J. Agric. Sci. Mansoura Univ., 28(3): 1599 - 1610, 2003

EFFECT OF FOLIAR APPLICATION OF PHOSPHORUS ON COTTON GROWTH, YIELD AND YIELD COMPONENTS

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ABSTRACT

Two series of experiments were carried out at Sakha Agricultural Research Station during 2001 and 2002 seasons to study the effect of foliar spray of the aqueous filtered solution resulting from superphosphate (15.5% P_2O_5) 5% concentration at start of flowering, start and peak of flowering, start and end of flowering, peak and end of flowering, end of flowering and start, peak and end of flowering stage on the earliness of cotton plants (Giza 86).

The experimental design was randomized complete blocks with four replications. The results revealed that: strong vegetative cotton plants become more sensitive for phosphorus application. All treatments decreased significantly final plant height (cm), leaf area $(cm)^2$/plant and dry weight g/plant, and increased number of open bolls per plant, seed cotton yield per feddan, seed index, earliness percentage and boll weight, however lint percentage was not affected. Also, all treatments increased significantly total carbohydrates, phosphorus content in cotton leaves. However nitrogen uptake and total chlorophyll in cotton leaves were reduced. On the other hand those treatments increased significantly seed oil content. However, seed protein percentage was not affected.

In conclusion, spraying with 5% concentration superphosphat three times at start, peak and end of flowering stage controlled the vegetative growth and hastened the maturity of cotton plants.

INTRODUCTION

Phosphorus fertilizer is very important to cotton plant. Also it is the most limiting factor for successful cotton production in most soils in Egypt. The positive effect of phosphorus on plant growth characteristics might be due to the fact that phosphorus element is an essential component of the energy transfer compounds (ATP and ADP), genetic information system, cell membranes, phospholipids, phosphoproteins and nucleic acids. In general, these compounds are considered very important to plant growth (Gardener *et al.,* 1985). On the other hand, phosphorus application hasten the ripening processes thus producing the same effect as a deficiency of water but to a less extent (Russell, 1961) and consequent reduction of vegetative growth. Thus, the use of phosphorus or other practices for vegetative control could be an essential part of cotton production scheme because without vegetative control (especially under high soil fertility and suitable moisture conditions), higher plant population and narrow rows will intensity the hazards caused by excessive vegetative growth. Spraying cotton plants with superphosphate create an appropriate balance between the vegetative and fruiting growth. Phosphate helps in shortening the vegetative stage. Phosphorus foliar spraying has been recommended by many workers to increase most of cotton yield characters; Abou-Ahmed (1985) indicated that spraying cotton plants with 4% superphosphate increased dry matter/plant, number of open bolls/plant, boll weight, seed index, seed cotton yield/plant and per feddan,

while lint percentage was not affected. El-Kashlan (1987), Hosney and Kadry (1989), Girgis *et al.* (1993) and Ali *et al.* (1996) revealed that spraying cotton plants with superphosphate increased plant height, number of flowers and green bolls/plant. El-Fouly and El-Sayed (1997) and Sawan *et al.* (1997) reported that foliar spraying with phosphorus increased percentage of open bolls/plant, boll weight, seed cotton yield per feddan, crop earliness, also seed content of oil and protein and leaf chlorophyll content. Abd El-Shafy (1999); Omran *et al.* (1999) and Gamalat *et al.* (2000).

The purpose of this investigation and evaluate was to study the physiological role of phosphorus foliar application on growth, yield and its components and seed content of oil and protein as well as chlorophyll in the leaves at cotton plants.

MATERIALS AND METHODS

Two series of experiments were conducted at Sakha Agricultural Research Station during 2001 and 2002 seasons, to study and evaluate the physiological influence of foliar application of phosphorus in controlling the excessive vegetative growth of cotton plant (Giza 86)..

Table 1: Mechanical and chemical analysis of the experimental soil.

Analysis		2001	2002
Mechanical analysis:			
Course sand	%	1.45	1.50
Fine sand	%	10.70	10.75
Silt	%	24.30	23.80
Clay	%	62.20	63.40
Soil texture		Clayey	Clayey
Calcium carbonate	%	1.50	1.55
Organic matter	%	1.60	1.65
pH (1: 2.5 suspension)		8.00	7.84
E.C. mmhos/cm		1.56	1.54
Cations meq L^{-1}			
	Ca^{++}	0.78	0.77
	Mg^{++}	0.22	0.21
	Na^{+}	1.48	1.47
	K^{+}	0.09	0.09
Anions (meq L^{-1}):			
	CO^{-}_{3}	-	-
	HCO^{-}_{3}	0.95	0.93
	Cl^{-}	0.94	0.95
	SO^{-}_{4}	0.68	0.66
Available nutrients (ppm)			
N (1% potassium sulphate extract)		42	43
P (0.5 N sodium bicarbonate extract)		11.0	10.0
K (1 N ammonium acetate extract)		289	295

* EC mmhos/cm at 25°C

The soil was thoroughly prepared and the phosphorus fertilizer was applied to the soil before seeding in the form of superphosphate (15.5% P_2O_5) at the rate of 150 kg/fed. Nitrogen fertilizer was added to the soil in the form of urea (46% N) at the rate of 62 kg/fed after thinning. Also, potassium fertilizer as K_2SO_4 at rate of 24 kg K_2O/feddan, was added before the third irrigation.

The experimental design was randomized complete blocks with four replications. Main plot area was 1/70 of feddan. In the two seasons, cotton seeds were planted on March 31 in hills 20 cm apart on rows of 60 width. Forty days later, the plants were thinned to 2 plants per hill. All the agriculturall practices were carried out as followed in Sakha region. Foliar application was performed using an aqueous filtered solution resulting from the superphosphate (15.5% P_2O_5), soaked in water for 24 hours. The concentration of superphosphate solution was 5%, the quantity of water for spraying were 400 liters per fed. The treatments ware as follows:

1. Control.
2. One phosphorus spray at start of flowering.
3. Two phosphorus sprays at start and peak of flowering.
4. Two phosphorus sprays at start and end of flowering.
5. Two phosphorus sprays at peak of flowering and end of flowering.
6. One phosphorus spray at the end of flowering.
7. Three phosphorus sprays at start, peak and end of flowering.

Five plants were randomly selected in each plot as a representative for chemical analysis of cotton leaves. Leaves from the main stem on the fourth node from the apex were taken after 15 days from foliar application for each treatment. However, five plants were also randomly selected in each plot for measuring plant height, yield and yield components. Data were taken and recorded as follows:

A. Growth characters:

1. Final plant height in cm at harvest was measured in cm. right from the cotyledonary nod to plant top.
2. Leaf area (LA) per plant: for leaf area measurements, the disc method was used according to Johnson (1967), leaf area (LA) = leaf dry weight x disc area)/disc dry weight. (LA) per plant was calculated as square centimeters (cm^2/plant). Leaf area was measured after 15 days from the end of foliar spraying of phosphorus.
3. Total dry matter per plant: All the plants in each sample were carefully uprooted, washed and dried to a constant weight in a forced-air oven at 90°C to obtain the dry weight/plant.

B. Yield and it's components:

1. Seed cotton yield per feddan (Kentar): one kentar = 157.5 kg.
2. Lint percentage: was obtained by using the percentage of the lint from a given weight of seed cotton yield.
3. Number of opened bolls per plant: was determine by taking the mean number of open bolls in 5 guarded plants.
4. Seed index was determined by weighting 100 seeds in grams.

5. Boll weight: yield of seed cotton picked from 5 selected plants in each plot was divided by the number of bolls that produced such yield to get average number of boll weight in grams.
6. Earliness percentage: $\frac{\text{Yield of the first pick}}{\text{Total yield}} \times 100$

C. Chemical analysis:

1. Total nitrogen (mg): total leaf nitrogen was determined according to A.O.A.C. (1970).
2. Total carbohydrate: in leaves were determined according to the procedure of Smith *et al.* (1956).
3. Phosphorus in leaves: were determined according to the procedure of Smith *et al.* (1956).
4. Total chlorophyll: was determined in leaves using the method of Arnon (1949).
5. Proteins percentage of seeds: were determined according to A.O.A.C. (1975).
6. Seed oil percentage: were determined in the seeds by the method described by A.O.A.C. (1975).

Statistical analysis: was performed according to Snedecor and Cochran (1981), and means were compared by LSD at the 0.01 and 0.05 levels of probability in both seasons.

RESULTS AND DISCUSSION

A. Effect of foliar application with phosphorus on growth character:

Final plant height (cm), leaf area $(cm)^2$/plant and dry weight, (g)/plant:

Data in Table 2 and Fig. 1 revealed that all these characters were decreased significantly by spraying of phosphorus. The data also indicated that application of phosphorus three times at start of flowering, peak of flowering and end flowering showed shortest plants with low leaf area and dry weight per plant in the two seasons. Such results may be attributed to the lower uptake of nitrogen, which stimulates plant growth. El-Kashlan (1987) and Gamalat (1990) reported that nitrogen is directly necessary for protein synthesis and growth. Similar results were obtained by Abou El-Nour (2001) and Gamalat *et al.* (2000).

B. Effect of foliar application with phosphorus on yield and its components:

Results in Table 3 and Figs. 2-a, 2-b, and 2-c reveal that foliar application of phosphorus at all flower stages tended to reduce the excessive vegetative growth of cotton plants except the treatment at end of flowering. It increased the number of bolls per plant. The beneficial effect of spraying phosphorus may be due to their (role) influence on fundamental metabolic reactions, in addition accelerating proteins synthesis which affect boll development and formation (El-Hamawi and El-Ghandour, 1974). These results are confirmed with Ziadah (1991), Girgis *et al.* (1993) and Gamalat *et al.* (2000). Also, spraying phosphorus increased significantly boll weight.

Spraying suberphosphate 3 times (start, peak and at end of flowering produced higher boll weight compared to the control.

Table 2: Effect of foliar application of phosphorus on cotton growth characters during 2001 and 2002 seasons.

Treatments	Final plant height (cm)		Leaf area $(cm)^2$/plant		Dry weight (g)/plant	
	2001	2002	2001	2002	2001	2002
• Control (water spray)	140.6	138.4	958.6	963.9	103.4	101.9
• Start of flowering	131.3	133.5	932.4	936.3	97.8	99.7
• Start and peak of flowering	128.8	130.4	940.5	946.5	101.2	98.1
• Start and end of flowering	123.9	130.7	948.6	950.4	102.9	101.8
• Peak and end of flowering	122.4	125.9	921.4	935.1	102.6	101.9
• End of flowering	124.4	128.4	954.3	960.3	97.1	97.9
• Start, peak and end of flowering	121.3	125.9	911.3	920.8	96.8	96.3
F. test	**	**	**	**	**	**
LSD 0.05	0.7	1.1	20.0	7.5	4.0	2.1
0.01	1.0	1.5	27.5	10.3	5.5	2.8

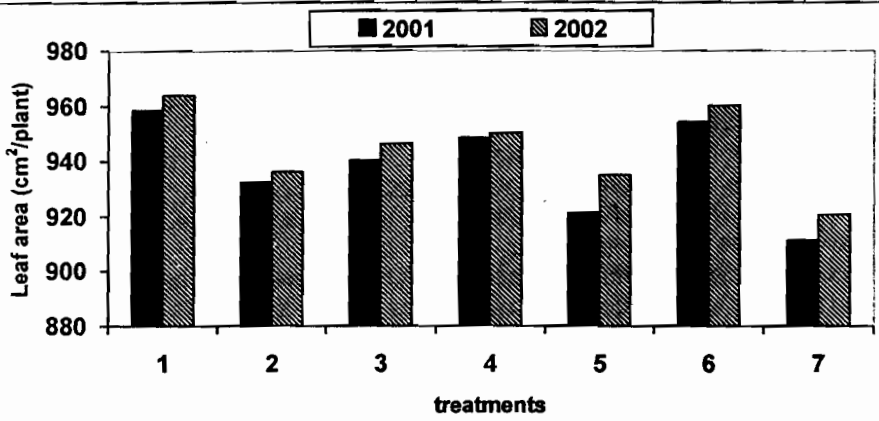

Fig. 1: Effect of foliar application with phosphorus on leaf area, during 2001 and 2002 seasons.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

The increase in boll weight may be due to that the phosphorus play an essential role in physiological processes in cotton plants (Epstein, 1972). These results are in accordance with those obtained by Ziadah (1991), Girgis *et al.* (1993) and Gamalat *et al.* (2000). Results also indicate that seed cotton yield per feddan was increased significantly with the application of phosphorus at all flowering stages (Table 3). These increases may be due to the increase in number of open bolls per plant and boll weight. In general, spraying superphosphate three times (at start, peak and at end of flowering) produced the highest yield of seed cotton per feddan. Concerning lint percentage, results revealed that all treatments did not show any significant effect on lint

percentage in the two seasons. These results are in conformity with those of Abd El-Aal *et al.* (1990), Omran *et al.* (1999) and Gamalat *et al.* (2000).

Results also showed that all treatments had no significant effect on seed index. However, such treatments tended to decrease slightly seed index as compared to the control and the results were confirmed in the two seasons. This may be due to that phosphorus application may alter the nitrogen balance of treated plants (Table 3), which may cause earlier maturation of plants (Mayer and Anderson, 1960). The same trend was observed by Omran *et al.* (1999) and Gamalat *et al.* (2000). Results of earliness percentage showed that the application of foliar spraying with phosphorus led to a significant increase in earliness percentage in both seasons.

Also, increasing number of sprays promoted earliness. The promotive effect of phosphorus in earliness percentage may be due to that spraying phosphorus may alter the nitrogen balance of the plant. Indication of this effect are the earlier maturation of cotton plants (Meyer and Aderson, 1972). Similar results were obtained by Abd El-Malak *et al.* (1997), Sawan *et al.* (1997), Abd El-Shafy (1999), and Gamalat *et al.* (2000).

C. Effect of foliar application with phosphorus on chemical composition of cotton leaves:

Data in Table 4 and Fig. 3a indicate that most of chemical compositions of cotton leaves responded significantly to the different times of application. Results of total nitrogen in cotton leaves showed that phosphorus application at flowering stages decreased total nitrogen uptake in treated plants compared with the control. This decrease may be due to the translocation of nitrogenous compounds to the developing bolls (El-Hamawi and El-Ghandour, 1974).

Also, the data showed that spraying cotton plants with phosphorus increased total carbohydrates in cotton leaves compared with the control. Spraying phosphorus at start, peak and end of flowering produced more total carbohydrates content in cotton leaves. This increase my be due to that phosphorus plays a fundamental role in large number of enzymic reactions that dependents on phosphorylation. Such results were confirmed by Gamalat *et al.* (2000).

On the other hand, data listed in Table 4 and Fig. 3b indicate that phosphorus application at different stages of flowering increased significantly phosphorus content in cotton leaves compared with the control plants. In general, spraying cotton plants with super-phosphate at start of flowering produced more phosphorus content in cotton leaves as compared with different other applications. Such results were in accordance with the findings of Omran *et al.* (1999), and Gamalat *et al.* (2000).

Table 3: Effect of foliar application of phosphorus on cotton, yield and yield components during 2001 and 2002 seasons.

Treatments	No. of open bolls/plant		Boll weight (g)		Seed cotton yield (kentar/fed)		Lint (%)		Seed index		Earliness (%)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
• Control (water spray)	12.9	12.9	2.30	2.32	5.80	5.87	35.90	35.95	9.82	9.95	59.80	57.40
• Start of flowering	14.9	15.1	2.35	2.36	6.46	6.55	34.60	34.55	9.73	9.92	78.20	76.30
• Start and peak of flowering	15.9	16.1	2.62	2.64	8.40	8.47	34.75	34.70	9.70	9.94	83.15	81.10
• Start and end of flowering	15.2	15.3	2.53	2.55	7.25	7.38	34.98	34.95	9.72	9.93	81.10	79.15
• Peak and end of flowering	14.1	14.2	2.40	2.43	6.30	6.35	35.05	35.10	9.71	9.89	75.10	72.25
• End of flowering	13.1	13.0	2.38	2.40	5.90	5.97	35.15	35.20	9.80	9.87	72.10	69.90
• Start, peak and end of flowering	18.8	18.9	2.70	2.7	8.50	8.61	34.25	34.35	9.81	9.86	85.40	83.20
F. test	*	**	**	**	**	**	N.S	N.S	-	-	**	**
LSD 0.05	2.2	1.9	0.01	0.04	0.4	0.1	-	-	-	-	1.9	2.3
0.01	-	2.6	0.02	0.09	0.6	0.6	-	-	-	-	2.6	3.1

Table 4: Effect of foliar application of phosphorus on chemical constituents of cotton leaves and seeds during 2001 and 2002 seasons.

Treatments	Total nitrogen (mg/g dry weight)		Total carbohydrates (mg/g dry weight)		Phosphorus (mg/g dry weight)		Total chlorophyll (mg/g dry weight)		Protein % in seeds		Oil % in seeds	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
• Control (water spray)	38.1	36.2	82.1	82.8	4.35	4.25	4.95	4.90	22.70	22.65	22.05	22.07
• Start of flowering	37.7	36.1	85.9	85.7	5.80	5.95	4.32	4.15	22.55	22.48	22.48	22.45
• Start and peak of flowering	35.2	34.3	87.8	88.6	5.55	5.55	4.17	4.22	22.80	22.50	22.65	22.63
• Start and end of flowering	34.2	32.8	86.2	87.4	5.15	5.40	4.75	4.30	22.75	22.73	22.57	22.55
• Peak and end of flowering	30.8	29.1	83.4	84.2	4.85	4.50	4.25	4.40	22.90	22.83	22.35	22.30
• End of flowering	29.4	27.6	82.7	83.4	4.40	4.35	4.18	4.27	22.85	22.79	22.10	22.08
• Start, peak and end of flowering	28.2	26.1	88.5	89.4	5.95	5.80	4.15	4.13	22.65	22.70	22.75	22.85
F. test	**	**	**	**	**	**	**	**	-	-	**	**
LSD 0.05	1.2	1.7	1.7	1.8	0.8	0.5	0.03	0.02	-	-	0.04	0.03
0.01	1.5	2.3	2.4	2.5	1.1	0.7	0.07	0.06	-	-	0.06	0.05

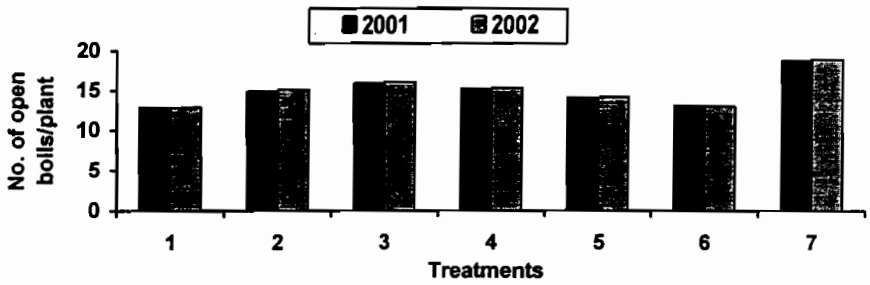

Fig. 2a: Effect of foliar application with phosphorus on no. of open bolls/plant in cotton leaves.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

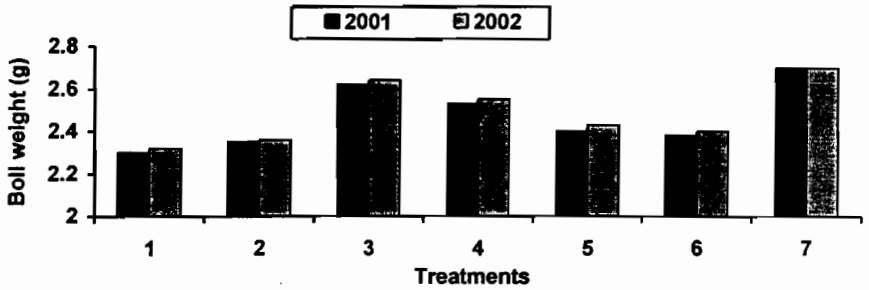

Fig. 2b: Effect of foliar application with phosphorus on boll weight (g) in cotton leaves.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

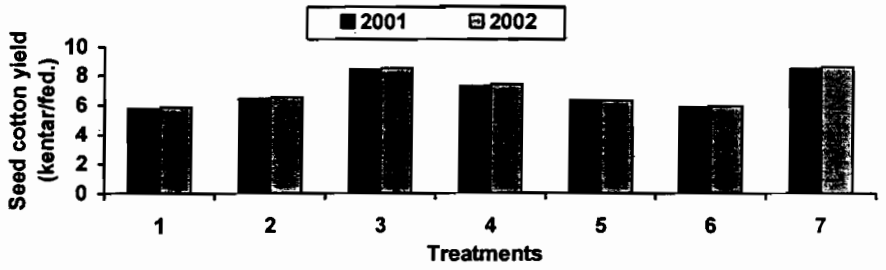

Fig. 2c: Effect of foliar application with phosphorus on seed cotton yield (kentar/fed) in cotton leaves.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

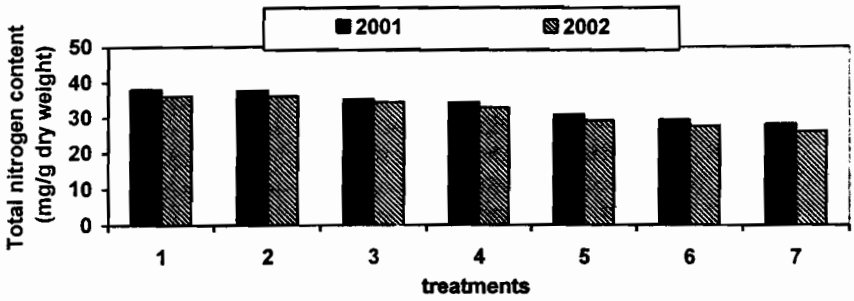

Fig. 3a: Effect of foliar application with phosphorus on total nitrogen content in cotton leaves.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

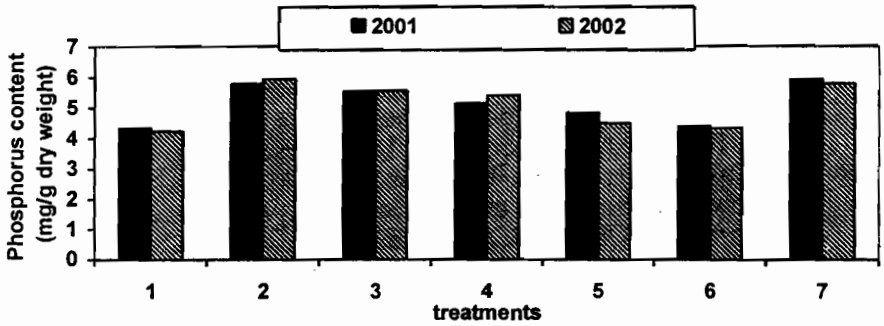

Fig. 3b: Effect of foliar application with phosphorus on phosphorus content in cotton leaves.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

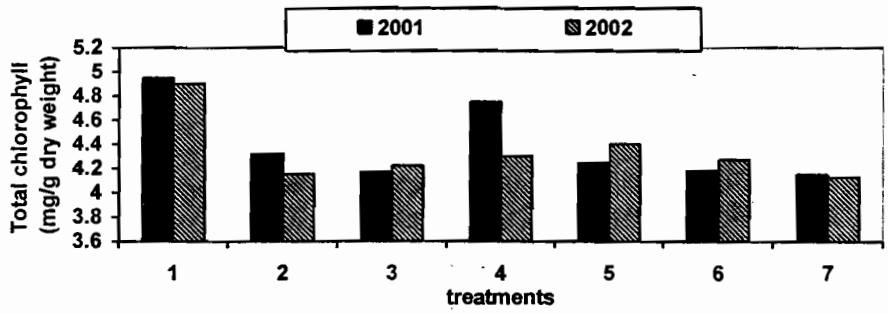

Fig. (3c): Effect of foliar application with phosphorus on total chlorophyll.

1. Control (water spray)
2. Start of flowering
3. Start and peak of flowering
4. Start and end of flowering.
5. Peak and end of flowering
6. End of flowering
7. Start, peak and end of flowering

Results in Table 4 and Fig. 3c indicate also that phosphorus application decrease total chlorophyll in cotton leaves. The data also show that application of phosphorus three times (at start, peak and end of flowering) was more effective in lowering the levels of total chlorophyll. These results are in accordance with Gamalat *et al.* (2000).

As for seed protein percentage, phosphorus foliar spraying also promoted seed protein content in cotton seeds, but this increase did not reach the level of significance. The data also proved that application of phosphorus promoted significantly seed percentage. The increases of seed protein and oil percentages could be attributed to the favourable effect of phosphorus on seed weight thus affecting the various constituents of the seed including protein and oil quantity El-Hamawi (1977).

These results are in agreement with those of Abd El-Aal *et al.* (1990), El-Kashlan *et al.* (1992), Girgis *et al.* (1993), Abd El-Shafy (1999) and Gamalat *et al.* (2000).

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تأثير الرش بالفوسفور على النمو والمحصول ومكوناته فى القطن

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا خلال الموسمين الزراعيين ٢٠٠١ ، ٢٠٠٢م لدراسة تأثير الرش بمحلول سوبر فوسفات الكالسيوم (١٥,٥% فو٢أ٥) بتركيز ٥%وكانت معاملات الرش كالآتى:

١- الرش بالماء.
٢- الرش بمحلول السوبر فوسفات رشة واحدة (عند بداية التزهير)
٣- الرش بمحلول السوبر فوسفات رشتان (عند بداية وقمة التزهير).
٤- الرش بمحلول السوبر فوسفات رشتان (عند بداية ونهاية التزهير).
٥- الرش بمحلول السوبر فوسفات رشتان (عند قمة ونهاية التزهير).
٦- الرش بمحلول السوبر فوسفات رشة واحدة (عند نهاية التزهير).
٧- الرش بمحلول السوبر فوسفات ثلاث رشات (عند بداية وقمة ونهاية التزهير).

وكان التصميم المتبع هو قطاعات كاملة العشوائية ذو أربع مكررات.

وتتلخص أهم النتائج المتحصل عليها فيما يلى:

- أدت جميع معاملات الرش بمحلول السوبر فوسفات عند كل المواعيد إلى نقص معنوي فى طول النبات ، المساحة الورقية للنبات (سم)^2 ، كذلك الوزن الجاف للنبات/بالجرام ــ بينما حدث زيادة معنوية نتيجة المعاملات فى عدد اللوز/المتفتح/نبات ، محصول القطن الزهر/للفدان ، معامل البذره وكلا من النسب المئوية للتبكير ومتوسط وزن اللوزة بينما لم يحدث أى تأثير معنوى لصفة النسبة المئوية للشعر.
- أيضا أحدثت جميع معاملات الرش بالسوبر فوسفات زيادة معنوية فى كل من محتوى الأوراق: من الكربوهيدرات والفسفور ومع ذلك فقد حدث نقص فى محتوى الأوراق من النيتروجين والكلوروفيل من ناحية أخرى أدت المعاملات إلى حدوث زيادة معنوية فى محتوى البذره من الزيت بينما لم يتأثر محتوها من البروتين.
- وعموما كان للرش بمنقوع السوبر فوسفات بتركيز ٥ % ثلاث مرات فى بداية وقمة ونهاية التزهير أفضل الأثر فى الحد من معدل النمو الخضرى الزائد للنباتات والاسراع فى نضج هذه النباتات وزيادة محصول القطن الزهر.