*J. Agric. Sci. Mansoura Univ., 32 (4): 2527 - 2541, 2007*

# PHYSIOLOGICAL RESPONSE OF TWO HYBRIDS OF YELLOW MAIZE TO FOLIAR APPLICATION OF ATONIK AND PACLOBUTRAZOL

**Amin, A.A.**
**Botany Department, National Research Centre, Dokki, Cairo, Egypt**

## ABSTRACT

Two field experiments were carried out during the two successive seasons of 2005 and 2006 to study the effects of different concentrations of atonik ( 0, 50, 100 and 150 mg/l ) and paclobutrazol ( 0, 30 and 60 mg/l ) as well as their interaction on growth, photosynthetic pigments, yield and its components as well as biochemical constituents of the produced grains of two hybrids of yellow maize.

The results showed that there were significant differences between the two yellow maize hybrids; single crosses ( S.C. 155 and S.C. 161 ) in most growth characters at different stages of growth, photosynthetic pigments content in the leaves, yield and its components as well as biochemical constituents of the grains. Spraying atonik with different concentrations at all stages led to significant increases in plant height, flag leaf area, 4$^{th}$ leaf area, LAI, SLW, CGR, dry weight/plant, photosynthetic pigments content, yield and biochemical constituents of grains. Spraying paclobutrazol up to 30 mg/l caused significant increase in most growth characters, photosynthetic pigments content, yield and its components as well as biochemical constituents in the grains. While spraying with 60 mg/l paclobutrazol led to significant decreases in plant height, flag leaf area, LAI, SLW, CGR at the different stages of growth compared with the control plants.

Spraying the two yellow maize hybrids with atonik at 150 mg/l or paclobutrazol at 30 mg/l caused the highest values in most of growth characters. Spraying with 100 and 150 mg/l atonik and paclobutrazol at 30 and 60 mg/l attained significant increases in economic yield and its components. Application of atonik treatments in general had positive effects on crude protein, carbohydrate and carotenoids contents in grains. The highest values was obtained at 30 mg/l on crude protein content and 60 mg/l on total carbohydrate and carotenoids content.

Interaction between atonik at 100 and 150 mg/l and paclobutrazol at 30 and 60 mg/l gave the highest increment in the growth characters and chlorophyll (a), (b) and total carotenoids. Application of atonik at 150 mg/l with paclobutrazol at 60 mg/l increased significantly yield and its components, carotenoids content in leaves and total carbohydrate content. Interaction between the two yellow maize hybrid and atonik at 150 mg/l or paclobutrazol at 60 mg/l gave the highest values in most growth characters, photosynthetic pigments content, yield components and carotenoids in produced grains.

**Keywords** : Bioregulators, yellow maize, growth, grain yield, protein, carbohydrate and carotenoids.

## INTRODUCTION

Maize is one of the most important cereal crop in Egypt and all over the world. Many traits were carried out to increase its production, either by increasing the cultivated area, or through using the new technology of the modern agricultural practices.

Recently, efforts are paid to increase the productivity of yellow maize through a number of plant growth regulators. Atonik is a new type of commercial plant stimulator supporting germination, rooting, growth and pest resistance ( Wojday, 2004 ). Application of atonik was effective in increasing

leaf area, number of boll set and dry weight of cotton plants (Abdel-Al, 1998). Also, Steger and Oosterhuis ( 1997 ) and Zhao *et al.* ( 1998 ) indicated that foliar application with atonik increased growth, yield and its components of cotton plants.

The highest growth, economic yield were obtained by spraying atonik solution ( Daping *et al.*, 2004 ). Moreover, Cerny *et al.* ( 2002 ) reported that atonik is a growth stimulator with positive effect on biochemical and physiological processes in sugar beet plants. Furthermore, Farahat (2002) and Amin (2003) noticed significant increases in spikes number/$m^2$, spikes and grain weight ( g/$m^2$) and grain yield (kg/fed) of wheat plants as a results of spraying atonik at 22.5 mg/l compared to untreated plants. Generally, Amin and Habba ( 2003 ) on lupine, Abdel-Wahed and Gamal El-Din (2005) on chamomile, concluded that spraying atonik with different concentrations led to significant increases in growth, yield and biochemical constituents compared to the control.

Plant growth retardants have been used in many field crops to control the vegetative growth and reduce the risk of logging. In barley, paclobutrazol reduced lodging by shortening the culm base when applied early ( Wheaton, 1989 and Cimen *et al.*, 1999 ) or by decreasing the length of upper internodes when applied at late growth stages ( Sanvicente *et al.*, 1999 ). In maize, paclobutrazol retarded vegetative growth, inhibited gibberellins biosynthesis, reduceo cell length, internode length, plant height, leaf area but increased the dry matter percentage and increased angle of lateral branch (Khalil and Rahman, 1995 and Cimen *et al.*, 2004). Foliar application of paclobutrazol is accepted as cultural practice for the management of excessive vegetative growth in temperate area ( Laz and Ismail, 2005 ). Paclobutrazol treated chrysanthemums showed anatomical changes like smaller stomata opertures and thicker cuticle which tended to increase drought resistance ( Smith *et al.*, 1990, Zhou and Xi, 1997 and Abo El-Kheir, 2000 ). Davis *et al.* ( 1988 ) indicated that growth retardants, in general, and triazole compounds in particular, are able to increase photosynthetic pigments content of treated plants. However, the use of paclobutrazol increased N, P and K content, proline and total carbohydrate in the jujube, soybean and gladiolus plants ( Laz and Ismail, 2005, Zhang *et al.*, 2006 and Youssef, 2007 ), respectively.

The present work was an attempt for raising the response of two yellow maize hybrid ( S.C. 155 and S.C. 161 ) to foliar application of atonik and paclobutrazol at different concentrations as well as their interactions on growth, photosynthetic pigments, yield and its component as well as biochemical constituents of grains.

## MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Experimental Station, National Research Center at Shalakan, Kalubia Governorate , Egypt during the two successive seasons of 2005 and 2006 to study the effect of different concentrations of atonik and paclobutrazol as foliar application on the growth, photosynthetic pigments, yield and its components as well as biochemical constituents of two yellow maize hybrids single crosses (S.C.

155 and S.C. 161). Two yellow maize hybrids were obtained from Agricultural Research Centre, Ministry of Agriculture. The treatments consisted of three concentrations ( 0, 50, 100 and 150 mg/l ) of atonik ( Sodium 5-nitroguaiacote + Sodium 1-nitrophenolate + sodium 4- nitrophenolate ) and two concentrations ( 30 and 60 mg/l ) of paclobutrazol ( 2RS,3RS )-1- (4-chlorophenyl)-4,4-dimethyl-2(1H-1,2,4-Triazol-1-yl) pentan-3-ol). In addition to the control sprayed with ( distilled water ) and the interaction between atonik and paclobutrazol treatments.

The experiments were laid in a split-plot design with six replications where yellow maize hybrids occupied the main plots and atonik and paclobutrazol treatments were allocated at random in sub-plots. Grains of two yellow maize hybrids ( S.C. 155 and S.C. 161 ) were sown on June 7$^{th}$ in the two seasons 2005 and 2006, in rows 70 cm apart and the distance between hills along the row 20 cm apart. Plot area was 10.5 $m^2$. The plants were sprayed twice during vegetative stage (30 and 45 days after sowing ).

After 15 days from the second spraying, photosynthetic pigment content of leaves was determined according to the method described by (Saric *et al.*, 1967). 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, as ammonium nitrate ( 33.5 % N ) was applied in two equal doses at the 1$^{st}$ and 2$^{nd}$ irrigation. The growth characteristics were measured at elongation stage (60 days after sowing) at silky stage ( 75 days after sowing ) and at milky stage ( 90 days after sowing ). The determined criteria are plant height, flag leaf area, dry weight/plant, 4$^{th}$ leaf area/plant ( Bremner and Taha, 1966 ), leaf area index "LAI" (Watson, 1952), specific leaf weight "SLW" mg/cm$^2$/days ( Pearce *et al.*, 1969), crop growth rate "CGR" mg/cm$^2$/days (Abdel-Gawad *et al.*, 1980).

At harvest, sample of ten plants was randomly drawn to determine the following; the yield attributes : stem diameter, ear diameter, ear length, seed index ( weight of 100 grains) grain and straw yield (g)/plant, grain and straw yield (ton/fed).

Chemical analysis: Grain samples were dried at 70 °C for constant weight and ground to determine the biochemical constituents which are crude protein (A.O.A.C., 1984), total carbohydrate (Dubois *et al.*, 1956) and total carotenoids (A.O.A.C., 1990).

The data were statistically analyzed for each season and then combined analysis of two seasons was carried out ( Snedecor and Cochran, 1990 ) for comparison between means, L.S.D. test at 5% level was calculated.

## RESULTS AND DISCUSSION

### A. Growth characters :-

### A.1- Hybrids differences :

Data in Table (1) show clearly that the two yellow maize hybrid significantly differed in vegetative growth parameters i.e. plant height, flag leaf area, 4$^{th}$ leaf area, LAI, SLW, CGR and dry weight (g)/plant at the three stages of growth. Single Cross 161 showed more response than Single Cross 155. The differences among the two hybrids ( S.C. 161 and S.C. 151 ) of yellow maize may be due to differences between genotypes of these hybrids

concerning partition of dry matter. Also, the differences in photosynthetic content ( Table 2 ), consequently increased plant growth ( Sadek *et al.*, 1994 and Zaki *et al.*, 1999). In addition, the two hybrids of yellow maize significantly differed in dry matter accumulation as they differed in partitioning and migration of dry matter ( Ahmed and Hassanein 2000 ).

**Table (1) : Effect of atonik and paclobutrazol on growth characters of two yellow maize hybrids at elongation, silky and milky stages.( Combined analysis of two seasons 2005 and 2006).**

| Stages | Treatments | | Plant height (cm) | Flag leaf area ($cm^2$) | 4th leaf area ($cm^2$) | LAI |
|---|---|---|---|---|---|---|
| Elongation | Hybrids | S.C. 155 | 181.50 | 136.80 | 289.50 | 2.76 |
| | | S.C. 161 | 187.60 | 142.60 | 296.82 | 2.88 |
| | L.S.D. at 5 % | | 0.77 | 2.23 | 2.71 | 0.10 |
| | Atonik mg/l | 0.0 | 178.98 | 131.74 | 269.52 | 2.69 |
| | | 50 | 182.66 | 138.21 | 293.09 | 2.74 |
| | | 100 | 189.01 | 143.82 | 307.11 | 2.86 |
| | | 150 | 197.59 | 148.97 | 321.32 | 3.21 |
| | L.S.D. at 5 % | | 5.71 | 2.37 | 3.67 | 0.13 |
| | Paclobutrazol mg/l | 0.0 | 172.47 | 129.51 | 259.01 | 2.63 |
| | | 30 | 188.81 | 139.66 | 282.26 | 2.81 |
| | | 60 | 180.90 | 137.80 | 290.33 | 2.75 |
| | L.S.D. at 5 % | | 4.23 | 2.09 | 3.01 | 0.09 |
| Silky stage | Hybrids | S.C. 155 | 269.87 | 147.90 | 311.19 | 3.68 |
| | | S.C. 161 | 280.46 | 156.26 | 343.28 | 4.02 |
| | L.S.D. at 5 % | | 2.01 | 1.80 | 4.86 | 0.22 |
| | Atonik mg/l | 0.0 | 261.44 | 149.10 | 296.37 | 2.98 |
| | | 50 | 269.25 | 152.37 | 309.46 | 3.39 |
| | | 100 | 278.36 | 159.06 | 352.55 | 3.64 |
| | | 150 | 286.21 | 162.01 | 366.64 | 4.00 |
| | L.S.D. at 5 % | | 6.29 | 2.88 | 8.62 | 0.37 |
| | Paclobutrazol mg/l | 0.0 | 254.14 | 148.44 | 289.73 | 2.93 |
| | | 30 | 276.35 | 156.31 | 312.82 | 3.48 |
| | | 60 | 262.67 | 144.95 | 301.90 | 3.05 |
| | L.S.D. at 5 % | | 5.36 | 2.01 | 5.77 | 0.30 |
| Milky stage | Hybrids | S.C. 155 | 279.05 | 154.60 | 361.50 | 3.92 |
| | | S.C. 161 | 286.91 | 161.76 | 382.72 | 4.64 |
| | L.S.D. at 5 % | | 2.85 | 1.86 | 5.44 | 0.31 |
| | Atonik mg/l | 0.0 | 274.46 | 154.20 | 215.37 | 3.44 |
| | | 50 | 285.06 | 159.10 | 379.90 | 4.21 |
| | | 100 | 292.33 | 160.29 | 401.43 | 4.59 |
| | | 150 | 298.50 | 167.38 | 426.51 | 5.33 |
| | L.S.D. at 5 % | | 7.23 | 2.39 | 9.52 | 0.67 |
| | Paclobutrazol mg/l | 0.0 | 272.03 | 152.76 | 306.20 | 3.38 |
| | | 30 | 289.44 | 164.47 | 364.39 | 4.61 |
| | | 60 | 276.51 | 159.56 | 335.48 | 4.11 |
| | L.S.D. at 5 % | | 3.94 | 1.69 | 6.12 | 0.55 |

**LAI : Leaf Area Index**
**SLW : Specific Leaf Weight**
**CGR : Crop Growth Rate :**

**A.2- Effect of atonik and paclobutrazol:**

The data presented in Table (1) reveal that plant height, flag leaf area, 4th leaf area, LAI, SLW, CGR and dry weight (g)/plant significantly responded to different treatments of atonik especially at 150 mg/l at the three physiological stages as compared with other treatments. Foliar spraying with atonik treatments caused significant increases in growth characteristics as its concentration increased from 50 to 150 mg/l. These increases might be due to the stimulation effect of atonik for increasing N uptake and, in turn, reflected on increasing the metabolic processes and this, in turn, on their vegetative growth represented in dry weight of the two yellow maize hybrid. Pulkrabek *et al.* ( 1999 ), Cerny *et al.* (2002) and Daping *et al.* ( 2004 ) reported parallel results on other plant species treated with atonik. In addition, Farahat ( 2002 ), Amin ( 2003 ) and Abdel-Wahed & Gamal El-Din ( 2005 ) reported that foliar application with atonik produced increase in vegetative growth characters which could be attributed to stimulating plant growth in critical stages. However, in case of paclobutrazol treatment, it is clear also that spraying yellow maize hybrids with paclobutrazol up to 60 mg/l resulted in significant decrease in the aforementioned growth parameters at the different stages of growth as compared to the untreated plants. These results could be in agreement with those obtained by Davis *et al.* ( 1988 ) on sunflower, Abo El-Kheir ( 2000 ) on soybean , Laz and Ismail ( 2005 ) on jujube and Yossef ( 2007 ) on gladiolus. The depressing effect of paclobutrazol may be attributed to the inhibition of cell division or cell elongation through functioning as antiauxins and antigibberellins, as paclobutrazol is classified as growth retardant ( Hamid and Williams, 1997 and Cimen *et al.*, 2004 ). Also, Mansour ( 1989 ) on *Peperomia obtusifolia* , Zedan (2000) on coriander and Zhang *et al.* ( 2006 ) on soybean observed that paclobutrazol treatments caused significant reductions in plant height, internodes length, leaf length and leaf area/plant, while dry weight per plant was increased.

**A.3- Effect of the interaction :**

Data in Table (2) indicated that plant height, flag leaf area at the silky and milky stages, 4th leaf area at the silky stage, RGR ( 60-75) days from sowing, LAI, SLW mg/cm2 and dry weight (g)/plant at silky stage had a significant response to the interaction between paclobutrazol and atonik. Concerning the combined effect of two yellow maize hybrids and atonik treatment, significant increases were obtained in the some mentioned characteristics of growth. Data in Table (3) showed that dry weight/plant at the different stages of growth, plant height at silky and milky stages. In addition, chlorophyll (a), (b) and carotenoids significantly responded to the interaction between yellow maize hybrids and atonik treatments. While, flag leaf area, LAI, 4th leaf area, SLW, CGR insignificantly responded to the interaction between the two hybrids of yellow maize and atonik at all physiological stages. It appears from the data presented in Table (3) found that dry weight/plant at elongation stage, CGR at 60-75 days from sowing, chlorophyll a, b and carotenoids significantly responded to the interaction between yellow maize hybrids and paclobutrazol concentrations.

**Table (2) : Effect of the interaction between paclobutrazol and atonik on growth characters at different stages of growth of two yellow maize hybrids. ( Combined analysis of two seasons 2005 and 2006 )**

| Treatments | | Plant height at silky stage | Flag leaf area ($cm^2$) | | 4th leaf area ($cm^2$) at milky stage | LAI at silky stage | SLW $mg/cm^2$ at silky stage | Dry weight (g)/plant at silky stage | CGR 60-75 |
|---|---|---|---|---|---|---|---|---|---|
| Paclobutrazol mg/l | Atonik mg/l | | silky stage | milky stage | | | | | |
| 0.0 | 0.0 | 260.9 | 148.56 | 153.23 | 278.81 | 2.99 | 6.48 | 262.49 | 6.11 |
| | 50 | 276.26 | 154.48 | 162.64 | 284.27 | 3.53 | 7.09 | 271.67 | 6.90 |
| | 100 | 289.91 | 158.66 | 167.28 | 289.36 | 3.63 | 7.42 | 278.51 | 7.32 |
| | 150 | 296.29 | 169.58 | 173.84 | 296.45 | 4.03 | 8.56 | 281.76 | 8.46 |
| 30 | 0.0 | 259.3 | 146.71 | 149.91 | 267.19 | 2.89 | 6.29 | 266.50 | 5.49 |
| | 50 | 270.3 | 150.96 | 159.40 | 279.20 | 3.31 | 6.72 | 269.96 | 5.89 |
| | 100 | 282.65 | 156.78 | 164.09 | 287.31 | 3.52 | 7.28 | 273.04 | 6.61 |
| | 150 | 290.77 | 165.69 | 169.81 | 289.42 | 3.77 | 7.69 | 278.92 | 7.43 |
| 60 | 0.0 | 255.6 | 143.90 | 147.58 | 264.53 | 2.76 | 5.59 | 259.21 | 4.89 |
| | 50 | 265.84 | 148.33 | 155.96 | 273.64 | 3.27 | 6.43 | 264.53 | 5.55 |
| | 100 | 271.76 | 152.46 | 159.80 | 280.75 | 3.34 | 6.70 | 267.69 | 6.78 |
| | 150 | 284.92 | 161.70 | 165.71 | 285.86 | 3.59 | 7.55 | 272.78 | 6.09 |
| L.S.D. at 5 % | | 3.89 | 4.71 | 5.88 | 2.03 | 0.11 | 0.69 | 6.63 | 0.65 |

**Table (3) : Effect of the interaction between two yellow maize hybrids, atonik and paclobutrazol on growth, yield, photosynthetic, chemical content of maize plants. (Combined analysis of two seasons 2005 and 2006)**

| Treatments | | Plant height | | Dry weight /plant | | | Chl (a) | Chl (b) | Total carotenoids |
|---|---|---|---|---|---|---|---|---|---|
| Hybrids | Atonik mg/l | silky stage | milky stage | elongation stage | silky stage | milky stage | | | |
| S.C. 155 | 0.0 | 255.18 | 269.06 | 161.57 | 256.52 | 290.31 | 0.49 | 0.29 | 0.38 |
| | 50 | 262.25 | 278.51 | 169.72 | 271.87 | 305.83 | 0.58 | 0.32 | 0.44 |
| | 100 | 274.36 | 288.46 | 175.21 | 278.27 | 312.66 | 0.69 | 0.34 | 0.50 |
| | 150 | 282.43 | 294.89 | 180.77 | 282.40 | 330.45 | 0.80 | 0.36 | 0.54 |
| L.S.D. at 5 % | | 2.34 | 3.16 | 2.42 | 5.67 | 9.55 | 0.05 | 0.02 | 0.03 |
| S.C. 161 | 0.0 | 259.89 | 272.34 | 165.03 | 259.86 | 293.80 | 0.57 | 0.31 | 0.43 |
| | 50 | 268.50 | 282.42 | 176.40 | 279.69 | 310.76 | 0.63 | 0.34 | 0.52 |
| | 100 | 279.61 | 293.50 | 180.92 | 284.75 | 318.54 | 0.70 | 0.37 | 0.57 |
| | 150 | 289.72 | 301.98 | 186.87 | 290.49 | 337.15 | 0.82 | 0.39 | 0.60 |
| L.S.D. at 5 % | | 4.01 | 5.12 | 3.77 | 6.66 | 8.24 | 0.06 | 0.03 | 0.05 |

| Hybrids | Paclobutrazole mg/l | Dry weight at elongation stage | 100-grain weight | Ear diameter | CGR 60-75 | Chl (a) | Chl (b) | Total carotenoids |
|---|---|---|---|---|---|---|---|---|
| S.C. 155 | 0.0 | 167.29 | 40.69 | 4.54 | 5.61 | 0.46 | 0.22 | 0.39 |
| | 30 | 179.21 | 42.90 | 4.89 | 7.01 | 0.53 | 0.26 | 0.47 |
| | 60 | 176.30 | 43.87 | 5.34 | 7.19 | 0.92 | 0.38 | 0.52 |
| L.S.D. at 5 % | | 2.11 | 1.22 | 0.30 | 0.26 | 0.04 | 0.02 | 0.04 |
| S.C. 161 | 0.0 | 170.49 | 41.09 | 4.60 | 6.78 | 0.45 | 0.24 | 0.42 |
| | 30 | 182.58 | 43.89 | 5.29 | 7.44 | 0.63 | 0.30 | 0.51 |
| | 60 | 179.67 | 43.76 | 5.62 | 7.51 | 0.99 | 0.39 | 0.59 |
| L.S.D. at 5 % | | 2.21 | 2.61 | 0.44 | 0.39 | 0.06 | 0.03 | 0.07 |

Concerning the combined effect of the two yellow maize hybrids, atonik and paclobutrazol treatments, it had no significant response in the most characteristics of growth.

**A.4- Photosynthetic pigments content :**

Data recorded in Table (4) show clearly that the two yellow maize hybrids (S.C. 155 and S.C. 161) significantly differed in chlorophyll (a) and carotenoids content at 75 days from sowing (silky stage), except chlorophyll b. However, foliar spraying with atonik treatments caused significant increases in photosynthetic pigments content as its concentration increased from 50 to 150 mg/l. Whereas, photosynthetic pigments content reached its maximum values at concentration of 150 mg/l atonik. Data in Table (2) show that spraying maize hybrids (S.C. 155 and S.C. 161) with paclobutrazol significantly increased photosynthetic pigments at the silky stage of growth under the higher concentration ( 60 mg/l ), paclobutrazol-treated plants leaves contained more photosynthetic pigments than the lower ones. In this respect, Elmaoafy (1996) on *Pelargonium graveolens*, Abo El-Kheir (2000) on soybean, Laz and Ismail (2005) on jujuba , reported that paclobutrazol increased chlorophyll a, b and carotenoids comparing with the untreated plants.

**Table (4) : Effect of atonik and paclobutrazol and their interaction on photosynthetic pigments in 4th leaf at silky stage of two yellow maize hybrids. ( Combined analysis of two seasons 2005 and 2006 )**

| Treatments | | Chl (a) | Chl (b) | Total carotenoids |
|---|---|---|---|---|
| Hybrids | S.C. 155 | 0.64 | 0.29 | 0.47 |
| | S.C. 161 | 0.68 | 0.30 | 0.51 |
| L.S.D. at 5 % | | 0.02 | n.s. | 0.02 |
| Atonik mg/l | 0.0 | 0.59 | 0.25 | 0.44 |
| | 50 | 0.62 | 0.29 | 0.49 |
| | 100 | 0.69 | 0.31 | 0.54 |
| | 150 | 0.81 | 0.34 | 0.56 |
| L.S.D. at 5 % | | 0.03 | 0.02 | 0.03 |
| Paclobutrazol mg/l | 0.0 | 0.44 | 0.22 | 0.46 |
| | 30 | 0.63 | 0.30 | 0.55 |
| | 60 | 0.96 | 0.38 | 0.59 |
| L.S.D. at 5 % | | 0.01 | 0.03 | 0.05 |
| Paclobutrazol mg/l | Atonik mg/l | | | |
| 0.0 | 0.0 | 0.64 | 0.27 | 0.45 |
| | 50 | 0.73 | 0.29 | 0.49 |
| | 100 | 0.77 | 0.32 | 0.52 |
| | 150 | 0.83 | 0.35 | 0.58 |
| 30 | 0.0 | 0.69 | 0.29 | 0.47 |
| | 50 | 0.74 | 0.34 | 0.50 |
| | 100 | 0.78 | 0.37 | 0.55 |
| | 150 | 0.86 | 0.39 | 0.59 |
| 60 | 0.0 | 0.76 | 0.32 | 0.51 |
| | 50 | 0.79 | 0.36 | 0.55 |
| | 100 | 0.82 | 0.39 | 0.59 |
| | 150 | 0.97 | 0.40 | 0.60 |
| L.S.D. at 5 % | | 0.04 | 0.02 | 0.03 |

**B- Yield and its components :**

**B-1- Hybrids differences :**

It was clear from the data in Table (5) that there were significant differences between two hybrids ( S.C. 155 and S.C. 161 ) in stem diameter, ear diameter, ear length, 100-grain weight, grain and straw yield ( per plant & per feddan ). These changes might be related with differences in the dry weight of vegetative organs which could be considered as a criterion for photosynthetic efficiency of the plant. It is noteworthy to mention that the results of hybrid differences in yield and its components were in agreement with those on maize hybrids reported by Sadek *et al.* ( 1994 ), Zaki *et al.* (1999) and Ahmed & Hassnein (2000). In addition to the varietal differences were reported in partition and migration of dry matter in S.C. 155 and S.C. 161 ( Abdel Gawad *et al.*, 1987 ).

**B-2- : Effect of atonik and paclobutrazol:**

The data presented in Table (5) reveal that stem diameter, ear diameter, ear length, 100-grain weight , grain yield and straw yield ( per plant & per feddan ) significantly responded to different treatment of atonik. The highest values were obtained with atonik at treatments 100 and 150 mg/l. These results are in agreement with those obtained by Pulkrabek *et al.* (1999) on sugar beet, Vostrel ( 2000 ) on jujuba and Farahat ( 2002 ) on wheat. Guo and Oosterhuis ( 1995 ) indicated that atonik increased cotton crop yield through enhanced assimilation nutrient uptake, nitrate reduction and photosynthesis, improved flow of assimilates ( translocation and cytoplasmic streaming ) and increased cell integrity. However, in case of paclobutrazol treatment, it is clear that spraying yellow maize hybrids with paclobutrazol up to 30 mg/l resulted in a significant increase in stem diameter, ear diameter, 100-grain weight, grain and straw yields ( per plant and per fed. ) as compared with the control.

**Table (5) : Effect of atonik and paclobutrazol concentration on yield and its components of two yellow maize hybrids. (Combined analysis of two seasons 2005 and 2006 )**

| Treatments | | Stem diameter (cm) | Ear diameter (cm) | Ear length (cm) | 100-grain weight (g)/plant | Grain yields (g)/plant |
|---|---|---|---|---|---|---|
| Hybrids | S.C. 155 | 2.77 | 4.92 | 23.90 | 41.80 | 267.61 |
| | S.C. 161 | 2.93 | 5.26 | 24.60 | 43.92 | 273.01 |
| L.S.D. at 5 % | | 0.06 | 0.11 | 0.19 | 1.76 | 2.09 |
| Atonik mg/l | 0.0 | 2.72 | 4.55 | 22.60 | 41.59 | 245.71 |
| | 50 | 2.82 | 4.78 | 23.44 | 43.76 | 272.56 |
| | 100 | 2.87 | 4.98 | 23.76 | 44.84 | 279.28 |
| | 150 | 2.91 | 5.01 | 24.51 | 44.96 | 288.27 |
| L.S.D. at 5 % | | 0.10 | 0.23 | 0.47 | 2.15 | 4.78 |
| Paclobutrazol mg/l | 0.0 | 2.75 | 4.62 | 22.73 | 41.47 | 246.16 |
| | 30 | 2.89 | 5.22 | 23.39 | 43.56 | 283.25 |
| | 60 | 3.01 | 5.09 | 23.02 | 42.93 | 273.34 |
| L.S.D. at 5 % | | 0.13 | 0.27 | 0.38 | 1.42 | 2.18 |

These finding are in agreement with those obtained by Elmaoafy (1996) Abo El-Kheir (2000) and Cimen *et al.* (2004). Also Zhou and Xi (1997) on rape, Zhang *et al.* (2006) on soybean and Youssef (2007) on gladiolus found that paclobutrazol treatments increased yield and its components compared with the untreated plants.

**B-3- Effect of the interaction :**

The combined effect of atonik and paclobutrazol treatments led to significant increases in some criteria of yield and its components especially paclobutrazol 60 mg/l with atonik 150 mg/l.

The data in Table (6) show that stem diameter, ear diameter, ear length, grain and straw yields ( per plant and per fed. ), straw yield/plant and 100-grain weight were significantly increased as a result of atonik alone or in combination with paclobutrazol. However, atonik at 100 and 150 mg/l and paclobutrazol at 30 and 60 mg/l were more effective in this respect. The results in the same Table indicate that atonik and paclobutrazol had a significant effect on 100-grain weight (g), grain and straw yield ( ton/fed. ). This effect of atonik and paclobutrazol could be due to the increases in 100-grain weight (g) and grain and straw yield (g)/plant over control.

So, atonik application was reported to be more effective in increasing yield and its components of cotton and sugar beet ( Abdel Al, 1998, Cerny *et al.*, 2002 and Daping *et al.*, 2004). In case of paclobutrazol treatment (Table 5) indicated that ear length, 100-grain weight, grain yield and straw yield per plant and per feddan decreased or slight affected as paclobutrazol concentration was increased from 30 to 60 mg/l. While , stem diameter was significantly increased by increasing concentration of paclobutrazol. The highest values of yield and its components were obtained at 30 mg/l. paclobutrazol, as compared with control. Similar results had been obtained on other plants. Zhou and Xi ( 1997 ) on rape, Cimen *et al.* ( 2004 ) on cotton and Zhang *et al.* ( 2006 ) on soybean.

**Table (6) : Effect of the interaction between paclobutrazol and atonik on yield and its components and some biochemical contents of maize plants.( Combined analysis of two seasons 2005 and 2006)**

| Treatments (mg/l) | | Stem diameter | Ear diameter | Ear length (cm) | Grain yield/ plant (g) | Straw yield/ plant (g) | 100-grain weight (g) | Grain yield (ton/fed) | Straw yield (ton/fed) |
|---|---|---|---|---|---|---|---|---|---|
| Paclobutrazole | Atonik | | | | | | | | |
| 0.0 | 0.0 | 2.78 | 3.68 | 21.65 | 263.23 | 372.11 | 40.93 | 2.99 | 4.38 |
| | 50 | 2.83 | 4.34 | 22.46 | 276.16 | 380.60 | 43.62 | 3.64 | 4.79 |
| | 100 | 2.94 | 4.67 | 23.50 | 281.05 | 391.32 | 44.90 | 3.85 | 4.87 |
| | 150 | 2.99 | 5.46 | 24.09 | 286.96 | 397.43 | 44.97 | 4.29 | 5.44 |
| 30 | 0.0 | 2.82 | 3.92 | 22.29 | 259.87 | 368.50 | 41.73 | 2.92 | 4.26 |
| | 50 | 2.89 | 4.65 | 23.24 | 266.70 | 376.69 | 42.89 | 3.42 | 4.59 |
| | 100 | 2.97 | 4.88 | 23.80 | 274.69 | 383.70 | 43.67 | 3.67 | 4.79 |
| | 150 | 3.01 | 5.56 | 23.97 | 281.50 | 392.87 | 44.79 | 4.11 | 5.09 |
| 60 | 0.0 | 2.88 | 4.36 | 22.38 | 260.41 | 371.93 | 41.80 | 2.89 | 4.29 |
| | 50.0 | 2.96 | 4.79 | 23.49 | 272.32 | 379.04 | 42.78 | 3.31 | 4.49 |
| | 100 | 3.09 | 5.26 | 24.37 | 276.62 | 384.51 | 43.98 | 3.59 | 4.77 |
| | 150 | 3.11 | 5.69 | 24.61 | 280.14 | 393.62 | 43.53 | 4.01 | 4.90 |
| L.S.D. at 5 % | | 0.09 | 0.41 | 0.22 | 3.78 | 4.08 | 0.47 | 0.10 | 0.09 |

Concerning the data in Table (3) show that 100-grain weight (g) and ear diameter were significantly affected by the interaction between the two yellow maize hybrid and the different concentrations of paclobutrazol.

**C - Biochemical constituents of grains :**

**C-1- Hybrid differences :**

Results of chemical compositions are presented in Table (7). Data revealed that there were significant differences among the two yellow maize hybrids in protein percentage, total carbohydrate and carotenoids content. In this connection, El-Tawil (1998), Masoud (2001), Iken *et al.* (2002), Mohamed (2003) and Mohamed and Abdel-Aal (2005) reported that 9.80-11.10 % protein, total carbohydrate 79.92 and 82, carotene content 16.31-17.06 ppm were determined in the grains of yellow maize.

**Table (7) : Effect of atonik and paclobutrazol concentration and their interaction on biochemical constituents in produced grains of two yellow maize hybrids. ( Combined analysis of two seasons 2005 and 2006 )**

| Treatments | | Crude protein % | Total carbohydrate % | Total carotenoids (ppm) |
|---|---|---|---|---|
| Hybrids | S.C. 155 | 9.76 | 79.09 | 16.33 |
| | S.C. 161 | 10.90 | 80.32 | 18.49 |
| L.S.D. at 5 % | | 0.36 | 1.33 | 1.62 |
| Atonik mg/l | 0.0 | 8.46 | 77.06 | 16.35 |
| | 50 | 9.86 | 79.70 | 17.86 |
| | 100 | 10.49 | 81.46 | 18.87 |
| | 150 | 11.04 | 80.99 | 19.01 |
| L.S.D. at 5 % | | 1.40 | 1.57 | 2.08 |
| Paclobutrazol mg/l | 0.0 | 8.25 | 76.68 | 16.62 |
| | 30 | 10.44 | 79.69 | 18.76 |
| | 60 | 9.92 | 80.97 | 19.92 |
| L.S.D. at 5 % | | 1.64 | 1.67 | 2.29 |
| Paclobutrazol mg/l | Atonik mg/l | | | |
| 0.0 | 0.0 | 7.42 | 78.70 | 17.09 |
| | 50 | 11.09 | 79.56 | 17.86 |
| | 100 | 8.97 | 80.09 | 18.49 |
| | 150 | 9.86 | 81.62 | 19.36 |
| 30 | 0.0 | 7.76 | 77.48 | 16.93 |
| | 50 | 10.63 | 78.90 | 18.39 |
| | 100 | 9.76 | 79.68 | 17.87 |
| | 150 | 9.43 | 80.21 | 19.77 |
| 60 | 0.0 | 7.89 | 76.93 | 17.30 |
| | 50 | 9.68 | 79.81 | 17.66 |
| | 100 | 10.66 | 79.94 | 18.73 |
| | 150 | 9.56 | 80.50 | 19.86 |
| L.S.D. at 5 % | | 0.33 | 0.87 | 0.12 |

**C-2- Effect of atonik and paclobutrazol:**

Data given in Table (7) indicated that the protein, total carbohydrate and carotenoid contents in produced maize grains were significantly increased at all applied levels of atonik especially at 150 mg/l. These results showed that bioregulators play an important role on protein and carbohydrate metabolism in plant. Whereas, Farahat (2002) found that increasing atonik concentration from 0.75 to 2.25 mg/l caused the highest increase in grain nitrogen percentage and nitrogen uptake of wheat plants. These results might be attributed to favorable effect of atonik for encouraging and increasing nitrogen uptake, carbohydrate and carotenoids content. These findings are in agreement with those obtained by Pulkrabek et al. (1999), Vostrel (2000), Amin and Habba (2003) and Abdel-Wahed and Gamal El-Din (2005).

The data reveal also that spraying two yellow maize hybrids with paclobutrazol significantly increased protein, carbohydrate and carotenoid content in the maize grains as compared to the untreated ones. The increment was directly proportional to the concentration used of paclobutrazol. Furthermore, foliar application with paclobutrazol treatment caused significant increase in chemical constituents of maize grains when its concentration increased from 30 to 60 mg/l. The increase in these chemical contents by paclobutrazol treatment could be attributed to higher photosynthetic activity and accumulation of dry matter and in turn reflected on the increasing in translocation and accumulation of certain nutrient elements in plant organs and this, in turn, on their biochemical constituents in maize grains ( Smith *et al.*, 1990, Khalil and Rahman 1995, Hamid and Williams, 1997 and Laz and Ismail 2005 ).

**C-3- Effect of the interaction :**

Concerning the interaction effect between atonik and paclobutrazol concentration, it was statistically significant for crude protein, total carbohydrate and carotenoids. However, interaction between atonik at 50 or 100 mg/l and paclobutrazol at 30 or 60 mg/l gave the highest values in crude protein, total carbohydrate and carotenoid contents.

From the above mentioned results, it can be concluded that the application of different concentrations of atonik and paclobutrazol, led to in pronounced increases in growth characters, yield components and some biochemical constituents of the grains (crude protein, total carbohydrate and carotenoids contents ). However, most of the previous characteristics were increased by increasing atonik treatment from 50 to 150 mg/l and paclobutrazol treatment up to 30 mg/l.

## REFERENCES

Abdel Al, M.H. (1998). Response of Giza 85 cultivar to the growth regulators pix and atonik. Egypt. J. Agric. Res., 76 ( 3 ) : 1173-1180.

Abdel-Gawad, A. A.; K. A. El-Shouny, S. A. Saleh and M. A. Ahmed (1980). The relation between the efficiency of leaf surface and the growth of some wheat varieties of Egypt. Res. Bull. No. 1412. Dec. Fac. Agric. Ain Shams Univ., 1-17.

Abdel-Gawad, A. A.; K. A. El-Shouny, S. A. Saleh and M. A. Ahmed (1987). Partition and migration of dry matter in newly cultivated wheat cultivars. Egypt. J. Agron., 12 ( 1-2 ) : 1-16.

Abd El-Wahed, M.S.A. and K.M. Gamal El-Din (2005). Effect of putrescine and atonik on growth and some biochemical constituents as well as essential oil composition of chamomile plant. J. Agric. Sci. Mansoura Univ. 30 (2) : 869-882

Abo El-Kheir, M.S.A. (2000). Response of soybean plants grown under water stress conditions to uniconazole application. Egypt. J. Appl. Sci., 15 (3): 112-125.

Ahmed M. A. and M. S. El- S. Hassanein (2000). Partition of photosynthates in yellow maize hybrids. Egypt. J. Agron. 22, (3) : 39-63.

Amin, A.A. (2003). Physiological response of wheat plant (*Triticum aestivum* L.) to foliar application of pix and atonik. J. Agric. Sci. Mansoura Univ. 28 (2) : 979-993.

Amin, A.A. and E. El. Habba (2003). Response of lupine (*Lupinus termis* L.) plant to foliar application of stigmasterol and atonik. Egypt. J. Appl. Sci., 18 (1) : 258-272.

A.O.A.C. (1984). Official Methods of Analysis of the Association of Official Analytical Chemists. 14th Ed. Association of Official Chemists. Washington D.C.

A.O.A.C. (1990). Official Method of Analysis of the Association of Official Agricultural Chemists. 15th Ed. Washington D.C. USA.

Bremner, P.M. and M.A. Taha (1966).Studies in Potato agronomy. 1. The effect of variety, seed size and spacing on growth, development and yield. J. Agric. Sci. ,66 : 241-252

Cerny, L.; V. Pacuta, J. Feckova and J. Golian (2002). Effect of year and atonik application on the selected sugar beet production and quality parameters. J. Central Eur. Agric., 3 (1) : 15-22.

Cimen, I.; G.Tufan and M.K. Gungor (1999). The studies in the effects of growth retardant paclobutrazol on shoot growth, fruit yield, quality and residue level in 'Yediveren' lemon. Plant protection Bulletin, Ankara-Turkey, 39 : 77-99.

Cimen, I.; S. Ba. Bag, M. Teniz and A. Sagr (2004). The effect of paclobutrazol, growth retardant on cotton growth and verticillium wilt (*Verticillium dahliae* Kleb.). Plant Pathology J. 3 (1) : 35-39.

Daping, Z.; T. Dan and D. Lixia (2004). Effect of applying atonik plant growth liquid on the growth to Citrus plant materials. South China Fruits. 33 (12) : 18.

Davis, T.D.; G.L. Steffan and N.Sankhla (1988). Triazole plant growth regulators. In : J. Janick (ed.) Horticultural reviews. Vol. 10 : 63-105. Timber press, Portland.

Dubois, M.; K. A. Gilles, J. Hamilton, R. Robers, and F. Smith (1956). Colorimetric methods for determination of sugar and related substances. Anal. Chem., 28:350.

Elmaoafy, D.A. (1996). Effect of nitrogen and paclobutrazol treatments on *Pelargonium graveolens* L. M.Sc. Thesis, Fac. Agric. Cairo Univ. Egypt.

El Tawil, R.H.A. (1998). Technological, biological and microbiological studies on bread produced from whole maize grain. Ph. D. Thesis, Fac. Agric. Cairo Univ., Egypt.

Farahat, M.M. (2002). Effect of Amcotone and Atonik with some additives on nitrogen accumulation and productivity of wheat (*Triticum aestivum* L.) plants. J. Agric. Sci. Ain Shams Univ., Cairo 10 (1) : 193-203.

Guo, C. and D.M. Oosterhuis (1995). Atonik. A new plant growth regulator to enhance yield in cotton. Proceeding Beltwide Cotton Conferences, San Antonio, T.X. USA. January, 4-7, (2) : 1086-1088.

Hamid, M.M. and R.R. Williams (1997). Translocation of paclobutrazol and gibberellic acid in Sturt's Desert pea (*Swainsona formosa*). Plant Growth Regul. 23 : 167-171.

Iken, J. E.; N. A. Amusa and V. O. Obatolu (2002). Nutrient composition and weight evaluation of some newly developed maize varieties in Nigeria. J. Food Techn. in Africa, 7 : 27-29.

Khalil, I.A. and H. Rahman (1995). Effect of paclobutrazol on growth, chloroplast pigments and sterol biosynthesis of maize ( *Zea mays* L. ) Plant Sci., 105: 15-21

Laz, I. S. and S. E. Ismail (2005). Effect of water stress and paclobutrazol application on growth of Jujube ( *Ziziphus jujuba* Mill ) seedlings. Egypt. J. Appl. Sci., 20 ( 4B ) : 609-825.

Mansour, H.A.G. (1989). The effect of paclobutrazol on the morphological and physiological behaviour of *Peperomia obtusifolia* L. Ph. D. Thesis, Fac. Agric. Ain Shams Univ. Egypt.

Masoud, M.A. (2001). Studies on some technological methods to improve quality for some bakery products. Ph. D. Thesis, Fac. Agric. Moshtohor, Zagazig Univ. Egypt.

Mohamed, M.O.F. (2003). Studies on germ and protein concentrate of corn seeds. Ph. D. Thesis, Fac. Agric. Mostohor, Zagazig Univ., Egypt.

Mohamed, M. A. and A. M. M. Abdel Aal (2005). Nutrient composition and physical evaluation of some white and yellow maize hybrids in Egypt. Egypt. J. Appl. Sci. 20 (12) : 189-200

Pearce, R.B.; G.E. Carlson, D. Barnes, R.H. Host and C.H. Hanson (1969). Specific Leaf weight and photosynthesis in alfalfa. Crop Sci.9: 423-426.

Pulkrabek, J.; J. Sroller and J. Zahradnicek (1999). The effects of the growth regulators on the yield and quality of sugar beet roots-Rostlinna Vyroba. 45 (8) : 379-386

Sadek, S.E.; H. Y. Sh. El-Sherbieny, M.A. Ahmed and M.A. Younis, (1994). Evaluation of eight yellow maize ( *Zea mays* L. ) hybrids grown in Egypt. 1- Growth analysis and grain yield components. J. Agric. Sci. Mansoura Univ. 19 (12) : 4151-4160.

Sanvicente, P.; S. Lazarevitch, A. Blouet and A. Guckert (1999). Morphological and anatomical modifications in winter barley culm after late plant growth regulator treatment. European J. Agron. 11, 45-51.

Saric, M.; R. Kastrori, R. Curic, T. Cupina, and I. Gric (1967). Chlorophyll Determination Univerzitet U Noveon Sadu Praktikum iz fiziologize Biljaka-Beograd, Hauena Anjiga. pp: 215.