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Cultivation of tuberose in pot and field with humic acid treatments under a semi-arid climate

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ABSTRACT

In order to find a suitable way for tuberose cultivation in cool and dry climates and study the effects of humic acid on growth, a factorial experiment was carried out based on a complete block design with three replications. Tuberose cv. Double was cultivated in two culture systems, *i.e.* field and pot. Three levels of humic acid (0, 2.5 and 5 kg/ha) were applied. Results showed that number of bulbs, number of side bulblets and main bulbs weight were significantly increased in the field culture system in comparison with greenhouse. However, characteristics such as leaf area, floret diameter, bud diameter, rachis length and flowering percentage were significantly higher in pot culture. Humic acid application (2.5 and 5 kg/ ha) improved some of the important characteristics such as flowering percentage in pot system and main bulb weight and total bulbs weight in field cultivation. Application of humic acid in pot culture was found as suitable cultivation system to enhance the flowering percentage. However, field culture system was more effective in bulb production.

Key words: Humic acid, tuberose, pot culture, protected cultivation.

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) is a major bulbous plant with attractive, elegant, fragrant and very aromatic flowers, which belongs to the Agavaceae family. The tuberose has a high economic potential for cut flower, perfume industry, essential oil and medicinal usage. The tuberose is native of Mexico (Asif *et al*., 1). It is cultivated mostly in tropical and sub-tropical areas of Mexico, Pakistan, India and Iran. Many zones in Iran have a cool and dry climate; subsequently tuberose planting is performed only in the sub-tropical areas. In this study we explored feasibility of tuberose cultivation in different regions, in terms of climate and soil conditions.

Humic acids are aromatic organic acids with high molecular weight. Humic acids are produced from organic materials and contain humic and fulvic acids, which are called humin materials (Khaled and Fawy, 7). Humic acid is confirmed to be effective in enhancing the mineral nutrient uptake in plants (Chang *et al*., 2). Uptake of potassium, by reducing soil potassium fixation, and phosphorus is increased when the amount of humic acid in soil is increased (Rengrudkij and Partida, 12). Kazemi (6) reported that humic acid increases the amount of potassium in cucumber plants. In several studies, it was shown that humic and fulvic acids can increase uptake of mineral elements and increase fresh and dry weights in crops (Khaled and Fawy, 7). Humics are ubiquitous organic materials in terrestrial and aquatic ecosystems (Jannin *et al*., 4) and are found in soil, peat, and lignite. Humic acid also improves soil physical properties, soil stability and element transportation to plant and stabilization of soil organic matter against microbiological attack (Sharif *et al*., 13). On the other hand, humic acid acts as a catalyst in promoting the activity of microorganisms in soil (Nikbakht *et al*., 11). Additionally, it could enhance aggregate stability and reduce leaching in soil (Jannin *et al*., 4). With regard to the above mentioned justification for providing a demanded nutrition supply for ideal plant production, we applied several humic acid treatments in the experimental designed plots for tuberose cultivation to assess the yield with respect to the given inputs.

In literature, there is no research on comparing tuberose cultivation in pot and field conditions. This plant has hardly ever been planted and/or brought up in cold and semi-arid regions with low humidity such as Bastam (in Shahrood). The objectives of this study are to evaluate humic acid application as an organic fertilizer on quality and quantity of tuberose in pot and field culture systems and to assess the feasibility of growing of this plant in a cool and semi-arid region.

MATERIALS AND METHODS

The field and pot experiments were carried out during two successive seasons in spring and summer

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of 2012 at Faculty of Agriculture, Shahrood University of Technology, Bastam 36° 29′ N latitude and 55°E longitude with an average altitude of 1366 m above sea level. Soil moisture regimes of the study region are Aridic and Torric and thermal regime is Mesic (Sharififar, 2012). The soil was a loam with a pH of 7.8. Soil phosphorous was 44.5 ppm, K 0.221 ppm, total OC 0.59% and total N 0.105%. Summary of 50-year mean climatic data are presented in Table 1.

A factorial experiment with two culture systems and three levels of humic acids (0, 2.5 and 5.0 kg/ha) were applied based on randomizided complete block design (RCBD) with three replications. The humic acid was mixed with the soil before planting in different treatments. The bulbs were sown in April 2012. In field, the plants were cultivated in plots having five rows with row spaced at 30 cm. The pots had 30 cm depth, 25 cm dia. and 9.5 kg soil. Pots were also placed in the field, in open air and irrigated periodically. Irrigation of the plots was applied once a week. The uniform bulbs of cv. Dobell had approximately 2.5 to 3.5 cm dia. supplied from the National Institute of Ornamental Plants of Iran.

Table 1. Mean temperature and precipitation data of the study area.

Season	Month	Tm (°C)	Tmax (°C)	Tmin (°C)	P (mm)
Winter	Dec	3.6	8.2	-1	16.7
	Jan	1.7	6.1	-2.7	18
	Feb	3.8	8.8	-1.3	18.3
Spring	Mar	8.5	14.1	2.8	29.6
	Apr	14.8	21.1	8.5	25
	May	19.6	26.3	13	20.2
Summer	Jun	24.2	31	17.5	4.7
	Jul	26.7	33.1	20.3	2.3
	Aug	25.8	21.4	19.1	1.5
Autumn	Sep	21.9	29	14.8	2.8
	Oct	15.6	2.4	8.8	6.2
	Nov	9	14.8	3.2	9.1
	Annual	14.6	20.6	8.6	154.4

Several vegetative and reproductive characteristics including leaf number, dry and fresh weights were measured at the beginning of the reproductive growth stage. Fresh weight of leaves was measured immediately after harvest and dry weights were measured after drying for 48 h in oven at 70°C. The weights of total and main bulbs were measured by digital scales after their harvest. Plant height and rachis length were measured at full bloom stage with a ruler. Number of rachis and florets per rachis were counted at full open stage. Number of bulblets was measured after harvesting. The diameters of inflorescence stem, floret and flower bud at the balloon stage and size of the bulb were recorded by electronic digital calipers. Leaf area was measured by level gauge leaf (model Delta-t, England). The average of chlorophyll amount was measured by sampling top, middle and the terminal leaves of four random plants in each plot using the Minolta SPAD 502 (Japan). Flowering percentage was calculated by dividing the number of flowering plants to total number of plants. The data analysis was performed by statistical comparison of means, using the LSD (Least Significant Difference) multiple range test method by SAS® 9.1 software.

RESULTS AND DISCUSSION

The ANOVA results (Table 2) showed the significant effects of culture system type on leaf fresh and dry weights and number. Leaf dry weight was also significantly increased by humic acid in field cultivation compared to pot cultivation ($p \leq 0.05$). Leaf fresh and dry weights were significantly increased in the field in comparison with pot culture (Table 3). Humic acid increased leaf weight of wheat (Ulukan, 15), cucumber growth, and the dry weight of leaves (Kazemi, 6). Dry and fresh weight increase is related

Table 2. ANOVA for growth characteristics of tuberose.

SOV	df	Amount of chlorophyll (SPAD)	Leaf area (cm^2)	Leaf No.	Leaf DW (g)	Leaf FW (g)
Replication	2	2.0196	0.5525	0.3159	4.7190	943.68
Culture system (C)	1	65.43*	11.60**	5.8368**	575.05**	3643.16**
Humic acid (H)	2	0.8169 ns	2.1238*	0.2222ns	17.31*	563.19*
C × H	2	2.4374 ns	2.3510*	2.3888*	0.2864ns	557.93ns
Error	10	8.7430	0.4970	0.4159	3.9998	256.84
CV (%)		7.82	31.37	7.75	11.46	16.86

*'**Significant at 5 & 1% levels

Table 3. The effects of interactive treatments on different traits in tuberose.

	Humic acid (kg/ ha)	No. of bulbs	No. of side bulblets	Main bulb dia. (mm)	Amount of chlorophyll (SPAD)	Leaf area (cm^2)	Leaf No.	Total wt. of bulbs (g)	Main bulb wt. (g)	Leaf DW (g)	Leaf FW (g)
Field	0	19.6a	7.39a	28.4a	39.76a	1.44bc	9.5a	133.09a	121.23b	21.71a	113.52a
	2.5	19.26a	8.45a	22.28a	40.13a	1.49bc	8.5ab	134.69a	101.02c	24.65a	115.78a
	5.0	19.66a	7.53a	27.64a	39.16a	1.4c	8.66ab	136.42a	141.43a	22.91a	98.48a
		19.50A	7.79A	25.99A	39.68A	1.44B	8.88A	134.73A	121.23A	23.09A	109.26A
Pot	0	3.08b	2.16a	28.02a	34.94a	2.05bc	6.91c	68.07c	33.09d	10.03c	62.91b
	2.5	4.91b	3.33a	26.13a	35.89a	2.69b	7.91bc	98.23bc	36.28d	13.83b	96.47a
	5.0	5.75b	4.25a	29.96a	36.78a	4.41a	8.41ab	106.36ab	46.26d	11.5bc	83.04a
		4.58B	3.25B	28.04A	35.87B	3.05A	7.75B	90.88B	38.54B	11.78B	80.81B

to plant nutrients and water availability. Humic acid increased water availability in soil and thus enhanced uptake of nutrient elements. Dry and fresh weight of tuberose is increased by nitrogen and potassium application (Mahgoub *et al*., 8). Leaf area was also significantly increased by humic acid application. The maximum leaf area, 4.41 cm^2, was observed in pot culture that was supplemented by 1.3 g/kg soil humic acid. The amount of chlorophyll was only affected by cultivation system. The field culture improved chlorophyll amount significantly. Since the range of SPAD values depends on nitrogen, irradiance and plant water status (Martínez and Guiamet, 10), higher water availability and lower amount of evaporation of field in comparison with pot culture resulted in higher chlorophyll in field compared with pot culture.

Total weight of the bulbs, main bulb weight, number of bulblets and number of side bulblets were significantly affected only by cultivation system. Field cultivation was more effective than pot culture (Tables 3 & 4). Main bulb weight was significantly increased by humic acid application. Diameter of the main bulb was not significantly affected by culture system and humic acid; however, diameter of bulbs in field was more than pot culture (Tables 3 & 4). The results show that bulb properties were significantly improved in field culture which may be related to higher water availability. Temperature fluctuation in pot culture was noticed more than field culture. The main bulb weight was enhanced due to humic acid application. Humic acid has many nutrient elements such as N, P and K and also improves uptake of other nutrients (Rengrudkij and Partida, 12). Higher potassium and nitrogen can increase bulb weight (Kabir *et al*., 5). There is a direct relationship between increase of main bulb weight and application of humic acid. Mahgoub *et al.* (8) reported that use of potassium and nitrogen improves the main bulb weight. Number of bulblets and side bulblets were also increased due to humic acid treatment.

The number of days to bolting (DB) and days from bolting stage to flowering stage (DBF)" were significantly affected by culture system and humic acid (Table 5). The best and the least DBF were obtained in pot culture system (Table 6). Flowering stem height was significantly affected by culture system and humic acid. Application of 1.3 g/ kg soil humic acid, increases number of florets, but it is not statistically significant. It was observed that floret diameter was significantly influenced by pot culture system; however, there are no significant differences among humic acid levels. The plants, which were

Table 4. ANOVA for characters of relating to tuberose bulblets.

SOV	Df	No. of bulbs	No. of side bulblets	Main bulbs dia.	Main bulbs wt.	Total wt. of bulbs
Replication	2	33.83	7.3939	18.94	351.473	1418.32
Culture system (C)	1	1002.47**	92.79**	39.97 ns	30766.05**	8652.70**
Humic acid (H)	2	2.8096 ns	2.4790 ns	36.43 ns	985.512**	709.707*
C × H	2	2.9163 ns	1.7840 ns	5.6945 ns	380.749*	519.708 ns
Error	2	6.8926	1.6029	15.79	82.91	337.695
CV(%)	10	21.79	22.93	14.71	11.39	16.28

*'** Significant at 5 & 1% levels

Table 5. ANOVA for reproductive and floret traits in tuberose.

SOV	Df	Flowering percent	Floret diameter	Bud diameter	Rachis length	No. of florets	Flowering stem diameter	Height flowering stem	Days required for reach stem to flowering	Days required to reach flowering stem
Replication	2	10.26	27.01	0.1338	3.3172	5.0555	0.3023	19.32	249.459	365.239
Culture system (C)	1	9142.49**	796.803**	1.9273*	263.733**	264.500**	6.2776**	1810.81**	1178.71**	7469.27**
Humic acid (H)	2	841.887**	27.58ns	1.7032*	12.62**	12.38ns	0.5964ns	138.13**	108.781*	165.267*
C x H	2	859.295**	82.59*	0.3205ns	3.0851ns	3.1666ns	1.4641*	2.5394ns	12.40ns	145.978ns
Error	10	22.89	14.30	0.4149	1.6752	4.5888	0.2562	12.28	27.26	95.86
CV (%)		19.63	12.25	8.95	10.18	17.44	9.98	8.01	15.31	11.48

*'**Significant at 5 & 1% levels

Table 6. The effects of interactive treatments on different traits in tuberose.

	Humic acid (kg/ha)	Flowering (%)	Floret dia. (mm)	Bud dia. (mm)	Rachis length (cm)	No. florets	Flowering stem dia. (mm)	Flowering stem length (cm)	Days of bolting to flowering	Days to bolting
Field	0.0	1.55c	23.56d	7.76a	16.01ab	15.33a	5.7a	49b	44.83a	62.66c
	2.5	2.33c	27.09cd	6.88a	15.5b	15a	5.92a	54.24ab	39.22ab	65.38c
	5.0	1.62c	21.99d	7.91a	18.1a	18a	5.34ab	57.97a	42.5a	66.5c
	Field	1.83B	24.21B	7.51A	16.53A	16.11A	5.66A	53.73A	42B	105.59A
Pot	0.0	29.62b	33.67bc	6.57a	6.9d	6.66b	3.71c	27.83d	31.33bc	107ab
	2.5	37.03b	35.12b	6.45a	9.25cd	9b	4.45bc	35.61c	20d	94.97b
	5.0	74.06a	43.78a	7.55a	10.5c	9.66b	5.26ab	37.58c	26.66cd	114.8a
	Pot	46.9A	37.52A	6.86A	8.88B	8.44B	4.47B	33.67B	26.18A	64.85B

cultured in pots went to bolting nearly 40 days earlier than field culture (Table 6). Plants in abiotic stress, such as water and thermal entered flowering earlier than other plants in normal conditions (El Balla *et al.*, 3). Beside abiotic stress, potassium can enhance flowering in tuberose (Mahmoodinezhade-Dezfully *et al.*, 9). Humic acid significantly increased flowering stem height (Table 6). On the other hand, flowering stem height was significantly greater in field culture system. The variation in soil environmental conditions such as temperature and moisture in field culture is lower than the pot culture, and also growth in pot may be affected by water deficiency. Flowering stem diameter was not significantly affected by humic acid, but it was significantly higher in field culture compared with pot culturing (Table 6). There are not considerable differences in bud diameter in different treatments. There is a highly significant difference in rachis length between two culture systems. In field culture, average rachis length was up to 16.53 cm, but in the pot culture it was only 8.88 cm. Higher flowering percentage was recorded in pot culture (Table 6).

The best results were obtained in 1.3 g/kg soil humic acid application. These results indicate that use of nutrient sources is important for tuberose production. This nutrition source has many elements and also enhanced nutrient uptake too (Khaled and Fawy, 7). Earlier, Kabir *et al.* (5) reported combined application of nitrogen, phosphorus and potassium sources, the flower yield is greater than use of only one source. On the other hand, there is much water stress in pot culture for stimulating flowering. Therefore, it can be stated that application of humic acid in pot culture enhances the growth and flowering in tuberose.

Application of humic acid, especially level of 5 kg/ha, can increase important characteristics such as flowering percentage, main bulb weight and total bulb weight. Of quantitative attributes, the humic acid can improve reproductive characteristics. Increase of flowering stem height, number of florets, floret diameter and rachis length with humic acid treatments could represent an increase of flower quality.

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