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Effect of spraying thiamin and salicylic acid on growth and flowering of *Zinnia elegans* L.

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Abstract. This study was conducted during spring and summer seasons of 2011 to study the effect of foliar spraying of thiamin at 0, 60 and 120 mg L^{-1} and/or salicylic acid at 0, 25 and 50 mg L^{-1} on growth and flowering of Zinnia plant in a factorial experiment designed with R.C.B.D. Means were compared according to R.L.S.D test at probability 0.05. Results showed a significant increase in plant height, number of leaves $plant^{-1}$, leaf area, (dry matter, total chlorophyll, protein, phosphorus and potassium content in leaves), number of roots $plant^{-1}$, root dry weight, number of flowers $plant^{-1}$, flower diameter, dry weight of flowers and vase life when spraying with thiamin at 120 mg L^{-1} or salicylic acid at 50 mg L^{-1}. The interaction between the two factors increased significantly the number of leaves $plant^{-1}$ to 32.00 when spraying with 120 mg L^{-1} thiamin + 25 mg L^{-1} salicylic acid, whereas spraying with thiamin at 120 mg L^{-1} + salicylic acid at 50 mg L^{-1} increased significantly number of roots $plant^{-1}$, root dry weight, number of flowers $plant^{-1}$ and flower diameter to (10.20 root $plant^{-1}$, 0.499 g, 16.00 flower $plant^{-1}$ and 8.68 cm, respectively) as compared to distilled water treatment which gave (6.30 root $plant^{-1}$, 0.31 g, 11.30 flower $plant^{-1}$ and 5.85 cm, respectively).

Key Words: Floriculture, plant hormones, vitamins, *Zinnia elegans* L.

Introduction. Zinnia (*Zinnia elegans*) is an important ornamental plant and a cut flower which can be easily grown in pots, borders, beds, edges, window boxes and rock gardens. It is a diverse genus of family *Asteraceae* having *Zinnia elegans* and *Zinnia haagaena* the two most promising among 20-30 species. Flowers are multi-colored i.e., pink, cherry, purple, red, orange, etc. (Reilly 1978; Yassin & Ismail 1994; Javid et al 2005).

Vitamins could be considered as bio-regulator compounds which affect plant growth when applying in low concentrations. Thiamin (vitamin B1) is an important cofactor for the transketolation reactions of the pentose phosphate cycle, which provides pentose phosphate for the reduced NADP required and for nucleotide synthesis or various synthetic pathways (Kawasaki 1992). Thiamin pyrophosphate (TPP) is an essential cofactor required by enzymes involved in a number of important metabolic processes including the production of acetyl-CoA, tricarboxylic acid cycle, Calvin cycle and branched chain amino acid biosynthesis (Hohmann & Meacock 1998).

Youssef & Talaat (2003) reported that vegetative growth and chemical constituents in rosemary plant were increased by foliar application of Thiamin. Whereas foliar spraying of gladiolus plant *Gladiolus grandiflorus* L. with 100 ppm thiamin increased plant height, number of leaves, shoot dry weight, number of florets, chlorophyll content, total soluble sugars and N, P and K % (Alabdaly 2012).

Al-Abbasi (2014) mentioned that plant length, root length, total soluble carbohydrate content in shoots and roots, protein content in shoots and roots and dry matter in roots of sweat pea *Lathyrus odoratus* L. were increased significantly as the applied concentration of vitamin B1 was increased.

Salicylic acid (SA) ($C_7H_6O_3$) is a phenolic plant hormone which is produced naturally from Salix tree, leaves and bark of these trees are used in some infections that affect human, which has led to the discovery of Salicil-n materials and produce Aspirin (Raskin

1992). SA has a positive effect on photosynthesis and carbohydrates accumulation in plants which might be the cause compactness of flower (Khodary 2004). Larqué-Saavedra & Martin-Mex (2007) suggested that the increase in bioproductivity of plants is mainly due to the positive effect of SA on root length and density.

Al-Dulaymy (2012) found that spraying Chinese ester plant *Callistephus chinensis* L. with SA increased leaf area and number of flowers. Hasan (2013) mentioned that spraying Marigold plant *Calendula officinalis* L. with SA at 50 mg L^{-1} resulted in a significant increase in plant height, flower dry weight.

An investigation on marigold plants to evaluate the effect of the two factors of our study was held in a factorial experiment by Soltani et al (2014) reported that, thiamin at 50 and 100 mg L^{-1} increased stem height while number of flowering stems was raised by applying SA at 50 mg L^{-1} + thiamin at 100 mg L^{-1}, whereas application of SA at 50 mg L^{-1} increased fresh and dry weights. The highest fresh and dry weight was obtained by thiamin at 100 mg L^{-1}.

For the importance of Zinnia plant, this experiment was conducted to study the effect of spraying three concentrations of thiamin and SA in the growth and flowering of this plant.

Material and Method. This study was carried out at the Center of Date Palm Researches, University of Basrah, during spring and summer seasons (16/3 to 31/7/2011) to evaluate the effect of thiamin and salicylic acid and their interaction combinations on growth and flowering of Zinnia plant. Harmonized Zinnia seedlings of 12 ± 2 cm length were transplanted in pots of 25 cm diameter filled with sand and organic fertilizer at 3:1. Plants were spread with thiamin solutions and/or SA twice, the first spraying was after 21 days of planting (1/4/2011), while the second one took part two weeks latter and control treatment plants were sprayed with distilled water instead. All pots received the same amount of irrigation water and all service operations were conducted as plants needed.

A factorial experiment designed with Randomized Complete Block Design (R.C.B.D.) was conducted with three replicates. The first factor was the three concentrations of thiamin (0, 60 and 120 mg L^{-1}), and the second the three concentrations of SA (0, 25 and 50 mg L^{-1}). Means were compared with the RLSD test at $p \leq 0.05$ (Al-Rawi & Khalaf-Alla 2000).

Data was recorded at 15/4/2011 which included:

- plant height (cm);
- number of leaves ($plant^{-1}$);
- leaf area (cm^2): was measured according to (Dvorinic 1965);
- dry mater in leaves (%). Fresh weight of leaves was measured, then they were dried in an aerated oven at 70 Cº for each plant then dry matter was calculated.
- total chlorophyll content in leaves (mg g^{-1} fresh wt): was estimated according to (Goodwin 1976);
- protein (%). Nitrogen was estimated as described by Jackson (1958). Then protein was evaluated according to the reported procedures in A.O.A.C. (1970) by the equation: (Protein = N % X 6.25);
- phosphorus and potassium (%). P % was evaluated using spectrophotometer, while flame photometer was used for the determination of K% (Page et al 1982);
- number of the main roots $plant^{-1}$: were calculated after extracting the plants from their pots and placing them in a water basin for 24 hours;
- roots dry weight (g): roots were cutting off the from the shoot then they were placed in an aerated oven at 70 Cº until the weight is constant;
- number of flowers $plant^{-1}$;
- flower diameter (cm): was measured by Varner Caliper at the maximum point breadth for each flower;
- flower dry weight (g): was determined by placing the flowers in an aerated oven at 70 Cº until the weight is constant;
- vase life (day). Three fully opened flowers were taken randomly from each treatment, placing in glass jars filled with distilled water at room temperature (25 ± 2 Cº) and vase

life was determined by calculating the number of days until the level of senescence became unacceptable (Schnelle et al 1992; Zarchini et al 2013).

Results and Discussion. Results showed that the higher rate values of plant height, number of leaves plant^{-1}, leaf area and dry matter in leaves (48.03 cm, 29.69 leaf plant^{-1}, 57.96 cm^2 and 32.77% respectively) were recorded by foliar application of thiamin at 100 mg L^{-1}, whiles spraying with SA at 50 mg L^{-1} the recordings was 44.66 cm, 28.59 leaf plant^{-1}, 56.22 cm^2 and 27.16%, respectively, compared to untreated plants.

The interaction between the two studied factors (thiamin at 60 mg L^{-1} + SA at 25 mg L^{-1}) affected vegetative growth, where the number of leaves increased significantly to 32.00 leaf plant^{-1}. On the contrary, no significant effect on plant height, leaf area and dry mater percentage in leaves was detected (Table 1).

Table 1

Effect of spraying thiamin and SA on vegetative growth parameters of Zinnia plant

Treatments			*Plant height (cm)*	*No. of leaves (plant^{-1})*	*Leaf area (cm^2)*	*Dry matter (%) in leaves*
Thiamin conc. mg L^{-1}		0	38.80	22.89	51.32	18.90
		60	43.90	27.70	54.41	4.762
		120	48.03	29.69	57.96	32.77
L.S.D. $_{0.05}$			1.655	1.645	1.557	2.421
SA conc. mg L^{-1}		0	41.93	24.54	52.86	22.72
		25	44.13	27.15	54.60	26.56
		50	44.66	28.59	56.22	27.16
L.S.D. $_{0.05}$			1.797	1.707	1.691	2.629
Thiamin conc. mg L^{-1} X SA conc. mg L^{-1}	0	0	37.50	21.52	49.89	17.20
		25	39.20	23.00	50.67	18.90
		50	39.70	24.17	53.41	20.61
	60	0	42.00	23.92	52.50	19.85
		25	45.10	32.00	54.02	26.00
		50	44.60	27.19	56.71	28.45
	120	0	46.30	28.20	56.20	31.12
		25	49.70	30.78	59.13	34.78
		50	48.10	30.11	59.55	32.42
L.S.D. $_{0.05}$			NS	3.444	NS	NS

NS = No significant differences among the means ($p<0.05$).

Also, applying thiamin at 120 mg significantly increased the leaf content of chlorophyll, protein, phosphorus and potassium (3.31 mg g^{-1}, 12.51%, 0.31% and 0.35%, respectively) (Table 2).

Similarly, these growth parameters were increased by applying SA at 50 mg L^{-1} and recorded 3.30 mg g^{-1}, 12.22%, 0.31% and 0.33%, respectively. But, the increasing of potassium percentage in leaves was not significant. Similar results were recorded in *Brassica juncea* plant (Fariduddin et al 2003) and in Gladiolus plant (Alabdaly 2012) by foliar application of thiamin, and by Hasan (2013) when applying SA, and Soltani et al (2014) by application of Thiamin and/or SA on Marigold plant.

Table 3 indicated that, spraying with thiamin at 120 mg L^{-1} has led to a significant increase in the number of main roots plant^{-1} and dry weight of roots (9.43 root plant^{-1} and 0.496 g, respectively) compared to control treatment. Data presented in Table 3 also showed that the SA has a positive effect on number of main roots plant^{-1} and dry weight of roots (8.43 root plant^{-1} and 0.444 g, respectively). But the interaction between the two studied factors showed a significant increase in number of roots plant^{-1} and dry weight of roots (10.20 root plant^{-1} and 0.499 g, respectively), these results was in lined with Al-Abbasi (2014) who mentioned that, thiamin improved root growth in sweat pea; on the other hand SA stimulates root growth by raising cytokine levels, which increase cell division.

Table 2

Effect of Spraying Thiamin and SA on some chemical characteristics of zinnia Plant

Treatments			Total chlorophyll in leaves (mg g^{-1})	Protein in leave (%)	Phosphorus in leaves (%)	Potassium in leaves (%)
Thiamin conc. mg L^{-1}	0		3.17	10.18	0.27	0.29
	60		3.26	11.93	0.29	0.34
	120		3.31	12.51	0.31	0.35
L.S.D. $_{0.05}$			0.027	0.834	0.009	0.030
SA con. mg L^{-1}	0		3.18	10.80	0.27	0.32
	25		3.27	11.60	0.28	0.33
	50		3.30	12.22	0.31	0.33
L.S.D. $_{0.05}$			0.027	1.160	0.009	NS
Thiamin conc. mg L^{-1} X SA conc. mg L^{-1}	0	0	3.09	10.05	0.25	0.28
		25	3.20	10.24	0.27	0.30
		50	3.23	10.24	0.29	0.31
	60	0	3.21	10.37	0.28	0.33
		25	3.25	11.74	0.28	0.35
		50	3.33	13.68	0.32	0.34
	120	0	3.24	11.99	0.29	0.35
		25	3.36	12.81	0.30	0.36
		50	3.35	12.74	0.34	0.35
L.S.D 0.05			NS	NS	NS	NS

NS = No significant differences among the means ($p<0.05$).

Table 3

Effect of thiamin and SA on root growth of Zinnia plant

Treatments			Average no. roots ($plant^{-1}$)	Dry weight of roots (g)
Thiamin conc. mg L^{-1}	0		6.80	0.331
	60		7.70	0.461
	120		9.43	0.496
L.S.D. $_{0.05}$			0.280	0.008
SA conc. mg L^{-1}	0		7.33	0.411
	25		8.16	0.433
	50		8.43	0.444
L.S.D. $_{0.05}$			0.294	0.008
Thiamin conc. mg L^{-1} X SA con. mg L^{-1}	0	0	6.30	0.315
		25	6.80	0.332
		50	7.30	0.347
	60	0	7.50	0.425
		25	7.80	0.471
		50	7.80	0.488
	120	0	8.20	0.493
		25	9.90	0.497
		50	10.20	0.499
L.S.D 0.05			0.554	0.014

NS = No significant differences among the means ($p<0.05$).

In current study we recognized that increasing thiamin concentration form 0 to 120 mg L^{-1} or SA from 0 to 50 mg L^{-1} led to a significant increase in number of flowers $plant^{-1}$, flower diameter, flower dry weight and vase life (Table 4), these results are in agreement with those reported by Soltani et al (2014), and Abdi et al (2009).

Table 4

Effect of thiamin and SA on some flowering indicators of Zinnia plant

Treatments			*Average no. of flowers ($plant^{-1}$)*	*Flower diameter (cm)*	*Flower dry weight (g)*	*Vase Life (day)*
Thiamin conc. mg L^{-1}		0	12.26	6.14	1.31	5.13
		60	14.06	7.08	1.95	7.06
		120	15.33	8.43	2.17	8.00
L.S.D. $_{0.05}$			0.192	0.071	0.317	0.300
SA conc. mg L^{-1}		0	13.10	6.79	1.63	6.40
		25	14.03	7.33	1.89	6.76
		50	14.53	7.53	1.92	7.03
L.S.D. $_{0.05}$			0.194	0.071	0.345	0.335
Thiamin conc. mg L^{-1} X SA conc. mg L^{-1}	0	0	11.30	5.85	1.20	4.90
		25	12.70	6.27	1.31	5.10
		50	12.80	6.30	1.41	5.40
	60	0	13.10	6.42	1.60	6.50
		25	14.30	7.21	2.15	7.30
		50	14.80	7.63	2.13	7.40
	120	0	14.90	8.11	2.09	7.80
		25	15.10	8.52	2.21	7.90
		50	16.00	8.68	2.22	8.30
L.S.D. $_{0.05}$			0.370	0.132	NS	NS

NS = No significant differences among the means ($p<0.05$).

In respect to the interaction between thiamin and SA, results showed that thiamin at 120 mg L^{-1} + SA at 50 mg L^{-1} increased significantly the number of flowers $plant^{-1}$ to 16.00 and flower diameter to 8.68 cm as compared to control treatment which gave the least values: 11.30 flower $plant^{-1}$ and 5.85 cm. Similar findings have been reported by Nahed et al (2009) when applying Thiamin at 100 ppm on gladiolus plants.

Several studies mentioned that application of thiamin increase the endogenous level of cytokinins and gibberellins and some other growth factors which affect meristem and enhanced plant growth in addition to the role of thiamin in plant biosynthetic pathways (Malamy et al 1996; Ahn et al 2005), while the increase of plant growth indicators by applying SA due to the important physiological roles of SA in plant growth, absorption of ions by plant, also stimulating chlorophyll formation, some enzymes and photosynthesis processes, it was suggested that it has an important role in the synthesis of chloroplasts (Hayat et al 2007).

However, the improvement of flowering criteria resulted from thiamin`s role in carbohydrate metabolism which controlled growth. Meanwhile the role of SA is attributable to improve vegetative growth and that lead to an increase in the absorption of nutrients, also it promotes photosynthesis in plant that lead to carbohydrate manufacturing which affected clearly in the differentiation of flowers and increased their number. SA also involve in Auxin increasing, which enhance flower growth, whereas the elongation of vase life due to SA role as an ethylene biosynthesis inhibitor that blocks the induction effect of ethylene on ACC-oxidase (1-aminocyclopropane-1-carboxylic acid) activity inhibition and consequently a delaying in flower senescence's symptoms occur (Hayat et al 2007; Zamani et al 2011).

Conclusions. The results obtained in this study cleared that spraying with thiamin or salicylic acid improved plant growth and flowering, while spraying with thiamin at 120 mg L^{-1} + salicylic acid at 50 mg L^{-1} improved roots growth and increased significantly the number of flowers per plant and flower diameter.

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