

EFFECT OF GA₃, PROMALIN AND KRISTALON ON "ANNA" APPLE SEEDLING GROWTH

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ABSTRACT

Foliar spray of gibberellic acid (GA₃) at 100 and 200 ppm, Promalin (GA₄₊₇ + BA)* at 25 and 50 ppm ; and Kristalon** at 0.1% each alone or combined together were applied five times on one-year-old "Anna" apple (*Malus domestica* Borkh) seedlings budded on MM 106 rootstock. The study was performed during two successive seasons (2001 and 2002).

All treatments increased transplant vegetative growth (seedling height, trunk diameter, number of lateral branches, number of leaves ; leaf area and leaf mineral contents) as compared with unsprayed transplant. The highest increment in transplant growth and NPK content in leaves was recorded by Kristalon treatment (0.1%) + promalin at 50 ppm followed by Kristalon (0.1%) + GA₃ at 200 ppm treatment and Kristalon (0.1%) alone.

Keywords: GA₃, Promalin, foliar fertilizer, apple (*Malus domestica* Borkh) and plant growth.

INTRODUCTION

"Anna" apple (*Malus domestica* Borkh) is a low chilling requirement cultivar grown in wide area in Egypt, especially in new reclaimed lands. Every commercial nursery needs to produced seedlings of good growth and quality in short time. In addition, the foliar fertilization reduces groundwater pollution. Various plant growth regulators had been used for this purpose. As regard to gibberellic acid, there are three important actions. The first that GA intensifies an organ ability to function as a nutrient sink. A second action is the ability of GA to increase the synthesis of IAA in plant tissues. The third action involves accelerating synthesis of hydrolytic enzymes as amylase and other hydrolytic enzymes in aleurone cell (Addicott and Addicott, 1982).

Gibberellic acid (GA₃) plays an important role in apple tree growth (William and Billingsly, 1970; Popenoe and Barritt, 1988; Jacyna, 1995; and Mokhtar, 1998) who reported that GA₃ application improves the growth of apple tree as measured by tree height, leaf area, crotch angle and number of primary branches.

Promalin (GA₄₊₇ + BA) had been used by many investigators to improve the growth of apple tree and produce suitable branches with wide angles (Forshey, 1982; Miller, 1985; Cody, et al., 1985; Hallama, 1987; Popenoe and Barsitt, 1988; Jaeassamrit, 1989; Koen, et al., 1989; Makarem et al., 1990; Keever, et al., 1993 and Jacyna, 1995). In addition, promalin at 700 ppm increased apple tree height, leaf number, stem diameter, nitrogen and potassium contents in leaves (Shahin, 1999).

* Promalin is a plant growth regulator contains GA₄₊₇ (1.8%) and Benzyle adenine Cytokinin (1.8%) or 1: 1 from GA₄₊₇ and BA, respectively.

** Kristalon is a foliar fertilizer contains N 19%, P 19%, K 19%, Mg 1.5% , B 0.025%, Mo 0.001%, Cu 0.01% and S 1%.

Provide (GA₄₊₇) was used also for the same purpose (Williams and Billingsly, 1970; Popenoe and Baritt, 1988; Jaumien, et al., 1993 and Wally, 1997). Greene and Miller (1988) and Keever, et al. (1993) stated that BA increased branching and crotch angle of apple and pear trees.

Daily NPK fertilization to citrus was found to promote tree growth and increase productivity (Bravdo, 1994). Akl, et al. (1995) found that foliar spray of urea (0.5%) and GA₃ at 25 ppm on "Washington" Naval Orange increased shoot length and leaf area. Kristalon at 0.1% plus provide (GA₄₊₇) increased young apricot tree growth (Wally, 1997).

The aim of this investigation was to study the effect of Gibberellic acid (GA₃), promalin (GA₄₊₇ + BA) and Kristalon (foliar fertilizer) on growth of young "Anna" apple transplant. budded on MM 106.

MATERIALS AND METHODS

This study was conducted through 2001 and 2002 seasons on one-year-old Anna apple cultivar budded on Malling Merton 106 (MM 106) and grown in pots of 30 cm diameter (5 Kg soil) in greenhouse of Sabahia Horticultural Research Station. The transplant seedlings were subjected to the same cultural practices used in the greenhouse and arranged in complete randomized block design with three replicates each represented by six transplant. On first of May, June, July, August and September the following foliar treatments were applied with spreading agent (Triton at 0.1%).

- 1) Control (tap water).
- 2) Gibberellic acid (GA₃) at 100 ppm.
- 3) Gibberellic acid (GA₃) at 200 ppm.
- 4) Promalin (GA₄₊₇ + BA) at 25 ppm each.
- 5) Promalin (GA₄₊₇ + BA) at 50 ppm each.
- 6) Kristalon (0.1%).
- 7) Kristalon (0.1%) + GA₃ at 200 ppm.
- 8) Kristalon (0.1%) + Promalin at 50 ppm.

The following measurements were estimated:

The height increment percentage was calculated as follow:

$$\text{Height Increment (\%)} = \frac{\text{Height at the end of September} - \text{Height at beginning of spray}}{\text{Height at beginning of spray}} \times 100$$

Trunk diameter (cm) above grafting union by 5 cm was measured at the end of season (end of September). Number of lateral branches was calculated. Leaf number and mature leaf area (cm²) were recorded by planimeter according to Nautiyal, et al. (1990), samples (10 leaves for each) were taken from the sixth nodes from the base of one-year-old shoots. Macro elements (N, P and K) were estimated according to Pregl (1945) for nitrogen; Jackson (1958) for phosphorus and Brown and Lilleland (1949) for potassium.

Data were subjected to analysis of variance according to Snedecor and Cochran (1980). Differences between means were compared by using LSD values at 5% level.

RESULTS AND DISCUSSION

Seedling height:

The effect of different foliar applications of gibberellic acid (GA_3), Promalin (GA_{4+7} + BA) and Kristalon on "Anna" apple transplant height during 2001 and 2002 seasons are presented in Fig. (1).

The highest significant increment percentages in transplant height (42.3 and 46.2%) for 2001 and 2002 seasons, respectively were recorded by the treatment of Kristalon (0.1%) + Promalin at 50 ppm, followed by (36.1 and 41.2%) resulted from the treatment of Kristalon (0.1%) + GA_3 at 200 ppm, as compared with the lowest increment in Height (20.2 and 19.1%) for the control treatment, for both seasons, respectively. The other treatments recorded in between values.

The present results are in harmony with previous works of using GA_3 as foliar spray on apple (Williams and Billingsly, 1970; Popenoe and Barritt, 1988; Jacyna, 1995; and Mokhtar, 1998) and of Promalin on apple (Forshey, 1982; Miller, 1985; Cody, *et al.*, 1985; Hallama, 1987; Popenoe and Barritt, 1988; Jaeassamrit, 1989; Koen, *et al.*, 1989; Makarem, *et al.*, 1990; Keever, *et al.*, 1993 and Jacyna, 1995) and of Kristalon (foliar fertilizer) on apricot (Wally, 1997). In addition, daily NPK fertilization to citrus was found to promote seedling growth and increase productivity (Bravdo, 1994).

Trunk diameter:

Trunk diameter of "Anna" apple seedling as affected by different applications of gibberellic acid (GA_3), Promalin (GA_{4+7} + BA) and Kristalon during 2001 and 2002 seasons are presented in Fig. (2). All treatments increased seedling trunk diameter as compared to the control and the differences were statistically significant (for the two seasons of study) between the treatments of Promalin and Kristalon each alone or combined together or with GA_3 and the control. The highest trunk diameters (1.5 and 1.9 cm) were recorded by the treatment of Kristalon (0.1%) + Promalin at 50 ppm, followed by (1.4 and 1.7 cm) resulted from the treatments of Promalin alone at 50 ppm or Kristalon (0.1%) + GA_3 at 200 ppm as compared with the lowest trunk diameter (0.7 and 1.0 cm) for the control treatment, for both, respectively. In between values were estimated by the other treatments.

Similar results were previously recorded by Williams and Billingsly (1970); Popenoe and Barritt (1988); Jacyna (1995); and Mokhtar (1998) on apple seedlings by using GA_3 as foliar spray; and by Forshey (1982); Miller (1985); Cody, *et al.* (1985); Hallama (1987); Popenoe and Barritt (1988); Jaeassamrit (1989); Koen, *et al.* (1989); Makarem, *et al.* (1990); Keever, *et al.* (1993) and Jacyna (1995) using Promalin on apple and by (Wally, 1997) using Kristalon (foliar fertilizer) on apricot.

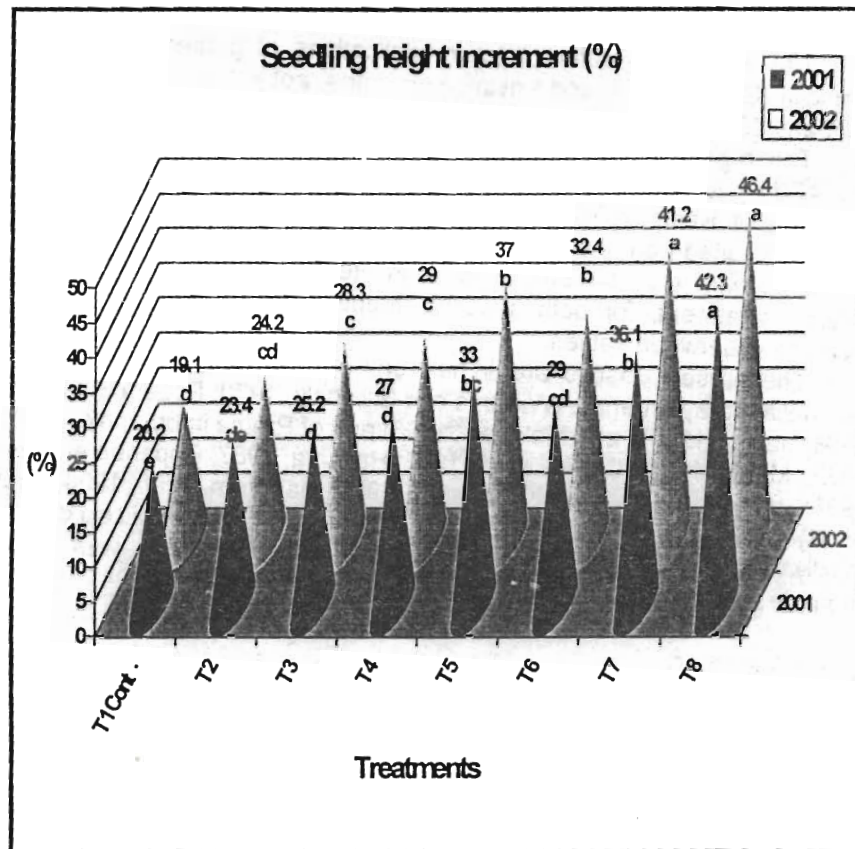


Fig.1. The effect of different foliar applications on "Anna" apple transplant. height increment percentage during 2001 and 2002 seasons. (T1 = Control, T2 = gibberellic acid (GA₃) at 100 ppm., T3 = gibberellic acid (GA₃) at 200 ppm., T4 = Promalin (GA₄₊₇ + BA) at 25 ppm., T5 = Promalin (GA₄₊₇ + BA) at 50 ppm., T6 = Kristalon (0.1%)., T7 = Kristalon (0.1%) + GA₃ at 200 ppm., T8 = Kristalon (0.1%) + Promalin at 50 ppm). Values having similar letters are not significantly different in the same season.

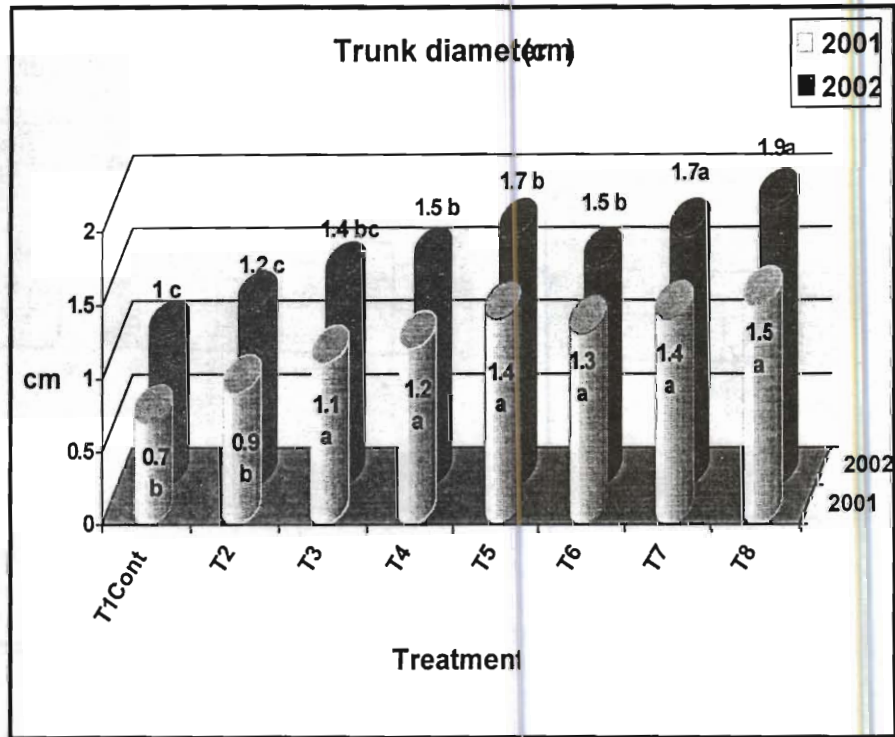


Fig. 2. The effect of different foliar applications on transplant trunk diameter (cm) of "Anna" apple during 2001 and 2002 seasons. (T1 = Control, T2 = gibberellic acid (GA₃) at 100 ppm., T3 = gibberellic acid (GA₃) at 200 ppm., T4 = Promalin (GA₄₊₇ + BA) at 25 ppm., T5 = Promalin (GA₄₊₇ + BA) at 50 ppm., T6 = Kristalon (0.1%), T7 = Kristalon (0.1%) + GA₃ at 200 ppm., T8 = Kristalon (0.1%) + Promalin at 50 ppm). Values having similar letters are not significantly different in the same season.

Number of lateral branches:

Results in Fig. (3) illustrate the effect of different foliar applications of gibberellic acid (GA₃), Promalin (GA₄₊₇ + BA) and Kristalon each alone or combined together on number of lateral branches of "Anna" apple transplant during 2001 and 2002 seasons. All treatments of Promalin at 25 or 50 ppm each alone, kristalon at 0.1% alone and the combinations of Kristalon at 0.1% + GA₃ at 200 ppm or Kristalon at 0.1% + Promalin at 50 ppm increased significantly the number of lateral branches as compared to the control. The highest number of lateral branches (5.5 and 10.5) for the first and second season, respectively, were recorded by the treatment of Kristalon at 0.1% + Promalin at 50 ppm. followed by both treatments of Kristalon at 0.1% + GA₃ at 200 ppm and Promalin at 50 ppm. alone which recorded (5 and 9.5), for first and second seasons, respectively, as compared to the control (3 and 4).

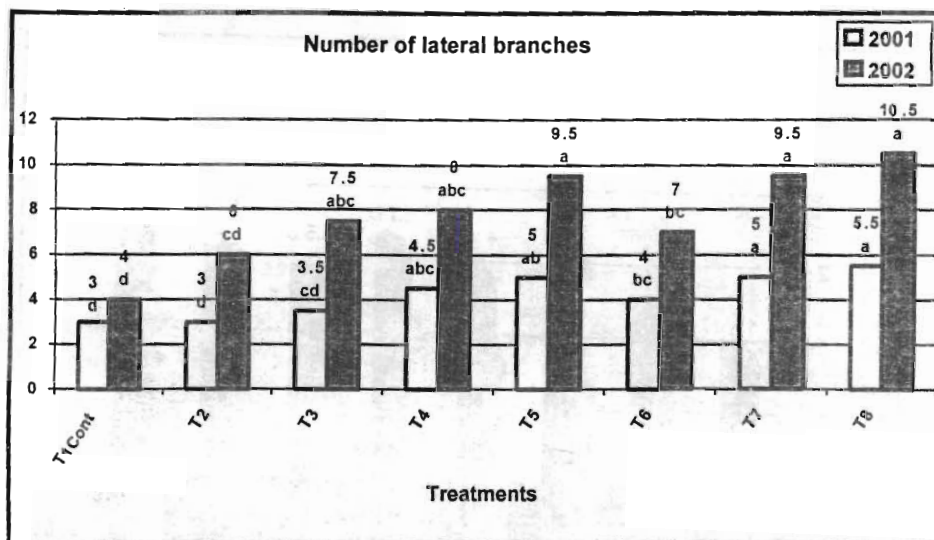


Fig.3. The effect of different foliar applications on number of lateral branches of apple transplant during 2001 and 2002 seasons. (T1 = Control, T2 = gibberellic acid (GA₃) at 100 ppm., T3 = gibberellic acid (GA₃) at 200 ppm., T4 = Promalin (GA₄₊₇ + BA) at 25 ppm., T5 = Promalin (GA₄₊₇ + BA) at 50 ppm., T6 = Kristalon (0.1%), T7 = Kristalon (0.1%) + GA₃ at 200 ppm., T8 = Kristalon (0.1%) + Promalin at 50 ppm). Values having similar letters are not significantly different in the same season.

The present results are in line with the previous results from using GA₃ on apple (Popenoe and Barritt, 1988; Jacyna, 1995; and Mokhtar, 1998) and from Promalin on apple (Forshey, 1982; Miller, 1985; Cody, et al., 1985; Hallama, 1987; Popenoe and Barritt, 1988; Jaeassamrit, 1989; Koen, et al., 1989; Makarem, et al., 1990; Keever, et al., 1993 and Jacyna, 1995) and Kristalon (foliar fertilizer) on apricot (Wally, 1997).

Leaf Number:

Leaf number as affected by different foliar applications of gibberellic acid (GA₃), Promalin (GA₄₊₇ + BA) and Kristalon each alone or combined together on "Anna" apple transplant during 2001 and 2002 seasons are presented in Fig. (4). It is evident that all treatments increased leaf number per transplant, as compared to the control, but the higher statistically differences than the control treatment were recorded by the treatment of Kristalon at 0.1% + Promalin at 50 ppm. (43 and 50 leaves/seedling) for the first and second season, respectively followed by Kristalon at 0.1% + GA₃ at 200 ppm. (42 and 47 leaves/seedling), Kristalon at 0.1% (39 and 44 leaves/seedling) and Promalin alone at 50 ppm. (32 and 37 leaves/seedling), respectively.

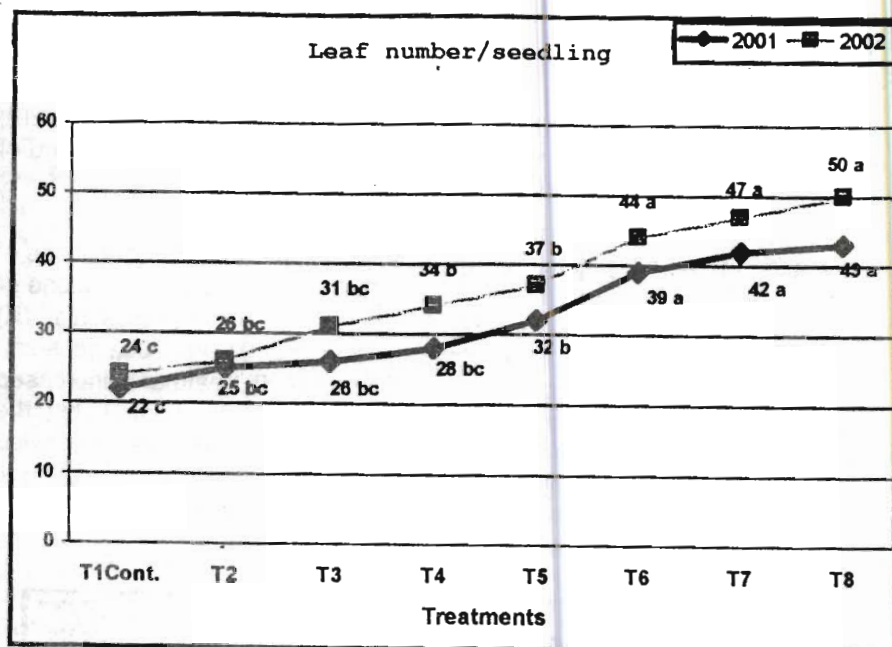


Fig.4. The effect of different foliar applications on leaf number/apple transplant. during 2001 and 2002 seasons. (T1 = Control, T2 = gibberellic acid (GA₃) at 100 ppm., T3 = gibberellic acid (GA₃) at 200 ppm., T4 = Promalin (GA₄₊₇ + BA) at 25 ppm., T5 = Promalin (GA₄₊₇ + BA) at 50 ppm., T6 = Kristalon (0.1%)., T7 = Kristalon (0.1%) + GA₃ at 200 ppm., T8 = Kristalon (0.1%) + Promalin at 50 ppm). Values having similar letters are not significantly different in the same season.

The obtained results are similar to the previous results of using GA₃ on apple (Popenoe and Barritt, 1988; Jacyna, 1995; and Mokhtar, 1998) and using Promalin on apple (Forshey, 1982; Miller, 1985; Cody, *et al.*, 1985; Hallama, 1987; Popenoe and Barritt, 1988; Jasassamrit, 1989; Koen, *et al.*, 1989; Makarem, *et al.*, 1990; Keever, *et al.*, 1993 and Jacyna, 1995) and Kristalon (foliar fertilizer) on apricot (Wally, 1997).

Leaf area:

The effect of different foliar applications of gibberellic acid (GA₃), Promalin (GA₄₊₇ + BA) and Kristalon (foliar fertilizer) on "Anna" apple transplant. leaf area (cm²) during 2001 and 2002 seasons are shown in Fig. (5). It is evident that all foliar applications significantly increased leaf area (cm²) as compared with the control. The highest leaf area (26.52 and 26.65 cm²) were recorded by Kristalon at 0.1% + Promalin at 50 ppm. for first and second season, respectively followed by (26.01 and 26.11 cm²) for the treatment of Kristalon at 0.1% + GA₃ at 200 ppm. as compared with the control (17.75 and 18.25 cm²) for first and second season, respectively. The other treatments gave in between values.

The obtained results take the same trend as that of Williams and Billingsly (1970); Popenoe and Barritt (1988); Jacyna (1995); and Mokhtar (1998) on apple trees by using GA_3 as foliar spray; and of Forshey (1982); Miller (1985); Cody, et al. (1985); Hallama (1987); Popenoe and Barritt (1988); Jaeassamrit (1989); Koen, et al. (1989); Makarem, et al. (1990); Keever, et al. (1993) and Jacyna (1995) using Promalin on apple and of (Wally, 1997) using Kristalon (foliar fertilizer) on apricot.

Nitrogen, Phosphorus and potassium leaf content:

Results in Table (1) illustrate the effect of different foliar applications of gibberellic acid (GA_3), Promalin (GA_{4+7} + BA) and Kristalon each alone or combined together on nitrogen (N), phosphorus (P) and potassium (K) contents in leaves of "Anna" apple transplant during 2001 and 2002 seasons.

As regard to nitrogen content in leaves (%), all treatments increased nitrogen content in the leaves as compared with the control, but the statistically significant increments in the two studied seasons were recorded by the treatments of Kristalon at 0.1% + Promalin at 50 ppm., Kristalon at 0.1% + GA_3 at 200 ppm., Kristalon at 0.1% and Promalin at 50 ppm., in descending order. The highest

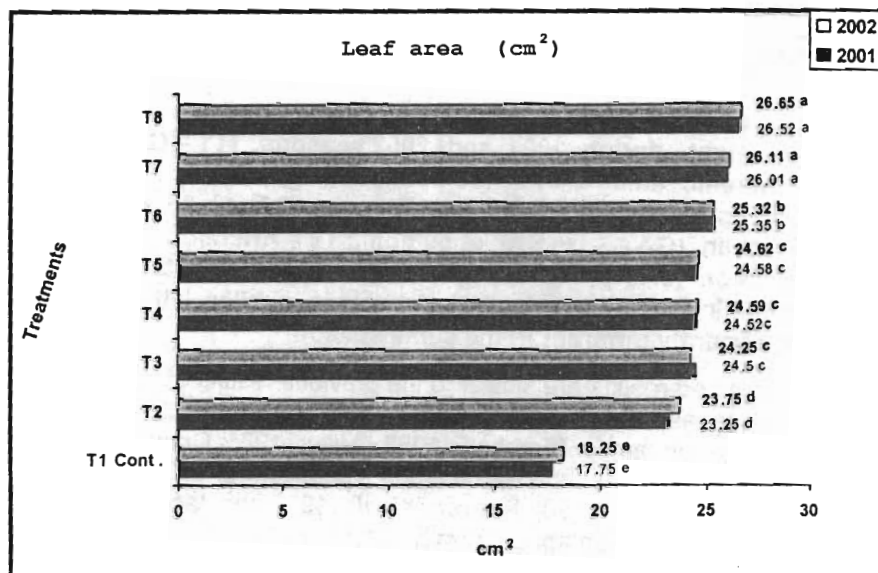


Fig.5. The effect of different foliar applications on leaf area (cm²) of "Anna" apple transplant. during 2001 and 2002 seasons. (T1 = Control, T2 = gibberellic acid (GA_3) at 100 ppm., T3 = gibberellic acid (GA_3) at 200 ppm., T4 = Promalin (GA_{4+7} + BA) at 25 ppm., T5 = Promalin (GA_{4+7} + BA) at 50 ppm., T6 = Kristalon (0.1%)., T7 = Kristalon (0.1%) + GA_3 at 200 ppm., T8 = Kristalon (0.1%) + Promalin at 50 ppm). Values having similar letters are not significantly different in the same season.

Table (1): The effect of different foliar applications on leaf mineral Nitrogen (N), phosphorus (P) and potassium (K) contents (%) of "Anna" apple transplant during 2001 and 2002 transplant seasons.

Treatments	N(%)		P(%)		K(%)	
	2001	2002	2001	2002	2001	2002
Control (tap water)	2.01c	2.02 c	0.20 c	0.22 f	1.18 c	1.22 d
Gibberellic acid (GA ₃) at 100 ppm.	2.08 b	2.10bc	0.22bc	0.21 f	1.20 bc	1.22 d
Gibberellic acid (GA ₃) at 200 ppm.	2.11 b	2.16 b	0.23 b	0.23 e	1.22 bc	1.23 d
Promalin (GA ₄₊₇ + BA) at 25 ppm.	2.07 b	2.10bc	0.24 b	0.23 e	1.23 bc	1.25 cd
Promalin (GA ₄₊₇ + BA) at 50 ppm.	2.14 b	2.16 b	0.26 b	0.25 d	1.26 b	1.28 c
Kristalon (0.1%)	2.14 a	2.22 a	0.27 a	0.27 c	1.28 ab	1.32 b
Kristalon (0.1%) + GA ₃ at 200 ppm	2.22 a	2.25 a	0.28 a	0.29 b	1.29 ab	1.35 b
Kristalon (0.1%) + Promalin at 50ppm.	2.24 a	2.31 a	0.30 a	0.32 a	1.35 a	1.40 a

Values having similar letters are not significantly different in the same column. percentage of N content (2.24 and 2.31%) in first and second season, respectively were recorded by Kristalon at 0.1% + Promalin at 50 ppm., followed by (2.22 and 2.25%) from using Kristalon at 0.1% + GA₃ at 200 ppm. as compared with the control (2.01 and 2.02%).

As regard to phosphorus content in leaves (%), all treatments increased significantly phosphorus content in leaves as compared with the control except the treatment of GA₃ at 100 ppm in the two studied seasons. The highest percentages of P content (0.30 and 0.32%) in first and second season, respectively were recorded by Kristalon at 0.1% + Promalin at 50 ppm., followed by (0.28 and 0.29%) from using Kristalon at 0.1% + GA₃ at 200 ppm. as compared with the control content (0.2% and 0.22%).

Potassium contents in leaves (%) were statistically affected by the treatments of Kristalon at 0.1% + Promalin at 50 ppm., Kristalon at 0.1% + GA₃ at 200 ppm; Kristalon at 0.1% and Promalin at 50 ppm., in the two seasons, in descending order. The rest of treatments gave insignificant values. The highest percentages of K content (1.35 and 1.40%) in first and second season, respectively were recorded by Kristalon at 0.1% + Promalin at 50 ppm. followed by (1.29 and 1.35%) from using Kristalon at 0.1% + GA₃ at 200 ppm. as compared with the control treatment (1.18 and 1.22%).

The present results are in harmony with those of Makarim et al. (1990) and Mokhtar (1998) on apple trees. Also, Rawash, et al. (1980) on Cleopatra mandarin and Sour orange seedlings, and Ibrahim (1990) on Valencia orange had confirmed the obtained results.

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تأثير حمض الجبريليك والبرومالين والكريستالون على نمو شتلات التفاح صنف "أنا"

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معهد بحوث البساتين - مركز البحوث الزراعية

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تم الرش الورقي لكل من حمض الجبريليك (GA_3) بتركيز ١٠٠ و ٢٠٠ جزء/مليون ، والبرومالين* ($GA_{4+7} + BA$) بتركيز ٢٥ و ٥٠ جزء/مليون والكريستالون** بتركيز ٠,١% ، كل على حده أو مخلوطة على شتلات تفاح "أنا" عمر سنة. وقد تم الرش خمسة مرات بمعدل مرة كل شهر بدأ من شهر مايو خلال موسمين متتاليين (٢٠٠١ ، ٢٠٠٢). وقد أدت كل المعاملات إلى زيادة نمو الشتلات (ارتفاع الشتلة وقطر الجذع وعدد الأفرع الجانبية وعدد الأوراق والمساحة الورقية ومحتوى الأوراق من العناصر الكبرى) عند المقارنة بالشتلات غير المرشوشة. وقد تم الحصول على أعلى زيادة في نمو الشتلات ومحتوى أوراقها من النيتروجين والفوسفور والبوتاسيوم (NPK) بالرش بمعاملة الكريستالون بتركيز ٠,١% + البرومالين بتركيز ٥٠ جزء/مليون وتبعها معاملة الكريستالون بتركيز ٠,١% + حمض الجبريليك بتركيز ٢٠٠ جزء/مليون ، ومعاملة الكريستالون منفرداً ، على التوالي.

* البرومالين منظم نمو يحتوى كل من الجبرلين (GA_{4+7}) (١,٨%) وبنزيل أدينين (BA) سيتوكينين (١,٨%) بنسبة ١:١.
** الكريستالون سماد ورقي يحتوى ١٩% نيتروجين و ١٩% فوسفور و ١٩% بوتاسيوم و ١,٥% ماغنسيوم و ٠,٢٥% بورون و ٠,٠٠١% موليبدنم و ٠,٠٠١% نحاس و ١% كبريت.