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Effects of Gibberellic Acid (GA_3) and Indole-3-acedic Acid (IAA) on Flowering, Stalk Elongation and Bulb Characteristics of Tulip (*Tulipa gesneriana* Var. Cassini)

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Abstract: This study was carried out to determination of GA_3 (Gibberellic acid) and IAA (Indole-3-Acetic Acid) on flower and bulb yield of tulip (*Tulipa gesneriana* Var. Cassini). 50 (G_1), 100 (G_2), 250 (G_3) and 500 (G_4) ppm concentrations of Gibberellic Acid (GA_3) and 500 (A_1), 1000 (A_2), 2500 (A_3) and 5000 (A_4) ppm concentrations of Indole-3-Acidic Acid (IAA) were applied. According to the results G_3 gave highest number of earlier flower (9.10 flower m^{-2}), but lowest number of earlier flower obtained from A_4 (5.56 flower m^{-2}). The bulb yield and bulb weight were highest on A_4 (671.7 g m^{-2} and 6.25 g) and G_3 caused reduction on bulb yield and bulb weight (494.2 g m^{-2} and 4.99 g). These results clearly indicated that GA_3 application stimulated flowering. But high dose of IAA application was detrimental, on the contrary bulb yield and individual bulb weight were increased. Stalk elongation was not affected significantly by GA_3 and IAA applications.

Key words: Tulip, GA_3, IAA, flowering, bulb yield

INTRODUCTION

In the world, 90% of flower bulbs (ornamental geophytes) production area comprise with tulip, gladiolus, hyacinthus, iris, lilium and narcissus. Tulip is the major produced flower bulb all over the world. Holland share world tulip production by 60%[1].

Researches on tulip aimed increase stalk elongation and bulb quality and stimulate early flowering, in recent years. Thus, researcher applied different temperature treatments and different doses of Plant Growth Regulators (PGRs) and before or after sowing.

The bulbs of tulips were treated with various temperature regimes and were stored at 17 and 9°C for 10, 16 and 18 weeks. Results of forcing have shown that in order to obtain good quality flowering plants of London it is sufficient to subject bulbs to 18 weeks of chilling at 9°C and treatment with GA through injection, soaking or watering with 0.1 and 0.5% of GA solution[2].

Gibberellic acid (GA_3), 6-benzylaminopurine (BA) and α-naphthalene acetic acid (NAA) were injected into 5°C bulbs at the time of planting at 15°C. Ethephon was sprayed on the plants at the onset of flowering. GA_3 reduced forcing-time, increased the number of bulblets, but decreased their size. BA and NAA did not affect forcing-time, number and size of bulblets. A lower number of bulblets from BA-treated bulbs formed flower buds. Flower buds were not induced in bulblets from ethephon-treated plants[3].

Leaves and/or flower-buds of Apeldoorn and Oxford were excised and IAA, BA, or GA_3 in lanolin paste, was applied at various sites. Excision of the leaves and flower-buds of cooled tulips inhibited the elongation of the stem internodes. Administration of auxin after leaf and flower excision restored the elongation, mainly basipetally from the site of application. Stems of uncooled tulips also elongated after IAA administration to the stem, but the response was slower and weaker[4].

0.5 g L^{-1} Benlate + 0.5 g L^{-1} Berelex (GA) and treatment in 5°C for 8 weeks on tulip bulbs gave higher marketable yield[5].

Vernalized bulbs of Oxford, Apeldoorn, General Eisenhower and President Kennedy sprayed with 25 and 50 ppm ancymidol and stalk elongation was reduced. This d etrimental effect of ancymidol was eliminated with 250 and 500 ppm GA on Golden Apeldoorn and Red Matador[6].

Apeldoorn bulbs were soaked with 0.5 g L^{-1} Berelex (GA) and stored in 5°C for 3, 6 and 9 weeks. Berelex was not affected on earliness. Nine weeks treatment provide 6-8 days earliness but stalk elongation was reduced and flowers were small[7].

IAA (0.2 and 0.005%), NAA, 2.4-D (0.2 and 0.05%) and IBA (0.2%) application on buds of Gudoshnik stimulated stalk elongation[8].

In direct-forced (5°C) tulips, gibberellin (GA) application results in earlier anthesis, shorter stem length and reduced floral bud blasting. Studies with

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GA were extended to tulips forced following traditional (9°C-cooling) methods. Except in non-cooled bulbs, where anthesis was greatly delayed, GA injections advanced the anthesis date. GA_{4+7} was more effective than GA_3, especially in Rose Copland which was less responsive than Apeldoorn. A study of the effect of time of GA injection revealed that application 4 weeks after the beginning of cold storage was most effective. However, the date of injection of GA had little effect on internode or flower length; GA increased flower and first internode length, but reduced overall stem length at anthesis. GA appeared to have potential for producing short pot-grown tulips with a reduced growing period in the glasshouse[9].

Indole-3-Acetic Acid (IAA) applied to the middle of the second or third internode after the excision of all leaves and the flower bud promoted the growth of the stem only in the basipetal direction. However, when IAA was applied together with STS the stem growth was stimulated below the place of IAA treatment and some growth of stem took place above the place of treatment with IAA[10].

Saniewski[11] found that paclobutrazol inhibit stalk elongation, but application of 500 ppm GA on plants were refused inhibition affects of paclobutrazol and stimulate stalk elongation.

Pisulevski *et al.*[12] investigated effects of GA (20 and 50 mg L^{-1}) and ethrel (25 and 50 mg L^{-1}) on stalk elongation and flowering on cutting flower. GA and Ethrel inhibited stalk elongation and no affected on vase life of flowers.

Saniewski *et al.*[13] reported that IAA applications inhibit stalk elongation, on the contrary, stimulation of GA_{4+7} and GA_3.

Ethylene increased number of flowering but reduced flowering period on stored in 20 °C for 0-6 weeks bulbs of Kees Nelis and Gander[14].

Scale wounding significantly accelerated flowering of tulip bulbs that had been stored for 3, 6 and 9 weeks at 2°C for Apeldoorn and for 3 and 6 weeks for Oxford. In addition, final scape length was significantly longer in plants produced from wounded bulbs after 3 and 9 weeks of precooling for Apeldoorn and after 3 weeks for Oxford. Wounding increased ethylene production in all treatments of both cultivars. Oxford produced significantly more ethylene than Apeldoorn, however, the increased ethylene production did not produce floral abortions[15].

Saniewski and Wegrzynowicz-Lesiak[16] treated with IAA (0 and 1%) for 1 and 4 day on different stages buds of Gudoshnik and they noticed that IAA is necessary for stem elongation.

The involvement of gibberellins in the regulation of stem elongation and flowering has been implicated in cold-requiring plants, including tulip (Apeldoorn). To investigate their role in tulip, an inventory was made of GA's, including conjugated forms, in sprouts of cooled and noncooled bulbs. Using GC-MS, GA_4, GA_9, GA_{12}, GA_{24}, GA_{34} and three GA-related compounds were detected. All detected GA's and GA-related compounds were found in the free, as well as in the conjugated form. They occurred in sprouts of both cold and noncold-treated bulbs[17].

In this study, the effects of different doses of GA_3 (Gibberellik Acid) and IAA (Indole-3-Acedic Acid) on flowering, stalk elongation and bulb yield of *Tulipa gesneriana* Var. Cassini were investigated.

MATERIALS AND METHODS

Materials: Tulip bulbs of cultivar Cassini used as PLANT material were obtained from Bilge Incorporated Company, Trabzon. Plant Growth Regulators (PGRs) GA_3 and IAA were purchased from Sigma Chemical Co.

The experimental area: This experiment was carried out at the application field of Blacksea Agricultural Research Institute in 2001-2002. The station is located in the center of Samsun at an altitude of approximately 3 m. During the experimental period, annual precipitation was 637 and 729 mm for 2001 and 2002.

Some major soil characteristics were found to be as follows; the soil texture is clay-loam, pH is 6.45, organic matter is 3.03%, extractable P by 0.5 N $NaHCO_3$ extraction is 4.2 mg kg^{-1}, exchangeable K by 1 N NH_4OAc extraction is 61 mg kg^{-1} and EC is 1.42 mS cm^{-1} in soil saturation extract.

Experimental Design was a Randomized Block arrangement with three replications. Each treatment plot was 3x7 m with distance of 0.5 m each plot. Firstly, application field fertilized with 8 ton da^{-1} farm manure.

Standardized (first class) bulbs of cultivar Cassini were sown apart from 25 x 10 cm in September of 2001. When the leaflets of bulbs reached 5-6 cm height, approximately, GA_3 (Gibberellik Acid) and IAA (Indole-3-Acedic Acid) sprayed with 7 days intervals for 5 times. 50 (G_1), 100 (G_2), 250 (G_3) and 500 (G_4) ppm concentrations of Gibberellic Acid (GA_3) and 500 (A_1), 1000 (A_2), 2500 (A_3) and 5000 (A_4) ppm concentrations of Indole-3-Acedic Acid (IAA) were sprayed by an atomizer. Pressure and nozzle size were adjusted to deliver the appropriate rate.

Stalk elongation was measured (cm) and number of flower was counted (number m^{-2}) with 2 days intervals for 6 times, at the stage of flowering. The bulbs were dismantled beginning from June and yield (g m^{-2}) and individual bulb weight (g) were estimated.

Statistical analyses of the results were ascertained by means of ANOVA. Mean differences between treatments and control were determined by LSD test (Level of significance p<0.01).

RESULTS AND DISCUSSION

According to the results of the variance analyses, number of earlier flower, bulb yield and bulb weight affected by PGR treatments, on the contrary stalk elongation was not affected by treatments tested ($p<0.01$).

The effects of hormone doses on stalk elongation were measured between 24.10 cm (A_4) and 27.07 cm (G_3), including compared to control. There were no significant difference between PGR treatments, but in general, GA_3 and IAA applications increased stalk elongation, except for A_4. In this respect, effects of GA_3 application were found more stimulate than IAA (Table 1).

All PGR treatments, except A_4 (5.56 flower m^{-2}) increased number of earlier flower when compared to control (6.00, 8.88, 7.62, 9.10, 7.44, 6.56, 6.22 and 6.66 flower m^{-2} for C, G_1, G_2, G_3, G_4, A_1, A_2 and A_3 respectively). Statistically, G_1 and G_3 gave best results and C, G_2, G_4, A_1, A_2 and A_3 were similar.

In general, all PGRs applications, except A_4, decreased bulb yield and bulb weight. A_4 gave highest values with 671.7 g m^{-2} and 6.56 g and the lowest values were obtained from G_3 (494.2 g m^{-2} and 4.99 g), respectively. In this respects, control (618.3 g m^{-2} and 5.77 g) and IAA applications was found favourable.

Previous experiments clearly demonstrated that effect of PGRs on tulip growth and development varied with greatly depending on PGRs and their doses.

Tulip (*Tulipa gesneriana* L.) is a bulbous plant species that requires a period of low temperature for proper growth and flowering (<10°C). If the cold-requirement is not fullfilled, slow growth and incomplete flowering with discoloured petal tips will follow[18].

The mechanism of sensing the low temperature period is unknown. But flowering on low temperatures is a well-known phenomenon and the involvement of gibberellins in this cold requirement. In tulip bulbs, GA application can partly substitute for the required cold treatment. Inhibition of GA biosynthesis greatly reduces stem elongation, both in whole flowering tulip bulbs. This inhibition is reversed by the application of various gibberellins, but no significant increase in endogenous gibberellins is found during cold treatment compared to untreated bulbs[19,20].

Stem length of the tulip flower after applying GA's has been reported to be longer, shorter or equal to untreated control plants at the moment of flowering. However, the reported data are difficult to compare, as there are differences in the cultivar used, the time after stage G before the cold period started, the duration of the cold-treatment and the way the cold-treatment was applied, the different GA's used and the method and time of GA application[18].

In tulips, auxin is also necessary for stalk elongation. Removal of the flower bud and leaves, both major auxin sources, before the rapid elongation of the floral stalk reduces floral stalk elongation considerably, whereas application of IAA reverses this effect[4,11,21]. The auxin-induced floral stalk elongation is inhibited by application of paclobutrazol, a GA biosynthesis inhibitor[11], suggesting that GA biosynthesis is also necessary for auxin-induced floral stalk elongation. Therefore, interaction of gibberellins and auxins is a prerequisite for stalk elongation in tulips. When tulip bulbs are properly precooled a massive carbohydrate flow from the scales towards the elongating stalk takes place. The genes for several proteins that were found to play an active role in this process[11,21-23]. These results are in accordance with these reported by us. In this article, PGRs treatments, except A_4, gave the better results than compared control on stalk elongation and number of early flower. GA_3 applications were favourable than IAA applications. But the highest dose of IAA reduced the number of earlier flower[6 8,11,13,17].

Planting of large mother bulbs resulted in large tulip flowers, planting of small mother bulbs in small tulip flowers. However, a heavier bulb gave a relatively lighter

Table 1: The effects of application on stalk elongation, number of earlier flower, bulb yield and bulb weight

Applications	Stalk elongation (cm)	Number of earlier flower (m^2)	Bulb yield (g/m^2)	Bulb weight (g)
Control © 24.21	6.00ab	618.3ab	5.77ab	
50 ppm GA_3 (G_1)	26.80	8.88a	526.0bc	5.09b
100 ppm GA_3 (G_2)	26.40	7.62ab	570.0bc	5.37ab
250 ppm GA_3 (G_3)	27.07	9.10a	494.2c	4.99b
500 ppm GA_3 (G_4)	26.07	7.44ab	540.7bc	5.55ab
500 ppm IAA (A_1)	25.80	6.56ab	585.0b	5.62ab
1000 ppm IAA (A_2)	25.80	6.22ab	615.0ab	5.75ab
2500 ppm IAA (A_3)	25.73	6.66ab	610.0ab	5.65ab
5000 ppm IAA (A_4)	24.10	5.56b	671.7a	6.25a
	NSD	LSD %1: 3.402	LSD %1: 67.66	LSD %1: 0.599

Small letter(s) in each column are significantly different (p<0.01) according to LSD test tulip flower, indicating different mechanisms for the redistribution of fresh weight and dry weight. Tulip flowers grown from big sized bulbs also contained a higher percentage dry weight than tulips grown from a small sized mother bulb. Injection of tulip bulbs with benzyladenine (BA) immediately before planting resulted in a higher fresh weight of the tulip flowers. As the dry weight of the tulips did not increase, this result is due to a higher water uptake. Therefore, the redistribution of DW from source to sink was unaffected by application of BA[24].

Changes in the economic yield were dependent on changes in total bulb weight per plant and the relationship between the economic and biological yield. Changes in the weight of the harvested bulbs were caused by differences in the size of the planted bulbs and the growing conditions[25].

In the bulb yield and bulb weight, A_4 application gave the best results. On the other hand, control value was found the higher than all GA_3 and other IAA applications. While, stalk elongation increased, bulb yield and individual bulb weight reduced. Because of, bulbs yield and bulbs weight were affected from blooming force of flowers, due to bulbs ensure all necessary nutrition and water for stalk elongation.

As a result of this study, all GA_3 and appropriate doses of IAA found very useful practice to enhance number of earlier flower. But, IAA should be used carefully, due to stalk elongation influenced negatively from high doses of IAA. On the contrary, high dose of IAA can be used to obtain bigger bulbs, but further studies will be needed to determine the most suitable concentrations for tulips.

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