*	NS	*	*	NS	*	*	NS	*	*	NS
NV	*	*	NS	*	*	NS	*	*	NS	*	*	NS
DNV	*	*	*	*	*	*	*	*	*	*	*	*
YV	-	-	*	-	-	*	-	-	*	-	-	*
YN	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YD	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YDN	-	-	NS	-	-	NS	-	-	NS	-	-	NS
YDV	-	-	*	-	-	*	-	-	*	-	-	*
YNV	-	-	*	-	-	*	-	-	*	-	-	*
YDNV	-	-	*	-	-	*	-	-	*	-	-	*

Table 2 : Means ($\overline{X}$) and environmental indices (I) for grain yield (ard/fed) of eighteen environments.

Environments		S.C.162		S.C.167		S.C.168		S.C.173		S.C. 176		T.W.C. 352		T.W.C. 353		Grand mean	
		$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I	$\overline{X}$	I
1	Y1D1N1	33.07	-0.19	32.40	-0.61	32.23	0.16	27.37	-0.37	31.97	0.83	32.50	1.00	33.63	2.26	31.88	0.44
2	Y1D1N2	33.90	0.64	32.37	-0.64	31.93	-0.14	27.70	-0.04	33.40	2.27	32.17	0.67	33.63	2.26	32.16	0.72
3	Y1D1N3	34.27	1.01	33.23	0.23	32.13	0.06	28.37	0.63	32.47	1.33	32.27	0.77	32.90	1.53	32.23	0.79
4	Y1D2N1	33.73	0.47	33.53	0.53	31.70	-0.37	27.77	0.03	32.43	1.30	31.87	0.37	31.27	-0.10	31.76	0.32
5	Y1D2N2	33.80	0.54	32.73	-0.27	31.83	-0.24	28.50	0.76	31.70	0.57	31.83	0.34	29.53	-1.84	31.42	-0.02
6	Y1D2N3	33.60	0.34	33.17	0.16	33.50	1.43	29.43	1.69	34.53	3.40	32.40	0.90	31.73	0.36	32.62	1.18
7	Y1D3N1	33.33	0.07	33.67	0.66	32.37	0.30	28.73	0.99	31.70	0.57	29.33	-2.16	32.33	0.96	31.64	0.20
8	Y1D3N2	31.77	-1.49	33.17	0.16	31.63	-0.44	29.67	1.93	31.60	0.47	32.87	1.37	32.57	1.20	31.90	0.46
9	Y1D3N3	33.03	-0.23	33.20	0.19	32.53	0.46	28.37	0.63	32.70	1.57	32.27	0.77	31.90	0.53	32.00	0.56
10	Y2D1N1	33.67	0.41	32.00	-1.01	33.40	1.33	27.77	0.03	29.13	-2.00	30.83	-0.66	32.10	0.73	31.27	-0.17
11	Y2D1N2	34.97	1.71	35.13	2.13	34.03	1.96	28.70	0.96	31.57	0.43	32.10	0.60	31.97	0.60	32.64	1.20
12	Y2D1N3	34.47	1.21	36.40	3.39	30.93	-1.14	27.53	-0.21	33.50	2.37	32.03	0.54	26.40	-4.97	31.61	0.17
13	Y2D2N1	33.60	0.34	30.80	-2.21	30.37	-1.70	25.70	-2.04	28.07	-3.07	30.40	-1.10	30.20	-1.17	29.88	-1.56
14	Y2D2N2	33.63	0.37	34.40	1.39	32.70	0.63	26.73	-1.01	28.30	-2.83	32.03	0.54	30.93	-0.44	31.25	-0.19
15	Y2D2N3	32.40	-0.86	33.47	0.46	32.47	0.40	28.80	1.06	31.33	0.20	31.60	0.10	32.07	0.70	31.73	0.29
16	Y2D3N1	31.00	-2.26	30.77	-2.24	29.47	-2.60	25.53	-2.21	27.20	-3.93	29.37	-2.13	29.00	-2.37	28.90	-2.53
17	Y2D3N2	31.37	-1.89	32.17	-0.84	30.97	-1.10	25.67	-2.07	29.87	-1.27	32.07	0.57	31.17	-0.20	30.47	-0.97
18	Y2D3N3	33.07	-0.19	31.50	-1.51	33.07	1.00	27.00	-0.74	28.93	-2.20	29.00	-2.50	31.30	-0.07	30.55	-0.89
Average over all		33.26		33.01		32.07		27.74		31.13		31.50		31.37		31.44	

D1 = 20.000 plant/fed D2= 25.000 plant/fed D3= 30.000 plant/fed N1 = 90 kg N/fed N2 = 120 kg N/fed N1 = 150 kg N/fed

ear length, ear diameter, number of rows/ear, number of kernels/row and 100-grain weight. The mean performance of grain yield was increased gradually from 20.000 plants/fed to 25.000 plants/fed and then tended to decrease with the plant density of 30.000 plants/fed in both seasons and combined data. Maize grain yield per plant decreases as the plant density increases (Al-Naggar *et al*., 2015). Reduction in grain yield is partly due to decrease in ear barrenness, decrease in number of grains per ear, or a combination of these components (Betran *et al*., 2003). At high densities, many kernels may not develop, an event that occurs in some hybrids following poor pollination resulting from a silking period that is delayed relative to tassel emergence and/or owing to a limitation in assimilate supply that causes grain and cob abortion (Daynard and Muldoon, 1983). However, under optimum water and nutrient supply, high plant density can result in an increased number of cobs per unit area, with an eventual increase in grain yield (Bavec and Bavec, 2002). Liu *et al*. (2004) stated that maize yield differed significantly at varying plant density levels, owing to differences in genetic potential.

1.B. Effect of nitrogen fertilizer

Data presented in table 1 showed that significant effects of nitrogen fertilization levels were obtained for all the studied traits. Increasing N levels from 90 to 150 Kg/fed significantly increased men performance of all the studied traits including grain yield and its components in both successive seasons. The increase in mean performance of these traits at high nitrogen level might be due to the simulating effect of nitrogen element on metabolic process of maize plants and accumulation of photosynthesis assimilates which increase yield attributes and finally grain yield. These

Table 3 : Analysis of variance for stability of grain yield for the seven maize hybrids evaluated under different environmental conditions.

S. O. V.	d.f	M.S
Genotypes (G)	6	59.83**
Env.+ (G×E)	119	2.10**
Environment (Linear)	1	109.37**
G×E (Linear)	6	2.33
Pooled Deviation	112	1.13*
S.C.162	16	0.77
S.C.167	16	1.26
S.C.168	16	0.70
S.C.173	16	0.50
S.C. 176	16	1.34
T.W.C. 352	16	0.82
T.W.C. 353	16	2.53**
Pooled error	216	0.813

* and ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 4 : Stability parameters of grain yield for seven maize hybrids evaluated under different environmental conditions.

Hybrids	Mean	bi± SE	S.Sdeviation from regressionn-2 (S^2di)	M.S deviation from regression (S^2di)	$\bar{S}^2$di
S.C.162	33.26	0.639±0.221	12.25	0.766	-0.073
S.C.167	33.01	0.933±0.284	20.18	1.261	0.422
S.C.168	32.07	0.839±0.211	11.14	0.696	-0.143
S.C.173	27.74	1.075±0.179	7.99	0.499	-0.340
S.C. 176	31.13	1.824*±0.293	21.39	1.337	0.498
T.W.C. 352	31.50	0.830±0.230	13.19	0.824	-0.015
T.W.C. 353	31.37	0.860±402	40.48	2.530**	1.691**
Pooled	31.44		126.62		

results are in general agreement with those obtained by Medici *et al.* (2004), El-Badawy (2013) and Kamara *et al.* (2014).

1.C. Varietal differences

Highly significant differences were detected among the tested hybrids for all the studied traits in both seasons and combined data (table 1). Results over the two seasons, showed that the highest yielder cross was S.C.162 (33.26 ard./fed.) followed by S.C.167 (33.01 ard./fed.) and S.C.168 (32.07 ard./fed. while, the least yielder hybrid was S.C. 173 (27.74 ard./fed). The SC173 was the earliest cross while, SC167 was the latest one. The cross SC 173 recoded the lowest mean values for plant and ear heights. Moreover, the crosses SC162, SC 167 and SC 168 showed that the most favorable estimates of yield components, *i.e.*, ear length, ear diameter, No. of rows/ ear, no. of kernels/row and 100-grain weight. The differences in hybrids may be due to the differences in growth habit and response of each one to environmental conditions which controlled by genetic factors.

1.D. Interactions

The interaction among the experimental factors, i.e., density (D), nitrogen levels (N) varieties (V) and years (Y) are shown in table 1. The first order interaction of D × N was not significant for all studied traits, except No. of kernels/row and grain yield at the combined data. The interactions D × V, N × V and Y × V were significant for all the studied traits in both seasons and combined data. These results indicate that the ranks of maize genotype differ from one nitrogen level to another, from one density to another, and from one year to another. In contrast, the interactions of Y × N and Y × D were not significant for all the studied traits. The second-order interactions D × N × V, Y × D × V and Y × N × V were significant for all studied traits, indicating that the genotypes ranks differently from one combination of D × N, Y × D and Y× N to another. Moreover, the third-order interaction Y × D × N × V was significant for all the studied traits, indicating that the rank of maize genotypes differ from a combination of D, N and year (Y × D × N) to another. The results are in line with those reported by Dawadi and Sah (2012) and Al-Naggar *et al.* (2015).

2. Phenotypic stability

The data shown in table 2 indicated that the average of grain yield for the seven maize hybrids across the 18 environments varied from (28.9 ardab/fed) for the environment 16 (Y2D3N1) to (32.64 ardab/fed) for the environment 11 (Y2D1N2). The wide range of environment indices (I) for grain yield (-2.53 to +1.20) indicated significant variation between the environments. The environmental indices covered a wide range and displayed a good distribution within the range. Therefore, the assumption for stability analysis is fulfilled (Mather and Calgari, 1974 and Becker and Leon, 1988). The TWC 353 had the widest range of environmental index (-4.97 to 2.26) followed by SC 176 (-3.93 to 3.40), while the TWC 352 had the closet one (-2.50 to 1.37). The wide ranges of the indices of the hybrids indicate that the hybrids respond differently in their yielding ability with the different environmental conditions. The analysis of variance for phenotypic stability (table 3) revealed that genotypes as well as environment (linear) mean squares were significant, indicating that the environments differed remarkably in their effect on the performance of the evaluated hybrids. Also, hybrids × environment interaction was significant, revealed that hybrids varied from each other in their response within the different environments. The hybrids × environments interaction was further partitioned into (H × Env.) linear and non-linear (pooled deviation) components. Linear component was not significant when tested against non-linear, indicating that the equal importance of both linear and non-linear interaction. Similar result were obtained by Worku *et al.* (2001) and Mosa *et al.* (2011). The significant of pooled deviation (residual of genotypes) cleared that the deviation of all hybrids from linearity was significant and more obvious. These results are in agreement with conclusions reached by Lee *et al.* (2003), Rasul *et al.* (2005) and Mosa *et al.* (2012). Eberhart and Russell (1966) reported that genotypes with high mean performance, a regression coefficient of unity (bi = 1) and deviation from regression of zero (S^2di = 0) showed better general adaptability across environments. Thus, the four hybrids SC 162, SC167, SC 168 and TWC 352 with above-average grain yield performances, regression coefficient (bi) values not significantly different from unity, and deviation from regression (S^2di) values not significantly different from zero, were found to be more stable than the other hybrids (table 4).

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