

## RESPONSE OF WHEAT PLANT (*Triticum aestivum* L.) TO FOLIAR APPLICATION OF SITOSTEROL AND ETHREL.

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### ABSTRACT

Two field experiments on wheat (*Triticum aestivum* L.) c.v. Gemmiza-9 were conducted to study the effect of different concentrations of sitosterol ( 100, 150 and 200 mg/l ) , ethrel ( 50, 100 and 150 mg/l ) and their interaction on growth, photosynthetic pigments, yield and its components as well as some bio-chemical constituents of wheat plant .

The data indicated that spraying sitosterol especially with concentrations (150 and 200 mg/l ) at all stages resulted in significant increases in plant height, number of tillers, number of spikes, blades area/plant, flag leaf area, dry weight of plant, photosynthetic pigment contents spike length, grain index, grain and straw yield per plant & per fed, crop index and harvest index. On the other side, spraying ethrel at the moderate and higher concentrations ( 100 & 150 mg/l ) led to significant decreases in plant height, both number of tillers and spikes/plant, flag leaf area, blades area/plant . Whereas dry weight / plant was significantly increased. The higher concentration of sitosterol ( 200 mg/l ) and the lower concentration of ethrel (50 mg/l) produced the highest values in most of growth characters at the different stages, while spraying plant with 200 mg/l sitosterol and 150 mg/l ethrel recorded the highest values in economic yield and its components as compared with other treatments.

Application of sitosterol or ethrel treatments in general had a positive effect in most cases on protein and total carbohydrate contents. The highest protein content recorded by the higher concentration of both sitosterol 200 mg/l or ethrel 150 mg/l while the lower ones ( 100 mg/l sitosterol & 50 mg/ ethrel ) resulted in the highest values of total carbohydrate content.

The interaction between sitosterol at the moderate & higher concentrations and all ethrel concentrations caused significant increases in plant height, dry weight/plant, blades area/plant, flag leaf area, photosynthetic pigments ( at the different stages of growth ) spike length and crude protein in most cases, while total carbohydrate was significantly increased under the lower & moderate concentrations of sitosterol and ethrel treatments. The results has been interpreted by the correlation coefficient between wheat plant characters under sitosterol or ethrel treatments which indicated that grain yield was positively and significantly correlated with plant height, number of tiller/plant, spike length, flag leaf area, 100 – grain weight, grain & straw yield per plant, harvest index and chemical content of grains.

**Keywords :** wheat, sitosterol, ethrel, growth, yield, chemical constituents.

### INTRODUCTION

Wheat is considered the most important strategic crop in Egypt. The strategic considerations of this crop are due to the gap between its current and steadily increasing consumption and its relatively low production at national level. Normal plant growth and development are at least in part controlled by substances produced by the plant itself including the endogenous plant growth regulators substances are extremely valuable in controlling crop growth and yield. Sitosterol is the major constituent of steroids in plant that plays a critical role in membrane function and plant development ( Bloch, 1983 ). Brassinosteroids have been found to evoke

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both cell elongation and cell division resulting in elongation, swelling, curvature and splitting of the internode ( Mandava, 1988 ). In addition, brassinosteroids caused changes in enzymatic activities, membrane potential, DNA, RNA, protein synthesis, photosynthetic activity and changes in the balance of endogenous phytohormones ( Steven and Jenneth , 1998 ). Also, Özdemir *et al.* ( 2004 ) found that sterols could be essential for normal plant growth and development and correlated with brassinosteroid contents. Furthermore, Abdel-Wahed ( 2005 ) and Abdel-Wahed *et al.* (2006) working on soybean and maize plants indicated that vegetative growth characters, yield & its components and grain chemical constituents were markedly increased by sitosterol treatments.

There is considerable interest in the use of ethrel as a plant growth regulator to reduce plant height, lodging and enhance yield for several crops. ( Fluglsang, 1986; Norberg *et al.*, 1989 and Mohamed *et al.*, 1990 ). Also, Habba *et al.* ( 2001), Al-Jamali *et al.* ( 2002 ) and Amin, ( 2003) found that increasing ethrel rates caused a significant reduction in vegetative growth characters, while yield and its components were increased. The objective of this study was to determine the effect of sitosterol & ethrel and their interaction on growth, photosynthetic pigments, yield and its components as well as some chemical constituents in grains of wheat c.v. Gemmiza-9.

## MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Experimental Station of National Research Center at Shalakan, Kaloubia Governorate during two successive seasons of 2004/2005 and 2005/2006 to study the effect of sitosterol and ethrel on growth, photosynthetic pigments contents, yield and its components as well as bio-chemical constituents of wheat plants ( *Triticum aestivum* L. ). Wheat grains ( Gemmiza-9 c.v. ) were obtained from Ministry of Agriculture. The treatments consisted of three concentrations of sitosterol ( 100, 150 and 200 mg/l. ). Sitosterol, (Stigmasta-5-en. 3  $\beta$ -ol: ( 24 R)-24 ethylcholest-5-en-3ol) was purchased of Merk Co. and three concentrations of ethrel( 50, 100 and 150 mg/l ) and the control ( Tap water ). The plants were sprayed twice during vegetative stage ( 45 and 60 days after sowing ). After 15 days from spraying, photosynthetic pigments contents of leaves were determined ( Saric *et al.*, 1967 ), at 75 , 90 and 105 days of plant age. The experiment was arranged as split plot design, keeping ethrel in main plots and sitosterol treatments in subplots with four replicates. Wheat grains cultivar Gemmiza-9 were sown on 18 and 21 November in the first and second seasons, respectively. Plot area was 12 m<sup>2</sup> ( 4  $\times$  3 m ) in the two seasons. Calcium super phosphate ( 15.5 % P<sub>2</sub>O<sub>5</sub> ) was added pre-sowing at 100 kg/fed, ammonium nitrate ( 33.5 % N ) at 100 kg N/fed. was applied at three equal doses namely. The first one week after emergence, the second, at tillering stage and the third, at booting stage. Potassium sulfate ( 48.5 % K<sub>2</sub>O ) at the rate of 50 kg/fed was added at two equal doses at the first and third irrigations. At elongation stage ( 100 days after sowing ) and at milky stage ( 120 days after sowing ) the following data were recorded : plant height, No. of tillers/plant, No. of spikes/plant, dry weight(g/plant), flag leaf

area and blades area ( $\text{cm}^2/\text{plant}$ ) were calculated according to Bremner and Taha ( 1966 ). At the harvest stage, the following plant characteristics were measured i.e., spike length ( $\text{cm}^2$ ), number of grains/spike, 100-grain weight (g), grain and straw yield ( $\text{g}/\text{plant}$ ), grain & straw yield (ton/fed), crop index and harvest index. Grain samples from all treatments were dried at  $70^\circ\text{C}$  till constant weight and analysed. Nitrogen percentage was determined according to the method of A.O.A.C. ( 1970 ) and protein percentage was calculated by multiplying the value of determined total nitrogen content by 5.70. The total carbohydrate percentage was determined according to the method described by Dubois *et al.* (1956). Combined analysis for data of the two seasons and the values of L.S.D. were calculated as described by Snedecor and Cochran ( 1990 ).

## RESULTS AND DISCUSSION

### 1- Effect of sitosterol and ethrel on growth characteristics :

Results in Table (1 and 2) indicated that spraying wheat plants with sitosterol strongly affected growth characteristics such as plant height, number of tillers and spikes/plant, dry weight/plant, blades area /plant and flag leaf area during elongation and milky stages, as compared to the control.

Increasing sitosterol concentration was associated by significant increase in all growth characteristics. Sitosterol concentration at 200 mg/l resulted in highest values of the growth parameters during the two physiological stages ( elongation and milky stages ). The increase in these growth characters by sitosterol treatment could be due to stimulating effect of sitosterol on cell division, cell elongation, leaf bending, vascular differentiation and in turn reflected on an increase in translocation and accumulation of certain microelements in plant organs and this in turn, reflected on their growth characters as suggested by many investigators ( Mandava, 1988 and Sasse, 1999 ). However, these studies provided strong evidence that sterols could be essential for normal plant growth and development as mentioned by Steven and Jenneth ( 1998 ), De Grauwe *et al.* ( 2005 ) and Abdel-Wahed *et al.* ( 2006 ).

In case of ethrel treatment, vegetative growth criteria viz., plant height, number of tiller and spikes/plant, flag leaf area, blades area/plant were significantly decreased or slightly affected as a result of foliar application with ethrel at the concentration of 50 to 150 mg/l. On the other side, increasing ethrel concentration was associated by increasing in dry weight/plant. These results are in true at elongation and milky stages. Gaska and Oplinger (1988), Norberg *et al.* ( 1989 ) and Wills *et al.* ( 2002 ) reported that increasing of ethrel concentration from 0.14 to 0.56 kg/ha led to significant decreases in plant height, ear height and length of internodes whereas, diameter and weight length of internodes increased when applied at elongation stage. Also, Mori *et al.* ( 1996 ), Habba *et al.* ( 2001 ) and Amin (2003 ) found that increasing ethrel rates caused a significant reduction in vegetative growth at the different stages of growth and increased stem diameter and root development.

Table (1): Effect of sitosterol and ethrel and their interaction on vegetative growth criteria of wheat plants at elongation stage .

( Combined analysis of the two seasons )

Ethrel mg/l.		0	50	100	150	Mean
Sitosterol mg/l.						
		Plant height ( cm )				
0		86.90	79.70	77.16	74.75	79.62
100		97.98	100.99	91.12	80.90	92.75
150		103.09	103.51	96.24	83.27	96.53
200		109.15	106.66	104.24	90.61	102.67
Mean		99.28	97.72	92.19	82.38	
		Number of tillers/plant				
0		4.96	5.08	4.31	4.36	4.99
100		5.01	5.67	4.84	4.74	5.12
150		6.98	5.46	5.87	4.77	5.77
200		6.98	6.57	5.90	4.55	6.35
Mean		5.92	5.70	5.23	4.61	
		Number of spikes/plant				
0		4.48	5.39	4.61	4.67	4.79
100		5.88	5.81	4.59	4.54	5.21
150		6.62	5.79	5.96	4.35	5.68
200		6.99	6.47	5.82	5.70	6.25
Mean		5.99	5.87	5.25	4.82	
		Dry weight / plant (g)				
0		9.91	10.67	10.94	10.88	10.60
100		10.94	10.76	11.92	11.97	11.40
150		11.77	11.36	12.86	12.95	11.71
200		12.02	12.87	12.98	12.90	12.62
Mean		11.16	11.42	12.18	12.19	
		Blades area (cm <sup>2</sup> )/plant				
0		459.54	389.68	368.32	381.78	399.08
100		460.17	448.90	375.17	366.43	412.67
150		474.63	476.20	441.44	388.33	445.15
200		503.80	550.71	459.04	468.60	495.38
Mean		474.54	466.37	410.24	401.24	
		Flag leaf area (cm <sup>2</sup> ) / plant				
0		21.74	20.50	21.06	22.01	21.33
100		26.70	23.14	24.46	22.47	24.19
150		29.43	26.41	25.12	24.19	26.29
200		31.20	27.57	29.62	27.25	28.91
Mean		27.27	29.70	25.07	23.98	
L.S.D. at 5%	Plant height	No. of tillers/ plant	No. of spikes/ plant	dry weight / plant	Blades area /plant	Flag leaf area
Sitosterol (a)	3.46	0.67	0.56	0.78	34.83	3.07
Ethrel (b)	2.82	0.40	0.39	0.38	29.06	2.21
a × b	9.22	n.s.	n.s.	1.72	66.45	8.66

**Table (2): Effect of sitosterol and ethrel and their interaction on vegetative growth criteria of wheat plants at milky stage ( Combined analysis of the two seasons )**

Ethrel mg/l.		0	50	100	150	Mean
Sitosterol mg/l.						
<b>Plant height ( cm )</b>						
0.0		97.68	99.47	100.56	93.27	97.75
100		109.55	106.30	102.46	103.37	105.42
150		112.60	109.09	107.62	109.01	109.58
200		116.33	112.78	109.21	109.96	112.07
Mean		109.04	106.91	104.96	103.90	
<b>Number of tillers/plant</b>						
0.0		5.71	6.84	5.49	5.45	5.87
100		6.22	6.73	5.61	5.26	5.96
150		7.38	6.62	6.72	5.78	6.63
200		7.24	7.51	6.43	6.88	7.02
Mean		6.64	6.93	6.29	5.84	
<b>Number of spikes/plant</b>						
0.0		5.74	6.90	5.46	5.60	5.93
100		6.27	6.70	5.59	5.35	5.98
150		7.66	6.72	6.96	5.79	6.78
200		7.48	7.54	6.89	6.80	7.18
Mean		6.79	6.97	6.23	5.89	
<b>Dry weight / plant (g)</b>						
0.0		13.38	16.07	15.68	16.96	15.45
100		15.04	15.41	15.70	18.78	17.82
150		16.89	17.76	19.80	17.67	18.03
200		18.78	19.91	18.88	19.85	19.36
Mean		16.02	16.79	17.27	18.32	
<b>Blades area (cm<sup>2</sup>)/plant</b>						
0.0		422.40	531.35	436.96	463.57	463.57
100		436.90	450.03	528.76	467.38	470.77
150		521.38	681.39	574.09	525.29	575.54
200		544.03	676.92	691.80	542.36	613.78
Mean		481.18	584.92	532.90	499.65	
<b>Flag leaf area (cm<sup>2</sup>) / plant</b>						
0.0		26.42	25.63	28.27	27.20	26.88
100		29.55	31.47	31.36	26.06	29.61
150		31.36	33.25	34.04	31.59	32.56
200		31.97	36.88	36.90	31.04	34.20
Mean		29.83	31.66	32.54	28.97	
<b>L.S.D. at 5 %</b>	<b>Plant height</b>					
Sitosterol (a)	3.59	0.49	0.62	2.84	59.57	3.99
Ethrel (b)	2.09	0.34	0.41	1.52	35.71	2.33
a × b	8.91	n.s.	n.s.	2.42	125.86	9.60

Concerning the combined effect of sitosterol and ethrel treatments, significant increases were obtained in some characteristics of growth. The most promising effect of these two bioregulators was noticed with sitosterol at 200 mg/l and ethrel at 50 mg/l at the different stage of growth. However, interaction between sitosterol at 150 or 200 mg/l with ethrel at either 50 or 100 mg/l produced the highest values of plant height, dry weight /plant, flag leaf area and blades area/plant at elongation and milky stages. While, tillers

number and spikes number/plant showed insignificant response to the interaction between sitosterol and ethrel at the two physiological stages.

### **2- Effect of sitosterol and ethrel on photosynthetic pigments:**

Data in Table (3) showed that spraying wheat plant with sitosterol and ethrel had an enhanced photosynthetic pigments during the different stages of growth in most cases. These increases reached the level of significance under the higher concentration of either sitosterol (200 mg/l) or ethrel (150 mg/l) except in Chl (b) and total carotenoids at 90 days from sowing as compared with control. In this respect, Ahmed and Shalaby (1994), Kurapov *et al.* (1996) and Steven and Jenneth (1998) found that foliar application of steroides enhanced photosynthetic apparatus and enzymatic activity. However, Mori *et al.* (1996) and Habba *et al.* (2001) found that foliar application of ethrel on wheat plants slightly affected the photosynthetic pigments.

Regarding the interaction effect, data illustrated in Table (3) showed clearly that photosynthetic pigments were affected significantly by using sitosterol and ethrel in combination with untreated plants. Foliar spraying sitosterol at 200 mg/l combined with high either 100 or 150 mg/l of ethrel tended to produce the highest values of Chl a, Chl b and total carotenoids in most cases.

### **3- Effect of sitosterol and ethrel on yield and its components:**

The data presented in Tables ( 4 and 5 ) reveal that spike length, 100-grain weight, No. of grains/spike, grain and straw yield (g/plant), grain and straw yield (ton/fed), crop index and harvest index were increased as sitosterol concentration increased. The highest values were obtained with sitosterol at 200 mg/l. These results are in agreement with those results obtained by Ahmed and Shalaby (1994), Kurapov *et al.* (1996) and Abdel-Wahed ( 2001). Also, Abdel-Wahed *et al.* (2006) mentioned that yield and its components i.e., ear length, grain yield/plant, grain yield/fed, crop index and 100- grain weight of maize plants were significantly increased at 0.15 mM level of applied sitosterol application. In addition, the increase in yield and its components caused by foliar application of sitosterol might be due to that the sitosterol enhanced photosynthetic apparatus, growth characters, cell division and enzymatic activity which in turn improved the characters yield and also increased grain yield / plant, harvest index and grain yield per fed. when compared to the control ( Steven and Jenneth, 1998, Özdemir *et al.*, 2004 and Abdel-Wahed, 2005 ). The same trend was observed under ethrel treatments. Data in ( Tables 4 & 5 ) indicated that 100- grain weight, grain yield/plant, spike length, grain yield (ton/fed) and crop index increased as ethrel concentration increased, reaching the highest values with the higher concentration of ethrel ( 150 mg/l ) in most cases. The increase in dry weight/plant as affected by ethrel treatment are reflected in increasing yield and its components. These results are in line with those obtained by Langan and Oplinger (1987), Habba *et al.* (2001) and Amin (2003)

Concerning the combined effect between sitosterol and ethrel variations in yield and its components did not reach the level of significance except in case of spike length.

**Table (3) : Effect of sitosterol and ethrel and their interaction on pigments content of the leaves of wheat plants (Combined analysis of the two seasons )**

Treatment	Concentration (mg/l)	Chl (A)			Chl (B)			Total carotenoids		
		At 75 days	At 90 days	At 105 days	At 75 days	At 90 days	At 105 days	At 75 days	At 90 days	At 105 days
Sitosterol	0.0	0.56	0.68	0.77	0.28	0.30	0.32	0.44	0.47	0.51
	100	0.76	0.80	0.83	0.30	0.33	0.35	0.45	0.48	0.52
	150	0.87	0.87	0.92	0.39	0.38	0.40	0.52	0.57	0.62
	200	0.94	0.96	1.03	0.42	0.40	0.41	0.56	0.59	0.64
L.S.D. at 5 %		0.03	0.03	n.s.	0.02	0.01	0.02	0.03	0.02	0.04
Ethrel	50	0.85	0.85	0.90	0.39	0.35	0.37	0.48	0.51	0.55
	100	0.92	0.92	0.95	0.35	0.37	0.38	0.51	0.55	0.59
	200	0.81	0.85	0.94	0.37	0.39	0.41	0.54	0.58	0.63
L.S.D. at 5 %		0.02	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.02
Interaction										
Ethrel	Sitosterol									
50	100	0.74	0.78	0.81	0.27	0.30	0.34	0.40	0.45	0.49
	150	0.84	0.87	0.89	0.43	0.37	0.38	0.50	0.53	0.59
	200	0.96	0.90	0.99	0.46	0.39	0.41	0.54	0.56	0.59
100	100	0.79	0.89	0.88	0.31	0.34	0.33	0.46	0.49	0.52
	150	0.95	0.91	0.98	0.35	0.38	0.41	0.52	0.57	0.60
	200	1.01	0.97	0.99	0.39	0.40	0.40	0.56	0.59	0.64
150	100	0.76	0.72	0.81	0.33	0.36	0.39	0.49	0.52	0.56
	150	0.81	0.84	0.89	0.38	0.40	0.41	0.54	0.60	0.66
	200	0.86	1.00	1.11	0.40	0.42	0.45	0.59	0.62	0.69
L.S.D. at 5 %		0.04	0.05	0.04	0.03	n.s.	0.01	0.02	n.s.	0.01

**4- Effect of sitosterol and ethrel on some biochemical constituent in grains:**

Data presented in Table (5) indicated that protein and total carbohydrate contents significantly responded to different treatments of sitosterol . Maximum concentration was recorded at 200 mg/l for protein and at 100 mg/l for total carbohydrate contents. These results might be attributed to the stimulation and enhancement of cell division and chlorophyll accumulation which led to higher photosynthetic activity of wheat plants and this in turn, enhanced wheat growth and increased protein and soluble sugar accumulation in wheat grains (Steven and Jenneth, 1998). Also, Vardhini and Seeta (1998) found that the exogenous application of brassinosteroids enhanced levels of DNA, RNA, Soluble protein, various carbohydrate and fat content of peanut seed. Abdel-Wahed (2001) and Abdel-Wahed *et al.* (2006) found that stigmasterol application increased protein and carbohydrate contents of maize seeds. This effect might be due to the effect of these substances on enzymatic activity and translocation of metabolites to wheat grains. However, Data in Table (5) indicated that foliar application of ethrel at the concentration of 50 and 100 mg/l gave significant enhancement effect on crude protein and total carbohydrate when compared with control treatment.

**Table (4) : Effect of sitosterol and ethrel and their interaction on yield and its components of wheat plants.**

( Combined analysis of the two seasons )

Ethrel mg/l. Sitosterol mg/l.	0	50	100	150	Mean
	<b>Spike length (cm)</b>				
0.0	13.16	15.78	14.07	14.34	14.34
100	14.90	15.96	16.47	15.31	15.66
150	15.80	16.84	16.95	15.47	16.27
200	16.01	17.36	17.33	16.92	16.91
Mean	14.97	16.49	16.21	15.51	
	<b>Number of grains/spike</b>				
0.0	49.60	50.90	52.20	56.10	52.20
100	51.50	56.10	61.30	65.80	58.70
150	55.30	59.20	66.40	69.70	62.70
200	61.40	59.70	67.50	70.60	64.80
Mean	54.50	56.50	61.90	65.60	
	<b>( 100-grain weight )</b>				
0.0	4.89	4.91	4.80	4.87	4.87
100	5.50	5.80	4.62	5.31	5.31
150	5.70	4.89	6.34	5.64	5.64
200	5.76	5.88	5.89	6.62	6.04
Mean	5.46	5.37	5.41	5.61	
	<b>Grain yield (g)/plant</b>				
0.0	7.27	7.96	8.11	8.60	7.99
100	7.36	8.45	8.85	9.01	8.42
150	8.43	9.57	8.87	9.58	9.11
200	8.39	8.90	9.98	9.69	9.24
Mean	7.86	8.72	8.95	9.22	
	<b>Straw yield (g)/plant</b>				
0.0	8.99	8.84	9.87	9.94	9.41
100	8.97	10.01	9.96	10.86	9.95
150	10.81	10.95	9.88	11.23	10.72
200	10.90	11.04	11.67	10.97	11.15
Mean	9.92	9.96	10.35	10.75	
<b>L.S.D. at 5 %</b>	<b>Spike length</b>	<b>No. grains/spike</b>	<b>100-grain weight</b>	<b>Grain yield/plant</b>	<b>Straw yield/plant</b>
Sitosterol (a)	0.87	0.29	2.34	2.01	0.76
Ethrel (b)	0.69	0.12	1.56	1.31	0.37
a × b	2.25	n.s.	n.s.	n.s.	n.s.

Habba *et al.* (2001) on wheat. and Amin (2003) on maize, found that protein percentage tended to increase with foliar application of ethrel, while, total carbohydrate in grains tended to decrease by increasing foliar application of ethrel. Concerning the combination treatment, sitosterol and ethrel treatment showed significant effect on protein and total carbohydrate of wheat grains. The maximum values of protein percentage were obtained as a result of foliar application of sitosterol at 200 mg/l with ethrel 150 mg/l, whereas, sitosterol at 100 mg/l and ethrel 50 mg/l caused the highest values of total carbohydrate contents.



**5- Simple correlation of grain yield and other characters of treated plants :**

The results of the correlation coefficient between grain yield and some characters of wheat plant under sitosterol and ethrel treatments are presented in Table (5).

**Table (5) : Effect of sitosterol and ethrel and their interaction on yield & its components and bio-chemical constituents of wheat plants.**

( Combined analysis of the two seasons )

Sitosterol mg/l.	Ethrel mg/l.	0	50	100	150	Mean
<b>Grain yield ( ton/fed. )</b>						
0.0		2.87	2.84	3.01	3.08	2.95
100		2.96	2.88	3.61	3.35	3.20
150		2.99	3.09	3.86	3.49	3.36
200		3.02	4.08	3.81	4.11	3.76
Mean		2.96	3.22	3.57	3.51	
<b>Straw yield (ton/fed.)</b>						
0.0		3.89	3.99	4.62	4.33	4.21
100		4.55	4.80	5.11	5.41	4.97
150		5.21	4.87	5.34	4.80	5.06
200		5.17	5.33	5.26	6.09	5.46
Mean		4.71	4.75	5.08	5.16	
<b>Crop index %</b>						
0.0		63.50	63.70	70.10	71.10	67.10
100		65.00	60.10	58.90	61.90	61.50
150		57.90	63.40	72.30	72.70	66.60
200		58.40	76.50	72.40	69.10	69.10
Mean		61.20	65.90	68.40	68.70	
<b>Harvest index %</b>						
0.0		38.80	38.90	40.20	41.10	39.80
100		39.40	40.50	39.10	39.20	39.60
150		36.50	38.90	42.10	46.50	41.80
200		40.90	43.90	42.80	48.70	44.10
Mean		38.90	40.60	40.90	43.90	
<b>Crude protein</b>						
0.0		9.88	10.43	11.24	12.09	10.91
100		10.69	11.32	12.01	11.59	11.40
150		11.08	11.66	12.34	12.26	12.01
200		12.13	12.69	13.06	13.11	12.75
Mean		10.95	11.53	12.16	12.26	
<b>Total carbohydrate %</b>						
0.0		58.54	65.97	66.61	66.98	64.53
100		65.38	76.89	72.81	70.31	71.35
150		67.84	70.56	67.45	66.50	68.09
200		63.46	67.52	62.77	60.59	63.55
Mean		63.81	70.24	67.41	66.10	

L.S.D. at 5 %	Grain yield	Straw yield	Crop index	Harvest index	Crude protein	Total carbohydrate
Sitosterol (a)	0.92	0.80	3.60	5.30	0.89	5.41
Ethrel (b)	0.64	0.49	2.01	2.46	0.39	3.76
a x b	n.s.	n.s.	n.s.	n.s.	2.36	3.97

It is clear that grain yield was significant and positive correlated with plant height, number of tillers/plant, spike length, flag leaf area, grain yield/plant, 100-grain weight, harvest index, crude protein and total carbohydrate under sitosterol or ethrel treatment. However, Habba *et al.* (2001) on wheat Amin and Habba (2003) on lupine, Abdel-Wahed *et al.* (2006) on maize showed that a positive and correlation between concentration of stigmasterol and growth, yield and chemical constituents of seeds. It appears that the improvement of growth reflected on increasing grain yield/fed. of wheat that showed high significant correlation between grain yield, number of tillers/plant, flag leaf area, grain and straw yield/plant, 100 – grain weight and harvest index under treating wheat with sitosterol and ethrel.

From the above mentioned results, it could be concluded that foliar application of sitosterol at 200 mg/l or ethrel at 100 mg/l to wheat plants c.v. Gemmiza-9 at vegetative stage improved growth, yield and its components as well as some biochemical constituents of wheat plants.

Table (6) : Simple correlation coefficient between grain yield ( ton/fed) with some yield attributes and chemical constituents under sitosterol and ethrel treatments

Characters	Sitosterol	Ethrel
Grain yield (ton/fed)		
1- Plant height	0.889**	0.784*
2- Number of tillers	0.841**	0.787*
3- Spike length	0.784*	0.708*
4- Flag leaf area	0.851**	0.871**
5- Grain yield/plant	0.864**	0.821*
6- Straw yield/plant	0.796**	0.875**
7- 100- grain weight	0.994**	0.886**
8- Harvest index	0.892**	0.967**
9- Crude protein	0.891**	0.723*
10- Total carbohydrate	0.583*	0.623*

\* and \*\* significant at 5 % and 1 % probability level, respectively.

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## استجابة نبات القمح للرش بالسيتوستيروول والإثيريل

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- أجريت تجربتان حقليتان بمزرعة المركز القومي للبحوث بشلقان - محافظة القليوبية وذلك لدراسة تأثير التركيزات المختلفة للسيتوستيروول ( ١٠٠، ١٥٠، ٢٠٠ ملليجرام/لتر ) والإثيريل ( ٥٠، ١٠٠، ١٥٠ ملليجرام/لتر ) وكذلك التفاعل بينهما علي صفات النمو والصيغات والمحصول ومكوناته ومحتوى الحبوب من البروتين والكربوهيدرات لنبات القمح ( صنف جميزة-٩ ) وأظهرت النتائج ما يلي :
- ١- أدت معاملة نباتات القمح بالسيتوستيروول خاصة مع التركيزات المتوسطة والمرتفعة ( ١٥٠، ٢٠٠ ملليجرام/لتر ) خلال مراحل النمو المختلفة إلى زيادة معنوية في صفات النمو والمحصول المتمثلة في ارتفاع النبات ، عدد الأشطاء/نبات ، والسنايل/نبات ، مساحة الأوراق(سم<sup>٢</sup>)/نبات ، مساحة ورقة العلم ، الوزن الجاف/نبات ، طول السنبل ، ومحتوى الأوراق من صيغات البناء الضوئي ، محصول الحبوب والقش للنبات والقدان ، ودليل الحصاد ، بينما أدى الرش بالتركيزات المتوسطة والمرتفعة من الإثيريل ( ١٠٠، ١٥٠ ملليجرام/لتر ) إلى حدوث نقص معنوي في ارتفاع النبات ، عدد الأشطاء والسنايل / نبات ، مساحة الأوراق/نبات ومساحة ورقة العلم .
  - ٢- أعطت معاملة نباتات القمح بالسيتوستيروول عند تركيز ٢٠٠ ملليجرام/لتر والإثيريل عند تركيز ٥٠ ملليجرام/لتر أعلى قيم لصفات النمو خلال مراحل النمو المختلفة في معظم الحالات - بينما حقق استخدام تركيز ٢٠٠ ملليجرام /لتر سيتوستيروول ، ١٥٠ ملليجرام/لتر إثيريل أعلى قيم لصفات المحصول ومكوناته ومحتوى الحبوب من البروتين والكربوهيدرات في معظم الحالات مقارنة بالكنترول والتركيزات الأخرى .
  - ٣- كان هناك تأثير معنوي وموجب للتفاعل بين التركيزات المتوسطة والمرتفعة من السيتوستيروول مع التركيزات المختلفة من الإثيريل لصفات ارتفاع النبات ، والوزن الجاف / نبات ، مساحة الأوراق/نبات ، وصيغات البناء الضوئي ( خلال مراحل النمو المختلفة ) ، طول السنبل ومحتوى الحبوب من البروتين في معظم الحالات . بينما أدى التفاعل بين التركيزات الأقل والمتوسطة من السيتوستيروول مع التركيزات المختلفة من الإثيريل إلى زيادة نسبة الكربوهيدرات الكلية في معظم الحالات .
  - ٤- وجد أن هناك ارتباط موجب وعالي المعنوية بين محصول الحبوب / فدان وارتفاع النبات ، وعدد الأشطاء والسنايل / نبات ، مساحة ورقة العلم ، طول السنبل ، وزن ١٠٠ حبة ، محصول الحبوب والقش/نبات ، دليل الحصاد ، ومحتوى الحبوب من البروتين والكربوهيدرات الكلية تحت تأثير التركيزات المختلفة لكل من السيتوستيروول والإثيريل.