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Effects of Benzyladenine on the Growth and the Flowering of *Sntrix* Rose

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THE EFFECTS of the growth promoter benzyladenine (BA), as a foliar spray on the growth, flowering and chemical compositions of *Sntrix* rose were studied under greenhouse conditions during two successive seasons. In each growing season, 0, 25, 50, 75, 100 or 200 ppm of BA were applied four times at monthly intervals. The results showed that all growth and flowering parameters were improved by all BA concentrations, with 75 ppm being the the most effective. At that level of BA, number of flowers per plant and fresh and dry weight of leaves per flowering stem were higher than at the other levels. The tallest, thickest and heaviest flowering stems were also recorded at 75 ppm. On the other hand, 100 and 200 ppm caused significant reductions in the parameters of both growth and flowering. However, their values were still slightly higher than those of the control. The data also showed that BA improved the total carbohydrates and the mineral content (N, P, K, Zn and Cu) of the leaves. The obtained results may indicate that suitable concentrations of BA may promote growth and flowering processes of Sntrix rose plants through its stimulating effects on mineral uptake and translocation as well as carbohydrate metabolism in plant leaves.

A great deal of interest in rose plants has recently arisen because of their significantly valuable values for both local and foreign markets. As one of the most important florist species, several attempts were done, and more are still needed, at improving its quantitative and qualitative characteristics. The use of growth regulators, particularly cytokinins such as kinetin and benzyladinine, was of the agents that have been claimed to play an effective role in improving the production potentiality of many florist corps, including rose varieties (Salisbury & Ross, 1992). In this regard, Zieslin & Khayat (1982) reported that cytokinins balance the inhibitory complex that is involved in the regulation of basal bud outgrowth and generation of rose plant.

Benzyladenine (BA) was found to produce similar physiological and morphological effects as the natural cytokinins and was used extensively, by many workers, to improve the growth and flowering stem measurements. Among those were Mazrou *et al.* (1988) on Queen Elizabeth rose, Mazrou & Al-Humaid (2000) on Evil Tower rose, Clark *et al.* (1991) and Van Telgen *et al.* (1992) on potted roses other than Sntrix cultivar. In another line of study, it was found that the application of kinetin or benzyladenine at certain doses improved the growth and flowering parameters of gladioli (Meawad, 1981), *Polianthus tubrosa* (El-Sayd *et al.*, 1989) and *Crinum longiflorum* and *Hemerocallis aurantiaca* (Nofal *et al.*, 1998).

Considering that the previously mentioned investigations were carried out under different environmental conditions and different cultivars from the one under study, and that some genetic differences exist among rose cultivars themselves, it was of interest to carry out the current study to investigate the response of Sntrix rose cv. to the application of benzyladenine (BA) under greenhouse conditions.

Material and Methods

Two experiments were carried out under greenhouse conditions during the two successive seasons of 2000/2001 and 2001/2002, at the Research Station of the College of Agriculture and Veterinary Medicine, King Saud University, Al-Qassim branch. The study aimed to investigate the effect of benzyleadinine (BA), a synthetic cytokinin, on the growth, flowering, chemical compositions and physiological behavior of Sntrix rose cv. grown in sandy soil under greenhouse controlled conditions (25/18°C day/night and 60% RH). The physical and chemical analyses of the soil are shown in Table 1.

TABLE 1. Chemical and physical analyses of the soil.

Chemical properties		Physical properties	
pH:	8.20	Fractions (%):	
ECe (ms):	2.06	Sand:	95.30
Soluble cations ($meq.L^{-1}$):		*Silt:*	*3.60*
		Clay:	1.10
Na^{+}	11.00		
Ca^{2+}	4.35		
Mg^{2+}	2.50		
Soluble anions ($meq.L^{-1}$):		Texture:	Sandy Soil
$CO_3^{2-} + HCO_3^{-}$	2.99		
SO_4^{2-}	11.70		
Cl^{-}	7.60		
$CaCO_3$	4.00%		
O.M.	*0.23%*		

Two year old *Sntrix* rose plants were obtained from the Research Station of Al-Kanater Al-Khairia, Egypt and adapted for cultivation under Al-Qassim environmental conditions by planting them for one season under the existing conditions. Then, plants were transplanted at distances of 25x50 cm in 1x1 m plots. The treatments were arranged in a complete randomized block design with 3 replicates.

On the first of Sept. of each year, 3 branches were randomly chosen on each rose bush and were carefully pruned to 40 cm in length. One month later, plants were sprayed with 0, 25, 50, 75, 100 and 200 ppm BA solutions. Treatments were repeated 3 more times at monthly intervals. Through the experimental course, the plants were fertilized with the commercial fertilizer "Singral" (20% N, 20% P, 20% K, 0.12% Mg, 70 ppm Fe, 14 ppm Zn, 16 ppm Cu, 42 ppm Mn, 72 ppm B and 24 ppm Mo), at a rate of 60 g m^2. Normal agricultural practices were performed during the experimental period. One month after the last spray, the following data were recorded:

Vegetative measurements: The number of leaves per flowering stem, the fresh and dry weights of leaves per flowering stem and the leaf absolute growth rate (LAGR) in mg/g $week^{-1}$ as described by Larcher (1995): LAGR= total leaf dry weight (g)/time (weeks). The relative water content (RWC) as percent of water in leaf tissues was determined as recorded by Salisbury & Ross (1992).

Flowering parameters: The number of flowers per plant, the length of flowering stem, the fresh weight of flowering stem, the thickness of flowering stem at top and base, the length and fresh weight of individual flowers were measured.

Chemical analysis: The following analyses were done on plant leaves; (a) total carbohydrates (the HCl acidic extracts) were estimated by the phenol-sulfuric acid method (Dubois *et al.*, 1956), (b) total nitrogen in plant leaves was determined by the modified "Micro-Kjeldahl" method as described by Chapman & Pratt (1978), (c) phosphorous percent was measured colorimetrically using Stannus chloride method as reported by Frie *et al.* (1964), (d) potassium was determined by flame photometry as described by Jones & Steyn (1973), (e) Zn and Cu were measured by the Perkin-Elmer Atomic Absorption Spectrophotometer (A.O.A.C., 1975).

All collected data were statistically analyzed according to Snedecor & Cochran (1973) with the aid of the COSTAT computer program for statistics. Differences among treatments were tested with LSD at 5% and 1% levels of significance.

Results and Discussion

Vegetative growth

Data recorded in Table 2 showed that the number of leaves, produced on the flowering stem increased with increasing BA concentrations in the spray solution up to 75ppm (47% increase) and then tended to decrease with increasing BA above that level although these values were still significantly higher than those recorded for the control.

TABLE 2. Effects of benzyladenine (BA) on vegetative growth of Sntrix rose during the two growing seasons.

BA conc. (ppm)	No. leaves / flow. stem	Fwt. leaves (g)	Dwt. leaves (g)	RWC (%)	LAGR (mg $g^{-1}week^{-1}$)
	First season				
00	11.33	12.47	4.24	66.20	270
25	13.84	15.18	5.31	65.00	330
50	14.52	16.07	5.69	64.60	360
75	16.55	18.42	6.70	63.60	420
100	16.47	18.45	6.69	63.70	418
200	15.26	16.88	6.08	64.00	380
LSD (5%)	1.23	1.34	0.52	0.65	15.5
LSD (1%)	1.75	1.91	0.74	0.74	22.5
	Second season				
00	10.67	11.88	4.27	64.10	270
25	13.50	14.65	5.38	63.30	340
50	14.92	16.29	6.03	63.00	380
75	15.94	17.86	6.63	62.90	410
100	15.60	17.21	6.49	62.30	409
200	15.30	16.78	6.21	63.00	390
LSD (5%)	1.11	1.02	0.41	0.45	13.6
LSD (1%)	1.58	1.45	0.58	0.65	17.5

During the first season, fresh and dry weights of flowering-stem leaves also increased linearly with increasing BA concentration following the same trend of leaf numbers. The 75ppm treatment caused an increase of about 48% and 59% for leaf fresh weight (Lfwt) and leaf dry weight (Ldwt), respectively as compared with the control. At the same time, 200 ppm treatment decreased both parameters by about 9% and 10%, respectively, compared with those recorded for the 75ppm. This tendency of results was nearly similar during both growing seasons. Similar results were obtained in earlier studies by Mazrou *et al.* (1988) on Queen Elizabeth rose plants, Mazrou & Al-Humaid (2000) on cv. Evil tower rose and Nofal *et al.* (1998) on *Crinum longiflorum* and *Hemerocallis aurantiaca*.

The increase in the number, and fresh and dry weights of leaves could be attributed to the role of BA in promoting cell division and enlargement in mature tissues of intact plants (Krishnamoorthy, 1981). In this regard, Salisbury & Ross (1992) reported that cytokinins, including BA and kinetin, stimulate leaf growth through their positive effects on the growth of mesophyll cells and leaf veins. This would suggest that BA can replace the need for a plant system to produce healthy leaf growth and continuous leaf differentiation (Wareing & Phillips, 1981).

An interesting observation was that the effect of BA, either as stimulatory at 75ppm or inhibitory at 200 ppm, was more pronounced on the Ldwt than that observed on the Lfwt. These results suggest that the mechanism of BA, like that of other cytokinins, works directly on the deposition of dry matter in plant cells rather than on cell water relation (Salisbury & Ross, 1992). The data in Fig. 1 & 2 may confirm this conclusion since recorded values of LAGR were closely related to BA doses, while the values of RWC% were fluctuating up and down without synchronization with BA concentrations. These findings may support the idea that BA promotes plant growth through its positive effects on mature tissues (such as cortex and pith) of intact plants (Krishnamoorthy, 1981).

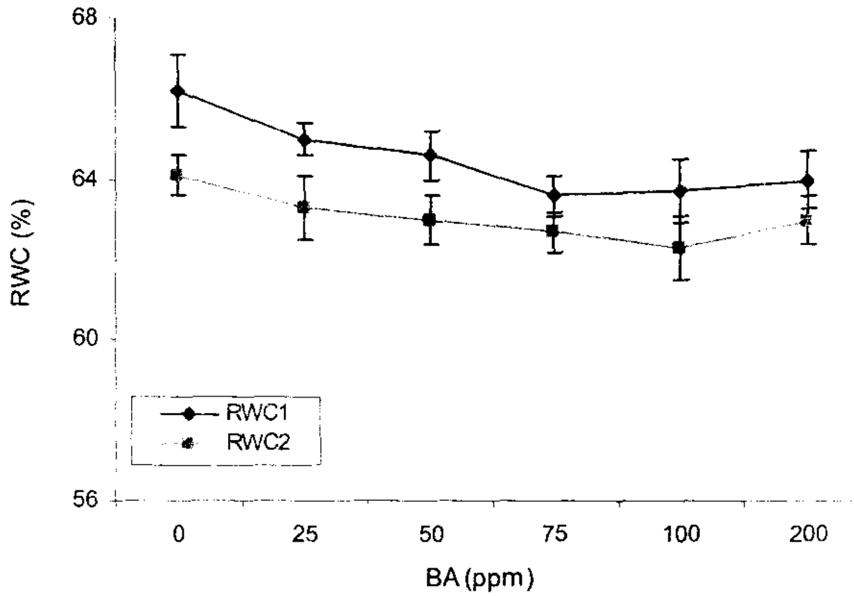

Fig. 1. Effects of BA on the relative water content in the first (RWC1) and second (RWC2) seasons.

Reproductive growth

a) Flower characteristics

The number of flowers per plant and the length and the fresh weight of individual flowers were significantly increased as a result of BA application, compared to the control in the two growing seasons (Table 3). In this regard, 200 ppm level gave the highest number of flowers/plant. While the other parameters showed highest values at 75 ppm. This was true in both experimental seasons. These results are in accordance with those obtained by Mazrou & Al-Humaid (2000) on Evil Tower rose plants and Nofal *et al.* (1998) on *Crinum longiflorum* and *Hemerocallis aurantiaca*.

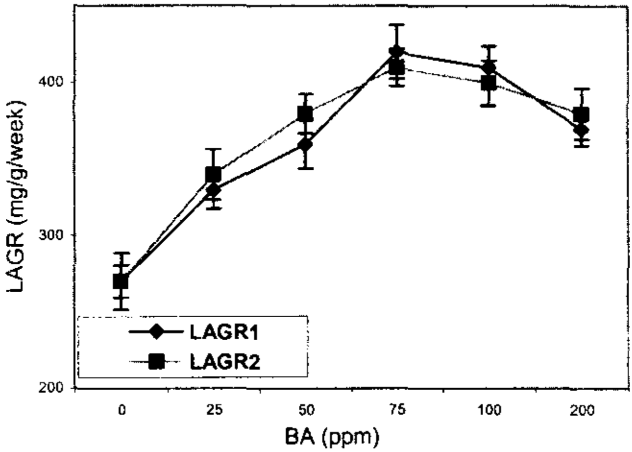

Fig. 2. Effects of BA on leaf absolute growth rate in first (LAGR1) and second (LAGR2) seasons.

TABLE 3. Effects of benzyladenine (BA) on the characteristics of flowers and flowering stems of Sntrix rose during two growing seasons.

BA conc. (ppm)	Flower characteristics			Flowering stem characteristics			
	Number / plant	Length (cm)	Fresh wt(g)	Length (cm)	Fresh wt(g)	Top-thickness(mm)	Base thickness(mm)
	First season						
00	5.50	4.63	6.34	66.22	22.58	3.00	5.30
25	6.30	5,49	8.70	85.71	33.52	4.30	7.50
50	7.81	5.65	9.03	101.75	38.52	4.60	8.80
75	9.50	6.25	11.90	112.57	52.13	4.80	10.80
100	10.45	5.93	10.90	108.50	47.04	4.80	11.30
200	11.17	5.89	10.10	107.25	45.75	4.70	9.80
LSD5%	0.70	1.05	0.64	4.40	5.30	0.40	1.50
LSD1%	1.00	1.49	0.90	6.26	7.54	0.60	2.10
	Second season						
00	6.31	4.68	6.03	72.18	25.40	3.50	5.10
25	7.49	5.60	7.58	87.89	36.23	4.50	5.90
50	8.51	5.80	9.33	101.61	38.70	4.60	8.90
75	10.09	6.31	12.25	112.47	52.75	4.80	11.30
100	11.25	6.25	10.87	109.50	48.17	4.60	10.20
200	11.80	5.98	10.13	109.29	44.83	4.80	9.70
LSD5%	1.50	0.44	1.56	3.49	4.94	0.70	0.20
LSD1%	2.15	0.62	2.22	4.97	7.03	0.90	0.28

In an attempt to explain the role of BA application in enhancing flowering, Jayroe & Newman (1995), working on tea rose, reported that suitable doses of BA have the tendency to stimulate the differentiation and growth of basal and axillary buds, thus improving the formation of flowering buds. However, it is important to realize that despite the evidence implicating cytokinins, such as BA and kinetin, in flowering bud differentiation and flower formation, there is also a considerable likelihood that cytokinins are not the only hormones involved in this matter. In this regard, an early study by Wareing & Phillips (1981) showed that BA, like other cytokinin members, stimulates the bud cell division and, when applied, interacts with other endogenous phytohormones in determining the direction which differentiation of cells would take, and that direction, in most cases, favors flowering bud formation.

b) Flowering-stem characteristics

Statistical analysis clearly showed that the length, thickness and fresh weight of flowering stem were substantially increased by all BA concentrations (Table3). These increases in flowering-stem attributes, with BA treatments, were significant at either 5% or 1% level of significance showing the potential effect of BA as a growth regulator on these parameters. In this regard, the 75 ppm BA produced the tallest and the heaviest flowering-stems. On the other hand, all values of flowering-stem characteristics tended to decrease at BA concentration higher than 75 ppm, particularly 200 ppm. These findings were alike for the two growing seasons.

It is worthy mentioning that the response of the flowering stem to BA was, in general, similar to that observed on vegetative growth. This may support the conclusion that BA has the tendency to activate the metabolism of some materials inside the plant tissues and thus accumulate more metabolites within the vegetative plant organs (Wareing & Phillips, 1981). Therefore, length, fresh weight, and thickness of flowering-stem were increased as a consequence of BA application. The beneficial effect of BA application at suitable concentrations on the flowering stem thickness, as well as flower length and fresh weights was stated also by Mazrou *et al.* (1988), Mazrou & Al-Humaid (2000), Clark *et al.* (1991) and Van Telgen *et al.* (1992) on roses and Nofal *et al.* (1998) on *Crinum longiflorum* and *Hemerocallis aurantiaca*. But, it should be mentioned that a characteristic feature of BA is that above a certain concentration, its effect is to inhibit rather than to stimulate growth. It appears that too high level of BA concentration disorganizes the delicate machinery of plant growth.

Chemical analysis

a) Total carbohydrates

Data presented in Table 4 showed that leaf total carbohydrate percent was lower in the control, and it increased linearly with increasing BA concentration in the spray solution up to 75 or 100 ppm and then tended to decrease at the higher levels (200 ppm), irrespective of the experimental season. In this regard, the highest values of total carbohydrates in the first season were recorded at 100 ppm, at which the increase in carbohydrates reached about 30% while in the second one, the greatest increase (12%), as compared with the control was obtained at 75 ppm. This trend of carbohydrate level was similar to that found by Mazrou & Al-Humaid (2000).

TABLE 4. Effects of benzyladenine (BA) on total carbohydrate and ineral elements Sntrix rose leaves during two successive growing seasons.

BA conc (ppm)	Tot. carbohyd (%)	N (%)	P (%)	K (%)	Zn (ppm)	Cu (ppm)
First season						
0.0	11.38	1.48	0.120	1.88	50.50	30.55
25	12.25	1.82	0.124	2.90	56.45	32.05
50	12.50	1.96	0.128	3.15	72.55	33.60
75	13.25	2.03	0.177	3.30	69.35	35.95
100	14.90	2.06	0.149	3.22	66.42	37.20
200	13.89	2.23	0.128	3.13	69.80	35.10
Second season						
0.0	12.27	1.38	0.135	2.40	54.35	29.50
25	12.84	1.75	0.138	2.56	54.79	33.80
50	13.65	1.88	0.143	2.98	55.42	33.82
75	13.77	2.11	0.148	3.18	62.81	35.75
100	12.12	2.30	0.145	3.15	60.43	35.60
200	12.17	2.35	0.138	2.96	63.50	34.20

As expected, the above results indicated that suitable levels of BA improved the percentage of the total carbohydrates of the leaf tissues. Such a stimulating effect could be ascribed to the positive effect of BA on the growth of leaf veins and mesophyll cells, as discussed above, containing more plastids and chlorophyll leading to an increase in photosynthesis and carbohydrate formation (Salisbury & Ross, 1992). Similarly, Awad *et al.* (1979) reported that BA increased CO_2 fixation leading to more sugar synthesis in bean leaves. In this connection, available evidence indicates that spraying plants with cytokinin compounds such as kinetin and BA promote the opening of stomata on plant leaves, thus enhancing gas (CO_2) exchange between the outside and the inside leaf tissues, increasing photosynthesis and consequently carbohydrate accumulation in the leaves of treated plants (Wareing & Phillipa, 1981).

b) Mineral elements

Except N and Zn which recorded the highest values at 200 ppm BA, all other elements (P, K, and Cu) were highest at 75 ppm (Table 4). As expected, the increase in N% was more pronounced than that in Zn%. In this regard, N concentration in 200 ppm treated-Sntrix leaves increased by about 51% in the first, while Zn increased by about 38%, as compared to control plants. A comparable trend of data was recorded at the second season. Similar results were obtained by Mazrou &Al-Humaid (2000) on Evil Tower rose plants.

These results could be explained through the role of BA in increasing the width of conductive tissues (xylem and phloem) and consequently increasing the absorption and translocation of the elements necessary for plant growth (Krishnamoorthy, 1981). Much of the evidence which associates the BA as a growth regulator with the increased elemental absorption has come from the substantial role of cytokinin-like substances in controlling the activity of vascular cambium in the roots, stimulating the division of the cells that intended to differentiate into vascular tissues (Wareing & Phillips, 1981). This, again, suggests that BA enhances secondary thickening in roots. Therefore, the size of root system becomes proportionally larger allowing more absorption of the nutrient elements from the growth media to plant roots and faster translocation to other plant organs.

In conclusion, the present study indicated that appropriate concentrations of BA can improve the vegetative growth, flowering activity, carbohydrate synthesis, nutrient absorption, and metabolic activities of Sntrix rose plants. In general, BA treatment of 75 ppm was the best among all other treatments for most parameters, while other levels higher than 75 ppm (such as 100 and 200) could not be recommended because they either reduce or do not have significant effects, at least on the parameters studied in this investigation.

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تأثير البنزيل أدنين على نمو وازهار نباتات الورد صنف سنتركس

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أجريت هذه الدراسة بمحطة البحوث والتجارب الزراعية التابعة لكلية الزراعة والطب البيطرى – جامعة الملك سعود فرع القصيم خلال موسمى ٢٠٠٠/٢٠٠١، ٢٠٠١/٢٠٠٢م ،وذلك بهدف دراسة تأثير معاملة نباتات الورد صنف سنتركس النامية تحت ظروف البيوت المحمية بمادة البنزيل أدنين. وفى هذه الدراسة تم رش النباتات أربعة مرات عل فترات شهرية ابتداء من شهر أكتوبر حتى يناير في كل من موسمى الدراسة وكانت التركيزات المستخدمة هى صفر ، ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠ ، ٢٠٠ جزء فى المليون. وأوضحت النتائج أن معاملة النباتات بالتركيزات المختلفة من البنزيل أدنين قد أدت إلى تحسن واضح في كل من النمو والقياسات الزهرية لصنف الورد سنتركس مقارنة بالنباتات الغير معاملة فى كل من موسمى الدراسة. وقد سجلت معاملة الرش بتركيز ٧٥ جزء في المليون من البنزيل أدنين أعلى زيادة معنوية في كل من عدد الأوراق على الساق الزهرية وكذلك وزنها الطازج والجاف مقارنة بباقي المعاملات. كما أدت نفس المعاملة إلى إنتاج أطول السيقان الزهرية وأكثرها سمكا وأثقلها وزنا مقارنة ببقية المعاملات ومعاملة المقارنة فى كل من موسمي التجربة، بينما أدت المعاملة بالتركيزات العالية (١٠٠ ، ٢٠٠ جزء فى المليون من مادة البنزيل أدنين) إلى حدوث تراجع فى تلك القياسات فى حين ظلت قيمتها أعلى من تلك الخاصة بالكنترول فى كلا الموسمين. بالإضافة إلى ذلك فقد تبعت صفات طول الزهرة ووزنها الطازج نفس الاتجاه السابق. كما أدت المعاملة بالتركيزات المختلفة من مادة البنزيل أدنين إلى تحسن واضح في محتوى الأوراق من الكربوهيدرات الكلية وكذلك عناصر النتروجين والفوسفور والبوتاسيوم والزنك والنحاس مقارنة بالقيم المتحصل عليها من نباتات المقارنة فى كل من موسمي التجربة.