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RESPONSE OF *SOLIDAGO HYBRIDA* VAR. "TARA" FLOWERING TO NPK FERTILIZATION, ETHREL TREATMENTS AND PINCHING APPLICATION.

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ABSTRACT: This study was carried out at the Experimental Farm of the Ornamental Plants Research Department, Hort. Res. Inst., Giza, Egypt during the two successive seasons 2006 / 2007 and 2007/ 2008. The study aimed to investigate the effect of N, P and K fertilization (ammonium sulphate (20.6% N), calcium superphosphate (15% P_2O_5) and potassium sulphate (50% K_2O) respectively) in different ratios (0.0, 10.0, 15.0 and 20.0 g/plant) added as soil drench, pinching at 5 cm. above ground surface, as well as the foliar spraying with ethrel (ethephon) at different concentrations of 0.0, 1500, 3000 and 4500 ppm, on the flowering of goldenrod (*Solidago hybrida,* "Tara"). The results showed that NPK at 15 g/plant plus spraying with ethrel at 1500 ppm significantly increased flowers weight, number of flowers and number of branches/ plant in both seasons. However, NPK at 15 g/plant plus spraying with ethrel at 3000 ppm significantly preponed flowering. On the other hand, pinching alone increased slightly flowering weight and number of flowering branches/plant, but decreased number of flowers/plant and delayed flowering.

INTRODUCTION

Solidago hybrida (family of Asteraceae) grows as a wildflower in North America, Asia and Europe. It is highly appreciated as a landscaping plant in gardens and as an excellent cut flower plant. *Solidago hybrid* var. Tara is a selected variety produced from an inter-generic cross between *Solidago* and *Aster*. It is highly productive, having good growing properties, easy to manage and outstanding post-harvest durability (Bartels, 2001).

Many authors found that, NPK increased number of flowers/plant in low and moderate rates (Lale et of (2003) on *Solidago Canadensis*, Hunmili and Paswan (2003) on gerbera and Kore *et al.*, (2004) on marigold). On the other hand Mansour (2003) reported that, the earliest flowering from *Grindelia* plants occurred with the lowest level (0.5 g/pot) of NPK (12:4:6), while the longest period to flowering was from the medium (2 g./pot) and the highest (3 g./pot) level of NPK (12:4:6) fertilization. El-Ghawwas (1988) On chamomile indicated that, the fresh and dry weights of the flower heads increased as the level of fertilization gradually increased from the low rate (100 kg/fed. of calcium ammonium nitrate + 100 kg/fed. of calcium superphosphate + 25 kg/fed. of potassium sulphate) reaching its maximum with the highest rate of NPK fertilization (300 kg/fed. of calcium ammonium nitrate + 300 kg/fed. of calcium superphosphate + 75 kg/fed. of potassium sulphate).

However, Abou-Dahab and Habib (2005) reported that the number of flowers/plant increased by pinching *Barleria cristata* plants at heights of 5 or 10 cm. On the same respect, Rakesh *et al.*, (2005) demonstrated that pinching *Chrysanthemum* at 35 days after transplanting significantly increased the number of flowers per plant, but decreased its flower weight. On the contrary, Iftikhar *et al.*, (2007) reported that pinching delayed flowering and shortened the blooming period of carnation.

Furthermore, the beneficial effect of ethephon is to produce flowers earlier and at a higher rate (Imanishi and Yue, 1987). Song *et al.* (1991) found that the application of 500 ppm ethephon increased number of flowers / plant in *Chrysanthemum.* Habib (1997) on *Dahlia hybrida* found that the biggest inflorescence number and diameter was obtained from plants treated with the highest rate of Ethryl (3000 ppm), compared to the control plants. Ohta *et al.*, (2008) studied the effects of ethephon (2-chloroethyl-1-phosphonic acid) on *Salvia coccinea* Juss. Ex Murray "Coral Nimph". Results showed that spraying ethephon at 500 and 1000 mg/L increased flower numbers and spike length.

This study was conducted to investigate the effect of NPK fertilization as a soil drench, pinching and ethrel (ethephon) on goldenrod (*Solidago hybrida*, "Tara"). The aim of the study is to find out the most suitable treatments which improve the flowering characteristics of goldenrod as one of the most important filler cut flowers.

MATERIALS AND METHODS

This study was carried out at the Experimental Farm of Hort. Res. Inst., Giza, Egypt during the two successive seasons 2006/2007 and 2007/ 2008 to investigate the effect of NPK fertilization as soil drench, pinching and foliar spraying with ethrel (ethephon) on flowering characteristics of goldenrod (*Solidago hybrida*, "Tara"), as one of the most important filler cut flowers.

Two-months-old goldenrod transplants with about 10 leaves, and 10 cm height were brought from Floramax Company, Mansoria, Giza . Seedlings were planted at mid April in rows (30 cm between rows and 25 cm apart)

All plants were exposed to additional light (to extend the day length to 16 hours) for approximately 5 weeks to produce a strong vegetative growth and delay flowering. After the lighting regime, plants begin to flower as found by (Armitage and Laushman, 2003). The additional light was applied by using 100 watt lamps at height of 1.5 m. above plants and 3 meters between lamps.

An experiment in a split plot design was laid out in order to examine the effect of two factors. The first factor was NPK application at 4 ratios as the main plot. The second factor comprised 5 treatments to encourage flowering as the sub-plot. Four of these treatments were ethrel (as aquous solution) at 0, 1500, 3000 and 4500 ppm used as foliar sprays, while the fifth treatment was pinching (decapitation) 5 cm above soil level as a substitute for ethrel. Ethrel and Pinching treatments were applied only once, 21 days after planting.

NPK treatments were prepared using ammonium sulphate (20.6% N), calcium superphosphate (15% P_2O_5) and potassium sulphate (50% K_2O) were used for preparing the suitable fertilization combinations according to the following formulae:

treatment	Total amount/plant (g)	ammonium sulphate (g)	calcium superphosphate (g)	potassium sulphate (g)
1	0	0	0	0
2	10.0	3.5	5.0	1.5
3	15.0	5.5	7.3	2.2
4	20.0	7.0	10.0	3.0

These amounts of fertilization were divided into two equal doses, the first one was applied as soil drench 45 days after planting and the other one was added one month later.

At the end of experiment the following data were recorded:

1- Flowering start date: Number of days from planting till the first flower open, (days)
2- Number of flowering branches/plant
3- Number of flowers/plant
4- fresh and dry weights of flowering stems (g)

The experiment was composed of twenty treatments, each treatment contained three replicates, each replicate contained twelve plants.

The aim of this study was to investigate the effect of NPK fertilization, ethrel and pinching on flowering yield and quality.

The obtained data were statistically analyzed using MSTAT-C (1985) Computer program. Mean were compared by L.S.D method. All percentages were transformed according to Snedecor and Chochran (1980).

RESULTS AND DISCUSSION

Flowering start date:

The effect of chemical fertilization (NPK), spraying with ethrel or pinching treatments on number of days from planting till flowering of *Solidago hybrida*, "Tara", was presented in Table (1). These data revealed the great influence of NPK at 15 g/plant in both seasons. Such treatment decreased the number of days required to flowering 88.90 and 86.60 days in the first and second seasons, respectively compared to control plants.

All concentrations of ethrel significantly decreased number of days from planting till flowering. Ethrel at 3000 ppm decreased the number of days required till flowering to 88.96 and 86.33 days in the first and second seasons respectively compared to control (untreated plants) which required more days to flowering.

On the other hand pinching plants at 5 cm above ground increased the number of days required till flowering compared to control and ethrel treatments.

Table (1): Effect of ethrel, pinching, chemical fertilization on number of days to flowering of goldenrod (*Solidago hybrida*, "Tara") plants during 2006/2007 and 2007/2008.

NPK levels / Ethrel & pinching		First season					Second season				
		NPK ratios (g/ plant)				Mean	NPK ratios (g/ plant)				Mean
		0.0	10	15	20		0.0	10	15	20	
Ethrel ppm	0	94.33	92.83	89.67	92.17	92.25	92.50	90.17	87.50	89.50	89.92
	1500	92.83	90.50	89.33	90.67	90.83	90.67	88.00	87.17	88.00	88.46
	3000	91.17	88.50	86.33	89.83	88.96	88.33	85.67	84.00	87.33	86.33
	4500	93.67	89.67	87.50	91.00	90.46	90.83	87.33	85.17	88.50	87.96
Pinching		96.00	94.67	91.67	92.33	93.67	93.17	92.33	89.17	90.50	91.29
Mean		93.60	91.23	88.90	91.20		91.10	88.70	86.60	88.77	
L.S.D 5%	NPK	0.537					0.679				
	Eth & Pinch	0.349					0.439				
	interactions	0.698					0.879				

The interaction between chemical fertilization and ethrel or pinching treatments, data in Table (1) showed that, NPK at 15 g/plant + spraying with ethrel at 3000 ppm decreased the number of days required till flowering by 86.33 and 84.00 days in the first and the second seasons, respectively compared to control (untreated plants) which required more days to flowering.

Number of flowering branches/plant:

Data in Table (2) revealed the promotive effect of NPK treatment at 15 g/plant in both seasons. It increased the values to 118.67 and 122.20 in the first and second seasons, respectively compared to 43.97 and 46.30 of the control plants.

Table (2): Effect of ethrel, pinching, chemical fertilization on number of flowering branches/plant of goldenrod (*Solidago hybrida*, "Tara") plants during 2006/2007 and 2007/2008.

NPK levels / Ethrel & pinching		First season					Second season				
		NPK ratios (g/ plant)				Mean	NPK ratios (g/ plant)				Mean
		0.0	10	15	20		0.0	10	15	20	
Ethrel ppm	0	36.83	74.00	89.50	88.67	72.25	39.17	72.67	92.42	94.08	74.58
	1500	34.50	68.50	202.00	95.33	100.08	36.17	72.58	204.75	96.58	102.52
	3000	51.33	77.50	121.33	142.17	98.08	56.00	83.08	121.58	149.42	102.52
	4500	57.00	101.17	114.83	144.50	104.38	58.25	104.25	117.17	153.33	108.25
Pinching		40.17	54.17	65.67	87.33	61.83	41.92	58.42	75.08	92.42	66.96
Mean		43.97	75.07	118.67	111.60		46.30	78.20	122.20	117.17	

L.S.D 5%	NPK	8.376	7.228
	Eth & Pinch	13.350	8.427
	Interactions	26.700	16.850

In respect to the effect of ethrel in different concentrations on number of flowering branches/ plant, data presented in Table (2) showed that, all concentrations of ethrel significantly increased number of flowering branches/plant, whereas Ethrel at 4500 ppm gave the highest mean values (104.38 and 108.25 in the first and second seasons, respectively) compared to the control untreated plants, which recorded 72.25 and 74.58 in the first and second seasons, respectively. On the other hand pinching plants presented the least values of 72.25 and 74.58 in the first and second seasons respectively.

Concerning interaction between chemical fertilization and ethrel or

pinching treatments, data in Table (2) show that, NPK at 15 g/plant + spraying with ethrel at 1500 ppm presented the highest values of number of flowering branches/plant, which recorded 202.00 and 204.75 in the first and second seasons respectively compared to the control plants which recorded only 36.83 and 39.17, in the first and second seasons, respectively.

Number of flowers/plant:

It is obviously clear from data in Table (3) that plants treated with NPK at 15 g/plant in both seasons increased the number of flowers to 4088.17 and 3916.12 in the first and second seasons, respectively compared to 2502.80 and 2475.82 of the control plants in the same seasons, respectively.

Dealing with the effect of ethrel in different concentrations on number of flowers/plant, data presented in Table (3) showed that all concentrations of ethrel significantly increased number of flowers/plant. Ethrel at 4500 ppm presented the highest values 3764.20 and 3712.27 in the first and second seasons to respectively compared to control untreated plants which recorded 3701.15 and 3584.18 in the first and second seasons respectively. On the other hand pinching plants showed the least values 2318.66 and 2363.59 in the first and second seasons respectively.

Data in Table (3) also showed that, NPK at 15 g./plant + spraying with ethrel at 1500 ppm presented the highest values of number of flowers/plant, which recorded 6731.23 and 6421.70 in the first and second seasons respectively compared to the control (NPK at 0.0 g./plant + ethrel at 0.0 ppm) which recorded 3115.20 and 3083.42, in the first and second seasons, respectively.

Flowering stems fresh weights (g):

Data representing the effect of chemical fertilization (NPK), spraying with ethrel or pinching treatments on flowering stems fresh weight of *Solidago hybrida*, "Tara" are tabulated in Table (4). These data indicated the greatest influence of treating plants with NPK at 15 g/plant in both expermintal seasons. This treatment increased the values up to 79.87 and 86.10 (g) in the first and second seasons, respectively compared with 17.78 and 20.48 (g) of the control plants.

Table (3): Effect of ethrel, pinching, chemical fertilization on number of flowers/plant of goldenrod (*Solidago hybrida*, "Tara") plants during 2006/2007 and 2007/2008.

NPK levels / Ethrel & pinching		First season					Second season				
		NPK ratios (g/ plant)				Mean	NPK ratios (g/ plant)				Mean
		0.0	10	15	20		0.0	10	15	20	
Ethrel ppm	0	3115.20	3316.38	4684.46	3688.54	3701.15	3083.42	3167.02	4050.23	4036.04	3584.18
	1500	1281.31	3545.18	6731.23	4147.98	3926.42	1204.10	3601.16	6421.70	3876.40	3775.84
	3000	2588.42	3776.49	2457.87	4233.41	3264.05	2736.80	3786.13	2352.47	4253.35	3282.19
	4500	3504.11	4084.67	3771.69	3696.35	3764.20	3499.22	3793.34	3812.29	3744.24	3712.27
Pinching		2024.98	1838.33	2795.61	2615.71	2318.66	1855.58	1911.87	2943.93	2742.98	2363.59
Mean		2502.80	3312.21	4088.17	3676.40		2475.82	3251.90	3916.12	3730.60	
L.S.D 5%		NPK		511					490		
		Eth & Pinch		1034					765		
		interactions		2068					1529		

Concerning the effect of ethrel at different concentrations on flowering stems fresh weight (g), data presented in Table (4) showed that ethrel at 4500 ppm resulted in the heaviest flowering stems as it recorded 72.42 and 78.88 g in the first and the second seasons, respectively compared to the control untreated plants which recorded 49.42 and 53.55 g. in the same seasons respectively. On the other hand, pinching plants reduced the fresh weight of flowering stems in both seasons.

In respect to the interaction between chemical fertilization and ethrel or pinching treatments, data in Table (4) showed that NPK at 15 g/plant + ethrel at 1500 ppm gave the highest values fresh weights of flowering stems which recorded 112.00 and 119.30 g in the first and the second

seasons, respectively compared to the control which recorded only 12.83 and 15.82 g in the first and second seasons respectively.

Table (4): Effect of ethrel, pinching, chemical fertilization on flowering stems fresh weights (g) of goldenrod (*Solidago hybrida*, "Tara") plants during 2006/2007 and 2007/2008.

NPK levels / Ethrel & pinching		First season					Second season				
		NPK ratios (g/ plant)				Mean	NPK ratios (g/ plant)				Mean
		0.0	10	15	20		0.0	10	15	20	
Ethrel ppm	0	12.83	60.33	58.33	66.17	49.42	15.82	65.58	63.87	68.92	53.55
	1500	17.90	31.00	112.00	51.00	52.98	21.37	36.18	119.30	54.35	57.80
	3000	17.98	69.50	89.00	74.92	62.85	20.66	77.90	94.82	82.31	68.92
	4500	20.67	83.50	92.33	93.17	72.42	23.01	90.21	98.37	103.94	78.88
Pinching		19.50	29.17	47.67	39.75	34.02	21.57	32.62	54.13	43.27	37.90
Mean		17.78	54.70	79.87	65.00		20.48	60.50	86.10	70.56	

L.S.D 5%	NPK	5.196	4.081
	Eth & Pinch	6.511	6.212
	interactions	13.020	12.420

Flowering stems dry weights (g.):

It is clear from data in Table (5) that the great influence of treated plants was with NPK at 15 g/plant in both seasons. This treatment increased the values to 24.49 and 30.23 g in the first and second seasons, respectively compared to 9.02 and 10.27 g of the control plants.

On the other hand, all concentrations of ethrel significantly increased flowering stems dry weights. Ethrel at 4500 ppm gave the heaviest plants of 22.68 and 26.621 g in the first and second seasons respectively.

compared to control untreated plants which produced 14.73 and 20.15 g in the first and second seasons, respectively. Moreover, pinching plants showed the least values (11.50 and 13.03 g. in the first and second seasons, respectively).

Concerning the interaction between chemical fertilization and ethrel or pinching treatments, data in Table (5) showed that NPK at 15 g/plant + spraying with ethrel at 1500 ppm or 3000 ppm yielded the highest values of flowering stem dry weight NPK at 15 g/plant + spraying with ethrel at 3000 ppm recorded 36.28 g in the first season compared to the control plants which recorded only 5.80 g, while NPK at 15 g/plant + spraying with ethrel at 1500 ppm. recorded 40.57 g in the second season compared to the control plants which gave only 7.11 g.

Table (5): Effect of ethrel, pinching, chemical fertilization on flowering stems dry weight (g.) of goldenrod (*Solidago hybrida,* "Tara") plants during 2006/2007 and 2007/2008.

NPK levels / Ethrel &pinching		First season					Second season				
		NPK ratios (g/ plant)				Mean	NPK ratios (g/ plant)				Mean
		0.0	10	15	20		0.0	10	15	20	
Ethrel ppm	0	5.80	14.15	18.60	20.37	14.73	7.11	24.28	23.24	25.97	20.15
	1500	10.87	9.73	31.70	19.60	17.98	11.69	10.40	40.57	22.32	21.24
	3000	9.78	17.67	36.28	21.82	21.39	12.20	18.03	40.17	28.71	24.78
	4500	9.25	27.20	23.35	30.92	22.68	10.58	28.73	31.38	35.80	26.62
Pinching		9.40	9.62	12.53	14.43	11.50	9.78	9.80	15.77	16.77	13.03
Mean		9.02	15.67	24.49	21.43		10.27	18.25	30.23	25.91	

L.S.D 5%	NPK	1.432	1.583
	Eth & Pinch	1.691	2.386
	interactions	3.383	4.772

Concerning the positive effect of NPK and ethrel on flowering of *Solidago hybrida*, "Tara", the results could be discussed as the following: the effect of NPK was investigated by some researchers. They found that NPK increased number of flowers/plant. (Lale (2003) on *Solidago canadensis*, Hunmili and Paswan (2003) on gerbera and Kore *et al.*, (2004) on marigold); induced earliest flowering from *Grindelia* plants Mansour (2003) and increased fresh and dry weights of the flower heads of chamomile El-Ghawwas (1988). Increasing flowering quality of *Solidago hybrida*, "Tara" would be reasonable since nutrition is very important for enhancing growth, due to the beneficial effects of different nutrients on activating vital processes, including essential compounds as carbohydrates, proteins, endogenous hormones, enzymes and energy reserve materials (Devlin, 1975).

Concerning the effect of ethrel, number of flowers/plant and inflorescence number increased by spraying with ethrel. (Song *et al.* (1991) on *Chrysanthemum*, Habib (1997) on *Dahlia hybrida* and Ohta *et al.*, (2008) on *Salvia coccinea* Juss. Ex Murray "Coral Nimph". Ethephon (2-chloroethyl phosphonic acid) exerts its effect by gradually releasing ethylene as a decomposition product close to the site of action in plant tissue (Yang, 1969). The beneficial effect of ethephon is to produce flowers earlier and at a higher rate (Imanishi and Yue, 1987). Ethylene gas is more effective than ethephon to achieve flowering induction (Py *et al.*, 1984). Ethylene is responsible for signaling the switch from vegetative into flowering stage (Burg and Burg, 1966 and Bartholomew, 1977).

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إستجابة الصفات الزهرية لنبات السوليداجو صنف تارا إلى معاملات التسميد بالـ (NPK) ، الإثريل ، التطويش و التفاعل بينهم

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الملخص العربى

تم إجراء هذه الدراسة بمزرعة التجارب، قسم بحوث نباتات الزينة، معهد بحوث البساتين، الجيزة، مصر، خلال موسمين متتالين ٢٠٠٦/٢٠٠٧ و٢٠٠٧ /٢٠٠٨ لبيان تأثير التسميد الكيماوي (NPK) بمعدلات مختلفة (صفر، ١٠ ، ١٥ ، ٢٠ جم/نبات) كإضافة للتربة، و التطويش على إرتفاع ٥ سم من سطح التربة، الرش الورقي بالإثريل (الاثيفون) بتركيزات مختلفة (صفر، ١٥٠٠ ، ٣٠٠٠ و ٤٥٠٠ جزء في المليون) على مواصفات الأزهار في نبات السوليداجو.

أظهرت النتائج ما يلي: التسميد الكيماوي (NPK) بمعدل ١٥ جم/نبات + الرش الورقي بالاثريل بتركيز ١٥٠٠ جزء في المليون أحدث زيادة معنوية في الوزن الطازج للسوق المزهرة في كلا الموسمين و الوزن الجاف للسوق المزهرة (جم) في الموسم الأول فقط وعدد الأزهار و الأفرع المزهرة/نبات في كلا الموسمين. التسميد الكيماوي (NPK) بمعدل ١٥ جم/نبات + الرش الورقي بالاثريل بتركيز ٣٠٠٠ جزء في المليون أبدت زيادة معنوية في الوزن الجاف للسوق المزهرة في الموسم الثاني، و نفس هذه المعاملة قللت معنوياً عدد الأيام من الزراعة حتى التزهير. من جهة أخرى وجد أن التطويش منفرداً عمل على إحداث زيادة طفيفة في وزن الأزهار و عدد الأفرع الزهرية/نبات و لكنه قلل من عدد الأزهار/نبات و أخر التزهير و ذلك مقارنة بباقي المعاملات.

• من خلال هذه النتائج يمكن التوصية بمعاملة نباتات السوليداجو بالتسميد الكيماوي (NPK) بمعدل ١٥ جم/نبات + الرش الورقي بالاثريل بتركيز ١٥٠٠ أو ٣٠٠٠ جزء في المليون للحصول على صفات زهرية جيدة للنباتات.