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Tuberose Production in Soil and Soilless Substrates

Maharik Z. Y.[1], W. M. Bazaraa[2], Neveen E. Metwally[1], A. A. Farag[1] and A. T. Elmorsy[1]

[1]Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Egypt.
[2]Floriculture Res. Dept., Horticulture Research Institute, Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

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ABSTRACT

Flowers are an integral part of our life due to their diversity in form, color and fragrance. Tuberose is a marketable ornamental species and considers as one of the most important ornamental flowers grown mainly due the long flowering period, which is an important aspect whether grown as cut flowers or landscaping. In this context, an experiment has been conducted under net greenhouse at the experimental site of Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center, Ministry of Agriculture and Land reclamation, Egypt during seasons of 2021 and 2022. The aim of the experiment was to study the effect of using gibberellic acid and potassium as spray materials on the growth and flower quality of tuberose grown in both soil and soilless media. Two main factors were under investigation in this experiment and their description were as follow; substrate types (soil cultivation "control", 50 % perlite: 50 % peat moss "PP", 90 % sand: 10 % compost "SC" and 100 % coco peat "CP"). The other factor was spray materials (water "control", 100ppm of gibberellic acid "GA", 100ppm of potassium "K" and 50ppm of gibberellic acid + 50ppm of potassium "GA+K"). Results indicated that soilless substrates regardless the substrate type recorded better results than soil production of tuberose regarding the vegetative growth, number of florets per spike, flower quality measurements and chemical measurements. Furthermore, results illustrated that coco peat was the best substrate for producing tuberose with high yield and quality, also using GA+K as a spray materials during growth of tuberose affected positively on the growth and quality on the produced tuberose flowers.

Keywords: Tuberose, Soilless, Substrates, Gibberellic acid, Potassium

1. Introduction

Flowers are prized as object of great beauty and diversity and are commercially valuable and highly perishable (O'Donoghue, 2006). Tuberose is popular flowering plant worldwide, uses usually as cut flower or garden decoration in pots, beds, borders, and for extraction of essential oil. Tuberose is popular among flowers loving people because of its sweet and pleasant fragrance and long vase life (Asif *et al.,* 2001; Singh and Shanker, 2011). Furthermore, Sood and Nagar, (2005) reported that tuberose produces attractive and fragrant white flowers which occupies very selective and special position among the ornamental bulbous plants, it is an important flower which have both aesthetic as well as economic value.

The term growing medium or substrates are used usually to describe the materials used to grow plants in containers. The good substrate should have some characteristics such as provide adequate amounts of aeration and water, allow for maximum root growth and support the plant. Substrates are often be single materials as inorganic or organic substrates, also substrate mixture or growing media are often formulated from a mix of different substrates in order to achieve the correct balance of air availability and water holding capacity for the plants to be grown well. Furthermore, composted

Corresponding Author: Neveen E. Metwally, Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Egypt.
E-mail: - neveen2000eg@yahoo.com

materials have routinely been used as a growing medium or components of growing media (Bilderback *et al*., 2005; Blok and Verhagen, 2009; Schroeder and Sell, 2009; Nair *et al*., 2011).

Moreover, substrates are defined as those materials that used alone or mixed together, that can provide the root system with better conditions (in terms of one or more aspects of plant growth) than those offered by soil cultivation. In soilless substrate culture, the substrate replaces the soil because the natural soil is often poorly suited to cultivation due to chemical (reaction, nutrient availability, etc...), physical (density, structure, water retention, etc...), or biological (presence of pathogens, exhaustion, etc...) limitations, or because in this way it controls plant growth better. Plants grown in pots are characterized by a particularly high (and unbalanced) ratio between the aerial part and root, and by much bigger water, air and nutrient requirements than those that are recorded on the soil (and in the open field) where growth rates are slower and the volume of soil available for the roots is theoretically unlimited (Gruda, 2012).

Potassium is one of the most important macronutrients that affect growth; it is involved in numerous biochemical and physiological processes vital to plant growth, yield, and quality (Marschner, 1995). Potassium deficiency reduced bud count, shortening of the flower stem, and delay flowering, also causes weak stalks and roots become more easily infected with root-rotting organisms. A potassium deficiency may affect respiration, photosynthesis, chlorophyll development, and water content of leaves (Salisbury and Ross, 1992; Sangakkara *et al*., 2000).

on the other hand, it has been known that growth regulators among the agriculture practices which is most favorable for promoting and improving plant-growth of different plants (Eid and Abou-Leila, 2006). Gibberellic acid application increased petiole length, leaf area and delayed petal abscission and color fading by the hydrolysis of starch and sucrose into fructose and glucose (Emongor, 2004; Khan and Chaudhry, 2006).

For that this work aimed to investigate the effect of using gibberellic acid and potassium as spray materials on the growth and flower quality of tuberose grown in both soil and soilless media

2. Materials and Methods

Place and plant materials

The experiment was conducted under net greenhouse in the experimental site of Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Dokki, Giza, Egypt, during two successive seasons of 2021 and 2022.

Bulbs of tuberose (*Polianthes tuberosa*) with 3-4 cm in diameter have been cultivated in pot system in the beginning of April each season. The plant density was 12 bulbs per m^2.

Pot system descripition

The pot system consisted of 12 black plastic pots per m^2. Pots (each pot filled with 8 liters of substrates) were put on a black polyethylene sheet on beds (0.5m width and 20m length). Each bed had one tank , the tank equipped with one submersible pump and drip irrigation set to deliver water and nutrient solution to each pot .The excess water and nutrient solution were allowed to run to waste (open system).

The nutrient solution that used in this experiment was described by El-Behairy, (1994). Furthermore, EC was adjusted at range of 2.00 – 2.20m.mhos^{-2}. Digital EC meter have been used to adjust the EC (electrical conductivity) to the required levels.

Treatments

Two factors have been tested in this experiment in relation to growth and flower quality of tuberose. The tested factors were as follow:

Factor (A): substrate types

1. Soil cultivation (control).
2. 50 % perlite: 50 % peat moss “PP”.
3. 90 % sand: 10 % compost “SC”.
4. 100 % coco peat “CP”.

Factor (B): spray materials

1. Water (control).
2. 100ppm of gibberellic acid “GA”.
3. 100ppm of potassium “K”.
4. 50ppm of gibberellic acid + 50ppm of potassium “GA+K".

Spray materials were applied once per month using all tested spray materials, and had repeated monthly in the same time during the experimental time.

Measurments

Different measurements have been recorded during the experimental time; vegetative growth measurements such as: leaves height (cm), number of leaves/ plant, leaves fresh and dry weights (g/ plant).

Flowering and flower quality measurements such as: number of florets/spike, number of days from planting to harvest (days), spike length (cm), spike base diameter (cm), spike fresh weight (g) and vase life (days).

Chemical measurements such as: total chlorophyll (SPAD) and (nitrogen & phosphorus & potassium) % in leaves.

Nitrogen, Phosphorus and Potassium % in leaves were measured using methods described by A.O.A.C., (1990).

Experimental Design and Statistical analysis

The experiment was arranged in split plot design with three replicates. The substrate types were arranged in the main plots, while spray materials were arranged in sub plots. Data were statistically analyzed using the analysis of variance method one way ANOVA with SAS package software version 6 (SAS Institute, 1990). The Dunkun's test was used to compare among means.

3. Results

Data in tables 1, 2 illustrate the effect of substrate type and spray material on vegetative growth measurements of tuberose grown in soil and soilless substrates.

Regarding the effect of substrate type on vegetative growth, plants grown in coco peat “CP” recorded the highest values for leaves height, number of leaves and leaves fresh & dry weights per plant, Followed by mixture of 50 % perlite and 50 % peat moss “PP “ with significant differences in most cases. On the other hand, plants grown in soil recorded the lowest values regarding vegetative growth measurements.

Regarding the effect of spray material on vegetative growth, spray tuberose plants with gibberellic acid (50ppm) + potassium (50ppm)“GA+K” recorded the highest values Followed by potassium (100ppm) “K” then gibberellic acid (100ppm) “GA” and finally water. These results were similar for leaves height, number of leaves and leaves fresh & dry weights per plant, except that in leaves height GA recorded higher values than potassium.

Regarding the effect of interaction between substrate type and spray material on vegetative growth, the interaction between coco peat and GA+K recorded the highest values for leaves height, number of leaves and leaves fresh & dry weights per plant, followed by interaction of PP and GA+K. on contrary, interaction between soil and water recorded the lowest vegetative growth values.

Data in tables 3, illustrate the effect of substrate type and spray material on number of florets/spike and flowering date of tuberose grown in soil and soilless substrates.

Regarding number of florets per spike

Data from both seasons indicated that coco peat recorded the highest number of florets per spike followed by PP, then SC and soil respectively. Moreover, there were significant differences among them.

For the effect of spray material, data from the first season clarified that GA+K treatment recorded the highest number of florets then potassium, gibberellic acid and water respectively. Furthermore, there were significant differences among treatments. Similar trend was observed in the second season except that the difference between potassium and gibberellic acid was not significant.

For the effect of interaction, data collected from both seasons illustrated that the interaction between coco peat and GA+K recorded the highest number of florets per spike, while interaction between soil and water recorded the lowest number of florets.

Regarding number of days from planting to harvest

Data collected from both seasons illustrated that soil and coco peat produced the earliest flower without significant difference between both of them, followed by PP and SC respectively.

Regarding the effect of spray material, data indicated that in both seasons plants sprayed with GA+K produced flowers earlier than all other tested spray materials, followed by water, potassium and gibberellic acid respectively. Furthermore, the differences among treatments were significant.

Concerning the effect of interaction, both interactions between coco peat and GA+K & soil and GA+K produced the earliest flowers, while interaction between PP and GA recorded the last harvest date.

Data in tables 4, 5 illustrate the effect of substrate type and spray material on flower quality measurements of tuberose grown in soil and soilless substrates.

Regarding the effect of substrate type on flower quality measurements, data collected from both seasons illustrated that flowers produced from coco peat recorded the highest values for (spike length, spike base diameter, spike weight and vase life) followed by PP, then SC and finally flowers produced from soil recorded the lowest quality values. Moreover, there were significant differences among treatments regarding spike length, spike base diameter, spike weight and vase life. Except in case of vase life, difference between CP and PP& difference between PP and SC was not significant in the first season, also difference between soil and SC was not significant in both seasons.

Regarding the effect of spray material on flower quality measurements, data collected from both seasons showed that flowers produced from plants that sprayed with "GA+K" recorded the highest values for spike length, spike base diameter, spike weight and vase life followed by "GA", then potassium and finally plants sprayed with water only produced flowers with the lowest quality values. Except in case of vase life, potassium treatment recorded longer vase life than "GA" in both seasons. Moreover, there were significant differences among treatments for all flower quality measurements.

Regarding the effect of interaction between substrate type and spray material on flower quality, the interaction between coco peat and GA+K recorded the highest values for spike length, spike base diameter, spike weight and vase life. On the contrary, data indicated that interaction between soil and water recorded the lowest flower quality values.

Data in tables 6, 7 illustrate the effect of substrate type and spray material on chemical measurements of tuberose grown in soil and soilless substrates.

Total chlorophyll

Data indicated that in the first season coco peat recorded the highest chlorophyll content followed by PP, SC and soil. Similar trend was observed in the second season.

Concerning the effect of spray material, GA+K treatment recorded the highest chlorophyll content followed by potassium, gibberellic acid and water respectively. Moreover, data indicated that there were significant differences among treatments in both seasons.

Concerning the interaction, the highest chlorophyll content was recorded with interaction between coco peat and GA+K, while interaction between soil and water recorded the lowest chlorophyll values.

Nitrogen %

Concerning the effect of substrate type, data showed that in both seasons coco peat recorded the highest nitrogen% followed by PP, SC and soil respectively. There were significant differences among treatments.

Concerning the effect of spray material, GA+K treatment recorded the highest nitrogen % then potassium, gibberellic acid and water respectively. Furthermore, there were significant differences among treatments except between GA+K and potassium.

Concerning the interaction, the highest nitrogen% was recorded with interaction between coco peat and GA+K, while interaction between soil and water recorded the lowest nitrogen%.

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Phosphorus %

Data indicated that in both seasons coco peat recorded the highest percentage then, PP, SC and finally plants grown in soil recorded the lowest phosphorus %. Differences among treatments were significant in both seasons.

Regarding the effect of spray material, data collected from both seasons illustrated that plants sprayed with GA+K recorded the highest phosphorus% then plants sprayed with potassium, followed by plants sprayed with gibberellic acid and finally water treatment recorded the lowest percentage. There were significant differences among treatments.

Regarding the interaction, the interaction between coco peat and GA+K recorded the highest phosphorus % in both seasons, while interaction between soil and water recorded the lowest phosphorus % in both seasons also.

Potassium %

For the effect of substrate type, data collected from first season showed that coco peat recorded the highest potassium % followed by PP, SC and soil respectively. Furthermore, there were significant differences among treatments except the difference between coco peat and PP & difference between PP and SC & difference between SC and soil were not significant. Similar trend was observed in the second season except that all differences among treatments were significant.

For the effect of spray material, plants sprayed with potassium recorded the highest potassium% followed by those sprayed with GA+K, then GA. On the contrary, plants sprayed with only water recorded the lowest potassium%. There were significant differences among treatments.

For the effect of interaction, the interaction between coco peat and potassium recorded the highest potassium % in both seasons. On the other hand, interaction between soil and water recorded the lowest potassium % in both seasons also.

Table 1: Effect of substrate type and spray material on leaves height and number of leaves of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Leaves height (cm)		Number of leaves/plant	
		First season	Second season	First season	Second season
		Substrate type			
SC		44.7 B	46.0 B	56.6 C	58.8 B
PP		56.1 A	57.6 A	61.8 B	66.0 A
CP		56.9 A	58.6 A	64.0 A	66.9 A
Soil		29.8 C	31.0 C	34.5 D	36.9 C
		Spray material			
	Water	43.3 D	44.7 D	50.6 D	54.2 C
	GA	47.9 B	49.2 B	53.4 C	56.2 B
	K	46.4 C	47.6 C	55.4 B	57.2 B
	GA+K	50.0 A	51.7 A	57.5 A	61.0 A
		Substrate * spray material			
SC	**Water**	41.9 f	42.8 f	56.6 cd	58.6 fg
	GA	47.0 e	46.2 e	56.0 cd	57.8 g
	K	45.0 e	48.0 e	55.8 d	58.4 fg
	GA+K	45.1 e	47.2 e	58.2 cd	60.5 ef
PP	**Water**	52.6 d	55.5 d	56.6 cd	61.9 de
	GA	56.9 b	58.2 c	59.0 c	64.0 cd
	K	54.8 bcd	54.8 d	66.1 ab	69.0 b
	GA+K	60.1 a	62.0 ab	65.3 b	68.9 b
CP	**Water**	53.7 cd	56.0 d	57.6 cd	62.3 de
	GA	57.1 b	60.3 bc	63.9 b	65.5 c
	K	55.4 bc	55.7 d	65.7 ab	65.1 c
	GA+K	61.2 a	62.3 a	68.6 a	74.9 a
Soil	**Water**	24.8 i	24.4 i	31.5 g	34.1 j
	GA	30.7 gh	32.2 h	34.6 f	37.5 hi
	K	30.3 h	32.0 h	34.0 fg	36.4 i
	GA+K	33.4 g	35.4 g	38.0 e	39.6 h

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

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Table 2: Effect of substrate type and spray material on leaves fresh and dry weights of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Leaves fresh weight (g / plant)		leaves dry weight (g / plant)	
		First season	Second season	First season	Second season
		Substrate type			
SC		153.3 C	144.4 C	44.4 C	39.9 C
PP		185.8 B	170.6 B	52.3 B	49.4 B
CP		208.6 A	201.5 A	60.2 A	58.5 A
Soil		123.6 D	115.6 D	33.0 D	33.3 D
		Spray material			
	Water	152.3 D	142.1 D	41.3 D	39.9 C
	GA	165.9 C	155.8 C	46.8 C	44.9 B
	K	170.3 B	159.5 B	48.7 B	46.0 B
	GA+K	182.8 A	174.7 A	53.1 A	50.2 A
		Substrate * spray material			
SC	**Water**	135.8 h	128.8i	38.3 h	34.7 j
	GA	155.9 g	144.0 h	46.1 g	39.1 hi
	K	151.7 g	142.0 h	43.8 g	39.7 h
	GA+K	169.5 f	162.6 f	49.6 f	45.9fg
PP	**Water**	168.2 f	153.4 g	44.6 g	43.9 g
	GA	182.7 e	165.2 f	50.6ef	49.0ef
	K	188.4 de	172.3 e	54.5 d	49.8 e
	GA+K	204.0 c	191.6 c	59.4bc	55.1 cd
CP	**Water**	191.8 d	183.2 d	54.0 de	53.2 d
	GA	203.9 c	197.8bc	58.7 c	57.5bc
	K	214.5 b	203.4 b	61.9 b	59.5 b
	GA+K	224.1 a	221.6 a	66.0 a	63.7 a
Soil	**Water**	113.2 j	103.0 k	28.6 k	27.9 k
	GA	121.1i	116.3 j	31.8 j	34.1 j
	K	126.5i	120.2 j	34.5i	35.0 j
	GA+K	133.8 h	123.1 h	37.2ij	36.3ij

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

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Table 3: Effect of substrate type and spray material on number of florets per spike and number of days from planting to harvest of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Number of florets/spike.		Number of days from planting to harvest (days)	
		First season	Second season	First season	Second season
			Substrate type		
SC		25.7 C	26.9 C	115.2 A	119.1 A
PP		27.2 B	28.4 B	111.4 B	113.1 B
CP		28.8 A	30.5 A	107.4 C	106.5 C
Soil		24.2 D	25.3 D	106.6 C	104.6 C
			Spray material		
	Water	24.7 D	26.1 C	106.9 C	107.1 C
	GA	25.9 C	27.0 B	115.9 A	118.9 A
	K	26.4 B	27.8 B	113.6 B	114.0 B
	GA+K	29.0 A	30.2 A	104.3 D	103.2 D
			Substrate * Spray material		
SC	**Water**	23.8 h	24.7 hi	111.7 de	119.3 b
	GA	25.1 fg	26.3 fgh	120.2 a	125.9 a
	K	25.8 de	27.1 efg	115.8bc	118.9 b
	GA+K	28.1 c	29.3 d	113.1 cd	112.1cde
PP	**Water**	25.4 ef	27.1 efg	105.2gh	104.1fgh
	GA	26.4 d	27.4 ef	121.5 a	128.5 a
	K	26.4 d	27.5 ef	116.2 b	117.1bc
	GA+K	30.5 a	31.6 ab	102.8 hi	102.6fgh
CP	**Water**	26.7 d	28.3 de	104.3gh	100.9gh
	GA	28.6 bc	30.0 cd	111.4 de	114.4bcd
	K	29.2 b	30.9 bc	113.1 cd	111.6cde
	GA+K	30.8 a	32.6 a	100.6 i	99.0 h
Soil	**Water**	22.9 i	24.1 i	106.2fg	104.2fgh
	GA	23.5 hi	24.2 i	110.5 de	106.6efg
	K	24.2 gh	25.6 ghi	109.1ef	108.3def
	GA+K	26.5 d	27.3 ef	100.7 i	99.0 h

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

Table 4: Effect of substrate type and spray material on spike length and spike base diameter of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Spike length (cm)		Spike base diameter (cm)	
		First season	Second season	First season	Second season
			Substrate type		
SC		82.3 C	88.0 C	0.94 C	1.04 C
PP		85.4 B	92.7 B	1.01 B	1.09 B
CP		91.1 A	101.3 A	1.11 A	1.17 A
Soil		75.4 D	79.3 D	0.87 D	0.91 D
			Spray material		
	Water	78.4 D	85.6 D	0.87 D	0.93 D
	GA	85.1 B	91.6 B	1.00 B	1.09 B
	K	82.3 C	88.3 C	0.95 C	1.02 C
	GA+K	88.5 A	95.6 A	1.11 A	1.17 A
			Substrate * Spray material		
SC	**Water**	76.9 g	82.5 gh	0.85 j	0.86 k
	GA	83.1 e	90.4 de	0.95 def	1.08 e
	K	80.2 f	85.4 fg	0.90 ghi	1.01 g
	GA+K	89.1 c	93.6 c	1.06 c	1.20 b
PP	**Water**	79.8 f	88.8 e	0.89 hij	0.98 gh
	GA	87.8 cd	93.2 cd	1.00 d	1.12 d
	K	82.7 e	88.5 ef	0.95 efg	1.00 g
	GA+K	91.4 b	100.1 b	1.21 a	1.25 a
CP	**Water**	87.4 d	96.5 c	0.99 de	1.05 f
	GA	92.7 ab	103.3 ab	1.13 b	1.22 b
	K	91.4 b	100.9 b	1.09 bc	1.15 c
	GA+K	93.1 a	104.5 a	1.23 a	1.26 a
Soil	**Water**	69.7 i	74.7 j	0.76 k	0.82 l
	GA	76.8 g	79.7 hi	0.92 fgh	0.95 i
	K	74.7 h	78.5 i	0.86 ij	0.91 j
	GA+K	80.3 f	84.3 g	0.94 fgh	0.97 hi

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

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Table 5: Effect of substrate type and spray material on spike fresh weight and vase life of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Spike fresh weight(g)		Vase life (days)	
		First season	Second season	First season	Second season
			Substrate type		
SC		87.3 C	94.4 C	6.5 BC	7.2 C
PP		92.5 B	99.0 B	6.7 AB	7.4 B
CP		111.2 A	119.9 A	6.9 A	7.5 A
Soil		70.5 D	75.9 D	6.4 C	7.1 C
			Spray material		
	Water	77.1 D	82.7 D	5.5 D	6.2 D
	GA	92.0 B	99.1 B	6.7 C	7.2 C
	K	87.8 C	93.3 C	6.9 B	7.6 B
	GA+K	104.6 A	114.1 A	7.5 A	8.2 A
			Substrate * Spray material		
SC	**Water**	72.3 i	74.9 g	5.3 gh	6.2 fg
	GA	86.8 gh	99.3 e	6.6 de	7.2 de
	K	85.4 h	88.9 f	6.7 de	7.2 de
	GA+K	104.7 cd	114.5 cd	7.3 bc	8.0 bc
PP	**Water**	74.0 i	79.4 g	5.6 fg	6.2 fg
	GA	96.4 ef	99.7 e	6.6 de	7.3 d
	K	92.3 fg	94.4 ef	7.2 bc	7.8 c
	GA+K	107.4 bcd	122.4 b	7.5 ab	8.2 ab
CP	**Water**	101.7 de	110.1 d	5.9 f	6.4 f
	GA	113.1 b	119.7 b	6.9 cd	7.2 de
	K	110.6 bc	120.9 b	6.8 de	8.0 bc
	GA+K	119.5 a	129.0 a	7.7 a	8.4 a
Soil	**Water**	60.2 j	66.3 h	5.1 h	6.0 g
	GA	71.8 i	77.9 g	6.4 e	7.0 e
	K	62.8 j	69.0 h	6.7 de	7.3 d
	GA+K	87.0 gh	90.4 f	7.4 abc	8.1 b

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

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Table 6: Effect of substrate type and spray material on total chlorophyll and nitrogen % in leaves of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Total chlorophyll (SPAD)		Nitrogen %	
		First season	Second season	First season	Second season
			Substrate type		
SC		28.7 B	27.7 B	1.78 C	1.85 C
PP		29.5 AB	29.4 A	1.84 B	1.97 B
CP		30.3 A	29.8 A	2.04 A	2.19 A
Soil		26.2 C	25.0 C	1.73 D	1.71 D
			Spray material		
	Water	24.8 D	24.7 D	1.60 C	1.68 C
	GA	28.1 C	27.8 C	1.77 B	1.85 B
	K	29.3 B	28.7 B	1.99 A	2.10 A
	GA+K	32.5 A	30.7 A	2.03 A	2.12 A
			Substrate * Spray material		
SC	**Water**	23.8fg	23.0jk	1.49 f	1.60 g
	GA	28.8 c	27.7efg	1.78 d	1.80 fg
	K	28.6 c	29.0 de	1.93 c	1.97 cd
	GA+K	33.5 ab	31.0 abc	1.91 c	2.03 c
PP	**Water**	25.5ef	26.5gh	1.63 f	1.70 gh
	GA	29.2 c	28.9def	1.78 de	1.87 ef
	K	29.1 c	30.4bcd	1.96 b	2.18 b
	GA+K	34.1 a	31.8 ab	1.99 b	2.14 b
CP	**Water**	26.6 de	27.1fgh	1.72 e	1.95 cde
	GA	28.6 c	29.9 cd	1.86 cd	2.01 cd
	K	31.8 b	29.6 cd	2.26 a	2.37 a
	GA+K	34.1 a	32.6 a	2.31 a	2.44 a
Soil	**Water**	23.5 g	22.1 k	1.54 f	1.45 i
	GA	25.6ef	24.7ij	1.66 e	1.73 g
	K	27.4 cd	25.9 hi	1.79 de	1.90 def
	GA+K	28.1 cd	27.3efgh	1.92 c	1.86 ef

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

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Table 7: Effect of substrate type and spray material on percentages of (phosphorus and potassium) in leaves of tuberose cultivated in soil and soilless substrates during seasons of 2021 and 2022.

Treatments		Phosphorus%		Potassium %	
		First season	Second season	First season	Second season
Substrate type					
SC		0.45 C	0.43 C	2.27 BC	2.45 C
PP		0.51 B	0.52 B	2.34 AB	2.54 B
CP		0.53 A	0.54 A	2.35 A	2.60 A
Soil		0.42 D	0.40 D	2.23 C	2.22 D
Spray material					
	Water	0.40 D	0.39 D	1.89 D	2.04 D
	GA	0.48 C	0.46 C	2.14 C	2.30 C
	K	0.51 B	0.50 B	2.71 A	2.85 A
	GA+K	0.52 A	0.54 A	2.44 B	2.62 B
Substrate * Spray material					
SC	Water	0.37 ef	0.35 i	1.87 ij	2.03 i
	GA	0.46 c	0.44 fg	2.12 fg	2.29 g
	K	0.48 c	0.45 efg	2.64 bc	2.80 bc
	GA+K	0.48 c	0.47 de	2.44 d	2.70 de
PP	Water	0.40 de	0.39 h	1.95 hi	2.17 h
	GA	0.52 b	0.51 c	2.15 ef	2.32 g
	K	0.59 a	0.58 ab	2.70 b	2.87 b
	GA+K	0.55 b	0.59 a	2.56 c	2.80 bc
CP	Water	0.46 c	0.50 cd	1.94 hi	2.18 h
	GA	0.53 b	0.50 cd	2.24 e	2.60 f
	K	0.55 b	0.55 b	2.81 a	2.96 a
	GA+K	0.59 a	0.60 a	2.41 d	2.67 ef
Soil	Water	0.36 f	0.33 i	1.81 j	1.77 j
	GA	0.42 d	0.39 h	2.04 gh	2.00 i
	K	0.40 d	0.43 g	2.70 b	2.76 cd
	GA+K	0.48 c	0.47 deg	2.37 d	2.33 g

PP: 50 % perlite: 50 % peat moss**, SC:** 90 % sand: 10 % compost**, CP:** 100 % coco peat
GA: 100ppm of gibberellic acid, **K:** 100ppm of potassium, **GA+K:** 50ppm of gibberellic acid + 50ppm of potassium

4. Discussion

From the above mentioned results it's clear that soilless substrates recorded better results than soil production of tuberose regardless the substrate type. This could be a result for the more suitability of soilless substrates for the growth needs of tuberose than soil cultivation. Vendrame *et al*., (2005) reported that substrate is known to have a significant effect on value of potted ornamental plants and plays an important role in many growth, yield and quality parameters such as plant height, number of leaves, spike length, number of florets per spike, spike diameter and yield… etc. furthermore, Grillas *et al*., (2001) illustrated that soilless culture guarantee flexibility and intensification and provide high crop yield and high-quality products, even in areas with adverse growing conditions. As well, Gruda *et al*., (2013) reported that substrates include materials that uses alone or in mixtures, can ensure better plant growth conditions than agricultural soil in at least one aspect. So far, substrates could be used for the production of high-quality vegetables and ornamentals as well as for plant propagation.

For the effect of substrate type, results indicated that tuberose plants grown in coco peat recorded the highest values among the tested substrates regarding leaves height, number of leaves/ plant, leaves fresh and dry weights, number of florets/spike, spike length, spike base diameter, spike fresh weight, vase life, total chlorophyll and (nitrogen & phosphorus & potassium) % in leaves. This may be a result to the good properties of the coco peat substrate that allow to tuberose plants to grow well. in this context, Lemaire, (1995) mentioned that one of the main factors affecting the physiological and productive performance of the plant in substrate culture is the type of substrate itself. Kang *et al.,* (2004) mentioned that a good plant growing substrate must be able to provide water, nutrients and oxygen for the plants as well as good physical support. As well, Pryce, (1990) reported that coco peat is available in large quantities as a by-product of the coconut industry. The particular structure and physical &chemical properties of coco peat, make it suitable for container media purposes. Coco peat is made of coir that contains equal portions of lignin and cellulose and is rich in potassium and the micronutrients Fe, Mn, Zn, and Cu (Savithri *et al.,* 1993). Furthermore, coco peat has a high-water holding capacity and in some cases, they add coco peat to soil in traditional cultivation to improve moisture retention capacity, and increase available nutrient content, infiltration rate, total porosity of that soil (Savithri and Khan, 1993).

For the effect of spray material, results indicated that tuberose plants sprayed with 50ppm of gibberellic acid + 50ppm of potassium "GA+K" recorded the highest values regarding leaves height, number of leaves/ plant, leaves fresh and dry weights, number of florets/spike, spike length, spike base diameter, spike fresh weight, vase life, total chlorophyll and (nitrogen & phosphorus) % in leaves. This may be a result to the idea of spray tuberose plants with gibberellic acid and potassium together "GA+K" has a positive effect on plant growth of tuberose that led to superier flower production and quality . In this context, Naznin *et al*., (2015) mentioned that tuberose requires a large quantity of nutrients. Furthermore, intensive cut flower production requires high level of fertilization; imbalance fertilization may reduce flower production (Mohsin *et al*., 2015). As well, foliar feeding of nutrients has become an excellent procedure for increasing yield and improves the quality of plants. This procedure improves nutrient utilization (Kannan, 2010). Foliar fertilization is more economical than root fertilization due to the efficiency and lower cost. Foliar application is also less likely to result in ground water pollution (Tomimori *et al*., 1995).

Gibberellic acid application increased petiole length, leaf area and delayed petal abscission and color fading by the hydrolysis of starch and sucrose into fructose and glucose (Emongor, 2004; Khan and Chaudhry, 2006). It has been observed that gibberellic acid can stimulate floral transition in some ornamental plants (Halevy, 1990). On the other hand, potassium is an essential element for plant nutrition and its ability to influence meristem growth, water status, photosynthesis, , enhance many enzyme actions, helps translocation of sugars and starches, increase protein content. Moreover, potassium plays roles in regulating the opening and closing of stomata and water retention. It promotes the growth of meristematic tissue, activates some enzymatic reactions, aids in synthesis of proteins and aids in carbohydrate metabolism (Mengel and Kirkby, 2001; Zörb *et al.*, 2014). For that the use of both gibberellic acid and potassium together enhance the growth and flower quality of tuberose than using one of them only.

5. Conclusion

It could be concluded that soilless substrates recorded better results than soil production of tuberose regardless the substrate type. For the effect of substrate type; coco peat was the superior substrate among the tested ones for producing tuberose with high yield and quality. It's also observed that using 50ppm of gibberellic acid + 50ppm of potassium as spray materials affected positively on the growth and production of tuberose.

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