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The use of spraying brassinolide to improve the genotypes yield of triticale *X Trititcosecal wittmack*

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ABSTRACT

This study was conducted to investigate the effect of brassinolide growth regulator concentrations on triticale yield *X Trititcosecal wittmack*. This study included three concentrations of brassinolide (0, 3 and 6 mg L^{-1}) and six genotypes of triticale (Mel 7, Farah, Muhannad, LIRON3, LIRON5 and LIRON6). Cultivation was carried out during the winter season 2020-2022 at the research station of the Field Crops Department, College of Agriculture - Tikrit University using a randomized complete block design (RCBD) with split plot design and with three blocks, the main plot included the three concentrations of brassinolide at the stage of tiller formation, while the secondary plot included six genotypes of triticale crop. The experimental unit included three lines, the length of the line (3 m) and the distance between one lines was (0.25 m), using 120 kg seed per dunum, and the data were recorded for the following characteristics: flowering up to 75% of spikes (day), plant height (cm), number of spikes per square meter, number of grains per spike, weight of 1000 grains (g), grain yield (ton ha^{-1}), biological yield (ton ha^{-1}) and harvest index (%). The results showed the superiority of the interactions (the second concentration X Farah variety) in most of the traits under study with a non-significant difference for the same concentration with LIRON3 variety except number of flowers up to 75%, the plant height, spikes number and grains numbers and this increase was achieved through the effect of growth regulator brassinolide on growth characteristics and yield.

استخدام الرش بالبراسينولايد لتحسين حاصل تراكيب وراثية من القمح الشيلمي *X Trititcosecal Wittmack*

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الخلاصة

اجريت هذه الدراسة لمعرفة تاثير تراكيز من منظم النمو البراسينولايد في انتاجية القمح الشيلمي *X Trititcosecal Wittmack*, حيث شملت الدراسة ثلاث تراكيز من البراسينولايد (0 و3 و6 ملغم لتر$^{-1}$) وستة تراكيب وراثية من القمح الشيلمي (امل7 و الفرح و المهند وLIRON3 وLIRON5 و LIRON6). تمت الزراعة خلال الموسم الشتوي 2020-2022 في محطة الابحاث التابعة لقسم المحاصيل الحقلية كلية الزراعة- جامعة تكريت بأستخدام تصميم القطاعات العشوائية الكاملة بنظام الالواح المنشقة وبثلاث قطاعات, اذ شملت الالواح الرئيسيه التراكيز الثلاثة من البراسينولايد عند مرحلة تكوين الاشطاء بينما شملت الالواح الثانوية ستة تراكيب وراثية لمحصول القمح الشيلمي, شملت الوحدة التجريبية ثلاث خطوط طول الخط (3 م) والمسافة بين خط واخر (0.25 م) وبكمية بذار 120 كغم دونم, وتم تسجيل البيانات للصفات التالية: التزهير حتى 75% من السنابل(يوم) وارتفاع النبات(سم) ووعدد السنابل في المتر المربع وعدد الحبوب بالسنبلة ووزن 1000 حبه (غم) وحاصل الحبوب (طن ه$^{-1}$) والحاصل البايلوجي (طن ه$^{-1}$) ودليل الحصاد(%), بينت النتائج تفوق التركيز (3 ملغم لتر$^{-1}$) في الصفات عدد الايام من الزراعة حتى طرد 75% من السنابل وارتفاع النبات وعدد الحبوب بالسنبلة ووزن 1000 حبة وحاصل الحبوب والحاصل البايلوجي ودليل الحصاد باستثناء التركيز(6 ملغم لتر$^{-1}$) لصفة عدد السنابل, كما تفوق التركيب فرح في عدة صفات منها اقل فترة لطرد 75% من السنابل (99.88) يوم بالاتجاه المرغوب وارتفاع النبات (133.11) سم وعدد الحبوب بالسنبلة (47.42) حبة سنبلة$^{-1}$ ووزن 1000 حبة (46.73) غم وحاصل الحبوب (5.39) طن ه$^{-1}$ والحاصل البايلوجي (15.08) طن ه$^{-1}$ ودليل الحصاد (38.1) %, اما التداخلات فقد تفوق (التركيز الثاني X التركيب فرح) في اغلب الصفات قيد الدراسة وبفارق غير معنوي لنفس التركيز عند التركيب LIRON3 باستثناء عدد التزهير حتى 75% سنابل وارتفاع النبات وعدد السنابل وعدد الحبوب وهذه الزيادة حققت من خلال تاثير منظم النمو البراسينولايد في صفات النمو والحاصل.

الكلمات الافتتاحية: رش البراسينولايد، القمح الشيلمي.

INTRODUCTION

Triticale *X Triticosecale wittmac*, one of the cereal crops belongs to Grassy family, was derived through cross-breeding between the two crops, *Triticum aestivam* L. and *Secale cereal* L. , this crop is similar in shape to wheat crop, and the protein percentage in the grain and its content of amino acid lysine is high compared with wheat by 4%. However, the quality of protein and its content of gluten, which is reflected in the quality of the baked goods, is lower than that of wheat crop (Khalil et al., 2015). It is also a dual-purpose crop used to produce green fodder for its good vegetative growth, especially the leaf area and formation of straws, in addition to its use for grain production. FAO statistics (2020) indicated the area harvested from this crop amounted to 3.81 million hectares and produced 5.36 million tons, with an average productivity of 4.03 tons ha^{-1} in 35 countries that produce this crop. Despite the importance of this crop and its multiple uses, interest in it and spreading its cultivation has become very limited in Iraq. Because knowledge of farmers lack about it, or the genetic structures lack of this crop, as well as the lack of studies on the performance of genetic structures, whether locally derived or introduced in terms of service operations, and the use of modern technologies to improve the performance of the crop in the field to develop growth characteristics and yield. Therefore, the study of genotypes behavior by researchers by determining the characteristics of growth and yield is of great importance in order to choose the appropriate variety for the area that responds to various agricultural and nutritional

treatments to bring the required and expected improvement in growth and yield characteristics (Menshawy, 2004), many studies showed different genotype in growth and yield traits, as well as the difference in the response amount to different treatments, including the study of Bektas (2016), Soresa (2016), Al-Mohammadi (2018) and Al-Dulaimi (2020).

The characteristics of this crop can be improved, such as growth, physiological and yield by using many practices and techniques, especially the use of dilute solutions of growth regulators as spraying on the vegetative part, plant growth regulators are considered organic compounds that are added as a spray to the vegetative part of plants, which have activities and similar effects to those of plant hormones produced internally in very small quantities. Brassinolide is one of these regulators that is added as a spray to the vegetative part and works to improve plant growth such as elongation of stems and roots, keeping leaves green for a long time and delaying their aging. In addition to its effective role in improving pollen fertility and increasing the relationship between source and estuary, so the use of these organizations is also one of the practices used to improve plant performance in terms of growth and production (Idris, 2009). The effectiveness of the use of brassinolide is determined by several factors, especially the concentration used, especially since the plant needs growth regulators in very low concentrations, and that a decrease in concentration from the required limit may not produce the required stimulation, and a high concentration can convert the growth regulator from a stimulator to an inhibitor that is counterproductive. Among the studies that dealt with this topic are the study of Anwer et al. (2014), Lal et al. (2019), and Bandar (2021).

Therefore, this research aims to determine the behavior of some genotypes of triticale under the influence of different concentrations of growth regulator brassinolide added by spray on the vegetative part, and to know the optimal concentration in addition to the interaction between them to achieve the highest grain yield under the conditions of the region.

MATERIALS AND METHODS

This experiment was conducted at the research station of Field Crops Department, College of Agriculture - Tikrit University, to find out the effect of brassinolide (Rasha) on some growth characteristics, yield and its components of different triticale genotypes, yield and its components during the season 2020-2021. Amal 7, Farah and Al Muhannad genotypes were obtained from the Ministry of Science and Technology - Agricultural Research Department, and the LIRON-3, LIRON-5 and LIRON-6 genotypes from Salahaddin University, College of Agriculture (Table 1). Plowing and leveling operations were carried out for the soil of the field and various samples were taken with a depth of 30 cm for analysis, the details of which are shown in Table (2).

Table (1) names of genotypes Included in the study and its proportions and source

Genotypes	Ratios	Sources
Farah	LOCAL CHECK**RWAIDA	Ministry of Technology and Science
Amal	LOCAL CHECK	Ministry of Technology and Science
Mohand	LOCAL CHECK	Ministry of Technology and Science
LIRON-3	LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/… CTSS02B00413S-22Y-2M-3Y-3M-2Y-0M	MXI07-08 C41ITYN190041
LIRON-4	LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/… CTSS02B00418S-22Y-4M-4Y-2M-1Y-0M	MXI07-08 C41ITYN190044
LIRON-6	LIRON_2/5/DIS B5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/… CTSS02B00419S-10Y-5M-3Y-4M-2Y-0M	MXI07-08 C41ITYN 190046

Table (2) Physical and chemical properties of the experimental field soil

Characteristic	Measuring unit	Value
Soil reaction level (pH)		**7.30**
EC	**Desimens M-1**	**2.98**
Organic matter	**g 100 g^{-1}**	**1.95**
ready-made nitrogen	**g 100 g^{-1}**	**1.51**
ready-made phosphorous	**g 100 g^{-1}**	**0.071**
Ready-made photasium	**ppm**	**92.73**
Sand	**g kg^{-1}**	**554**
Silt	**g kg^{-1}**	**251**
Mud	**g kg^{-1}**	**198**

The experiment was carried out according to randomized complete block design by split plots design and with three blocks. The study included two factors, first one was growth regulator, brassinolide, with three concentrations (0, 3 and 6 mg L^{-1}), which represented the main plots, which were sprayed on the vegetative part at the beginning of the formation of the tillers. The second factor was six genotypes of triticale crop, which represented the secondary plots, and the experimental unit consisted three lines with a length of (3) m and a distance between them was (0.25) m using (120) kg ha^{-1} of seeds, nitrogen fertilizer was added at a rate of 200 kg of nitrogen ha^{-1} in the form of urea by two dates of adding, the first at planting and the second half after 30 days of planting, and triple super phosphate fertilizer (phosphorous pentoxide ha^{-1}) at a rate of 120 kg ha^{-1} at planting time (Sibahi 2011). Harvest was done at full maturity. The data was recorded for the following characteristics: the period from planting to 75% spike emergence (represented the period from the date of planting until the stage when plant reached 75% of spike emergence)

and the plant height (measured by a tape measure and taken for ten plants from the median lines except for the awn, and extract their average), and the spikes number m^2 (the spikes numbers confined to a distance of 50 cm from the median lines was calculated and converted to square meter). Number of grains spike^{-1}, and the weight of 1000 grains (estimated by a sensitive scale from each treatment for 1000 grains taken from the crop randomly) grain yield kg ha^{-1} (a line of 1 meter length was harvested from each treatment by cutting and collecting the spikes, discarding the spikes, and then weighing the grains with a sensitive scale to extract the grain yield for each experimental unit, and then converted to ton ha^{-1}) the biological yield is tons ha^{-1} (represents the weight of the whole plant, straw and ears without roots, and it was calculated for a whole line and then converted on the basis of tons of hectares (Donad and Hamblin, 1976), harvest index (HI) = (grain yield / biological yield) x 100.

Statistical analysis was carried out according to the used design and the averages were tested according to Duncan's multiple range tests with significant indication of (5%) by SAS program (AL-Zubaidy and AL-Flahy 2016).

RESULT AND DISCUSSION

It is clear from Table (3), which represents the analysis of variance of the traits under study, that spraying with brassinolide was significant at the probability level (1%) for all studied traits, also the genotypes factor was significant at the probability level (5%) for all studied traits. While, the interaction between the two factors of the study was significant at the probability level of (1%) for the plant height and biological yield, and significant at the probability level of (5%) for the both characteristics, grain yield and harvest index. Meanwhile, it did not reach the statistical significance limits for the rest of the traits. The variation of the genotypes of triticale and its response to growth regulator (brassinolide) caused significant differences in the studied traits, and these results are agree with the results of Lal et al. (2019), Bender (2020), Hussain et al. (2022), Sharqi et al. (2023), Shaaban and Omer (2023) and Al-Bayati and Al-Namrawi (2023).

Table (3) Variance analysis represented by average of squares for the studied traits

Sources of difference	Blocks	Brassinolide A	Error A	Genotypes B	interaction	Error B
Freedom degrees traits	2	2	4	5	10	30
Number of days to spike emergence (day)	6.508	60.10**	1.38	62.99*	3.39	2.68
Plant height	0.135	134.14**	0.25	106.87*	1.623**	0.59
Spikes number plant $^{-1}$	1073.5	5372.2**	118.71	6824.69*	80.15	46.00
Spike grain number^{-1}	3.88	19.71**	1.28	68.67*	0.32	1.31
Weight of 1000 grain (g)	0.54	22.68**	0.10	15.36*	0.15	0.93
Yield (ton ha^{-1})	0.33	1.92**	0.10	0.57*	*0.07	0.03
Biological yield (tons ha^{-1}	0.11	0.84**	0.00	6.25*	0.09**	0.02
Harvest Index (%)	0.23	102.83**	5.62	3.21*	3.45*	1.33

The plants treated with the concentration of brassinolide (3 mg L^{-1}) recorded the least number of days until 75% of the spike emergence (102.31) days, while the concentration (6 mg L^{-1}) recorded the longest period for spike emergence (105.95 days), the reason for this is due to the role of brassinolide in shortening the time required to the spikes emergence, through the processes of growth and development in the plant, such as increasing division rates, elongation and development of physiological processes, raising photosynthesis rates in plant which affected the increase of water transport and some nutrients, which reduces the internal competition of one plant, and accelerates the completion of the hormonal balance and the formation of the floral and fruit parts (Chakma 2014) raising the concentration to (6 mg L^{-1}) was not appropriate for early occurrence, and this may be due to the increase in concentration led to loss of brassinolide for its stimulating property, or that the increase led to a hormonal imbalance within the plant that had an effect on this characteristic. It was a factor in delaying access to this trait, and these results are in agreement with the results of Bandar (2021), the composition was Farah the earliest of the structures and was distinguished by the lowest average of 99.88 days and a significant difference from the rest of the structures, but the highest average given by the cultivar Muhannad was 107.63 days This is due to the genetic difference between the structures. The interaction between the concentrations of brassinolide and the structures had significant differences according to Duncan's multi-range test, as the composition Farah at a concentration of 3 mg L^{-1} recorded the lowest average of 98.66 days (in the desired direction), while the composition recorded Muhannad at a concentration of 6 mg L^{-1} the highest average was 111.33 days (in the undesirable direction).

Table (4) Effect of brassinolide and genotypes and their interaction on number of days for spikes emergence (day)

Genetics	**Brassinolide**			**Genetic average**
	0 mg L^{-1}	**3 mg L^{-1}**	**6 mg L^{-1}**	
Amal7	106.44bc	104.00c-f	106.89 bc	105.77b
farah	99.22gh	98.66 h	101.77 efg	99.88d
almohanad	107.22 b	104.33 b-f	111.33 a	107.63a
Liron3	102.33 def	101.55 fg	104.66 b-f	102.85c
Liron4	105.44 bcd	102.66 def	106.22 bc	104.77b
Liron6	105.33bcd	102.66 def	104.88b-d	104.29bc
brassinolide averages	104.33b	102.31c	105.96a	

The concentrations of brassinolide recorded significant differences in plant height through the superiority of 3 mg L^{-1} concentration with an average of 130.25 cm, while the concentration 6 mg L^{-1} gave the lowest average plant height of 124.80 cm (Table 5). The increase in plant height is due to the effect of brassinolide on cell division and an increase in cell elongation through its effect on the apical meristem and an increase in activities of growth regulator (auxin) and its effect on the flexibility of membranes, and thus the plant height increase on one hand, and on the other hand, it was observed when the concentration of brassinolide was increased, it inhibited the plant (Eleiwa et al., 2011). This result is consistent with LaL et al. (2019) and Surender and Slvakumar (2020) results. Farah cultivar recorded the highest plant height of 133.11 cm with a significant difference from the rest of other genotypes, while amal 7 cultivar gave the lowest average and

reached 123.78 cm, that the difference in the genetic nature of varieties and their ability to respond to environmental conditions led to the disparity in vegetative growth, which was reflected in the height of the plant (Wie and Li, 2016). Also it was observed that the correlation between the trait of emergence of spikes with the plant height reached (-0.892) according to Table (12), that is, the older the plants, the more they give the full opportunity to give the highest plant height. These results are agree with the results of Jadoua et al. (2017) and Al Dulaimi (2018). As for the combinations between the two factors of the study, it was significant, as the combination (3 mg L^{-1} x composition Farah) excelled with the highest average of 135.95 cm, with a significant difference from the rest of the combinations, and the lowest value recorded by Amal cultivar at a concentration of 6 mg L^{-1} with an average of 121.81 cm.

Table (5) Effect of brassinolide and genotypes and their interaction on plant height (cm)

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	123.18 i	126.35 h	121.81 j	e 123.78
farah	133.28 b	135.95 a	130.09 d	133. 11 a
almohanad	126.08 h	127.86 fg	122.93 ij	125.63 d
Liron3	131.73 c	132.92 bc	126.40 h	130.35 b
Liron4	125.81 h	128.69 ef	123.99 i	126.16 cd
Liron6	126.62 gh	129.74 de	123.58 i	126.65 c
brassinolide averages	127.28 b	130.25 a	124.80 c	

It is evident from the results of Table (6) that the concentration of brassinolide (3 mg L^{-1}) was superior with highest average of spikes number M^{-2}, which amounted 357.72 spike m^{-2}, and spikes number decreased to the lowest average at the concentration of 6 mg L^{-1} (33.8 spike m^{-2}). This may be due to the fact that spraying brassinolide led to an increase in carbonization process through its role in distributing the products to all parts of the plant, and in turn led to an increase in tillers number in the plant and a decrease in competition between the vegetative and fruit groups for the outputs of carbonization process, which led to its transformation into effective tillers holding spikes, and this was reflected on the increase of spikes number per unit of area (Salehzade et al., 2009). These results are in agree with the results of Bender (2021), and the structures differed significantly among themselves through the superiority of the Farah construct (391.37 spike m^{-2}), while the Almuhannad gave the lowest number of spikes (324.96 spike m^{-2}). The reason that Farah variety excelled is attributed to the consideration of high branching for this variety, which gives the highest number of spikes, in addition to the difference in genetic nature and its connection to the formation of effective tillers that cause an increase in the number of spikes, in addition to the negative correlation between this trait and the spike emergence according to Table (12). These results are consistent with the results of Salman (2016) and Singh (2018) who noted that the interaction between Farah at a concentration of 3 mg L^{-1} was significant and reached an average of 410.00 spike m^{-2} for this trait, and the least interaction was recorded by Amal 7 variety at a concentration of 6 mg L^{-1}, reaching 303.77 spike m^{-2}.

Table (6) Effect of brassinolide and genotypes and their on number of spikes m^{-2}

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	343.33 ef	392.55 ghi	303.77 k	325.55 d
farah	397.11 b	410.00 a	367.00 cd	391.37 a
almohanad	327.89 ghi	334.77fgh	312.22 jk	324.96 d
Liron3	365.88 d	378.11 c	333.55fgh	359.18 b
Liron4	323.78 hji	330.77 ghi	307.33k	320.63 d
Liron6	337.00 fg	349.33 e	319.44 ji	335.25 c
brassinolide averages	346.88 b	357.72 a	323.8 c	

Table (7) shows the superiority of brassinolide concentration (3 mg L^{-1}) with an arithmetic mean (44.17 grain $spike^{-1}$), while the concentration 6 mg L^{-1} gave the lowest average for this trait, which was 42.26 grain $spike^{-1}$. The characteristic of grains number depends mainly on providing the necessary food from the carbon metabolism processes, transferring nutrients to the spike, and distributing them regularly in addition to holding the florets and reducing the abortion of spikes during the emergence period of the flowering parts, as well as the effectiveness of pollen grains and raising the fertilization rates and thus increasing the largest grains number (Yasmeen et al (2013) The compositions differed among themselves in this trait and gave significant differences through the superiority of Farah variety with an average of 47.42 grain $spike^{-1}$, while Muhannad varity gave the lowest average in this trait amounted 40.31 grain $spike^{-1}$. The superiority of Farah variety is due to the fact that it was one of the early varieties in emergence the spikes, which provided a sufficient opportunity to form the largest possible amount of nutrients, and this was reflected in the increase the grains number in the spike, and this was observed through the negative and highly significant correlation (-0.900), and this result agrees with Almohamady (2018) and Al Dulaimi (2019). Meanwhile, the interaction (farah variety x concentration of 3 mg) gave the highest average of 48.57 grains $spike^{-1}$ with a significant difference from the rest of the interactions according to Duncan's multiple-range test, except the same variety with control and 6 mgL^{-1} treatments, while the least interaction was recorded with Amal 7 at a concentration of 6 mg L^{-1}.

Table (7) Effect of brasssinolide and genotypes and their interaction on number of grains $spike^{-1}$

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	40.20 hi	42.30 e-h	39.93 i	40.81 d
farah	46.83 ab	48.57 a	46.86 ab	47.42 a
almohanad	40.11 i	41.32 f-i	39.51 i	40.31 d
Liron3	44.59 cd	46.15 bc	43.52 de	44.75 b
Liron4	40.41 hi	42.33 e-h	40.72 ghi	41.15 d
Liron6	42.68 d-g	44.34 cde	43.01 def	43.34 c
brassinolide averages	42.47 b	44.17 a	42.26 b	

It is evident from the results of Table (8) on the effect of brassinolide and the genotypes and interaction between them for the weight of 1000 tablets, where the concentration of brassinolide (3 mg L^{-1}) was significantly higher than the other two concentrations with an arithmetic average of 45.66 g, while the lowest average concentration was recorded (6 mg L^{-1}) and reached 43.57 g this is due to its effect on carbonization process, collecting dry matter and transforming it into the fruiting parts and activating the transport process during the period of filling the grain, and thus led to an increase in the grains weight of the triticale crop, and this result is consistent with the result of Bandar (2021). the genotypes gave significant differences for this trait, as Farah variety outperformed all the genotypes, with the highest weight of 1000 grains and reaching 46.73 g, and the lowest weight at the 7 genotypes was 43.55 g. This variety (Farah) gave the shortest period of the spikes emergence until 75% of the spikes were emerged and thus increased the period of fruit growth compared to the rest of the varieties, which was reflected in the benefit of more products of photosynthesis, which increases the grain weight in addition, the correlation relationship between the trait of spikes emergence and this trait according to table (12), These results are agree with the results of Al-Mohammadi (2019) and Al-Dulaimi (2018). Regarding the interactions, it was noted that there were significant differences between them according to Duncan's multiple range test through the superiority of the interaction between (Farah variety x 3 mg L^{-1} concentration) with an average of 48.06 g and a significant difference from the rest interactions except the formulation LIRON3 at the same concentration (3 mg L^{-1}) Whereas, the lowest interaction was recorded by Al muhanad variety at a concentration 0 mg L^{-1} and it was 42.22 g.

Table (8) Effect of brassinolide and genotypes and their interaction on weight of 1000 grains (g)

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	43.03 fgh	44.72 c-f	42.90 gh	43.55 c
farah	46.63 bc	48.06 a	45.76 bcd	46.73 a
almohanad	42.22 h	44.87 c-f	gh42.96	43.68 c
Liron3	44.42 d-h	46.73 ab	42.11 d-h	45.08 b
Liron4	42.67 fgh	44.52 d-h	42.73 fg	43.30 c
Liron6	43.76 e-h	45.08 b-e	42.95 gh	43.93 c
brassinolide averages	43.91 b	45.66 a	43.57 c	

The concentrations of brassinolide achieved significant differences in the grain yield, where it was significantly superior to (3 mg L-1) concentration with an average of 5.24 tons ha^{-1}, while the treatment at a concentration of 6 mg L^{-1} gave the lowest average of 4.61 tons ha^{-1}(table 9), and this is due to the effect of brassinolide on the yield components such as spikes number (Table 6), grains number in the spike (Table 7) and the weight of 1000 grains (Table 8), and this was reflected on the yield characteristic, that is, by raising the plant's ability to produce more spikes and raising the spikes number and florets during The germination period, and raising the contract level to produce a larger number of grains, as well as converting the largest amount of dry matter into grains, and thus an effect on increasing the grain yield, and these results are consistent with the results of Anwar et al. (2016), With regard to the varieties, Farah variety gave the highest

average of 5.39 tons ha^{-1} with a significant difference from the rest of the varieties, while Al-Muhannad variety recorded the lowest average of 4.79 and reached the ton ha^{-1}. The superiority of Farah is due to its superiority in the yield components (the spikes number, the grains number in the spike, and the weight of 1000 grains), which supports this is the significant correlation between them (Table 12), which was reflected in an increase in yield and thus an increase in grain yield. The interaction (the second concentration x Farah variety) gave the highest arithmetic average and it was 5.57 tons ha^{-1} and a significant difference from the rest of the interactions except for LIRON3 with the comparison treatment and 3 mg L^{-1}, while the interaction (concentration for the third x al muhannad variety) recorded the lowest arithmetic average and it reached 4.60 tons ha^{-1}.

Table (9) Effect of brassinolide and genotypes and their interaction on grain yield (ton ha^{-1})

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	4.97 de	4.43 g	4.90def	4.85 cd
farah	5.04 cde	5.57 a	5.03 cde	5.39 a
almohanad	4.38 g	4.79 ef	4.35 gh	4.79 cd
Liron3	5.35 abc	5.40ab	4.78 ef	5.18 b
Liron4	4.98 de	5.19 bcd	4.62fg	4.74 d
Liron6	4.87 def	4.94 def	4.41 g	4.93 c
brassinolide averages	4.61 b	5.24 a	4.60b	

It is noticed from table (10) for the biological yield trait that the concentration (3 mg L^{-1}) was significantly superior with an average of 13.90 tons ha^{-1}, while the concentration (6 mg L^{-1}) gave the lowest average in this trait amounting to 13.47 tons ha^{-1}, This is due to its superiority in the plant height, grain yield and its components, which led to an increase in plant weight and thus an increase in biological yield and that many researchers agreed on the fact , which stated that the brassinolide achieved an increase in biological yield of the plant, including Jangid et al. (2017). The genotypes differed in this trait, Farah variety was significantly superior on all genotypes and achieving the highest arithmetic average 15.08 tons ha^{-1} and the lowest average recorded by Al-Muhannad variety, which amounted to 12.97 tons ha^{-1}. The superiority of Farah variety in number of spike (Table 6) and grain yield (Table 9) reflected as increase in biological yield compared with other genotypes, and these results are in agreement with Al-Dulaimi (2019), Al-Muhammadi (2018) and Al-Obaidi (2020) results. As for the interaction between the two factors of the study, Farah variety and LIRON3 at a concentration of 3 mg L-1 achieved the highest average It was 15.38 and 15.13 tons ha^{-1}, respectively, with a significant difference from the rest interactions, but the interaction between Amal 7 variety at a concentration of 6 mg L^{-1} gave the lowest average (12.93 tons ha^{-1}).

Table (10) Effect of brassinolide and genotypes and their on biological yield (ton ha^{-1})

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	12.98 f	13.20 ef	12.93 f	13.04 e
farah	14.76 b	15.38 a	14.73 b	15.08 a
almohanad	13.20 f	13.93 e	12.97 f	12.98 e
Liron3	14.47 b	15.13 a	13.81 c	14.31 b
Liron4	13.24 ef	13.58 cd	12.98 f	13.27 d
Liron6	13.48 de	13.65 cd	13.38 ed	13.50 c
brassinolide averages	13.72 b	13.90 a	13.47 c	

Table (11) shows the effect of brassinolide and genotypes and the interaction between them on harvest index (%), as significant differences were observed between the averages of brassinolide through the superiority of the concentration (3 mg L^{-1}) and the comparison treatment except for (6 mg L-1) treatment with an average of 37.78% While the last concentration gave the lowest average of 33.64%.Growth regulators with low concentrations including brassinolide help increase growth by increasing dry matter production and distributing it in the plant on regularly. Moreover, it raises the dry matter transfer level from the vegetative part to the fruit part, which leads to an increase in this trait value. Farah variety was distinguished by giving the highest harvest index with an average of 38.17% and a non-significant difference with the varieties LIRON3 and LIRON6, while the LIRON4 gave the lowest average 36.77%, and this indicates the efficiency of the Farah variety in ability to convert the product from photosynthesis to grains and increase the grain yield, and these are consistent Findings with those of Al-Azzawi et al. (2018),), and f about the combinations, it achieved (the second concentration x Farah) the highest interaction with an average of 40.27% and a non-significant difference with the same variety when the comparison treatment and the concentration 6 mg L-1 for the variety LIRON at the same concentration, but the least interaction was recorded (the third concentration x Amal 7) with an arithmetic average It reached 34.05%, that the superiority of this interaction is due to Farah variety as a result of giving it a high dry matter and a high grain yield in addition to the nature of the variety in converting these inputs into an economic yield. These results agree with the results of Hussain (2017) and Al-Muhammadi (2018).

Table (11) Effect of brassinolide and genotypes and their interaction on harvest index (%)

Genetics	Brassinolide			Genetic average
	0 mg L^{-1}	3 mg L^{-1}	6 mg L^{-1}	
Amal7	36.43 cd	37.54 bcd	34.05 ed	37.23 b
farah	38.77 ab	40.27a	38.38 abc	38.17 a
almohanad	36.08ed	37.22 bcd	34.32 ef	36.96 b
Liron3	38.08 bcd	38.98 ab	37.83 bcd	37.96 ab
Liron4	36.86bcd	37.50 bcd	36.09 ef	36.77 b
Liron6	37.80 bcd	38.39 abc	36.92 bcd	37.53 ab
brassinolide averages	37.78 a	37.79 a	33.64 b	

Table (12) Simple correlation between measurements

Traits	X_6	X_1	X_2	X_3	X_4	X_5	X_7	X_8
X_6	1.00	0.094-	0.090	**0.908	0.345	0.044	**0.596	**0.636
X_1		1.00	**0.892-	0.425-	0.900**-	**0.860-	**0.717-	*0.585
X_2			1.00	0.396	**0.892	**0.924	**0.692	*0.557-
X_3				1.00	**0.633	0.381	**0.836	0.290
X_4					1.00	**0.899	**0.889	0.438-
X_5						1.00	**0.732	**0.647-
X_7							1.00	0.239-
X_8								1.00

X_1=Days number to spike emergence (day), X_2= plant height (cm), X_3= Spikes number plant^{-1}, X_4= Grains number spike^{-1}, X_5= Weight of 1000 grain (g), X_6= Total yield (ton ha^{-1}), X_7= Biological yield (ton ha^{-1}), X_8= Harvest index (%)

CONCLUSION

This study highlighted the positive impact of brassinolide growth regulator on triticale yield. The 3 mg L-1 concentration, particularly with the Farah genotype, showed significant improvements in key traits such as flowering time, plant height, and grain yield. These results suggest that brassinolide can be an effective tool for enhancing triticale production. Further research could investigate its effects across different genotypes and conditions.

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