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Growth and flowering of tuberose (*Polianthes tuberosa* L.) as affected by adding poultry litter to the culture medium

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Abstract

This research was conducted to investigate the effect of poultry litter (PL) on vegetative growth and flower characteristics of tuberose (*Polianthes tuberosa* L.). The experiment was carried out as a completely randomized design with nine treatments (each treatment with 4 replications): 29.0 (T1), 31.5 (T2), 34.0 (T3), 36.5 (T4), 39.0 (T5), 41.5 (T6), 44.0 (T7), 46.5 (T8) and 49.0 g (T9) PL in the soil mixture per pot (equivalent to 116, 126, 136, 146, 156, 166, 176, 186 and 196 g m^{-2} in field) along with control. Results indicated that PL increased the height of flowering stem at T4, T5, T6 and T7; flower diameter at T8; diameter of flowering stem at T7; fresh weight of flowering stem at T3, T4, T5, T6, T7 and T8; fresh and dry weight of bulblet at T4 and shoot at T2; chlorophyll content at T3, T4, T5 and T6; bulblet diameter at T6; number of floret per inflorescence at T6 and T9; number of bulblet at T4; but had no effect on the length of flower, leaf area and root fresh and dry weight. Overall, adding PL had positive effect on tuberose growth and flowering and is recommended for using in the soil mixture of tuberose. To our knowledge this is the first report on using PL in the soil mixture of tuberose. Further investigations are needed to clarify how PL works on this bulbous plant.

Additional key words: composting; organic farming; soil mixture.

Resumen

Cambios en caracteres del crecimiento y de las flores del nardo (*Polianthes tuberosa* L.) por la adición de gallinaza al suelo

Este trabajo investigó el efecto de la gallinaza (PL) en el crecimiento vegatativo y caracteristicas florales del nardo (*Polianthes tuberosa* L.). Se realizaron nueve tratamientos (cada uno con 4 réplicas) en un diseño completamente aleatorio, añadiendo 29,0 (T1), 31,5 (T2), 34,0 (T3), 36,5 (T4), 39,0 (T5), 41,5 (T6), 44,0 (T7), 46,5 (T8) y 49,0 g (T9) de PL en la mezcla de tierra de cada tiesto (equivalente a 116, 126, 136, 146, 156, 166, 176, 186 y 196 g m^{-2} en el campo), además de un control. Los resultados indicaron que PL aumentó la altura del tallo floral en T4, T5, T6 y T7; el diámetro de las flores en T8; el diámetro del tallo floral en T7; el peso fresco del tallo floral en T3, T4, T5, T6, T7 y T8; el peso fresco y seco del bulbillo en T4 y de los brotes en T2; el contenido de la clorofila en T3, T4, T5 y T6; el diámetro del bulbillo en T6; el número de floretes por inflorescencia en T6 y T9; y el número de bulbillos en T4. Pero PL no tuvo ningún efecto sobre la longitud de las flores, el área foliar o el peso fresco y seco de la raíz. En general, la adición de PL tuvo un efecto positivo sobre el crecimiento y la floración del nardo y se recomienda su uso en la mezcla de tierra. Este es el primer reporte sobre el uso de PL en la mezcla del suelo de nardo; se necesitan más investigaciones para aclarar cómo actúa en esta planta bulbosa.

Palabras clave adicionales: agricultura ecológica; compostaje; mezcla de tierra.

Introduction

Tuberose (*Polianthes tuberosa* L.), as an ornamental bulbous plant native to Mexico, is one of the most important cut flowers in tropical and subtropical areas. The long spike of flowers is excellent for cut flowers and people like their sweet fragrance (Benschop, 1993).

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Abbreviations used: CPL (composted poultry litter), PL (poultry litter).

Animal manures contain all the essential micro (Br, Cl, Cu, Mn, Fe, Zn and Ni) and macro elements (N, P, K, Ca, Mg and S) required for plant growth (USDA, 1979; Barker and Pilbeam, 2006). Application of up to 60 tons of dry weight manure per hectare increased yield in corn that decreased with further increase of manure (USDA, 1979). Abou-Hussein *et al*. (2003) reported that potato tuber yield and specific gravity increased with combined application of cattle manure and chicken litter. Animal manure can be a plentiful source of organic soil amendments but proper management is imperative to prevent adverse environmental effects that can result from application of manure to soil. Poultry wastes contain higher concentrations of N, Ca, and P than wastes from other farm animals (Stephenson *et al*., 1990). Problems concerning the environmental impact of agriculture have led to a reassessment of the conventional practices used since the 1940s, and a renewed interest by growers in organic farming began during the 1980s. Consumer interest has also increased dramatically, both for health and environmental reasons (Lampkin, 1990; Uri, 1999; Greene, 2000). Organic mulches made from manures that are rich in nutrients may release significant quantities of nutrients if they are not managed properly (Anonymous, 1999). N mineralization rates for poultry litter (PL) provide the basis for field application rates, but do not guarantee that the amount applied to the soil is fully utilized by the crop. Laboratory and field work has indicated that P may become increasingly available to plants grown in composted PL-amended soil (Preusch *et al*., 2002; Preusch and Tworkoski, 2003).

Plant analysis is necessary to document that soil nutrient estimates correlate with nutrient uptake by plants (Munson and Nelson, 1990). Application of PL as a source of N and P has been shown to increase yields of crops such as corn and pastures (Sims, 1986; Ma *et al*., 1999). Furthermore, studies have shown that PL improves soil chemical properties compared with inorganic sources of N such as ammonium nitrate (Nyakatawa *et al*., 2001). Organic amendments, such as PL, are often applied to supplement soil N. In strawberry (*Fragaria* × *ananassa* Duch) plants, the critical foliar N concentration is 2.8% (Ulrich *et al*., 1992) and CPL could be used to increase soil N. However, applications of CPL to supply N needs may result in over application of other nutrients. Concentration of Cu and Zn in PL can vary widely due to differences in poultry feed and pest control (Van der Watt *et al*., 1994; Pesti and Bakalli, 1996). The aim of this experiment was to study the effect of PL on vegetative growth and flower characteristics of tuberose (*Polianthes tuberosa* L.).

Material and methods

A greenhouse experiment was conducted on *Polianthes tuberosa* L. bulbs (2.5-3 cm in diameter) were planted in 6 kg pots (20 cm width and 37 cm length) containing 0 (control), 29.0 (T1), 31.5 (T2), 34.0 (T3), 36.5 (T4), 39.0 (T5), 41.5 (T6), 42.0 (T7), 46.5 (T8) and 49.0 (T9) g poultry litter in the soil mixture per pot (equivalent to 0, 116, 126, 136, 146, 156, 166, 176, 186 and 196 g m^{-2} in field, respectively) following commercial recommendation of the company, Bioran, Shiraz, Iran for some vegetables such as potato, onion, and some ornamental plants such as roses. Characteristics of the soil mixture was: pH = 7.41; electrical conductivity (EC) = 1.16 dS m^{-1}; N = 0.11%; saturation percent (SP) = 45.81%; organic carbon (OC) = 2.06%; organic matter (OM) = 3.5%; SO_4^{-2} = 4 meq L^{-1}; HCO_3^{-1} = 4 meq L^{-1}; Cl = 0.4 meq L^{-1}; Ca = 7.8 meq L^{-1}; Mg = 9 meq L^{-1}; Na = 19.12 mg L^{-1}; Fe = 7.9 mg L^{-1}; Zn = 0.7 mg L^{-1}; Mn = 15 mg L^{-1}; Cu = 1.9 mg L^{-1}; K = 21.26 mg L^{-1}; and P = 19 mg L^{-1}. Soil texture = silty loam with clay = 14.4%, silt = 51.96% and sand = 33.3%. Chemical analysis of the poultry liter was as follows: pH = 6.5-7.5, N = 5%, P = 4%, K = 4%, Mn = 1.1%, S = 0.5%, Ca = 4.5%, Na = 4.5 g kg^{-1}, Fe = 1,300 mg kg^{-1}, Mg = 450 mg kg^{-1}, Zn = 300 mg kg^{-1} and Br = 45 mg kg^{-1}. For growth of tuberose air temperature should be between 20 and 30 °C for maximum bulb production (Mukhopadhyay, 1987). For bulb production, the tuberose must be grown in full sun (Howard, 1985). Plants were maintained in a greenhouse under natural light (> 800 µmol m^{-2} s^{-1}) at a day temperature of 30 ± 3°C and night temperature of 20 ± 3°C and relative humidity (RH) of 55 ± 5%.

Height of flowering stem, height of inflorescence, flower diameter (mean diameter of single floret) and inflorescence length (mean distance between the bottom floret towards the terminal floret), flowering stem diameter, leaf area, fresh and dry weight of bulblet, root, and shoot, and fresh weight of flowering stem, chlorophyll content, number and diameter of bulblet and number of florets per inflorescence were measured. Immediately after harvest, shoot, root, bulblet and flowering stem were weighed as fresh weight and then

Table 1. Effects of poultry litter on height of flower, flowering stem diameter, flower diameter and flower length of *Polianthes tuberosa* L. In each row means followed by the same letter(s) are not significantly different using LSD test at 5% level

	Poultry litter in soil mixture (g pot^{-1})									
	0 (Control)	**29.0 (T1)**	**31.5 (T2)**	**34.0 (T3)**	**36.5 (T4)**	**39.0 (T5)**	**41.5 (T6)**	**44.0 (T7)**	**46.5 (T8)**	**49.0 (T9)**
Height of flowering stem (cm)	40.75^{b}	63.00^{ab}	66.00^{ab}	56.25^{ab}	62.00^{ab}	73.50^{a}	80.25^{a}	67.25^{a}	70.50^{a}	63.25^{ab}
Flowering stem diameter (cm)	00.40^{b}	00.47^{ab}	00.45^{ab}	00.43^{ab}	00.50^{ab}	00.47^{ab}	00.49^{ab}	00.45^{ab}	00.52^{a}	00.49^{ab}
Flower diameter (cm)	03.05^{ab}	03.10^{ab}	03.25^{ab}	02.87^{ab}	02.77^{b}	03.30^{ab}	03.30^{ab}	03.30^{ab}	03.40^{ab}	03.45^{a}
Flower length (cm)	05.32^{a}	05.30^{a}	04.85^{a}	05.40^{a}	05.52^{a}	05.37^{a}	05.32^{a}	05.72^{a}	05.57^{a}	05.62^{a}
Number of florets per inflorescence	13.50^{b}	24.50^{ab}	21.50^{ab}	20.25^{ab}	25.25^{ab}	25.25^{ab}	28.25^{a}	19.50^{ab}	22.75^{ab}	28.00^{a}

dried at 70°C inside an oven (Korl Kolb 112SL) for 48 h and weighed as dry weight. Leaf area was measured by a leaf area meter (Delta-T Devices, Ltd). Leaf area of five leaves in each plant was measured and means were used for analysis. Chlorophyll content was determined by spectrophotometeric method (Saini and Buvalda, 1998).

This research was carried out in a completely randomized design with 9 treatments along with control and 4 replications. Data were analyzed by MTATC software (Freed and Eisensmith, 1989) and means were compared using LSD test at 5% level.

Results

Height of flowering stem

Application of PL in the pot mixture increased height of flowering stem. This increase was significantly different in T5, T6, T7 and T8 (156, 166, 176 and 186 g m^{-2} in field) PL treatments compared to control. Application of T9 (196 g m^{-2} in field) of PL had no significant effect compared to control (Table 1). Correlation effect of added PL to the soil mixture on height of flowering stem of tuberose is shown in Figure 1a.

Flowering stem diameter and flower diameter and length

Poultry litter only in T8 significantly increased flowering stem diameter; more application of PL (T9) had no significant increase compared to control (Table 1). The treatment T9 significantly increased the diameter of flower. Application of PL had no any significant effect on flower length (Table 1).

Shoot, root and bulblet dry weights and fresh weight of flowering stem

Application of PL significantly increased fresh weight of flowering stem in all treatments except T1,

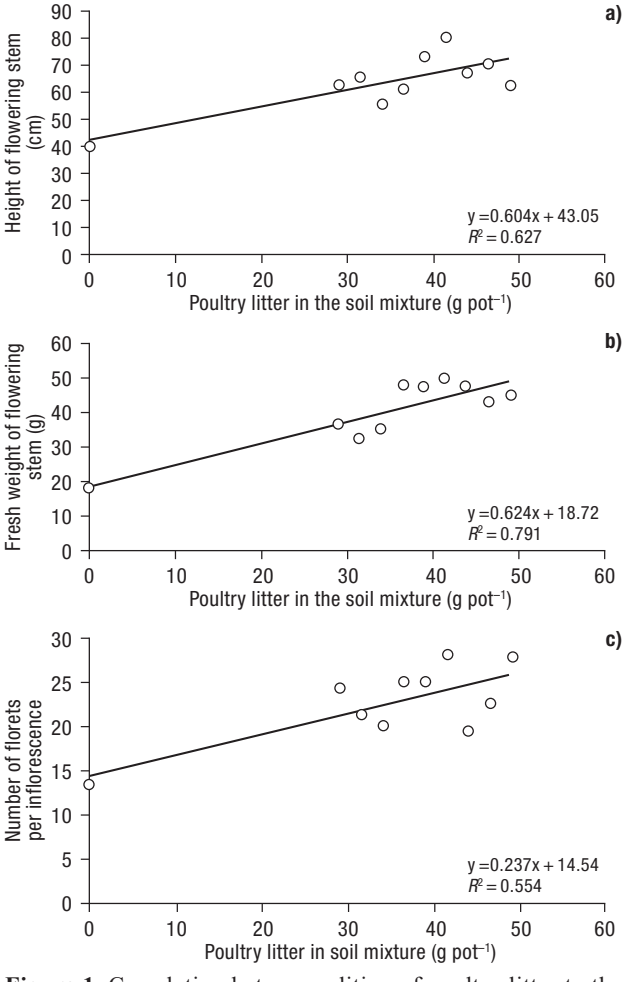

Figure 1. Correlation between adition of poultry litter to the soil mixture and a) height of flowering stem (cm), b) fresh weight of flowering stem (g), and c) number of florets per inflorescence.

Table 2. Effects of poultry litter on shoot, root and bulblet dry weights and fresh weight of flowering stem of *Polianthes tuberosa* L. In each row means followed by the same letter(s) are not significantly different using LSD test at 5% level

	Poultry litter in soil mixture (g pot^{-1})									
	0 (Control)	**29.0 (T1)**	**31.5 (T2)**	**34.0 (T3)**	**36.5 (T4)**	**39.0 (T5)**	**41.5 (T6)**	**44.0 (T7)**	**46.5 (T8)**	**49.0 (T9)**
Dry weight of shoot (g)	06.02^{b}	07.180^{ab}	09.34^{a}	07.27^{ab}	08.69^{ab}	08.74^{ab}	07.59^{ab}	06.53^{ab}	07.08^{ab}	06.81^{ab}
Dry weight of root (g)	03.99^{a}	04.13^{a}	03.95^{a}	03.81^{a}	04.06^{a}	04.04^{a}	03.67^{a}	03.79^{a}	03.79^{a}	04.09^{a}
Dry weight of bulblet (g)	20.42^{bc}	31.69^{abc}	30.49^{abc}	19.67^{c}	40.16^{a}	37.06^{ab}	22.65^{bc}	23.49^{abc}	18.05^{c}	22.04^{bc}
Fresh weight of flowering stem (g)	18.75^{b}	36.50^{ab}	33.00^{ab}	35.50^{ab}	48.00^{a}	48.00^{a}	50.00^{a}	47.75^{a}	43.50^{a}	45.50^{a}

T2, T3 and control. PL in soil mixture had no effect on dry weight of root, but it significantly increased dry weight of bulblet in T4 and dry weight of shoot in T2. There is a an interesting pattern in the data for the dry weight of the bulblet wherein the weight increase with application of PL up to the 36.5 g application per pot(T4), and then decreases as the PL application increase (Table 2). Correlation effect of added PL to the soil mixture on fresh weight of flowering stem of tuberose is shown in Figure 1b.

Leaf area, leaf chlorophyll content, number and bulblets diameter and number of florets per inflorescence

Adding of PL to pot mixture had no significant effects on leaf area. Chlorophyll content increased in T3, T4, T5 and T6 but was not significant. The maximum diameter of bulblet was produced in T6 treatment; number of florets per inflorescence significantly increased in T4 and T9; and number of bulblets was significantly different in T4 (Table 3). Correlation effect of added PL to the soil mixture on number of florets of tuberose is shown in Figure 1c.

Total crop weight and root: shoot ratio

Poultry litter in all treatments increased total crop weight of tuberose compared with control. This increase was significant in T4 and T5. Root: shoot ratio decreased by adding PL to soil mixture. That was significant in T2 (Table 4).

Table 3. Effect of poultry litter on leaf area, leaf chlorophyll content, number and bulblets diameter and number of florets per inflorescence of *Polianthes tuberosa* L. In each row means followed by the same letter(s) are not significantly different using LSD test at 5% level

	Poultry litter in soil mixture (g pot^{-1})									
	0 (Control)	**29.0 (T1)**	**31.5 (T2)**	**34.0 (T3)**	**36.5 (T4)**	**39.0 (T5)**	**41.5 (T6)**	**44.0 (T7)**	**46.5 (T8)**	**49.0 (T9)**
Leaf area (cm^2)	52.79^{a}	46.73^{a}	39.64^{a}	54.98^{a}	47.76^{a}	52.81^{a}	43.62^{a}	40.17^{a}	40.99^{a}	47.61^{a}
Chlorophyll content (mg g^{-1} fw.)	13.74^{ab}	13.13^{abc}	13.15^{abc}	14.02^{a}	13.92^{a}	14.06^{a}	14.08^{a}	13.63^{abc}	11.83^{c}	13.62^{abc}
Number of bulblets	05.00^{ab}	05.50^{ab}	04.50^{ab}	04.75^{ab}	08.25^{a}	07.00^{ab}	05.75^{ab}	04.25^{b}	05.00^{ab}	04.75^{ab}
Bulblets diameter (cm)	00.82^{ab}	01.10^{ab}	01.02^{ab}	01.07^{ab}	01.27^{ab}	01.20^{ab}	01.43^{a}	01.23^{ab}	01.15^{ab}	00.75^{b}

Table 4. Effect of poultry litter on total crop weight and root: shoot ratio of *Polianthes tuberosa* L. In each row means followed by the same letter(s) are not significantly different using LSD test at 5% level

	Poultry litter in soil mixture (g pot^{-1})									
	0 (Control)	**29.0 (T1)**	**31.5 (T2)**	**34.0 (T3)**	**36.5 (T4)**	**39.0 (T5)**	**41.5 (T6)**	**44.0 (T7)**	**46.5 (T8)**	**49.0 (T9)**
Total crop weight (g)	107.23^{c}	151.32^{bc}	161.48^{abc}	139.34^{bc}	207.69^{a}	182.8^{ab}	149.79^{bc}	136.49^{bc}	129.04^{bc}	139.27^{bc}
Root:shoot ratio	0.25^{a}	0.23^{ab}	0.14^{b}	0.19^{ab}	0.16^{ab}	0.15^{ab}	0.16^{ab}	0.26^{a}	0.18^{ab}	0.25^{a}

Discussion

Results of present study indicated that soils amended with PL had a positive effect on vegetative growth and flowering of tuberose. Application of PL significantly improved the most parameters of growth and flowering compared to control treatment. Height of flowering stem increased in all treatments compared with control, the increment was significant at 39.0, 41.5, 44.0 and 46.5 g PL in pot. Flowering stem diameter was increased in all treatments compared with control. These two characters (height and diameter of flowering stem) are the main factor in quality of cut flowers, and we found that application of PL could improve them. Our findings were in agreement with Yusef (1997) who reported that application of organic fertilizers had the best effects on growth of four annual flowers petunia (*Petunia hybrida* L.), snapdragon (*Antirrhinum majus* L.), celosia [*Celosia plumosa* (Voss) Burv.] and marigold (*Tagetes erecta* L.) and organic fertilizer increased plant height, flower diameter, number of flowers (Yusef, 1997). The organic fertilizer treatments were better than the control because of the nutrients (5.2-2.1-1.1% NPK, respectively) that the organic fertilizer contains (Yusef, 1997). In our experiment PL contained 5-4-4% NPK, respectively. That high percent of both N and P might increase the growth of tuberose. Hamdar and Rubeiz (2000) indicated that PL could be an economically attractive source of N for growing strawberry plants (*Fragaria ananassa* L.) in greenhouse. Kraus and Warren (2000) found composted Turkey litter could provide necessary P for container-grown *Rudbeckia fulgida* L. and *Cotoneaster dammeri* L. Ghanbarian *et al*. (2008) reported that physical properties, growth and yield of the cantaloupe cultivars were positively affected with broiler litter application and the response was better at higher rates of broiler litter. Results of the present study in some variables approved their report. The greatest flower diameter of tuberose was produced in the highest level of PL (T9: 49.0 g pot^{-1}). However for flowering stem diameter the best amount of PL was 46.5 g (T8), and 39.0-46.5 g (T5 to T8) for height of flowering stem, and higher amount of PL had no any significant increase in the height of flowering stem. Overall, PL added to soil mixture had positive effect on tuberose growth and flowering and the use of it could be recommended. To our knowledge this is the first report on using poultry litter in the soil mixture of tuberose. Further investigations are needed to clarify how poultry litter work on this bulbous plant.

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