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Effect of high doses of Mepiquat chloride (pix) on Egyptian cotton productivity under North Delta conditions

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Abstract: Two field experiments were conducted during 2017 and 2018 seasons to study the effect of high doses of mepiquat chloride at rates of 0, 1, 1.5 and 2 liter/ fed on growth, phytohormones and yield of cotton plants cv. Giza 94. The experiment was conducted in Sakha, Kafr El-Shiekh Governorate, Egypt in a randomized complete block design. In the beginning of square and after 15 days from squaring, the cotton cultivars were foliar sprayed by with different doses of pix. Short internodes of 5 to 7 cm observed in spraying of different concentration of pix, while long internodes below 10 cm developed in control. As a conclusion, the results showed that, in general spraying mepiquat chloride (pix) had a significant effect on the growth of cotton plants i.e, reduction of plant height, absolute growth rate and concentration percentage of Gibberellins in cotton plants. On the other hand, spraying cotton plants with pix using 1 liter/ fed. significantly increased crop growth rate, photosynthesis pigments, number of open bolls/ plant, seed cotton yield/ Fadden compared with control and other doses.

Keywords: Pix, spraying, cotton, growth analysis and yield

تأثير التركيزات العالية من كلوريد الميبكويت (البكس) على إنتاجية نباتات القطن المصري تحت ظروف شمال الدلتا

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الملخص: أجريت تجربتان حقليتان بمحطة بحوث سخا- محافظة كفر الشيخ- مصر خلال موسمي 2017 و 2018 لدراسة تأثير الرش الورقي بمعدلات عالية من كلوريد الميبكويت (البكس) وهي (1- 1.5 و 2 لتر للفدان) بالإضافة الى النباتات الغير معاملة (كنترول) على نمو ومحصول نباتات القطن في صنف (جيزة 94). صممت التجربة بتصميم قطاعات كاملة. العشوائية خلال 15، 30 يوماً من بداية تكوين الوسواس على الترتيب تم رش النباتات بالجرعات المحددة من البكس. خلال نمو النباتات تم ملاحظة صغر طول السلامية (5- 7) أما في النباتات العادية (الغير معاملة) كان حوالى 10 سم. وتبين النتائج وجود تأثيرات معنوية مختلفة من خلال المعاملات على نباتات القطن مثل، قصر طول النبات ومعدل نمو المحصول ونسبة هرمون الجبرللين في النبات. على الجانب الآخر، رش النباتات باستخدام تركيز 1 لتر/ فدان أعطى زيادة معنوية في العديد من صفات النمو والمحصول مقارنة بباقي الجرعات الأخرى والكنترول.

الكلمات المفتاحية: بكس و الرش و القطن و تحليل النمو والمحصول.

INTRODUCTION

Mepiquat chloride as a hormonal growth regulator agent is available in the market in several brans (for example, pix, Mepachlor and Microflo). Plant growth regulators are substances when added in small amounts modify the growth of plant usually regulation, they are considered as a new generation of agro chemicals after fertilizers, pesticides and herbicides (Niakan and Habibi, 2013). The use of these compounds to reduce plant height in cotton results in earlier maturity and under some circumstances increased the yield. Plant growth regulators play a key role in internal control mechanism of plant growth by interacting with the metabolic. Processes such as nucleic acid and protein synthesis (Gencsoylu, 2009).

Moisture supply and heat generally and high amounts of nitrogen fertilizer result in vigorous growth in early season. Plant height may easily exceed 80 cm at early bloom in some cotton fields. Growers need adequate vegetative growth to support the soon-to-develop boll load, but if the plant is allowed to run away, it can impact management, especially fruit retention. History of vigorous early season growth and current crop condition may be the major factors in selecting the proper program.

Cotton (Gossypium barbadense L.) is a subtropical perennial crop with an indeter-minate growth habit and one it is one of the important cash crops in the world (Gencsoylu, 2009). Vegetative and reproductive growth occurs simultaneously while vegetative growth is necessary to support reproductive growth. Cotton plant has a natural mechanism to prevent excessive vegetative growth, which leads to severe production problems such as fruit abortion, delayed maturity, boll rot and harvest difficulties. In many cases growth regulators are needed to maintain proper plant size and to promote boll set and early maturity (Niakan and Habibi, 2013).

Pix is commonly used as growth retardant, when applied as foliar spray vegetative growth, reduced, leaves become coarser and dark green in color (Brigg and Beltwide, 2008). Pix inhibit Gibberellin biosynthesis, which implies that they cause growth reduction by decreasing cell elongation and reduce the elongation of the internodes below the meristem (Gencsoylu, 2009). This work was aimed to study the effect of hormonal growth regulator spraying and topping on yield components of newly released cotton cultivars.

The aim of the search:

The excessive growth of cotton plants, growing under full irrigation and high amounts of nitrogen fertilizer, is one of the most serious problems facing cotton production. Aiming to control the vegetative growth for the sake of improving boll setting.The present study aimed to investigate the effect of pix (mepiquat chloride) at high concentration to control excessive vegetative growth of cotton.

MATERIALS AND METHODS

This experiment was conducted in Sakha, Agricultural Research Station, Agricultural Research Center, Kafr El-Sheikh Governorate, Egypt, to study the effect of four treatments including foliar application with three rates of mepiquat chloride (pix); 1, 1.5 and 2 L/ fed. and control treatment on plant growth, earliness leaf chemical composition, yield and its components of Egyptian cotton (Gossypium barbadense L), Giza 94 cultivar.

Randomized complete blocks design with three replicates was used in the two seasons of study, where the following four treatments were evaluated:

1- Untreated plants (control treatment).
2- Spraying with 1 L/ fed. mepiquat chloride/ L.
3- Spraying with 1.5 L/ fed. mepiquat chloride/ L.
4- Spraying with 2 L/ fed. mepiquat chloride/ L.

Foliar application was carried out two times (at squaring stage and at start of flowering).The experimental plot area was 14 m^2 (5 rows, 4m long and 70 cm apart). Sowing took place on 25 April in hills 25 cm apart leaving two plants/ hill at thinning time in both seasons. Phosphorus fertilizer was added at the rate of 22.5 kg P_2O_5/ fed as calcium super phosphate (15.5 % P_2O_5) during land preparation. Nitrogen fertilizer at a rate of 80 kg N/ fed as ammonium nitrate (33.5 % N) was applied in two equal doses, immediately before the first and the second irrigation to produced excessive vegetative growth in cotton. Potassium fertilizer in the form of potassin -F was applied as foliar application three times at the rate of 500 cm^3/ fed. The previous crop was Egyptian clover. Normal agricultural practices were followed during the two growing seasons.

Studied characters:

1- Leaves chemical composition:

In 2017and 2018 seasons, after seven days from the second foliar application, a representative leaf sample (10 leaves) was taken from the upper 4th leaf on the main stem from each plot to determine the following:

Chemical analysis:

Chlorophyll a, chlorophyll b, total chlorophyll (a+b) and carotenoids contents in leaves were determined according to A.O.A.C. (1995).

2- **Growth traits;** Final plant height (cm), number of fruiting branches/ plant and Absolute growth rate (plant height and dry matter) at two periods (75-90 and 100-115 DAS).

- Absolute growth rate

The rate of increase in growth variable at time (t) is called as AGR. It was measured by differential coefficient of (w) with respect of time (t). Absolute growth rate was calculated for two growth variables by using following formula (Reford, 1967).

$$\text{Absolute growth rate (plant height)} = \frac{H2-H1}{T2-T1}$$

$$\text{Absolute growth rate (dry matter)} = \frac{W2-W1}{T2-T1}$$

H1, H2 and W1, W2 refer to the plant height (cm) and dry matter weight (g) at the time T1 and T2, respectively. It was expressed in cm/ day in case of plant height and g/ day in case of dry matter production per plant.

3- **Endogenous hormones. At 100 DAS,** the concentrations of the following endogenous hormones were determined:

1. Gibberilic acid (GA)
2. Abscisic acid (ABA)

The concentration of the two endogenous hormones were determined according to the method described by Shindy and Smith (1975) Twenty grams of fresh green leaves (fourth upper leaf) on the main stem were taken at random from each plot. The concentrated aqueous phase was adjusted to pH 8.8 by using 1% NaoH. The alkaline aqueous residue was shaken three times with equal quantities of ethyl acetate using separating funnel. The combined ethyl acetate fraction was evaporated to dryness and held for further purification. The aqueous fraction was acidified to pH 2.8 with 1% HCl and shaken three times with equal volumes of ethyl acetate. The remaining aqueous phase was discarded.The combined acidic ethyl acetate phase was reduced to volume (fraction I) to be used for GLC.

To determine the acidic hormones (Gibberellin and Abscisic acids), the dried basic ethyl acetate fraction was dissolved in 80% methanol. The methanol was evaporated under vacuum leaving an aqueous phase, which adjusted to pH 2.8 with 1% HCl and extracted three times with ethyl acetate. The ethyl acetate phases were combined (fraction II) reduced to 5 ml volume and stored at −20°C for GLC analysis for neutral auxins.

4- Seed cotton yield and its components.

Number of open bolls/ plant, boll weight (g), seed cotton yield/ plant, Earliness percentage and seed index (g). The yield of seed cotton per fadden was estimated as the weight of seed cotton in kilogram picked twice from each plot, then converted to yield per fadden in kentar (one kentar = 157.5 kg).

The data thus collected will be subjected to statistical analysis using Analysis of variance technique and LSD (Least Significant Test) to determine the superiority of treatment means using Mstat-C Computer Statistical Software, following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Leaves chemical composition

Photosynthesis pigments (Chlorophyll (a), (b), total chlorophyll and carotenoids concentrations in cotton leaves as influenced by the tested treatments in the two growth seasons are shown in Table 1. The differences among the tested treatments were significant, in favor of foliar spraying with Mepiquat chloride at 1 liter/ fadden compared with other treatments and untreated plants which produced the lowest values of these traits.

The effect of mepiquat chloride (pix) in delaying leaf chlorophyll degradation and increasing its content in cotton leaf which enhances photosynthesis rate (Gausman et al.1981). Mepiquat chloride has been used to improve carbohydrate source-sink relations to enhance efficiency of cotton yield formation (Gwathmey and Clement, 2010).

Table (1) Effect of foliar application with different doses of Pix (Mepiquat Chloride) on photosynthesis pigments of cotton plants in 2017 and 2018 seasons.

CHARACTERS / TREATMENTS	CHLOROPHYLL (A)	CHLOROPHYLL (B)	CHLOROPHYLL (A+B)	CAROTENOIDS
	FIRST SEASON (2017)			
plants CONTROL untreated	2.53 b	1.81 b	4.34 b	0.95 b
Spraying pix at 1.00 liter/ fed.	3.23 a	2.35 a	5.58 a	1.23 a
Spraying pix at 1.50 liter/ fed.	2.53 b	2.18 ab	4.72 b	1.06 b
Spraying pix at 2.00 liter/ fed.	2.07 b	2.01 ab	4.08 b	1.03 b
L.S.D at 1%	0.40 **	0.34 *	0.50 **	0.11 *
	SECOND SEASON (2018)			
CONTROL untreated plants	2.46 c	2.26 c	4.72 d	0.86 c
Spraying pix at 1.00 liter/ fed.	3.45 a	2.64 a	6.09 a	1.65 a
Spraying pix at 1.50 liter/ fed.	3.00 b	2.59 a	5.59 b	1.12 b
Spraying pix at 2.00 liter/ fed.	2.86 b	2.38 b	5.24 c	1.00 b
L.S.D at 1%	0.68 **	0.37 *	1.36 **	0.49 *

2- Growth traits

Means of final plant height, no. of fruiting branches/ plant at harvest Absolute growth rate (plant height and dry matter) at two growth periods (75-90 and 100-115 DAS) as influenced by the tested treatments in 2017 and 2018 seasons are shown in Table 2.

Table (2): Effect of foliar application with different doses of Pix (Mepiquat Chloride) on some growth characters of cotton plants in 2017 and 2018 seasons.

CHARACTERS / TREATMENTS	Final plant height (cm)	No. of Sympodial branches/ plant	AGR at (75-90 DAS) for plant height (cm/ week)	AGR at (100-115 DAS) for plant height cm/ week	AGR at (75-90 DAS) For dry matter GM/ week	AGR at (100-115 DAS) for dry matter GM/ week
	FIRST SEASON (2017)					
CONTROL (untreated plants)	164.66 a	16.50 a	7.50 a	5.20 a	16.72 b	11.21 c
Spraying pix at 1.00 liter/ fed.	140.83 b	14.30 a	5.70 b	3.14 b	19.17 a	14.13 a
Spraying pix at 1.50 liter/ fed.	126.83 c	12.50 b	4.27 c	2.54 c	18.69 a	12.76 b
Spraying pix at 2.00 liter/ fed.	111.66 d	11.06 c	3.52 c	1.13d	16.27 b	11.80 c
L.S.D at 1%	8.56 **	0.29 *	2.11 *	2.24 *	0.79 **	0.72 **
	SECOND SEASON (2018)					
CONTROL (untreated plants)	166.15 a	17.23 a	8.12 a	5.84 a	17.25 b	11.75 c
Spraying pix at 1.00 liter/ fed.	135.45 b	15.75 b	4.88 b	3.16 b	20.15 a	14.36 a
Spraying pix at 1.50 liter/ fed.	125.46 c	14.23 b	4.32 b	2.69 c	18.26 ab	12.45 b
Spraying pix at 2.00 liter/ fed.	110.12 d	12.65 c	3.50 c	2.00 c	17.36 b	11.45 c
L.S.D at 1%	20.45 **	5.26 *	5.16 **	2.16 **	4.15 **	2.78 *

The tested treatments gave significant effect on final plant height and number of sympodial branches/ plant at harvest in the two seasons of study.

Foliar application with mepiquat chloride at 2.00 liter/ fed significantly reduced final plant height followed by foliar application with mepiquat chloride at 1.50 liter/ fed and 1.00 liter/ fed in descending order. While control treatment recorded the tallest plants (164.66 and166.15 cm) in the first and second season respectively. The significant decrease in plant height due to these treatments as compared with control especially when used in combination or at high concentration where this reduction increased with increasing mepiquat chloride level up to 1.00 liter/ fed. may be attribute to, The primary effect of MC in reducing stem elongation, node formation and leaf expansion (Reddy et al. 1990) who found that plant hight reduced by adding pix. In this concern, the use of plant growth retardant, pix (mepiquat chloride) resulted in a significant reduction in plant height as compared with untreated control plants Gwathmey et

al. (1995). No. of sympodial branches/ plant were effected by studied treatments, foliar application with 1.00 liter/ fed of pix and untreated plants gave the height values of no. of sympodial branches/ plant (compared with other treatments. Consider to absolute growth rate for plant height at two stages, we find that, it is reducing by increasing the modified dose of pix, so we obtained that untreated plants and in the next adding pix in 1.00 liter/ fed gave the highest values. This result may be attributing to the inhibitory effect of mepiquat chloride on the synthesis of gibberellins which have a role in cell division and cell expansion (Reddy et al., 1992).

It is clear from data recorded in the same table that, absolute growths rate for dry matter at two stages that, foliar application with pix at 1.00 liter/ fed was superior at crop growth rate compared with other treatments and control plants. Which indicated that AGR based on total dry matter accumulation per plant per day was very slow in high doses of pix than 1. Liter/ fed.

3- Endogenous hormones

The effect of plant physiology is dependent on the amount of hormone present and tissue sensitivity to the plant growth regulator. The objective of this part is to study endogenous hormones, i.e Gibberellins (GAs), and Abscisic acid (ABA) in the leaves of cotton plant as influenced by different rates of Pix at two growth stages, i.e 100 DAS during 2017 and 2018 seasons as shown in Table (3).

Table (3) Effect of foliar application with different doses of Pix (Mepiquat Chloride) on Endogenous hormones in cotton leaves in 2017 and 2018 seasons.

CHARACTERS / TREATMENTS	Gibberellin (mg/ 100g fresh weight)	ABA (mg/ 100g fresh weight)
CONTROL (untreated plants)	FIRST SEASON (2017)	
	13.14 a	13.24 d
Spraying pix at 1.00 liter/ fed.	10.12 b	20.76 c
Spraying pix at 1.50 liter/ fed.	9.12 c	22.47 b
Spraying pix at 2.00 liter/ fed.	8.10 d	25.83 a
L.S.D at 1%	0.21 **	1.17 **
	SECOND SEASON (2018)	
CONTROL (untreated plants)	14.23 a	14.56 c
Spraying pix at 1.00 liter/ fed.	10.56 b	20.15 b
Spraying pix at 1.50 liter/ fed.	8.13 c	23.45 a
Spraying pix at 2.00 liter/ fed.	7.26 c	24.16 a
L.S.D at 1%	7.56 **	6.48 **

a) Gibberellins content (mg/ 100 g fresh weight)

Data recorded in Table (3) show that there are significant differences among the different concentration of pix in the two growth seasons. It can be observed that untreated plant gave the highest values of gibberellins (13.14 and 14.23) compared with different concentration of Pix (three levels). It is associated with stem elongation and some leaf enlargement, but has been shown to increase fruit retention in cotton. Pix is an anti-gibberellin, meaning that it reduces the production of Gibberellin in the plant, which normally would enlarge plant cells. These results were obtained by (Oosterhuis and Zhao, 1993)

b) Abscisic acid content (mg/ 100 g fresh weight)

ABA plays important role in controlling stomatal opening and closing.

Data presented in Table (3) show that ABA concentration significantly affected by adding pix in different concentrations, foliar application with high concentration of Pix (2 liter/ fed) gave the highest values of ABA (25.83 and 24.16) in the next, 1.5 and 1.00 liter/ fed respectively which compared with untreated plants who gave the lowest values of ABA

4- Seed cotton yield and its components.

Means of number of open bolls/ plant, boll weight (g), seed cotton yield/ plant, Earliness percentage and seed index (g) as influenced by the tested treatments in 2017 and 2018 seasons are shown in table (4).

The treatments under study had significant effect in all of these characters in both seasons of study (Table 4), in favor of foliar spraying with mepiquat chloride at 1.00 liter/ fadden for some of studied characters as (no. of open bolls (25.15 and 24 65), boll weight (3.60 and 3.85), seed index (11.15 and 10.58) and seed cotton yield/ fed.(7.92 and 7.23) which obtained the highest values in the first and second seasons. On the other hand, no. of un opining bolls was decreased by increasing the dose of pix. Consider to earliness %, the all concentration of pix increased earliness % but untreated plants decreased the earliness %.Various aspects of the use of pix i.e. high solar radiation can be synchronized with the optimal boll setting period, thus contributing to the total yield increase (Yao et al., 1990).In this regard, pix application increased significantly seed cotton yield/ unit area [Yao et al (1990), Azab et al. (1993), Girgis (1993) and El-Beily et al. (2001)]. Ali et al. (2012) found that foliar spraying with mepiquat chloride significantly increased yield of cotton as compared with untreated plants. Badr (1986) found that pix application reduced vegetative growth of some cotton cultivars. This might be due to an increased phenolic compounds content in leaves which might have excreted an inhibiting effect on auxin metabolism and consequently retarded growth of cotton plants.

Table (4) Effect of foliar application with different doses of Pix (Mepiquat Chloride) on yield and its components of cotton plants in 2017 and 2018 seasons.

CHARACTERS / TREATMENTS	NO. OF OPEN BOLLS/ PLANT	NO. OF UN OPEN BOLLS/ PLANT	BOLL WEIGHT (G)	EARLINESS PERCENTAGE	SEED INDEX (G)	SEED COTTON YIELD/ PLANT
	FIRST SEASON (2017)					
CONTROL (untreated plants)	22.15 b	2.96 a	3.35 ab	61.11 b	10.79 b	6.52 b
Spraying pix at 1.00 liter/ fed.	24.65 a	1.95 b	3.60 a	66.60 a	11.15 a	7.92 a
Spraying pix at 1.50 liter/ fed.	20.50 c	1.38 bc	3.12 b	67.42 a	10.37 c	6.23 b
Spraying pix at 2.00 liter/ fed.	20.23 c	0.66 c	2.81 c	68.69 a	10.40 c	5.97 b
L.S.D at 1%	1.53 *	0.94 *	0.30 **	1.95 **	0.21 **	0.74 **
	SECOND SEASON (2018)					
CONTROL (untreated plants)	22.56 b	3.12 a	3.56 ab	64.23 b	10.36 a	7.00 b
Spraying pix at 1.00 liter/ fed.	25.15 a	2.00 b	3.85 a	67.53 a	10.58 a	7.23 a
Spraying pix at 1.50 liter/ fed.	21.45 c	1.36 c	3.00 b	68.13 a	10.15 a	6.54 c
Spraying pix at 2.00 liter/ fed.	20.45 c	1.12 c	2.85 c	68.42 a	10.10 a	6.12 d
L.S.D at 1%	5.45 *	2.13 *	1.45 *	4.75 *	N.S	0.85 **

CONCLUSION

In general, growing cotton under light amount of nitrogen fertilizer is one of the most serious problems facing cotton production, to control the excessive vegetative growth for the sake of improving yield and its components, pix (Mepiquate chloride) was successfully used under special condition. It could be concluded that foliar application with mepiquat chloride at 1 liter/ fed. at two times or foliar application with mepiquat chloride at $3cm^3$/ L three times (at beginning of squaring stage and the start of flowering) for producing better leaf chemical composition, growth characters, boll retention and yield of Egyptian cotton (Giza 94 cultivar), under the conditions of Sakha location.

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