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Evaluation of some wheat genotypes for tolerance to water deficit based on some agronomic, yield components and chemical traits.

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ABSTRACT

Fifteen wheat genotypes were evaluated under normal and water deficit irrigation by using different statistical procedures. The resulted showed that the phenotypic coefficients of variation were high for ash percentage, plant height, spike length and grain yield per plot under normal and water stress irrigation. Genotypic coefficients of variation were high for plant height, spike length and grain yield per plot under normal and water irrigation. positive correlation coefficients were observed under normal and water stress irrigation as follows; position correlation coefficient among number of spikes/m^2 each of 100- kernel weight, number of kernels/spike each of 100- kernel weight, number of kernels/spike each of grain weight/plot, 100- kernel weight with grain weight/plot and the last positive correlation coefficient was between Protein percentage with Ash percentage under normal and water deficit irrigation. The direct contribution of 100- kernel weight to grain yield was highest under normal irrigation followed by number of kernels per spike at water deficit. 100- Kernel weight had the highest indirect effect an appreciable indirect effect via a number of kernels per spike under normal irrigation followed by a number of spikes per m^2 under normal irrigation. Number of kernels per spike also had an appreciable indirect effect via a number of spikes per m^2 at water stress followed by 100- kernel weight of water deficit. The results of the principal component analysis showed that the first two components explained (40.62 and 18.20%) and (32.42% and 22.41%) under normal and water deficit irrigation respectively, of the total variation.

KEYWORDS: wheat–normal irrigated-water stress-correlation-path coefficient-Principal component

1. INTRODUCTION

Wheat is an important cereal crop used as major human consumable commodity in most areas of the world. Differential characterization between Egyptian old varieties, genetic resources according to geographical distribution, for example old bread wheat represent an important genetic resource that can be used to improve modern varieties by introducing new alleles or combinations of genes. The old varieties may include genetic sources for biotic and abiotic stress resistance quality, grain yield especially in environments not tested in major breeding programs.

Water deficit is main abiotic constraint on cereal yield, especially in countries with low rainfall rates, therefore researchers are working to develop varieties adapted to water deficit conditions and keeping reasonable high yield. For successful breeding program basic information about the breeding material must be available to the breeders. Firstly, there must be significant variability in genotypic responses to water stress and second, this variation must be genetically controlled. Thus, an understanding of the knowledge of these two components about the breeding material under consideration is necessary (Mitra, 2001).

The correlation coefficient is an important statistical method, which help wheat breeders in selection for high yield. Correlation among different characteristics is generally due to the presence of linkage and pleotropic effect of different genes. Environment plays an important role in the development of phenotype correlation (Ali *et al.*, 2009).

As such, heritability, and both phenotypic and genotypic coefficients of variability can be used to identify key traits to improve drought tolerance (Sohail *et al.*, 2018).

Genetic variation and heritability estimates in early generations are important in identifying superior families that can be targeted for genetic advancement (Kwame et al., 2019).

Path coefficients have been used to develop selection criteria for complex traits in several crop species of economic importance such as wheat Aydin *et al.*,

(2010) and is used to determine the amount of direct and indirect effects of the causal components. Path coefficient analysis revealed that grain yield of triticale depended on the effect of four yield components (number of spike per plant, grains number per spike and thousand grain weight was positive while protein was negative) whereas grain yield of bread and durum wheat was mainly due to plant height, length of spike, a protein, in addition to these, spike weight for durum wheat. Even though the effect of spike weight was positive, plant height and protein had a negative effect on the grain yield of durum wheat (Gulmezoglu *et al.*, 2010).

Since coefficients of correlation may singly not provide thorough information about the relations of different traits and given the various advantages of multivariate statistical analyses for deep understanding of data structure and factor analysis Naghavi and Khalili (2017). The objectives of this study were:

- Study the relationship among morphology, chemical characters and yield components.
- Detect the direct and indirect effective traits on grain yield under normal irrigation and water deficit conditions to determine water deficit tolerance character.
- Assessing the usefulness of applying principal component analysis to research on wheat genotypes.

2. MATERIALS AND METHODS

This experiment was carried out at Sids Agricultural Research Station in two successful seasons, 2017/2018 and 2018/2019. Thirteen wheat landraces as well as two commercial cultivars regenerated and evaluated for tolerance and decrease water (Table 1). These landraces collected by National Gene Bank (NGB) team from diverse areas in Egypt. The experiment is grown in a randomized complete block design with three replications. The first experiment normally irrigated (five times) and the second experiment irrigated only once after 20 days from the sowing date. Each plot consisted of six rows; each row was 3 meters long and 30cm apart. Plants within rows were 20cm distant.

1. Days to heading (DH).
2. Plant height (PH).
3. Number of spikes /m2 (No.S/m2).
4. 100- Kernel weight (100-KW).
5. Days to maturity (DM).
6. Spike length (SL).
7. Number of kernels /spike (No.K/S).
8. Grain weight / plot (GW/P).

2.1. Estimation of protein, carbohydrate and ash percentages: -

Total seeds storage protein percentage, carbohydrate percentage and ash percentage were determined by near infra analyzer (NIR), according to Zhao *et al.*, (2004). The protein percentage content, carbohydrate and ash percentage contents, then expressed in g /100g of the seeds.

Table 1. Barcoding number and sources of wheat genotypes.

No	Barcoding number	Source	No.	Barcoding number	Source
1	112866	Egypt	9	112889	Egypt
2	112868	Egypt	10	112891	Egypt
3	112869	Egypt	11	112893	Egypt
4	112871	Egypt	12	112895	Egypt
5	112872	Egypt	13	112896	Egypt
6	112874	Egypt	14	Sids 13	Cultivar
7	112875	Egypt	15	Yacora	Cultivar
8	112876	Egypt			

2.2. Statistical analysis

The genotypic and phenotypic variances were calculated from the partitioning mean squares expectation; where, g and r are a number of genotypes and replications, respectively. Broad sense heritability (H^2) was estimated from the formula of (Roy 2000 and Abraha et al. 2017) as follows;

Genotypic variance: $Ó^2 g = \frac{M3 - M2}{ry}$; Genotype- year variance: $Ó^2 gy = \frac{M2 - M1}{r}$

Error: $Ó^2 e = M1$;

Phenotypic variance (overall variance):

$$Ó^2 ph = Ó^2 g + \frac{Ó^2 gy}{y} + \frac{Ó^2 e}{gry}$$

Broad sense heritability: $h^2_{b.s.} = \frac{Ó^2 g}{Ó^2 ph}$

Coefficient of genetic variation (CGV) =

$$\frac{(\text{genetic variance})^{1/2}}{\text{Overall mean}} \times 100$$

Coefficient of phenotypic variation (PGV) =

$$\frac{(\text{phenotypic variance})^{1/2}}{\text{Overall mean}} \times 100$$

The correlation coefficient calculated according to the method outlined by (Snedcore and Cochran 1967). The simple phenotypic correlations were made among morphological, three chemical traits and yield component characters.

Path coefficient analysis performed to divide the correlation coefficient between grain yield and the agronomic traits (r*iy*) into direct (p*iy*) and indirect effects (r*iy* p*iy*) according to the following equation:

$r1y = p1y + riy\ piy$

The technique allowed the evaluation of the direct causal effect or path coefficient (piy) of a cause (i) on an effect (y i.e. grain yield) and indirect effect of that cause through another causal variable (j). A single direct effect (unidirectional pathway) is quantitatively equal to piy while an indirect effect expressed as pjyrij of various agronomic traits on grain yield. rij is correlation between i and j and r*iy* p*iy* is the indirect effect of trait i on Y via j. For example, in the equation:

$r_1y = p_1y + r_{12}\ p_2y,\ p_1y$

Where the direct effect of trait 1 on response variable (Y) (the path coefficient), while $r_{12}\ p_2y$ is the indirect effect of trait 1 on Y via 2.

The principal component analysis method explained by (Yan 2011) was followed in the extraction of the components. Principal Component Analysis was performed using XLSTAT 2014 software.

3. RESULTS AND DISCUSSION

3.1. Means performance

Means performance of all genotypes under normal and water stress irrigation are presented for all studied characters in Table 2. The earliest in days to heading is recorded for accession 3 and commercial cultivar Yacora with values 106.67 day and 107.33 day under normal irrigation, respectively. While Yacora gave the earliest heading with value 90 days under water deficit irrigation respectively, followed by accession 4, Sids 13 and accession 7 with values (101.67, 101.67 and 102) at water deficit, respectively. The demonstrated clearly that there were marked differences among genotypes in heading date and varied in their response from normal to deficit treatments.

As for days to maturity, four accessions (5, 6 and 4) under normal irrigation gave the earliest mature with the lowest mean value (152.67, 152.67 and 152.83), respectively. Meanwhile, the accessions 7,8,6,5 and Sids 13 obtained the earliest mature with the lowest mean values (144.33, 145,146.33, 147.33 and 147.50 days) at water deficit irrigation, respectively. It observed that the lowest mean value for earliness if it found in wheat is favorable for escaping from disease as well as high temperature in maturity and stress conditions that have the same effect. The plant height ranked from (80 -159.83cm) and (77.33- 127.17cm) for each of accessions (4 and 1) under normal and deficit irrigation, respectively. According to the variation among genotypes, which will, helping the plant breeders to select for lodging resistant trait. The highest mean value for spike length ranked from (6.17 -10.33cm) and (5.17- 8.83cm) for each of accessions (4and 12) under normal and stress irrigation, respectively. Indicate that there was a variation among genotypes studied that contributory plant-breeding program. As for number of spikes/m^2 both of accession 4 and 6 recorded the highest numbers of plant under normal and water deficit irrigation. Regarding too number of kernels /spike showed that Sids 13 and accession 3 obtained the greatest value (50.07 and 50.00) under normal irrigation on the other hand accessions 6 and 5 gave the greatest values (37.73 and 37.08) at water deficit. Meanwhile, accession 12 recorded the lowest values under normal and water deficit irrigation.

As for 100-Kernels weight four genotypes; accessions (4, 3, 5) and Sids13 obtained the greatest values under normal irrigation with values (6.66, 6.11, 6.07 and 6.19), respectively. On the other side, accession 11 recorded the highest values under water deficit irrigation with value (5.93gm) followed by accession 5 and Sids 13. As for protein percentage, the mean values of accession 11 recorded the highest values (12.57) under normal. Meanwhile, four accessions (6, 5, 12 and 13) showed the highest values (14.84, 14.51, 14.46 and 14.15) at water deficit. It was clear that most of the protein percentage increased under water stress and that was applicable for the most genotypes studded. In addition, accessions (5 and 6) recorded the highest values for carbohydrate percentage under normal irrigation and water stress with values (68.22, 66.82) and (68.27, 67.12), respectively. As for ash percentage the accessions (3, 10 and 13 recorded the lowest values (0.53, 0.55 and 0.56) under normal irrigation, respectively. On the other hand, the accessions

Table 2. Mean performance of wheat germplasm under normal and irrigation.

No	DH		DM		PH		SL		No.S/m^2	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
1	118.33	112.00	164.67	162.50	159.83	127.17	7.67	6.33	364.58	347.22
2	113.67	108.67	156.83	151.33	135.83	113.50	8.33	6.67	375.69	334.03
3	106.67	105.00	155.83	150.17	132.17	108.67	8.83	6.33	379.17	363.19
4	109.00	101.67	152.83	150.33	80.00	77.33	6.17	5.17	387.50	365.28
5	110.33	107.00	152.67	147.33	98.67	91.33	7.17	6.33	359.03	352.08
6	110.67	107.00	152.67	146.33	100.67	91.67	7.00	6.50	385.42	369.50
7	112.00	102.00	153.50	144.33	92.33	80.33	8.00	6.67	370.83	352.08
8	108.33	107.00	154.67	145.00	112.67	95.00	7.83	6.83	375.00	350.69
9	117.00	110.67	160.67	154.67	135.83	115.67	10.00	8.33	377.78	340.97
10	119.00	114.00	165.00	164.50	135.50	117.17	6.17	6.00	372.92	353.47
11	119.33	114.33	165.00	160.17	151.67	126.00	9.17	8.50	383.33	362.50
12	116.33	108.33	156.67	151.00	151.67	123.50	10.33	8.83	354.86	343.06
13	117.33	111.67	160.83	157.17	138.00	107.50	6.67	6.33	380.22	359.72
14	109.00	101.67	153.17	147.50	91.83	80.83	9.33	7.83	381.94	363.89
15	107.33	90.00	156.83	150.67	99.33	91.83	8.67	7.67	370.14	351.94
Mean	**112.96**	**106.73**	**157.46**	**152.20**	**121.07**	**103.17**	**8.09**	**6.96**	**374.56**	**353.98**
L.S.D5%	**2.69**	**2.30**	**1.83**	**2.43**	**6.43**	**4.60**	**1.49**	**1.22**	**18.34**	**28.37**

Table 2. Continue.

No.	No.K/S		100- KW		Protein%		Carbo.%		ash%		GW/P	
	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
1	44.20	31.40	5.26	5.29	9.61	12.44	63.77	64.62	1.18	1.22	1.63	1.48
2	37.73	30.53	4.97	5.23	8.12	11.86	63.77	64.67	0.70	1.31	1.33	1.25
3	50.00	36.70	6.11	5.17	7.61	12.14	65.02	65.87	0.53	0.98	2.02	1.61
4	47.63	33.13	6.66	5.09	10.39	12.14	67.22	64.62	0.73	1.41	2.20	1.24
5	48.10	37.08	6.07	5.67	8.92	14.51	68.22	66.82	1.26	1.54	2.00	1.81
6	43.80	37.73	5.99	5.40	9.70	14.84	68.27	67.12	1.37	1.97	2.01	1.93
7	40.10	34.40	5.63	5.23	7.76	12.31	68.17	65.62	0.88	1.28	1.68	1.45
8	42.60	33.23	5.61	5.31	6.93	12.41	64.22	65.37	0.82	0.89	2.16	1.59
9	40.00	32.00	5.50	4.52	6.87	13.99	67.07	65.97	0.69	1.32	1.40	1.04
10	39.87	36.80	5.48	5.30	7.55	12.46	67.62	64.07	0.55	1.01	1.71	1.58
11	44.93	31.97	5.25	5.93	12.57	12.64	66.17	61.82	1.14	1.34	1.48	1.45
12	35.97	29.27	4.61	4.79	8.42	14.46	64.67	63.77	0.80	1.22	1.68	1.29
13	38.77	30.73	5.49	5.05	7.23	14.15	65.97	64.22	0.56	1.28	1.63	1.31
14	50.07	35.00	6.19	5.51	8.65	13.10	67.02	63.67	1.19	1.10	2.35	1.65
15	36.13	27.43	5.67	4.76	8.84	12.47	64.82	64.62	0.83	1.31	1.85	1.07
Mean	**42.66**	**33.16**	**5.63**	**5.22**	**8.61**	**13.06**	**66.13**	**64.81**	**0.88**	**1.28**	**1.81**	**1.45**
L.S.D5%	**7.12**	**8.76**	**1.05**	**0.85**	**0.22**	**0.34**	**0.62**	**0.37**	**0.09**	**0.07**	**0.39**	**0.39**

(8 and 3) showed the lowest values at water deficit. It is clear that protein percentage increased significantly with deficit compared with non-stress condition for the most genotypes. While, the carbohydrate percentage decreased significantly to deficit compared with non-stress condition, indicating that selection for stress tolerance should give a positive yield response under stress. Also, the results indicated that selection under irrigated environment would be less effective for improving grain yield under water deficit than direct selection in the stress condition, Dawwam et al., (2012) and EL-Hosary et al., (2012) found that there were significant increase of protein for the most genotypes, carbohydrate and ash percentage exhibited to abiotic stress. In addition, Kramer (1983) recorded that, carbohydrate and protein metabolism are disturbed under water deficit and this often leads to accumulation of sugar and amino acids.

Regarding grain weight / plot: three genotypes; commercial variety Sids 13 and accessions (4 and 8) obtained the greatest values under normal irrigation with values (2.35kg, 2.20kg and 2.16kg), respectively. On the contrary, both of accessions (6 and 5) showed the highest values (1.93 and 1.81) at water stress. Atlin and Frey (1989) demonstrated that grain yield in stress or low productively environments were not controlled by same genes, making indirect selection unattractive. In addition, results indicated that the mean value of the normal environment of yield and its components was higher than with stress condition.

3.2. Variability and genetic parameters

The estimates of phenotypic variances (σ^2ph), genotypic variances (σ^2g), phenotypic coefficients of variation (P.C.V), genotypic coefficients of variation (G.C.V) and broad sense heritability (H^2) given in Table 3. The estimates of PCV were a highly for ash percentage with values (29.88 and 24.32) followed by plant height with values (21.77 and 21.40), spike length With values (19.48 and 17.52) and grain yield per plot with values (19.68 and 21.46) under normal irrigation and water stress, respectively. Carbohydrate percentage showed a low PCV value (2.54 and 2.11) under normal and water stress irrigation, respectively. A highly GCV for plant height values (21.43 and 21.15) followed by Spike length with values (14.28 and 13.47) and grain yield per plot with values (15.31 and 14.91) under normal and water stress irrigation, respectively.

Table 3. Estimation of genetic parameters for different quantitative traits in wheat germplasm under normal and water stress irrigation.

	DH	DM	PH	SL	No.S/m2	No.K/S	100- KW	Protein%	Carbo.%	ash%	GW/P
					Normal irrigation						
δ^2g	19.50	21.02	673.31	1.33	79.32	19.72	0.13	2.28	2.67	0.07	0.08
δ^2ph	23.24	22.39	694.73	2.48	108.56	29.16	0.53	2.30	2.81	0.07	0.13
PCV	4.27	3.00	21.77	19.48	2.78	12.66	12.97	17.63	2.54	29.88	19.68
GCV	3.91	2.91	21.43	14.28	2.38	10.41	6.48	17.55	2.47	29.00	15.31
H^2	83.90	93.88	96.92	53.69	73.06	67.62	25.00	99.13	95.02	94.23	60.53
					Water stress						
δ^2g	37.75	38.81	476.22	0.88	81.85	0.84	0.04	1.03	1.83	0.07	0.05
δ^2ph	40.50	41.87	487.20	1.48	138.83	26.95	0.30	1.07	1.88	0.10	0.10
PCV	5.96	4.25	21.40	17.52	3.33	15.65	10.50	7.93	2.11	24.32	21.46
GCV	5.76	4.09	21.15	13.47	2.56	2.77	3.83	7.78	2.09	20.20	14.91
H^2	93.21	92.69	97.75	59.13	58.96	3.13	13.33	96.27	97.34	68.97	48.28

δ^2g = Genotypic variance, δ^2ph = Phenotypic variance, PCV = Phenotypic coefficient of variance, GCV = Genotypic coefficient of variance, H² = Broad sense heritability.

Number of spikes per m^2 and carbohydrate percentage showed a low GCV value (2.38 and 2.56) under normal, water stress irrigation. The PCV values were higher than GCV values for all the traits in normal and water stress irrigation. Which indicated that the association between these traits was largely under genetic control and indicated the preponderance of genetic variation in expression of traits (Tsegaye et al. 2012)? Estimates of heritability in the broad sense ranged from (25%) for 100-kernel weight to (99.13%) for protein percentage of normal irrigation, 3.13% for number of kernels per spike to 97.75 for plant height of water stress. Tripathi et al., (2015) reported high heritability estimates for thousand-grain weight and Yahaya (2014) for plant height. Heritability alone provides no indication of the amount of genetic improvement that would result from the selection of individual genotype. Hence, knowledge on heritability coupled with genetic advance is useful Rosmaina et al., (2016).

3.3. Correlation analysis

Correlation coefficients among chemical and yield component traits are presented in table 4. Data revealed that eight positive correlation coefficients observed under normal and water stress irrigation as follows; the correlation Data revealed that coefficients between days to heading each of Days to maturity, days to heading each of plant height, days to maturity each of. Plant height, number of spikes/m^2 each of 100- kernel weight, number of kernels/spike vs. 100- kernel weight, number of kernels/spike vs. Grain weight/plot, 100- kernel weight vs. Grain weight/plot and the last positive correlation coefficient was between Protein percentage vs. Ash percentage of normal and water stress irrigation. Three correlation coefficients found at water stress; the first one was between numbers of kernels/spike each of Number of spikes/m^2. The second one was between grain weight/plot each of. Number of spikes/m2. The third one was between numbers of kernels/spike vs. Carbohydrate percentage.

Table 4. Correlation coefficients between morphological and yield component traits in wheat germplasm under normal and water deficit irrigation.

Normal irrigation	DH	DM	PH	SL	No.S/m^2	No.K/S	100- KW	Protein %	Carbo.%	Ash %	GW/P
DM	0.83**	1.00									
PH	0.76**	0.81**	1.00								
SL	0.04	0.03	0.32	1.00							
No.S/m^2	-0.17	-0.06	-0.28	-0.24	1.00						
No.K/S	-0.40	-0.29	-0.33	-0.15	0.35	1.00					
100- KW	-0.66**	-0.54*	-0.78**	-0.44	0.51*	0.73**	1.00				
Protein %	0.14	0.14	0.00	-0.03	0.22	0.32	0.11	1.00			
Carbo%	-0.04	-0.28	-0.55*	-0.34	0.24	0.30	0.53	0.10	1.00		
Ash %	-0.07	-0.22	-0.22	0.03	-0.08	0.38	0.15	0.58*	0.27	1.00	
GW/P	-0.75**	-0.65**	-0.70**	-0.25	0.21	0.64**	0.77**	0.02	0.25	0.26	1.00
					Water	**r deficit**					
DM	0.60*	1.00									
icit PH	0.72**	0.81**	1.00								
SL	0.01	0.01	0.29	1.00							
No.S/m^2	-0.07	-0.17	-0.34	-0.18	1.00						
No.K/S	0.21	-0.20	-0.25	-0.45	0.62*	1.00					
100- KW	0.30	0.03	-0.03	-0.17	0.59*	0.51*	1.00				
Protein %	0.20	-0.14	-0.01	0.29	0.32	0.15	-0.10	1.00			
Carbo%	-0.11	-0.52*	-0.36	-0.42	0.14	0.54*	-0.15	0.34	1.00		
Ash %	-0.06	-0.21	-0.24	-0.08	0.29	0.15	0.12	0.56*	0.38	1.00	
GW/P	0.21	-0.23	-0.18	-0.31	0.72**	0.83**	0.72**	0.26	0.39	0.21	1.00

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Nevertheless, there were four negative correlation coefficients between 100-kernel weight and plant height and grain weight/plot and plant height under normal irrigation. As well as the association negative correlation between carbohydrate percentage and plant height and grain weight/plot with days to heading under normal irrigation. These results are agreed with Khaliq et al. (2004) and (Nayeem and Baig 2003). (Garcia del Moral et al, 2005) found that the correlation coefficient measures the relationship between two characters and does not indicate the relative importance of each factor. Correlation coefficients show relationships among independent variables. However, it is not sufficient to describe this relationship when the causal relationship among variables is needed (Korkut and Bilir 1993). (Mahdi et al, 2017) showed that grain yield had the highest correlation with harvest index under all conditions, indicating importance of harvest index to improve grain yield.

3.4. Path coefficient analysis

Path coefficient analysis for traits studied of wheat genotypes on the grain yield / plant under normal and water deficit irrigation are presented in table 5. The direct contribution of 100- kernel weight to grain yield was highest (0.78) under normal irrigation followed by number of kernels per spike at water deficit (0.54). Number of kernels per spike also had an appreciable indirect effect via a number of spikes per m2 at water deficit (0.34) followed by 100- kernel weight of water deficit (0.28). 100- Kernel weight had the highest indirect effect an appreciable indirect effect via a number of kernels per spike under normal irrigation (0.57) followed by a number of spikes per m2 under normal irrigation (0.40). The residual effect was 0.36 and 0.18 under normal and water

Table 5. Path coefficients of grain yield and its related characters in wheat genotypes under normal and water deficit irrigation.

Character	Direct effect	Indirect effect		
		No.S/m^2	No.K/S	100- KW
Normal irrigation				
No.S/m^2	-0.24		0.06	0.40
No.K/S	0.16	-0.09		0.57
100- KW	0.78	-0.13	0.12	
Residual effect=0.36				
Water deficit				
No.S/m^2	0.18		0.34	0.20
No.K/S	0.54	0.11		0.17
100- KW	0.34	0.10	0.28	
Residual effect=0.18				

deficit irrigation, respectively, which indicated that some more other traits were responsible for contributing to grain yield but not taken into consideration in the present investigation. The path coefficient analysis appeared as a clue to the contribution of various yield components for grain yield in the genotypes under the study. It provides an effective way of finding out direct and indirect sources of correlation. These results agree with El Shal (2016), Okuyama et al. 2004) found that the grain yield is a complex trait which is influenced by many factors, and plant breeders are interested to know the nature of the relationship and the kind of correlation among traits.

3.5. Principal component analysis

Principal component analysis shows the significance of the major contributor to the total variation in each dimension of differentiation. The eigenvalues help to identify the number of factors to be retained table 6. The results showed that the first two components explained (40.62 and 18.20%) and (32.42% and 22.41%) under normal irrigation and water stress of the total variation. The first component (PC1) mostly was affected dellete by a positive and negative coefficient with values 0.93 for 100-kernel weight and -0.90 for plant height under normal irrigation, plant height and days to maturity with, positive coefficient at water stress.

Table 6. Loadings of PCA for the estimated traits of wheat genotypes under normal and water deficit irrigation.

	Normal irrigation		Water stress	
	PCA 1	**PCA2**	**PCA 1**	**PCA2**
DH	-0.75	0.48	0.39	0.79
DM	-0.75	0.45	0.72	0.52
PH	-0.90	0.24	0.78	0.47
SL	-0.37	-0.14	0.42	-0.20
No.S/m^2	0.45	0.25	-0.63	0.48
No.K/S	0.67	0.37	-0.66	0.58
100- KW	0.93	0.03	-0.26	0.68
Protein %	0.15	0.83	-0.32	0.20
Carbohydrate%	0.58	0.25	-0.71	-0.04
Ash %	0.33	0.59	-0.52	0.13
Eigenvalue	4.06	1.82	3.24	2.24
% variance	40.62	18.20	32.42	22.41
Cumulative %	40.62	58.82	32.42	54.84

The most effective indices in the second component (PC2) were protein and ash percentages with positive coefficients under normal irrigation, days to heading and 100-kernel weight with positive coefficients at water deficit. Mohammed and Kadhem (2017) showed that PCA were significantly inter-correlated with each other indicating that several of the statistics probably measure similar aspects of drought tolerance. Naghavi, et al., (2015)and Naghavi and Khalili (2017)showed that used factor analysis to identify growth and morphological characters relevant to yield in wheat and introduced factors which included yield components, morphological characters, spike length and the number of grain per plant. Also, factor analysis under normal and drought stress, yield components factor with description of high amount from total variation was common that it showed importance of related traits to it.

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الملخص العربي

تقييم بعض التراكيب الوراثية من القمح للتحمل للحرمان المائي باستخدام بعض الصفات الزراعية والمحصولية والكميائية

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أجريت هذه التجربة علي خمسة عشر مورد وراثي من القمح بمحطة بحوث سدس خلال موسمين ٢٠١٧/٢٠١٨ و ٢٠١٨ /٢٠١٩ باستخدام تصميم القطاعات الكاملة العشوائية في تجربتين حقليتين تحت ظروف الري الطبيعي والإجهاد المائي وذلك لدراسة العلاقات المتبادلة والتأثير المباشر وغير المباشر علي صفة المحصول ومكوناته. كانت قيم الاختلاف المظهري عالية لكل من صفات نسبة الرماد، ارتفاع النبات وطول السنبلة ومحصول الحبوب/ قطعة تجريبية تحت ظروف الري الطبيعي والإجهاد المائي. كما كانت قيم الاختلاف الوراثي عالية لصفات إرتفاع النبات، طول السنبلة ومحصول الحبوب / قطعة تجريبية تحت ظروف الري الطبيعي والإجهاد المائي. كما لوحظ وجود ارتباط معنوي موجب بين كلا من ميعاد التزهير و ميعاد النضج ، ميعاد التزهير و ارتفاع النبات ميعاد النضج و ارتفاع النبات ، وعدد السنابل / م ٢ و وزن–١٠٠ حبة ، وعدد الحبوب / السنبلة و وزن–١٠٠ حبة ، وعدد الحبوب / السنبلة و محصول الحبوب/ قطعة تجريبية ، ووزن ١٠٠ حبة و محصول الحبوب/ قطعة تجريبية وأخيرا معامل الارتباط الموجب بين نسبة البروتين ونسبة الرماد تحت ظروف الري و الإجهاد المائي كما أظهرت نتائج معامل المرور أن صفة وزن ١٠٠ حبة كانت ذات التأثير المباشر الأول فى وزن محصول الحبوب/قطعة تجريبية تحت ظروف الري العادي وصفة عدد حبوب السنبلة تحت ظروف الإجهاد المائي. أظهرت النتائج أن التفاعل بين وزن ١٠٠ حبة ومحصول الحبوب ذات تأثير مباشر عالي تحت ظروف الري الطبيعي تبعه عدد الحبوب بالسنبلة تحت ظروف الإجهاد كما أظهر وزن ١٠٠ حبة ذات تأثير غير المباشر لصفة عدد الحبوب للسنبلة تحت ظروف الري العادي، وأيضا كان هناك تأثير غير مباشر مع عدد الحبوب بالسنبلة تبعة صفة عدد السنابل / م ٢ .أظهرت نتائج تحليل المكون الرئيسي أن المكونين الأولين قد أظهر (٤٠.٦٢ ٪ و ١٨.٢٠٪) و (٣٢.٤٢٪ و ٢٢.٤١٪) تحت ظروف الري العادي و الإجهاد المائي على التوالي من التباين الكلي.