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Enhancing early blooming and flower quality of tulip (*Tulipa gesneriana Linn*.) through application of plant growth regulators

Zahoor Ahmed[1*], M. Q. Sheikh[2], M. A. A. Siddique[2], M. Iqbal Jeelani[3], A. Singh[5], Gazala Nazir[4], Nomita Laishram[5] and S. I. Rehman[2]

[1]Krishi Vigyan Kendra, Kupwara, SKUAST-K, India.
[2]Division of Floriculture Medicinal and Aromatic Plants, SKUAST-K, Shalimar, India.
[3]Division of Agricultural Statistics, SKUAST-K Shalimar, India.
[4]Krishi Vigyan Kendra, Gandarbal, SKUAST-K, India.
[5]Division of Floriculture Medicinal and Aromatic Plants, SKUAST-J Jammu,India.

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A study was carried out to investigate the effect of plant growth regulators on growth and flowering of tulip using two cultivars viz, Apeldoorn and Golden Oxford. The bulbs were given dip treatment in three different growth regulator solutions viz., indole acetic acid at 750, 500, and 250 ppm; 2-choloroethyl trimethyl ammonium chloride at 750, 500 and 250 ppm; 2,3,5 triiodobenzoic acid at 200, 150 and 100 ppm) along with control for two hours. Treated bulbs were then planted under open field conditions in three replications in randomized block design. The results revealed that treatment with indole acetic acid at a concentration of 500 ppm recorded minimum days to bulb sprouting, maximum plant height, number of leaves/plant, leaf area, leaf area index and scape length in both the cultivars as compared to control. The same treatment also recorded minimum days to floral bud appearance, colour break and flower opening, while 2-choloroethyl trimethyl ammonium chloride at a concentration of 500 ppm recorded maximum flower diameter, scape thickness, scape weight, flower duration and vase life in both cultivars as compared to control. It can thus be concluded that indole acetic acid was most effective for enhancing the early flowering and 2-choloroethyl trimethyl ammonium chloride improved most of the quality parameters of tulip. 2-choloroethy trimethyl ammonium chloride and 2,3,5 triiodobenzoic acid can be used for producing dwarf tulips suitable for bedding and pot plant production. Apeldoorn was observed to perform better than Golden Oxford for most of the characters.

Key words: Growth, flowering, growth regulators, tulip.

INTRODUCTION

Tulip (*Tulipa gesneriana* Linn.), the premier ornamental flowering bulb, belongs to family Liliaceae. It is one of the commercially important bulbous ornamental plants owing to its unsurpassed beauty and economic value. It stands at 4th position among the top ten cut flowers in global floriculture trade (Jhon and Neelofer, 2006). Because of large number of cultivars available, there are tulips for all uses and for all climatic zones (Pathania and Seghal, 1997). Tulips are forced to use as cut flowers, potted plants and popularly grown as bed flowers. In India tulips are successfully grown mainly under the temperate regions of Jammu and Kashmir, Himachal Pradesh and

*Corresponding author. E-mail: zahoor.rthr@gmail.com.

Uttrakhand but do not grow very well in plains owing to its high chilling requirements. In tulip cultivation, short blooming period is the major problem. The exogenous application plant growth regulators (PGRs) play an important role in manipulating growth and flowering behaviour of ornamental plants. The net growth and development of a plant is the result of many combined signals (Kumar et al., 2013). Hormones can influence the biosynthesis of each other like auxins can induce gibberellin biosynthesis. It has been found in pea seedlings that level of gibberellins drops as the level of auxins drops. If auxin is given exogenously, the level of gibberellins is restored. Auxins promote the transcription of GA_3 oxidase and repress the transcription of GA_2 oxidase which results in the formation of active gibberellin compound (Reid et al., 2011).

Indole acetic acid AA is the predominant auxin in plants and is an indispensible phytohormone with a well documented ability to regulate many aspects of plant development. Auxins (IAA) cause a 5 to 10 fold increase in growth rate by increasing wall extensibility. This increase in wall extensibility is mediated by protons (Taiz and Zeiger, 2003) Growth retardant viz, 2-chloroethyl trimethyl ammonium chloride (CCC) inhibit gibberellic acid biosynthesis (Moore, 1989). Triiodobenzoic acid at high concentration acts as an auxin efflux inhibitor and prevented the normal relocalisation of efflux carriers on the plasma membrane (Peer et al., 2004). TIBA also altered the endocytotic cycling of the plasma membrane H^+-ATPase and other proteins. Thus TIBA directly inhibit the transport of efflux carrier complexes of auxin on plasma membrane (Taiz and Zeiger, 2003). Studies on plant growth regulators in relation to tulips have received attention only during the past three decades. However, the basic information regarding the effect of plant growth regulators on growth and flowering of tulip has not been extensively investigated under Kashmir conditions which have a temperate type of climate. Therefore, the present investigation was undertaken to ascertain the optimum concentration of indole acetic acid (IAA), CCC and 2,3,5 triiodobenzoic acid (TIBA) on vegetative growth and flowering of tulip under open field conditions.

MATERIALS AND METHODS

The present study was carried out at the Floriculture Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, India during 2007-2008. The experimental field is situated at an altitude of 1587 meters above the mean sea level and lies between 34″05′ N latitude and 74° 98′ longitude. Two cultivars of tulip (Apeldoorn and Golden Oxford) were used as planting material. Apeldoorn belongs to Darwin hybrid group tulip bearing cherry-red flowers with signal-red margins. It has black anthers and flowers in mid-Spring. Golden Oxford is also Darwin hybrid group-tulip producing pure yellow flowers, sometimes narrowly margined red, with black anthers and blooms in mid-Spring. Healthy and uniform bulbs of two cultivars having 10 to 12 cm circumference were used as planting material. The bulbs were kept in storage at room temperature before treatment. The experiment was laid out in randomized block design. There were twenty (20) treatment combinations which comprised of two cultivars), three growth regulators viz., IAA (750, 500 and 250 ppm), CCC (750, 500 and 250 ppm), TIBA (200, 150 and 100 ppm) and two controls. The treatment was given by soaking the bulbs of two cultivars separately in different concentrations of growth regulator solutions for two hours. After the treatment period was over, the solution was drained and bulbs were dried at room temperature for overnight before planting. The bulbs were taken out and fifty bulbs per treatment per replication of each cultivar were planted in the month of November and the biometric observations were recorded on 10 randomly selected plants from the experimental plot excluding the border effect. Cultural operations, viz. fertilizer application, irrigation, weeding etc. were attended uniformly. The data on following parameters was recorded from ten randomly selected plants leaving border effect.

Days to sprouting of bulb (day)

Days taken to sprouting were counted from date of planting to sprouting of bulb.

Plant height (cm)

Plant height was measured with the help of scale from the ground level to the top of plant when flowers were fully opened.

Number of leaves per plant

Number of leaves per plant was counted from randomly selected plants at the end of flowering.

Leaf area (cm^2)

Leaf area was measured with the help of leaf area meter.

Days to flower bud appearance

Days to flower bud appearance were recorded by counting the number of days from date of bulb sprouting to appearance of flower buds.

Days to colour break stage

Date of full colouration of the outside of perianth segment was recorded and days taken to colour break were calculated from the date of visibility of floral bud to colouration of flower bud.

Days to flower opening stage

Days to flower opening stage were recorded by counting the number of days from colour break stage to full opening of flower.

Flower quality parameters

Flower diameter (cm)

The flower diameter was measured with the help of measuring scale when it was fully open in east-west and north-south direction and mean values were worked out.

Table 1. Effect of plant growth regulators on vegetative characters of tulip.

Treatment (GR)		Days taken to bulb sprouting			Plant height (cm)			No. of leaves per plant			Leaf area (cm^2)			Leaf area index		
		A	G.O	Mean	A	G.O	Mean	A	G.O	Mean	A	G.O	Mean	A	G.O	Mean
T_1	IAA 750 ppm	86.93	87.47	87.20	39.17	37.92	38.54	4.00	4.00	4.00	100.66	67.74	84.20	0.33	0.22	0.28
T_2	IAA 500 ppm	86.73	87.20	86.97	41.25	40.70	40.98	4.66	4.66	4.66	103.40	82.74	93.07	0.34	0.27	0.31
T_3	IAA 250 ppm	87.47	88.13	87.80	38.79	32.04	35.42	4.66	4.00	4.33	96.94	64.43	80.68	0.32	0.21	0.26
T_4	CCC 750 ppm	88.60	91.47	90.00	26.96	25.04	26.00	4.00	4.00	4.00	77.03	55.51	66.27	0.26	0.18	0.22
T_5	CCC 500 ppm	88.80	89.73	89.27	29.71	29.46	29.58	4.33	4.33	4.33	86.05	58.27	72.16	0.29	0.19	0.24
T_6	CCC 250 ppm	88.47	89.40	88.93	35.87	31.92	33.90	4.00	4.00	4.00	90.28	59.70	74.99	0.30	0.20	0.25
T_7	TIBA 200 ppm	88.40	90.07	89.23	33.46	31.18	32.32	4.00	4.00	4.00	75.13	70.09	72.61	0.25	0.23	0.24
T_8	TIBA 150 ppm	88.33	89.25	88.79	35.67	33.08	34.37	4.33	4.33	4.33	88.32	62.43	75.37	0.29	0.21	0.25
T_9	TIBA 100 ppm	88.27	89.30	88.78	37.13	33.46	35.44	4.00	4.33	4.33	91.47	63.48	77.47	0.30	0.21	0.25
T_{10}	Control	88.00	88.60	88.30	35.08	31.58	33.33	3.33	3.33	3.33	74.10	58.47	66.28	0.25	0.19	0.22
	CD (GR)	0.05	1.35	0.75	2.75	4.41	2.75	NS	NS	NS			14.08	NS	NS	0.02
	CD (Var)			0.33			1.23			NS			6.30			0.02
	CD (GR x Var)			NS			NS			NS			NS			NS

GR, Growth regulator; Var, variety; A, Apeldoorn; G.O, Golden Oxford; IAA, indole acetic acid; CCC, 2 chloroethyl trimethyl ammonium chloride; TIBA,2,3,5 triiodobenzoic acid

Scape length and thickness (cm)

Scape length was measured from base of wrapper leaf to top of plant when flower was fully open. Scape thickness was measured by recording stem diameter from three points (upper, middle and lower) with the help of digital vernier calliper and mean was worked out.

Flower duration and vase life (day)

Flower duration was counted from opening of first flower to wilting of last flower. Vase life was counted from opening of flower bud till the flower lost its decorative value.

Statistical analysis

The experiment was laid out in randomized block design and statistical analysis was carried out in R and S-plus software packages which is the implementation of Box et al. (1978).

RESULTS AND DISCUSSION

The various attributes recorded on tulip can be studied under the following headings.

Growth parameters

The observations recorded on vegetative characters of tulip are presented in Table 1. Plant growth regulators significantly influenced the mean days taken to bulb sprouting, plant height, leaf area and leaf area index. However, number of leaves/plant did not differ significantly. Application of IAA lead to early sprouting of bulbs and earliest sprouting was recorded in 500 ppm IAA (86.97 days) as compared to control. There is considerable amount of evidence both in monocots and dicots that auxins can regulate GA biosynthesis (Reid et al., 2011). The targets for auxin regulation, that is, which genes are up or down regulated are different in different species (Taiz and Zeiger, 2003). Auxins promote the transcription of GA_3 oxidase and repress the transcription of GA_2 oxidase which results in the formation of active gibberellin compound. Increased level of gibberellin probably reduced the levels of inhibitor (Geng et al., 2007) and leading to early sprouting. Induction of early sprouting by the application of IAA in narcissus was reported by Hanks and Rees (1977). CCC and TIBA caused delayed sprouting with most pronounced in CCC 750 ppm (90.00 days) and TIBA 200ppm (89.23 days) as compared to control. The inhibition of the cyclization of geranyl geranyl pyrophosphate to copallyl pyrophosphate is the primary mode of action of cycocel leading to inhibition of gibberellin formation which is an important bud dormancy breaking factor (Arteca, 1997). 500 ppm IAA being statistically at par with

Table 2. Effect of growth regulators on flowering characters of tulip.

Treatment (GR)		Days to floral bud appearance			Days to colour break			Days to flower opening		
		A	G.O	Mean	A	G.O	Mean	A	G.O	Mean
T_1	IAA 750 ppm	27.58	25.42	26.50	8.26	8.20	8.23	4.40	4.00	4.20
T_2	IAA 500 ppm	27.06	24.13	25.60	6.40	6.88	6.63	3.87	2.87	3.37
T_3	IAA 250 ppm	28.00	25.33	26.67	7.45	7.35	7.40	3.97	3.90	3.93
T_4	CCC 750 ppm	30.80	30.20	30.50	11.20	10.33	10.77	8.10	7.07	7.58
T_5	CCC 500 ppm	29.00	28.00	28.50	9.80	9.26	9.53	6.27	5.93	6.10
T_6	CCC 250 ppm	29.06	29.66	28.27	8.60	8.80	8.70	7.13	4.60	5.87
T_7	TIBA 200 ppm	29.33	29.66	29.50	9.20	9.26	9.23	6.13	7.20	6.67
T_8	TIBA 150 ppm	29.00	26.93	27.97	8.66	8.93	8.80	6.07	5.60	5.83
T_9	TIBA 100 ppm	28.86	25.46	27.17	8.60	8.53	8.57	5.07	4.20	4.63
T_{10}	Control	28.93	26.53	27.73	8.40	8.40	8.40	5.13	4.60	4.87
	CD (GR)	0.91	1.59	0.89	0.93	1.20	0.76	0.92	0.69	0.55
	CD (Var)			0.39			NS			0.25
	CD (GR x Var)			1.26			NS			0.78

GR, Growth regulator; Var, variety; A: Apeldoorn; G.O, Golden Oxford; IAA, indole acetic acid; CCC, 2 chloroethyl trimethyl ammonium chloride; TIBA, 2,3,5 triiodobenzoic acid.

750 ppm IAA recorded significantly maximum plant height (40.98 cm) as compared to control.

The expression of many cell cycle genes is induced by application of exogenous auxins. This induction is mediated through both proteosome dependant and auxin binding protein-1 pathways and that auxin has many potential targets. These include proteins that are involved in transition throughout the cell cycle like entry into S-phase and G2-M transition (William et al., 2006). Auxins promote cell elongation by causing increase in wall plasticity and decreased plasticity; synthesize enzymes required for synthesis of cell wall and cytoplasmic components; induce deformation and loosening of cell wall by breaking cross links between cell wall components. Similar results were obtained by Kawa and Saniewski (1989) and Saniewski et al. (1999), who reported elongation of stem by application of IAA in tulip. 750 ppm CCC recorded significantly minimum plant height (26.00 cm) while TIBA at all doses did not cause much significant impact on plant height as compared to control. CCC, a gibberellin biosynthesis inhibitor, decreases the concentration of gibberellins in plants and inhibits cell expansion by lowering the gibberellin-dependant cell wall relaxation (Cosgrove and Sovonick Dunford, 1989). The decrease in stem length by application of CCC in tulip was reported by Kumar et al. (2013). All treatments of IAA increased leaf area and maximum leaf area (82.74 cm^2) was recorded with 500 ppm IAA followed by 750 ppm IAA (67.74 cm^2), while CCC and TIBA at all concentrations were not significant in affecting the leaf area. Auxin transported to vegetative buds regulates leaf initiation and phylotaxy, the pattern of leaf emergence from the shoot apex (Taiz and Zeiger, 2003). The enlargement of leaf area by IAA is probably due to an increase in cell division and cell enlargement. Similarly 500 ppm IAA followed by 750 ppm IAA registered maximum leaf area index (0.31) while as, CCC and TIBA at all doses were ineffective in recording higher leaf area index as compared to control. These results were in close agreement with various workers in bulbous crops (Dantuluri et al., 2002; Gaur et al., 2003).

Flower attributes

The results obtained on the effect of plant growth regulators on flowering or blooming are presented in Table 2. Results indicate that application of growth regulators significantly affected flowering attributes. All plant growth regulators follows almost similar trend in both varieties while enhancing early flowering. The overall effect indicates that 500 ppm IAA recorded minimum days to floral bud appearance (25.60 days), colour break (6.63 days) and flower opening (3.37 days) as compared to rest of the treatments. The improvement in floral characters in response to indole acetic acid is due to its favourable effects on vegetative growth. These results are in agreement with several workers in various flower crops (Meher et al., 1999; Gaur et al., 2003). Whereas, 750 ppm CCC took significantly maximum days to floral bud appearance (30.50 days), colour break (10.77 days) and flower opening (7.58 days) as compared to control. Delayed flowering was reported by Taha (2012) in iris with CCC application. Delayed anthesis in tulip with CCC application was also obtained by Mohamed and Fawzi (1980). Similarly, TIBA at a higher dose of 200 ppm significantly delayed flowering by exhibiting 29.50 days to floral bud appearance, 9.23 days to colour break and 6.67 days to flower opening. Delayed flowering due to growth retardants is apparently the result

Table 3. Effect of growth regulators on Scape characteristics of tulip.

Treatment (GR)		Flower diameter (cm)			Scape length (cm)			Scape thickness (mm)			Scape weight (g)		
		A	G.O	Mean	A	G.O	Mean	A	G.O	Mean	A	G.O	Mean
T_1	IAA 750 ppm	6.50	5.75	6.12	36.17	34.92	35.54	3.94	3.43	3.69	24.93	13.38	19.16
T_2	IAA 500 ppm	6.44	6.60	6.52	38.25	37.71	37.98	4.30	3.49	3.89	23.12	14.55	18.83
T_3	IAA 250 ppm	7.44	7.00	7.22	35.96	29.04	32.50	4.60	3.77	4.18	17.00	21.77	19.38
T_4	CCC 750 ppm	7.20	7.40	7.30	23.96	22.04	23.00	5.27	4.73	5.00	17.57	19.72	18.64
T_5	CCC 500 ppm	7.33	7.40	7.36	26.71	26.46	26.58	6.05	5.35	5.70	24.20	19.83	22.02
T_6	CCC 250 ppm	6.89	7.11	6.99	32.87	28.92	30.90	4.72	5.00	4.86	24.38	16.33	20.36
T_7	TIBA 200 ppm	6.83	6.72	6.77	30.46	28.18	29.32	4.67	3.99	4.33	19.32	15.28	17.30
T_8	TIBA 150 ppm	6.04	6.77	6.40	32.67	30.08	31.37	4.45	3.72	4.09	16.48	25.57	21.02
T_9	TIBA 100 ppm	6.53	6.60	6.56	34.42	30.46	32.44	4.13	3.44	3.79	20.13	17.40	18.77
T_{10}	Control	6.22	6.00	6.11	32.07	28.58	30.33	3.95	3.45	3.70	15.50	17.50	16.50
	CD (GR)	NS	NS	NS	3.45	4.41	2.76	0.90	0.86	0.66	5.52	3.73	NS
	CD (Var)			NS			1.24			0.30			NS
	CD (GR x Var)			NS			NS			NS			NS

GR, Growth regulator; Var, variety; A: Apeldoorn; G.O, Golden Oxford; IAA, indole acetic acid; CCC, 2 chloroethyl trimethyl ammonium chloride; TIBA, 2,3,5 triiodobenzoic acid.

of growth inhibition rather than direct effect upon flowering stimulus. These results were in consonance with the findings of Mohariya et al. (2003).

Perusal to data (Table 3) on quality of scape indicated that plant growth regulators show the almost similar trend in both varieties with respect to scape length and thickness. 500 ppm IAA being statistically at par with IAA-750 ppm recorded maximum scape length (37.98 cm) as compared control. These results are in close conformity with the findings of Kawa and Saniewski (1989) and Saniewski et al. (1999), all of whom reported increased shoot length by application of IAA in tulip. 750 ppm CCC recorded significantly minimum scape length (23.00 cm) as compared to control. However, TIBA at all doses did not exhibit any significant impact on scape length. Similar results were reported by Laskowska et al. (1998) in tulip. 500 ppm CCC recorded significantly maximum scape thickness (5.70 mm) as compared to control. The increase in scape thickness may be attributed by the decreased scape length induced by CCC. The results obtained are in close confirmation with those reported by Weryszko et al. (1997) in tulip. IAA and TIBA at all doses were observed to be ineffective in influencing the scape thickness as compared to control. However, IAA at low concentration was observed to have a favourable effect on scape thickness. Fresh weight of scape was not affected significantly by the application of growth regulators. Maximum duration of flowering (>13 days) was recorded by CCC followed by TIBA in both the varieties (Figures 1 and 2) as compared to control. However, TIBA and IAA at all doses were ineffective in inducing significant change in flower duration as compared to control. Kumar et al. (2013) also reported increased flower duration in tulip after application of CCC. Kirad et al. (2001) also reported increased flowering duration by application of CCC in gladiolus. 500 ppm CCC also recorded maximum vase life of greater than 9 days in both cultivars as compared control. Growth retardants have the ability to alter the sensitivity of plants to a number of environmental stresses. These have an ability to decrease the transpiration loss either due to their ability to induce smaller leaves or fewer or smaller stomata in the leaves (Steinberg et al., 1991). Besides these also inhibit ethylene production by blocking the conversion of 1-aminocylopropane-1-carboxylic acid (ACC) to ethylene which is considered as an important senescence factor (Kraus et al., 1991). These factors might have attributed for the increased vase life of cut tulips by application of growth retardants. Similar results were obtained by several workers in bulbous crops (Nair et al., 2002; Dantuluri et al., 2002). IAA did not cause any significant effect on vase

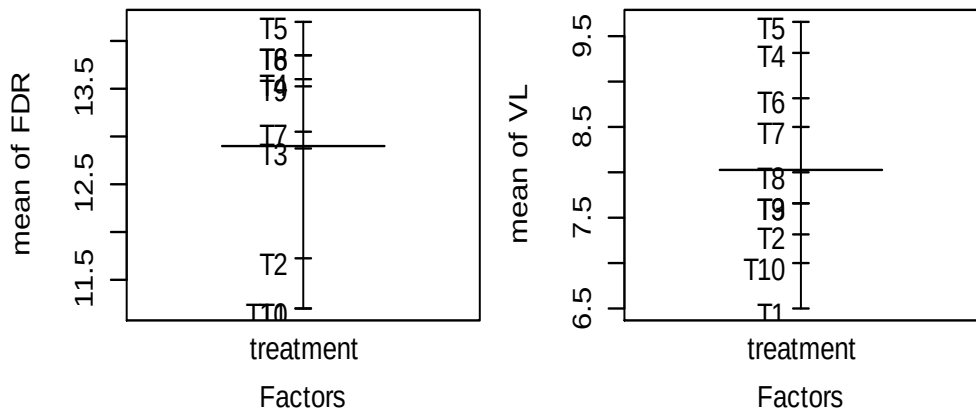

Figure 1. Effect of plant growth regulators on flower duration and vase life of tulip Cv. Apeldoorn. FDR, Flower duration in days; VL, vase life in days.

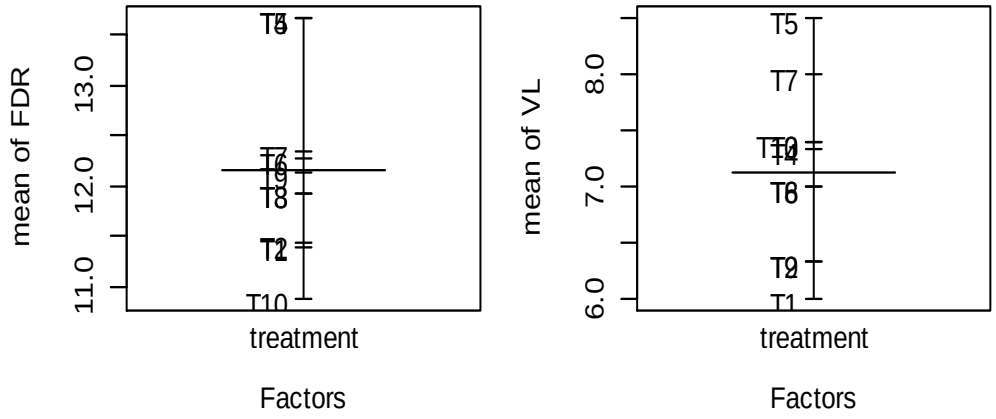

Figure 2. Effect of plant growth regulators on flower duration and vase life of tulip Cv. Golden Oxford. FDR, Flower duration in days; VL, vase life in days.

life in Apeldoorn but it significantly reduced the vase life in Golden Oxford at higher concentration. Similar results were reported by Guo Wei et al. (2003) in chrysanthemum.

Effect of cultivars

The cultivars under study varied significantly for all vegetative and floral characters, except number of leaves/plant, days taken to colour break, flower diameter and scape weight. Cultivar Apeldoorn was observed to be superior to Golden Oxford in recording minimum days to bulb sprouting and higher plant height, leaf area, leaf area index, scape length, scape thickness, flower duration and vase life. While as, Golden Oxford was superior to Apeldoorn in recording minimum days to floral bud visibility and flower opening. The difference between the two cultivars may be attributed due to their genetic makeup.

Interaction effect

Data in Table 3 indicate that the interaction of PGRs and cultivars showed significant effect on days taken to floral bud visibility, flower opening and vase life. Golden Oxford treated with 500 ppm IAA took minimum days to floral bud visibility (24.13 days) and flower opening (2.87 days). While as, Apeldoorn treated with 750 ppm CCC took maximum days to floral bud visibility (30.80 days) and flower opening (8.10 days). Further, Apeldoorn when treated with 500 ppm CCC recorded maximum vase life (9.67 days). However, all vegetative characters, days taken to colour break, flower diameter, scape length, thickness and weight and flower duration remained statistically non significant.

Conclusion

It is proved from the present research that application of

IAA improved vegetative growth and flowering attributes of tulip, while application of CCC reduced plant height, delayed flowering but improved duration of blooming and vase life over control.

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