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Article

Impact of sowing rates and humic acid application on productivity of some triticale genotypes at East El-Quntra station

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Abstract

The present research was carried out at Agriculture Research Station, Desert Research center, at El- Quntra East, North Sinai Governorate, Egypt, 2017-2018 and 2018-2019 winter seasons to study the effect of three seeding rates (45,55and 65kg/fed), and three levels of humic acid application (0,4and 8 kg/fed) on the yield and yield components of four triticale genotypes (T11, 8, ICBA triticale and T6). A split split plot design with three replication was used, where the genotypes of triticale were arranged in the main plots, seeding rates were placed in the sub plots while humic acid application were allocated randomly to the sub-sub plots. Results indicated that Triticale T11) genotype with sowing at 55 kg seeds/fed and 8 kg HA leveled gave the highest number of plants/, tillers and spikes/m2, grain and straw yields kg/fed in both seasons. Triticale11 genotype significantly surpassed the other three triticale genotypes (ICBA, t8, t6) for all studied characters in the two seasons. Pearson's correlations analysis showed that GY was significantly and positively correlated with all studied traits. Principal component analysis revealed that the first main PC (PC1) had eigenvalues greater than one (6.689) and contributed 95.6% of the total variation existing among studied traits regarding seeding rate, humic acid rate and variety variables. The contributions of PC1 to the total variance were higher than that of PC2 (3.10%).

Keywords: seeding rates, humic acid, triticale genotypes, PCA, Heat map correlation.

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1.Introduction

Triticale (*xTriticosecale Wittm.*), is the first man – synthesized species obtained by crossing wheat (*Triticum spp*.) with rye (Secale cereal). to combine the good quality of the wheat grain with tolerance of abiotic and biotic stresses of rye (**Villegas et al., 2010).**Triticale possesses the genetic yield potential of wheat and the efficient use of nutritive additives of rye (**Ayalew et al., 2018;Wojcik-Gront and Studnicki,2021)**,more tolerant to abiotic stresses **(Deng et al., 2020)** ,very modest in its soil requirements (**Lyson and Biel,2016)**,more resistant to diseases (**Goral et al.,2021**) and higher grain yield potential (**Roques et al., 2017**) and forage mass (**Estrada-Campuzano et al., 2012)** compared to common wheat.

With the forecasted drastic effects of climate change on field crops, especially in arid regions, interest in triticale production and variety improvement is becoming increasingly important .New varieties ,equal or superior to other cereals, have been developed for grain yield, forage and biomass production for human food , animal feed and industrial applications(**Nefir and Tabara 2011).**The current world area of this crop is about 3.5 million hectares (**FAO,2020**) grown with about 334 triticale varieties (**EU Catalogue of Varieties of Agricuture,2019) .**It is important to cultivate the suitable triticale cultivar in specific region since wide variation were reported for grain yield and yield components of triticale , such as number of grains per spike, grain weight per spike, spikes number per m2 and 1000 grain weight (**Esra et al., 2010**).

Seeding rate is one of the important inputs in triticale production, since higher rates than optimal will impose higher intra competition between plants and adversely affect crop yield while lower seeding rates than optimal usually produces low yield (Mut et al., 2005).Several researchers reported that optimum seeding rate to optimal resulted in increased grain yield (**Mohammad &Hamed 2013 Ahmad &Begum 2017).Gibson et al., (2008**) found that increasing seeding rate increased grain yield of triticale quadratically and the highest grain yield was obtained at 516 plants/m^2.**Tolstova et al.(2018)** found that increasing seeding rate increased grain yield through higher removal of nutrients from the soil and that was dependent on triticale variety. Organic fertilizers have become very important in agroecosystems to increase the quality of agricultural product, improve healthy food production, and enhance the tolerance of field crops to adverse environmental conditions.

Humic acid (HA) is a key source of humic compounds ,which make up the majority of soil's organic matter (**Gerke, 2018).**It has numerous advantages ,including phytohormone-like activities that influence plant physiological processes ,such as improving photosynthesis ,increasing root growth ,and enhancing seed germination and seedling growth, which increases plant height ,the number of spikes/m^2,and the grain yield **(Fahmi et al., 2020**) .It plays a vital role in the acceleration of plant cell division and promoting development, increasing seed germination and root respiration and arrangement (**Bijanzadeh and Perssarakli, 2020**).**). Abd-Elatty et al. (2022)** found that application of highest humic acid level (9.6 kg/ha) resulted in highest grain yield due to increase of yield components such as 100 grain weight and number of spikes/m^2. The increase in forage yield, protein content, and neutral detergent fiber due to adding humic acid may be attributed to the ability of humic acid to improve a crop's nutrient uptake (**Daur, &Bakhashwain 2013). Parvin et al. (2020)** found that the interaction between humic acid of time and concentration effects were significant on spike length, grain yield and harvest index. They concluded that increasing the application of organic fertilizer such as humic acid in triticale cultivation not only improve grain yield and crop quality but also reduce consumption of chemical fertilizer in agroecosystem.

The extent of the relationship between root biomass and yield components can be explored through path coefficient and principal component analyses to identify influential
traits for cultivar development.

The objective of this study was to investigate the effect of seeding rate and humic acid application on the yield and yield components of some winter triticale genotypes in North Sinai.

2. MATERIALS AND METHODS

***Site description*:**

Two field experiments were conducted at the Agricultural Research Station, (30^0 49'07.5"N,$32^0$24'15.9"E) Desert Research Center at El-Qanttara East, North Sinai Governorate, Egypt, during 2017-2018 and 2018-2019 seasons are presented to study the impact of seeding rates and humic acid application on productivity of some triticale genotypes

Soil analysis:

Mechanical and chemical soil analyses of the experimental soil as well as some chemical properties of the irrigation water during 2017/18 and 2018/19 seasons in Table (1). Collected soil samples for this study were air dried. Particle size analyses (dry sieving) were accomplished according to **Jackson (1973**). Then soil samples were crushed and sieved with 2mm sieve. Soil samples were analyzed for chemical properties: PH, Electrical conductivity (EC) and Cationic compositions according to the methods described by **Jackson (1973**), while total carbonates were determined by the method of **Piper (1950).**

Treatments:

The experiments included 36 treatments, which were a combination of four triticale genotypes, three sowing rates and three levels of humic acid application

1- **Triticale genotypes**:

Four genotypes were imported from the International Center for Biosaline in Agriculture, Dubai, Arab Emirates. These genotypes were ICBA triticale (V_1), T_8 (V_2), T_{11} (V_3), and T_6 (V_4).

2-Seeding rates:

Seeding rates used in the present study were 45(D_1), 55(D_2) and 65(D_3) kg / feddan.

3-Humic acid levels:

Three levels of humic acid i.e. 0 (H_0, control), 4(H_1) and 8(H_2) kg /fed., were broadcast at completion of tillering stage (25 days after sowing)

The previous mentioned treatments were arranged in a split split plot design with three replications where triticale genotypes were arranged in the main plots, sowing rates were devoted to the sub plots while humic acid levels were allocated randomly in the sub-sub-plots. The area of the experimental unit was 30 m^2. Numbers of rows were 20 per plot, 15 cm apart and length 10 m.

***Recommended P and N fertilizers as follow*:**

1- Phosphorus fertilizer was pre sowing applied fully at the rate of 200 kg/fed as calcium mono phosphate (15.5% p_2o_5)
2- Nitrogen fertilizer (ammonium nitrate 33.5%) was added at the rate of 75 kg nitrogen /fed divided into three doses, (15 kg nitrogen /fed) was added after 15 days from sowing , (30 kg nitrogen/fed) after 30 days from sowing , and (30 kg nitrogen/fed)after 65 days from sowing.
3- Triticale genotypes were sown on 15^{th} November 2017 and 25^{th} November 2018 in the first and second seasons respectively, while the harvesting

dates were 15 April and 25 April in the first and second seasons respectively.

Yield and its components measurements:

A quadrat of ($1m^2$) was harvested from each sub-sub plot, and the following measurements were recorded:

Triticale yield and its components:

1- Number of plants /m^2
2- Number of tillers/ m^2
3- Number of spikes\m^2
4- Number of grains / spikes
5- 1000 grain weight (g)
6- Biological yield (kg/fed)
7- Straw yield (kg/fed)
8- Grain yield (kg/ fed)

Statistical analysis:

Data obtained were statistically analyzed using the appropriate analysis of variance according to **Gomez and Gomez (1984)**. LSD at 5% level was used to compare between means of treatments. The data of seed yield and its components were analyzed by the following statistical procedures. Significance of correlation coefficients was tested in the probable levels of 0.05 and 0.01. Plot Pearson's correlation coefficient and principal component analysis (PCA) were ap-plied for a better understanding of the relationship among studied traits across experimental factors. The ANOVA, Plot Pearson's correlation coefficient and PCA were done using a computer software program SPSS version 25 and Origin Pro 2021 version b 9.5.0.193

Table (1): Mechanical and chemical soil analyses of the experimental soil as well as some chemical properties of the irrigation water during 2017/18 and 2018/19 seasons.

Soil analyses			2015/16 season		2016/17 season	
			0-15	15-30	0-15	15-30
1: Mechanical analysis.						
Sand (%)			87.40	87.40	86.02	86.02
Silt (%)			9.20	9.20	9.65	9.65
Clay (%)			3.40	3.40	4.23	4.23
Soil texture class			Sandy	Sandy	Sandy	Sandy
2: Chemical analysis.						
CaCo3			0.37	0.20	0.33	0.23
PH			7.95	8.34	7.86	8.53
E.C. ($dS.m^{-1}$)			0.72	0.55	0.70	0.54
Organic matter (%)			0.54	0.54	0.68	0.65
Na^+			3.85	2.72	3.74	2.71
K^+			0.36	0.29	0.35	0.28
Ca^{++}			1.66	1.43	1.58	1.42
Mg^{++}			1.33	1.07	1.31	1.05
HCO_3^-			1.99	1.72	1.97	1.71
Cl^-			3.32	2.86	3.30	2.85
$SO4^{--}$			1.89	0.93	1.87	0.91
SAR			3.15	2.43	3.14	2.42
ESP			3.27	2.26	3.26	2.24
3: Irrigated water.						
E.C. (µS/cm)			2960		2974	
PH			8.3		8.6	
Soluble ions (meq L^{-1})	Cation	Ca^{++}	6.71		6.86	
		Mg^{++}	8.39		8.43	
		Na^+	14.35		14.47	
		K^{++}	0.28		0.29	
	Anion	$CO3^-$	0.3		0.4	
		HCO_3^-	2.9		2.9	
		Cl^-	22.2		22.4	
		$SO4^{--}$	3.1		3.6	

Soil and Water Analysis, Lab., Desert Research Center

3. Results and discussion:

1-Effect of triticale genotypes:

The vegetative, yield and yield components of different genotypes of triticale are presented in table (2).The data indicated that T_{11} was superior to other triticale genotypes in all studied characters in the two seasons .That genotype gave the highest grain yield 1420.7 and 1520.6 kg/fed, in the first and second seasons, respectively, due to its higher yield components, i.e. number of spikes/m^2, number of grains / spike and 1000-grain weight. Those results are in accordance with those obtained by **Joshi et al. (2002) and Esra et al. (2010**). The superiority of T_{11} may be attributed to its better formation of rooting system thus enabling the plants to acquire better removal of mineral nutrition from the soil (**Tolstova et al., 2018).**

Table (2) Effect of triticale genotypes in the yield and yield components of triticale in the two growing seasons (2017-2018 and 2018-2019).

	2017/18 Season							
treatment	No. of plants/m2	No. of tillers/m^2	No. of spikes/m^2	No. of grains/spike	1000-grain weight	Grain yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
V1	153.40	273.70	209.56	51.50	37.52	1229.30	2960.00	4189.30
V2	130.59	223.80	186.22	49.07	35.67	1128.50	2753.00	3881.50
V3	175.47	300.30	245.85	55.89	39.81	1420.70	3495.00	4915.70
V4	113.52	214.70	170.74	46.59	34.78	1038.10	2555.00	2693.10
LSD at 5%	3.45	9.13	3.32	1.37	0.94	22.72	101.80	124.52
2018/19 Season								
V1	164.56	293.30	224.80	55.59	40.26	1318.40	3219.00	4537.40
V2	139.96	239.40	199.40	52.56	38.33	1206.50	2922.00	4128.50
V3	189.56	322.30	263.60	59.81	42.78	1520.60	3711.00	5231.60
V4	121.78	229.80	182.70	49.93	37.33	1114.10	2728.00	3842.10
LSD at 5%	3.82	9.72	4.66	1.13	1.04	18.08	11.70	29.78

V1 (ICBA triticale), V2 (T8), V3 (T11), V4 (T6)

Effect of seeding rates:

The grain yield and yield attributes of the tested genotypes of triticale showed considerable variation depending on the seeding rates used for planting. In the two seasons, the application of the higher seeding rate gave significantly higher yield in all tested varieties compared to the application of the lower sowing rate

Data in table (3) revealed a gradual significant increase in the yield and yield attributes of triticale genotype with increasing seeding rates, The increase of number of plants/m^2, tillers/m^2, spikes/m^2, grain and straw yields kg/fed increased with increasing seeding rate from 45 to 65 kg, in both seasons,. Therefore, the lowest value of yield and yield character were obtained by seeding rates at 45 kg/fed in the first and second seasons respectively. While the number of grains/spike and 1000 grain weight increasing seeding rate from 45 to 55 kg/fed, those two characters were resulted decreasing with increasing seeding rate up to 55 kg in both seasons. Our results agree with **Milan et al. (2017). Mut and Culimser. (2005).** In his regard **Bokan and Malesevis (2004**), which indicated a decrease in the number of grains per spike with increasing seeding rate. **Miric et al. (2007)** reported that 1000 grains weight decreased with the increasing of seeding rate. The results of the present study indicated that the most important contributor for high yield is the number of productive stems (number of spikes) per unit area (**Skuodiene and Nekrosiene, 2009).**

Table (3) Response of the yield and yield components to the seeding rates in the tow successful seasons (2017-2018 and 2018-2019)

Characters / Treatment	No. of plants/ m^2	No. of tillers/ m^2	No. of spikes/ m^2	No. of grains/spike	1000-grain weight	Grain yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
2017/18 Season								
D1	118.75	222.40	174.22	46.31	35.25	1104.50	2705.00	3809.50
D2	141.96	247.80	204.28	54.44	38.86	1179.80	2898.00	4077.80
D3	169.25	289.20	230.78	51.69	36.72	1328.10	3219.00	4398.80
LSD at 5%	4.99	5.92	4.85	0.71	0.65	15.52	37.80	136.50
2018/19 Season								
D1	127.44	238.10	186.80	49.64	37.86	1181.20	3219.00	4400.20
D2	153.12	256.40	219.00	58.31	41.81	1264.70	3084.00	4348.70
D3	181.42	310.20	247.10	55.47	39.36	1424.00	3461.00	4885.00
LSD at 5%	5.26	6.62	5.12	0.82	0.74	15.81	59.50	75.31

D_1 (45kg/fed), D2 (55kg/fed), d3 (65) kg/fed

Effect Humic acid levels:

The data presented in table (4) showed that humic acid application had a positive significant effect on all studied characters in both seasons .Increasing humic acid rate from 0 to 8 kg/fed led to a gradual and significant increase in grain yield and yield attributes which reflect the favorable role of humic acid in improving early plant growth and increasing dray matter accumulation in triticale grains (**Statt and Martin,1990).**In addition ,humic acid benefits plant growth through increasing the availability of nutrients in the root zone and buffering PH (**Julie and Bugbee,2006). Ayas and Gulser (2005)** concluded that humic acid leads to increased growth ,and subsequently increased biological yield through increasing nitrogen content of the plants .The present finding were in accordance with those reported by **Parvin et al., (2020) and Abd-Elatty et al., (2022**) who found that higher levels of humic acid application enhanced plant growth and increased grain yields of triticale through increasing important yield attributes such as number of spikes/m^2, number of grains/spike and 1000 grains weight.

Since the three – factor interaction was significant for all studied characters, in the two seasons, it is statistically appropriate to present and discuss the results of that interaction regardless of any significant two-factor interaction.

The results of variety*seeding rate*humic acid levels interaction table (5) revealed that the variations in varieties response to seeding rate and humic acid levels was due to the difference in the intensity of increase from the lowest to higher levels of both factors. Taking grain yield/fed as an example, the data indicated that grain yield.in all varieties, increased with increasing seeding rate and humic acid levels. These findings were in accordance with those of **Gibson et al. (2008)** who found that increasing seeding rate increased grain yield of triticale quadratically and the highest grain yield was obtained at the highest plant density. **Sukhanberdina et al. (2022**) reported the same trend of findings and added the presence of variation between varieties of triticale in productivity in response to seeding rate. In the present study, the highest increase in grain yield V1(ICBA triticale) was achieved, in the control, with increasing seeding rate from 45 to 65 kg/fed (26%), whereas for V2(T_8) and v4(T_6), the highest increase in grain yield were achieved with increasing seeding rate from 45 to 65 kg/fed (35and 40%, respectively). On the other hand, V3 (T_{11}) showed minor response to increasing seeding rate.

With Regard to humic acid effect, the highest increase in grain yield was obtained with increasing humic acid application from 0 to 8 kg/fed in all varieties at all plant densities. Moreover, increasing humic acid application from 0 to 8 kg/fed showed relatively low or no response in grain yield. These results agreed with those reported by **Abd-Elatty et al. (2022**) who found that application of the humic acid level resulted in highest grain yield of triticale due to increase of yield components such as 1000 grain weight and number of spike/m^2. **Parvin et al. (2020)** concluded that application of organic fertilizer such as humic acid to triticale cultivation not only improve grain yield but also reduces application of mineral fertilizers in agricultural ecosystems.

Pearson's Correlation Coefficient

Based on the main effects of four triticale genotypes as affected by the three-plant density (D1, D2, D3), under three humic acid application (H0, H1, H2). Pearson's correlations analysis was performed to study the relationship between the grain yield and other studied traits. The number of positive correlations among studied traits during the first and second seasons were similar (Figures 1a and b). Among the first season, the traits of NP, NT, NS, NG/S, 1000-GW, GY, SY and BY showed a significant correlation among them ($p<0.01$). The GY showed significant positive correlation with all studied traits except CI ($p<0.01$). The following traits showed positive correlation with both, NP with NT, NS, NG/S, 1000-GW, SY and BY ($p<0.01$). NT with NS, NG/S, 1000-GW, SY and BY ($p<0.01$). Also, NS with NG/S, 1000-GW, SY and BY ($p<0.01$). However, NG/S with SY and BY ($p<0.01$). In this concern, SY with NP, NT, NS, NG/S, 1000-GW, SY and BY ($p<0.01$). Whereas, BY with NP, NT, NS, NG/S, 1000-GW, SY and GY ($p<0.01$). On contrast, CI did not show any significant correlation with all triticale genotypes traits ($p>0.05$), (Figures 1a and b).

Table (4) Influence of humic acid on the yield and yield components of triticale in the two growing seasons (2017-2018 and 2018-2019)

Characters / Treatment	2017/18 Season							
	No. of plants/m^2	No. of tillers/m^2	No. of spikes/m^2	No. of grains/spike	1000-grain weight	Grain yield (kg/fed)	Straw yield (kg/fed)	Biological yield (kg/fed)
H0	107.42	179.80	140.44	43.53	33.28	893.00	2182.00	3075.00
H1	143.58	255.60	205.50	51.86	37.31	1280.00	3104.00	4384.00
H2	178.78	324.00	263.33	57.06	40.25	1439.50	3535.00	4815.00
LSD at 5%	3.78	5.20	4.89	0.69	0.59	15.97	70.60	1510.10
2018/19 Season								
H0	115.22	192.50	150.60	46.56	35.61	954.30	2372.00	3326.30
H1	155.19	274.00	220.20	55.69	40.14	1369.50	3327.00	4696.50
H2	191.47	347.00	282.20	61.17	43.28	1546.00	3780.00	5149.50
LSD at 5%	4.09	5.63	5.33	0.81	0.66	19.84	68.10	1614.10

H_0 (control), H1 (4kg/fed), H2 (8kg/fed)

Table (5) Interaction between triticale genotype, seeding rate and humic acid application on the yield and yield components in the two growing seasons ((2017-2018 and 2018-2019)

Characters / Treatment	No. of. Plants\m^2		NO. of tillers\m^2		No of spikes/m^2		N.OF.G. SP		1000.G. W		G.Y.kg/fed		Straw.Y.kg/fed		B.Y.kg/. fed	
	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019
V1d1h0	85	91.7	169	181.3	132.7	142	42	45.3	32	34	705	754	1727.7	1838	2433.	2592
V1d1h1	135	145.7	253	271	175.3	187.8	48	52.3	36	39	1269	1357.7	3119	3312.7	4670	4388
V1d1h2	153	163.7	332.3	356	235.3	253	52.7	57	39.3	42.3	1435	1554.7	3560	3797	5352	4995
V1d2h0	134.7	144.7	205	219.6	147	157.7	48.7	52.3	36	39	888.7	950.7	2173.3	2316	3267	3062
V1d2h1	145.3	156	272.3	293.6	222	238	55.7	59.7	39.3	42.3	1291.7	1382	3160.7	3370	4752	4452
V1d2h2	173.3	185.7	355	380	280.7	301.3	60	64.1	42	45	1453.7	1592.7	3562.3	3887	5480	5016
V1d3h0	141	151	207.3	221.7	151.7	162.7	46	49.1	34.3	36.7	991.7	1061	2412.7	2585	3646	3404
V1d3h1	182.7	196	297.7	318.7	231.7	248.3	54.3	58.3	38	41	1440	1540.7	3087.7	3760.7	5301	4528
V1d3h2	230.7	246.7	372	398.3	310	332.3	58	62.4	40	43	1571	1681	3831.7	4102.3	5403	5783
V2d1h0	78.3	84.3	146	156.3	130.3	139.7	40	43	30.7	32.7	673.3	720.7	1638.7	1753.7	2474	2312
V2d1h1	92.3	99.3	180.3	193	155.7	166.3	44.3	47.4	34	36.7	1167	1249	2848.3	3045.3	4294	4015
V2d1h2	147.3	158	234	250.2	188.3	201.5	48	51.2	37.3	40.3	1250	1338.7	3053	3261.7	4600	4303
V2d2h0	91.3	98	152	162.7	134.7	144.3	46.3	49.3	34.3	37	697.3	736.3	1701	1786	2522	2398
V2d2h1	132	141.7	213.7	228.3	184.3	197.3	53	56.9	37.7	40.7	1238	1325.3	3020	3232.3	4558	4258
V2d2h2	157.7	167.3	260.7	279	236.7	253.3	59	63	40.3	43.3	1321.7	1414	3228.7	3450	4864	4550
V2d3h0	111.3	119.7	186	199.3	144	154.3.	45.3	46.7	32.3	34.3	938	1003.7	2287.3	2442.3	3446	3225
V2d3h1	155	166	291.7	312.1	221.7	237.3	51.3	55.3	36.7	38.7	1366.7	1462.3	3336	3398	4860	4703
V2d3h2	210	225.3	349.7	374.3	280.3	300.5	55	58.99	38.3	41.3	1503	1609	3670	3926	5535	5173
V3d1h0	104.3	111.67	200.3	214.3	161	173	45	47	35	37.7	1152	1232.7	2875	3005.3	4238	4027
V3d1h1	161.3	176.3	280	299.7	215.3	231	51	54.7	38	41	1356	1451.3	3311.3	3541.3	4993	4667
V3d1h2	203	217.67	363.7	389.7	290.3	311	56.7	60.7	43	46	1505	1610.7	3675.7	3927	5538	5181
V3d2h0	137	147.3	229.7	245.98	166	178	50.3	54	37	40.3	1185	1268	2885.7	3092.7	4361	4071
V3d2h1	168.7	190.67	296.7	317.6	254.7	274.7	61	65.3	41.7	44.7	1438	1538.7	3504.7	3755.3	5294	4943
V3d2h2	227	243	374.4	401	328.3	351.7	67.67	71.7	45	48.3	1643.7	1758.7	4011.7	4293.3	6052	5655
V3d3h0	144.67	154	244	261.3	182.7	196	48.67	52.7	36.3	39	1`275.3	1368	3112	3341.7	4710	4387
V3d2h1	191.67	206	307.7	329.7	277.7	296.3	57	61	40	43	1486	1590.7	3825.7.	3884	5475	5312
V3d2h2	241.67	259.3	406.67	438	336.3	360.7	65.7	70.3	42	45	1744	1867	4254	4562	6429	5998
V4d1h0	68	73	126	135	104	111.7	32.3	34.3	26.7	28.7	576	617.3	1400.3	1506	2123	1976
V4d1h1	91.3	97.7	176.7	189	142	152.3	46	49	33.3	35.3	1000.7	1070.7	2436.7	2616.3	3687	3437
V4d1h2	102.7	110.3	207	221.4	160.7	172	49.7	53.3	37.7	40.7	1145.3	1225.3	2820	3085.7	4311	3965
V4d2h0	70	75	131.7	140.7	111.7	119.3	44	47	34.6	34,7	681	729	1653.3	1772.7	2502	2334
V4d2h1	126	135.7	214	229	170.3	182.3	51.7	55	38	41	1070	1145	2606	2790	3935	3676
V4d2h2	141	151.3	268.7	287.3	215	230	56.7	60.7	40	43	1248.3	1335.7	3263	3262	4598	4511
V4d3h0	123.3	132.3	139.7	171.3	120	128	34.3	37.1	29	31.3	952	1018.7	2317	2484	3503	3269
V4d3h1	141	151.3	283.7	303.7	215	230	49.7	53.2	35.6	38.3	1234.7	1321	3003.7	3222.7	4544	4238
V4d3h2	158	169.3	364.3	389.7	298	318.7	55.7	59.7	38	41	1433.7	1564.7	3492.3	3816.7	5381	4926
L.S.D 5%	13.411	14.39	18.76	20.41	15.852	17.32	2.512	2.765	2.084	2.765	50.44	62.50	230.8	242.9	305	281

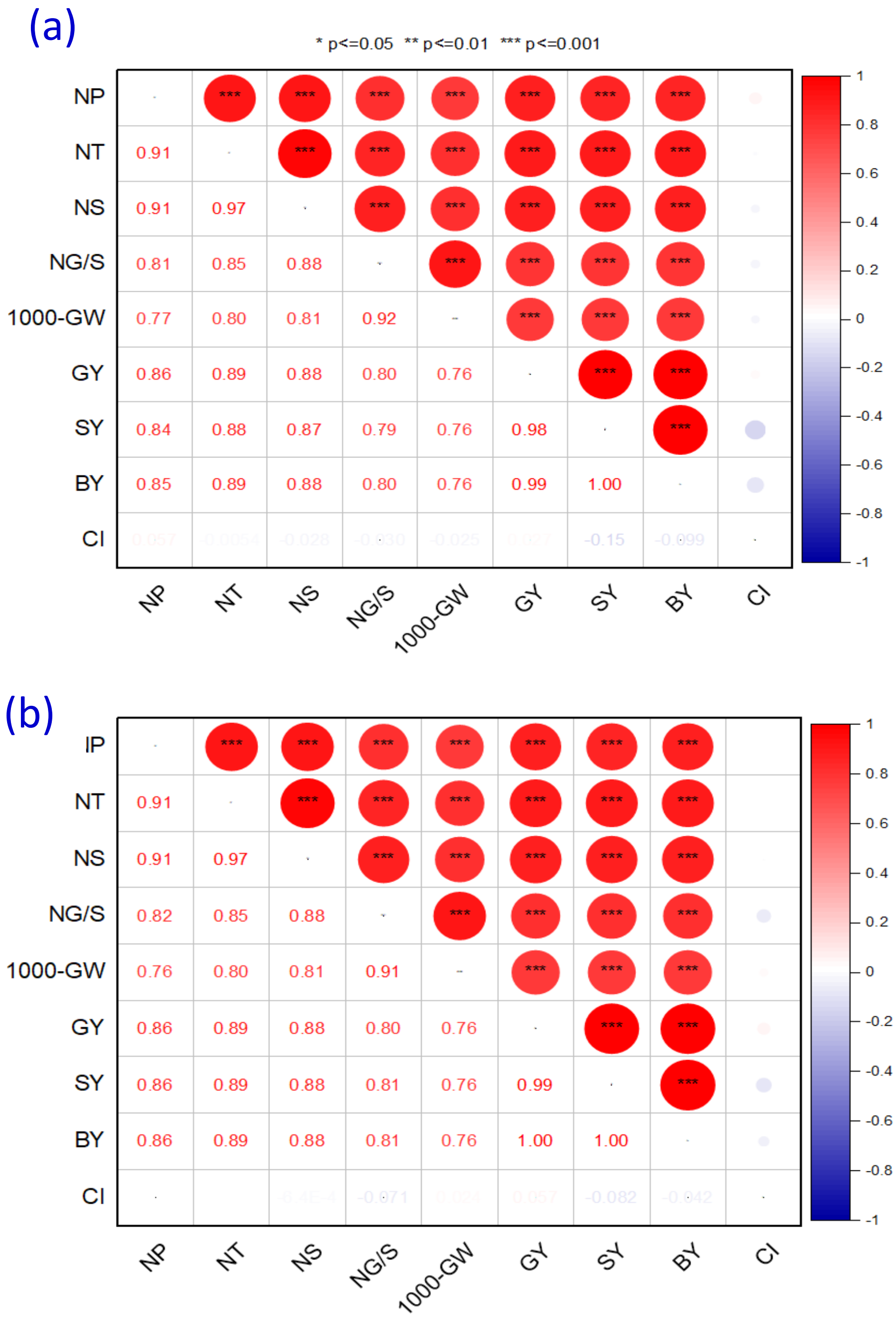

Figure 1a & b Pearson's correlation between the studied traits of triticale genotypes under the studied experimental factors. NP: No. of plant/m^2, NT: No. of tiller/m^2, NS: No. of spikes/m^2, NG/S: No. of grains/spike, 1000-GW: 1000-grain weight, GY: Grain yield (kg fed^{-1}), and SY: Straw yield (kg fed^{-1}). The large and medium red (positive) and blue (negative) circles indicates a significant (*p<0.05) or highly significant correlation (**p<0.01), while the small red (positive) and blue (negative) circles indicates non-significant correlations.

Principal Component Analysis (PCA)

The seven PCs for all triticale genotypes traits based on D, HA, and V treatments are shown in Table 6. Out of all PCs, the first main PCs (PC1) extracted had eigenvalues larger than one (Eigenvalue >1) with values of 6.689. Meanwhile, the rest of the other PCs had eigenvalues less than one (Eigenvalue <1). Therefore, PC1 was retained for the final analysis, in which these two PCs explain more variance than an individual attribute [42] and express more variability and support to select the trait with a positive loading factor. The first PCs contributed 95.6% of the total variation existing among studied traits regarding D, HA, and V variables. The contributions of PC1 to the total variance were higher than that of PC2 (3.10%), with PC1 describing approximately only 95.6% % of the measured data total variability.

Based on all measured data, PC1 mainly distributed and distinguished the experimental factors and studied traits in different groups. Therefore, the first two PCs were employed to draw a biplot (Figure 2). The data of variables studied displayed a positive correlation between most studied traits, but they differed in their degree and consistency in quantity. The biplot diagram depicted the contribution of D, HA, and V increasing variability of all traits measured. In PC1 (Figure 2), 1000-GW and NG/S traits of triticale genotypes (V8, V11), were highly and positively associated with seeding rate 55 kg fed^{-1} (D2), in both seasons, under 4 and 8 kg humic acid fed^{-1} , which was in the first and fourth quarters. However, GY, SY, NS, NT, and NP traits of triticale genotype (ICBA triticale), were highly and negatively associated with seeding rate 65 kg fed^{-1} (D3), in both seasons.

The PCA scree plot for D, HA, and V on GY of triticale and other traits evaluated showed that the PC1 eigenvalues correspond to the whole percentage of the variance in the dataset (Figure 3). **Shamuyarira et al., (2022)** found that, the rotated component matrix showing the percentage variance of different principal components (PCs) and the respective loadings of recorded traits is shown in the first four PCs under non-stressed conditions had a cumulative variance of 79.93%. The first PC had the highest variation of 37.04%, followed by PC2 with 15.27%. Shoot biomass, PB and grain yield made the highest contributions to PC1, followed by root biomass, RS and TKW with positive contributions to PC2. The highest positive loadings for PC3 and PC4 were for RS and DTM, respectively. Under drought-stressed conditions, the first PC had a percentage variance of 39.19% and was positively correlated with PB, shoot biomass, SPS, spike length and plant height. The second and third PCs were correlated with DTH and TKW, respectively. Principal components 4 and 5 had high positive loadings for root-related traits, such as RS and root biomass, respectively.

Also, PCA analysis by **Rapacz et al., (2015)** indicated that the main factor affecting relationships between different OJIP- test parameters was the environmental conditions before sampling. All late-winter-measured data points were placed on the right side of the PCA plot, whereas both early-winter and laboratory-sampled data appeared on the left. Interestingly, most of the OJIP-test parameters were responsible for the variation seen between accessions in the left part of the graph, with only three parameters contributing to those on the right. ABS/RC and DI o/RC were responsible for observed differences in the late-winter sampling in 2011/12 (and DIo /CS also in the case of late winter sampling in 2012/13); in addition, these two parameters, together with TR o/RC and ABS/CS, were the main source of variation in late winter in 2010/11. Measurement year also had an important effect on late-winter measurements, as its contributions to principal components 1 and 2 (PC1 and PC2) respectively increased or decreased according to winter severity. Among early-winter samplings, the results obtained during the winter of 2011/12, when plants were damaged in the field before early-winter measurements, were distinct from those of the remaining winters. In the case of wheat, the results were very similar to those of the laboratory sampling. Differences between species were evident regardless of winter and measurement date, with one exception less freezing-tolerant triticale cultivar Fredro, which performed similarly to wheat genotypes in 2012/13. Authors also found it remarkable that results of the OJIP analysis highly correlated with freezing tolerance and field survival, namely, the second sampling date during the winter of 2011/12 in the case of triticale and the second sampling date in 2012/13 for common wheat, had very similar positions on the PCA plot, with PC2 close to 0 and PC1 with a low, positive value.

Table 6. Results of principal component analysis (PCA) in the first seven principal components (PCs) for the studied triticale traits as affected by the three experimental factors (i.e., plant density, humic acid application and triticale genotypes).

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
NP	0.37734	-0.29161	0.63763	0.4918	0.33546	-0.10372	0.029226
NT	0.38055	-0.28333	0.20496	-0.68731	0.090621	0.49656	0.075614
NS	0.38443	-0.14459	0.083737	-0.27977	-0.50277	-0.68106	-0.17148
NG/S	0.37242	0.54569	0.1795	0.25594	-0.54968	0.39011	0.10712
1000-GW	0.36745	0.64736	-0.095214	-0.20861	0.56698	-0.2507	-0.09491
GY	0.38141	-0.23431	-0.48623	0.26657	0.031783	0.23823	-0.65907
SY	0.38186	-0.20502	-0.51643	0.16551	0.043114	-0.08391	0.71356
Eigenvalue	6.689	0.219	0.056	0.022	0.011	0.005	0.000
Variance (%)	0.956	0.031	0.008	0.003	0.002	0.001	0.000
Cumulative (%)	0.956	0.987	0.995	0.998	0.999	1.000	1.000

NP: No. of plant/m^2, NT: No. of tiller/m^2, NS: No. of spikes/m^2, NG/S: No. of grains/spike, 1000-GW: 1000-grain weight, GY: Grain yield (kg fed^{-1}), and SY: Straw yield (kg fed^{-1}).

Table 7. Results of principal components (PCs) for the studied four triticale genotypes traits as affected by the three-plant density (D), and three humic acid application (HA).

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
V1	0.66114	-0.04823	0.24504	-0.11395	0.10768	0.12292	-0.00957
V2	-1.3095	0.041406	-0.05287	0.14888	-0.10564	-0.06081	-0.02171
V3	3.1922	0.050411	-0.07402	0.1357	0.13465	-0.07345	0.013586
V4	-2.5438	-0.04359	-0.11815	-0.17063	-0.13669	0.011348	0.017693
D1	-2.0028	-0.17572	-0.35741	-0.13763	0.12661	-0.03032	-0.0069
D2	0.45352	1.0655	0.15167	0.038475	-0.04447	0.01515	0.00296
D3	1.5493	-0.88975	0.20574	0.099154	-0.08214	0.015165	0.003945
H0	-4.4111	-0.05685	0.31159	0.059235	0.080072	-0.0439	0.004408
H1	0.5354	0.033952	-0.35423	0.16548	-0.0232	0.10551	0.001563
H2	3.8757	0.022896	0.042645	-0.22472	-0.05687	-0.06161	-0.00597

V1: ICBA triticale, V2: triticale 8, V3: triticale 11, V4: triticale 6, D1, D2, and D3 indicate plant densities 45, 55, and 65 kg fed^{-1}. H0, H1, and H2 indicate the addition of 0, 4, and 8 kg fed-1 humic acid, respectively.

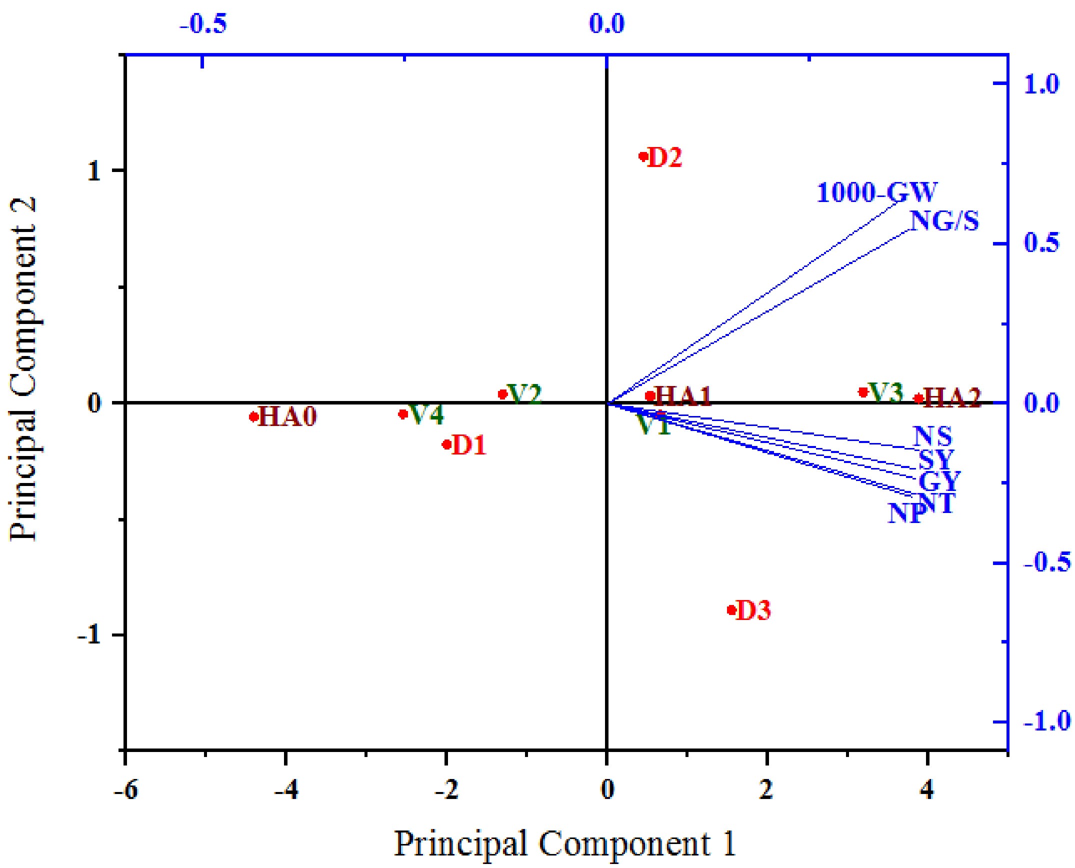

Figure 2. Biplot diagram of PC1 and PC2 shows similarities and dissimilarities in relationships between the studied traits of triticale genotypes for the studied factors. HA0, HA1, and HA2 indicate the addition of 0, 4, and 8 kg fed^{-1} humic acid, respectively. NP: No. of plant/m^2, NT: No. of tiller/m^2, NS: No. of spikes/m^2, NG/S: No. of grains/spike, 1000-GW: 1000-grain weight, GY: Grain yield (kg fed^{-1}), and SY: Straw yield (kg fed^{-1}).

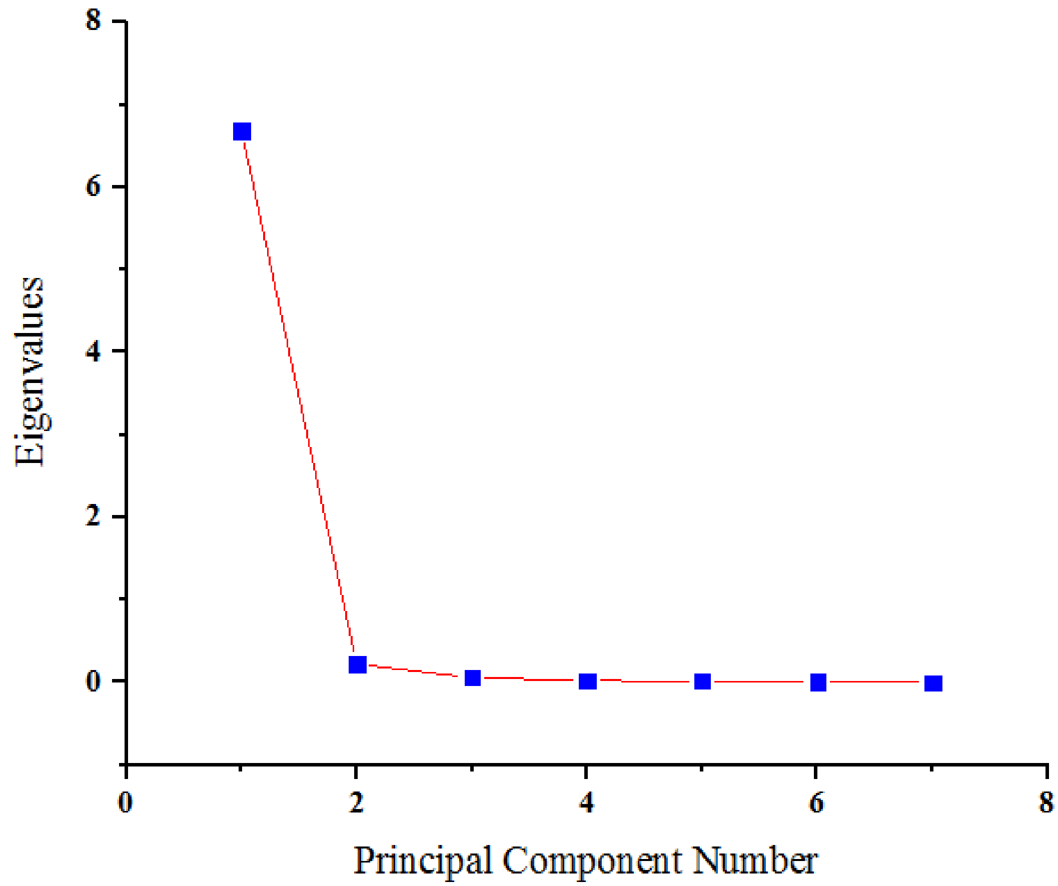

Figure 3. Scree plot of principal component analyses (PCA) between respective eigenvalues % and components number.

Conclusion:

In order to increasing the yield and attributes of any cops depending on agriculture practices, as example cultivars, genotypes , fertilizer ,bio fertilizer , irrigation system, and regime, and another factors. In this study depending on genotypes, seeding rates and humic acid levels, the highest values of the yield and attributes were obtained by T_{11} (v3) genotype, with 65 kg seeding rates and 8 kg humic acid levels, while the lowest values were obtained by T6 (v4) genotype with 45 kg seeding rate and 0 humic acid levels**.**Pearson,s correlations analysis revealed that GY was significantly and positively correlated with all studied traits. Principal component analysis revealed that the first main PC (PC1) had eigenvalues greater than one (6.689) and contributed 95.6% of the total variation existing among studied traits regarding seeding rate, humic acid rate and variety variables. The contributions of PC1 to the total variance were higher than that of PC2 (3.10%)

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تأثير معدل الزراعة وإضافة الهيومك اسد على إنتاجية بعض التراكيب الوراثية من التريتيكال بمحطة بحوث القنطرة شرق

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الملخص العربي

أجرى هذا البحث فى محطة بحوث تابعة لمركز بحوث الصحراء بالقنطرة شرق- شمال سيناء – مصر , فى الموسمين الشتويين 2017-2018 و2018-2019 , لدراسة تأثير ثلاثة معدلات من التقاوى وهى 65,55,45 كجم/فدان من التقاوى وثلاثة مستويات من حمض الهيومك(0(كنترول) , 4 , 8كجم/فدان) على المحصول ومكونات المحصول لأربعة تراكيب وراثية من التريتيكال وهى تريتيكال11 , اجبا تريتيكال وتريتيكال 6,8 , و كان التصميم التجريبى قطع منشقة مرتين بحيث أحتلت التراكيب الوراثية القطع الرئيسية , ومعلات التقاوى القطع الفرعية ومستويات حمض الهيومك القطع تحت الفرعية فى ثلاث مكررات , وأوضحت النتائج أن التركيب الوراثى تريتيكال 11 مع معدل الزراعة 55 كجم/فدان ومستوى حمض الهيومك 8 كجم/فدان أعطى أعلى القيم لكل من عدد النباتات/م^2 وكلا من عدد الأشطاء والسنابل/م^2, وإنتاجية كلا من الحبوب والقش كجم/فدان , وأعطى التركيب الوراثى تريتيكال11 أعلى معنوية عن بقية التراكيب الوراثية إجبا تريتيكال , وتريتيكال 6,8 فى كل الصفات تحت الدراسة فى كلا من الموسم الأول والثانى على التوالى , وأوضح تحليل معامل الإرتباط أن إنتاجية الحبوب كانت معنوية فى الإرتبط مع كل الصفات تحت الدراسة.

أظهر تحليل مكونات المحصول أن المكون الاول (PC1) له قيم ذاتية أكبر من الواحد الصحيح وهي (6.689) وساهم بنسبة 95.6٪ من التباين الكلي الموجود بين الصفات المدروسة فيما يتعلق بمعدل التقاوى ومعدل حمض الهيوميك ومتغيرات الصنف. أيضا كانت نسبة مشاركة المكون الأول فى التباين الكلي أعلى من نسبة مشاركة المكون الثانى في التباين (3.10٪(مما يشير الى نجاح إمكانية استخدام المكون الأول في تحليل مكونات المحصول مقارنة بباقى المكونات الأخرى.

بناءً على جميع البيانات المقاسة، قام المكون الرئيسي الاول (PC1) بشكل أساسي بتوزيع وتمييز العوامل التجريبية والصفات المدروسة في مجموعات مختلفة. كما أظهرت بيانات المتغيرات المدروسة ارتباطًا إيجابيًا بين معظم الصفات المدروسة، لكنها اختلفت في درجتها واتساقها في الكمية .لوحظ مساهمة المعاملات المدروسة في زيادة التباين في جميع الصفات قيد الدراسة في المكون الرئيسي الاول (PC1) ، حيث كانت صفتى وزن الالف حبة وعدد لكل من الصنفين 8و 11 مرتبطة ارتباطًا وثيقًا وإيجابيًا بمعدل التقاوى 55 كجم فدان ، في كلا الموسمين ، عند معدل حامض هيوميك 4 و 8 كجم /ف والتي كانت في الربعين الأول والرابع.من تحليل مكونات المحصول ومع ذلك ، كانت صفات المحصول والقش والبيولوجى وباقى معظم الصفات مرتبطة بشكل كبير وعكسى بمعدل التقاوى 65 كجم فدان ، في كلا الموسمين .