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EFFECTS OF GROWTH REGULATOR APPLICATIONS ON POD YIELD AND SOME AGRONOMIC CHARACTERS OF PEANUT IN MEDITERRANEAN REGION

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ABSTRACT

This study was conducted to determine the effects of Cytozyme Crop Extra, Pix and Atonic on the seed yield and yield components of main cropped peanut in a Mediterranean type of environment. Compared with the control, the three growth regulators significantly increased pod yield. Especially application of growth regulators at the peg formation and pod development were more effective on pod yield than single application. The highest pod yield increase (43.4%) was obtained from Cytozyme Crop Extra followed by Pix (31.9%) and Atonic (27.8%).

Key words: Peanut, Growth regulator, Agronomic characters, Yield

INTRODUCTION

As the world population continues to increase geometrically, great afford is spent to provide an adequate supply of food. According to the World Bank and the United Nations, more than 2 billion people are thought to be malnourished worldwide, due to inadequate food supply and distribution problems. If the world population grows in the current rate, the world population will be 12 billion in less than 50 years (Pimentel et al., 1997). As the world population expands in the current rate, enhancing food demand will be more critical, possibly with the numbers of malnourished reaching 3 billion. The per capita availability of food is now greater than before, despite the population increase over this period. Therefore, crop yield per land area has to be increased in order to feed growing world population.

Plant growth regulators are known to enhance the yield, oil and fatty acids content in peanut (Malik et al., 1988; Savage and Keenan, 1994;). For this reason, there is a considerable interest in the use of plant growth regulators to enhance crop yield, increase number of pegs by increasing the flowering period, to increase the number of pod bearing pegs by reducing plant height, reduce shall ratio, increase pod number and size (Arıoğlu et al., 2003).

Peanut is one of the most important and economical oilseeds in tropical and subtropical regions which is mostly grown due to its oil, protein and carbohydrates It is an annual shrub of Leguminosae family and Arachis genus which has a main straight root. Peanut has been gaining importance as a food crop, due to its high content of digestible proteins, vitamins, minerals, and phytosterols, and to increased consumer preference after value addition. Despite the improved superior cultivars and proper cultural techniques, maximum seed yield can not be achieved. One of the most important reasons of these is the environmental factors affecting plant growth and development. To minimize or eliminate negative effects of environment on crop plants for maximum yield, the use of growth regulators are needed to regulate plant growth and development (Güllüoğlu and Arıoğlu, 2004).

Numerous studies have revealed a wide range of beneficial effects of plant growth regulator applications on plants, such as seed germination, seedling establishment, increased seed yield, elevated resistance to biotic and abiotic stress, and reduced pod shattering (Singh et al., 1978; Hallock, 1982; Reddy and Patil, 1983; Venkateswariu et al., 1986; Arslantaş, 1990; Arıoğlu et al., 2003; Jeyakumar and Thangaraj, 2008; Verma et al., 2009; Gulluoglu and Arıoglu, 2004; Norrie and Keathley, 2006).

This study was conducted to determine the effects of Cytozyme Crop Extra, Atonic and Pix on growth and development, seed yield and yield components of peanut.

MATERIALS AND METHODS

Field experiments were conducted at Field Crops Department Research Area (41°04´N, 36°71´E, and 36 m), Agricultural Faculty, University of Cukurova, during the 2008 and 2009 growing seasons. The peanut cultivar was Sultan (Virginia market type) and growth regulators were Cytozyme Crop Extra, Atonic and Megahix. The climate of the experimental site is typical Mediterranean, with mild and rainy winters, and hot and dry summers. Sultan is a Virginia-type of semi-runner cultivar and reaches harvest maturity between 140 -150 days.

The soil of experimental area is classified as a sandy loam in the upper 0-30 cm profile, which contained an average 1.3% organic matter with pH 7.11, 478 K mg/kg, 15 P

mg/kg, 0.69 Zn mg/kg, 12.4 Mn mg/kg, 1.26 Cu mg/kg and 9.6 Fe mg/kg. Mediterranean climate prevails in this region. The warmest months are July and August, the coldest month is January. Nearly 90 % of annual rainfall falls in the winter months from December to April. Evaporation losses and relative humidity are high in summer. The data taken from the State Meteorology Institute, Adana (Turkey) showed that climatic conditions varied slightly between the experimental years. Mean temperatures were 19 ^{o}C in both years. The highest temperatures of first and second years were 42 ^{o}C in the August and 38 ^{o}C in the June respectively.

The experiment consisted of a completely randomized block with three replications in each year. Each plot consisted of two rows of 5 m in length with an inter-row spacing of 70 cm and intra-row spacing of 15 cm. There were 2-m spaces left between blocks to reduce the edge effects. The treatments consisted of the control and the commercial plant growth regulators Atonic (Sodium 5-nitroguaiacolate, sodium O-sitrophenolate and sodium P-nitrophenolate), Megahix (1,1-dimethylpiperidinium chloride) and Cytozeme Crop+Extra (Amino acid, karbohidrate, hdrolize proteins, organic acids, stric acid, lactic acid and micro elements). Each treatment was applied at recommended rates at peg formation of pod formation. The application doses and application times were given in Table 1.

Table 1. The plant growth regulators and application doses.

Application Time	Application doses of growth regulators		
	Cytozyme Crop Extra	Atonic	Megahix (Pix)
Peg formation (A)	100 cc/da (Crop-1)	60 cc/da (Atonic-1)	150 cc/da(Pix-1)
Pod development (B)	100 cc/da (Crop-2)	60 cc/da (Atonic-2)	150 cc/da(Pix-2)
A+B	100+100 cc/da (Crop-3)	60+60 cc/da (Atonic-3)	100+100 cc/da(Pix-3)

Table 2. Effect of plant growth regulators on pod number/plant and pod yield/plant.

Application	Pod number per plant (number/plant)			Pod yield per plant (g/plant)		
	2008	2009	Mean	2008	2009	Mean
Pix-1	38.10 cde	31.70 bc	34.90 b	80.80 cd	72.33 bcd	76.57 de
Pix-2	29.97 h	30.73 bc	30.35 c	69.67 e	68.40 d	69.03 f
Pix-3	43.93 ab	35.57 ab	39.75 a	96.87 ab	77.47 ab	87.17 b
Crop-1	32.47 fgh	36.07 ab	34.27 bc	73.60 de	71.60 bcd	72.60 def
Crop-2	34.93 efg	33.40 abc	34.17 bc	68.10 e	69.73 bcd	68.92 f
Crop-3	42.10 abc	38.53 a	40.32 a	104.00 a	85.33 ab	93.67 a
Atonic-1	35.90 def	33.83 abc	34.87 b	72.60 e	69.20 cd	70.90 ef
Atonic-2	39.80 bcd	34.53 abc	37.17 ab	84.30 c	74.67 bc	79.48 cd
Atonic-3	44.73 a	36.20 ab	40.47 a	92.63 b	76.33 bc	84.48 bc
Control	31.10 gh	29.20 c	30.15 c	66.80 e	65.37 d	66.08 f
LSD (%5)	4.25	5.71	4.49	8.02	8.06	7.25

The seed bed was prepared by deep plowing, disking and loosening. In this study, 36 kg /ha N and 92 kg/ha were provided fertilizer prior to planting. Seeds were planted manually on 14 April and 16 April in 2008 and 2009, respectively. The plants harvested on 12 October 2008 and 9 October 2009. Irrigation was applied directly after planting, water application of 59 mm was applied over the entire field via sprinklers, to ensure uniform initial growth, and subsequent irrigations were applied based on water balance equation. As the plant grew older, irrigation was done by flood method. Hand weeding was performed throughout the growing period when necessary.

The pod number/plant, Pod yield per plant, Seed number/plant first quality pod rate and second quality pod rate were determined from 10 randomly selected plants from each plot. The cultural practices used in these experiments are representative of the production practices in the Cukurova region. Post-harvest and seed quality observations were recorded from each treatment randomly.

The data were statistically analyzed by computing MSTAT-C package program with randomized block design.

RESULTS AND DISCUSSION

Pod number/plant

The highest pod number/plant values varied between 29.97-44.73 pod/plant in 2008 and between 29.20-38.53 pod/plant in 2009 (Table 2). When two years mean values were considered, the highest pod number/plant was obtained from the growth regulators (Pix-3, Crop-3 and Atonic-3) applied at peg formation and pod development stages. In both years, application of growth regulators significantly increased pod yield/plant compared with the control. The two years mean pod number per plant increase was about 10 pod/plant with the application of growth regulators. Our findings consistent with the findings of Singh et al. (1978), Venkateswariu et al. (1986) and Verma et al. (2009).

Pod Yield/plant

The highest pod yield/plant (104.00 and 85.33 g/plant) values were obtained from Crop-3 and the lowest was obtained from control treatment with 65.37 and 66.80 g/plant (Table 2). Two year mean pod yield/plant varied between 66.08-93.67 g/plant. The highest pod yield/plant (93.67 g/plant) was obtained from Crop-3 applied at peg formation and pod development stages, followed by Pix-3 (87.17

g/plant) and Atonic-3 (84.48 g/plant). The lowest (66.08 g/plant) was obtained from the control treatment. When mean pod yield/plant was considered, the Crop-3, Pix-3, and Atonic-3 had 41.8, 31.9 and 27.8% higher pod yield/plant, respectively than the control treatment. Our result was in a good agreement with the findings of Singh et al. (1978), Hallock (1982), Arslantaş (1990), Arıoğlu et al. (2003), Jeyakumar and Thangaraj (2008) and Verma et al. (2009).

Shelling percentage (%)

Application of growth regulators greatly increased shelling percentage of the peanut in both years (Table 3). When the mean shelling percentage was in consideration, shelling percentage was recorded 64.93, 68.23 and 68.23% from control, Crop-1 and Crop-3, respectively. Applications of Cytozyme Crop Extra highly increased shelling percentage of peanut compared with the other applications. Our findings confirm the findings of Verma et al. (2009).

Table 3. Effects of growth regulators on shelling percentage and 100 seed weight.

Application	Shelling percentage (%)			100 seed weight (g)		
	2008	2009	Mean	2008	2009	Mean
Pix-1	67.33 ab	68.43 ab	67.92	112.00 abc	126.70 d	119.30 cde
Pix-2	66.97 ab	68.73 a	67.85	110.00 abc	130.00 cd	120.00 bcd
Pix-3	66.83 ab	66.30 ab	66.57	114.70 ab	131.30 bcd	123.00 abc
Crop-1	69.07 a	68.60 a	68.83	114.00 ab	138.00 a	126.00 ab
Crop-2	66.43 ab	66.57 ab	66.50	111.30 abc	131.30 bcd	121.30 abcd
Crop-3	67.33 ab	69.13 a	68.23	116.70 a	136.00 ab	126.30 a
Atonic-1	66.17 b	68.03 ab	67.10	102.70 de	128.00 cd	115.30 de
Atonic-2	67.30 ab	68.40 ab	67.85	105.30 cde	132.00 bc	118.70 cde
Atonic-3	66.40 ab	68.30 ab	67.35	108.00 bcd	128.00 cd	118.00 cde
Control	64.47 b	65.40 b	64.93	99.00 e	128.00 cd	113.50 e
LSD (%5)	4.44	3.11	ÖD	8.62	4.27	6.27

Table 4. Effects of plant growth regulators on pod number on first quality and second quality pods rates.

Application	First quality pod rate (%)			Second quality pod rate (%)		
	2008	2009	Mean	2008	2009	Mean
Pix-1	49.07 ab	41.70 ab	45.39 a	50.93 de	58.30 ab	54.61 b
Pix-2	47.57 bc	43.97 ab	45.77 a	52.43 cd	56.03 ab	54.23 b
Pix-3	54.57 a	42.03 ab	48.30 a	45.43 e	57.97 ab	51.70 b
Crop-1	42.23 cd	41.13 ab	41.68 ab	57.77 bc	58.87 ab	58.32 ab
Crop-2	46.00 bc	42.50 ab	44.25 ab	54.00 cd	57.50 ab	55.75 ab
Crop-3	47.07 bc	42.97 ab	45.02 a	52.93 cd	57.03 ab	54.98 b
Atonic-1	34.87 e	48.67 a	41.77 ab	65.13 a	51.33 b	58.23 ab
Atonic-2	38.60 e	44.93 ab	41.77 ab	61.40 ab	55.07 ab	58.23 ab
Atonic-3	46.47 bc	42.10 ab	44.28 ab	53.53 cd	59.90 ab	55.72 ab
Control	33.90 e	39.57 b	36.73 b	66.10 a	60.43 a	63.27 a
LSD (%5)	5.67	7.90	7.04	5.67	7.90	7.04

100 Seed weight (g)

In both years, the application of plant growth regulators significantly increased 100 seed weight compared with the control (Table 3). A hundred seed weight varied between 99.00 and 116.70 g in 2008 and between 126.70 and 138 g in 2009. The highest mean 100 seed weight value (126.30 g) obtained from Crop-3 application followed by Crop-1 (126.0 g) application. A hundred seed weight value was 113.50 g in the control treatment. Similar results were found by Venkateswariu et al. (1986) and Arslantaş (1990).

Pod quality rates (%)

The first quality pod rates varied between 33.90-49.07% in 2008 and between 39.57-48.67in 2009 (Table 4). In 2008, Pix-3 had the highest first quality pod rates with 54.57% followed by Pix-3 with 47.57%. However, application of Atonic-2 (44.93%) and Atonic-1 (48.67%) had the highest first quality pod rates in 2009. When first pod quality rate mean values for two years were considered, application of plant growth regulators did not significantly affect the first quality pod rates. The highest mean first quality pod rate was obtained from Pix-3 with 48.30%. Compared with other growth regulators, Pix applications highly increased mean first quality pod rates. Since Pix slowed peanut growth and accelerate the entrance of pegs into the soil and stimulate pod growth (Venkateswariu et al., 1986).

Second quality pod rate varied between 45.43 and 66.10% in 2008 and between 51.33 and 60.43% in 2009 (Table 4). Compared with the control, application of the growth regulators had lower second quality pod rates. The lower rate of second quality pod rate is a desired parameter for peanut growers. In this point of view, Pix-3 application was more effective than the other growth regulators.

Oil content (%)

Among growth regulators, oil content values significantly varied in 2008, but it did not significantly varied in 2009 (Table 5). The oil content varied between 49.30 and 54.23%

Table 5. Effects of plant growth regulators on oil and protein content.

Application	Oil content (%)			Protein content (%)		
	2008	2009	Mean	2008	2009	Mean
Pix-1	52.80 abc	53.83	53.32 ab	19.66 c	19.16 cd	19.41 d
Pix-2	53.17 ab	52.70	52.75 abc	22.19 b	22.76 ab	22.47 bc
Pix-3	52.43 bc	53.07	52.93 abc	21.27 b	21.09 bc	21.18 c
Crop-1	50.23 de	51.07	50.65 cd	18.83 c	18.88 d	18.85 d
Crop-2	54.23 a	53.03	53.63 a	21.21 b	21.40 b	21.31 c
Crop-3	52.47 bc	52.70	52.58 abc	18.79 c	18.35 d	18.57 d
Atonic-1	49.30 e	50.70	50.00 d	21.47 b	21.62 b	21.55 c
Atonic-2	51.20 cd	52.20	51.70 abcd	23.80 a	24.02 a	23.91 ab
Atonic-3	51.70 cd	51.83	51.73 abcd	24.70 a	24.53 a	24.61 a
Control	50.40 de	51.67	51.03 bcd	21.14 b	21.70 b	21.42 c
LSD (%5)	1.88	Ö.D	2.53	1.35	2.09	1.56

in 2008. The highest oil content was obtained from the application of Crop-3. The oil content in the control plots were 50.40 and 51.67% in 2008 and 2009, respectively.

When the mean oil contents were in consideration, the highest oil content was obtained from Crop-3 (53.63%) followed by Pix-1(53.32%) and Pix-3 (52.93%) applications. Similar results were found by Singh et al. (1978).

Protein content (%)

Application of growth regulators significantly affected protein rate in both years (Table 5). Protein content varied between 18.79 and 24.70% in 2008; varied between 18.35 and 24.53% in 2009. The highest mean protein content was obtained from Atonic-3 (24.61%) followed Atonic-2 (23.91%) and Pix-2 (22.47%) applications. The mean protein content in the control plots was 18.57%. The lowest protein content was obtained from Atonic-1 application with 18.57%.

Pod yield (kg/ha)

Pod yield values varied between 6298 and 9823 kg/ha in 2008 (Table 6). The highest pod yield value was obtained from Crop-3 application with 9823 kg/ha followed by Pix-3 (9136 kg/ha) and Atonic-3 (8736 kg/ha) applications. The lowest pod yield value was obtained from the control plots with 6298 kg/ha.

Table 6. Effects of plant growth regulators on pod and oil yield.

Application	Pod yield (kg/ha)			Oil yield (kg/ha)		
	2008	2009	Mean	2008	2009	Mean
Pix-1	7621 cd	6863 bcd	7279 d	2939 bc	2527 abc	2733 b
Pix-2	6570 e	6514 cd	6574 f	3229 ab	2595 ab	2912 ab
Pix-3	9136 ab	7377 ab	8298 b	2363 e	2378 bc	2371 de
Crop-1	6939 de	6819 bcd	6914 def	2433 de	2388 bc	2410 cd
Crop-2	6421 e	6640 bcd	6563 f	2335 e	2340 bc	2337 de
Crop-3	9823 a	8126 a	9025 a	3417 a	2868 a	3143 a
Atonic-1	6846 e	6590 cd	6752 ef	2253 e	2270 bc	2262 de
Atonic-2	7950 c	7110 bc	7571 cd	2770 cd	2538 abc	2654 bc
Atonic-3	8736 d	7269 bc	8045 bc	3027 abc	2574 ab	2800 b
Control	6298 e	6225 d	6293 f	2093 e	2193 c	2143 e
LSD (%5)	753	763	686	402	367	263

Among growth regulators, Pod yield values varied between 6225 and 8126 kg/ha in 2009. Similar to the first year of the experiment, the highest pod yield was obtained from Crop-3 application (8126 kg/ha) followed by Pix-3 (7377 kg/ha) and Atonic-3 (7269 kg/ha) applications. The lowest pod yield was obtained from control plots with 6225 kg/ha. When pod yield values of 2008 and 2009 were compared, plants had higher pod yield in 2008 that resulted from environmental differences. When mean pod yield values for two years were in consideration, the highest seed yield was obtained from Crop-3 with 9025 kg/ha. Compared with the control, about 43.4% pod yield increase was obtained. The pod yield increases were 31.9% for Pix-3, 27.8% for Atonic-3, 20% for Atonic-2 and 16.0% Pix-1 applications. Applications of the other growth regulators did not remarkably increase pod yields. These results showed that growth regulator applications at two application times one in peg formation and the other one in pod development had the highest pod yields. Especially application of Crop-3 had the best result in terms of pod yield increase due to its versatile effects on the crops (Anonymous, 2000). Pod yield increase of Pix-3 application was attributed to crop growth decrease that stimulate peg formation and entrance of the pegs into the soil (Anonymous, 2002). Pod yield increase of

Atonic applications resulted from the improved fruiting due to improved pollination and fertilization (Anlağan, 2001). Our finding are in a good agreement with the findings Singh et al. (1978), Hallock (1982), Arslantaş (1990), Arıoğlu et al. (2003), Jeyakumar and Thangaraj (2008).

Oil yield (kg/ha)

The highest oil yields (3417 and 2868 kg/ha, in 2008 and 2009, respectively) were obtained from Crop-3 applications in Table 6. When compared with the control treatment, significantly oil yield increases were obtained by the applications of growth regulators. Compared with the control, applications of growth regulators highly increased oil yield in both years of the experiment. Mean oil yield increases were 46.7% for Crop-3, 35.9% for Pix-2 and 30.7% for Atonic-3. These oil yield increase was resulted from pod yield increase per hectare. Similar results were reported by Singh et al. (1978), Hallock (1982), Arıoğlu et al. (2003), Jeyakumar and Thangaraj (2008).

CONCLUSION

According the two years results conducted in 2008 and 2009, the highest seed yield and oil yield were obtained from Crop-3 followed by Pix-3 and Atonic-3 applications in both years. Compared with the control treatment, 43.4, 31.9 27.8 and 20.3% pod yield increase were obtained from Crop-3, Atonic-3, Atonic-2 and Pix-1 treatments, respectively. Two applications of growth regulators one at peg formation and the other one at pod formation stages had the best results. Our two year experiment showed that application of Pix, Atonic and Cytozyme Crop+Extra increase seed yield of main cropped peanut, and that can be suggested for main crop peanut when applied at both peg and pod formation stages

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