International Journal of Natural and Social Sciences
Print: 2617-6637 < ISSN > Online: 2313-4461

Influence of anti-transpirant and cycocel on growth and flowering of tuberose under different moisture regimes

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ARTICLE INFO

Article history

Accepted 20 July 2019
Online release 13 Aug 2019

Keywords

Anti-Transpirant
Tuberose
Growth
Moisture regimes

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ABSTRACT

A pot experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted of two factors: Factor A: Different moisture regime; I_0= 100% ET irrigation (control), I1=75% ET irrigation, I_2=50% ET irrigation; Factor B: Foliar application of anti-Transpirant and Cycocel (CCC); F_0 = Foliar spray with water (control), F_1= Foliar spray with 3% kaolin, F_2 = Foliar spray with 1000ppm CCC, F_3=Foliar spray with 3% kaolin and 1000ppm CCC. The two factor experiment was laid out in Randomized Complete Block Design with three replications. Application of kaolin and CCC with different irrigation level showed significant variations on most of the parameters. In case of kaolin and CCC; the highest spikelet per spike was recorded 50.02 from F_3, highest length of flowering stalk 91.00 cm from F_0, the highest length of rachis area 31.80 cm from F_0, the highest weight of bulb 152.70 g from F_3.In case of different moisture regime the highest spikelet per spike 52.50 was found from I_0, the maximum length of flowering stalk 94.65 cm from I0, the maximum length of rachis 31.27 cm I_0. For combined effect the highest spikelet per spike 60.00 I_0F_3,the maximum length of flowering stalk 103.00 cm from I_0F_0, the maximum length of rachis 38.70 cm from I_0F_0, the maximum weight of bulb 43.70 g from in I_1F_3.The I1F3 treatment showed better performance for growth and flowering of tuberose.

INTRODUCTION

Tuberose (*Polianthestuberosa L.*) cv. double is the most valuable cut flower that bloom during summer season. It is originated to Mexico and belongs to family Amarylladaceae. It is commercially and aesthetically valuable for producing conspicuous. Its cultivation in Bangladesh is gaining popularity because cultivation practice is easy, low input, wide adaptability, multipurpose use and higher return. This crop has lingering delightful fragrance, excellent keeping quality and easy cultivation are the predominant characteristics. Tuberose flowers are in great demand as cut flowers, preparation of most artistic garlands, floral ornaments, bouquets, button holes and for their essential oil. The long spikes are excellent for table decoration. The tuberose flowers are durable and remain fresh for pretty long time and stand long distance transportation due to their waxy nature. In summer season it is getting more importance among growers and floriculturists due to its production and unavailability of other ornamental flower bulbs during this period. There is a critical balance between water requirement and water consumption of the crops. Thus, conserving water is an important aspect for agricultural expansion particularly in arid and semiarid regions where water deficit and high temperature are the main limiting factors for plant growth and productivity (Taiz and Zeiger, 2002). At present and most probably also in the future, as a result of global warming, irrigated agriculture will take place under water scarcity. In other words, irrigation management in arid and semi-arid regions will shift from emphasizing production per unit area towards maximizing the production per unit of water consumed (Fereres and Soriano, 2007). Due to the important and precious values of water in recent years and in the same time the need for using such valuable plant, much more attention must be given to study the growth and productivity within appropriate water consumption (Halepyati et al. 1996) on tuberose plants found that transpiration rate was increased with increasing irrigation levels. Water deficit often causes reduction in plant growth by inhibiting leaf and

How to cite this article: Khondoker R, Monir MR and Kabir MH (2019). Influence of anti-transpirant and cycocel on growth and flowering of tuberose under different moisture regimes. International Journal of Natural and Social Sciences, 6(2): 27-43.

stem elongation (Younis et. al., 2000) and by reducing nutrient uptake by plants. In addition, water deficit affects negatively the process of flowering in many plant species by reducing the fertility of newly formed flowers (Slawinska et. al., 2001). Under such drought conditions, actively growing plants transpire a weight of water equal to their leaf fresh weight each hour if water is adequately supplied (Moftah, 1997). Thus, it is necessary to find ways by which available water could be economically utilized. One way to achieve this goal is by reducing the transpiration rate using anti-transpirants to minimize the amount of applied water. Anti-transpirants were grouped into three categories, namely film-forming types (which coat leaf surface with films that are impervious to water vapor), reflecting materials (which reflect back a portion of the incident radiation falling on the upper surface of the leaves) and stomatal closing types (which affect the metabolic processes in leaf tissues. Anti-transpirants are chemical compounds applied to regulate the transpiration of plants and maintain a favorable plant water status. Kaolin is a non-abrasive, non-toxic aluminosilicate clay mineral that has been formulated as a wet table powder for application with conventional spray equipment. Use of Kaolin increase efficiency and photosynthetic activity of plants under drought condition (Al-Humaid and Moftah 2005). Foliar applications of kaolin particle films reduce plant stress, which is important for optimum plant growth, yield and quality. Kaolin cools tissues and protects plants from extreme heat and ultraviolet radiation by increasing leaf reflectance and reducing transpiration rate (Glenn et al. 2010). Early studies demonstrated that Kaolin improved the water status and the growth of water-stressed tuberose plants (Glenn et. al., 2003). Application of growth retardant such as cycocel (CCC) at certain doses had an effective role on the growth, flowering and bulb productivity of many flowering bulbs. Growth retardants CCC (2-chloroethyl trimethyl ammonium chloride) markedly reduced stem length, number of leaves / plant of ornamental plants. It is found that CCC at 1000 ppm increased chlorophyll a, b and carotenoides contents of leaves plant of ornamental plants. It is found that CCC at 1000 ppm increased chlorophyll a, b and carotenoides contents of leaves (Hassanein and Manoly, 2004). However, the present study was undertaken to know the physiological status of tuberose under different moisture regime; and determine the effect of kaolin and CCC on the flowering and yield of tuberose under different moisture status.

MATERIALS AND METHODS

Experimental site and duration

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka;from 01 May to 30 November, 2013. The experimental soil belongs to the Modhupur Tract under AEZ No. 28.

Planting materials

Bulbs of tuberose were used as planting materials and they were collected from the Horticultural Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh.

Pot soil collection and preparation

The soil was collected one month prior to setting the experiment. The top soil at a 15cm depth was collected from the Horticultural Farm area of North-East corner, mixed thoroughly and makes it clean by removing stones, grass, roots and other debris.

Fertilizer mix with soil

Recommended dose of organic and inorganic fertilizer was added in the soil prior 21 days of filling the pots and wrapped with polythene sheet.

Pot preparation

Earthen pots were used in this experiment. The height and width of each pot was 28cm and 44cm respectively. Two holes were made in the middle of the bottom of each pot and holes were covered by the broken pieces of earthen pot. All the pots were washed with ash and tap water by rubbing and sun dried. The fertilizer mixed soil was made well pulverized and dried in the sun. Final check was made to remove plant propagates, inert materials, visible insects and pests.

Raising of seedlings

Tuberose cv. double bulbs of about 2.5-1.5cm in diameter were planted on May 02, 2013. Pots were placed in a shed and allowed to grow for four weeks at 30-35^{0}C temperature. Plants were irrigated to field condition for another four weeks, to prevent stress, and ensure seedling establishment.

Irrigation procedure

Gravimetric method was used to find out proper strategy to irrigate pot plants. In this method, earthen pots with soil was weighed using weighing balance and all the earthen pots was made in equal weight including soil which was 11kg where only empty earthen pot was 4kg. Water was added in each pot to make it well saturated condition. The difference between two weights is the evaporation rate. Pot with soil was allowed for two days tying with polythene sheet. After two days, the earthen pot with wetted soil was weighted. The loss of water = weight of pot soil in saturated condition – weight of pot soil after allowing two days. The amount of water lost during the 2 days was recovered completely by irrigation, for control pots only. Other pots received 75% and 50% of the water added to the control plants.

Anti-transpirant treatment (AT)

A hydrophilic, kaolin particle film, wetting & sticking agent was applied at 3%. AT were prepared using water only. Tuberose plants were sprayed every week interval with fine mist, starting 59 DAP, using a hand pressure sprayer.

Preparation of cycocel (CCC)

A 1000ppm stock solution of Cycocel was prepared by dissolving 1ml CCC with distilled water in 1 litre of volumetric flask.

Treatment of the experiment:

The study consisted of two factors, which are given below.

Factor A: Different moisture regime: I_0 = 100% Evapotranspiration irrigation (Control); I_1=75% Evapotranspiration irrigation; I_2 = 50% Evapotranspiration irrigation

Factor B: Foliar application of anti-transpirant and growth retardant: F_0 = Foliar spray with water (control); F_1= Foliar spray with 3% kaolin; F_2 = Foliar spray with 1000 ppm CCC; F_3=Foliar spray with 3% Kaolin and1000 ppm CCC.

Design of the experiment

The experiment was carried out in a Randomized Complete Block Design (RCBD) with 5 replications. Five plants were exposed to each treatment. The distance between two replications and two treatments were maintained 50cm and 30cm respectively. The seedlings were planted in the middle of the pot soil and 5 pots were placed in each plot.

Intercultural operation

When the seedlings started to emerge in the pots it was always kept under careful observation. After emergence of seedlings, various intercultural operations such as weeding, mulching was accomplished for better growth and development of tuberose seedlings.

Plant protection

For controlling leaf caterpillars Nogos @ 1ml/L water was applied 2 times at an interval of 10 days starting soon after appearance of infestation. No remarkable attack of disease was found.

Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment- Plant height, number of leaves per plant, leaf temperature, relative water content, CO_2 assimilation rate, stomatal conductance, measurement of chlorophyll, length of flowering stalk, number of spikelet per spike, number of bulblet per plant, weight of bulb, diameter of bulblets, dry weight of bulb per plant.

Statistical analysis

The collected data were statistically analyzed to find out the level of significance using MSTAT-C software. The significance of the difference among the treatment mean was estimated by Least Significance Difference (LSD) Test at 1% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The results obtained from the study have been presented, discussed and compared in this chapter through table(s), and figures under the following headings.

Plant height

The plant height of tuberose was measured at 80, 100, 120 and 140 days after planting (DAP). It was evident from Figure 1 that the height of plant was significantly influenced by different moisture regime at all the sampling dates. At 80, 100, 120 and 140 DAP, 100% evapotranspiration irrigation treatment showed the longest plant (60.08, 63.45, 67.66 and 72.40 cm, respectively) whereas, the shortest plant (56.34, 59.71, 63.92 and 66.00 cm, respectively) was found from 50% ET irrigation treatment. In the present experiment since tuberose was grown in the same environment and were given same cultural practices except irrigation. So, the variation of plant height might be due to the effect different moisture regimes.

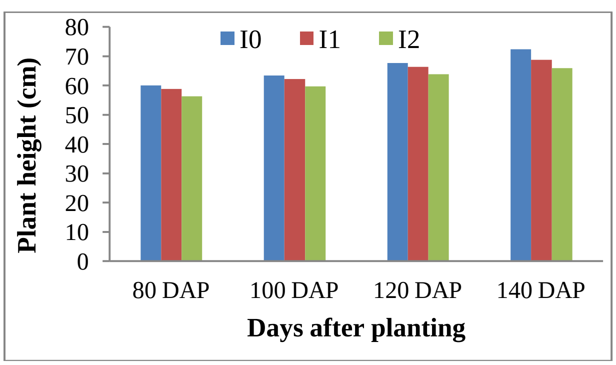

Figure 1
Effect of moisture regimes on plant height of tuberose.

Al-Humaid and Moftah(2005) found that height of tuberose significantly reduced by water deficit treatments, particularly 60% ET regime as compared with the control.

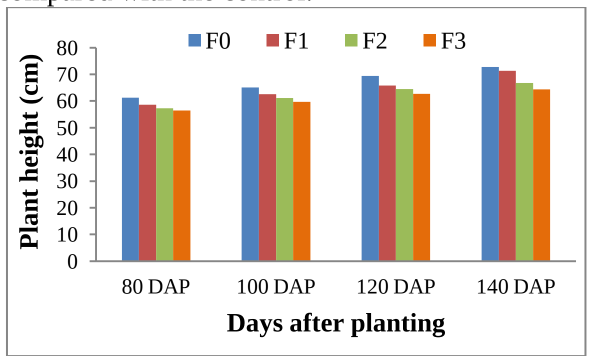

Figure 2
Effect of kaolin and CCC on plant height of tuberose

Significant variation of plant height was found due to kaolin and CCC in all the studied durations (Figure 2). At 80, 100, 120 and 140 DAP, the highest plantheight (61.23, 65.08, 69.46 and 72.80 cm, respectively) was found in foliar spray with water treatment foliar spray with Kaolin and CCC treatment and lowest plant (56.47, 59.73, 62.69 and 65.33 cm, respectively) was foliar spray with Kaolin and CCC treatment. CCC reduced plant height without any malformation by reducing cell elongation and also by lowering cell division (Rademacher and Jung,1986; and Lone, 2001).

Significant Interaction effects of moisture regime and kaolin and CCC on plant height was observed at 80, 100, 120 and 140 DAP (Table 1). Plant height increased with advanced growing period irrespective of application of kaolin and CCC (Table 1). At 80, 100, 120 and 140 DAP, the tallest plant (63.00, 67.25, 72.12 and 74.98 cm, respectively) was obtained from I0F0 treatment whereas, the shortest plant (52.34, 55.26, 59.38 and 62.20 cm, respectively) was obtained from I2F3 treatment.

Table 1
Interaction effect of moisture regimes and kaolin and CCC on plant height of tuberose at different days after planting (DAP).

Treatments	Plant height (cm) at			
	80 DAP	100 DAP	120 DAP	140 DAP
I_0F_0	63.00 a	67.25 a	72.12 a	74.98 a
I_0F_1	60.00 b	63.49 b	67.76 b	70.62 c
I_0F_2	57.00 d	60.49 cd	64.76 f	67.62 f
I_0F_3	60.70 b	64.19 b	68.46 b	71.32 b
I_1F_0	57.00 d	60.49 cd	64.76 f	67.62 f
I_1F_1	58.00 bc	61.49 c	65.76 de	68.62 e
I_1F_2	59.30 b	62.79 bc	67.06 bc	69.92 d
I_1F_3	58.90 b	62.39 bc	66.66 d	69.52 d
I_2F_0	54.97 f	58.46 f	62.73 g	65.59 g
I_2F_1	58.00 bc	61.49 c	65.76 de	68.62 e
I_2F_2	56.67 e	60.16 d	64.43 f	67.29 f
I_2F_3	52.34 g	55.26 g	59.38 h	62.20 h
$LSD_{(0.05)}$	1.88	1.03	1.26	0.82
CV (%)	4.91	5.38	3.58	4.81

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Number of leaves per plant

Different irrigation regime exhibited significant variation in results revealed that, the number of leaves per plant of tuberose increased gradually with decreased the irrigation up to 75% at 80, 100, 120 and 140 DAP (Figure 3). At 80, 100, 120 and 140 DAP, the maximum leaves number plant-1 (15.57, 26.16, 35.10 and 42.67espectively) was observed from I0 treatment and the minimum number (13.60, 20.93, 29.50 and 35.53 respectively) was observed from I_2 treatment. The present study referred that 100% ET irrigation produced maximum number of leaves.

The number of leaves plant-1 was significantly influenced by foliar application of kaolin and CCC at 80, 100, 120 and 140 DAP (Figure 4). At 80, 100, 120 and 140 DAP, the maximum leaves number plant-1 (16.90, 28.90, 42.36 and 50.67 respectively) was observed from F_3 treatment whereas the minimum number (13.10, 22.86, 30.18 and 38.23, respectively) was observed from F_0 treatment.

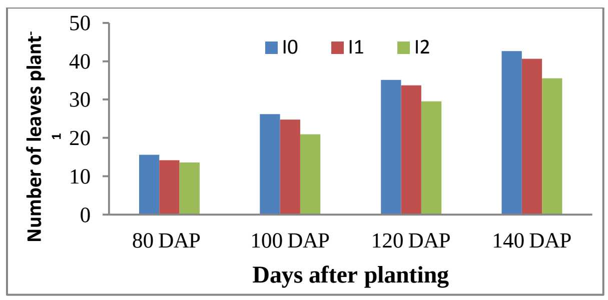

Figure 3
Effect of moisture regimes on number of leaves plant-1 of tuberose.

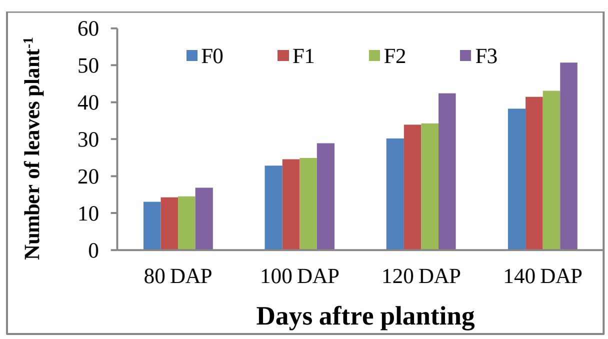

Figure 4
Effect of kaolin and CCC on number of leaves plant-1 of tuberose

Table 2
Interaction effect of moisture regimes and kaolin ,CCC on number of leaves plant-1 of tuberose at different days after planting (DAP).

Treatments	Number of leaves plant^{-1} at			
	80 DAP	100 DAP	120 DAP	150 DAP
I_0F_0	14.00 c-e	23.58 bc	31.97 d	42.00 bc
I_0F_1	14.00 c-e	23.68 bc	32.07 c	42.30 bc
I_0F_2	13.70 de	23.38 bc	31.77 d	39.30 cd
I_0F_3	18.00 a	34.53 a	46.92 a	52.70 a
I_1F_0	13.30 e	22.98 cd	31.37 d	36.00 e
I_1F_1	15.70 b	25.38 b	33.77 b	43.00 b
I_1F_2	15.30 b	24.98 b	33.37 b	43.00 b
I_1F_3	15.00 bc	24.68 b	33.07 b	41.00 c
I_2F_0	12.00 f	20.49 e	28.88 e	33.70 f
I_2F_1	13.00 ef	22.68 cd	31.07 d	39.00 cd
I_2F_2	14.70 b-d	24.38 bc	32.77 c	39.70 cd
I_2F_3	14.70 b-d	24.38 bc	32.77 c	42.70 bc
$LSD_{(0.05)}$	1.21	1.03	1.00	1.53
CV (%)	4.95	5.38	7.45	1.99

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

There was significant variation among the interaction of irrigation and kaolin, CCC on the total numbers of leaves plant-1 at 80, 100, 120 and 140 DAP (Table 2). At 80, 100, 120 and 140 DAP, the maximum number of leaves plant-1 (18.00, 34.53, 46.92 and 52.70, respectively) was recorded with the combination of 100% ET irrigation and foliar spray with Kaolin & CCC (I1F3) treatment whereas, the minimum (12.00, 20.49, 28.88 and 33.70, respectively) was recorded from the combination of 50% ET irrigation and foliar spray with water (I2F0) treatment. Present study showed that 100% ET irrigation and foliar spray with Kaolin & CCC produced maximum number of leaves.

Leaf temperature

Leaf temperature significantly influenced by irrigation regime at 80, 100, 120 and 140 DAP (Figure.5). At 80, 100, 120 and 140 DAP, 100% ET irrigation produced maximum leaf temperature (37.63^0C, 35.69^0C, 33.07^0C and 31.17^0C respectively) whereas, the minimum was (35.60^0C, 33.65^0C, 30.27^0C and 28.83^0C respectively) I_2 treatment.

Leaf temperature varied significantly with kaolin and CCC at 80, 100, 120 and 140 DAP (Figure 6). At 90, 80, 100 and 120 DAP, the highest leaf temperature (38.60^0C, 36.62^0C, 33.97^0C and 32.50^0C respectively) was produced from foliar spray with water and foliar spray with Kaolin while, the lowest (36.34^0C, 34.10^0C, 30.43^0C and 28.29^0C, respectively) was found from foliar spray with Kaolin and CCC. Glenn et al. (2003) reported that Kaolin reduces leaf temperature by increasing leaf reflectance. Similar results were observed by Jifon et al. (2003) who observed that foliar applications of kaolin reduced leaf temperature at midday (Tlf ≈ 3°C) in grapefruits and apple leaves respectively. Interaction effect of different irrigation regime and kaolin, CCC influenced the leaf temperature at 80, 100, 120 and 140 DAP (Table 3). At 80, 100, 120 and 140 DAP it was observed that the maximum (39.07^0C, 36.93^0C, 34.94^0C and 32.60^0C, respectively) was obtained from I_0F_0 treatment whereas the minimum (35.30^0C, 34.20^0C, 31.83^0C and 28.27^0C respectively) was recorded from I_2F_3 treatment.

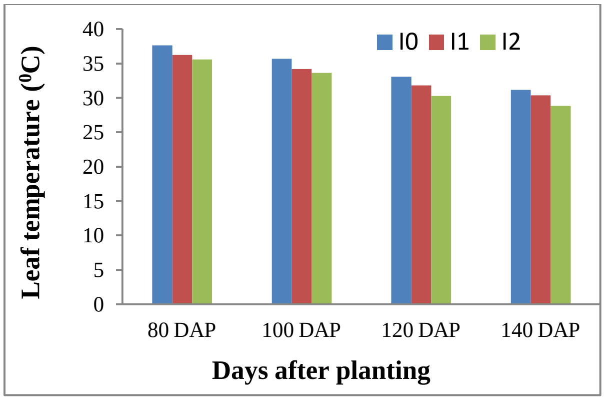

Figure 5
Effect of moisture regimes on leaf temperature of tuberose

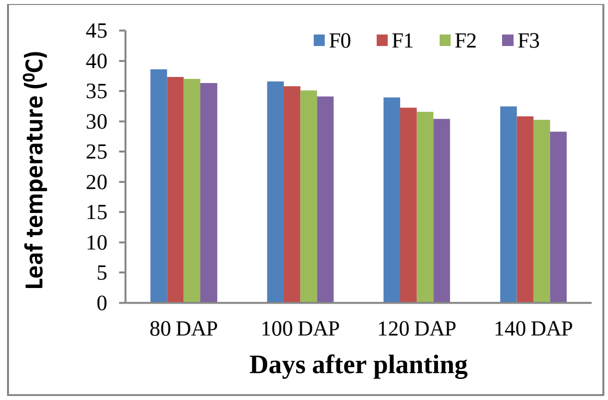

Figure 6
Effect of kaolin and CCC on leaf temperature of tuberose.

Table 3
Interaction effect of moisture regimes and kaolin, CCC on leaf temperature of tuberose at different days after planting (DAP).

Treatments	Leaf temperature (^{0}C) at			
	80 DAP	100 DAP	120 DAP	140 DAP
I_0F_0	39.07 a	36.93 a	34.94 a	32.60 a
I_0F_1	37.70 b	35.83 b-d	33.69 b-d	30.03 c-e
I_0F_2	37.93 b	35.53 de	33.39 cd	29.83 de
I_0F_3	37.47 b	35.33 ef	33.19 d	30.90 b
I_1F_0	37.93 b	35.80 b-d	33.66 b-d	29.93 de
I_1F_1	37.40 bc	36.07 b	33.93 bc	30.13 b-d
I_1F_2	36.67 de	34.87 g	32.73 e	30.80 bc
I_1F_3	36.70 d	35.77 b-d	33.63 b-d	29.83 de
I_2F_0	36.67 de	35.00 fg	32.86 ef	29.97 c-e
I_2F_1	37.03 cd	35.63 c-e	33.49 cd	30.27 b-d
I_2F_2	36.83 d	36.20 b	34.06 b	30.17 b-d
I_2F_3	35.30 f	34.20 h	31.83 f	28.27 f
$LSD_{(0.05)}$	0.36	0.33	0.50	0.84
CV (%)	3.58	4.56	3.58	1.62

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Relative water content

Relative water content signifies the water content of plant. The relative water content was significantly influenced by irrigation regime (Table 4). The highest percentage of RWC (95.78 %) was found from I_0 (100% ET irrigation) treatment whereas the lowest (83.34 %) was obtained from I_2 (50% ET irrigation) treatment. Differences in RWC might be due to the morpho-physiological differences among the irrigation. Al-Humaid and Moftah(2005) found that RWC decreases under water deficit conditions. There is significant effect of low RWC on the photosynthetic rate.

Relative water content was influenced by plant growth substance. The highest percentage of RWC (96.37 %) was obtained from F_3 (foliar spray with Kaolin & CCC) treatment and the lowest (80.96 %) was found in F_0 (foliar spray with water) treatment (Table 5). Atmospheric relative humidity and temperature greatly influence the RWC of plant leaves.

Interaction of irrigation regime and plant growth substance had a significant influence on relative water content of tuberose (Table 6). The highest percentage of RWC (123.6 %) was obtain from the combination of 100% ET irrigation and foliar spray with Kaolin and CCC (I_0F_3) treatment whereas, the lowest (76.70 %) with the combination of 50% ET irrigation and foliar spray with water (I_2F_0) treatment.

Table 4
Effect of moisture regime on relative water content and number of spikelet per spike of tuberose.

Treatments	Relative water content (%)	Number of spikelet per plant
I_0	95.78 a	52.50 a
I_1	88.87 b	47.64 b
I_2	83.38 c	34.20 c
$LSD_{(0.05)}$	2.71	1.73
CV (%)	2.09	2.64

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Table 5
Effect of growth substance on relative water content and number of spike per spike of tuberose.

Treatments	Relative water content (%)	Number of spikelet per plant
F_0	80.96 d	40.41 c
F_1	92.04 b	42.78 b
F_2	96.37 a	43.89 b
F_3	87.99 c	50.04 a
$LSD_{(0.05)}$	3.13	2.00
CV (%)	2.09	2.64

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Table 6
Interaction effect of moisture regimes and growth substance on relative water content and number of spike per spike of tuberose.

Treatments	Relative water content (%)	Number of spikelet per spike
I_0F_0	93.09 b	54.33 b
I_0F_1	75.40 g	51.33 c
I_0F_2	90.98 bc	44.33 ef
I_0F_3	123.6 a	60.00 a
I_1F_0	90.66 c-d	42.89 f
I_1F_1	80.86 f	45.22 e
I_1F_2	86.31 e	48.67 d
I_1F_3	92.39 b	53.78 b
I_2F_0	76.70 g	29.00 j
I_2F_1	88.63 c-e	31.78 i
I_2F_2	86.69 e	38.67 g
I_2F_3	87.75 de	36.33 h
$LSD_{(0.05)}$	3.13	2.00
CV (%)	2.09	2.64

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Number of spikelet per spike

Number of spikelet per spike content was significantly influenced by irrigation regime (Table 4). The highest spike per plant (52.50) was found from the 100% ET irrigation whereas, the lowest (34.20) was obtained from the 50% ET irrigation.Number of spikelet per spike was influenced by plant growth substance. The highest spike per plant (50.02) was obtained from the foliar spray with Kaolin & CCC whereas, the lowest (40.41) was recorded in the foliar spray with water (Table 5).Interaction of irrigation regime and plant growth substance had a significant influence on number of spike per plant of tuberose (Table 6). The highest spike per plant (60.00) was obtain from the combination of 100% ET irrigation and foliar spray with Kaolin and CCC (I_0F_3) treatment whereas, the lowest (29.00) with the combination of 50% ET irrigation and foliar spray with water (I_2F_0) treatment.

Chlorophyll content of leaves (SPAD value)

Chlorophyll content of tuberose leaves were significantly affected by the irrigation regime at 80 and 140 DAP (Figure 7). The maximum chlorophyll content (SPAD value) (63.56 and 54.93 %, respectively) was recorded from I_1 treatment whereas, the minimum (60.28 and 49.48 % respectively) was recorded from I_2 treatment. The increase in chlorophyll content under mild water stress may be due to the increased thickness of leaves and compacted mesophyll cells of stressed-leaves, consequently more chloroplasts per unit area as often in the case under stress conditions (Delperee et al., 2003).

Chlorophyll content of tuberose leaves were significantly affected by foliar application of kaolin and CCC at 80 and 140 DAP (Figure 8). The highest chlorophyll content (SPAD value) (64.70 and 60.81 %, respectively) was recorded from F_3 treatment whereas, the minimum (53.39 and 49.37 %, respectively) was recorded from F_0 treatment. Al-Humaid and Moftah (2005), found that under 80% irrigation regime, Kaolin treatments significantly increased chlorophyll content in water stressed-plants compared to the control plants.

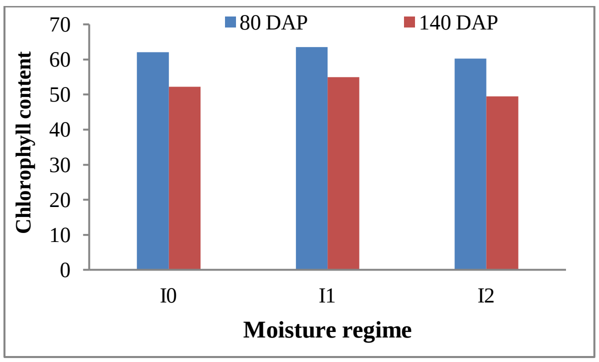

Figure 7
Effect of moisture regimes on chlorophyll content of tuberose.

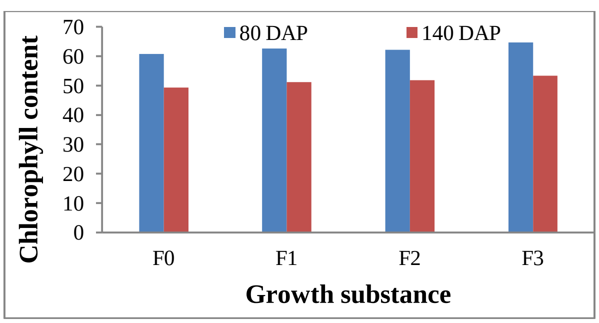

Figure 8
Effect of kaolin and CCC on chlorophyll content of tuberose.

Interaction effect of different irrigation regime and kaolin, CCC in terms of chlorophyll content at 80 and 140 DAP (Table 7). The maximum chlorophyll content (SPAD value) (67.50 and 55.98 %, respectively) was recorded from the combination of 100% ET irrigation and foliar spray with Kaolin & CCC (I_1F_3) treatment. On the other hand, the minimum chlorophyll content (SPAD value) (58.80 and 49.00 %, respectively) was recorded from the combination of 50% ET irrigation and foliar spray with water (I_2F_0) treatment.

Table 7
Interaction effect of irrigation and kaolin, CCC on chlorophyll content (SPDA value) of tuberose at different days after planting (DAP).

Treatments	Chlorophyll content (SPAD value) at	
	80 DAP	140 DAP
I_0F_0	60.81 f	51.29g
I_0F_1	63.70 c	55.27 b
I_0F_2	62.63 d	53.48 d
I_0F_3	67.50 a	55.98 a
I_1F_0	62.63 d	53.49 d
I_1F_1	62.10 e	52.49 e
I_1F_2	64.30 b	55.34 b
I_1F_3	60.10 g	51.94 f
I_2F_0	58.80 h	49.00 h
I_2F_1	64.70 b	54.90 c
I_2F_2	61.93 e	53.45 d
I_2F_3	62.13 e	51.58 fg
$LSD_{(0.05)}$	0.44	0.50
CV (%)	3.42	4.29

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Stomatal conductance

Stomatal conductance significantly influenced by irrigation regime at 80, 100, 120 and 140 DAP (Figure 9). At 80, 100, 120 and 140 DAP, 100% ET irrigation (I0) treatment produced highest stomatal conductance (20.58, 29.96, 37.98 and 54.26 mmol ms-2, respectively) whereas, the lowest (17.17, 25.55, 33.02 and 39.71 mmol ms-2, respectively) was found from 50% ET irrigation (I_2) treatment. Water deficit conditions strongly reduced the number of stomata per mm2 of tuberose leaves at all stages of plant growth with mature stages being most affected. The negative effect of water stress on stomata formation as a result of decreasing leaf cell division and enlargement was reported by Taiz and Zeiger (2002).

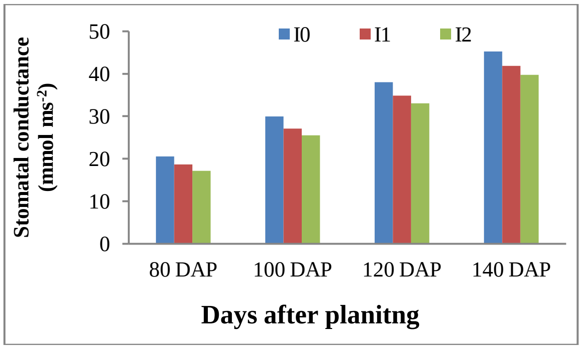

Figure 9
Effect of moisture regimes on stomatal conductance of tuberose

Stomatal conductance varied significantly with kaolin and CCC application at 80, 100, 120 and 140 DAP (Figure 10). At 80, 100, 120 and 140 DAP, the maximum stomatal conductance (19.57, 29.14, 37.50 and 444.84 mmol ms-2 respectively) was produced from F_3 treatment whereas minimum (16.53, 24.91, 32.33 and 38.27 mmol ms-2 respectively) was found from F_0 treatment. The number of stomata per unit area of Kaolin-sprayed leaves had increased compared with unsprayed, stressed plants, with Kaolin having greater effects at all growth stages. Application of Kaolin in stomata regulation may have been brought about by the great ability of Kaolin particles to reduce heat stress and solar injury (Glenn et al., 2003) causing only partial closure of stomata.

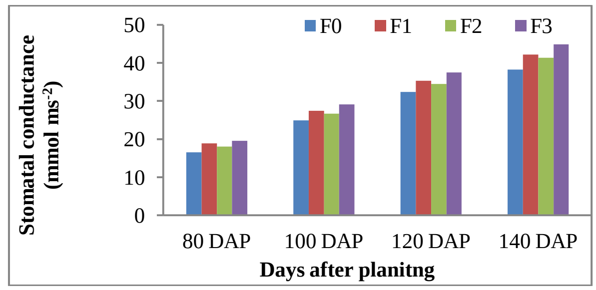

Figure 10
Effect of kaolin and CCC on stomatal conductance of tuberose.

Table 8
Interaction effect of moisture regimes and growth substance on stomatal conductance of tuberose at different days after planting (DAP**).**

Treatments	Stomatal conductance (mmol ms^{-2}) at			
	80 DAP	100 DAP	120 DAP	140 DAP
I_0F_0	17.40 f	26.08 f	33.52 g	51.70 g
I_0F_1	19.20 d	27.85 bc	35.29 cd	55.40 d
I_0F_2	17.10 fg	25.56 g	33.00 h	47.80 i
I_0F_3	20.60 a	36.97 a	57.44 a	78.60 a
I_1F_0	18.50 e	27.18 cd	34.62 e	62.50 c
I_1F_1	19.90 b	28.47 b	35.91 b	54.70 e
I_1F_2	19.30 cd	27.98 bc	35.42 bc	71.40 b
I_1F_3	19.10 d	27.44 c	34.88 de	47.40 i
I_2F_0	13.70 h	22.38 i	29.82 i	44.00 j
I_2F_1	19.60 bc	28.16 b	35.60 bc	49.80 h
I_2F_2	18.40 e	26.79 e	34.23 ef	52.90 f
I_2F_3	17.00 g	25.37 h	32.81	55.90 d
$LSD_{(0.05)}$	0.31	0.40	0.66	0.97
CV (%)	1.02	2.48	5.48	1.12

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Interaction effect of irrigation regime and kaolin, CCC influenced the stomatal conductance at 80, 100, 120 and 140 DAP (Table 8). At 80, 100, 120 and 140 DAP, the highest stomatal conductance (20.60, 36.97, 57.44 and 78.60 mmol ms-2 respectively) was obtained from the combination of100% ET irrigation and foliar spray with Kaolin and CCC while, the lowest (13.70, 22.38, 29.42 and 44.00 mmol ms-2, respectively) was recorded from the combination of 50% ET irrigation and foliar spray with water.

CO_2 assimilation

Different irrigation regime significantly influenced CO_2 assimilation of tuberose at 80, 100, 120 and 140 DAP (Figure.11). At 80, 100, 120 and 140 DAP, the highest CO_2 assimilation (1.65, 2.78, 3.69 and 4.65 respectively) was found in I0 treatment and the lowest (1.07, 1.79, 2.59 and 3.12 respectively) was found in I2 treatment. Study referred that 100% ET irrigation exposed best result in terms of CO_2 assimilation. Photosynthetic CO_2 assimilation (A) and transpiration (E) rates were significantly lower in water-stressed tuberose plants relative to non-stressed plants at all growth stages.

Foliar application of kaolin and CCC significantly influenced CO_2 assimilation of tuberose at 80, 100, 120 and 140 DAP (Figure 12). At 80, 100, 120 and 140 DAP, the highest CO_2 assimilation (1.93, 3.06, 4.38 and 5.33, respectively) was recorded from F3 treatment whereas, the lowest (1.10, 2.17, 2.58 and 3.00, respectively) was counted from F0 treatment. The study of Glenn et al. (2003) on the use and effect of Kaolin indicated that the reflective coating spray on plants under water stress provided more benefit in reducing the heat load than a reduction in CO_2 assimilation due to light obstruction.

CO_2 assimilation of tuberose significantly influenced by the Interaction effect of irrigation and kaolin, CCC at 80, 100, 120 and 140 DAP (Table 9). At 80, 100, 120 and 140 DAP, the maximum CO_2 assimilation (2.40, 3.38, 4.74 and 5.90, respectively) was recorded from the combination of 100% ET irrigation and foliar spray with Kaolin and CCC (I_1F_3) treatment. On the other hand, the lowest CO_2 assimilation (1.00, 1.53, 2.11 and 3.20 respectively) was recorded from the combination of 50% ET irrigation and foliar spray with water (I_2F_0) treatment. The study indicated that 100% ET irrigation and foliar spray with Kaolin and CCC revealed better performance in terms of CO_2 assimilation of tuberose.

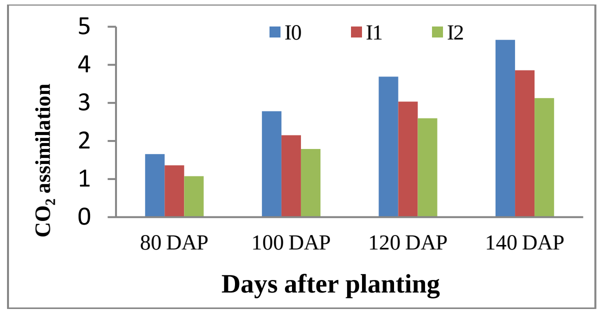

Figure 11
Effect of moisture regimes on CO2 assimilation of tuberose

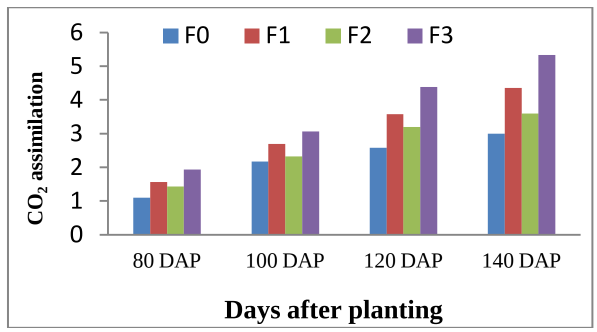

Figure 12
Effect of kaolin, CCC on CO2 assimilation of tuberose.

Evapotranspiration rate (ET)

Different irrigation regime significantly influenced transpiration rate of tuberose at 80, 100, 120 and 140 DAP (Figure 13). At 80, 100, 120 and 140 DAP, the highest transpiration rate (0.32, 0.87, 1.32 and 1.50 respectively) was found form 100% ET irrigation (I_0)treatment whereas, the lowest (0.20, 0.55, 0.71 and 1.05 respectively) was recorded from 50% ET irrigation (I_2) treatment. Study referred that 100% ET irrigation exposed best result in terms of evaporation rate. Al-Humaid and Moftah (2005), found that transpiration (E) rates were significantly lower in water-stressed tuberose plants relative to non-stressed plants at all growth stages.

Table 9
Interaction effect of moisture regime and kaolin, CCC on CO2 assimilation of tuberose at different days after planting (DAP).

Treatments	CO_2 assimilation at			
	80 DAP	100 DAP	120 DAP	140 DAP
I_0F_0	1.30 fg	1.83 e-g	2.51 ef	4.30 b-d
I_0F_1	2.10 b	2.63 b	3.31 b	4.06 c-e
I_0F_2	1.80 cd	2.33 bc	3.01 bc	3.80 e
I_0F_3	2.40 a	3.38 a	4.74 a	5.90 a
I_1F_0	1.30 fg	1.83 e-g	2.51 ef	4.50 bc
I_1F_1	1.70 c-e	2.23 de	2.91 cd	3.80 e
I_1F_2	1.60 de	2.13 ef	2.81 cd	3.90 de
I_1F_3	1.80 cd	2.33 b-d	3.01 bc	5.40 b
I_2F_0	1.00 h	1.53 h	2.11 g	3.20 f
I_2F_1	1.30 fg	1.83 e-g	2.51 ef	4.50 bc
I_2F_2	1.50 ef	2.03 ef	2.71 de	4.70 b
I_2F_3	1.90 bc	2.43 b-d	3.11 b	5.40 b
$LSD_{(0.05)}$	0.26	0.30	0.37	0.45
CV (%)	10.03	7.45	6.59	6.68

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Foliar application of kaolin and CCC significantly influenced transpiration rate of tuberose at 80, 100, 120 and 140 DAP (Figure 14). At 80, 100, 120 and 140 DAP, the highest evaporation rate (0.43, 0.94, 1.27 and 1.47, respectively) was recorded from foliar spray with Kaolin and CCC (F_3) treatment whereas, the lowest (0.22, 0.58, 0.76 and 0.98, respectively) was counted from foliar spray with water (F_0) treatment. Water stress significantly reduced transpiration rate (E), while antitranspirants enhanced it either at 60% or 80% ET irrigation Al-Humaid and Moftah (2005), observed that in tuberose plants.

Transpiration rate of tuberose significantly influenced by the Interaction effect of irrigation and plant growth substance at 80, 100, 120 and 140 DAP (Table 10). At 80, 100, 120 and 140 DAP, the maximum transpiration rate (0.56, 1.06, 1.49 and 1.91, respectively) was recorded from the combination of 100% ET irrigation and foliar spray with Kaolin and CCC (I_0F_3) treatment. On the other hand, the lowest transpiration rate (0.18, 0.30, 0.66 and 0.71, respectively) was recorded from the combination of 50% ET irrigation and foliar spray with water (I2F0) treatment. The study indicated that 100% ET irrigation and foliar spray with Kaolin and CCC revealed better performance in terms of transpiration rate of tuberose.

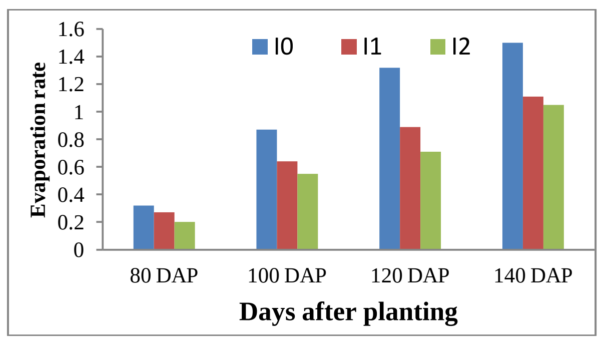

Figure 13
Effect of moisture regimes on evapotranspiration rate of tuberose.

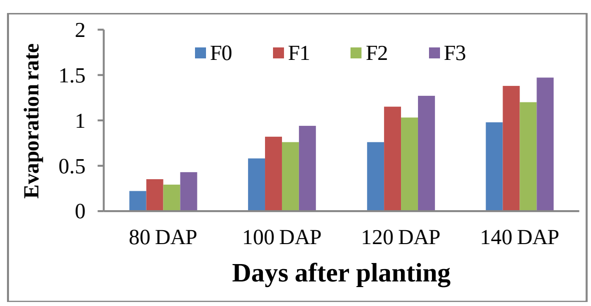

Figure 14
Effect of kaolin and CCC on evapotranspitration rate of tuberose.

Table 10
Interaction effect of moisture regimes and kaolin, CCC on evapotranspiration rate of tuberose at different days after planting (DAP).

Treatments	Evapotranspiration rate at			
	80 DAP	100 DAP	120 DAP	140 DAP
I_0F_0	0.22 e-g	0.44 de	0.70 d	0.93 h
I_0F_1	0.25 d-f	0.47 de	0.73 e	0.94 h
I_0F_2	0.25 d-f	0.67 c	0.93 c	1.36 d
I_0F_3	0.56 a	1.06 a	1.49 a	1.91 a
I_1F_0	0.26 c-e	0.48 de	0.74 d	1.07 g
I_1F_1	0.20 fg	0.72 c	0.98 c	1.30 e
I_1F_2	0.27 c-e	0.89 b	1.25 b	1.73 b
I_1F_3	0.47 b	0.69 c	0.95 c	1.24 f
I_2F_0	0.18 g	0.30 f	0.66 f	0.71 j
I_2F_1	0.28 cd	0.50 d	0.76 d	1.62 c
I_2F_2	0.31 c	0.53 d	0.79 d	0.82 i
I_2F_3	0.26 c-e	0.48 de	0.74 e	1.07 g
$LSD_{(0.05)}$	0.05	0.11	0.07	0.05
CV (%)	11.01	8.48	10.75	2.50

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Number of bulbs

Different irrigation regime exhibited significant variation. The results revealed that, the number of bulbs of tuberose increased gradually with decreased the irrigation up to 75% (Table 11). The maximum bulbs number (24.08) was observed from I_1 treatment whereas, the minimum (18.68) was observed from I_2 treatment. The present study referred that 75% ET irrigationproduced maximum number of bulbs.

The number of bulbs was significantly influenced by kaolin and CCC (Table 12). The highest bulbs number (23.78) was observed from F_3 treatment whereas, the minimum number (19.33) was observed from F_0 treatment.

There was significant variation among the interaction of irrigation and application of kaolin and CCC on numbers of bulbs (Table 13). The maximum number of bulbs (25.67) was recorded with the combination of 75% ET irrigation and foliar spray with Kaolin & CCC (I_1F_3) treatment whereas the minimum (16.00) was recorded from the combination of 50% ET irrigation and foliar spray with water (I_2F_0) treatment. Present study revealed that 100% ET irrigation and foliar spray with Kaolin & CCC produced maximum number of bulbs.

Diameter of bulb

Significant difference was found on diameter of bulb for the different irrigation regime (Table 11). The highest diameter of bulb (4.10 cm) was found from I_1 treatment while, the lowest (3.30 cm) was observed from I_2 treatment.

Foliar application of kaolin and CCC differed non significantly on diameter of bulb of tuberose (Table 12). But numerically, the highest diameter of bulb (3.93 cm) was found from F_3 (foliar spray with Kaolin and CCC) treatment whereas, the lowest (3.26 cm) was found from F_0 (foliar spray with water) treatment.

Table 11
Effect of moisture regimes on bulb yield of tuberose.

Treatments	Number of bulb	Diameter of bulb (cm)	Weight of bulb (g)	Bulb dry weight (g)
I_0	21.83 b	3.62 b	144.0 b	37.14 b
I_1	24.08 a	4.10 a	168.8 a	38.97 a
I_2	18.68 c	3.30 c	104.5 c	35.72 c
$LSD_{(0.05)}$	1.15	0.31	9.66	0.42
CV (%)	3.64	5.80	4.74	2.77

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Table 12
Effect of kaolin and CCC on bulb yield of tuberose.

Treatments	Number of bulb	Diameter of bulb cm)	Weight of bulb (g)	Bulb dry weight (g)
F_0	19.33 c	3.26 c	125.3 c	36.02 c
F_1	21.44 b	3.56 b	138.0 b	37.41 b
F_2	21.57 b	3.63 b	140.3 b	37.07 b
F_3	23.78 a	3.93 a	152.7 a	38.62 a
$LSD_{(0.05)}$	1.32	0.23	11.16	0.48
CV (%)	3.64	5.80	4.74	2.77

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Significant variation was recorded due to combined effect of different irrigation regime and kaolin, CCC in terms of diameter of bulb of tuberose (Table 13). The maximum diameter of bulb (4.40 cm) was recorded from the treatment combination of I_1F_3 treatment whereas the minimum diameter of bulb (3.20 cm) was recorded from I_1F_2 treatment.

Weight of bulb

Weight of bulb showed statistically significant differed due to the different irrigation regime (Table 11). The highest weight of bulb (168.80 g) was observed from the 75% ET irrigation. On the other hand, the lowest weight of bulb (104.50 g) was found from the 50% ET irrigation.

Application of kaolin and CCC differed significantly on the weight of bulb of tuberose (Table 12). The highest weight of bulb (152.70 g) was observed from foliar spray with Kaolin and CCC. On the other hand, the lowest weight of bulb (125.30 g) was found from foliar spray with water. Interaction effect of different irrigation regime and plant growth substance varied significantly in terms of weight of bulb of tuberose (Table 13). The maximum weight of bulb (194.00 g) was observed in I_1F_3 treatment (75% ET irrigation and foliar spray with Kaolin and CCC) whereas, the minimum (70.00 g) was observed from I_2F_0 treatment.

Bulb dry weight

Weight of dry bulb showed statistically significant differed due to the different irrigation regime (Table 11). The highest weight of dry bulb (38.97 g) was observed from the 75% ET irrigation treatment. On the other hand, the lowest weight of dry bulb (35.72 g) was found from the 50% ET irrigation treatment.

Foliar application of kaolin and CCC differed significantly on the weight of dry bulb of tuberose (Table 12). The highest weight of dry bulb (38.62 g) was observed from foliar spray with Kaolin and CCC treatment. On the other hand, the lowest weight of bulb (36.02 g) was found from foliar spray with water treatment.

Table 13
Interaction effect of moisture regimes and kaolin, CCC on bulb yield of tuberose.

Treatments	Number of bulb	Diameter of bulb (cm)	Weight of bulb (g)	Bulb dry weight (g)
I_0F_0	24.00 bc	3.66 cd	190.0 a	41.93 b
I_0F_1	21.70 de	3.66 cd	138.0 c	37.30 d
I_0F_2	21.30 ef	3.63 d	161.0 b	33.67 h
I_0F_3	20.33 f	3.73 cd	87.00 d	35.67 g
I_1F_0	24.00 bc	3.73 cd	154.0 b	38.00 c
I_1F_1	22.30 de	3.50 de	187.0 a	38.00 c
I_1F_2	24.33 b	3.60 d	140.0 c	36.20 ef
I_1F_3	25.67 a	4.40 a	194.0 a	43.70 a
I_2F_0	16.00 i	3.20 e	70.00 e	32.30 i
I_2F_1	17.33 h	4.20 ab	96.00 d	35.90 fg
I_2F_2	22.70 cd	4.00 bc	156.0 b	38.20 c
I_2F_3	18.70 g	3.80 cd	96.00 d	36.50 e
$LSD_{(0.05)}$	1.32	0.35	11.16	0.48
CV (%)	3.64	5.80	4.74	2.77

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

Interaction effect of different irrigation regime and kaolin, CCC varied significantly in terms of weight of dry bulb of tuberose (Table 13). The maximum weight of bulb (43.70 g) was observed in I_1F_3 (75% ET irrigation and foliar spray with Kaolin and CCC) treatment whereas, the minimum (32.30 g) was observed from I2F0 (50% ET irrigation and foliar spray with water) treatment.

Length of flowering stalk and length of rachis

Length of flowering stalk of tuberose were significantly affected by the irrigation regime (Table 14).

Table 14
Effect of moisture regimes on length of flowering stalk and length of rachis of tuberose.

Treatments	Length of flowering stalk (cm)	Length of rachis (cm)
I_0	94.65 a	31.27 a
I_1	88.36 b	29.60 b
I_2	81.25 c	28.10 c
$LSD_{(0.05)}$	2.22	0.85
CV (%)	1.77	1.95

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

The maximum length of flowering stalk (94.65 cm) was recorded from I_0 treatment. On the other hand, the minimum length flowering stalk (81.25 cm) was recorded from I_2 treatment.Length of flowering stalk of tuberose leaves were significantly affected by foliar application of kaolin and CCC (Table 15). The highest length of flowering stalk (91.00 cm) was recorded from F_0 treatment. On the other hand, the lowest length of flowering stalk (78.77 cm) was recorded from F_3 treatment.

Table 15.
Effect of kaolin and CCC on length of flowering stalk and length of rachis of tuberose**.**

Treatments	Length of flowering stalk (cm)	Length of rachis (cm)
F_0	91.00 a	31.80 a
F_1	87.33 b	30.70 b
F_2	82.00 c	29.80 b
F_3	78.77 d	26.33 c
$LSD_{(0.05)}$	2.56	0.97
CV (%)	1.77	1.95

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

The maximum length of flowering stalk (103.00 cm) was recorded from the combination of 100%

ET irrigation and foliar spray with water treatment whereas, the minimum (71.70 cm) was recorded from the combination of 50% ET irrigation and foliar spray with kaolin and CCC (I_2F_3) treatment (Table 16).

Length of rachis

Different irrigation regime exhibited significant variation in length of rachis results revealed that, length of rachis of tuberose increased gradually with increased the irrigation up to 100% (Table 14). The maximum length of rachis (31.27 cm) was observed from 100% ET irrigation (I0) treatment whereas, the minimum (21.00 cm) was observed from 50% ET irrigation (I_2) treatment. The present study referred that 100% ET irrigation produced height length of rachis. It was significantly influenced by kaolin and CCC (Table 15). The highest length of rachis (31.80 cm) was observed from foliar spray with water (F0) treatment whereas, the lowest (26.33 cm) was observed from foliar spray with Kaolin and CCC (F_3) treatment. There was significant variation among the interaction of irrigation and kaolin, CCC on length of rachis (Table 16). The maximum length of rachis area (38.70 cm) was recorded with the combination of 100% ET irrigation and foliar spray with water (I0F0) treatment whereas, the minimum (21.00 cm) was recorded from the combination of 50% ET irrigation and foliar spray with kaolin and CCC (I_2F_3). Present study revealed that 100% ET irrigation and foliar spray with water produced maximum length of rachis.

Table 16
Interaction effect of moisture regimes and kaolin, CCC on length of flowering stalk and length of rachis of tuberose

Treatments	Length of flowering stalk (cm)	Length of rachis (cm)
I_0F_0	103.00 a	38.70 a
I_0F_1	80.70 fg	32.70 d
I_0F_2	63.30 i	22.70 g
I_0F_3	86.70 e	30.70 e
I_1F_0	82.30 f	23.00 g
I_1F_1	98.30 b	25.70 f
I_1F_2	95.00 c	31.00 e
I_1F_3	92.00 d	35.00 b
I_2F_0	78.30 g	26.00 f
I_2F_1	94.00 cd	33.70 c
I_2F_2	81.00 f	35.70 b
I_2F_3	71.70 h	21.00 h
$LSD_{(0.05)}$	2.56	0.97
CV (%)	1.77	1.95

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

CONCLUSION

Considering the findings of the experiment, it may be concluded that application of anti-transpirant kaolin and CCC were found to enhance all parameters in plants subjected to mild water stress (75% ET), while at higher stress (50%ET) anti-transpirant could not induce suitable physiological performance. At mild water stress (75% ET) plant growth and flowering parameters are not negatively affected but at severe stress (50% ET) growth and flowering are negatively affected.In addition to I_0F_3 (100% irrigation and foliar application of kaolin and CCC)the treatment combination of I_1F3 (irrigation 75% ET and foliar application of kaolin and CCC) showed better performance. Further studies at different agro-ecological zone of Bangladesh are needed for precise recommendation.

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