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Effects of different soil media amendments on the growth and flowering characteristics of two exotic rose cultivars

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Abstract

The rational of the study was to compare and contrast the compost prepared from the locally available organic waste material with that of commercial peat compost and their impact on the growth and flowering traits of two rose cultivars. A glasshouse experiment based on different types of compost (poultry litter, peat, food waste, cow dung, leaf and wood chips) mixed with 1:1 ratio of sand was conducted using two cultivars of roses (Amber Queen and Pearl). The experiment was laid out on two-factor factorial arrangement using a completely randomized design with five replications. All plant growth and flowering characteristics were significantly ($P \leq 0.05$) affected by different types of compost treatments. The difference between two rose cultivars was also significant. Both cultivars positively response to the compost prepared from poultry litter followed by the commercial peat compost and food waste compost. However, compost prepared from wood chip and leaf materials were least effective as compared to the rest of treatments. Compost prepared from cow dung were superior than wood chip and leaf compost. The quantitative data indicated that compost prepared from poultry litter when applied to Amber Queen cultivar significantly enhanced plant height (85.67 cm), No. of branches per plant (15.67), leaf numbers (255.67), No. of flowers per plant (14) and No. of petals per flower (36), whereas days taken to flowering were reduced to 68.67, which were slightly higher than cultivar Pearl (62).Hence, it is concluded that under the agro-climatic condition of Al-Ahsa, Kingdom of Saudi Arabia, poultry litter compost and food waste compost are the most effective and inexpensive source of organic material, which can be used as an alternative to the expensive commercial peat compost available in supermarkets.

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Introduction

Kingdom of Saudi Arabia has rapid industrial development, high population growth rate and fast urbanization. Therefore, urban waste management is a great challenge for the government and local councils in the Kingdom (Ouda *et al.*, 2016). It generates more than 15 million tons of waste per year and the per capita waste is estimated as 1.5 to 1.8 kg per person per day. In many countries including Saudi Arabia, a large quantity of reusable urban waste is not properly disposed of and usually diverted to landfills and dumpsites in the outskirts of cities that is posing an environmental threat due to the presence of harmful pathogens and toxic compounds. All activities associated to waste management are organized and financed by the Saudi government. Around 10-15% waste is recycled which is mostly manual and labor demanding. The growing level of environmental awareness leads to recycle organic waste material for compost making that contribute to sustainable agro-ecosystems by making them less dependent on inorganic fertilizer. Making compost out of household organic waste is also gaining interest in Saudi Arabia due to the high organic content in it (De Araújo *et a1.*, 2009; Alnuwairan, 2015; Zafar, 2015).

Although, inorganic fertilizers have largely used instead organic fertilizers in agronomic practices, which also have detrimental effects on human health and environment (Darusman *et al.*, 1991). The continuous application of chemical fertilizers often lowers the amount of soil organic matter and increases soil acidity (Moody and Aitken, 1997), leading to adverse effects on the microbial activities (Olayinka, 2001) and soil health (Dubey *et al.* 2012). Moreover, well-prepared compost is an excellent source of plant nutrients, which has been extensively studied as a plant growth media and amendment in many plants (Tejada *et al.*, 2009; Naz *et al.*, 2013; Alhajhoj, 2015). It contains high plant available N contents and most nutrients are faster to release to be the available forms such as nitrate, phosphates, exchangeable calcium and potassium (Ogundare and Lajide, 2013; Horrocks *et al.*, 2016).

Roses belong to the six most economically important and nineteenth largest crop plant families, Rosaceae, which is extensively grown in Turkey, Bulgaria, Iran, Morocco, India, Pakistan, Afghanistan, France, Saudi Arabia, China and Ecuador. The highest rose flower producer is Turkey, which produces 6,500 tons flower per year (Baser and Arslan, 2014). The growth and development of roses is affected by the quality of organic growing media. Several commercial growing media are available in the supermarkets, but they are expensive. The available ones are mostly peat based and imported by the superstores from abroad, which further increased the price and make them out of the reach of common rose gardeners. It is essential to find out an appropriate and economical growing media prepared from local organic waste for rose cultivation in Al-Ahsa region. Therefore, the present study was designed to determine the possible use of organic waste such as poultry litter, food waste, cow dung, leaf and wood chips to convert them to compost and to compare them with the commercial peat based compost under the climatic conditions of Al-Ahsa, Kingdom of Saudi Arabia.

Materials and methods

Plant materials and location

Two rose cultivars (Amber Queen and Pearl) budded on *Rosa damascene* Dieck. rootstock, were brought from the local commercial nursery and were planted in pots (4L volume) containing various types of compost (as mentioned in Table 2)in a glass house at Agricultural Research and Veterinary Experimental Station, King Faisal University, Al-Ahsa, Saudi Arabia during October, 2016. Its geographical coordinates are: 25.271872 latitude and 49.707218 longitude and at an altitude 153.2 m.

Preparation of compost

Organic compost was prepared separately using poultry litter, food waste, cow dung, leaves and wood chips along with a readymade commercial peat compost purchased from the local superstore. These organic materials were placed separately in a 80 cm deep and 35 cm wide containers in June when the ambient day temperature was around 48-50°C and were covered with polyethylene sheet.

Water was sprinkled over the pile regularly to make it like damp and lime was mixed with the organic materials to facilitate their breakdown that would have been resisted by the lignin of the cell wall due to dehydration. The decomposing organic material was consistently checked and turned it once a week with a garden fork to maintain proper aeration. The hot compost was ready to use after 4 months. The chemical composition of each compost was determined in Soil Testing Laboratory (Table 1) and 4L pots were filled with sand and compost (1:1 ratio) as mentioned in Table 2.

Cultural practices and growth attributes

A recommended dose of NPK (175:50:190 kg.ha^{-1}) was applied to all treatments. Full dose of potassium and phosphorus and half dose of nitrogen were applied at potting. The remaining half dose of nitrogen was applied at flower bud initiation stage. Plants were observed daily and water was applied manually with the help of sprinkler whenever needed. Care was taken not to apply excess water to minimize any chance of disease. Due to organic nature of compost, weeds were rooted out by hand whenever emerged. The growth and flowering parameters measured were: plant height, number of branches per plant, leaf numbers, days taken to first flower opening, number of flowers per plant, and number of petals per flower.

Experimental design and statistical analysis

The experiment was laid out on two-factor factorial arrangement using a completely randomized design with five replications in each treatment. Data were analysed using Genstat-11(VSN International, U.K.) statistical software and Duncan's Multiple Range test was applied to calculate least significance of differences among means.

Results

The data presented in Fig.1 regarding plant height indicated a significant variation among six types of compost, rose cultivars and their interaction at 5% level of probability. Rose cultivar Amber Queen produced taller plants (77.33 cm) than Pearl (58.44 cm).

Table 1. Elemental analysis of six types of compost.

Compost	pH	N	P_2O_5	K_2O
		(kg.t^{-1})		
Poultry litter	7.1	11.5	12.3	14.4
Peat	4.8	3.0	5.1	8.3
Food waste	6.5	0.6	3.8	8.1
Cow dung	6.7	1.2	1.9	7.2
Leaf	6.6	0.2	3.2	5.5
Wood chip	5.5	8.9	2.9	7.7

The comparison of different types of compost showed that the most suitable was the one which was prepared by poultry litter (75.50 cm) followed by peat compost (70.67 cm) and food waste compost (69.50 cm). While minimum plant height was recorded in wood chip compost (61.17 cm).

Table 2. Different types of compost treatments.

Treatments	
T_1	Sand + Poultry litter compost (1:1 v/v)
T_2	Sand + Peat compost (1:1 v/v)
T_3	Sand + Food waste compost (1:1 v/v)
T_4	Sand + Cow dung compost (1:1 v/v)
T_5	Sand + Leaf compost (1:1 v/v)
T_6	Sand + Wood chip compost (1:1 v/v)

The interaction of composts and cultivars showed that both cultivars grown in poultry litter compost were tallest than other treatments i.e. 85.67 cm (Amber Queen) and 65.33 cm (Pearl) followed by peat compost (80.67 cm, Amber Queen; 60.67 cm, Pearl) and food waste compost (79.33 cm, Amber Queen; 59.67 cm, Pearl), whereas minimum plant height was recorded in wood chip compost treatment (69.67 cm, Amber Queen; 52.67 cm, Pearl).Correlation analysis (Table 3) revealed that plant height was significantly and positively correlated with No. of branches per plant, leaf number, No. of flowers per plant and No. of petals per flower while it was non-significant but positively correlated with days to flowering parameter.

Table 3. Correlation matrix of different plant characteristics of two rose cultivars (Amber Queen and Pearl) grown in different compost media (poultry litter, peat, food waste, cow dung, leaf and wood chips) under the agro-climatic conditions of Al-Ahsa.

	No. of branches plant^{-1}	Leaf number	Days to flowering	No. of flowers plant^{-1}	No. of petals flower^{-1}
Plant height	0.88*	0.91*	0.40^{NS}	0.81*	0.94*
No. of branches plant^{-1}		0.95*	-0.01^{NS}	0.93*	0.95*
Leaf number			0.05^{NS}	0.95*	0.93*
Days to flowering				-0.19^{NS}	0.12^{NS}
No. of flowers plant^{-1}					0.90*

* Significant at 1% probability level. ^{NS} Non-Significant at 5% probability level.

Number of branches per plant in Fig.2showed a significant difference among compost types, rose cultivars and their interaction at 5% level of probability. Cultivar Amber Queen produced maximum number of branches per plant (12.78) than Pearl (9.89). However, maximum number of branches (13.83) were counted when both cultivars were grown in poultry litter compost followed by peat compost (12.67). While minimum branches were estimated in wood chip compost (8.83).

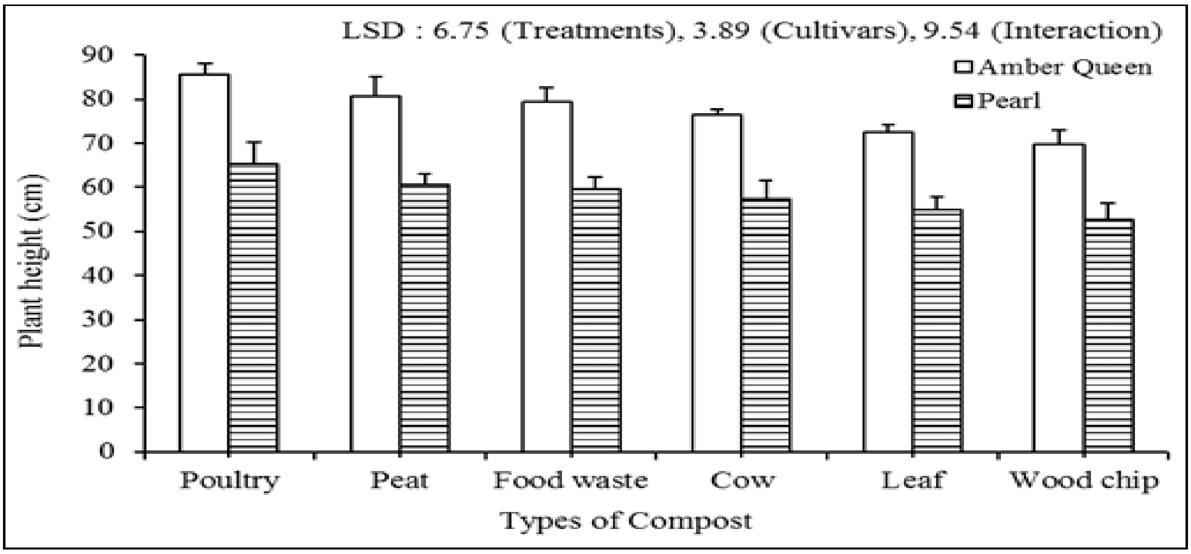

Fig. 1. Effect of types of compost on plant height (cm) of two rose cultivars *viz.* Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

The interaction showed that both cultivars grown in poultry litter compost produced maximum branches i.e. 15.67 (Amber Queen) and 12.00 (Pearl) followed by peat compost (14.00, Amber Queen; 11.33, Pearl), whereas plants grown in wood chip compost produced minimum branches (9.67, Amber Queen; 8.00, Pearl).Correlation of No. of branches per plant with other parameters such as leaf number, No. of flowers per plant and No. of petals per flower indicated that there was a positively significant association while it had a non-significant negative association with days to flowering (Table 3).

Fig. 3 showed that leaf number parameter was significantly affected by different types of compost, rose cultivars and their interaction at 5% level of probability.

Maximum leaf number were counted in rose cultivar Amber Queen (228.83) followed by Pearl (192.39) whereas both cultivars were more responsive to poultry litter compost and produced 242.67 leave per plant followed by peat compost (227.50), while minimum leaf number were recorded in wood chip compost (182.33). The interaction of both factors indicated that the two cultivars grown in poultry litter compost produced maximum leaf number i.e. 255.67 (Amber Queen) and 229.67 (Pearl) followed by peat compost (244.33, Amber Queen; 210.67, Pearl), while minimum leaf number were counted in wood chip compost treatment (199.33, Amber Queen; 165.33, Pearl).Correlation analysis revealed that leaf number had significantly positive correlation with No. of flowers per plant and No. of petals per flower (Table 3). Correlation between leaf number and days to flowering was positive but non-significant.

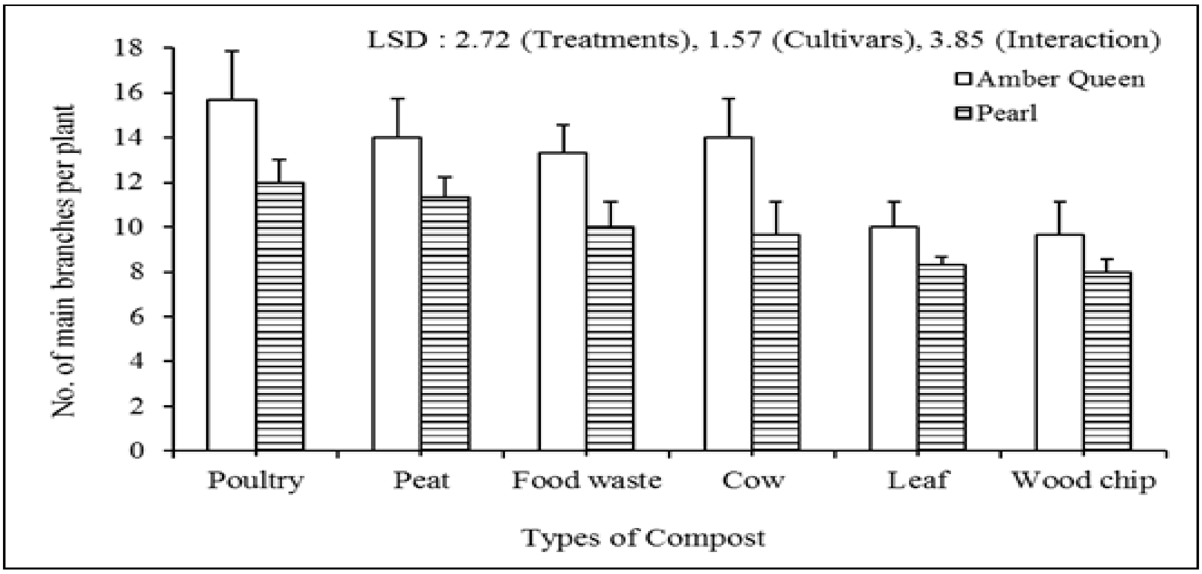

Fig. 2. Effect of types of compost on number of main branches per plant of two rose cultivars viz. Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

Data exhibited in Fig.4 regarding days taken to first flower opening indicated a significant variation among six types of compost, rose cultivars and their interaction at 5% level of probability. Rose cultivar Pearl took minimum days to flower (65.56) than Amber Queen (74.33). Mean effect of different composts indicated that both cultivars took minimum days to flower when they were grown in poultry litter (65.33) followed by peat compost (67.00). While maximum days were recorded in wood chip compost (75.50). The interaction of composts and cultivars showed that both cultivars grown in poultry litter compost took minimum days to flower i.e. 62.00 (Pearl) and 67.67 (Amber Queen) followed by peat compost (64.00, Pearl; 70.00, Amber Queen), whereas plants subjected to wood chip compost took maximum days to flower (70.00, Pearl; 81.00, Amber Queen).

Table 3 revealed that the correlation between days to flowering and No. of flowers per plant was negatively non-significant whereas as it was positively non-significant when correlated with No. of petals per flower.

Number of flowers per plant in Fig.5 indicated a significant difference among compost types, rose cultivars and their interaction at 5% level of probability. Cultivar Amber Queen produced maximum number of flowers per plant (10.17) than Pearl (7.56). However, maximum number of flowers (12.50) were counted when both cultivars were grown in poultry litter compost followed by peat compost (10.50) and food waste compost (10.17). While minimum flowers were counted in wood chip compost and leaf compost (6.00).

The interaction showed that both cultivars grown in poultry litter compost produced maximum flowers per plant i.e. 14.00 (Amber Queen) and 11.00 (Pearl) followed by peat compost (12.00, Amber Queen; 9.00, Pearl), food waste compost (12.00, Amber Queen; 8.33, Pearl). Both cultivars produced 7.00 (Amber Queen) and 5.00 (Pearl) flowers per plant when grown in wood chip compost and leaf compost. Correlation analysis (Table 3) revealed that No. of flowers per plant was significantly and positively correlated with No. of petals per flower character.

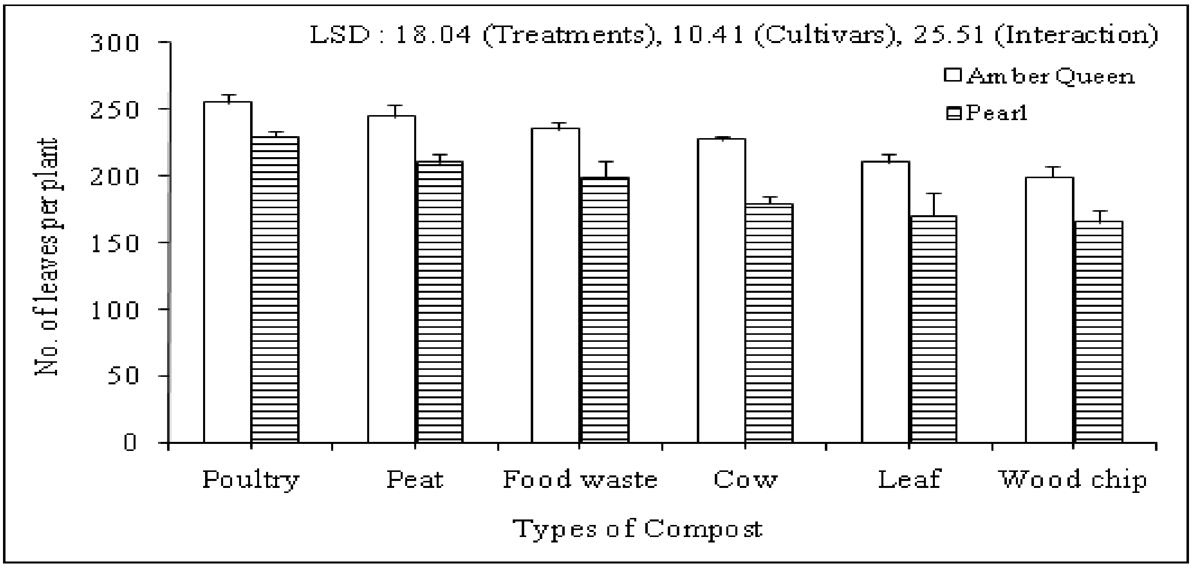

Fig. 3. Effect of types of compost on number of leaves per plant of two rose cultivars *viz.* Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

Similarly, Fig.6 showed that number of petals per flower parameter was significantly affected by different types of compost, rose cultivars and their interaction at 5% level of probability. Maximum number of petals per flower were counted in rose cultivar Amber Queen (31.06) followed by Pearl (22.33) whereas both cultivars produced maximum petals per flower when grown in poultry litter compost (31.00) followed by peat compost (30.00) and food waste compost (29.00).

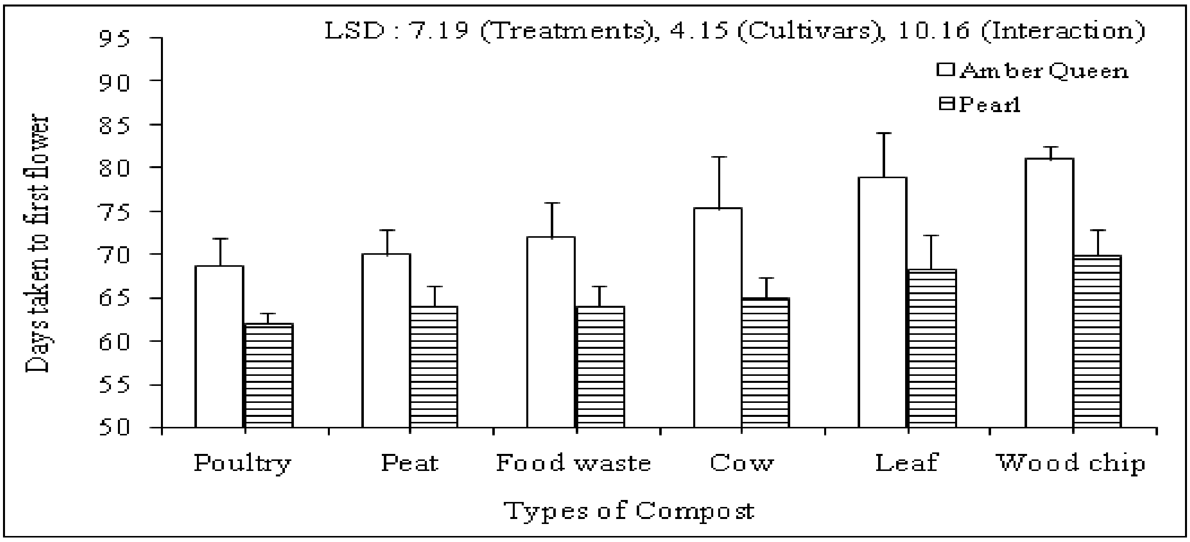

Fig. 4. Effect of types of compost on days taken to first flower of two rose cultivars *viz.* Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

While minimum petals per flower were recorded in wood chip compost (21.00).

The interaction of both factors (composts and cultivars) indicated that the two cultivars grown in poultry litter compost produced maximum petal number i.e. 36.00 (Amber Queen) and 26.00 (Pearl) followed by peat compost (36.00, Amber Queen; 24.00, Pearl) and food waste compost (35.00, Amber Queen; 23.00, Pearl), whereas plants grown in wood chip compost media produced minimum number of petals per flower (23.00, Amber Queen; 19.00, Pearl).

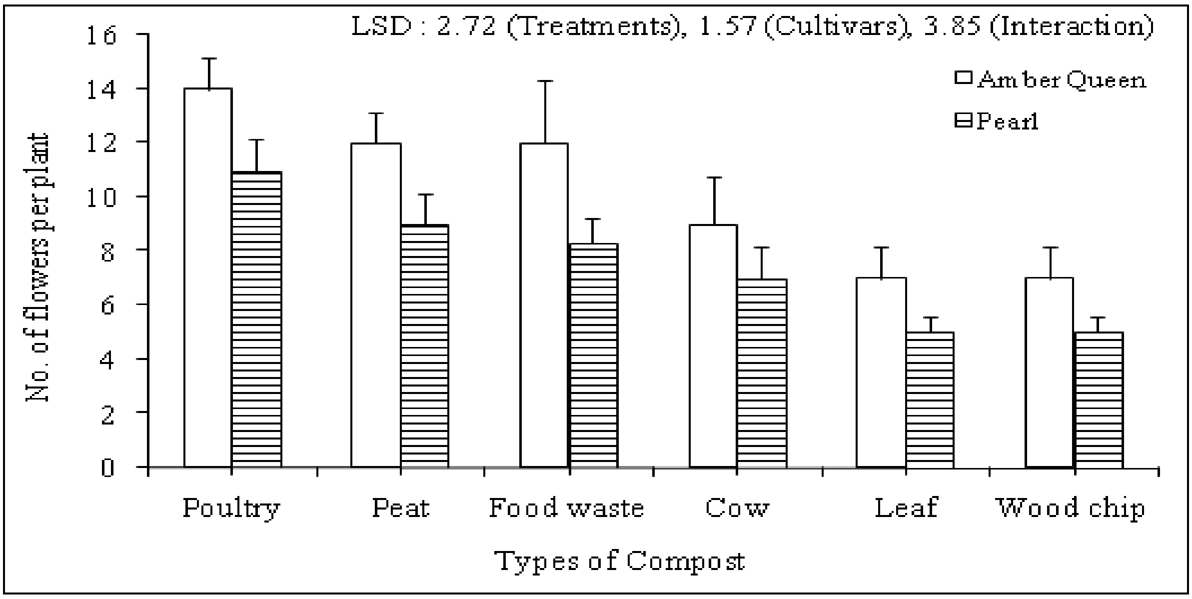

Fig. 5. Effect of types of compost on number of flowers per plant of two rose cultivars *viz.* Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

Discussion

Findings of present research showed that the composts prepared from naturally different organic materials (poultry litter, peat, food waste, cow dung, leaf and wood chips) have distinctive effects on plant height, number of branches per plant, leaf number, days taken to flowering, number of flowers per plant and number of petals per flower.

The two rose cultivars (Amber Queen and Pearl) were also distinct to each other; however, the responsive trend of both cultivars to different composts was analogous. Although, the above-mentioned plant traits were positively affected by all types of composts, however, compost prepared from poultry litter stood out above the rest due to have higher nutrients composition (Table 1).

Commercial peat compost and food waste compost showed more or less similar results and were more or less statistically alike when compared to poultry litter compost. Therefore, there is a wide scope of utilizing different organic materials as compost for better recycling of wastes (Bachman and Metzger, 2008).

Present study results agreed with Olubode *et al.* (2015) who reported that poultry manure improved plant height, number of leaves, number of flowers and flower yield of rose cultivars Immaculate and P.H. Baby. The poultry litter compost has long been known as a suitable organic material because it has many essential plant nutrients (Altunga, 2007). The nitrogen, phosphorus and potassium components of poultry manure are relatively higher than others elements, which are mainly needed by plant in relatively high quantities (Dikinya and Mufwanzala, 2010).

Poultry litter compost applied in present research also indicated higher concentrations of these macro-nutrients (Table 1), that might be the best explanation of positive effect of the compost on growth and development of roses. Kolich and Ritz (2016) stated that poultry compost increased soil nitrogen by as much as 25-30%. Similarly, the application of poultry manure enhanced soil productivity, increased the soil organic carbon content, soil micro-organisms, improved soil structure, nutrients level of the soil and eventually the crop yield is enhanced (Hochmuth *et al.*, 2016). Besides plant nutrient supply, the increased soil microbial activity in the enriched compost media may indirectly have contributed to enhance aerial growth of rose (Yadav and Garg, 2015). Moreover, the application of compost improved the soil environment that stimulated the proliferation of roots, which in turn pull more water and nutrients from larger areas that could justify the best growth observed in present study.

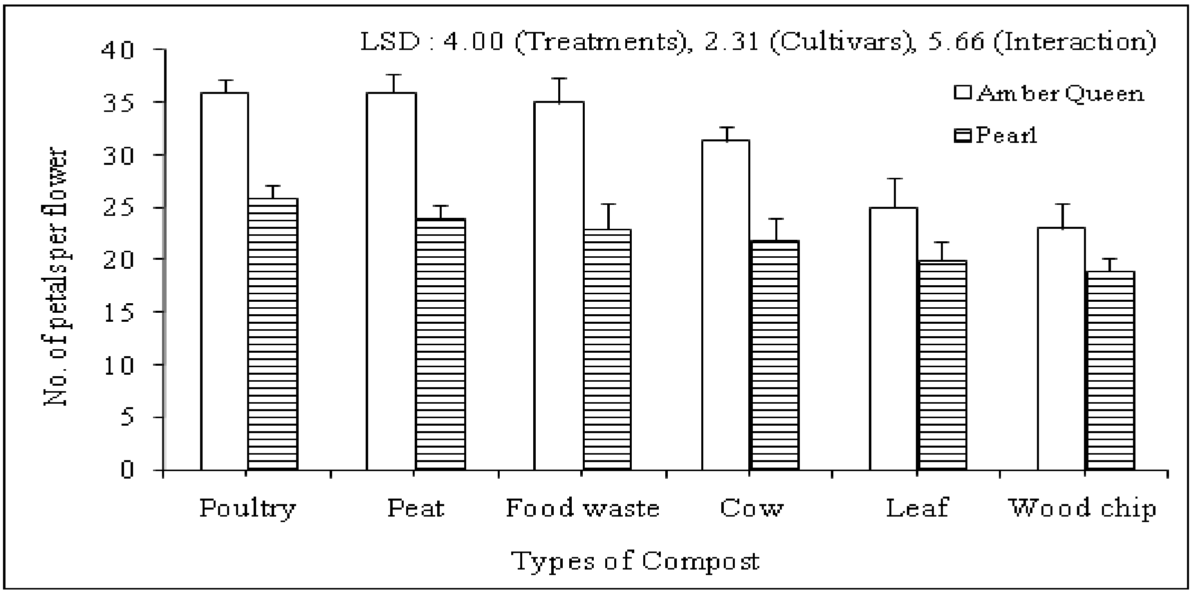

Fig. 6. Effect of types of compost on number of petals per flower of two rose cultivars *viz*. Amber Queen (white bars) and Pearl (horizontal lines bars). LSD is the least significant difference between treatments at 5% probability level. Standard errors on bars represent the variability within replications.

Although, different types of compost significantly influence days to flowering, however, flowering initiation process is triggered by the three environmental cues such as photoperiod, temperature and gibberellins (O'Neil, 1992; Bradley *et al.*, 1996). The positive effect of available plant nutrients in compost might enhanced the overall plant growth traits and the apical floral meristem become competent in a short period of time to perceive the floral stimulus (Hackett and Srinivasan, 1985; Baloch *et al.*, 2009; Munir *et al.*, 2015). The correlation analysis (Table 3) showed a positive significant association among all growth characters except with days to flowering, which was non-significant with all parameters and negative with No. of branches per plant and No. of flowers per plant.

The reason could be that the flowering induction is influenced by the three pathways i.e. photoperiod, temperature and gibberellins (Bradley *et al.*, 1996). Hence, days taken to flowering was not influenced by plant height, No. of branches per plant, leaf number, No. of flowers per plant and No. of petals per flower.

Conclusion

Results of present study showed a possible use of conventional waste materials such as poultry litter, food waste, cow dung, leaf and wood chips for making compost and its application for pot growing roses. Among all, poultry litter compost and food waste compost were superior to others, which was closely followed by commercial peat compost. However, the later one is much expensive than the former ones. Compost prepared cow dung also gave promising results. It is therefore concluded that cost-effective valuable compost can be prepared from poultry litter, food waste and cow dung, which can be used as potting mixture with sand for rose cultivation under the ecological conditions of Al-Ahsa, Kingdom of Saudi Arabia.

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