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Effect of cytokinin and yeast extract foliar application on vegetative growth parameters of wheat (*Triticum aestivum L.*) under different levels of zinc

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ABSTRACT

Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture, Fayoum University at "Demo" Fayoum Governorate, Egypt during the two successive seasons of 2018/2019 and /2019/2020. The main objective of this study was to determine the effect of cytokinin, yeast extract, zinc and their interaction on growth of wheat (*Triticum aestivum L.*). The experimental layout was a split- split plot arranged in randomized complete block design with three replications where zinc concentrations (control, 1g/liter, 2g/liter) were considered as the main plot, cytokinin rates (control, 0.25ml/liter, 0.50ml/liter)arranged in the sub plot and the sub-sub plot occupied by yeast extract levels treatments(control, 5g/liter, 10g/liter).

Data indicated that zinc concentrations had insignificant effect on the characteristics of number of tillers/plant, number of leaves/plant, plant leaf area, and leaf content of chlorophyllat 100 days from sowing (DAS). While the addition of mid-level of zinc zn_1 (1g/l) led to a significant increase at 70 and 85 DAS. Increasing the cytokinin concentration led to an increase in plant height at 100 DAS in the second season only. As for the number of tillers/plant in both seasons at 85 DAS, but the number of leaves/plant it did not reach the significant level. Cytokinin concentration had no significant effect on leaf area/plant, flag leaf area and leaf content of chlorophyll. Increasing the concentration of yeast extract which foliar application to wheat plants led to a significant increase in the leaf area/plant and leaf content of chlorophyll.

Key Words: Wheat, Cytokinin, Yeast extract, Zinc, Growth and interaction.

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most important food grain crops grown in the world, which has been used as food since prehistoric times. Wheat is used mainly as as human food. It is easily processed into various types of food like bread, macaroni, biscuit, and sweets. In Egypt, wheat is cultivated on an area of 1.343 million hectares season with an annual production of 8.800 million tons, with an average yield of 6.55 t/ha **(FAO, 2020).**

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Wheat provides 37% of the total calories for the people and 40% of the protein in the Egyptian diet **(Mujeeb et al., 2008).** Recently, great attention of several investigators has been directed to increase the productivity of wheat to minimize the gap between Egyptian production and consumption **(Masoud et al., 2012 and Manal et al., 2016)**. The utilization of necessary plant nourishing in the most favorable quantity, right forms, and proper application are major to increase and sustain crop productivity. Micronutrients play a vital role in enhancing crop productivity. Intensification of agriculture with high yielding varieties, continuous use of high analysis fertilizers, restricted supply of organic manures, and negligible crop residue return to soil led to micronutrient deficiency. Small quantities of Zn are vital for plant growth because it is involved in the formation and breakdown of plant proteins, activates biosynthetic growth hormones, and contributes to germination and ripening of caryopsis (**Cakmak, 2008**).

Zinc is considered of these essential nutrients. Zinc is considered to be one of the top responsible essential micronutrients vital for most favorable crop growth. It is a substantial element and activator of various enzymes engaged in the metabolic process such as energy production, protein synthesis, and growth regulation. Moreover, zinc is an ingredient that directly influences yield and quality because of its activity in biological membrane stability, enzyme activation ability, and auxin synthesis **(Marschner, 1997).**

Many studies have been shown that one of the effective and productive ways to improvement in cereal grains is application of zinc fertilizer either to the soil or foliar application **(El-Metwally et al., 2012).**

Hassanein et al (2019) in Egypt, using four treatments of Zinc foliar fertilizer (Control (without zinc foliar application, 0.4%, 0.6% and 0.8% Zn SO_4. H_2O/feddan) with Two cultivars (Sids-12 and Misr 2). They indicated that zinc foliar increased significantly growth characters under study at 90 and 105 days from sowing. It is clear from data that all the zinc treatments significantly increased growth characters as compared to control, also it indicated the best treatment was 0.8% zinc foliar fertilizer.

Plant hormones play a vital role in coordination of many growth and behavioral processes in the plant life. They regulate the amount, type and direction of plant growth. The plant hormone group, the cytokinins, has been strongly implicated in many aspects affecting yield, particularly grain number and size **(Jameson and Song, 2016).** Cytokinins regulate cell division and differentiation in certain plant tissues and participate in many developmental processes e.g. senescence, photosynthesis, flower formation and photosynthate partitioning etc. Yeast is considered as a new promising plant growth promoting for different crops. Yeast extract is a natural source of many growth substances (thiamine, riboflavin, niacin, pyridoxine and vitamins B1, B2, B3 and B12), cytokinins and many of the nutrient elements as well as organic compounds i.e., protein, carbohydrates, nucleic acid and lipids **(Barnett et al., 1990). Mohamed (2005)** also found that active dry yeast as foliar application had a beneficial effect on growth, yield and chemical constituents of plants. Yeast is considered as a new promising plant growth promoting for different crops.

The present study was conducted to evaluate the effects of cytokinin, yeast extract, zinc and their interaction on growth of wheat cv. Giza 171.

2. MATERIALS AND METHODS

/2019/2020 (SII). The representative soil samples (0-30 cm depth) were taken before adding fertilizers and during soil preparation for assessing physical and chemical properties of the experimental soil in (Table 1).

Experimental site and plant materials:

Two field experiments were conducted at Experimental Station Farm, Faculty of Agriculture, Fayoum University, Fayoum Governorate Egypt, during the two successive seasons of 2018/2019 (SI) and

Table 1. The mechanical and chemical analysis of the experimental soil in both growing seasons of 2018/2019 and /2019/2020.

2018/2019				2019/2020			
Mechanical analysis							
Sand, %	**Silt %**	**Clay %**	**Texture Class**	**Sand %**	**Silt %**	**Clay %**	**Texture Class**
80.00	9.50	10.50	Sandy loam	77.43	11.20	11.37	Sandy loam
Chemical analysis							
Organic M %	**CaCo3 %**	**PH**	**EC(ds/m)**	**Organic M %**	**CaCo3 %**	**PH**	**EC(ds/m)**
1.33	6.57	7.42	3.56	1.33	10.43	7.76	7.66

Layout and experimental design:

The experiments were laid-out in a split – split plot design, having three replications, the treatments of the experimental factors were allocated as follows: Three zinc concentration i.e. tap water, 1g/liter and 2g/liter 45 and 60 days after sowing (DAS) in the main plots, while three foliar spraying with cytokinin concentrations i.e. tap water, 0.25ml/L^{-1} and 0.50 ml/L^{-1} at 30 and 45 days after sowing (DAS)in the sub – plots. Also, the YE was foliage sprayed with three concentrations [0 as a control (YE_0), 5 g/l (YE_1), and 10 g/l (YE_2)] at 30 and 45 days after sowing (DAS) in the sub-sub-plots. The YE treatments were sprayed using a hand-operated compressed air sprayer with a rate of 200 L fed^{-1}. According to **Spencer et al. (1983),** the extract of dry bread yeast scientifically known as Saccharomyces cerevisiae, was freshly prepared using a technique that enables yeast cells (pure active dry yeast 100 g l^{-1}) to be grown and effectively multiplied during aerobic and nutritional conditions. These optimal conditions allow producing useful components such as total carbohydrates, soluble sugars, total proteins, amino acids, fatty acids, hormones, etc. These chemical components could be released from yeast cells in readily form by two freezing cyclesand. The net size of plot unit was 3×3.5 m, resulted an area of 10.5 m^2 (1/400 fed). Wheat grains cv. Gizaa 171 were obtained from the Wheat Department, Field Crops Institute Research, Agricultural Research Center, Giza, Egypt. Sowing dates was done in 22 November in both seasons. While seeding rate was 50 kg/fed. The preceding summer crop was maize (Zea mays, L.) in both seasons.

Cultural practices:

Nitrogen fertilizer was added on the form of ammonium nitrate (33.5% N) at rate of 75 kg N/fed., was added in three doses the first dose (15 kg N/fed.) was added at sowing time, the second dose (30 kg N /fed.) was added before the first irrigation (21 days after sowing) and the third dose (30 kg N / fed.) was added (21 days after the first irrigation). 150 kg calcium super-phosphate; (15.5% P_2O_5) was added during the soil preparation. Potassium fertilizer was applied before sowing (during seedbed preparation) at rate of 50 kg/fed., in the form of potassium

5- Flag leaf area "cm2" (FLA): Data on length and width of flag leaf were recorded after heading by taking a sample of five flag leaves per entry in each replication and calculated from the product of leaf length and maximum breath x 0.75, according to **Richards(1983).**
6- Leaf chlorophyll content.

All data obtained in both seasons were subjected to analysis using of variance (ANOVA) by GenStat Statistical computer software (edition12). Treatment means were compared using the least significant difference (LSD) test according to **(Gomez and Gomez, 1984)** at the 5% level of significance.

sulphate (48% K_2O). The first Irrigation was applied at 21 days after sowing then plants were irrigated every 21 days till the dough stage. All other agricultural treatments for wheat production were carried out as recommended by the Ministry of Agriculture.

Data recorded:

Vegetative measurements were taken to study the growth characteristics. Sample of five plants/plot were taken after 70, 85 and 100 days from sowing date follows:

1- Plant height (cm): It measured from the soil surface to the top of the main stem spike.
2- Number of tillers/plant: was counted as the number of tillers per plant.
3- Number of leaves/plant.
4- Total leaf area/plant (cm2).

3.RESULTS AND DESCUSSION

CY_2) produced the tallest wheat plants (88.24 cm) in the second season at 100 days after sowing.

Yeast extract foliar application (YE_0, YE_1, and YE_2) was non-significant on plant height at 70, 85, and 100 days after sowing except at 70 days after sowing only in first season. 10 ml L^{-1} (YE_2) possessed the superiority with (46.88 cm) in the second seasons. Adversely, the lowest values of plant height were obtained from control treatment (without Yeast extract foliar application) (44.09 cm) at 70 days after sowing in second season.

2- Number of tillers/plant:

Data given in Table (2) obviously show the average of number of tillers/plant as a result of zinc, cytokinin, yeast extract foliar application and their interactions.

Number of tillers plant^{-1} was no significant except at the second age 85 days after sowing in the first season and at the first and second ages 70 and 85 days after sowing in the second season. Adding the highest Zinc level (Zn_2) resulted in the maximum number of tillers plant^{-1} (2.91) at 85 days after sowing in the first season, while the mid zinc level (Zn_1)

Results of the main effects of cytokinin, yeast extract, zinc and their interaction (first and second orders) on wheat crop will be elicited and discussed under following topics:

1- Plant height (cm):

Table (2) display the main and interaction impacts of zinc, cytokinin, yeast extract foliar application and their interactions on plant height at three growth ages. Results showed that foliar spraying zinc significantly increased plant height of wheat plants as compared with control at 70 and 85 days after sowing in both seasons mid zinc rate (Zn1) recorded the highest result (50.90 and 69.59 cm) at 70 and 85 (DAS) in the first season, and (48.32 and 67.04 cm) at 70 and 85 (DAS) in the second season. While the shortest plants were obtained by higher levels of zinc (Zn2). A similar result was observed by **Afzal et al (2017)** and **Arif et al (2017).**

Different levels of cytokinin foliar application had insignificant effect on plant height at three ages of wheat growth in the both seasons except at 100 days after sowing only in the second season. Foliar application high concentration of cytokinin (0.50 ml/liter

Three concentrations of yeast extract (YE_0, YE_1, and YE_2) significantly affected number of tillers per plant at 70, 85 and 100 days after sowing in the second season and in the first age 70 days after sowing in the second season. The YE_2 treatment resulted in the most number of tillers plant^{-1} at the both seasons, and third ages, as shown by the numbers (3.11, 2.88, and 2.85) and (3.10, 2.75 and 2.67) in the first and second seasons at three ages, respectively. The obtained findings are consistent with those previously published by **Nassar et al., (2011)**, **Nassar et al., (2015),** and **Abu Khouder et al., (2019)** resulted in the maximum number of tillers plant^{-1} (3.10 and 2.74) at 70 and 85 days after sowing in the second season. The obtained findings are corroborated by those of **Shaheen et al (2007), Afzal et al (2017)** and **Arif et al (2017).**

Cytokinin foliar application (CY_0, CY_1, and CY_2) at 70, 85, and 100 days after sowing was significant on number of tillers per plant in both seasons at all ages except at 85 days after sowing in the first season. Application of 0.50 ml/liter (CY_2) possessed the superiority with (3.27, 2.85, and 3.15) and (3.17, 2.85 and 2.79) in the first and second seasons at three ages, respectively.

Table 2 : Effect of Zinc, Cytokinin, Yeast extract and their interactions on plant height and number of tillers/plant of wheat, during 2018/2019 and 2019/2020 seasons.

Trait	Plant height						Number of tillers/plants					
	2018/2019			2019/2020			2018/2019			2019/2020		
	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample
A- Zinc (Zn)												
Zn_0	50.89	66.64	91.33	46.81	65.54	87.87	2.97	2.56	2.80	2.72	2.50	2.45
Zn_1	50.90	69.59	89.44	48.32	67.04	88.46	3.15	2.89	2.91	3.10	2.74	2.69
Zn_2	47.19	62.82	87.75	42.43	61.47	84.51	2.89	2.91	2.80	2.88	2.74	2.60
B- Cytokinin (Cy)												
Cy_0	50.07	66.06	89.86	45.96	64.66	86.82	2.93	2.84	2.77	2.70	2.66	2.61
Cy_1	48.52	66.56	88.54	45.58	63.93	85.80	2.81	2.70	2.59	2.67	2.47	2.35
Cy_2	50.39	66.45	90.11	46.03	65.46	88.24	3.27	2.85	3.15	3.17	2.85	2.79
C- Yeast extract (YE)												
YE_0	49.04	66.15	89.83	44.09	65.04	86.85	3.01	2.77	2.85	2.87	2.64	2.54
YE_1	49.68	65.96	90.05	46.60	64.20	86.80	2.89	2.71	2.85	2.72	2.59	2.53
YE_2	50.26	66.95	88.63	46.88	64.81	87.20	3.11	2.88	2.82	3.10	2.75	**2.67**
$L.S.D_{(0.05)}$												
Zn	3.01	4.15	ns	2.20	3.89	ns	ns	0.23	ns	0.25	0.18	ns
Cy	Ns	ns	ns	ns	Ns	1.91	0.31	ns	0.29	0.31	0.27	0.30
YE	Ns	ns	ns	1.80	Ns	ns	ns	ns	ns	0.26	ns	ns
Zn x Cy	Ns	ns	ns	ns	Ns	ns	ns	ns	0.50	ns	ns	0.52
Zn x YE	Ns	ns	ns	3.12	Ns	ns	ns	ns	ns	0.45	ns	ns
Cy x YE	Ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns
Zn x Cy x YE	Ns	ns	ns	3.40	Ns	ns	ns	ns	ns	ns	ns	ns

3- Number of leaves/plant:

Table (3) displays the main and interaction impact of zinc, cytokinin, yeast extract foliar application and their interactions on Number of leaves plant^{-1} at three growth ages. Results

concentration of yeast extract (YE2) was used. And from the other hand, at all growth levels, the application YE0 has the smallest leaf area (322.89, 500.53, and 549.13 cm2). These findings were obtained by **Hamad and Ali, (2014) and El-Hawary et al., (2019).**

5- Flag leaf area "cm^2" (FLA):

The average of mean flag leaf area (cm2) as affected by zinc, cytokinin, yeast extract foliar application and their interactions on flag leaf area per plant (FLA) at growth stages of 70, 85, and 100 days after sowing are given in the Table (4).

Effect of Zinc:

Statistical analysis showed that there were non-significant differences between Zinc nutrient rates (Zn0, Zn1, and Zn2) on flag leaf area plant-1 at 70, 85 and 100 (DAS) in the 1st and the 2nd seasons except at 85 days after sowing in the first season. In this regard the application zn1 resulted in the greatest values of flag leaf area (49.68 cm^2) at 85 days after sowing in the 1st season. The increment in growth characters due to foliar application of zinc might be due to their critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates. The reduction of photosynthesis observed in zinc deficient plants can be due, in part, to a major decrease in chlorophyll content, reduction in the activity of the enzyme carbonic anhydrase and the abnormal structure of chloroplasts **Alloway, 2008.** These results are in accordance with those recorded by **El-Metwally et al., 2015.**

Effect of Cytokinin:

Statistical analysis showed that there were non-significant differences between Cytokinin foliar application (CY0, CY1, and CY2) on flag leaf area plant-1 at 70, 85 and 100 (DAS) in the 1st and the 2nd seasons.

Effect of yeast extract:

Statistical analysis showed that there were non-significant differences between yeast extract (YE0, YE1, and YE2) on flag leaf area plant-1 at 70, 85 and 100 (DAS) in the showed that foliar spraying zinc concentration had no significant effect on number of leaves plant^{-1} in both season except at 85 days after sowing in the second season.

Cytokinin foliar application treatments significantly affected number of leaves per plant at 70, and 100 days after sowing in the two growing seasons of this study. The maximum values of number of leaves per plant at 70 and 100 days after sowing were produced from using 0.50 ml/liter (CY_2) with (17.32, and 19.00) in the first season and (17.98) at 70 days after sowing in the second season.

The three concentrations of yeast extract (YE_0, YE_1, and YE_2) had no significant effect on the efficiency of the number of leaves per plant, in both seasons at different ages except at 85 days after sowing in the first season.

4- Total leaf area /plant:

The average of total area plant^{-1} as affected by zinc, cytokinin, yeast extract foliar application and their interactions are given in the Table (3) Statistical analysis showed that there were non-significant differences between Zinc nutrient rates (Zn_0, Zn_1, and Zn_2) and cytokinin foliar application treatments on leaf area plant^{-1} at 70, 85 and 100 (DAS) in the 1st and the 2nd seasons. was no significant except at the second age 85 days after sowing in the first season and at the first and second ages 70 and 85 days after sowing in the second season.

Cytokinin (Cy) affected the plant height significant in both seasons. Increasing the application level of Cy from control Cy_0 to Cy_2 caused significant increases in Total leaf area/plant from 349.54 to 386.67 with increasing percentage of 4.9% and from 326.53 to 380.72 with increasing percentage of 4.6% at the 1st and 2nd seasons, respectively.

foliar application of yeast extract had important effects on LA via all vegetative cycles. Maximum leaf area (398.29, 698.56, and 666.98 cm2) was achieved in 70, 85, and 100 days, respectively, when the highest

greatest values of flag leaf area (51.57 cm2) at 100 days after sowing in the second season. 1st and the 2nd seasons except at 100 days after sowing in the second season. In this regard the application YE2 resulted in a

Table 3 : Effect of Zinc, Cytokinin, Yeast extract and their interactions on number of leaves/plant and total leaf area/plant of wheat, during 2018/2019 and 2019/2020 seasons.

Trait	Number of leaves/plants						Total leaf area/plant (cm2).					
	2018/2019			2019/2020			2018/2019			2019/2020		
	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample
A- Zinc (Zn)												
Zn_0	15.71	21.27	15.24	15.44	15.94	11.95	387.24	562.38	651.27	353.69	563.48	642.91
Zn_1	16.47	22.23	19.09	16.96	16.23	13.44	389.84	602.42	694.68	380.21	579.28	684.16
Zn_2	16.38	22.09	17.56	16.47	17.48	12.65	324.15	532.34	564.34	312.05	502.78	537.51
B- Cytokinin (Cy)												
Cy_0	16.31	21.98	17.45	15.78	16.39	14.36	349.54	577.99	686.42	326.53	558.98	671.60
Cy_1	14.92	21.08	15.43	15.12	15.62	11.99	365.02	545.58	607.13	338.70	537.42	581.64
Cy_2	17.32	22.53	19.00	17.98	17.63	11.69	386.67	573.55	616.74	380.72	549.13	611.34
C- Yeast extract (YE)												
YE_0	15.75	19.88	17.12	15.59	15.79	11.92	322.88	500.53	549.13	311.74	464.28	543.16
YE_1	16.19	22.13	17.41	16.33	16.66	13.26	380.06	507.05	666.98	344.91	517.62	659.37
YE_2	16.61	23.52	17.35	16.95	17.20	12.86	398.28	689.56	666.40	389.29	663.64	662.05
$L.S.D_{(0.05)}$												
Zn	Ns	ns	ns	ns	0.90	ns	ns	ns	ns	ns	ns	ns
Cy	1.83	ns	1.73	1.78	ns	1.65	ns	ns	ns	ns	ns	ns
YE	Ns	2.03	ns	ns	ns	ns	57.40	169.66	90.46	46.93	142.67	109.19
Zn x Cy	Ns	ns	2.99	ns	ns	2.86	ns	ns	ns	ns	ns	ns
Zn x YE	Ns	ns	ns	ns	ns	2.41	ns	ns	ns	ns	ns	ns
Cy x YE	Ns	ns	ns	ns	ns	2.41	ns	ns	ns	ns	ns	ns
Zn x Cy x YE	Ns	ns	ns	ns	ns	4.17	ns	ns	ns	ns	ns	ns

6- Leaf chlorophyll content:

wheat plants in both seasons. As well as cytokinin effect. While effect of yeast extract on chlorophyll content (SPAD) in leaves of wheat plants had significant effect on both seasons. The highest chlorophyll fluorescence and SPAD values were achieved when the highest concentration of yeast extract (YE2) was used.

Table (4) display the main and interaction impacts of zinc, cytokinin, yeast extract foliar application and their interactions on chlorophyll content (SPAD) in leaves of wheat plants.

Effect of Zinc:

Results showed that foliar spraying zinc concentration had no significant effect on chlorophyll content (SPAD) in leaves of

Table 4 : Effect of Zinc, Cytokinin, Yeast extract and their interactions on Flag leaf area and leaf chlorophyll content of wheat during 2018/2019 and 2019/2020 seasons.

Trait	Flag leaf area "cm2" (FLA)						Leaf chlorophyll content.	
	2018/19			2019/20			2018/19	2019/20
	1st sample	2nd sample	3rd sample	1st sample	2nd sample	3rd sample		
A. Zinc (Zn)								
Zn_0	25.52	45.12	49.89	25.79	44.98	50.00	49.00	48.85
Zn_1	28.60	49.68	53.09	28.60	49.68	53.10	49.14	48.78
Zn_2	29.91	42.85	47.67	27.27	43.42	49.46	49.26	48.42
B. Cytokinin (Cy)								
Cy_0	27.04	46.03	49.75	26.04	46.26	51.31	49.83	48.94
Cy_1	27.67	45.42	50.52	26.56	45.23	51.29	49.09	48.98
Cy_2	29.32	46.21	50.40	29.06	26.55	49.95	48.49	48.13
C. Yeast extract (YE)								
YE_0	26.97	44.66	49.16	25.41	44.77	49.08	49.11	48.71
YE_1	28.06	45.80	50.28	28.78	45.99	51.51	48.20	47.92
YE_2	29.00	47.21	51.22	27.48	47.88	51.97	50.10	49.92
$L.S.D_{(0.05)}$								
Zn	ns	4.95	ns	ns	ns	ns	ns	Ns
Cy	ns	ns	ns	ns	ns	ns	ns	Ns
YE	ns	ns	ns	ns	ns	2.78	1.64	1.65
Zn x Cy	ns	ns	ns	ns	ns	ns	ns	Ns
Zn x YE	ns	ns	ns	ns	ns	ns	ns	Ns
Cy x YE	ns	ns	ns	ns	ns	ns	ns	Ns

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الملخص العربى

تأثير الرش الورقى بالسيتوكينين ومستخلص الخميرة على خصائص النمو الخضرى للقمح تحت مستويات مختلفة من الزنك

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اجريت تجربتان حقليتان بالمزرعة التجريبية بكلية الزراعة جامعة الفيوم (بدمو) خلال موسمى 2019/2018 و 2020/2019 لدراسة تأثير الرش الورقى للسيتوكينين ومستخلص الخميرة على نمو القمح صنف جيزة 171 تحت مستويات مختلفة من الزنك. وقد تم اجراء التجارب فى تصميم القطع المنشقة مرتين فى ثلاث مكررات. حيث احتلت تركيزات الزنك (صفر،1جم/لتر، 2جم/لتر) القطع الرئيسية اما القطع الفرعية فاحتوت على ثلاث تركيزات من السيوكينين(صفر، $0.25ml/L^{-1}$، $0.50ml/L^{-1}$) بينما مستخلص الخميرة ثلاث تركيزات (صفر،5جم/لتر، 10جم/لتر) تم توزيعها فى القطع المنشقة الثانية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

1- تأثير الزنك:

لم يكن هناك تأثير معنوى للمستوبات المختلفة من الزنك على صفات عدد الأفرع/نبات، وعدد الأوراق/نبات ، مساحة أوراق النبات ، ومساحة ورقة العلم ، ومحتور الورقة من الكلوروفيل. بينما أدى أضافة المعدل المتوسط من الزنك Zn_1 (1جم/لتر) إلى زيادة معنوية عند 70 ، 85 يوم من زراعة القمح.

2- تأثير الستوكينين:

ادى زيادة تركيز السيتوكينين إلى زيادة فى طول النبات عند عمر 100 يوم من زراعة القمح فى الموسم الثانى فقط واظهرت النتائج وجود تاثير معنوى للسيتوكينين على عدد الافرع/نبات و عدد الاوراق/نبات عند جميع الاعمار وكلا الموسمين عدا عند 85 يوم من الزراعة فى الموسم الأول بالنسبة لعدد الافرع/نبات وفى كلا الموسمين بالنسبة لعدد الاوراق/نبالت لم تصل إلى حد المعنوية.

لم يكن لتركيز السيتوكينين تأثير معنوى على مساحة أوراق النبات ومساحة ورقة العلم ونسبة الكلوروفيل بالورقة.

تأثير مستخلص الخميرة :

ادى زيادة تركيز مستخلص الخميرة المضاف رشا على نباتات القمح الى زيادة معنوية فى مساحة أوراق النبات وكذلك نسبة الكلوروفيل بالاوراق.