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THE INFLUENCE OF ORGANIC FERTILIZER (POTASSIUM HUMATE) ON THE GENETICS, PHENOTYPIC VARIATIONS, AND HERITABILITY OF WHEAT VARIETIES

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Abstract

This field experiment was conducted during the winter season of 2022-2023 in a community located south of Fallujah, Al-Anbar, Iraq and involved the use of seeds from five different wheat varieties, namely Mahmoudia, Diyar, Wafiyya, Edna 99, and Rashid. The seeds were treated with 1000, 2000, and 3000 $gm.h^{-1}$ of potassium humate 90% fertilizer. Data analysis showed significant differences across all variables and treatments. The genetic variance was found to be greater than the environmental variance for all tested variables, and this difference increased with higher levels of humic fertilizer. However, in the case of leaf area, genetic variance decreased with higher amounts of humic fertilizer. The number of spikes per square meter exhibited the highest broad-sense heritability 0.958 at the 2000 $gm.ha^{-1}$ level of humic fertilizer. This was followed by the number of grains per spike with a heritability of 0.909 at the 3000 $gm.ha^{-1}$ level. The standard coefficient and genetic variance values varied depending on the amount of humic fertilizer applied, resulting in increased grain yield, number of grains per spike, and number of spikes per square meter.

Keywords: Wheat, Genotypic variance, Heritability, Humic fertilizer.

تأثير السماد العضوي (هيومات البوتاسيوم) على التغايرات الوراثية والمظهرية والتوريث لأصناف من الحنطة

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الخلاصة

في الموسم الشتوي 2022–2023 أجريت تجربة حقلية في جنوب الفلوجة، محافظة الأنبار، العراق. تضمنت التجربة استخدام بذور خمسة أصناف مختلفة من الحنطة وهي المحمودية، الديار، الوافية، إدنا 99، والرشيد. تم اضافة ثلاث مستويات من السماد الدبالي (هيومات البوتاسيوم) بالمستويات التالية 1000، 2000، و3000 غم.ه$^{-1}$ من هيومات البوتاسيوم 90%. اظهر تحليل البيانات وجود فروق ذات دلالة إحصائية في جميع الصفات المدروسة. وجد أن التباين الوراثي أكبر من التباين البيئي لجميع الصفات المدروسة تحت المستويات الثلاثة، ازداد هذا التباين مع زيادة مستويات الأسمدة. أما في المساحة الورقية فقد حدث انخفاض في التباين الوراثي مع زيادة كمية الأسمدة. أظهر عدد السنابل لكل متر مربع أعلى نسبة توريث بالمعنى الواسع 0.958 عند مستوى 2000 غم.ه$^{-1}$ من الأسمدة العضوية. وتلا ذلك عدد الحبوب لكل سنبلة والتي بلغت نسبة التوريث لها 0.909 عند مستوى 3000 غم.ه$^{-1}$. تباينت قيم المعامل الاختلاف والتباين الوراثي تبعا لكمية الأسمدة، مما يؤدي إلى زيادة إنتاج الحبوب، وعدد الحبوب لكل سنبلة، وعدد السنابل لكل متر مربع.

كلمات مفتاحية: القمح، التباين الوراثي، التوريث، هيومات البوتاسيوم.

Introduction

Wheat, or *Triticum aestivum* L., is grown on a global scale as both a staple food and a valuable strategic resource. It is a primary source of vegetable protein worldwide, boasting the highest protein content compared to other crops and is a cereal that surpasses both maize (corn) and rice in terms of nutritional value. Among the various food crops, wheat has much versatility as it is used to make leavened, flat, and steamed breads, as well as beer and alcohol through fermentation. The modern agricultural industry relies heavily on the utilization of affordable organic fertilizers and plant growth stimulants to address the challenge of increasing productivity and enhancing the quality of agricultural products (15). Particularly in high carbonate crops like potatoes, carrots, maize, rice, and wheat, the application of humic acid, also known as "plant food," has a positive impact on enzyme activity, plant nutrients, and growth stimulation.

As a staple food in many countries, wheat not only plays a crucial role in meeting over half the daily calorie requirements it also places significant emphasis on its quality. Wheat feeds 36 percent of the global population and contributes to 20 percent of the world's total calorie supply. Wheat bread is a dietary staple in most countries, providing 80 percent of human protein intake (7). As such, the use of organic instead of harmful chemical fertilizers in agriculture represents a contemporary method of crop cultivation (15). In terms of organic matter, humic acids are an essential component found in both soil and municipal waste compost, playing a significant role in the cycling of environmental elements and the ecological functions of soil. Humic acid, found in humus, is an essential component for soil health and plant growth. It improves soil structure, enhances water retention, supports the growth of beneficial organisms, and acts as a complex for absorbing and retaining vital inorganic nutrients needed by plants (8). Extensive research has been conducted on the use of humic acid in soil, particularly its ability to form complexes with elements like Na, K, Mn, Zn, Ca, Fe, and Cu, effectively addressing deficiencies in specific nutrients (18).

The positive impact of humic acid on crop growth has generated significant interest in specific conditions (8). Humic acid is derived from the decomposition of organic matter and consists of nitrogen, oxygen, hydrogen, and carbon in varying ratios. When integrated into plant nutrition, these compounds play a crucial role in promoting growth by influencing photosynthesis and respiration processes (17). Recognizing the significance of genetic variability is paramount for a successful breeding program. It is essential to understand the extent and nature of variations within breeding materials and the relationships between quantitatively inherited traits and grain yield to effectively select high-yielding varieties (8 and 18). Analyzing phenotypic diversity is a valuable tool for assessing successful crossbreeding which relies on the genetic diversity of crop genetic resources, making it a crucial factor. Identifying this relationship can significantly contribute to the enhancement of breeding programs by providing valuable insights (8).

The application of various classical breeding methods has led to the development of cultivars that possess desirable traits such as short stems, resistance to lodging, increased productivity, and improved grain quality (17). Successful plant breeding programs are dependent on maintaining genetic variability within the breeding materials. This allows for the broadening of the gene pool, which is essential for the development of superior cultivars. Heritability is an important indicator in the enhancement of breeding programs and depends greatly on the genetic diversity found within crop genetic resources, making it an essential element. Recognizing this connection can offer valuable insights for contributing to the success of crossbreeding efforts (16).

Phenotypic and genotypic coefficients of variation and heritability have been extensively utilized in the field of wheat breeding. These allow for the evaluation of the extent of variability within breeding materials, assist in determining appropriate selection procedures, and facilitate predictions of breeding advancements for important traits (6 and 11). Traits that exhibit a significant coefficient of variation and high heritability, along with a substantial genetic advance, may be influenced by additive genes and can be improved through simple plant selection methods.

Conversely, traits with low values of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, and genetic improvement may be better suited for utilization in heterosis breeding approaches (3 and 4). The aim of this study is to determine the role of potassium humate and its effect on a number of wheat varieties and to identify selection evidence for distinguishing the trait or traits that most affect yield at different levels of organic fertilizers.

Materials and Methods

A field experiment was conducted in a village south east of Fallujah city, Al-Anbar, Iraq. Seeds from five wheat genotypes, Mahmoudia (G1), Diyar (G2), Wafiyya (G3), Edna 99 (G4), and Rashid (G5) were sown under three levels of humic fertilizer (1000, 2000, 3000 Potassium Humate 90% gm. h^{-1}) during the 2022-23 winter season. This RCBD study utilized a split-plot design with three replications to examine the effects of the H1, H2, and H3 humic fertilizer levels in the main plot and in the different genotype (G) sub plots using various agricultural parameters. Each plot measured 2*2 m and contained 10 rows spaced 20 cm apart.

All recommended agricultural practices, including fertilizer application, irrigation, soil preparation, and weed control, were implemented. Data on leaf area (cm^2), number of spikes per square meter, number of grains per spike, 1000-grain weight (g), and grain yield (tonnes per hectare) were collected and analyzed using GenStat software. The variance of each trait and the covariances among all traits at each level of humic fertilizer were examined separately.

$\sigma^2 G$= Genotypic variance (16)

$\sigma^2 G = msv - mse/r$

σ^2 E= Environmental variance

$\sigma^2 e = mse$

σ^2 P=Phenotypic variance

$\sigma^2 p = \sigma\ G^2 + \sigma^2 E$

CV%= Coefficient of Variance $CV\% = \overline{SD}/\bar{Y} \times 100$

GCV%= Genotypic Coefficient of Variance $GCV = \frac{\sigma G}{\bar{Y}}\ X100$

PCV%= Phenotypic Coefficient of Variance $PCV = \frac{\sigma P}{\bar{Y}}\ X100$

$H_{b.s}$= Broad-sense Heritability (16) $h.ns = \sigma^2 G/\sigma^2 P$.

Results and Discussion

The findings as presented in Table 1 provide evidence of major disparities among the studied genotypes and their response to the environment. This is supported by the highly significant effects observed for all variables and levels of humic fertilizer treatments. This variation in the extent of the genotypes’ response to environmental factors (organic fertilizer) is due to the nature of the genetic factors carried by the genotype and the extent to which it is affected by the surrounding environment. These results suggest the possibility of selecting the most optimal genotypes based on their performance. The variance components differed depending on the level of humic fertilizer applied.

Table 1: Mean squares for analysis of variance of different traits at different humic fertilizer levels.

S.O.V	D.f.	Humic fertilizer (gm. ha^{-1})	Leaf area (cm^{-2})	No. of spikes.m^{2}	No. of grain spikes^{-1}	1000-grain weight (gm)	Grain yield (t. ha^{-1})
Replications	2	1000	1.44	250.18	3.8	1.11	0.129
		2000	6.22	102.32	23.66	9.12	0.802
		3000	2.99	309.1	0.166	2.40	1.15
Genotypes	4	1000	59.16**	4788.7**	179.01**	48.19**	2.12**
		2000	53.8**	4810.2**	104.53*	70.3**	2.25**
		3000	35.63**	9470.6**	301.19**	59.67**	6.72**
Error	8	1000	3.014	201.08	14.26	6.33	0.179
		2000	4.12	69.56	22.16	4.75	0.288
		3000	5.60	911.97	9.42	3.23	0.598

*and ** significance at p= 0.05 and 0.01, respectively.

As shown in Table 2, the genotypic variance values exceeded the environmental variance values for the traits examined. Moreover, these values increased together with the levels of humic fertilizer applied, except for leaf area, which decreased due to a decline. Specifically, the genotypic variance values for the number of spikes per square meter increased from 1529.21to 2852.88, the number of grains per spike from 53.92 to 94.30, the weight of 1000 grains from 13.14 to 18.55 grams, and total yield from 0.599 to 2.40 tonnes per hectare as the humic fertilizer dosages rose from 1000 to 3000 grams per hectare.

The substantial value deviations observed in this study point to the importance of genetic factors in explaining the variations, indicating the potential effectiveness of selection. Characteristics showing greater genetic to environmental variations are easier to select because they are governed by the genetic factor, which is responsible for their transmission from one generation to another. This helps in developing electoral evidence because the trait is governed by genetic factors and therefore facilitates the selection process, Additionally, (18) noted an upward trend in the environmental variance values as the humic fertilizer levels increased (1, 2 and 8). The impact of increased environmental variance on broad-sense heritability is evident in the rise of its relative proportion compared to genotypic variance.

Applying humic fertilizer at varying levels (ranging from 1000 to 3000 gm/ha produced an increase in the heritability of several important traits in the plants, including the number of grains, Spike-1, weight of 1000 grains, and total yield (Table 2). The heritability values for these traits ranged from 0.789 to 0.909, 0.675 to 0.852, and 0.770 to 0.801, respectively. However, the heritability values of the leaf area recorded a gradual decline of 0.869, 0.806, and 0.667 corresponding to the increasing levels of humic fertilizer, suggesting the stronger influence of environmental factors on leaf area variations.

Further, the heritability of the number of spikes per square meter also decreased due to the high environmental variance associated with this trait. These significant heritability values offer plant breeders the opportunity to selectively enhance these traits, ensuring that the observed phenotypic characteristics are passed on to future generations. This study's findings align with (18) who also observed varying levels of heritability in different traits (9, 10 and 13).

Table 2: Values for environmental, genotypic, and phenotypic variances, as well as broad-sense heritability.

	HUMIC FERTILIZER (GM. HA-1)	LEAF AREA (CM^2)	NO. OF SPIKES.M^{-2}	NO. OF GRAIN SPIKES^{-1}	1000-GRAIN WEIGHT (G)	GRAIN YIELD (KG. HA^{-1})
$\sigma^2 G$	1000	18.72	1529.21	53.29	13.14	0.599
	2000	16.56	1580.21	30.25	21.66	0.66
	3000	10.01	2852.88	94.3	18.55	2.4
$\sigma^2 E$	1000	3.014	201.08	14.26	6.33	0.179
	2000	4.12	69.56	22.16	4.75	0.288
	3000	5.6	911.97	9.42	3.23	0.598
$\sigma^2 P$	1000	21.72	1730.29	67.55	19.47	0.778
	2000	20.68	1649.77	52.41	26.41	0.948
	3000	15.61	3764.85	103.72	21.78	2.998
$H_{B.S}$	1000	0.861	0.884	0.789	0.675	0.770
	2000	0.801	0.958	0.577	0.820	0.696
	3000	0.641	0.758	0.909	0.852	0.801

Standard, genotypic and phenotypic coefficients of variance: When comparing populations, using variance and standard deviation methods may not be reliable since traits with high means often have high variance values as well. Instead, it is preferable to compare characteristics using covariance coefficients. According to Table 3, the application of humic fertilizer led to significant increases in genotypic and phenotypic variance values for grain yield, as well as the number of grain spikes-1 and number of spikes-2. Specifically, at a rate of 3000 gm/ha, the highest genotypic coefficient of variance was observed for total grain yield and number of grains per spike at 22.70 and 19.18, respectively, while the phenotypic coefficient of variance was 27.78 and 19.63, respectively.

The genotypic coefficient of variance ranged from the highest value of 18.79 for the number of grains per spike at 3000 gm. ha^{-1} to the lowest at 8.89 for 1000-grain weight at 1000 gm. ha^{-1}. As clear from the table, the values for the genetic variation coefficient (GCV) are lower than for the phenotypic coefficient of variation (PCV) for all traits. This indicates that the differences were not the result of genetic structures alone, but rather that environmental influences had a role. The high dispersion of values under all fertilization levels makes selection easy and effective. Since the plant yield trait is considered one of the complex quantitative traits and the result of several traits (number of grains, grain weight, etc.), yield component selection has a greater impact in increasing plant yield than selection for the yield trait itself. These significant differences between traits have allowed for highly effective selections compared to other traits (5, 12 and 14).

Table 3: Standard, genotypic and phenotypic coefficient of variance.

	Humic fertilizer (gm. ha^{-1})	Leaf area (cm^2)	No. of $spikes.m^{-2}$	No. of grain $spikes^{-1}$	1000-grain weight (gm)	Grain yield ($tonne.ha^{-1}$)
CV%	1000	5.44	5.66	6.4	5.14	7.65
	2000	5.96	4.23	8.59	6.38	9.18
	3000	6.98	10.15	6.45	6.74	1318
GCV%	1000	11.23	15.28	10.26	8.89	10.55
	2000	12.45	16.37	9.46	11.76	12.36
	3000	11.25	18.01	18.79	12.57	22.70
PCV%	1000	11.98	16.14	11.84	9.33	13.44
	2000	14.22	15.72	12.97	11.82	15.24
	3000	12.97	19.64	19.63	13.49	27.78

Conclusions

Significant differences were recorded between the varieties at each fertilizer level. This is evidence of the influence of environmental factors and the use of organic fertilizer (humic fertilizer) on these varieties. It appears that the inheritance of traits reflect a higher degree of genetic variation compared to environmental variation, and that the majority of traits exhibited a significant level of heritability.

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Author 1: methodology, writing, and original draft preparation. Author and Author writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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