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EFFECT OF DIFFERENT CONCENTRATIONS OF STIGMASTEROL ON GROWTH, YIELD AND IT'S COMPONENTS OF MAIZE PLANTS

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ABSTRACT

Two field experiments were conducted during the two growing seasons, 1997 and 1998 at the Experimental Station of the National Research Centre at Shalakan, Kalubia, Egypt, to study the effect of different concentrations (0,20,40 and 80 mg/l) of stigmasterol on the growth yield, and its components as well as chemical composition of maize grain.

Vegetative growth of maize plants (plant height, leaf area/plant, leaf area index (LAI), total plant dry weight and net assimilation rate (NAR) were significantly increased at all applied concentrations of stigmasterol which were given twice as foliar spray when the plants were at elongation and tassel appearance stages. However, insignificant effect was observed on crop growth rate (CGR). Yield and its components (ear length, ear diameter, number of grain rows/ ear, weight of 100-grain, shelling percentage, and grain yield/plant were significantly increased for plants which were twice sprayed by the stigmasterol, especially at 80 mg/l..

Total sugars, crude protein and oil percentage of maize grains were increased as the number of sprays and concentrations of stigmasterol increased. Increasing the number of sprays or concentrations of stigmasterol were significantly effective for increasing vegetative growth, yield and its components as well as the chemical composition of maize plants.

Highly significant and positive simple correlation was obtained between concentrations of stigmasterol, growth characters, yield and its components of maize plants.

Multiple correlation between the number of sprays, concentrations of stigmasterol, growth characters, and yield and its components were highly significant.

Key words : Stigmasterol, growth, yield, sugars, oils, maize.

INTRODUCTION

Maize plant is considered as one of the most important cereal crops used in human consumption, animal feeding, starch industry and oil production. Therefore, continuous attempts were carried out for increasing its productivity to face urgent demands of increasing population especially in Egypt through the last period. This can be obtained through breeding programs to produce highly productive and qualitative gene forms as well as adjusting the growth regulator in respect to arrive to that strategy.

Brassinolide (BR) (22R , 23R, 24S) – 2 œ, 3 œ , 22, 23 – tetrahydroxy – 24 – Methyl – B- Homo – 7- Oxa – 5 œ – Cholestan – 6- one -) was reported to stimulate leaf elongation (Braun and wild, 1984 a and b; Fujii, *et al*., 1991 ; and Fujioka, *et al*., 1995). In addition, BR showed continuous increases in fresh and dry weight of leaves and shoots which were accompanied by intense rate of growth (Krizek and Mandava, 1982 a and b; Yokota, *et al*., 1991 ; and Izzo and Navori, 1993).

Application of BR to intact plants such as lettuce, cucumber, mustard and wheat under hydroponic conditions contributed auxins, cytokinins which stimulate growth of whole plants including the roots (Greogory and Mandava, 1982 on mung bean ; Adam, *et al.*, 1991 ; and Dogra and Kaur, 1994 on wheat).

Furthermore , Hirai*, et al .,* (1991) found that foliar application of 0.01 and 1 mg/l brassinolide to rice plant at spikelet differentiation meiosis and heading gave 62 and 75% riped grains, respectively as compared with 57.5% for the control. Brassinolide promoted grain ripening of barley and wheat (Prusakova, *et al*., 1995), & wheat (Kurapov, *et al*., 1996) and of rice (Steven and Jenneth 1998). Furthermore, Tao – Yoabao, *et al*., (1998) indicated that foliar application of 5 and 10 mg/l of synthetic brassinosteroid to wheat plants at the beginning of flowering increased the length of the main spike, the number of spikelets/spike, the weight of grains/spike and grain yield. Dogra and Kaur (1994), working on wheat , as well as Fujii, *et al*., (1991) and Wang – Sangen and Wang (1997) working on rice; concluded that protein, carbohydrate, and concentration of nutrient elements in the grains of both plants were markedly increased by steroid treatment.

Thus, the objective of this study is to investigate the effect of the plant growth regulator (Stigmasterol) on vegetative growth and grain yield, in relation to sugars and protein contents of grains for *Zea mays L*.

MATERIAL AND METHODS

Two field experiments were carried out at the Experimental Station of National Research Centre, Shalakan, Kalubia Governorate during the two successive seasons of 1997 and 1998, to study the effect of foliar application of different concentrations of stigmasterol at various growth stages of maize on vegetative growth, yield and its components as well as sugars, protein and oil content of the grains. The treatments were divided into two groups ; at the first group the plants were sprayed once at elongation stage with three concentrations (20, 40 and 80 mg/l) of stigmasterol (Stigmasta-5,22-Diene-3B-OL; (24S)- 24 Ethylcholesta – 5,22 dien – 3 B-OL) which was purchased from Merck – Co. and at the second group, the plants were sprayed twice at elongation and tassel appearance stages with the same concentrations of stigmasterol Additional control treatment was sprayed with distilled water.

Grains of maize (*Zea mays L*.) cv. single cross 10 were sown on 8 June, 1997 for 1st season and 12 June, 1998 for the 2nd season in rows 70 cm apart and the distance between hills along the row 20 cm apart. Plot area was 10.5m^2 (3.0 m in width and 3.5m in length).

The experimental design was split plot with six replications. The plants sprayed only at elongation stage occupied the main plots while those sprayed, at elongation and tassel appearance stages were at subplots.

Pre-sowing, 100 kg/fed. of calcium super–phosphate (15.5% P_2O_5) was applied to the soil. While, for nitrogen fertilizer, 120 kg N/fed. Ammonium nitrate (33.5% N) was applied in two equal doses before the 1st and 2nd irrigation.

The following growth characteristics were measured at silky stage (75 days after sowing) and at milky stage (90 days after sowing): Plant height (cm). number of leaves/plant. leaf area (cm^2/plant) : (using the disk method according to Bremner and Taha , 1966), Leaf area index (LA1) : (according to Watson, 1952). Total plant dry weight (g/plant), Net assimilation rate (NAR) (mg/cm^2/day), crop growth rate (CGR) : (g/day) : (Abd-Gawad, *et al* ; 1980); relative growth rate (RGR) : (mg/g/day) : (Blackman, 1951).

At harvest "dent stage" (120 days), samples of ten plants were randomly taken to determine the following : The yield components : ear length, ear diameter, No. of rows/ ear, No. of grains/row, seed index (weight of 100-grain), grain yield/plant (g), shelling percentage, harvest index and grain yield (ton/feddan).

Chemical analysis of grains: Grain samples of all treatments were dried at 70º C for constant weight and ground to determine the following :

1. Total sugars content was determined colorimetrically according to the method described by Dubois, *et al*., (1956).
2. Crude protein percentage. According to the method of A.O.A.C. (1955) (calculated by multiplying the values of total nitrogen content by 6.25)
3. Oil percentage in maize grain was extracted by using solvent hexanol in a Soxhlet apparatus according to method of A.O.A.C. (1988).

The data were statistically analyzed for each season and then combined analysis of the two seasons was carried out (Snedecor and Cochran, 1980). For comparison between means, L.S.D. at 5% level was determined. Simple and multiple correlation coefficients between growth characters, yield and its components and the studied treatments, i.e., concentrations of stigmasterol and number of sprays as well as the changes of studied stages as a response to this treatment were determined according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of stigmasterol on growth characters :

Effect of foliar application of different concentrations (0,20,40 and 80 mg/l of stigmasterol) at two stages (elongation and tassel appearance) on maize growth characters were presented in Table (1). The data show that plant height, leaf area/ plant, leaf area index (LAI), total plant dry weight, net assimilation rate (NAR), relative growth rate (RGR) were significantly increased over the corresponding control values in a magnitude proportional to the increase in the concentrations and number of sprays of stigmasterol applied at both stages of maize plants. Number of leaves/plant was significantly increased in a similar trend at the silky stage as presented in Table (1). Whereas, at the milky stage, treatments with stigmasterol at the concentrations of 20 and 40 mg/l after the first spray and with 20 mg/l after the second spray resulted in nonsignificant increase in the number of leaves/ plant, whereas other treatments caused significant increases in their number.

Net assimilation rate (NAR) was significantly increased with all concentrations used of stigmasterol except treatment at 40 mg/l after the first spray which significantly resulted in decreasing the values of NAR . The favourable effect of stigmasterol on growth characters of maize plants as presented in Table (1) could be attributed to stimulated action of stigmasterol on the phytohormones, such as auxin and cytokinins which in turn induced cell elongation and division and consequently increased growth of plant organs. This interpretation was supported by Greogory and Mandava (1982), who concluded that application of brassinosteroid to intact plants such as lettuce, cucumber, mustard and wheat contributed auxins and cytokinins to stimulate growth of whole plants including roots . In addition, Braun and Wild (1984 a and b) concluded that the promoting effect of brassinosteroid on vegetative growth characters could be attributed to the stimulation of cell elongation and division. Similar results were obtained by other authors e.g. Izzo and Navari (1993) on maize plant; Prusakova, *et al* , (1995) on wheat; and Tao-Yoabao, *et al*. (1998) on rice.

The increase in dry weight of total plant as presented in Table (1) was directly proportional with the increase in growth characters of maize plants such as stem length, number of leaves/ plant, leaf area/plant and leaf area index. This response was more pronounced in plants received twice foliar application of stigmasterol than in plants received only one. Similar results were obtained for increasing dry matter accumulation of wheat plants (Ahmed and Shalaby, 1994) , barley plants (Shalaby and Ahmed, 1994) and for rice plants (Wang – Sangen and Wang, 1997) .

In order to find the most effective growth characters when stigmasterol was applied to maize, simple and multiple correlation coefficients were calculated.

The results of the simple correlation coefficient between concentrations of stigmasterol and growth characters at silky stage as shown in Table (2) were positively significant with plant height, number of leaves/plant, leaf area/plant, total dry weight/plant, NAR and CGR, also these characters contribute to increasing grain yield in maize. with the following rats for plant height (64.3%), number of leaves/plant (89.5%), leaf area/plant (77.8%), total dry weight/plant (82.4%), NAR (54.0%) and CGR (73.8%). However, these characters were also positive but not significantly with, LAI and RGR at silky stage. Whereas, plant height, number of leaves, leaf area, leaf area index and CGR show high significant positive correlation at milky stage. These characters contribute with increasing grain yield, as follow : plant height (79.7%), number of leaves (67.9%) leaf area/plant (73.4%) LAI (73.9%) and CGR (73.4%).

Correlation coefficients between number of sprays and growth characteristics were significantly positive for plant height, leaf area/plant, LAI and RGR. Also, number of leaves/plant, total dry weight/plant, NAR and CGR were positively correlated but insignificant. However, at milky stage the correlation coefficients between sprays and growth characters especially plant height, number and area of leaves were significant and positive. These characters contribute with increasing grain yield of maize as follows : plant height (74.8 %) number of leaves/plant (89.9 %), leaf area/plant (94.7%), LAI (94.7 %) and total weight/plant (67.7 %).

Effect of stigmasterol on yield, and its components:

Data presented in Table (4) show that increasing stigmasterol concentrations or number of sprays were proportional with the increases in yield and yield components characters of maize. Consequently, the most favourable effects on yield and yield component parameters were obtained in plants received twice foliar application of stigmasterol than in plants received one foliar spray. Ear characters of maize plants i.e, ear length, ear diameter and number of rows/ear were significantly increased by increasing the concentration and number of stigmasterol sprays. This effect was true at all stages but failed to reach the significant level at 5% at treatment with 20 mg/l of stigmasterol given once: Number of grains/row was increased at all treatments of stigmasterol, but these increases were not significant (Table, 4).

Grain yield/plant were significantly increased at all concentrations used of stigmasterol in both growth stages of maize plants. The increases in grain yield/plant could be attributed to significant increase in weight of 100-grain at all concentrations of stigmasterol and shelling percentage at treatment with 80 mg/l stigmasterol given once or twice at both stages of growth. Whereas, grain yield (ton/fed) was insignificantly increased at all concentrations of stigmasterol applied at both stages of maize growth. Previous studies confirmed the present obtained positive response to the foliar application of barssionsteroid on different plants species. (Ahmed and Shalaby (1994) on wheat, Shalaby and Ahmed (1994); Prusakova *et al*. (1995) and Kurapov, *et al*. (1996) on barley as well as Tao-Yoabao, *et al*., (1988) on rice. In addition, the increase in yield and its attributes by foliar application of stigmasterol might be due to the fact that, the stigmasterol enhanced photosynthetic apparatus, growth parameters, cell division and enlargement and enzymatic activity (Kalinich, *et al* , 1985 ; Wang-Sangen and Wang, 1997; and Steven and Jenneth, 1998).

In addition, the present result revealed that application of stigmasterol improved the growth of whole plants and dry matter accumulation, which in turn improved the characters of ears and also increased grain yield/ plant, harvest index, shelling percentage and grain Yield (ton/fed.). When compared to the control.

Simple correlation coefficient between concentrations of stigmasterol, yield and its component at silky and milky stages Tables (2 and 3) indicated, high significant positive correlation between concentration of stigmasterol and yield components, ear length, ear diameter, grain yield/plant, seed index, harvest index, whereas, grain yield/fed., number of rows/ear and number of grains/ row were positively correlated but insignificantly with concentration of stigmasterol .

These characters contribute by increasing grain yield of maize at milky stage as follows ear length (70.6 %) , grain yield/plant (77.9%), seed index (82.4 %), shelling percentage (74.6%), harvest index (76.2 %) and grain yield (83.2 %). But at silky stage correlations were to each of ear length, (67.7 %), grain yield/plant, (77.6 %) seed index; (62.4 %) shelling percentage, (56.6 %) and harvest index (78.3 %) .

Tables (2 and 3) indicate high significant positive correlations between number of sprays and yield components at silky and milky stages with each of ear length, ear diameter. number of grains / row, grain yield/plant and grain yield/fed. These characters contribute with increasing of grain yield in maize at milky stage as follows; ear length (79.2 %) number of grains/row (66.4 %), grain yield / plant (86.2 %) , seed index (83.7 %), shelling percentage (79.0 %), harvest index (94.1%) and grain yield/fed. (96.4 %).

Table (5) show the data of multiple correlation coefficient between growth characters, yield and its components and grain yield and both of concentrations of stigmasterol and number of stigmasterol application. Highly and positively correlation coefficient were obtained between rates of stigmasterol, number of sprays, growth characters, and yield and its components. The variables leaf area index; total plant dry weight; CGR, ear length; No. of grains/ row; grain yield/ plant; seed index; grain yield/fed. were responsible for (62.9 %); (51.5 %); (73.4 %); (57.6 %); (59.2 %); (78.1 %); (69.6 %) and (71.6 %) respectively of the yield variation. as affected by stigmasterol.

Concentrations of stigmasterol and number of stigmasterol application showed high significant association with, leaf area/plant ; total plant dry weight, CGR, ear length, number of grain row; grain yield/plant; seed index and grain yield/fed.

Table (5): Multiple correlation coefficients between number of sprays, concentrations and grain yield and relative contributions of 8 characters in grain yield of maize

Characters	B	R	R_2 %
Leaf area/plant	0.77	0.793*	62.9
Total dry weight per plant	0.68	0.711*	51.5
Crop growth rate	0.84	0.857*	73.4
Ear length	0.75	0.759*	57.6
Number of grains/row	0.78	0.769*	59.2
Grain yield/plant	0.87	0.884*	78.1
Seed index	0.81	0.834*	69.6
Grain yield/feddan	0.83	0.843*	71.1

R = Correlation coefficient **R_2% = coefficient of determination**
Multiple = 0.953 R squared = 0.909
Adjusted R squared = 0.864 Standard error of estimate = 3.594
$Y = a + b1X1 + b2 \times 2$
$R = R_2$ %
*** and **Significant at 5 % and 1% Probability levels respectively.**

Effect of stigmasterol on sugar, protein and oil contents

Data presented in Table (6) indicated that, increasing the level of stigmasterol or number of stigmasterol applications increased the content of total sugars, protein and oil percentage in produced maize grain. This response was more pronounced in plants received stigmasterol twice than those received one application as indicated by the percentages of each component to that of the corresponding control. In addition, the increases in chemical constituents reached their heighest values in plants treated with higher concentrations of stigmasterol

It might be concluded that the increases in growth and yield of stigmasterol treated plants were accompanied with relatively pronounced increases in total sugars, protein and oil content of produced maize grains . In this respect , Kalinich, *et al*., (1985) reported that treatment with BR significantly increased RNA and DNA polymerase activities and the synthesis of RNA, DNA and protein in bean and mung bean. In addition, Petzold, *et al*., (1992) found that brassinosteroids promoted sucrose uptake in faba bean plant and this probably due to modulation of H^+ ATP – are activity. They also added that, brassinosteroid enhanced translocation of C^{14} compounds to the apical sink region and affected phloem unloading of C^{14} compounds.

From the present results , it could be concluded that foliar application of different concentrations of stigmasterol applied at elongation and tassel appearance stages especially at 80 mg/l resulted in pronounced increases in growth characters, yield and yield components and some chemical constituents of grains in treated plants twice at elongation and tassel stages over those received one foliar application at elongation stage as presented in Tables (1,4 and 6) . It is worthly to mention that the favourable effect of stigmasterol on productive efficiency of maize plants could be attributed to stimulation of cell division and elongation (Braun and Wild, 1984 a,b) and the increase in fresh and dry weight of leaves and shoots (Krizek and Mandava, 1982 a and b), contributing auxin and cytokinins contents which stimulate growth of whole plant including the roots (Gerogory and Mandava 1982, Braun and wild 1982 a and b) and promoting seed ripening (Hirai *et al*., 1991) . Moreover, enhanced translocation of C^{14} compounds to the sink was reported by Petzold, *et al*., (1992).

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تأثير التركيزات المختلفة للإستجماستيرول على النمو والمحصول والتركيب الكيماوى لنباتات الذرة الشامية

محمد سلامة أحمد عبد الواحد ، أبو بكر أحمد السيد أمين و زكريا أمين على
قسم النبات – المركز القومى للبحوث

أجريت هذه الدراسة خلال موسمى ١٩٩٧ ، ١٩٩٨ بمحطة التجارب الزراعية للمركز القومى للبحوث بشلقان – قليوبية بهدف دراسة تأثير التركيزات المختلفة للإستجماستيرول (صفر ، ٢٠، ٤٠، ٨٠ جزء فى المليون) وكذلك عدد الرشات على االنمو والمحصول والتركيب الكيماوى لنباتات الذرة الشامية (صنف هجين فردى ١٠) وكانت أهم النتائج المتحصل عليها كالآتى :-

1- أدت معاملة نباتات الذرة الشامية بالإستجماستيرول خلال مرحلة الإستطالة، ومرحلة ظهور الحريرة (أى بعد عمر ٤٥ و٦٠ يوم من الزراعة) إلى زيادة معنوية فى صفات النمو الخضرى المتمثلة فى طول النبات، عدد الأوراق للنبات، مساحة الورقة للنبات، دليل مساحة الأوراق والوزن الجاف الكلى للنبات، معدل الكفاءة التمثيلية ، والسرعة النسبية للنمو بينما لم تعطى صفة سرعة نمو المحصول أى إستجابة معنوية نتيجة للمعاملة.

2- أدت المعاملة بالإستجماستيرول إلى زيادة معنوية للمحصول ومكوناته حيث زاد كل من طول الكوز، وقطر الكوز، وعدد الصفوف بالكوز ومحصول الحبوب ، بالنبات، وزن ١٠٠ حبة، نسبة التصافى ، دليل الحصاد، ومحصول الحبوب للفدان زيادة معنوية بينما لم تعطى صفة عدد الحبوب ، دليل الحصاد

، محصـول الحبـوب بـالكوز أى إستجابة معنويـة. وذلك للنباتـات التـى عوملت بالإستجماستيرول خاصـة بتركيز ٨٠ مجم/لتر الذى تم رشه فى مرحلتى الإستطالة وظهور الحريرة.

3- أوضحت نتـائج التحليل الكيمـاوى للحبوب إلـى زيـادة فـى محتـوى الحبـوب مـن البروتين، والسكريات ، والزيت عند رش نباتات الذرة بالإستجماستيرول خلال مرحلتـى الإستطالة، وظهـور الحريـرة. حيث زاد محتواها من البروتين والسكريات والزيت عند تركيز ٨٠ مجم /لتر (رشتين).

4- وجد أن الإرتباط البسيط عالى المعنوية بين كل مـن صـفات النمـو الخضـرى المتمثلـة فـى طـول النبـات، عـدد الأوراق / نبـات، مسـاحة الورقـة / نبـات والـوزن الجـاف الكلـى للنبـات، ومعـدل الكفـاءة التمثيليـة، وسرعة نمو المحصـول) وكل مـن عـدد الرشاشـات أو تركيـزات الـرش بالإستجماسـتيرول، وكـان هنـاك إرتباط موجب وغير معنوى بين صفات النمو المتمثلة فى ودليل مساحة الورقة والسرعة النسبية للنمو.

5- كان الإرتباط البسيط بين كل من المحصـول ومكوناتـه وتركيـزات الإستجماستيرول أو عـدد الرشاشـات موجبـاً وعـالى المعنويـة للصـفات الأتيـة طـول الكـوز، محصـول الحبـوب/ نبـات، وزن ١٠٠ حبـة، ومحصول الحبوب / فدان . بينمـا كـان الإرتبـاط البسيط غيـر معنـوى للصـفات التاليـة قطـر الكـوز ، عـدد الصفوف للكوز، وعدد الحبوب بالصف.

6- أظهرت نتـائج الإرتبـاط المتعـدد بوجـود إرتبـاط موجب وعـالى المعنويـة بـين كـل مـن محصـول الحبـوب ومكوناته وكل من عدد الرشات وتركيزات منظم النمو إستجماستيرول لنباتات الذرة وذلك خلال موسـمى الزراعة .

7- مما تقدم أكدت حسابات الإرتبـاط البسيط والمتعدد النتائج المتحصل عليها من زيـادة فـى النمـو الخضـرى والمحصول ومكوناته والصفات التى تأثرت أكثر من غيرهـا بتركيـز ٨٠ جـزء فـى المليـون المعطـى فـى مرحلتى الإستطالة وظهور الحريرة لنباتات الذرة الشامية (هجين فردى ١٠).

Table (1): Effect of Stigmasterol on vegetative growth characteristics of maize plants (Average of two seasons, 1997 and 1998)

Stigmasterol treatment		Plant height (cm)		No. of Leaves/plant		Leaf area/plant (cm^2)		Leaf area index (LAI)		Total plant dry weight (gm)		NAR Mg/ cm/ day	CGR gm/day	RGR mg/gm/day
Stages of application	Concen-trations (mg/l)	A	B	A	B	A	B	A	B	A	B	A – B	A – B	A – B
Elongation	00	225.41	277.38	14.79	14.39	6567.76	7160.74	2.63	2.91	190.39	197.26	4.03	0.46	2.47
	20	270.72	286.56	15.01	14.37	7673.90	8325.28	3.07	4.21	210.80	222.79	5.09	0.78	2.05
	40	283.31	289.44	15.38	14.66	8463.75	9138.99	3.38	4.57	216.25	226.42	2.87	0.80	3.28
	80	288.01	293.81	15.69	15.35	8441.58	9425.92	3.41	4.71	225.55	242.98	4.42	1.17	5.42
Elongation and tassel appearance	20	284.90	289.20	15.19	14.90	9269.38	9972.42	3.71	4.99	212.46	231.91	4.02	1.39	3.69
	40	288.96	291.60	15.58	15.46	9582.61	10134.28	3.83	5.02	222.51	245.03	4.66	1.51	3.75
	80	294.39	302.21	15.80	15.70	10038.05	10667.33	4.02	5.34	239.74	266.61	4.98	1.81	4.38
L.S.D. at 5% level		6.67	8.40	0.56	0.77	690.10	822.1	0.28	0.42	7.07	9.92	0.36	N.S.	2.26

- **A: Silky Stage**
- **B: Milky Stage**

Table (2) : Simple correlation coefficients between number of sprays, concentrations and growth characters at silky stage as well as yield and its component at dent stage

Characters	Concentrations		Number of Sprays	
	R	R_2 %	R	R_2 %
Plant height	0.802*	64.3	0.601*	36.1
Number of leaves/plant	0.946**	89.5	0.445	20.7
Leaf area/plant	0.882**	77.8	0.827*	68.4
Leaf area index	0.696	48.4	0.821*	67.4
Total dry weight/plant	0.908**	82.4	0.497	25.0
Net assimilation rate	0.735*	54.0	0.486	24.1
Relative growth rate	0.659	43.4	0.863*	74.5
Crop growth rate	0.857*	73.8	0.515	27.2
Ear length	0.823*	67.7	0.784*	61.5
Ear diameter	0.740*	54.8	0.686*	47.1
Number of rows/ear	0.550	30.3	0.572	33.2
Number of grains/row	0.684	46.8	0.790*	62.4
Grain yield/plant	0.881*	77.6	0.707*	50.8
Seed index	0.790*	62.4	0.643	41.3
Shelling percentage	0.752*	56.6	0.425	19.0
Harvest index	0.885*	78.3	0.620	38.4
Grain yield/feddan	0.930**	81.5	0.917**	84.0

R = Correlation coefficient **R_2% = Coefficient of determination**
*** and ** Significant at 5% and 1% Probability levels, respectively.**

Table (3) : Simple correlation coefficients between number of sprays, concentrations and growth characters at milky stage as well as yield and its component at dent stage.

Characters	Concentrations		Number of sprays	
	R	R_2 %	R	R_2 %
Plant height	0.894**	79.7	0.865*	74.8
Number of leaves / plant	0.824*	67.9	0.948**	89.9
Leaf area per plant	0.857*	73.4	0.971**	94.3
Leaf area index	0.859*	73.9	0.973**	94.7
Total dry weight per plant	0.690	47.6	0.823**	67.7
Net assimilation rate	0.659	43.4	0.744	55.4
Relative growth rate	0.469	22.9	0.758	57.5
Crop growth rate	0.857*	73.4	0.776	60.2
Ear length	0.840*	70.6	0.890**	79.2
Ear diameter	0.647	42.6	0.699	48.9
Number of rows/ear	0.677	45.8	0.773	59.8
Number of grains/row	0.630	40.9	0.815*	66.4
Grain yield/plant	0.883*	77.9	0.930**	86.5
Seed index	0.908**	82.4	0.915**	83.7
Shelling percentage	0.864**	74.6	0.889**	79.0
Harvest index	0.873*	76.2	0.970**	94.1
Grain yield/feddan	0.912**	83.2	0.982**	96.4

R = Correlation Coefficient **R_2% = Coefficient of determination**

*** and ** Significant at 5% and 1% Probability levels, respectively.**

Table (4): Effect of different concentration of stigmasterol on yield and yield components of maize plant (Average of two seasons, 1997 and 1998)

Stigmasterol treatment		Ear length (cm)	Ear diameter (cm)	No. of rows/ear	No. of grains/ row	Grain yield / plant (gm)	Weight 100-grain (gm) (seed index)	Shelling (%)	Harvest index	Grain yield (t/fed.)
Stages of application	Concentration (mg/l)									
Elongation	Control	20.98	3.68	12.98	41.51	192.85	39.14	83.59	0.74	3.74
	20	21.05	3.92	13.30	42.11	201.15	41.47	84.11	0.75	4.34
	40	21.63	4.06	13.66	43.86	208.49	41.6	84.48	0.78	4.70
	80	22.13	4.22	13.89	44.61	210.94	42.81	85.45	0.81	5.0
Elongation and tassel appearance	20	22.20	4.18	14.61	43.81	215.35	42.85	84.85	0.79	4.94
	40	22.65	4.24	14.70	44.24	217.23	43.27	84.36	0.80	5.01
	80	23.78	4.45	14.95	45.51	220.66	44.05	85.90	0.84	5.24
L.S.D. at 5 % level		0.51	0.21	0.29	N.S.	7.22	1.51	1.36	N.S	N.S

Table (6) : Effect of foliar application with stigmasterol on total sugar , protein and oil percentage in maize grains (Average of two growing seasons, 1997 and 1998)

Stages of application	Stigmasterol concentration mg/l	Crude protein (mg N/g D.w.)		Total sugar percentage		Oil Percentage	
		Absolute value	% of the control	Absolute value	% of the control	Absolute value	% of the control
Elongation	Control	11.53	-	63.96	-	7.05	-
	20	12.92	112.06	68.80	107.57	7.51	106.52
	40	13.09	113.53	72.91	114.0	7.86	111.49
	80	14.11	122.38	74.76	116.89	8.19	116.17
Elongation and tassel appearance	20	13.51	117.17	71.33	111.52	7.95	112.76
	40	14.24	123.50	73.69	115.21	8.39	119.07
	80	14.37	124.63	75.01	117.28	8.46	120.0