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SELECTION CRITERIA FOR IMPROVING WHEAT GRAIN YIELD UNDER NORMAL IRRIGATION AND DROUGHT STRESS ENVIRONMENTS

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ABSTRACT

Sixteen bread wheat genotypes were evaluated for days to 50% heading and maturity, plant height, number of kernels/spike, number of spikes/m^2, 1000-kernel weight and grain yield under normal irrigation and drought stress environments at five different locations representing different governorates of lower and upper Egypt during two growing seasons of 2011/2012 and 2012/2013. The analysis of variance showed highly significant genotypic differences for all characters. Highly significant differences were also observed among environmental factors (locations and years). All values of measured characters were higher under normal irrigation environments than those under drought stress conditions. The genotypic correlation coefficients were greater for most characters than the corresponding phenotypic ones. Wheat grain yield had significantly positive correlation with each of plant height, number of 1000-kernel weight, number of kernels/spike, while negatively correlated with days to 50% heading and maturity as well as number of spikes/m2 under both normal irrigation and drought stress environments at phenotypic and genotypic levels. The results of path analysis revealed that, selection should be practised on 1000-kernel weight followed by number of kernels/spike, number of spikes/m^2 and then plant height for improving wheat grain yield under normal irrigation environment, while it should be carried out on plant height followed by 1000-kernel weight and number of kernels/spike under drought stress condition.

Key words: Bread wheat, correlation coefficient, drought stress, path analysis.

INTRODUCTION

Selection criteria in wheat would be considered as an important plant breeding tools for facilitating wheat grain yield improvement. Correlation is a pragmatic approach to develop selection criteria for accumulating optimum combination of yield contributing characters in a simple wheat genotype. The correlation among different traits is generally due to the presence of linkage and pleotropic effects of various genes. Phenotypic correlation is the net result of genetic and environmental conditions (Anwar *et al.*, 2009). Genotypic correlation determined the degree of grain yield association with various yield contributing characters.

Many earlier researchers studied the phenotypic and genotypic correlation coefficients of various grain yield contributing characters with grain yield (Munir *et al.,* 2007; Akram *et al.,* 2008; Khamssi 2012). Days to maturity and number of tillers/ plant had positive direct effect on grain yield/ plant (Anwar *et al.,* 2009). Ferdous *et al.,* (2010) suggested that grains/ spike followed by 1000-grain weight and effective tillers/ plant contributed maximum to grain yield positively and directly. Meantime, grain yield/plant was positively and highly significantly correlated with days to maturity but negatively associated with plant height (Khokhar *et al.*, 2010).

According to Sokoto *et al.* (2012) wheat grain yield had significantly positive correlation

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with plant height, number of spikes/m^2, spike length, spikelets/spike, number of grains/spike and 1000-grain weight. Meanwhile, Fellahi *et al.* (2013) reported that number of spikes/plant, number of grains/spike and 100-grain weight were the most important variables contributing to wheat grain yield variation, assuming that selection for these characters would be effective for improving wheat grain yield.

The present study was undertaken to evaluate sixteen wheat genotypes at different locations for seven grain yield contributing traits and determine the relationship between these traits, especially those affecting grain yield and its components on wheat genotypes grown under normal irrigation and drought conditions.

MATERIALS AND METHODS

This study had been performed at five Agriculture Research Stations representing different governorates in lower and upper Egypt, *i.e.* Kafr El-Hamam (Sharkia), Gemmeiza (Gharbia), Sids (Bany Sweif), Nubaria (Alexandria) and Shandweel (Sohag) belonged to Agriculture Research Center, Egypt during two successive growing seasons 2011/ 2012 and 2012/2013.

The experimental materials comprised of sixteen diverse wheat genotypes laid out in a randomized complete block design with three replicates under both normal and drought stress conditions. The seeds of the studied wheat genotypes were sown by hand drilling in six rows of 3 meters long with 20 cm between rows at 2-3 cm depth with the rate of 60 kg/fad. Plot to plot distance was 50 cm. The pedigree and origin of the studied bread wheat genotypes are shown in Table 1.

Plots were irrigated immediately after sowing and subsequent irrigations were done at tillering, jointing, flowering and grain filling stages under normal irrigation treatment. However, under water stress treatment, irrigation was prevented after tillering stage up to maturity, expect at Nubaria location in which irrigation was prevented after jointing stage up to maturity.

Fertilizer was applied at the recommended rate of 75 kg N and 31 kg P_2O_5/fad., with one third dose of nitrogen and full dose of phosphorous worked into the soil during seed bed preparation. Phosphorous was added as calcium superphosphate (15.5% P_2O_5). Whereas the second dose of 50 kg N/fad., was applied prior to tillering stage using urea (46% N). Weed control was done manually and the other recommended cultural practices for wheat production were followed during the growing seasons.

The following data were recorded on plot basis:

1. Days to 50% heading: It was computed as number of days from sowing to the time of comblete emergence of the spikes from the flag leaf sheathes of 50%of the plot.
2. Days to 50% maturity: It was calculated as number of days from sowing to the time of end 50% of spikes maturity and peduncles turned to yellow color.
3. Plant height (cm): was measured from the base of the culm to the tip of the spike, excluding awns.
4. Number of grains/spike: This trait was determined by counting number of grains/ spike of ten spikes and the average was calculated.
5. Number of spikes/m^2: It was counted from randomly selected square meter area from the inner rows in each plot.
6. 1000-kernel weight (g): Two random samples from each plot were used to determine the weight of 1000-grains and the average was calculated.
7. Grain yield (ardab/fad.): The grain yield was estimated from the middle four rows of each plot to eliminate any border effects and the yield of grains (ardab/fad.) was calculated.

Statistical Analysis

The obtained data were subjected to statistical analysis using the method outlined by Steel *et al.*, (1997). Data for the seven traits of the studied wheat genotypes depicting significant differences were further analyzed and phenotypic and genotypic correlation coefficients were estimated using variances and covariances as described by Sharma (1998). Path coefficient analysis was computed according to Dewey and Lu (1959).

Table 1. The pedigree and origin of the studied bread wheat genotypes

Serial number	Genotypes	Pedigree	Origin
1	**Gemmeiza11**	BOW"s"/KVZ//7C/SERI82/3/GIZA168/SAKHA61	EGYPT
2	**Sids 12**	BUC//7C/ALD/5/MAYA74/ON//1160.47/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4/*5X.	EGYPT
3	**Sakha 93**	SAKA92/TR810328.	EGYPT
4	**Shandweel 1**	SITE/MO/4/NAC/TH.AC//3*PVN/3/MIRLO/BUC.	EGYPT
5	**Line 20**	KS82142/2*WBLL1.	Mexico
6	**Line 35**	KS82W418/SBN/3/CHEN/AE.SQ//2*OPATA/4/FRET2.	Mexico
7	**Line 44**	CROC_1/AE.SQUARROSA(224)//OPATA/3/SOKOLL.	Mexico
8	**Line 21**	92.001E7.32.5/SLVS.	Mexico
9	**Line 24**	PASTOR//HXL7573/2*BAU/3/CMH82.575/CMH82.801.	Mexico
10	**Line 33**	BERKUT/3/ATTILA*2//CHIL/BUC.	Mexico
11	**Line 36**	KS82W418/SPN/3/CHEN/AE.SQ//2*OPATA/4/FRET2.	Mexico
12	**BATTELL-1**	SHUA"s"/TAMEGA//BOW≠1/FENGKANG15	Syria
13	**QIMMA-8**	R/5/MYNA/VUL	Mex/Syr
14	**BATTELL-2**	SHUA"s"/TAMEGA//BOW≠1/FENGKANG15	Syria
15	**ALSHOROQ-1**	BOCRO-4/3/MAYON"s"//Crow"s"/VEE"s"	Syria
16	**Giza168**	MIL/BUC//Seri:CM93046-8m-oy-om-2y-OB.	EGYPT

RESULTS AND DISCUSSION

Variance Analysis

The results of analysis of variance Table 2 showed highly significant genotypic differences ($P < 0.01$) for days to 50% heading and maturity, plant height, number of grains/spike, number of spikes/m^2, 1000-grain weight and grain yield/ fad., indicating the presence of adequate genetic variability. These results are in agreement with the findings of Gashaw *et al.* (2007) and Anwar *et al.* (2009). Thus, the evaluated sixteen bread wheat genotypes exhibited tremendous genetic variability. However the genotypic mean squares for the seven studied traits under drought stress condition were lower than those under normal irrigated environments. These results are in accordance with the findings of Shahryari and Mollasadeghi (2011).

Highly significant differences ($P<0.01$) were also observed among environmental factors, *i.e.* locations, years and their interactions with wheat genotypes for all the traits considered, showing that bread wheat genotypes interacted significantly with both locations and years for all studied traits under both normal irrigation and drought stress environments.

Mean Performance

Mean performance of the studied traits under both normal irrigation and drought stress environments are shown in Table 3. It is obvious that all values of the measured traits under normal irrigation were higher than those under drought stress conditions. This result may be due to that drought stress restricted the production of wheat grain yield and its contributing characters. Similar results were obtained by Khamssi (2012). Drought stress environments decreased number of days to 50% heading about 2-5 days as compared to normal irrigation condition and about 6-9 days for number of days to 50% maturity. The reduction in number of days to heading and maturity due to drought stress could be discussed on the basis that drought stress accelerated all phenological growth stages, reduced the normal growth and development periods. These results are in agreement with the findings of Kilic and Yagbasanlar (2010). Reducing heading time has been a successful strategy when breeding for environments characterized by drought stress. This strategy has achieved good results because earliness is probably the most effective way to increase yield under drought stress conditions (Moslem *et al.*, 2013). Number of days from

Table 2. Mean squares of various traits of wheat genotypes under normal irrigation and drought stress across ten environments

S.O.V	D.F	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No. of kernels/ spike	No. of spikes/m^2	1000 - kernel weight	Grain yield (ardb/fad.)
				Normal irrigation				
Reps(Env.)	20	5.15**	3.08	44.05*	30.41	708.95	1.51	2.97
Treatments	159	98.46**	106.76**	159.86**	196.42**	9657.97**	33.40**	92.72**
Genotypes (G)	15	204.70**	82.72**	325.50**	380.70**	7355.94**	146.01**	27.94**
Environments (E)	9	1230.90**	1588.36**	1364.23**	1894.03**	121016.58**	135.97**	1479.25**
Locations (L)	4	343.74**	1068.07**	1814.61**	3357.77**	193882.99**	136.75**	3234.52**
Years (Y)	1	7946.27**	7489.20**	78.41	492.08**	69120.00**	65.86**	18.81**
L x Y	4	439.22**	633.46**	1235.31**	780.79**	61124.31**	152.71**	89.09**
G x E	135	11.16**	10.66**	61.16**	62.77**	2489.85**	14.05**	7.49**
G x L	60	17.95**	10.40**	87.97**	84.68**	2720.04**	22.87**	8.33**
G x Y	15	10.08**	5.41**	27.61	52.40**	2487.43**	6.02	4.46**
G x L x Y	60	4.65**	12.22**	42.74**	43.45**	2260.26**	7.24**	7.39**
Error	300	1.36	1.71	20.63	19.51	770.42	3.02	1.65
				Drought stress				
Reps(Env.)	20	4.01**	3.33	18.63	8.90	1114.55	3.78	1.95
Treatments	159	116.17**	57.33**	201.38**	127.49**	9013.48**	38.53**	46.67**
Genotypes (G)	15	173.16**	79.97**	299.97**	156.77**	5042.64**	66.62**	12.48**
Environments (E)	9	1604.05**	704.76**	2087.90**	1281.66**	115664.13**	275.01**	748.23**
Locations (L)	4	122.96**	295.10**	2316.10**	2403.48**	215274.93**	164.65**	1627.52**
Years (Y)	1	12060.08**	4112.55**	307.20**	9.35	3136.52	45.79**	137.84**
L x Y	4	471.12**	262.47**	2304.88**	477.92**	44185.22**	442.69**	21.54**
G x E	135	10.65**	11.65**	64.66**	47.29**	2344.65**	19.65**	3.70**
G x L	60	11.48**	14.06**	73.73**	65.96**	2163.02**	26.22**	5.11**
G x Y	15	16.85**	7.79**	52.90**	27.14**	3318.77**	25.37**	1.93
G x L x Y	60	8.26**	10.20**	58.52**	33.66**	2282.74**	11.65**	2.74**
Error	300	1.09	2.00	13.83	11.22	1063.59	2.95	1.17

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

Table 3. The mean performance of 15 wheat genotypes under normal irrigation and drought stress across ten environments

Genotype	Days to 50% heading		Days to 50% maturity		Plant height (cm)		No. of kernels / spike		No. of spikes / m^2		1000- kernel weight		Grain yield (ardb/fad.)	
	I	D	I	D	I	D	I	D	I	D	I	D	I	D
Gemmeiza 11	96.10	92.83	145.47	138.10	110.80	100.70	57.60	48.10	329.83	277.93	50.071	43.542	21.464	15.913
Sids 12	97.07	93.50	147.87	139.20	107.37	99.30	55.33	45.40	355.53	300.63	43.609	40.206	21.273	15.716
Sakha 93	94.37	91.53	146.87	138.40	100.30	90.63	48.27	42.63	357.07	294.40	42.778	38.916	18.547	14.327
Shandweel 1	95.07	91.63	145.37	137.20	101.67	93.73	57.40	48.47	360.63	307.27	47.526	41.311	21.796	15.578
Line 20	98.80	95.27	146.47	139.17	109.00	98.93	46.87	41.47	383.40	317.03	46.945	41.185	21.995	14.916
Line 35	96.90	93.90	145.33	138.20	109.70	97.30	52.33	44.60	356.17	302.40	45.974	40.674	20.588	14.743
Line 44	97.30	93.60	146.43	138.63	109.63	100.47	55.50	47.60	376.60	314.37	42.435	37.708	20.157	14.916
Line 21	93.80	90.97	144.73	137.83	104.23	97.17	47.73	41.33	391.83	316.77	45.738	40.278	19.150	15.120
Line 24	98.80	95.17	145.80	137.87	107.97	99.50	49.43	42.80	375.60	323.93	42.716	39.883	19.427	14.419
Line 33	97.77	94.40	147.13	138.67	105.90	97.80	49.90	45.20	385.70	320.63	45.247	41.284	20.789	14.226
Line 36	97.83	94.37	145.10	137.20	106.47	96.00	52.77	45.67	373.33	318.50	42.663	39.311	19.963	14.815
BATTELL-1	101.97	97.63	149.20	141.17	102.17	93.00	51.33	43.13	365.53	320.70	43.196	38.115	19.529	14.122
QIMMA-8	102.23	98.80	149.87	143.13	104.73	95.37	51.83	45.70	380.13	327.83	44.599	39.977	19.833	13.647
BATTELL-2	101.83	98.60	150.03	141.63	106.43	92.97	46.80	41.67	386.37	324.53	47.072	42.469	20.515	14.339
ALSHOROQ-1	96.83	92.77	146.90	139.00	102.37	93.67	49.87	44.97	364.17	314.97	44.527	40.189	20.206	14.191
	95.17	92.43	146.50	138.83	102.07	92.47	48.70	43.97	369.30	310.53	43.074	39.594	20.703	14.063
L.S.D.0.05	1.88	1.68	2.10	2.27	7.30	5.98	7.10	5.38	44.60	52.40	2.792	2.759	2.064	1.737

I=Normal irrigation D= Drought stress

sowing to heading varied from 94.37 days (Sakha 93) and 93.80 days (Line 21) to 102.23 days and 98.8 days (QIMMA- 8) under normal irrigation and drought stress environments, respectively. Meaningful differences between bread wheat genotypes for days to heading were also reported by Parchin *et al.* (2011)

The tallest plants under normal irrigation was detected in Gemmeiza 11 followed by Line 35, Line 44 and then Line 20, However Sakha 93 had the shortest plant height under both normal irrigation and drought stress environments. Number of kernels/spike under normal irrigation environments varied from 46.87 (Line 20) to 57.60 (Gemmeiza 11) and ranged from 41.5 (Line 20) to 48.5 (Shandweel 1) under drought stress conditions. Number of spikes/m^2 ranged from 364.2 (ALSHOROQ-1) to 391.8 (Line 21) under normal irrigation conditions and from 277.9 (Gemmeiza 11) to 323.9 (Line 24) under drought stress environments. One thousand kernel weight varied from 50.1 g (Gemmeiza 11) to 42.4 g (Line 44) under normal irrigation and from 37.7g (Line 44) to 43.5 g (Gemmeiza 11) under drought stress conditions.

Under normal irrigation environments, grain yield of the evaluated wheat genotypes ranged from 18.5 ardab/fad., (Sakha 93) to 21.9 ardab/ fad., (Line 20). Bread wheat genotypes Line 20 had the highest grain yield followed by Shandweel 1, Gemmeiza 11 and then Sids 12. However under drought stress environments, grain yield varied from 13.6 ardab/fad., (QIMMA- 8) to 15.9 ardab/fad., (Gemmeiza 11). The highest wheat grain yield was detected in the cultivar Gemmeiza 11 followed by Sids 12, Shandweel 1, and then Line 21.In this connection, drought stress shortens the grain filling period because it leads to premature desiccation of the endosperm and limits embryo size, reduced the weight of the grains, number of spikes/ plant, number of grains/spike and consequently final grain yield (Cooper *et al.*, 1994 ; Bindraban *et al.*, 1998).

The differences between wheat genotypes for grain yield and its attributes under normal irrigation and drought stress environments were previously reported by Arega *et al.*, (2007); Parchin *et al.*, (2011) and Tsegaye *et al.*, (2012).

It is obvious that the high potential yield under irrigated conditions does not necessarily result in high yield under water stress environments. Thus, indirect selection for drought tolerance based on the results of irrigated conditions will not be efficient. These results are in accordance with the finding of Talebi *et al.* (2009) who reported that indirect selection under water stress environment is better than selection under non water stress conditions.

It is interest to mention that bread wheat genotypes which exhibited relatively high grain yield were characterized by early heading and maturity as well as heavy 1000- kernel weight under both normal and water stress environments.

Correlation coefficients

The simple linear correlation (r) measures the linear association between two variables. Correlation coefficient value of -1 or +1 indicates perfect correlation. The values close to +1 indicate high positive correlation. While, the values close to -1 indicate high negative correlation, Moreover, the r values equal zero, indicate that there is no association between variables. The results of correlation coefficients between wheat grain yield and different yield contributing characters at both phenotypic and genotypic levels under normal irrigation and drought stress environments showed that wheat grain yield/fad., had significantly positive correlation with each of plant height (rp = 0.33 and rg = 0.44) and (rp = 0.48 and rg = 0.57), 1000-kernel weight (rp = 0.55 and rg = 65) and (rp = 0.39 and rg = 0.4) and number of kernels/spike (rp = 0.35 and rg = 0.42) and (rp = 0.36 and rg = 0.44) under both normal irrigation and drought stress environments, respectively as given in Table 4. Similar results were observed by Yagdi and Sozen (2009) and Tsegaye *et al.* (2012). The positive correlation coefficients of grain yield with plant height, number of kernels/ spike and 1000-kernel weight, implying that improving one or more of these characters could result in high grain yield. These results are substantiated with Tsegaye *et al.* (2012).

It is interest to mention that the genotypic correlation coefficient values were greater for most studied traits than their corresponding

Table 4. Genotypic (rg) and phenotypic (rph) correlation coefficient of various metric traits of wheat genotypes under normal irrigation and drought stress conditions across ten environments

Traits		Days to 50% heading		Days to 50 % maturity		Plant height (cm)		No. of kernels/ spike		No. of spikes / m^2		1000- kernel weight		Grain yield (ardb/fad.)	
		I	D	I	D	I	D	I	D	I	D	I	D	I	D
Days to 50% heading	rg			0.798**	0.838**	0.175	-0.053	-0.163	-0.239	0.325*	0.666**	-0.064	0.013	-0.025	-0.533**
	Rph			0.754**	0.802**	0.168	-0.042	-0.151	-0.196	0.275	0.492**	-0.066	0.017	-0.010	-0.466**
Days to 50 % maturity	rg					-0.220	-0.280	-0.233	-0.240	0.238	0.527**	-0.120	-0.035	-0.097	-0.598**
	Rph					-0.177	-0.253	-0.229	-0.216	0.194	0.319*	-0.122	-0.045	-0.111	-0.521**
Plant height	rg							0.286	0.297*	-0.120	-0.189	0.335*	0.224	0.441**	0.568**
	Rph							0.262	0.250	-0.080	-0.099	0.282	0.185	0.325*	0.477**
No. of kernels/ spike	rg									-0.701**	-0.443**	0.224	0.083	0.420**	0.443**
	Rph									-0.555**	-0.336*	0.172	0.101	0.346*	0.362*
No. of spikes / m^2	rg											-0.301*	-0.401**	-0.244	-0.740**
	Rph											-0.234	-0.225	-0.237	-0.522**
1000 kernels weight	rg													0.652**	0.403**
	Rph													0.553**	0.392**

I=Normal irrigation D= Drought stress *, Significant at 0.05 and 0.01 levels of probability, respectively**

phenotypic correlation values, indicating the existence of inherent association among the considered traits. These results are in accordance with those obtained by Gashaw *et al.* (2007) and Tsegaye *et al.* (2012).

On the contrary, grain yield had highly significantly negative correlation coefficient with each of days to 50% heading (rp = -0.47 and rg=-0.53), days to 50% maturity (rp = -0.52 and rg = -0.60) and number of spikes/m^2 (rp = -0.52 and rg = -0.74) under drought stress environments. However the values of correlation coofficient between grain yield and the above mentioned traits under normal irrigation conditions were insignificantly negative with values being (rp = -0.01 and rg = -0.03), (rp = -0.11 and rg = -0.10) and (rp = -0.24 and rg = -0.24) in the same respect.

The negative correlation of grain yield with days to 50% heading and days to 50% maturity suggests that early heading and maturity wheat genotypes would not give high grain yield. These results are in agreement with the findings of Arega *et al.* (2007) and Tsegaye *et al.* (2012).

The negative correlation between grain yield and number of spikes/m^2 may be attributed to the significantly negative correlation between number of spikes/m^2 and each of number of kernels/spike and 1000-kernel weight, in addition to the significantly positive correlation with number of days to 50% heading and maturity which negatively correlated with grain yield.

Days to 50% heading was found to be positive and significantly correlated with days to maturity and number of spikes/m^2, while negatively correlated with plant height, number of kernels/spike and 1000-kernel weight. Mean while, plant height was positively correlated with number of kernels/spike, 1000-kernel weight and grain yield, but negatively correlated with number of spikes/m^2. In this connection, Fellahi *et al.* (2013) reported that plant height was positively correlated with 1000-kernel weight and wheat grain yield which agrees with our findindgs herin.

Path Analysis

Path coefficient analysis partitions the components of correlation coefficient of different traits into direct and indirect effects and visualizes the relationship in more meaningful way. In the present work, the response variable grain yield and six predictor variables, *i.e.* days to 50% heading, days to 50% maturity, plant height, number of kernels/spike; number of spikes/m^2, 1000-kernel weight were assessed for path coefficient under normal irrigation and drought stress environments (Table 5).

Table 5. Direct (Diagonal) and indirect effect of various metric traits of 15 wheat genotypes on grain yield (ardab/fad.) under normal irrigation and drought stress conditions across ten environments

Traits		Days to 50% heading	Days to 50 % maturity	Plant height (cm)	No. of kernels / spike	No. of spikes / m^2	1000 kernel weight	Correlation with yield
				Normal irrigation				
Days to 50% heading	rg	-0.323	0.259	0.050	-0.072	0.097	-0.036	-0.025
	Rph	0.045	-0.009	0.020	-0.036	0.002	-0.032	-0.010
	re	0.182	0.034	-0.031	0.000	-0.012	0.003	0.176
Days to 50% maturity	rg	-0.258	0.324	-0.064	-0.103	0.071	-0.068	-0.097
	Rph	0.034	-0.012	-0.021	-0.055	0.002	-0.059	-0.111
	re	-0.038	-0.161	-0.037	0.004	-0.001	0.003	-0.231
Plant height	rg	-0.056	-0.071	0.289	0.127	-0.036	0.189	0.441
	Rph	0.008	0.002	0.117	0.063	-0.001	0.136	0.325
	re	0.029	-0.031	-0.196	-0.002	-0.014	0.003	-0.210
No. of kernels / spike	rg	0.053	-0.076	0.083	0.444	-0.210	0.126	0.420
	Rph	-0.007	0.003	0.031	0.242	-0.005	0.083	0.346
	re	-0.004	0.034	-0.024	-0.017	0.010	0.005	0.004
No. of spikes / m^2	rg	-0.105	0.077	-0.035	-0.311	0.299	-0.170	-0.244
	Rph	0.012	-0.002	-0.009	-0.134	0.009	-0.113	-0.237
	re	0.010	-0.001	-0.012	0.001	-0.215	-0.001	-0.218
1000- kernel weight	rg	0.021	-0.039	0.097	0.099	-0.090	0.564	0.652
	Rph	-0.003	0.001	0.033	0.042	-0.002	0.482	0.553
	re	-0.020	0.023	0.023	0.004	-0.010	-0.024	-0.005
		Residual rg = 0.477			Rph = 0.632			
				Drought stress				
Days to 50% heading	rg	0.036	-0.206	-0.019	-0.013	-0.331	0.001	-0.533
	Rph	-0.135	-0.172	-0.013	-0.018	-0.131	0.004	-0.466
	re	0.036	-0.033	0.016	-0.006	-0.001	0.039	0.052
Days to 50% maturity	rg	0.030	-0.246	-0.103	-0.013	-0.262	-0.004	-0.598
	Rph	-0.108	-0.215	-0.081	-0.020	-0.085	-0.012	-0.521
	re	0.009	-0.140	0.000	0.005	0.070	-0.050	-0.106
Plant height	rg	-0.002	0.069	0.367	0.016	0.094	0.024	0.568
	Rph	0.006	0.054	0.320	0.023	0.026	0.047	0.477
	re	0.008	0.000	0.078	-0.002	-0.042	-0.042	0.000
No. of kernels / spike	rg	-0.009	0.059	0.109	0.054	0.220	0.009	0.443
	Rph	0.026	0.046	0.080	0.094	0.089	0.026	0.362
	re	0.005	0.017	0.003	-0.040	0.039	0.073	0.097
No. of spikes/ m^2	rg	0.024	-0.130	-0.069	-0.024	-0.497	-0.043	-0.740
	Rph	-0.066	-0.069	-0.032	-0.032	-0.266	-0.058	-0.522
	re	0.000	0.039	0.013	0.006	-0.253	0.086	-0.109
1000- kernel weight	rg	0.0005	0.009	0.082	0.005	0.199	0.108	0.403
	Rph	-0.002	0.010	0.059	0.009	0.060	0.256	0.392
	re	0.004	0.017	-0.008	-0.007	-0.054	0.400	0.351

Residual rg = 0.4776 Rph = 0.6319

Under normal irrigation conditions, the highest positive direct effects on wheat grain yield were exhibited by 1000-kernel weight at both phenotypic (0.482) and genotypic (0.564) levels. The positive direct effects of 1000-kernel weight were previously reported in wheat by (Iftikhar *et al.*, 2012). Similary, 1000-kernel weight showed positive indirect effects through plant height and number of kernels/spike. In this connection, positive indirect effects of 1000-kernel weight *via* plant height were recently reported by Fellahi *et al.* (2013).

The results of path analysis showed also that number of kernels/spike had positive direct effects on grain yield at both phenotypic (0.242) and genotypic (0.444) levels. The positive direct effects of number of kernels/spike were also reported by Pirdashti *et al.* (2012) in wheat. Number of kernels/spike had positive indirect effects on wheat grain yield through plant height and 1000-kernel weight. Plant height had positive and direct effects on wheat grain yield at both phenotypic (0.117) and genotypic (0.289) levels. Similary, plant height showed positive indirect effects on grain yield through number of kernels/spike and 1000-kernel weight, while it was negative through number of spikes/m^2.

It could be concluded that 1000-kernel weight followed by number of kernels/spike, number of spikes/m^2 and plant height contributed maximum to wheat grain yield positively and directly. Thus, selection based on these traits might be effective for improving grain yield under normal irrigation conditions.

Under drought stress environments, the results of path coefficient analysis showed that the highest positive direct effects were exhibited by plant height at both phenotypic (0.320) and genotypic (0.367) levels. In this connection, Ferdous *et al.* (2010) reported that plant height influenced wheat grain yield directly in positive direction. In addition, plant height had positive indirect effects on wheat grain yield *via* days to 50% maturity, number of kernels/spike, number of spikes/m^2 and 1000-kernel weight. Thousand kernel weight showed also positive direct effects on wheat grain yield at both phenotypic (0.256) and genotypic (0.108) levels. The positive direct effect of thousand kernel weight on wheat grain yield was also reported by Iftikhar *et al.* (2012). Thousand kernel weight had positive indirect effects on wheat grain yield *via* days to 50% maturity, plant height, number of kernels/spike and number of spikes/m^2. Number of kernels/spike showed positive direct effects on wheat grain yield at phenotypic (0.094) and genotypic (0.054) levels. Number of kernels/spike had also positive indirect effects on grain *via* days to 50% maturity, plant height, number of spikes/m^2 and 1000-kernel weight.

On the other hand, days to 50% maturity recorded negative direct effects on wheat grain yield at both phenotypic (-0.215) and genotypic (-0.246) levels. This negative direct effects is desirable for selecting early maturity wheat genotypes with high grain yield. In this connection, negative direct effects were exhibited by days to 50% maturity on wheat grain yield (Ferdous *et al.*, 2010; Fellahi *et al.*, 2013). Number of days to 50% maturity exhibited negative indirect effects on wheat grain yield *via* plant height, number of kernels/spike, number of spikes/m^2 and 1000-kernel weight.

It could be concluded that selection through plant height followed by 1000-kernel weight and then number of kernels/spike contributed maximum to wheat grain yield positively and directly. So these characters could be considered as a selection criteria for improvement wheat grain yield under drought stress environments.

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المعايير الإنتخابية لتحسين محصول حبوب القمح تحت ظروف الرى العادى والجفاف

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أجريت عدة تجارب حقلية لتقييم ستة عشر تركيباً وراثياً من القمح لصفات عدد الأيام حتى طرد السنابل والنضج، طول النبات، عدد حبوب السنبلة، عدد السنابل بالمتر المربع، وزن الألف حبة ومحصول الحبوب تحت ظروف الري العادي وظروف الجفاف في خمس مناطق تمثل المحافظات المختلفة للوجه البحري والقبلي بجمهورية مصر العربية خلال موسمي ٢٠١٢/٢٠١١ ، ٢٠١٣/٢٠١٢، أظهرت نتائج تحليل التباين اختلافات عالية المعنوية بين التراكيب الوراثية لجميع الصفات تحت الدراسة ، كما كانت الاختلافات عالية المعنوية بين المناطق المختلفة وكذلك بين سنوات الدراسة، وأظهرت نتائج الدراسة ارتفاع قيم هذه الصفات تحت ظروف الري العادي بالمقارنة بظروف الجفاف، وقد أوضحت نتائج معامل الارتباط أن معامل الارتباط الوراثي كان مرتفعاً عن قيم الارتباط المظهري لمعظم الصفات تحت الدراسة وقد أظهر محصول الحبوب ارتباطاً موجبا و معنوياً لصفات طول النبات، وزن الألف حبه وعدد حبوب السنبلة، في حين كان هذا الإرتباط سالبا و معنوياً مع ميعاد طرد السنابل وميعاد النضج وكذلك عدد السنابل بالمتر المربع تحت ظروف الري العادي وظروف الجفاف علي مستوي الارتباط المظهري والوراثي، أظهرت نتائج معامل المرور أن الانتخاب لصفات وزن الألف حبه يليها عدد حبوب السنبلة، عدد سنابل المتر المربع وطول النبات يؤدي إلى تحسين محصول الحبوب تحت ظروف الري العادي، بينما تحت ظروف الجفاف فإن الانتخاب لصفات طول النبات يليها وزن الألف حبة وعدد حبوب السنبلة يؤدي إلى التحسين المتوقع.

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