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Genetic Stability of Different Genotypes of Bread Wheat (*Triticum aestivum* L.) Grown Under Levels of Nitrogen Fertilizer

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Abstract: Obtaining highly productive and stable varieties through different environments is one of the most important goals sought by plant breeders. A field experiment was carried out to investigate the effect of different nitrogen fertilizer levels on the stability of growth and grain yield in eight cultivars of bread wheat during two growing seasons (2020-2021 and 2021-2022), using split plot arrangement in randomized complete block design (RCBD) with three replications. The results showed that there was a significant response of some genotypes to the levels of nitrogen fertilizer for grain yield and its components during the two growing seasons. The Iba99 genotype was characterized by the highest mean of grain yield, number of grains. spike^{-1} and spike length, followed by the Baghdad2 genotype. The genotypes under study differed in the stability of traits in different environments. Baghdad2 showed the highest stability for important traits such as grain yield, weight of 1000 grains, number of grains spike-1 and spike length, while unstable and responded to different environments for plant height and a number of spikes.m^{-2}. Whereas, Iba99 showed good stability for the spike length and the number of spikes.m^{-2}, with its response to the environments for the other traits under study. Both stability phenotypic and genotypic resultant method and the stability triangle method showed very similar results with Eberhart and Russell method, therefore it is possible to rely on these two methods to estimate the stability of genotypes due to their lower complexity. Consequently, the stable genotypes traits in different environments can be selected and introduced directly into future breeding programs for the purpose of adopting new varieties. Although other genotypes showed superior characteristics of grain yield and its important components, they suffer by responding to different environments, thus they can be included in hybridization breeding programs with local varieties to transfer their desirable traits.

Keywords: Bread wheat, Genetic stability, Genotypic resultant, Nitrogen fertilizer level

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide and occupies the largest agricultural area, high productivity and a significant position in the international food grain trade (Ray *et al.,* 2015). The highest per capita consumption of wheat is throughout all human societies especially in Central Asia, while Western Europe and North America account for half of this consumption (Dror *et al.,* 2020).

The global need for wheat is constantly increasing, and it is expected that the demand for wheat production will increase dramatically, because the world population is expected to reach 9.7 billion people by the next two decades (Barnes, 2022). Recent studies indicated that the world will need one billion tons of wheat to meet the global requirement, compared to the current production, which does not exceed (778.6) million tons (STATISTA, 2022). By 2050, it is predicted that cereal crop production must grow by 940 million Mg in order to meet population demand. (Hatfield & Walthall, 2015)

In Iraq, wheat is one of the important and main crops, and there are great efforts to expand the cultivation of this crop (Abdul Rahman *et al.,* 2023), however, the productivity of the winter season 2021 does not exceed 4,234 thousand tons, on a cultivated area of 2,366 thousand hectares. Consequently, the current productivity does not meet Iraq's need, which exceeds three and a half million tons of wheat annually (Central Statistical Organization, 2022).

Application of modern and different agricultural practices, soil nitrogen is a common plant nutrient for wheat production, therefore the optimal use of nitrogen fertilizers plays an important role in increasing wheat production to meet global demand (Cormier *et al.,* 2016). Worldwide increased use of artificial nitrogen fertilizers has increased the grain yield per unit area (Wang *et al.,* 2021). Besides, the grain yield increases significantly, by improving the main yield components that respond to the availability of nitrogen, such as the number of tillers per plant. The ideal use of nitrogen can be further improved by using hybrids cultivars, selecting high grain yield traits across seasons and different nitrogen levels (Brasier *et al.,* 2020).

The phenotypes of growth and productivity traits are affected by a genetic factor and in partnership with the environment in their expression, which is known as genotype × environment interactions (GEI) (Bassi & Sanchez-Garcia, 2017; Megahed *et al.,* 2022). The response of genotypes to environmental changes makes it difficult for plant breeders to identify superior ones. Therefore, plant breeders resort to paying attention to those that show a lack of environmental genetic interaction, as the genotypes that is selected for a high yield under a specific environmental condition is not always required to be superior to other genotypes under different environmental conditions. Accordingly, selecting genotypes that are characterized by worthy characteristics, high production, and stability in a wide range of varying environmental conditions is the most important goal of most breeding programs (Knapp *et al.,* 2017).

When there is environmental genetic interaction, one of the options available to plant breeders is to use stability analysis to identify the most productive and stable genotypes in their performance. For this reason, several statistical methods were proposed and adopted to study the adaptation and stability of varieties to different environmental conditions; Russel & Eberhart (1966), Singh & Chouhdry (1978) and Bhargava & Srivastava (2019). The current study aims to evaluate new genotypes of bread wheat under different environmental conditions of nitrogen fertilization through two agricultural seasons to determine their response and stability to different environments by adopting different stability parameters.

Materials & Methods

The study was carried out in a field in Babylon Governorate, Iraq on 1st December for two seasons 2020-2021 and 2021-2022, with seeding rate of 160 $kg.ha^{-1}$ (Bander & Al-Hilfy, 2022). Each experiment included two factors, the first factor is three levels of nitrogen fertilizer (urea fertilizer, 46% N) at levels of 0, 140, 220 $kg.ha^{-1}$, added in two batches, the first at planting day and the second after a month of planting). The second factor included eight genotypes of bread wheat (*Tritcum aestivum* L.), namely: Furat, Rashid, Baghdad1, Abu-Ghraib, Babil, Faris, Baghdad2 and Iba99. A split plot arrangement was used in a randomized complete block design (RCBD) with three replications. Nitrogen fertilizer levels included the main plots and the genotypes occupied sub plots. Each single experimental unit contained four lines of 2.5 m in length. The triple superphosphate fertilizer P_2O_5 used as a source of phosphorus at a rate of 200 $kg.ha^{-1}$. Crop managing included weed control and irrigation were carried out as needed. Field soil was analyzed and their contents estimated from some physical and chemical properties before planting (Table 1.). At maturity, data were recorded for plant height (cm), spike length (cm), Number of $spikes.plant^{-1}$, number of grains.spike-1, weight of 1000 grains (g) and grain yield ($kg.h^{-1}$).

Several methods were used to determine the genetic stability of selected genotypes included six environments resulting from three levels of nitrogen during the two cultivation seasons. The first method used Eberhart & Russell (1966) according as the following linear regression model: $Yij = \mu + biIj + \delta ij + eij$, where, ***Yij*** represents genotype mean ***i*** in Environment ***j***, μ is the mean of all varieties in all the environment, ***bi*** is genotype regression coefficient of ***i*** at specific environmental index, which means the response genotypes to changes of environments, and ***Ij*** is the environmental index, defined as the deviation of the all genotypes mean in a specific environment over general averages and ***δij*** represented deviation from the regression of genotype ***i*** by environment ***j*** and ***eij*** characterize experimental error.

Table (1): Some physical and chemical properties of the field soil during two seasons (2020-2021 and 2021-2022).

Properties	Unit	2021	2022
pH 1:1	-	7.3	7.5
E.C. 1:1	$ds\,cm^{-1}$	2.5	2.36
Nitrogen	$mg.kg^{-1}$	1.3	1.6
Potassium	$mg.kg^{-1}$	169.0	177
Phosphorous	$mg.kg^{-1}$	7	8
Organic matter	$mg.kg^{-1}$	1.4	1.2
$CaSO_4$	$mg.kg^{-1}$	0.237	0.344
Sand	$g.kg^{-1}$	382.0	
Slit	$g.kg^{-1}$	344.0	Texture
Clay	$g.kg^{-1}$	274.0	Loam

A combined analysis of the variance of data for traits across seasons performed according to the experimental design method used (eight genotypes and six environments). Thus, the differences between genotype mean were compared by Duncan's multiple range test and the three levels nitrogen were compared according least significant difference (LSD) test at the probability level of 0.05 (Ireland, 2010).

Based on Singh & Chaudhary (1978) two parameters of genetic stability were measured as follows: (1) coefficient of regression representing the regressive behavior for single genotype in different environments, which estimated by equation: $bi = \Sigma\, Yij\, Ij / \Sigma\, Ij^2$, where: $\Sigma\, Yij\, Ij$ represents the sum of the multiplication resultants and $\Sigma\, Ij^2$ is the sum of squares and (2) the mean deviation from the linear regression (S^2di) which represents: $[\Sigma\, \delta ij^2 /s\text{-}2)] - S^2e/r$, where $\Sigma\, \delta ij^2 = [\Sigma\, Yij^2 - Yi2/t] - (\Sigma\, Yij\, Ij)^2 / \Sigma Ij^2$ and S^2e is the pooled error. The regression coefficients significant were tested for the items and each trait by **t-test**. Linear response to environmental change measured by the linear regression coefficient of the relationship between each trait of the genotype traits in each environment and the yield and response of each trait from the environmental mean, therefore, the mean of deviation from regression (S^2di) is a measure of heterogeneity. The response of genotypes and the stability of their traits are determined as follows: If (1) S^2di = *zero* and **bi > 1** indicates the response of genotype to suitable environmental conditions, and (2) S^2di = *zero* and **bi = 1** represents the genotype had highly stable and low respond to environmental changes, and (3) $S^2di = 0$ and **bi < 1** indicates that the genotype had response to the poor environmental conditions, and (4) $S^2di > 0$ linear prediction is impaired.

The second method was used as suggested by Finlay & Wilkinson (1963) and adopted by Al Falahi *et al.* (2021) to estimate genotypes stability, where genotypes are distributed according to the values of the regression coefficient and the averages of each trait in the stability triangle. So that the genotypes located near the end of the top of the triangle are very adaptable to all environments. The genotypes located in the upper corner of the base, it adapted to the preferred environments. While genotypes placed in the far left of the stability line of the mean are poorly adapted to different environments. As for those located below the triangle and to the left, they are adapted to unfavorable environments.

The third method was used as suggested by Elsahookie (1985). Where the genotypic resultant (GR) value for each genotype measured as follows, **GR=(PS)(yi. /y..)**, where PS represents the phenotypic stability **PS=1-(S/yi.)**, where S represents standard division, **yi.** is genotype mean over environments and **y..** is general mean of trait. According to this method, the genotype stability increases when the value of phenotypic stability (PS) is close to 85%. All statistical analyses were performed using the prepackaged programs, GenStat program 12th edition and OPSTAT Website, furthermore, Microsoft Office Excel 2016.

Results & Discussion

The combined variance analysis of bread wheat genotypes grown under three nitrogen fertilizer levels during two seasons (Table 2). The results of seasons (S) showed highly significant differences at probability level 0.01 for all traits. Also, nitrogen levels (N) effect showed highly significant differences for all traits under study. The interaction of season and nitrogen levels (S×N) were high significant difference for all traits at 0.01 expect number of spike.m^{-2} was not significant. This indicates that the traits of some wheat genotypes may superior of their performance relatively on some nitrogen levels and in some seasons than in other seasons. The results of this study agree with the findings of (Ali, 2017; Ibrahim & Said, 2020; Nyol *et al.*, 2020; Said *et al.*, 2020)

Furthermore, genotypes (G) showed high significantly differences for all traits. These significant differences among genotypes are a very imperative indicator that they are genetically different, due to genetic factors that may control the traits inheritance of these genotypes (Kumar *et al.,* 2021).

Regarding to the interactions between genotypes and seasons (G×S) showed significantly different at the probability level of 0.01 for all traits expect spike length and number of grains.$spike^{-2}$ was significant at 0.05. While, interactions between genotypes and seasons (G×N) showed significant different at the probability level of 0.01 for all traits. Russell *et al.* (2017) indicated that the genotypes × N levels interactions were significant.

The triple interaction genotypes, season and nitrogen levels (G×S×N) showed significant differences at 0.01 for all traits except the number of spikes.m^{-2} which was at 0.05. The variance of this source indicates that some genotypes may enhance the production in some seasons with some nitrogen level than others. Therefore, before selecting a genotype with a desired target trait, several analyzes should be performed for the purpose of ascertaining the adaptability and stability of the genotypes. Thus, these results are encouraging to continue the search for superior and stable genotypes to be tested in multiple environments. These results are comparable with the findings of (Ibrahim & Said, 2020; Kumar *et al.* 2021; Bouchareb & Guendouz, 2022) in their study at different environments.

Table (2): Combined analysis of variance for eight bread wheat genotypes grown under three nitrogen levels replicated over two seasons (2020-2021 and 2021-2022).

S.O.V	d.f	Mean squares for traits					
		Plant height (cm)	Spike length (cm)	Number of spikes. m^{-2}	Number of grains. spike^{-1}	1000 grain weight (g)	Grain yield (kg.ha^{-1})
Seasons (S)	1	8372.3**	5.889**	136255.4**	26.1**	36.8**	19481983**
Nitrogen (N)	2	1230.7**	23.33**	76311.6**	615.9**	317.4**	20438931**
S × N	2	16.2**	1.206**	313.1n.s	33.8**	8.78**	77686117**
Rep. (Env.)	12	2.72	0.060	162.6	1.05	0.56	8440
Genotype (G)	7	2195.8**	23.71**	156197.7**	607.8**	606.5**	41149292**
G × S	7	161.9**	0.289*	2363.6**	2.49*	31.46**	723709**
G × N	14	20.0**	1.644**	4137.1**	40.9**	18.32**	567820**
G × S × N	14	30.2**	0.712**	863.8*	10.5**	3.339**	888509**
Error	84	3.33	0.099	461.3	1.02	0.753	16623

(**) and (*) represent a significant at probability level of 0.01 and 0.05, respectively.

Table (3) showed nitrogen levels means in two seasons for traits in bread wheat genotypes. First season 2020-2021 (S1) exhibited superior in most traits values compared to second season 2021-2022 (S2) over three nitrogen levels. Besides, the high level nitrogen (220 kg.h^{-1}) applied showed the highest means of all traits using in this study compared to other two nitrogen levels (0 and 140 kg.h^{-1}). The response of the genotypes to the fertilizer increases gives an opportunity to increase the production in wheat yield when using additional amounts and more than the highest amount which it used (220 kg.h^{-1}) in this study. Brasier *et al.* (2020) observed for grain yield when three or more N rates additions. Russell *et al.* (2017) mentioned that reduced N levels had no negative effect on grain yield for any genotype.

Table (3): Means of nitrogen levels over two seasons (2020-2021 and 2021-2022) for traits in bread wheat genotypes.

Nitrogen levels (N)	Traits means											
	Plant height (cm)		Spike length (cm)		Number of spikes. m^{-2}		Number of grains. $spike^{-1}$		1000 grain weight (g)		Grain yield ($kg.ha^{-1}$)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
0 $Kg.h^{-1}$	95.3	79.6	9.6	8.89	287.4	231.7	30.5	31.3	35.8	34.4	3,342	5,530
140 $Kg.h^{-1}$	100.9	84.5	9.9	9.8	330.5	267.0	36.2	35.5	37.4	37.4	4,558	2,613
220 $Kg.h^{-1}$	104.4	90.7	10.8	10.5	371.9	306.6	36.6	39.1	41.0	39.5	6,093	3,644
Mean(S)	100.2	84.9	10.1	9.7	329.9	268.4	34.4	35.3	38.1	37.1	4,665	3,929
$LSD_{0.05}$ (S)	1.038		0.154		8.020		0.645		0.471		57.788	
$LSD_{0.05}$ (N)	1.271		0.189		9.823		0.789		0.577		70.776	

The value of the difference between two means is greater than the LSD value is significant at 0.05. Where, S1 is 2020-2021 season and S2 is 2021-2022 season.

We can conclude from the results above that the high effect of genotypes and environmental and genetic interactions indicate the presence of different environmental groups for each of the genotypes. It should be taken into consideration that selecting the optimum fertilizer amount at each season to keep pace with the changing field conditions and the current and expected climatic changes can determine the optimal conditions at different times during the season and across different years. If the optimum cultivation requirements are met, the wheat (local variety) grown has the highest yield and grain quality potential and has the greatest chance of producing a successful wheat crop. Some of the current elite genotypes had encouraging results and could have a impeccable position as promising varieties in the future if they were tested in different studies under different experimental conditions. Brasier et al., 2021; Hitz *et al.*, 2017; Russell *et al.* 2017 ; Al-Falahi *et al.* 2021; Brasier *et al.*, 2021) pointed a significant difference in the performance of genotypes under the effect of nitrogen fertilization.

The results of table (4) shows the pooled variance analysis of genotypes in different environments using the Eberhart & Russell (1966) method for the traits of the grain yield and some of its components. The mean squares of the linear environments for all traits had high significant differences. The source significance indicates the response to changed environments genetically controlled (Krupal *et al.,* 2018).

Besides, the mean squares of the linear component of the of genotype × environment interaction against to pooled deviation exhibited high significant differences at the probability level of 0.01 for a plant length, No. grain $spike^{-1}$, 1000 grain weight and grain yield. Whereas, the mean squares of the pooled deviation for spike length had not significantly differences, this means that the base component of genotypes stability for this trait is based on the linear regression and its predicting is possible (Naheed & Rahman, 2021).

The mean squares of the linear component of genotypes × environments interaction for the number of $spikes.m^{-2}$ had not significant differences, while the pooled deviation error was significant. This means that the deviation from the linear function gives to the deviation in the stability of the traits of the genotypes. Generally, deviation from the linear function is one of the most important parameters of the stability. However, other traits were significant for both components, which means that the differences in the stability of genotypes are attributed to both linear regression and deviation from the linear function. Whereas, the pooled deviation was significant for the spike length trait, but its pooled error is not significant, this indicates that the main component of the differences in the stability of the genotypes for this trait is due to linear regression and that its predictability is possible (Singh & Chaudhary, 1978).

Table (4): Pooled variance of stability analysis for eight bread wheat genotypes in six environments.

S.O.V	d.f	M.S for traits					
		Plant height (cm)	Spike length (cm)	Number of spikes. m^{-2}	Number of grains. $spike^{-1}$	1000 grain weight (g)	Grain yield ($kg.ha^{-1}$)
Verities (Var.)	7	731.94**	7.903**	52065.6**	202.61**	202.15**	13716530**
Environments(Env.)	5	725.48**	3.664**	19299.8**	88.38**	45.95**	14382273**
Var.× Env.	35	19.04	0.333	824.44	7.021	4.986	242405
Env.+Var. ×Env.	40	107.35	0.750	3133.9	17.19	10.106	2009889
Env. (Linear)	1	3627.42**	18.320**	96499.4**	441.91**	229.73**	71911365**
Env.×Var.(Linear)	7	52.04**	0.751**	761.33	20.08**	11.87**	536855**
Pooled deviation	32	9.443**	0.200n.s	735.19	3.286**	2.858**	147694**
Pooled Error	84	3.325	0.099	461.25	1.021	0.753	16621

(**) and (*) are significant probability level at 0.01 and 0.05, respectively.

According to Eberhart & Russell (1966) method have used in current study, there are two main components, the first is linear (the coefficient of regression bi) and the second, is nonlinear (deviation from the regression S^2di), these two components are essential in determining the stability of genotypes. Generally, when the regression coefficient is close to one followed by value of deviation from the regression equal to zero, in this case, the genotypes exhibit high stability with a low response to environmental changes Whereas the value of the regression coefficient is greater than one indicates the genotypes are termed highly responsive to changes in the environment and acclimating to suitable environments. While, the regression coefficient value is less than one means that the genotypes might be resistant to changes in environments, increasing the adaptation limitation and response to poor production environments.

The values of the regression coefficients that resulted from the linear regression of the average of any of the six traits for any genotype from the average of all genotypes in each environment ranged between 0.76 -1.81 for plant height, 0.26-1.82 for the spike length; 0.66-1.46 for the number of spikes.m^{-2}; 0.23-1.83 for number of grain $spike^{-1}$; 0.26-2.06 for the weight of 1000 grain and 0.62-1.43 for the grain yield. These large changes in the regression coefficients, especially for the characteristics of the spike length, number of grain in spike and the weight of 1000 grain indicate that the different responses of the genotypes to the environmental changes (Tables 5, 6 and 7).

The present study showed that the highest means for the plant height were for Furat genotype (115.6 cm), whereas, Abu-Ghraib genotype had 82.50 cm plant height, but it did not differ significantly from genotype Babil (83.00 cm). However, the genotypes Rashid, Abu-Ghraib, Babil and Faris showed regression coefficients not significant from one (***bi*** = 1) and the deviation from the regression from zero (S^2di = 0) was significant, this indicate those genotypes an unstable response to the environments. Whereas, the other genotypes showed significant differences for both regression coefficients and deviation from the regression, which indicate that those genotypes have a non-stable response to the different environments and linear prediction is impaired.

The method proposed by Elsahookie (1985) in the same table (5), the genotype Furat showed a coefficient of phenotypic stability by 0.85 and genotypic resultant close to 1.0, the highest value for the coefficient of variation was 15 29 with the highest average of plant height 115.6 cm, this indicates the high stability of this genotype. While Rashid, Abu-Ghraib, Babil and Faris genotypes showed phenotypic stability very close to 0.85.

These results agree with those obtained from the stability triangle in the manner explained by Al Falahi *et al.* (2021) and illustrated in fig. (1.A). It is noted that the genotype of Baghdad2 was close to the regression line and located to the right of the average inside the triangle, indicating its high stability. However, other genotypes placed to the left and inside the triangle, indicating that they have medium to weak stability. While the genotype (Furat) placed to the right of the triangle and outside the triangle, which indicates its response to favorable environments.

For the spike length (Table 5), the genotype Iba99 had the longest spike length (12.14 cm), which is significantly different from all other genotypes. While, Abu-Ghraib showed the lowest spike length (8.69 cm). The genotypes (Faris and Iba99) had non-significant for both regression coefficients from one (***bi*** = 1) and deviation from zero (S^2di = 0), which indicates that they are characterized by their high stability for spike length.

Table (5): Stability parameters of plant height and spike length in eight bread wheat genotypes in six environments.

Genotypes	Plant height (cm)						Spike length (cm)					
	Mean	***Bi***	S^2di	**C.V%**	**PS**	**GR**	**Mean**	***Bi***	S^2di	**C.V%**	**PS**	**GR**
Furat	115.6a	1.81*	16.91*	15.29	0.85	1.06	9.65c	0.61*	-0.01	4.51	0.96	0.93
Rashid	92.9c	0.96	6.19*	10.14	0.89	0.90	9.37d	0.58*	0.01	4.68	0.95	0.90
Baghdad1	91.6d	0.78*	0.28*	8.21	0.92	0.91	9.79c	1.82*	0.06	12.86	0.87	0.86
Abu-Ghraib	82.5g	0.95	2.50*	11.10	0.89	0.79	8.69e	1.50*	0.29	13.13	0.87	0.76
Babil	83.0g	0.99	0.69*	11.42	0.88	0.79	9.74c	0.50*	0.54	7.76	0.92	0.91
Faris	87.8e	0.91	3.84*	10.11	0.89	0.85	8.88e	1.29	0.08	10.45	0.89	0.80
Baghdad2	100.7b	0.85*	34.65*	9.63	0.90	0.98	11.04b	1.42*	0.29	9.86	0.90	1.00
Iba99	86.2f	0.76*	1.61*	8.55	0.92	0.85	12.14a	0.26	0.07	2.81	0.97	1.19
S.E (*Bi*)		0.144						0.296				

(*) represents a significant at probability level of 0.05. The values followed by the different letters for each trait are significantly different from each other (Duncan test at 0.05), *Bi* is regression coefficient, S^2di is deviation from the regression C.V% is coefficient variance, PS is phenotypic stability and GR is genotypic resultant.

From the same table (5) above, the genotypes of Baghdad1, Abu-Ghraib and Faris showed the closest values of the phenotypic stability coefficient of 0.85 and the value of the genotypic resultant less than 1.0 and high values of the coefficient of variation were 12.82, 13.13 and 10.45, respectively, with an average spike length low, this indicates the high stability of the three genotypes. While the genotype of Iba99 had the highest mean for this trait 12.14 cm, with the lowest value for the coefficient of variation was 2.81, the coefficient for phenotypic stability was 0.97, and the genotypic resultant was 1.19.

These results agree with the triangle of environments in the way in fig. (1b), as it is noted that Faris genotype is located inside the triangle and on the left side of the average, this indicates its stability for the spike length. While the two genotypes, Iba99 and Baghdad2, were closest to the regression line and placed to the right of the average and outside the triangle, which indicates its response to favorable environments.

It is also noted from table (6) that the highest number of spikes.m^{-2} was for the Baghdad2 genotype (510.8) and differed significantly from all other genotypes. While, the lowest spikes.m^{-2} was for genotypes (Rashid and Faris) with values of 218.1 and 211.3, respectively. The genotypes (Rashid and Iba99) showed non-significant for both regression coefficients and deviation from regression, which means these genotypes had high stability under different environments. Whereas, The (Baghdad1, Abu-Ghraib and Faris) had regression coefficients more than one (***bi*** > 1) and non-significant deviation from the regression (S^2di = 0), this means those genotypes responses to suitable environments. Whereas, Furat, Rashid and Babil had regression coefficients less than one and non-significant deviation from the regression, this indicates those genotypes responses to poor environments.

These results agreed with the method used by Elsahookie (1985) in the same table (6). The genotype of Iba99 showed phenotypic stability and genotypic resultant reached 0.85, the lowest value for the coefficient of variation was 7.17 with an average of 302.6. This indicates the high stability of this genotype. While, Furat, Babil and Faris had low values for the number of spikes.m^{-2} were 276.4, 211.3, and 285.1 respectively. The values of phenotypic stability were 0.75, 0.76, and 0.69, with a high coefficient of difference of 24.79, 23.89, and 30.88, respectively. This indicates that these genotypes are the least stable among the genotypes used in the study. Whereas, the other genotypes had stability for this trait that could not be predicted in different environments, especially for the Baghdad2, because its phenotypic stability values were far from the stability value of 0.85.

These results are comparable with those obtained from the stability triangle in the manner shown by Al Falahi *et al.* (2021) and illustrated in Figure (1.C), where the genotype of Iba99 was closest to the regression line, this indicates its high stability the number of spikes.m^{-2}. While, Baghdad2 was the closest from the regression line and located to the right of the average and outside the triangle, indicating its weak stability and responding to different environments. However, other genotypes were located to the left of average and inside the triangle, indicating that they have medium stability.

The genotypes showed different averages for the number of grain per spike, which ranged between the highest average (46.37) for the Iba99 genotype and the lowest average (27.55) for the Baghdad2 genotype. The genotype (Baghdad2) showed non-significant for both regression coefficients (***bi*** <1) and deviation from regression zero (S^2di = 0), this indicates the genotype less response to environmental changes and have a high stability for this trait. Whereas, the other genotypes showed significant differences for both regression coefficients and deviation from the regression, which indicate that those genotypes have a non-stable response to the different environments and linear prediction is impaired.

These results were similar to the method proposed by Elsahookie (1985), where the Baghdad2 genotype showed the closest values of the phenotypic stability coefficient was 0.86, the value of the genotypic resultant was close to 1.0, and the lowest value for the variation coefficient was 3.18, this indicates the high stability of the Baghdad2. While the genotype of Iba99 had the highest mean for this trait by 46.37, the lowest value for the coefficient of variation was 3.28, the coefficient for phenotypic stability was 0.97, and the genotypic resultant was 1.29. These results agree with the environments triangle Figure (1.D), Baghdad2 placed inside the triangle, on the regression line, on the left side of the mean line, this indicates its good stability for the number of grains.spike^{-1}. Whereas, Rashid, Abu-Ghraib and Iba99, were located to the right of the mean and outside the triangle, which indicates its response to favorable environments.

Table (6): Stability parameters of number of spikes.m^{-2} and number of grains.spike^{-1} in eight bread wheat genotypes in six environments.

Genotypes	Number of spikes.m^{-2}						Number of grains.spike^{-1}					
	Mean	*Bi*	S^2di	C.V%	PS	GR	Mean	*Bi*	S^2di	C.V%	PS	GR
Furat	276.4c	1.26*	391.8*	24.79	0.75	0.69	30.41g	0.60*	3.82*	8.89	0.91	0.79
Rashid	218.1d	0.84	-47.1	19.28	0.81	0.59	38.65b	1.49*	3.13*	13.57	0.89	0.81
Baghdad1	315.8b	0.92	165.1*	15.17	0.85	0.89	32.79e	1.83*	4.73*	19.53	0.81	0.76
Abu-Ghraib	273.5c	0.89	182.4*	17.145	0.83	0.756	35.11d	1.67*	8.58*	17.53	0.83	0.83
Babil	211.3d	0.98	148.4*	23.89	0.76	0.54	36.27c	0.78	1.46*	7.85	0.92	0.96
Faris	285.1c	1.46*	885.6*	30.88	0.69	0.66	27.55h	1.01	1.57*	11.19	0.97	0.77
Baghdad2	410.8a	0.66*	189.1*	7.17	0.93	1.59	31.71f	0.23	-0.14	3.18	0.86	0.96
Iba99	302.6b	0.98	36.32	16.45	0.84	0.85	46.37a	0.39*	0.42*	3.28	0.97	1.29
S.E (*Bi*)		0.144						0.244				

(*) represents a significant at probability level of 0.05. The values followed by the different letters for each trait are significantly different from each other (Duncan test at 0.05), *Bi* is regression coefficient, S^2di is deviation from the regression C.V% is coefficient variance, PS is phenotypic stability and GR is genotypic resultant.

The genotypes showed different averages for the weight of 1000 grain (Table 7), which ranged between the highest mean by (43.66 g) for the Baghdad2 genotype and the lowest average (30.05) for the Furat genotype. The genotype (Baghdad2) showed significant regression coefficients (***bi*** <1) and non-significant for deviation from regression zero (S^2di = 0), this indicates the genotype less response to environmental changes and have a high stability for 1000 grain weight. While, Furat, Rashid and Iba99 genotypes showed significant differences for both regression coefficients and deviation from the regression, which indicate that those genotypes have a non-stable response to the different environments and linear prediction is impaired. Furthermore, Baghdad1, Abu-

Ghraib, Babil and Faris showed non-significant differences for regression coefficients and significant differences deviation from the regression, which indicate that those genotypes have a response to the different environments and less stability for this trait.

The above results similar with the results of the method proposed by Elsahookie (1985) in the same table (9). The genotype of Baghdad2 showed a coefficient of phenotypic stability that was closest to stability according to this method (0.85) with the highest average weight of 1000 grain reaching 43.66 g, this indicates the high stability of this genotype. Iba99, Rashid, Baghdad1 and Babil genotypes showed high values for an average weight of 1000 grain close to 40 g, with phenotypic stability values of 0.90 and coefficient of variation close to 10. This indicates that these genotypes respond to differences in environments that cannot be predicted in different environments.

Stability triangle method results that explained by Al Falahi *et al.* (2021) and illustrated by Figure (1.E), where the Baghdad2 was closest to the regression line and located to the right of the line within the triangle, this indicates its high stability for the weight of 1000 grains, followed by the genotype Baghdad1. Whereas, Iba99 was close from the regression line and placed to the right of the average and outside the triangle, indicating its weak stability and responding to different environments.

From the same table (7) the grain yield trait of the Iba99 genotype had 6,664 kg.ha^{-1} and significantly differences from the all genotypes used in this study, while the genotype (Faris) had the lowest grain yield (2,911 kg.ha^{-1}). Baghdad2 exhibited non-significant regression coefficients of less than one ($\boldsymbol{bi}$=1) and a non-significant deviation from zero ($\boldsymbol{S^2di}$=0), which means that they are less responsive to environmental changes. Whereas the Furat, Abu-Ghraib, Babil and Iba99 showed non-significant from one ($\boldsymbol{bi}$<1) of the regression coefficients and significant from the deviation of the regression ($\boldsymbol{S^2di}\neq 0$), this indicates that they have response to the unsuitable and poor environments. Whereas, other genotypes (Rashid, Baghdad1 and Faris) had significant for both regression coefficients and deviation from the regression, indicating that they are characterized by a non-stable response to the different environments and its linear prediction is not possible.

These findings corroborated the findings of the method proposed by Elsahookie (1985) in the same table (7). Baghdad2 genotype showed a coefficient of optimal phenotypic stability amounted to 0.85, genotypic resultant was 0.93 and the lowest value for the coefficient of variation was 14.67, with a grain yield of 6,518 kg.ha^{-1}. This indicates that Baghdad2 have high stability. While the genotype of Iba99 had the highest grain yield of 6,664 kg.ha^{-1}, with values of phenotypic stability of 0.84 with a coefficient of variation of 14.67.

The results presented above are consistent with the findings of environments triangle method that obtained by Al Falahi *et al.* (2021) and illustrated by Figure (1.F), where the genotype (Baghdad2) was close to the regression line and located to the right of the mean line and within the triangle, and this indicates its high stability for the trait followed by genotype Baghdad1. While the genotype of Iba99 was closest from the regression line and located to the right of the average and outside the triangle, indicating its weak stability and responding to different environments

Eberhart & Russell (1966) indicated that the two components, linear (the regression coefficient *bi*) and non-linear (the deviation from the regression $\boldsymbol{S^2di}$), are both important in refereeing the stability of genotypes. When the regression coefficient is close to one and is associated with a value of deviation from the regression equal to zero, this means the genotypes have a low response to environmental changes and high stability Bhargava & Srivastava (2019). When the regression coefficient is greater than one, the genotypes described as being highly sensitive to environmental changes and adapting to highly favorable environments. Nonetheless, the regression coefficient is less than one, it is evidence that the genotypes have a tolerance to environmental changes and that it increases the limitation of adaptation to poorly yield environments.

The linear regression of the average of any of the six traits of a single genotype over the average of all genotypes in each environment resulted in regression coefficient values that ranged between 0.647-3.244 for the number of days to 50% flowering; 0.256-2.881 (day) for plant height, 0.619-2.126 (cm) for the panicle length; 0.504-1.771 (gm) for the weight of 1000 grains, 0.379 and 1.158 (day) for the number of days until physiological maturity and between 1.138 and 1.561 (ton.ha^{-1}) for the grain yield. These large changes in the regression coefficients, especially for the characteristics of the number of days to flowering 50%, plant height and the number of days until physiological maturity indicate the different responses of the genotypes to environmental changes (Table 7).

Table (7): Stability parameters of 1000 grain weight and grain yield in eight bread wheat genotypes in six environments.

Genotypes	1000 grain weight (g)						Grain yield (kg.ha^{-1})					
	Mean	*Bi*	***S²di***	C.V%	PS	GR	Mean	*Bi*	***S²di***	C.V%	PS	GR
Furat	30.05a	2.06*	4.56*	17.64	0.82	0.66	3,089f	0.87	0.31*	29.15	0.71	0.66
Rashid	39.52d	0.26*	1.82*	3.61	0.96	1.01	3,633d	0.62*	0.09*	21.40	0.89	0.77
Baghdad1	41.16c	1.06	0.98*	6.63	0.93	1.02	4,662c	1.43*	0.17*	27.01	0.81	0.79
Abu-Ghraib	31.20e	0.71	1.85*	6.86	0.93	0.77	3,255e	0.86	0.02*	25.15	0.82	0.88
Babil	42.19b	0.71	0.79*	4.57	0.95	1.07	3,640d	1.04	0.15*	29.25	0.96	1.31
Faris	30.89e	0.99	7.18*	11.01	0.89	0.73	2,911g	1.39*	0.19*	33.43	0.76	0.88
Baghdad2	43.66a	0.39*	-0.02	2.36	0.88	1.13	6,518b	0.89	0.04	14.62	0.85	0.93
Iba99	41.93b	1.83*	3.71*	11.28	0.89	0.99	6,664a	0.88	0.16*	14.67	0.84	1.09
S.E (*Bi*)		0.315						0.128				

(*) represents a significant at probability level of 0.05. The values followed by the different letters for each trait are significantly different from each other (Duncan test at 0.05), *Bi* is regression coefficient, ***S²di*** is deviation from the regression C.V% is coefficient variance, PS is phenotypic stability and GR is genotypic resultant.

The present study showed that the lowest averages for the number of days until flowering 50% were for T93 genotype by 98.417 days earlier in maturity, but it did not differ significantly from genotype K2 (98.667 days). However, the genotypes T93, K2, T65, Anber33 and Ghader showed regression coefficients not significant from one (***bi*** = 1) and significant for the deviation from the regression from zero (***S²di*** = 0), which means that they have an unstable response to the environments.

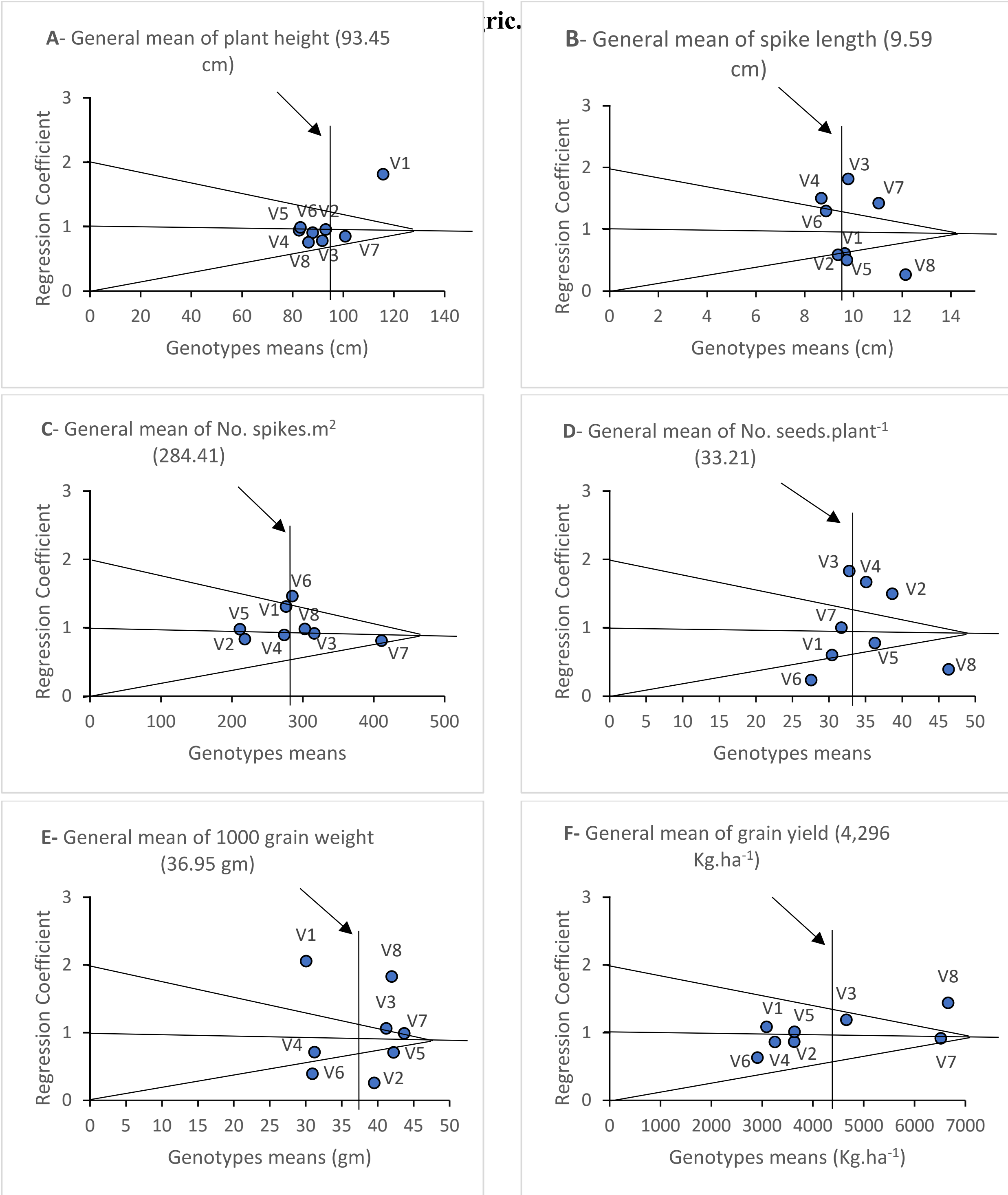

Fig. (1): Distribution of genotypes in the stability triangle for the traits. Where: A- plant height (cm), B- spike length (cm), C- number of spikes. m^{-2}, D- number of grains. spike^{-1}, E- 1000 grain weight (g), F-grain yield (kg. h^{-1}). Furat (V1), Rashid (V2), Baghdad1 (V3), Abu-Ghraib (V4), Babil (V5), Faris (6), Baghdad2 (7) and Iba99 (V8).

While the Forat1 genotype exhibited non significance for both regression coefficients and deviation from the regression, which indicates that it responds to suitable environments.

The plant height trait showed averages that ranged from the lowest plant height was Forat1

(83.42 cm), which differed significantly from all the genotypes, whereas, the highest plant height was Anber33 genotype (136.17 cm). The T94, K2 and T65 genotypes were the lowest in the height of the plant (92.08, 93.33 and 94.58 cm) respectively. The genotypes (T65 and T94) had significant regression coefficients for one and non-significant for the rest of the genotypes, with a significant deviation from the regression coefficients for all genotypes. These results indicate that they were non-stable and responsive to different environments.

A summary of the results of the stability parameters according of the Eberhart & Russell (1966) method, which were compared with other two different stability methods that used in current study, the first method was proposed by Elsahookie (1985) and the second method explained by Al Falahi *et al.* (2021). The genotypes under study exhibited differences in the stability of their traits over environments. The genotypes (Iba99, Baghdad2, and Baghdad1) were characterized by the highest yields of grain, reaching 6,664, 6,518, and 4,662 kg.ha^{-1}, respectively. Whereas, Baghdad2 had the highest stability for important traits such as grain yield, weight of 1000 grain, number of grains.spike^{-1}, and spike length, while its performance regarding plant height and number of spikes. m^{-2} was unstable and responded to different environments. The genotype of Iba99 stats second in terms of good stability for spike length and number of spikes.m^{-2}. However, the Baghdad1 showed high stability in the traits of grain yield, weight of 1000 grains, and number of spikes. m^{-2}.

There was a great convergence in the results of the three methods that were used in the current study, which provides an opportunity to select one of these methods with high efficiency to know the stability of genotypes in different environments. Singh *et al.* (2020) found two from 50 genotypes showed the most stable genotypes based on three methods. Whereas, Said *et al.* (2020) found grain yield was stable only in Eberhart & Russell method and unstable in Tai method. Also, Naheed & Rahman (2021) indicated a difference in the stability of traits; grains spike^{-1}, tillers.m^{-2} and grain weight for 35 genotypes used by three different stability models. Happ *et al.* (2021) referred to results similar to the current study that when trying to modify G×E interactions in different genotypes, the lack of cross results between different methodologies confirms the importance and possibility of using stabilization methods in many different cases.

Conclusions

The results of the current study showed a clear response of some genotypes to the increases in nitrogen fertilizer applications for grain yield and its components. The genotype of Iba99 exhibited superiority in grain yield, number of grains.spike^{-1} and spike length. Baghdad2 genotype followed in second term of grain yield, but Baghdad2 had the highest means for the number of spikes.m^{-2} and weight of 1000.

In addition, the genotypes under study differed in the stability of their different traits. Although, Baghdad2 had a lower grain yield than Iba99, but it showed the highest stability for important traits such as grain yield, weight of 1000 grains, number of grains.spike^{-1} and spike length, while its performance regarding plant height and number of spikes per plant was unstable and responded to different environments. Accordingly, its stable traits can be selected and introduced directly into future breeding programs for the purpose of adopting it as a new variety. Whereas, Iba99 showed good stability for the traits of the spike length and number of spikes.m^{-2}, but its other traits showed response to the environments. There was a great convergence in the results of the two methods, the phenotypic stability method and the stability triangle method with the Eberhart & Russell method. Therefore, it is possible to rely on these two methods to estimate the stability of genotypes because they are among the least complicated methods.

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Conflicts of interest

The author declare that they have no conflict of interests.

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References

Abdul Rahman, T. F., Osamah, K. J. & Bilal, N. J. (2023). Impact of improved seeds and some modern technologies on increasing the supply of wheat crop in Iraq for the agricultural season 2019-2020. *Iraqi Journal of Agricultural Sciences, 54*(1), 176-188. https://doi.org/10.36103/ijas.v54i1.1689

Al-Falahi, M.A.H., Dawod, K.M. & Omer, F.A. (2021). Yield stability evaluation for bread wheat genotypes under environmental variations. *Iraqi Journal of Agricultural Sciences, 52*(6), 1449–1460. https://doi.org/10.36103/ijas.v52i6.1486

Ali, M. (2017). Stability analysis of bread wheat genotypes under different nitrogen fertilizer levels, *Journal of Plant Production, 8*(2), 261–275. https://doi.org/10.21608/jpp.2017.39617

Barnes, J. (2022). *Staple Security*, Buke University Press, p.320. https://www.dukeupress.edu/staple-security

Bassi, F.M., & Sanchez-Garcia, M. (2017). Adaptation and stability analysis of ICARDA durum wheat elites across 18 countries. *Crop Science, 57*(5), 2419 -2430. https://doi.org/10.2135/cropsci2016.11.0916

Bhargava, A. & Srivastava, S. (2019). *Participatory Plant Breeding: Concept and Applications.* Springer; Singapore, p. 255. https://link.springer.com/book/10.1007/978-981-13-7119-6

Bouchareb, R. & Guendouz, A. (2022). Grain yield stability analysis of some durum wheat (*Triticum durum* Desf.) genotypes growing under sub-huid conditions. *Agricultural Science Digest*, (42), 48-52. http://doi.org/10.18805/ag.D-308

Brasier, K., Oakes, J., Balota, M., Reiter, M., Jones, N., Pitman, R., Sneller, C., Thomason, W. & Griffey, C. (2020). Genotypic variation and stability for nitrogen use efficiency in winter wheat. *Crop Science, 60*(1), 32-46. https://doi.org/10.1002/csc2.20006

Bandar, S. J., & Al-Hilfy, I. H. (2022). Effect of brassinolide on some growth traits and biological yield of bread wheat. *Iraqi Journal of Agricultural Sciences, 53*(2), 322–328. https://doi.org/10.36103/ijas.v53i2.1539

Central Statistical Organization (2022). Wheat and Barely production. *Directorate of Agricultural Statistics, Ministry of Planning, Iraq – Baghdad*. (in Arabic). https://cosit.gov.iq/ar/agri-stat/veg-prod

Cormier, F., Foulkes, J., Hirel, B., Gouache, D., Moënne-Loccoz, Y., & Le Gouis, J. (2016). Breeding for increased nitrogen-use efficiency: A review for wheat (*Triticum aestivum* L.). *Plant Breeding, 135*(3), 255-278. https://doi.org/10.1111/pbr.12371

Dror, Y., Rimon, E., & Vaida, R. (2020). *The whole-wheat bread.* 1-20. In Dror, Y., Rimon, E., & Vaida, R. (Editors). *Whole-Wheat Bread for*

Human Health, Springer, Cham. https://doi.org/10.1007/978-3-030-39823-1_1

Eberhart, S.A. & Russell, W.A. (1966). Stability parameters for comparing varieties 1,” *Crop Science*, *6*(1), 36–40. https://doi.org/10.2135/cropsci1966.0011183x000600010011x

Elsahookie, M. M. (1985). Homeostasis estimation for crop germplasm adaptation. *Journal of Agriculture and Water Resources Research, 4*(2), 1-15. https://agris.fao.org/agris-search/search.do?recordID=IQ8600154

Finlay, K. W., & Wilkinson, G. N. (1963). The analysis of adaptation in a plant-breeding programme. *Australian Journal of Agricultural Research, 14*(6), 742-754. http://doi.org/10.1071/ar9630742

Hatfield, J., & Walthall, C. (2015). Meeting global food needs: Realizing the potential via genetics × environment × management interactions. *Agronomy Journal, 107*(4), 1215-1226. https://doi.org/10.2134/agronj15.0076

Happ, M. M., Graef, G. L., Wang, H., Howard, R., Posadas, L., & Hyten, D. L. (2021). Comparing a mixed model approach to traditional stability estimators for mapping genotype by environment interactions and yield stability in soybean [*Glycine max* (L.) Merr.]. *Frontiers in Plant Science, 12*, 630175. http://doi.org/10.3389/fpls.2021.630175

Hitz, K., Clark, A. J., & Van Sanford, D. A. (2017). Identifying nitrogen-use efficient soft red winter wheat lines in high and low nitrogen environments. *Field Crops Research*, *200*, 1-9. https://doi.org/10.1016/j.fcr.2016.10.001

Ibrahim, K., & Said, A. (2020). Grain yield stability of new bread wheat genotypes (*Triticum aestivum* L.) under normal and heat stress conditions. *Egyptian Journal of Agronomy*, *42*(2), 171-184. https://doi.org/10.21608/agro.2020.32118.1216

Ireland, C. R. (2010). *Experimental Statistics for Agriculture and Horticulture. Modular texts*, CAB International, British Library, London. https://www.sandbarbookstore.com/book/9781845935375

Knapp, S., Brabant, C., Oberforster, M., Grausgruber, H., & Hiltbrunner, J. (2017). Quality traits in winter wheat: Comparison of stability parameters and correlations between traits regarding their stability. *Journal of Cereal Science, 77*, 186-193. https://doi.org/10.1016/j.jcs.2017.08.011

Krupal, S. M., Rathod, S. T. & Kamble, B. G. (2018). Stability analysis for yield and quality traits in wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding, 9*(1), 160-168. https://doi.org/10.5958/0975-928x.2018.00019.4

Kumar, A., Chand, P., Thapa, R. S. & Singh, T. (2021). Assessment of stability performance and G × E interaction for yield and its attributing characters in bread wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding, 12*(1), 235-241. https://ejplantbreeding.org/index.php/EJPB/article/view/3712

Megahed, E. M. A, Awaad, H. A., Ramadan, I. E., Abdul-Hamid, M. I. E, Sweelam, A. A., El-Naggar, D. R., & Mansour, E. (2022). Assessing performance and stability of yellow rust resistance, heat tolerance, and agronomic performance in diverse bread wheat genotypes for enhancing resilience to climate change under Egyptian conditions. *Frontiers in Plant Science, 13*, 1014824. https://doi.org/10.3389/fpls.2022.1014824

Naheed, H., & Rahman, H. U. (2021). Stability analysis of bread wheat lines using regression models. *Sarhad Journal of Agriculture, 37*(4), 1450-1457. https://doi.org/10.17582/journal.sja/2021/37.4.1450.1457

Nyol, S., Swami, P., & Munjal, R. (2020). Selection of wheat genotypes under variable sowing conditions based on stability analysis. *Journal of Cereal Research, 12*(2). https://doi.org/10.25174/2582-2675/2020/99755

Ray, D., Gerber, J., MacDonald, G., & West, P. (2015). Climate Variation Explains a Third of Global Crop Yield Variability. *Nature Communications*, *6*, 5989. https://doi.org/10.1038/ncomms6989

Russell, K., Lee, C. & Van Sanford, D. (2017). Interaction of genetics, environment, and management in determining soft red winter wheat yields. *Agronomy Journal, 109*(6), 2463-2473. https://doi.org/10.2134/agronj2017.02.0126

Said, A., Motawea, M., Hassan, M. & Roshdy, R. (2020). Mean performance and stability parameters for comparing bread wheat cultivars under different environmental conditions. *SVU-International Journal of Agricultural Sciences, 2*(2), 484-497. https://doi.org/10.21608/svuijas.2020.47432.1047

Singh, C., Gupta, A., Kumar, P., Sendhil, R., Gopalareddy, K., Gupta, V., Singh, S. K., Sharma, A. K., Tyagi, B. S., Singh, G., Chatrath, R., & Singh, G. P. (2020). Multi-environment analysis of grain yield in a diverse set of bread wheat genotypes. *Journal of Cereal Research, 12*(1), 29-39. http:// doi.org/10.25174/2582-2675/2020/92977

Singh, R. K., & Chaudhary, B. D. (1978). *Biometrical methods in quantitative genetic analysis.* Kalyani, Ludhiana, 304pp. https://www.cabdirect.org/cabdirect/abstract/19801689021

STATISTA (2022). Grain production worldwide by type, food and agricultural organization of the United Nations. (Accessed: 23/12/2022). https://www.statista.com/statistics/263977/World - grain- production-by-type /

Wang, Y., Wang, D. Tao, Z., Yang, Y., Gao, Z. Zhao, G., & Chang, X. (2021). Impacts of nitrogen deficiency on wheat (*Triticum aestivum* L.) grain during the medium filling stage: Transcriptomic and metabolomic comparisons. *Frontiers in Plant Science (12) article 674433.* https://doi.org/10.3389/fpls.2021.674433

الاستقرارية الوراثية لتراكيب وراثية مختلفة من حنطة الخبز (*Triticum aestivum* L.) نامية تحت مستويات من السماد النتروجيني

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المستخلص: يعد الحصول على أصناف عالية الإنتاجية ومستقرة في بيئات مختلفة أحد أهم الأهداف التي يسعى إليها مربي النباتات. تم إجراء تجربة حقلية لمعرفة تأثير مستويات الأسمدة النيتروجينية المختلفة على استقرارية صفات النمو وحاصل الحبوب في ثمانية تراكيب وراثية من حنطة الخبز خلال موسمي الزراعة (2020-2021 و2021-2022) باستخدام ترتيب الالواح المنشقة في تصميم القطاعات العشوائية الكاملة (RCBD)، إذ شغلت مستويات التسميد الالواح الرئيسة والاصناف شغلت الالواح الثانوية وبثلاثة مكررات. أظهرت النتائج وجود استجابة معنوية لبعض التراكيب الوراثية لمستويات السماد النتروجيني لحاصل الحبوب ومكوناتها خلال موسمي الزراعة. تميز التركيب الوراثي لـ Iba99 بأعلى متوسط لحاصل الحبوب وعدد الحبوب بالسنبلة وطول السنبلة، متبوعاً بالتركيب الوراثي Baghdad2. اختلفت التراكيب الوراثية قيد الدراسة في استقرارية صفاتها في البيئات المختلفة، حيث أظهر Baghdad2 أعلى استقرار لصفات مهمة مثل حاصل الحبوب ووزن 1000 حبة وعدد الحبوب بالسنبلة وطول السنبلة، بينما غير مستقر واستجاب لبيئات مختلفة لصفات ارتفاع النبات وعدد السنابل في المتر المربع. بينما أظهر التركيب الوراثي Iba99 استقرارا جيدًا لطول السنبلة وعدد السنابل بالمتر المربع مع استجابته لبيئات المختلفة للصفات الأخرى قيد الدراسة. اظهرت كل من، طريقة الاستقرارية المظهرية والمحصلة الوراثية وطريقة مثلث الاستقرار نتائج متشابهة جدًا مع طريقة Eberhart وRussell، لذلك من الممكن الاعتماد على هاتين الطريقتين لتقدير استقرارية التراكيب الوراثية بسبب انخفاض تعقيدها. وبالتالي، يمكن انتخاب صفات التراكيب الوراثية المستقرة في بيئات مختلفة وإدخالها مباشرة في برامج التربية المستقبلية لغرض تبني أصناف جديدة. على الرغم من أن التراكيب الوراثية الأخرى أظهرت خصائص متفوقة لحاصل الحبوب ومكوناته المهمة، إلا أنها تعاني من الاستجابة لبيئات مختلفة، وبذلك قد يمكن إدراجهم في برامج التهجين مع الاصناف المحلية لنقل صفاتها المرغوبة.

الكلمات المفتاحية: حنطة الخبز، استقرارية وراثية، محصلة وراثية، مستويات تسميد نيتروجين.