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Correlation, Path and Regression Analysis in Some Bread Wheat (*Triticum aestivum* L) Genotypes under Normal Irrigation and Drought Conditions

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THE OBJECTIVE of this study was to assess correlation, path and regression analysis in 39 F6 bread wheat (Triticum aestivum L) genotypes during two seasons, i.e., 2015/2016 (F7) and 2016/2017 (F8) under irrigation and drought stress conditions at Fac. Agric. Edu. Farm, Minia University, Egypt. A positive correlation was found between grain yield and each of the number of spikes/plant and number of grains/spike under the two conditions. Path analysis revealed high positive direct effects on grain yield/plant via the number of grains/spike (0.929) under irrigation and number of spikes/plant (0.973) under drought. The direct effect of 100-grain weight on grain yield/plant was positive under irrigation (0.649) and drought (0.260). The indirect effects of these traits were negative under the two conditions. Stepwise regression analysis revealed that three models no. 8, 9 and 10 were fitted for each environment. The model no. 8 included one trait; the number of grains/spike under irrigation and number of spikes/plant under drought. Its relative contributions in grain yield were 0.180 and 0.693 under irrigation and drought; respectively. The model no. 9 in the two environments included two traits; the number of grains/spike and number of spikes/plant, its relative contributions in grain yield/plant were 0.544 and 0.836 under normal and drought conditions, respectively. The model no. 10 included three traits number of grains/spike, number of spikes/plant and 100-grain weight, its relative contribution in grain yield/plant were 0.0.931 and 0.978 under normal and drought conditions, respectively. This model no. 10 is fit and superior to use in selection for grain yield/plant.

Keywords: Bread wheat (*Triticum aestivum* L), Correlation, Path, Regression, Drought stress, Stepwise.

Introduction

Bread wheat (*Triticum aestivum* L) is an important cereal crop not only all over the world, but also in Egypt. The grain yield in the wheat is a complex character that can be determined by several components, which reflect positive or negative effects upon this trait (Singh & Chaudhary, 2006).

Grain yield is a quantitative trait and highly influenced by many genetic and environmental factors. Therefore, direct selection for grain yield is not effective in most cases and successful selection depends upon genetic variability and correlation between grain yield and morpho-physiological traits. Thus, Selection could be made for the yield components (Dixet & Dubey, 1984).

Abd El-Mohsen & Abd El-Shafi (2014) found highly significant differences among cultivars for all studied traits. Bhutto et al. (2016) revealed that significant differences among the genotypes for no. of spikes/plant, no. of grains/spike and grain yield/plant.

Correlations study is very important in plant breeding, because it reflects the dependence degree between two or more traits. If there is genetic correlation between two traits, direct selection of one trait can cause change in the other trait (Zecevic et al., 2004). Correlations between traits are depending of genetic and environmental factors. Environmental conditions can cause variability, not only in some traits but also interrelationships between them (Khan et al., 2005).

Khokhar et al (2010), Rasheed et al (2015), Khames et al (2016) and Jan et al (2017) observed positive phenotypic correlation for the grain yield with no. of tillers/plant and 1000-grain weight. Nasri et al (2014) showed significant positive

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correlation between the 1000-grain weight and no. of grains/spike. Bhutto et al (2016) observed highly positively phenotypic correlation between tillers/plant and grains/spike. Thus estimation of correlation and regression analysis among yield and yield components may provide effective selection criteria to improve wheat grain yield. Guler et al (2001) revealed that determining correlations among yield components traits was insufficient to selection in chickpea breeding. It was essential determine the direct and indirect effects of the causal components on the effect component.

Path analyses provide a measure of relative importance of each independent variable to predict changes in the dependent one. A path coefficient estimates the direct and indirect effects for one variable upon another and divides of correlation coefficient into direct and indirect effects. Consequently, correlation studies along with path analysis provide a better understanding of the association of different yield traits with grain yield (Dewey & Lu, 1959) and (Dixet & Dubey, 1984). Çifci (2012) and Desheva (2016) found that no. of grains/spike and no. of spikes/plant had strongest direct effect on the grain yield/plant. Abd El-Mohsen & Abd El-Shafi (2014) and Rasheed et al (2015) revealed that the magnitude of positive direct effect on grain yield was through no. of grains/spike and 100-grain weight. Khokhar et al (2010) found that the highest positive indirect effect on yield was the no. of spikes/plant, indicating that the no. of spikes/plant may be an effective trait to select high yielded genotypes. Janmohammadi et al (2014) and Abd El-Mohsen & Abd El-Shafi (2014) found that the 1000-grain weight had the most direct and positive effect on the grain yield.

Abd El-Mohsen & Abd El-Shafi (2014) found that no. of grains/spike had the most direct and positive effect on grain yield (0.212). Khan et al (2013) showed that spikes/m^2, and the 1000-grain weight had significant positive direct effects on the grain yield. However, the grains/spike had low direct positive effect but in low magnitude. Jan et al (2017) observed that the no. of grains/spike had negative (-0.15) direct effect with the grain yield. Khan & Naqvi (2012) revealed that the no. of spikes and the no. of grains had direct positive effect on the grain yield under irrigated condition. Therefore, it is concluded that these traits could be selected for the different stress environments and it would be beneficial for the yield.

Stepwise regression is a method that is used to estimate the value of a quantitative variable regarding its relation with one or some other quantitative variables. This relation is such that it is possible to predict other changes using one variable. Many investigators have been used this technique on wheat such as Mohamed (1999) and Soleymanifard et al. (2012).

Nasri et al (2014) stated that stepwise regression was used to remove the effects of ineffective or low impact on yield traits in the regression model. Stepwise multiple linear regressions proved to be more efficient than the full model regression to determine the predictive equation for yield (Mohamed, 1999). Stepwise multiple linear regression aims to construct a regression equation that includes the traits accounting for the majority of the total yield variation. Spikes number and seed index were the most important variables contributing the total variability of the grain yield (Mohamed, 1999 and Abd El-Mohsen & Abd El-Shafi, 2014).

Abd El-Mohsen & Abd El-Shafi (2014) revealed that based on simple regression analysis, linear regression of no. of tillers/plant, the no. of grains/spike, and the 1000-grain weight leads to increase the grain yield/plant by 0.67, 0.30, 0.64 units, respectively. Also, stepwise multiple linear regression analysis revealed that four traits, i.e., the no. of tillers/plant, the no. of grains/spike, harvest index and the 1000-grain weight with R^2 = 97.29%, had justified the best prediction model.

The objectives of this study were to: 1- Study the correlation between yield and its components in bread wheat genotypes under normal and drought stress environment. 2- Assess the contributions of highest correlated traits with yield via path coefficient analysis under the two conditions. 3- Determine the better models had the significance of the yield components affecting the grain yield via the simple, multiple and stepwise regression analyses.

Materials and Methods

Thirty seven F_6 genotypes derived from the cross Giza 168 x Sids 4 in addition to the two parents were grown in two separate experiments; normal irrigation (irrigated 6 times) and drought stress condition (irrigated only one time three weeks after planting irrigation) on November 20th

in the two successive seasons of 2015/2016 (F_7-generation) and 2016/2017 (F_8-generation) at the Fac. Agric. Edu. Farm, Minia University, Egypt. These materials were derived from the materials of Ph.D. study of the author. A randomized complete blocks design with three replications was used. The plot size was one row, 1.5m in length, and 0.2m in width. Seeds were sown by hand, 5cm apart within a row. The recommended cultural practices for wheat production were adopted throughout the growing seasons. The pedigree of the parents is given in Table 1.

Studied traits

In each season, data for the following studied traits were recorded as mean of ten guarded plants; the grain yield per plant (GY/P) in g, the number of spikes per plant (NS/P), the number of grains per spike (NG/S) and the 100 grain weight (100-GW) in g.

Statistical procedures

Analysis of variance was performed on the studied traits as outlined by Steel & Torrie (1980). The form of analysis of variance and expected mean squares are presented in Table 2.

The phenotypic (σ^2p) and genotypic (σ^2g) variances were calculated according to the following formulas:

$$\sigma^2 g = (M_3 - M_1)/r.$$
$$\sigma^2 p = \sigma^2 g + \sigma^2 e/r.$$

Mean comparisons were calculated using Revised Least Significant Difference (RLSD) according to El Rawi & Khalafalla (1980) as follows:

RLSD of Genotypes = $t\backslash.\sqrt{\frac{2Mse}{r}}$ to compare among genotypes means.

where r: Number of replicates and t\ is the t value from "minimum-average-risk t-table" at F-value of treatments, treatment d.f and experimental error d.f.

Phenotypic correlation coefficient was calculated as the procedure outlined by Johnson et al. (1955), as follows:

Phenotypic correlation $rp_{xy} = covp_{xy}/(\sigma p_x .\sigma p_y)$.

Path coefficient analysis was done to divide the phenotypic correlation coefficients into direct and indirect effects. Path-analysis was done for grain yield/plant as dependent variable (effect) affected by three independent variables (causes), i.e., no. of spikes/plant, no. of grains/spike and 100-grain weight. Path coefficient was estimated according to method of Deway & Lu (1959).

Also, the regression analysis was done to determine the relationship between the causal, effect and significance the three independent yield components on grain yield. IBM SPSS Statistics program of ver. 21 was used to calculate simple, multiple, stepwise regression and coefficient of determination (R^2) in the two generations of both conditions.

TABLE1. The pedigree of the parents of the wheat genotypes.

Parental cultivars	Pedigree
Giza 168	MIL/Buc//Seri CM93046-8M-04-0M-2Y-0B
Sids 4	Maya (S)/Man (S)//CMH74A-592/3/Giza 157*2

TABLE 2. Form of combined analysis and expected mean squares.

S.V	d.f.	M.S.	E.M.S.
Years (y)	y-1	M5	-
Reps x Years	y(r-1)	M4	-
Genotypes (g)	(g-1)	M3	σ^2 e + ry σ^2 g
G x Y	(g-1)(y-1)	M2	σ^2 e + r σ^2 g y
Error	ygr-1	M1	σ^2 e

where: S.V: Source of variation; d.f.: Degree of freedom; M.S.: Mean squares and E.M.S.: Expected mean squares.
r and g are number of replications and genotypes; respectively,
σ^2 e and σ^2 g are error and genetic variance; respectively.

Results and Discussion

The combined analysis over the two years (Table 3) revealed that genotypes, years x genotypes interactions exhibited significant differences for all studied traits under the two environments Table 3. Many researchers found similar results such as Mahdy et al. (2015), and Bhutto et al (2016).

Means and reduction percentage of the studied traits for genotypes under normal and drought stress conditions averaged over the two seasons are presented in Table 4.

Average of the grain yield/plant, the no. of spikes/plant, the no. of grains/spike and the 100-grain weight were 28.23 and 19.07 gm., 6.93 and 5.87, 77.58 and 70.39 and 5.44 and 4.73 under normal irrigation and drought stress conditions, respectively. Drought caused reduction in these four traits by 32.45, 15.29, 9.04 and 13.08% respectively. (Mahdy et al 2015).

Phenotypic correlation coefficients among the studied traits under normal and drought stress conditions are presented in Table 5. Under normal irrigation, positive correlation was found between the grain yield/plant and each of the no. of spikes/plant (0.332), the no. of grains/spike (0.425) and the 100 grain weight (0.385). Under drought stress, phenotypic correlation was positive between the grain yield/plant and the no. of spikes/plant (0.832). Correlation coefficients between the grain yield/plant and the 100 grain weight was changed from positive (0.385) under the normal irrigation to negative correlation (-0.211) under the drought stress. Negative phenotypic correlation coefficients were found among the no. of spikes/plant, the no. of grains/spike and the 100 grain weight under the two environments. Similar results were obtained by Janmohammadi et al. (2014), Abd El-Mohsen and Abd El-Shafi (2014), Rasheed et al. (2015), Khames et al. (2016), Desheva (2016) and Jan et al. (2017).

On the other hand, path analysis was used to divide the phenotypic correlation into direct and indirect effects. Therefore, the highest direct effect on the grain yield/plant was the no. of grains/spike (0.929), followed by the no. of spikes/plant (0.864) and the 100 grain weight (0.649) under the normal irrigation. While, under the drought stress, the highest direct effect on the grain yield/plant was the no. of spikes/plant (0.973) followed by the 100 grain weight (0.260) and the no. of grains/spike (0.258) (Table 6). Similar results were obtained by Abd El-Mohsen and Abd El-Shafi (2014) and Rasheed et al (2015).

The results of path coefficient analysis (Table 6 and Figure. 1) exhibited high positive direct effect of the number of spikes/plant on the grain yield under irrigation (0.864) and drought stress (0.973). These results were in agreement with Khan and Naqvi (2012). Moreover, its indirect effects were negative via other intervening traits such as the number of grains/spike and the 100-grain weight (-0.438 and -0.041) and (-0.094 and -0.100) under the normal irrigation and drought stress, respectively.

TABLE 3. Mean square for the studied traits of genotypes under normal irrigation and drought combined over the two years.

Environ.	S.V	d.f	GY/P	NS/P	NG/S	100GW
Irrigation	Years	1	173.70**	4.75	2383.51*	1.57
	Reps x Years	4	65.66	0.17	306.24	0.07
	Genotypes	38	79.60**	3.97**	668.44**	1.60**
	G x Y	38	43.25**	1.99**	278.83**	0.52**
	Error	152	5.07	0.10	24.77	0.38
Drought	Years	1	112.58	4.77**	7520.24**	21.28
	Reps x Years	4	174.11	2.79	461.66	0.32
	Genotypes	38	56.23**	8.02**	418.28**	0.67**
	G x Y	38	13.02**	0.68**	142.18**	0.67**
	Error	152	2.08	0.16	10.69	0.02

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

TABLE 4. Means and reduction percentage in the studied traits for genotypes under normal and drought averaged over two seasons.

Gen. No	GY/P			NS/P			NG/S			100GW		
	N	D	% Red	N	D	% Red	N	D	% Red	N	D	% Red
1	28.81	18.66	35.24	7.11	5.13	27.96	79.80	68.65	13.97	5.11	5.32	-4.25
13	28.93	19.24	33.52	6.15	5.65	8.18	102.03	72.65	28.80	5.03	4.77	5.20
39	33.34	17.77	46.71	6.17	5.39	12.67	92.21	71.12	22.87	5.86	4.64	20.81
42	30.79	14.44	53.11	6.27	5.08	18.94	84.57	56.28	33.45	5.93	5.09	14.19
48	23.50	14.17	39.68	5.85	4.93	15.63	76.97	64.60	16.07	5.26	4.49	14.62
62	29.01	20.72	28.58	7.38	6.66	9.75	76.10	61.96	18.59	5.26	5.01	4.72
63	29.81	15.97	46.42	6.76	4.04	40.22	71.73	74.35	-3.65	6.56	5.24	20.22
68	35.53	18.99	46.56	7.16	4.73	33.95	82.38	81.08	1.58	6.19	4.92	20.51
74	29.45	12.85	56.38	5.50	3.25	41.01	92.42	84.09	9.01	6.24	4.74	24.05
92	31.16	16.02	48.57	6.27	4.12	34.25	105.62	97.19	7.99	5.06	4.01	20.71
95	28.18	20.44	27.47	6.91	6.57	4.95	82.71	65.48	20.83	4.98	4.77	4.20
104	30.96	18.95	38.80	6.94	6.62	4.56	96.72	69.06	28.60	4.60	4.21	8.35
124	29.80	18.50	37.94	7.30	5.58	23.61	71.04	65.41	7.92	5.82	5.05	13.09
129	27.36	16.28	40.49	6.80	4.97	26.83	74.71	66.12	11.51	5.43	4.94	8.95
139	37.85	16.29	56.96	6.81	4.06	40.37	86.64	81.23	6.25	6.83	4.98	27.05
145	25.33	19.96	21.22	6.28	5.68	9.51	79.83	75.25	5.74	5.09	4.68	8.00
150	23.92	15.83	33.81	6.50	5.14	20.93	75.44	67.82	10.10	4.83	4.62	4.30
151	25.48	20.36	20.07	7.98	7.23	9.31	58.46	58.36	0.18	5.61	4.82	13.97
170	29.26	22.17	24.25	7.96	7.62	4.26	65.41	62.54	4.40	5.78	4.64	19.66
202	30.54	21.58	29.34	7.01	6.18	11.77	78.79	71.11	9.74	5.59	4.90	12.29
206	27.91	20.69	25.88	6.18	5.87	5.06	86.86	76.90	11.47	5.22	4.63	11.28
209	27.78	18.46	33.55	7.05	5.69	19.32	75.75	72.88	3.78	5.26	4.50	14.42
245	25.86	17.32	33.01	6.80	5.35	21.39	79.12	73.83	6.69	4.93	4.43	10.13
246	24.94	17.38	30.30	7.72	7.06	8.60	66.71	57.06	14.48	4.99	4.31	13.69
296	25.04	21.87	12.63	8.08	7.49	7.34	72.64	76.26	-4.98	4.35	3.96	9.07
300	27.72	20.42	26.33	7.39	6.86	7.29	68.81	63.99	7.01	5.46	4.73	13.40
306	27.88	23.99	13.93	6.93	6.82	1.57	71.97	69.17	3.90	5.61	5.13	8.62
343	27.21	18.67	31.39	7.61	6.08	20.00	70.04	62.99	10.07	5.21	4.93	5.28
352	26.96	17.45	35.29	7.73	6.07	21.50	60.64	63.38	-4.52	6.08	4.60	24.25
378	31.95	24.91	22.04	7.52	7.27	3.29	83.57	74.01	11.44	5.11	4.70	8.16
379	30.07	25.30	15.84	8.19	7.38	9.87	74.81	83.48	-11.59	4.95	4.14	16.31
389	27.22	20.13	26.03	6.95	5.60	19.44	67.78	68.59	-1.19	5.98	5.23	12.41
395	28.31	24.02	15.16	6.76	7.40	-9.44	80.44	75.28	6.41	5.23	4.33	17.17
397	31.21	23.32	25.28	7.97	7.60	4.57	74.00	69.61	5.94	5.35	4.51	15.64
423	25.53	19.29	24.45	7.30	6.28	13.94	65.16	65.45	-0.46	5.56	4.69	15.70
459	21.41	17.51	18.22	5.71	5.83	-2.12	67.15	63.96	4.75	5.52	4.77	13.49
463	32.06	22.45	29.97	8.36	6.56	21.55	72.71	72.47	0.33	5.18	4.77	7.88
Sids4	18.23	14.51	20.42	4.53	3.47	23.37	79.26	80.11	-1.08	5.29	5.25	0.71
Giza168	24.77	16.85	31.95	6.39	5.65	11.63	66.82	61.35	8.19	5.77	4.86	15.86
Average	28.23	19.07	32.45	6.93	5.87	15.29	77.38	70.39	9.04	5.44	4.73	13.08
RLSD0.05	3.49	2.16	-	0.46	0.59	-	5.61	4.78	-	1.06	0.19	-
RLSD0.01	2.79	1.95	-	0.43	0.52	-	6.82	4.40	-	0.26	0.17	-

where: GY/P: Grain yield/plant, NS/P: Number of spikes/plant, NG/S: Number of grains/spike, N: Normal irrigation and D: Drought.

TABLE 5. Phenotypic correlation coefficients among traits the under normal (below diagonal) and drought (above diagonal).

Trait	GY/P	NS/P	NG/S	100GW
GY/P		0.832	0.008	-0.211
NS/P	0.332		-0.159	-0.383
NG/S	0.425	-0.471		-0.368
100GW	0.385	-0.145	-0.150	

where: GY/P: Grain yield/plant, NS/P: Number of spikes/plant, NG/S: Number of grains/spike.

TABLE 6. Direct (diagonal) and indirect effects of the yield components on the grain yield under the normal irrigation and drought conditions.

Traits	Irrigation				Drought			
	NS/P	NG/S	100GW	rp	NS/P	NG/S	100GW	rp
NS/P	**0.864**	-0.438	-0.094	0.332	**0.973**	-0.041	-0.100	0.832
NG/S	-0.407	**0.929**	-0.097	0.425	-0.154	**0.258**	-0.096	0.008
100GW	-0.129	-0.139	**0.649**	0.385	-0.372	-0.099	**0.260**	-0.211
Residual effect	0.263				0.492			

where: GY/P: Grain yield/plant, NS/P: Number of spikes/plant, NG/S: Number of grains/spike.

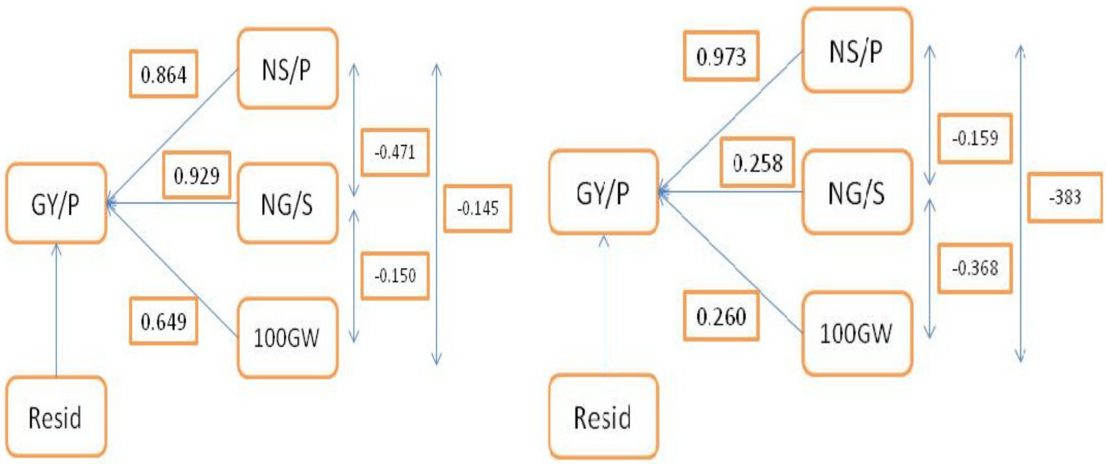

Fig. 1. Path coefficient diagram of the grain yield per plant indicating direct effects (single headed arrows) and correlation (double headed arrows) under normal irrigation (left) and drought stress (right). Where: GY/P: grain yield/plant, NS/P: Number of spikes/plant, NG/S: Number of grains/spike, 100GW: 100 grain weight and Resid: Residual effect.

Number of the grains/spike showed high positive direct effect (0.929) on the grain yield/plant under irrigation and low direct effect (0.258) under the drought stress. Its indirect effects for the number of grains/spike on grain yield were negative via the number of spikes/plant and the 100-grain weight in both conditions. These results were in agreement with Çifci (2012) and Khan & Naqvi (2012).

The direct effect of 100-grain weight on the grain yield per plant was positive under the irrigation (0.649) and the drought (0.260), its indirect effects characters were negative under the two conditions.

Simple, multiple and stepwise regression analyses are listed under irrigation (Table 7) and drought (Table 8). Results of the simple regression analyses revealed that the superior trait relative to other traits in its relative contributions in the grain yield/plant was the number of grains/spike (model no. 2) (0.180) under the normal irrigation and number of the spikes/plant (model no. 1) (0.693) the under drought stress. The 100-grain weight (model no. 3) was in the second order in the traits contributing in the grain yield/plant in the two environments. Similar results were reported by Abd El-Mohsen & Abd El-Shafi (2014).

Multiple regression analyses revealed that under the normal irrigation (Table 7) the highest contribution in grain yield/plant was obtained via model no. 7 (0.931) followed by model no. 4 (0.544). The two models included two traits, i.e., the number of spikes/plant and the number of grains/spike in addition to the 100-grain weight in model no. 7. Model no. 5 gave the lowest contribution in the grain yield/plant (0.302).

Under the drought stress, model no. 7 was the highest contribution in the grain yield by 0.978 followed by model no. 4 (0.836) then model no. 5 (0.707) (Table 8), where, these two models included two traits, i.e., the number of spikes/plant and the number of grains/spike in addition to the 100-grain weight in model no. 7. Model no. 6 gave the lowest contribution in the grain yield/plant (0.046).

Stepwise regression analysis revealed that the three models were fitted for each environment. The model no. 8 included one trait in both environments, i.e., number of the grains/spike and its relative contribution in the grain yield was 0.180 under the normal irrigation and the number of spikes/plant and its relative contribution in the grain yield was 0.693 under drought condition. The model no. 9 in the two environments included two traits, i.e., number of the grains/spike and the number of spikes/plant and its relative contribution in the grain yield/plant were 0.544 and 0.836 under the normal and the drought stress conditions, respectively. The model no. 10 included three traits (NG/S, NS/P and the 100-grain weight) and its relative contribution in the grain yield/plant were 0.931 and 0.978 under the normal and the drought stress conditions, respectively. This model no. 10 is fit and superior to use in selection for grain yield/plant. The stepwise regression used to remove the effects of ineffective or low the effective on the yield components in regression model. Moreover, the stepwise multiple linear regressions proved to be more efficient than the full model regression to determine the predictive equation for yield. These results are similar to reported by Abd El-Mohsen & Abd El-Shafi (2014).

Values of χ^2 between the realized and expected of the grain yield/plant were significant for all the studied models except model no. 7 out of multiple regression models and model no. 10 from models of stepwise regression under normal irrigation (Table 9). Moreover, the correlation coefficients between realized and expected grain yield were positive and highly significant for these models.

Under the drought stress, values of χ^2 between the realized and expected the grain yield/plant were significant for model no. 1 from simple regression, models no. 4, 5 & 7 out of multiple regression models and models no. 9 & 10 from models of the stepwise regression (Table 10). Moreover, the correlation coefficients between realized and expected the grain yield values were positive and highly significant for these models.

It could be concluded that model no. 7 equal to model no. 10 under both environments and included three traits, i.e., NS/P, NG/S and 100-GW and model no. 4 equal to model no. 9 under drought stress included only two traits, i.e., NS/P, NG/S. Each of two models from these models possessed the same values of χ^2, R and R^2, indicating that variance of grain yield/plant can be estimated by regression equations, where regression equation for model no.7 and 10 containing three traits, were $\hat{Y} = -48.25 + 0.320$ NG/P + 3.867 NS/P + 4.57 100-GW under normal irrigation and $\hat{Y} = -39.204 + 3.413$ NS/P + 0.246 NG/S + 4.423 100-GW under drought stress. Moreover, models no. 4 and 9 containing only two traits and its regression equation was $\hat{Y} = -7.167 + 2.648$ NS/P + 0.152 NG/S under drought condition.

TABLE 7. Simple, multiple and stepwise analysis in different models for grain yield/plant under irrigation.

Reg type	Model No.	Independent trait/s	R^2	Regression equation
Simple	1	NS/P	0.110	$\hat{Y}$ = 17.932+ 1.46 NS/P
	2	NG/S	0.180	$\hat{Y}$ = 16.892+ 0.1456 NG/S
	3	100GW	0.148	$\hat{Y}$ = 13.477+ 2.713 100GW
Multiple	4	NS/P, NG/S	0.544	$\hat{Y}$ = -12.930 + 3.062 NS/P + 0.258 NG/S
	5	NS/P, 100GW	0.302	$\hat{Y}$ = -1.018 + 1.774 NS/P + 3.119 100GW
	6	NG/S, 100GW	0.386	$\hat{Y}$ = -2.523 + 0.170 NG/S + 3.234 100GW
	7	NS/P, NG/S, 100GW	0.931	$\hat{Y}$ = - 48.25 + 3.867 NS/P + 0.320 NG/S + 4.578 100GW
Stepwise	8	NG/S	0.180	$\hat{Y}$ = 16.892 + 0.147 NG/S
	9	NG/S, NS/P	0.544	$\hat{Y}$ = -12.930 + 0.258 NG/S + 3.062 NS/P
	10	NG/S, NS/P, 100GW	0.931	$\hat{Y}$ = - 48.25 + 0.320 NG/S+ 3.867 NS/P+4.578 100GW

TABLE 8. Simple, multiple and stepwise analysis in different models for grain yield/plant under drought.

Reg. type	Model No.	Independent trait/s	R^2	Regression equation
Simple	1	NS/P	0.693	$\hat{Y}$ = 6.136+ 2.203 NS/P
	2	NG/S	0.000	$\hat{Y}$ = 18.867+ 0.003 NG/S
	3	100GW	0.043	$\hat{Y}$ = 28.059 -1.902 100GW
Multiple	4	NS/P, NG/S	0.836	$\hat{Y}$ = -7.167 + 2.648 NS/P + 0.152 NG/S
	5	NS/P, 100GW	0.707	$\hat{Y}$ = -0.311 + 2.335 NS/P + 1.20 100GW
	6	NG/S, 100GW	0.046	$\hat{Y}$ = 30.256 - 0.021 NG/S - 2.055 100GW
	7	NS/P, NG/S, 100GW	0.978	$\hat{Y}$ = -39.204 + 3.413 NS/P + 0.246 NG/S + 4.423 100GW
Stepwise	8	NS/P	0.693	$\hat{Y}$ = 6.136+ 2.203 NS/P
	9	NG/S, NS/P	0.836	$\hat{Y}$ = -7.167 + 2.648 NS/P + 0.152 NG/S
	10	NG/S, NS/P, 100GW	0.978	$\hat{Y}$ = -39.204 + 3.413 NS/P + 0.246 NG/S + 4.423 100GW

TABLE 9. Realized and expected grain yield/plant from different models of simple, multiple and stepwise regression analysis and their Chi ^{2}, correlation (R) and determination (R^2) coefficients under normal irrigation.

Gen. no	Realized GY/P, gm	Expected GY/P (gm)									
		Simple regression			Multiple regression				Stepwise regression		
		Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7	Mod. 8	Mod. 9	Mod. 10
1	28.81	28.32	28.51	27.33	29.04	27.53	27.56	28.17	28.51	29.04	28.17
13	28.93	26.91	31.75	27.13	31.72	25.60	31.10	31.24	31.75	31.72	31.24
39	33.34	26.94	30.32	29.38	29.30	28.21	32.10	31.95	30.32	29.30	31.95
42	30.79	27.09	29.21	29.57	27.67	28.62	31.04	30.23	29.21	27.67	30.23
48	23.50	26.47	28.10	27.74	24.45	25.76	27.57	23.07	28.10	24.45	23.07
62	29.01	28.71	27.97	27.75	28.92	28.49	27.43	28.73	27.97	28.92	28.73
63	29.81	27.80	27.34	31.28	25.90	31.44	30.89	30.87	27.34	25.90	30.87
68	35.53	28.38	28.89	30.26	29.83	30.98	31.48	34.11	28.89	29.83	34.11
74	29.45	25.96	30.35	30.39	27.30	28.20	33.35	31.15	30.35	27.30	31.15
92	31.16	27.09	32.27	27.19	33.00	25.88	31.78	32.95	32.27	33.00	32.95
95	28.18	28.03	28.94	26.97	29.17	26.77	27.63	27.73	28.94	29.17	27.73
104	30.96	28.06	30.97	25.94	32.79	25.63	28.78	30.57	30.97	32.79	30.57
124	29.80	28.60	27.24	29.26	27.41	30.08	28.36	29.35	27.24	27.41	29.35
129	27.36	27.85	27.77	28.20	26.78	27.97	27.73	26.78	27.77	26.78	26.78
139	37.85	27.87	29.51	32.00	29.83	32.35	34.28	37.05	29.51	29.83	37.05
145	25.33	27.10	28.52	27.28	26.50	26.00	27.50	24.88	28.52	26.50	24.88
150	23.92	27.42	27.88	26.58	26.05	25.58	25.92	23.13	27.88	26.05	23.13
151	25.48	29.58	25.40	28.69	26.29	30.62	25.54	26.97	25.40	26.29	26.97
170	29.26	29.56	26.42	29.16	28.00	31.14	27.29	29.93	26.42	28.00	29.93
202	30.54	28.16	28.36	28.65	28.46	28.86	28.95	29.66	28.36	28.46	29.66
206	27.91	26.96	29.54	27.64	27.98	26.24	29.13	27.35	29.54	27.98	27.35
209	27.78	28.23	27.92	27.74	27.82	27.89	27.35	27.32	27.92	27.82	27.32
245	25.86	27.86	28.41	26.85	27.91	26.43	26.87	25.94	28.41	27.91	25.94
246	24.94	29.21	26.61	27.02	27.59	28.26	24.96	25.81	26.61	27.59	25.81
296	25.04	29.73	27.47	25.28	30.19	26.89	23.89	26.16	27.47	30.19	26.16
300	27.72	28.73	26.91	28.28	27.12	29.13	26.83	27.35	26.91	27.12	27.35
306	27.88	28.05	27.37	28.70	26.51	28.79	27.86	27.28	27.37	26.51	27.28
343	27.21	29.04	27.09	27.61	28.08	28.72	26.23	27.42	27.09	28.08	27.42
352	26.96	29.22	25.72	29.96	26.08	31.66	27.44	28.87	25.72	26.08	28.87
378	31.95	28.90	29.06	27.35	31.23	28.26	28.22	30.96	29.06	31.23	30.96
379	30.07	29.89	27.78	26.90	31.07	28.95	26.20	30.01	27.78	31.07	30.01
389	27.22	28.08	26.76	29.69	25.50	29.95	28.32	27.67	26.76	25.50	27.67
395	28.31	27.80	28.60	27.67	28.13	27.30	28.07	27.58	28.60	28.13	27.58
397	31.21	29.57	27.67	27.99	30.19	29.81	27.36	30.74	27.67	30.19	30.74
423	25.53	28.59	26.38	28.55	25.90	29.27	26.53	26.27	26.38	25.90	26.27
459	21.41	26.26	26.67	28.44	21.53	26.32	26.73	20.56	26.67	21.53	20.56
463	32.06	30.13	27.48	27.52	31.05	29.95	26.57	31.02	27.48	31.05	31.02
Sids4	18.23	24.54	28.43	27.82	20.98	23.50	28.05	18.82	28.43	20.98	18.82
Giza168	24.77	27.27	26.62	29.13	23.56	28.33	27.50	24.28	26.62	23.56	24.28
Chi ^{2}		16.34	14.56	15.16	8.2	12.57	10.98	1.19	14.56	8.2	1.19
R		0.332	0.425	0.385	0.738	0.550	0.621	0.965	0.424	0.738	0.965
R^2		0.110	0.180	0.148	0.544	0.303	0.386	0.931	0.180	0.544	0.931

TABLE 10. Realized and expected grain yield/plant from different models of simple, multiple and stepwise regression analysis and their Chi ^{2}, correlation (R) and determination (R^2) coefficients under drought.

Gen. no	Realized GY/P, gm	Expected GY/P, gm.									
		Simple regression			Multiple regression				Stepwise regression		
		Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7	Mod. 8	Mod. 9	Mod. 10
1	18.66	17.43	19.07	17.93	16.84	18.04	17.88	18.35	17.43	16.84	18.35
13	19.24	18.58	19.08	18.98	18.83	18.61	18.92	18.65	18.58	18.83	18.65
39	17.77	18.01	19.08	19.23	17.92	17.85	19.23	16.83	18.01	17.92	16.83
42	14.44	17.34	19.04	18.37	14.85	17.67	18.61	14.15	17.34	14.85	14.15
48	14.17	17.00	19.06	19.52	15.72	16.60	19.67	13.03	17.00	15.72	13.03
62	20.72	20.81	19.05	18.52	19.89	21.26	18.65	20.46	20.81	19.89	20.46
63	15.97	15.03	19.09	18.10	14.83	15.40	17.94	15.73	15.03	14.83	15.73
68	18.99	16.55	19.11	18.70	17.68	16.63	18.45	18.28	16.55	17.68	18.28
74	12.85	13.29	19.12	19.05	14.21	12.95	18.76	13.27	13.29	14.21	13.27
92	16.02	15.22	19.16	20.43	18.53	14.13	19.98	16.21	15.22	18.53	16.21
95	20.44	20.61	19.06	18.99	20.19	20.75	19.09	19.95	20.61	20.19	19.95
104	18.95	20.73	19.07	20.05	20.87	20.21	20.15	18.54	20.73	20.87	18.54
124	18.50	18.43	19.06	18.44	17.55	18.78	18.50	17.89	18.43	17.55	17.89
129	16.28	17.09	19.07	18.66	16.05	17.23	18.72	15.52	17.09	16.05	15.52
139	16.29	15.08	19.11	18.58	15.93	15.14	18.32	16.36	15.08	15.93	16.36
145	19.96	18.66	19.09	19.15	19.32	18.58	19.05	19.00	18.66	19.32	19.00
150	15.83	17.45	19.07	19.26	16.74	17.23	19.33	15.09	17.45	16.74	15.09
151	20.36	22.07	19.04	18.88	20.86	22.37	19.12	20.65	22.07	20.86	20.65
170	22.17	22.93	19.05	19.23	22.53	23.06	19.40	22.19	22.93	22.53	22.19
202	21.58	19.76	19.08	18.73	20.02	20.01	18.68	20.64	19.76	20.02	20.64
206	20.69	19.07	19.10	19.25	20.06	18.95	19.12	19.81	19.07	20.06	19.81
209	18.46	18.67	19.09	19.50	18.97	18.37	19.48	17.63	18.67	18.97	17.63
245	17.32	17.91	19.09	19.63	18.21	17.49	19.60	16.42	17.91	18.21	16.42
246	17.38	21.68	19.04	19.86	20.19	21.34	20.20	17.47	21.68	20.19	17.47
296	21.87	22.63	19.10	20.53	24.25	21.92	20.53	22.07	22.63	24.25	22.07
300	20.42	21.24	19.06	19.07	20.71	21.37	19.20	20.35	21.24	20.71	20.35
306	23.99	21.17	19.07	18.30	21.42	21.78	18.27	23.29	21.17	21.42	23.29
343	18.67	19.54	19.06	18.67	18.52	19.82	18.80	18.44	19.54	18.52	18.44
352	17.45	19.51	19.06	19.30	18.54	19.38	19.47	17.03	19.51	18.54	17.03
378	24.91	22.15	19.09	19.13	23.33	22.29	19.05	24.05	22.15	23.33	24.05
379	25.30	22.39	19.12	20.18	25.06	21.89	19.99	24.31	22.39	25.06	24.31
389	20.13	18.47	19.07	18.10	18.08	19.04	18.06	19.52	18.47	18.08	19.52
395	24.02	22.44	19.09	19.82	23.87	22.17	19.77	23.20	22.44	23.87	23.20
397	23.32	22.89	19.08	19.47	23.55	22.86	19.52	23.29	22.89	23.55	23.29
423	19.29	19.97	19.06	19.15	19.41	19.98	19.25	18.61	19.97	19.41	18.61
459	17.51	18.97	19.06	18.98	17.98	19.02	19.11	17.11	18.97	17.98	17.11
463	22.45	20.58	19.08	18.99	21.21	20.72	18.94	21.61	20.58	21.21	21.61
Sids4	14.51	13.78	19.11	18.07	14.20	14.09	17.79	15.31	13.78	14.20	15.31
Giza168	16.85	18.59	19.05	18.82	17.12	18.71	18.99	16.24	18.59	17.12	16.24
Chi ^{2}		5.60	18.65	17.8	3.03	5.37	17.78	0.86	5.6	3.03	0.86
R		0.832	0.000	0.207	0.914	0.841	0.214	0.989	0.832	0.914	0.989
R^2		0.693	0.000	0.043	0.836	0.707	0.046	0.978	0.693	0.836	0.978

Conclusion

Grain yield was positively correlated with each of a number of spikes/plant and number of grains/spike under the two conditions. Path analysis revealed positive direct effects on grain yield/plant via a number of grains/spike under irrigation and number of spikes/plant under drought. The direct effect of 100-grain weight on grain yield/plant was positive under the two environments. The indirect effects of these traits were negative under the two conditions. Stepwise regression analysis revealed that model no. 10 was fitted for each environment and superior to use in selection for grain yield/plant.

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تحليل الأرتباط والمرور والإنحدار في بعض التراكيب الوراثية من قمح الخبز تحت ظروف الري والجفاف

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الهدف من هذه الدراسة هو تقدير تحليل الإرتباط والمرور والإنحدار فى 39 تركيب وراثى من قمح الخبز خلال موسمين 2016/2015 (الجيل السابع) و 2017/2016 (الجيل الثامن) تحت ظروف الرى والجفاف فى المزرعة التعليمية بكلية الزراعة – جامعة المنيا – مصر، حيث وجد ارتباط موجب بين محصول الحبوب وكلا من عدد السنابل/نبات وعدد حبوب السنبلة تحت كلا من الظرفين، وأظهر تحليل المرور تأثيرات مباشرة موجبة عالية على محصول الحبوب عن طريق عدد حبوب السنبلة (0.929) تحت الرى، وعدد السنابل/نبات (0.973) تحت الجفاف، كما كان التأثير المباشر لوزن المائة حبة على محصول الحبوب موجباً تحت الرى (0.649) وتحت الجفاف (0.246)، بينما كانت التأثيرات الغير مباشرة لهذه الصفات سالبة على محصول الحبوب فى كلا البيئتين، وقد أظهر تحليل الإنحدار المتدرج أن ثلاثة موديلات هى ارقام 8، 9، 10 كانت ملائمة لكل بيئة، ويشمل الموديل 8 صفة واحدة هى عدد حبوب السنبلة تحت الرى وعدد السنابل/نبات تحت الجفاف، وكانت مساهمتهم النسبية فى محصول الحبوب 0.180 و0.693 تحت الرى والجفاف على التوالى، والموديل رقم 9 فى كلا البيئتين يحتوى على صفتين هما عدد حبوب السنبلة وعدد السنابل/نبات ومساهمتهم النسبية فى محصول الحبوب كانت 0.544 و 0.836 تحت ظروف الرى والجفاف على الترتيب، والموديل رقم 10 يشمل ثلاث صفات هى عدد حبوب السنبلة وعدد السنابل/نبات ووزن المائة حبة ومساهمتهم النسبية فى محصول الحبوب 0.931 و 0.978 تحت ظروف الرى والجفاف على التوالى ، ويعتبر هذا الموديل 8 مناسب واكثر ملائمة للانتخاب لمحصول الحبوب لكل نبات.