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ORIGINAL ARTICLE

EFFECT OF GA3 AND ATONIK ON VEGETATIVE GROWTH AND FLOWERING OF *CELOSIA CRISTATA*

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Abstract: This study was conducted in the lath house belonging to the Department of Plant Production Techniques, Al-Mussaib Technical College during the spring season 2018-2019 to study the effect of spraying growth regulator Atonik with four levels (0, 1, 2, 3) ml.L^{-1} symbolized by (A0, A1, A2, A3) and gibberellin acid with four levels (0, 50, 100, 150) mg.L^{-1} symbolized by (G0, G1, G2, G3) on the vegetative and flowering traits of a *Celosia cristata* plant. A factorial experiment was conducted according to the Completely randomized design (CRD) with three replicates, and the averages were compared according to the least significant difference test (LSD) at the 0.05% probability level. The results showed that the treatment (A1) significantly excelled and gave the highest average of leaf area 43.2 cm^2, the fresh weight of the vegetable growth 39.3 g, dry weight of inflorescence 0.98 g and the inflorescence length 6.94 cm. Where treatment A3 gave the highest average of leaves number reached 47.3 leaf.$plant^{-1}$ and treatment A2 gave the highest value of flower stalk length 39.79 g and the fresh weight of inflorescence 6.52 g. The A3 and A2 treatments also significantly excelled and gave the highest values for the vase life (18.67 and 18.33 day), as for spraying gibberellin, where the treatment G1 was significantly excelled and gave the highest average for traits leaf area 37.2 cm^2, the fresh weight of the vegetable growth 41.7 g, dry weight of vegetative growth 5.21 g. The inflorescence length 6.98 cm, while the G2 treatment was also significantly excelled and gave the highest values for traits flower stalk length 41.25 cm, flower stalk diameter 11.63 mm and The inflorescence diameter 49.5 mm. While the treatment of A2 + G2 excelled and gave the highest average of flower stalk length and the fresh weight of inflorescence amounted to (44.00 cm and 7.20 g).

***Key words*:** Atonik, Gibberellin, *Celosia cristata*, Completely randomized design (CRD).

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1. Introduction

Celosia cristata, which belongs to the Amaranthaceae family and is a summer annual plant, the flowers are found in its inflorescence at the plant top the similar to the crista galli, hence the name came, and this custom is different colours, including scarlet red, yellow, orange, pink [Ilodibia *et al*. (2016)]. Plant height can reach one meter, stem vertical, single polygon, branched from above. The leaves are simple, oval, greenish-red, with filaments, the stalk is thick, spike-like, and its native habitat in Indonesia [Altaee and Alsawaf (2019)]. It prefers low wet and sunny places. Atonik is considered one of the modern plant growth regulators and it is an aromatic nitrogenous compound that causes its users to increase the biological activities of the plant and without causing any distortion or toxicity to the plant treated with it [AL-Chalabi *et al*. (2019)]. It is easily absorbed by plant members and increases the flow of plant sap, which gives additional strength and vitality to plant cells and also helps early production. The increase in biological and biochemical activities in the plant without causing any deformation or toxicity on the surfaces of the plants it is treated with, either chemically it is the term Sodium ortho-

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nitrophenolate. This gives it easy absorption by the vegetative growth in the plant and increases the flow of vegetable succulents, thus giving additional strength and vitality to the plant cells and also helps in early production [Al-Bayati (2006)]. It also has a role in effecting changes towards increased stimuli before the flowering process. Gibberellins also play a major role in growth, allocating tissues functionally, and redistributing dry matter within the plant for the benefit of biological activities [Khader *et al*. (2001)]. Gibberellins are described as a group of hormonal growth stimulants, which is one of the phytohormone that are naturally manufactured within Endogenous plant tissues. Terpenoids possess carboxyl groups and this is why they are called gibberellic acid [Raghda'a *et al*. (2020)]. Gibberellin is a plant growth regulator that has a major role in increasing growth through its effect on biological activities in the processes of division and cellular expansion, as it increases the size of the meristem region and has a clear effect on the expansion of the cell wall and thus affects the building of nuclear acids, DNA, RNA and protein and all these effects have a great role in Physiological processes within plants [Tiwari *et al*. (2018)]. The research aims to study the effect of foliar spraying of the Atonik and gibberellin on the vegetative and flowering traits of a *Celosia cristata* plant.

2. Materials and Methods

This research was conducted in the lath house belonging to the Department of Plant Production Techniques, Al-Mussaib Technical College during the spring season 2018-2019 to study the effect of spraying growth regulator Atonik and gibberellic acid on the vegetative and flowering traits of a *Celosia cristata* plant. The seeds were cultivated in cork dishes containing Peat moss and after the growth of seedlings and four leaves on them were transferred to black bags of polyethene with a capacity of 17 × 15 cm filled with river soils + peat moss at the percentage of 2:1, all servicing operations were conducted from weeding, hoeing and irrigation throughout the experiment period, The experiment factors: The first factor: spray with Atonik growth regulator has four levels (0, 1, 2, 3) $ml.L^{-1}$ and which are symbolized by (A0, A1, A2, A3), the second factor: spraying with gibberellic acid and four levels (0,50,100,150) $mg.L^{-1}$ and which are symbolized by (G0, G1, G2, G3). The spraying operations started one week after cultivated seedlings, at the rate of three sprayers between one spray and another two weeks, and in each spray, the Atonik is sprayed, then after two days the spraying is made with gibberellin until the end of the spraying operations, and the following traits were measured (number of leaves ($leaf.Plant^{-1}$), leaf area (cm^2), the fresh weight of the vegetable growth (g), dry weight of vegetative growth (g), the leaf content of chlorophyll (Spad), flower stalk diameter (mm), flower stalk length (cm), dry weight of inflorescence (g), the inflorescence diameter (mm), the inflorescence length (cm), the fresh weight of inflorescence (g), vase life (day)).

A factorial experiment was conducted according to the Completely randomized design (CRD) with three replicates, and the averages were compared according to the least significant difference test (LSD) at the 0.05% probability le.)].

3. Results and Discussion

3.1 Number of leaves (leaf. $Plant^{-1}$)

The results in Table 1 showed that the A3 treatment was significantly excelled and gave the highest average number of leaves reached 47.3 $leaf.Plant^{-1}$, while A2 gave the lowest number of leaves amounted to 36.5 $leaf.Plant^{-1}$, and the results showed that the spray of gibberellin had a significant effect in increasing the number of leaves on *Celosia cristata*, its treatment G3 significantly increased and gave the higher average number of leaves reached 48.9 $leaf.Plant^{-1}$, where the control treatments G0 gave the lowest average number of leaves amounted to 40.6 $leaf.Plant^{-1}$ and the results also showed that the interaction treatments between the experiment factors had a significant effect on increasing the number of leaves, where the interaction treatments (A3 + G3) and (A1 + G1) significantly excelled and without significant differences between them and gave the highest average the number of leaves

Table 1: The effect of spraying with Atonik and Gibberellins and their interaction in the number of leaves of *Celosia cristata* plant.

Atonik (A) $ml.L^{-1}$	GA3 (G) $mg.L^{-1}$				Average
	G0	G1	G2	G3	
A0	17.83	21.70	20.73	8.40	17.17
A1	7.93	9.53	8.20	8.97	8.66
A2	8.17	7.07	7.43	10.17	8.21
A3	8.73	8.20	8.00	7.80	8.18
Average	10.67	11.63	11.09	8.83	
L.S.D 0.05	A= 2.33		G= 2.33		A*G= 4.66

Table 2: The effect of spraying with Atonik and Gibberellins and their interaction in the leaf area (cm^2) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	29.3	41.2	32.1	33.4	34.0
A1	29.5	39.5	32.6	35.1	43.2
A2	36.5	36.1	26.4	28.5	31.9
A3	26.7	32.2	29.8	28.7	29.3
Average	30.5	37.2	30.2	31.4	
L.S.D 0.05	A= 6.12		G= 6.12		A*G= 12.24

reached (53.3, 54.0 leaf.Plant^{-1}). It excelled on the control treatment (A0 + G0), which gave the lowest average number of leaves reached 32.7 leaf.Plant^{-1}.

3.2 Leaf area (cm^2)

Table 2 results showed the significant effect of Atonik spray on increasing the leaf area of the Celosia cristata, where treatment A1 significantly increased and gave the highest average of leaf area amounted to 43.3 cm^2, while treatment A3 gave the lowest average of leaf area reached 29.3 cm^2. The results also showed that the spraying of gibberellin had a significant effect in increasing the leaf area, where G1 treatment gave the highest average of leaf area reached 37.2 cm^2, while the control treatment gave the lowest average of leaf area reached 30.5 cm^2, while the results also showed that the interaction between gibberellin and Atonik had a significant effect on the average of the leaf area, where the interaction treatment (G0 + A2) and (A2 + G1) significantly excelled and without significant differences between them and gave the highest average reached (36.1, 36.5 cm^2) while the control treatment (G0 + A0) gave the lowest average area 29.3 cm^2.

3.3 The fresh weight of the vegetable growth (g)

The results in Table 3 showed the significant effect of Atonik in increasing the fresh weight of the vegetative growth, where the (A2, A1, A0) treatments significantly excelled and gave the highest average amounted to (36.76, 39.3, 39.3 g), respectively, while the A3 treatment gave the lowest values amounted to 28.6 g. The results also showed significantly excelled of gibberellin spray, where G1 treatments gave the highest fresh weight of the vegetative growth amounted to 41.7 g, where G3 treatments gave the lowest average fresh weight amounted to 52.7 g. The effect of interaction treatments between the experiment factor (gibberellin, Atonik) was significant in the traits of the fresh weight

Table 3: The effect of spraying with Atonik and Gibberellins and their interaction in the fresh weight of the vegetable growth (g) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	29.6	48.8	39.7	38.9	39.3
A1	33.7	50.3	32.4	40.8	39.3
A2	34.9	40.3	43.6	27.9	36.7
A3	35.9	27.9	27.9	23.3	28.6
Average	33.5	41.7	35.9	32.7	
L.S.D 0.05	A= 7.94		G= 7.94		A*G= 15.88

of vegetative growth, where the treatment (G2 + A2) and (G1 + A2) was significantly excelled and gave the highest average of fresh weight reached (43.6, 40.36) g respectively, excelled on the control treatment (G0 + A0), which gave the lowest weight amounted to 29.6 g.

3.4 The dry weight of the vegetative growth (g)

The results in Table 4 showed that the A0 treatment significantly excelled and gave the highest average of the dry weight of the vegetative growth amounted to 4.95 g, where A3 treatment gave the lowest average amounted to 3.42 g, while Gibberellin spray G1 gave the highest average dry weight of the vegetative growth amounted to 5.21 g, excelled on the control treatment that gave the lowest average reached 4.06. As for the effect of interaction between the experiment factors, the interaction (G1 + A1) gave the highest average dry weight amounted to 6.17 g, while the (G3 + A3) gave the lowest average dry weight reached 2.67 g.

3.5 The leaf content of chlorophyll (spad)

Table 5 showed that the treatments (A1, A2) were significantly excelled and gave the highest average amounted to (20.76, 21.95) spad, respectively, excelled on the control treatment (A0) , which gave the lowest average of chlorophyll in the leaves amounted to 15.99 spad. The results showed that the G0 and G3 treatments

Table 4: The effect of spraying with Atonik and Gibberellins and their interaction in the dry weight of the vegetative growth (g) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	3.50	5.83	5.47	5.00	4.95
A1	4.03	6.17	4.03	5.23	4.87
A2	4.63	5.13	5.13	3.70	4.65
A3	4.07	3.70	3.23	2.67	3.42
Average	4.06	5.21	4.47	4.15	
L.S.D 0.05	A= 1.00		G= 1.00		A*G= 2.01

Table 5: The effect of spraying with Atonik and Gibberellins and their interaction in the leaf content of chlorophyll (spad) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	15.47	15.23	15.80	17.47	15.99
A1	25.37	18.13	17.83	21.70	20.76
A2	23.83	18.10	21.27	24.60	21.95
A3	19.37	11.77	16.73	21.47	17.33
Average	21.01	15.81	17.91	21.31	
L.S.D 0.05	A= 3.15		G= 3.15	A*G= 6.30	

significantly excelled and gave the highest average of chlorophyll content reached (21.31, 21.01) spad, respectively, while G1 gave the lowest average of chlorophyll content reached 15.81 spad, and the same table results also showed the significant effect of interaction between gibberellin and Atonik in increasing the chlorophyll content, where the interaction treatment (G0 +A1) gave the highest average of chlorophyll in the leaves was (25.37) spad, while the control treatment gave the lowest leave content of chlorophyll reached 15.47 spad.

3.6 The flower stalk diameter (mm)

The results in Table 6 showed that the A0 treatment significantly excelled and gave the highest average of flower stalk diameter to a *Celosia cristata* plant amounted to 17.17 mm, while the treatment A3 gave the lowest average amounted to 8.18 mm. The results also showed that spraying the gibberellins had a significant effect in increasing the flower stalk diameter. Where treatments (G1 and G2) were significantly excelled and gave the highest values for the flower stalk diameter amounted to (11.09, 11.63) mm, respectively, while the treatment G3 gave the lowest average amounted to 8.83 mm. While the results showed

Table 6: The effect of spraying with Atonik and Gibberellins and their interaction in the flower stalk diameter (mm) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	17.83	21.70	20.73	8.40	17.17
A1	7.93	9.53	8.20	8.97	8.66
A2	8.17	7.07	7.43	10.17	8.21
A3	8.73	8.20	8.00	7.80	8.18
Average	10.67	11.63	11.09	8.83	
L.S.D 0.05	A= 2.33		G= 2.33	A*G= 4.66	

Table 7: The effect of spraying with Atonik and Gibberellins and their interaction in the flower stalk length (cm) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	39.80	34.89	39.67	39.17	38.37
A1	39.50	36.17	39.83	37.33	38.21
A2	39.67	32.33	44.00	43.17	39.79
A3	37.67	37.67	41.50	35.50	38.08
Average	39.16	35.25	41.25	38.79	
L.S.D 0.05	A= 2.95		G= 2.95	A*G= 5.90	

the interaction between gibberellin and Atonik, the interaction treatments (G1 + A2) and (G2 + A0), and without significant differences between them and gave the highest average amounted to (21.70 and 20.73) mm, respectively, while the interaction treatment (G1 + A2) gave the lowest average flower stalk diameter reached 7.07 mm.

3.7 The flower stalk length (cm)

The results in Table 7 showed that the A2 treatment significantly excelled and gave the highest average of flower stalk length 39.79 (cm), while the A3 treatment gave the lowest average amounted to 38.08 cm, and the results showed that Gibberellin spray had a significant effect on increasing flower stalk length, the G2 treatment significantly increased and gave the highest average of flower stalk length reached 41.25 cm while treatment G1 gave the lowest average of 35.25 cm. As for the interaction between the Gibberellin and Atonik, treatment (A2 + G2) was significantly excelled and gave the highest average amounted to 44.00 cm, while treatment (A1 + G1) gave the lowest amounted to 32.33 cm.

3.8 The dry weight of inflorescence (g)

The results in Table 8 showed that Atonik spraying

Table 8: The effect of spraying with Atonik and Gibberellins and their interaction in the dry weight of inflorescence (g) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	1.06	0.60	1.26	0.90	0.95
A1	1.00	0.96	0.86	1.10	0.98
A2	0.80	0.80	1.16	1.06	0.95
A3	1.03	0.86	0.43	0.50	0.70
Average	0.97	0.80	0.93	0.89	
L.S.D 0.05	A= 0.31		G= 0.31	A*G= 0.62	

had a significant effect on the dry weight of inflorescence of *Celosia cristata* plant. The results showed a significant increase in the treatment (A1) and gave the highest dry weight amounted to 0.98 g, while the A3 treatment gave the lowest average of the dry weight of inflorescence amounted to 0.70 g. The treatment G0 was significantly excelled and gave the highest dry weight of inflorescence amounted to 0.97 g, while the G1 treatment gave the lowest dry weight of inflorescence reached 0.8 g, as the results showed the significant effect of the interference between the experiment factors, while the interaction treatment (A0 + G2) was significantly higher and gave the highest average amounted to 1.26 g, while the interaction treatment (A3 + G2) gave the lowest average dry weight of inflorescence amounted to 0.43 g.

3.9 The inflorescence diameter (mm)

The results in Table 9 showed the significant effect of Atonik in increasing the inflorescence diameter (mm), where the (A0, A3) treatments significantly excelled and gave the highest average amounted to (50.7,51.8 mm), respectively, while the A1 treatment gave the lowest values amounted to 45.0 mm. The results also showed significantly excellence of gibberellin spray, where(G2 and G3) treatments gave the highest inflorescence diameter amounted to (49.3, 49.5 mm), where G1 treatments gave the lowest average amounted to 48.2 mm. The effect of interaction treatments between the experiment factor (gibberellin, Atonik) was significant in the traits of the inflorescence diameter, where the treatment (G2 + A0) was significantly excelled and gave the highest average reached (59.9 mm) g, respectively, excelled on the control treatment (G0 + A1), which gave the lowest weight amounted to 41.8 mm.

3.10 The inflorescence length (cm)

The results in Table 10 showed the significant effect of Atonik in increasing the inflorescence length (cm), where the (A1) treatment significantly excelled and gave the highest average amounted to (6.94 cm), respectively, while the A0 treatment gave the lowest values amounted to 6.60 cm. The results also showed significantly excelled of gibberellin spray, where (G1) treatments gave the highest the inflorescence length amounted to (6.98 cm), where G0 treatments gave the lowest average amounted to 6.40 cm. The effect of interaction treatments between the experiment factor (gibberellin, Atonik) was significant in the traits of the inflorescence length (cm), where the treatment (G3 + A2) was significantly excelled and gave the highest average reached (8.08 cm), respectively, excelled on the control treatment (G3 + A3), which gave the lowest weight amounted to 5.50 cm.

Table 9: The effect of spraying with Atonik and Gibberellins and their interaction in the inflorescence diameter (mm) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	49.1	51.3	59.9	42.6	50.7
A1	41.8	42.8	38.0	57.5	45.0
A2	53.6	43.4	44.6	50.8	48.1
A3	48.5	57.2	55.5	46.2	51.8
Average	48.2	48.7	49.5	49.3	
L.S.D 0.05	A= 7.35		G= 7.35		A*G= 14.69

Table 10: The effect of spraying with Atonik and Gibberellins and their interaction in the inflorescence length (cm) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	6.33	6.50	7.08	6.50	6.60
A1	6.17	7.17	6.83	7.58	6.94
A2	5.67	7.08	5.83	8.08	6.67
A3	7.42	7.17	7.00	5.50	6.77
Average	6.40	6.98	6.69	6.92	
L.S.D 0.05	A= 0.83		G= 0.83		A*G= 1.67

3.11 The fresh weight of inflorescence (g)

The results in Table 11 showed the significant effect of Atonik in increasing the fresh weight of inflorescence (g), where the A2 treatment was significantly excelled and gave the highest average amounted to (6.52 g), respectively, while the A3 treatment gave the lowest values amounted to 4.26. The results also showed significantly excelled of gibberellin spray, where G0 treatments gave the highest fresh weight of

Table 11: The effect of spraying with Atonik and Gibberellins and their interaction in the fresh weight of inflorescence (g) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	6.43	5.50	5.53	5.57	5.76
A1	4.70	6.80	6.10	6.87	6.12
A2	6.90	6.17	7.20	5.80	6.52
A3	5.37	4.17	3.83	3.67	4.26
Average	5.85	5.66	5.67	5.48	
L.S.D 0.05	A= 0.99		G= 0.99		A*G= 1.98

Table 12: The effect of spraying with Atonik and Gibberellins and their interaction in the vase life (day) of *Celosia cristata* plant.

Atonik (A) ml.L^{-1}	GA3 (G) mg.L^{-1}				Average
	G0	G1	G2	G3	
A0	15.00	18.67	15.67	17.67	16.75
A1	17.33	19.00	18.33	18.67	18.33
A2	16.33	21.33	14.33	15.33	16.83
A3	17.00	17.33	19.00	21.33	18.67
Average	16.42	19.08	16.83	18.25	
L.S.D 0.05	A= 1.42		G= 1.42		A*G= 2.84

inflorescence (g) amounted to (5.85 g), where G3 treatments gave the lowest average amounted to 5.48 g. The effect of interaction treatments between the experiment factor (gibberellin, Atonik) was significant in the traits of the fresh weight of inflorescence (g), where the treatment (G2 + A2) was significantly excelled and gave the highest average reached (7.20 g), respectively, excelled on the control treatment (G3 + A3), which gave the lowest weight amounted to 3.67 g.

3.12 The vase life (day)

The results in Table 12 showed the significant effect of Atonik in increasing the vase life (day), where the (A3, A2) treatment significantly excelled and gave the highest average amounted to (18.67, 18.33 day), respectively, while the A0 treatment gave the lowest values amounted to 16.75 day. The results also showed significantly excellence of gibberellin spray, where G1 treatment gave the highest vase life (day) amounted to (19.08 day), where G0 treatments gave the lowest average amounted to 16.42 day. The effect of interaction treatment between the experiment factor (gibberellin, Atonik) was significant in the traits of the vase life (day), where the treatment (G1 + A2) and (G3+A3) was significantly excelled and gave the highest average reached (21.33, 21.33 day), respectively, excelled on the control treatment (G2 + A2), which gave the lowest weight amounted to 14.33 day.

The effect of spraying Atonik growth regulator on increasing the average of vegetative traits may be due to the chemical composition of the nutrient solution, which includes compounds with the ability to divide plant cells and increase their content of chlorophyll, which in turn increases the average of photosynthesis and the speed of flow of plant sap [Khader *et al*. (2001)] and its reflection on the increase in the growth of the vegetative growth. On the other hand, it has a biological role in improving the plant's push for flowering, as well as its ability to increase the level of internal hormones and the flowering content of plant pigments. This may be due to the role of Atonik in increasing the flower stalk length and the surface area of the leaves, where it is known that growth regulators have an effect on stimulating vegetative growth of intentions, and thus increasing the manufacture of nutrients in the leaves, which are reflected in the increase in the fresh and dry weight of the vegetative growth as well as the increase of nutrient accumulation in flowers. The increase in the number of leaves may be due to the role of Atonik, which contains sodium phenolate, which is similar in composition to salicylic acid and thus will be similar to its work to encourage plant growth [Shakirova *et al*. (2003)], due to the role of Atonik in increasing the efficiency of photosynthesis process as a result of increasing CO_2 absorption in chloroplasts [Khan (2003)]. The increase in the leaves number can be due to the effect of gibberellin acid in increasing cell division and enlargement in addition to stimulating growth and expansion of cells by increasing the ductility of the cell walls [Saleh (1990)]. Also, gibberellin has the ability to delay leaf senescence and stimulate protein formation and RNA New, thereby increasing the total chlorophyll content**.** It also works to increase the formation of carbohydrates inside the leaves and increase these materials is a good sign of increasing the dry and soft weight of the leaves. Gibberellin works to increase and stimulate photosynthesis, providing plants with monosaccharides, such as glucose [Stefanov *et al*. (1998)] and a stimulating effect cycle to distribute the soluble to different growing regions and reduce competition between plant consumption centers [Mukhtar (2008)], thus increasing flowering traits.

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