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EFFECTS OF ORGANIC MANURES ON GROWTH, YIELD AND QUALITY OF GYPSOPHILA (*GYPSOPHILA PANICULATA* L.)

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Abstract

Cost effective and environmentally friendly crop production using a variety of animal manures is possible for all horticultural production systems including floriculture. Efficient production of summer cut flowers like gypsophila is feasible under small-holder production system. The objective of this study was to determine the effect of different types and application rates of animal manures on growth, yield and quality of gypsophila cut flowers grown under field conditions. The experiment was carried out in the Horticulture Department Farm, Faculty of Agriculture, Luyengo Campus of the University of Swaziland to determine the growth, yield and quality of gypsophila when fertilised with kraal manure, poultry manure and inorganic fertilisers. The treatments were kraal manure applied at 10, 20, 40 and 80 t/ha; and chicken manure applied at 5, 10, 20, and 40 t/ha. A control of inorganic fertiliser (2:3:2 (22) + 5% Zn) was applied at 1,400 kg/ha. The design of the study was a Randomised Complete Block Design (RCBD). Data collected was subjected to analysis of variance (ANOVA). Where significant results were obtained, means were separated using the Duncan's New Multiple Range Test (DNMRT). The results showed that chicken and kraal manure levels affected growth of gypsophila, with chicken manure at 40 t/ha inducing the highest plant height of 54.7 cm followed by kraal manure applied at 80 t/ha (52.6 cm). The lowest plant height of 38.4 cm was observed in plants applied with the inorganic fertiliser. Plants supplied with chicken manure at 40 t/ha had the highest cut flower length of 53.9 cm followed by kraal manure at 80 t/ha with 48.6 cm whilst inorganic fertiliser induced the lowest cut flower stem length of 37.5 cm. Gypsophila applied with chicken manure at 40 t/ha had the highest number of marketable cut flowers (7.1) followed by kraal manure at 80 t/ha with 6.7 cut flowers. Plants supplied with inorganic fertiliser had the lowest number of marketable cut flowers (5.1). The application of chicken manure at 40 t/ha induced the highest fresh and dry masses whilst inorganic fertiliser application resulted in the lowest values. There were no significant differences in the accumulation of N, P, and K in gypsophila plants due to the different treatments. It was concluded, therefore, that farmers should use chicken manure applied at 40 t/ha or kraal manure applied at 80 t/ha for profitable production of gypsophila under field conditions in Eswatini.

Keywords: Gypsophila, kraal manure, chicken manure, inorganic fertiliser, cut flower length

INTRODUCTION

Gypsophila (*Gypsophila paniculata* L.), also referred to as baby's breath is the mainstay filler plant in the floral industry, that is used for flower arrangements and bouquets, especially roses (Elgar, 2013; Missouri Botanical Garden, 2013). It requires a free draining, preferably calcareous soil with a pH of 6.5-8.0. It grows and flowers naturally outdoor and in full sun in many parts of the world including New Zealand and USA (Elgar, 2013; Missouri Botanical Garden, 2013). Gypsophila has low nutrient requirement. Too much fertiliser results in thin, weak and poor quality stems (Tregea, 2013). It requires frequent irrigation following planting to avoid moisture stress. Once established, gypsophila is relatively drought tolerant due to its deep root system (Tregea, 2013).

The cut flower trade is a multibillion dollar world industry. Flowers are grown in many countries and, due to their perishability, must be rapidly transported by air often to farflung destinations. The Netherlands largely dominates this industry; more than 60% of the international trade in cut flowers is conducted from there, much of it at the flower auctions. Although the Netherlands is itself a major producer of cut flowers, some of the flowers it exports are imported to it from other countries and pass through the auctions before heading to their export destinations. In 2003, Kenya was by far the biggest supplier to the Netherlands auctions. Kenya and Zimbabwe are the leading flower exporters in Africa. South Africa, Uganda, Tanzania, and Zambia are also major producers, while some other African countries export much smaller volumes (Bonarriva, 2003).

The most common organic manure used in Swaziland is cattle manure because cattle are the most common livestock in the country. Chicken manure is the second most popular manure, while other types such as goat and sheep manure which may be available in smaller quantities depending on locality. The application of cattle manure to farmland is an economic and environmentally sustainable mechanism for increasing crop production (Reddy *et al*., 1980; Ogunlela *et al*., 2005; Saskatchewan Soil Conservation Association, 2014). Nutrients in cattle manure can replace commercial fertilisers. It is an excellent soil amendment capable of increasing soil quality, yield, and organic matter content, improving soil structure and water infiltration (Saskatchewan Soil Conservation Association, 2014). Many of the nutrients in cattle manure, however, are tied up in the organic fraction and must go through decomposition process to be converted to inorganic forms available to crops. Getting maximum value out of cattle manure requires applying the manure at the proper rates and frequencies. Over-application can lead to transport of nutrients into the ground water through leaching and/or overland flow, and pollution of atmosphere with ammonia and nitrous oxide. (Saskatchewan Soil Conservation Association, 2014).

Land application of poultry manure should be managed to recycle plant nutrients rather than for disposal. Increasing environmental concerns about agricultural non-point source pollution make it imperative to use poultry manure in the manner most beneficial for the environment- both on and off the farm (Zang *et al*., 2014). Proper management of poultry manure includes determination of crop nutrient requirement based on a realistic yield goal and soil test data, determination of nutrient content of poultry litter, determination of litter application rate to supply crop nutrient needs, and determination of supplemental nutrients needed for optimum crop growth (Department of Agriculture, Fisheries and Forestry, 2014; Virginia Cooperative Extension, 2014; Zang *et al*., 2014). The nutrient composition of poultry manure varies with the type of bird, the feed ration, the proportion of litter to droppings, the manure handling system, and the type of litter (Zublena *et al*., 2014; Ofori, 1980). Chicken litter is typically applied at the application rate can supply about 160 kg N, 111 kg P and 62 kg K/ha to the soil of about 15 m^3 per ha (Department of Agriculture, Fisheries and Forestry, 2014).

The potential use of animal manures such as cattle manure and chicken manure could offer a cheap and readily available alternative source of nutrients since these residues release and return valuable nutrients to the soil in a variety of ways. These manures could bring multiple benefits in cut flower production. Such benefits include improvement in soil structure, soil moisture retention and protection from adverse temperature such as chilling injury and frost-causing temperatures (Snyder and de Melo-Abreu, 2005). The objectives of the study were to determine the effects of different application rates of chicken and cattle manure on growth, yield and quality of cut flowers as well as to determine the effects of the organic manures on the accumulation of nitrogen, phosphorus and potassium in gypsophila plants.

MATERIALS AND METHODS

Experimental site

The research was carried out in the Horticulture Department Experimental Farm, Faculty of Agriculture, Luyengo Campus of the University of Swaziland. The farm is located at Luyengo, Manzini Region, in the Middleveld agro-ecological zone, between May and September 2015. Luyengo is located at 26º34’ S and 31º34’ E. The average altitude of this area is 750 m above sea level. The mean annual precipitation is 980 mm with most of the rain falling between October and April. Drought hazard is about 40%. The average summer temperature is 27ºC and winter temperature is about 15ºC. The soils of Luyengo are classified under Malkerns series. They are Ferrasolic or merely a Ferralitic soil intergrade to Fersialitic soils or typic Ultisols. The soils in the experimental area are sandy loams (Murdoch, 1970).

Fertilizer application and planting

The area was demarcated into 40 plots each measuring 3 x 3 m with one metre footpaths between plots. Organic manures (chicken and kraal manure) were applied into experimental plots two months before transplanting, this was to give it time to naturally breakdown and release nutrients as much as possible so that they would be available to the plants at the time of planting. This was done by evenly broadcasting the manures in each plot and incorporating the manures in the soil using a hoe. Kraal manure was applied at 10, 20, 40, and 80 t/ha. Chicken manure was applied at 5, 10, 20, and 40 t/ha. In experimental plots where synthetic fertilisers were used (control), 2:3:2 (22) fertiliser was applied at a rate of 40 g/plant (1,400 kg/ha). The fertiliser was applied in splits during the duration of the experiment. Ten grams was applied at transplanting then 15 g every four weeks for two months (two splits). Seedlings were transplanted into the plots at a spacing of 60 x 45 cm.

Experimental design

The treatments were laid out in a 2 x 5 factor arrangement and laid in a Randomized Complete Block Design (RCBD). There were nine treatments replicated four times. The total number of plots was 36.

Data collection and analysis

Data was collected a month after transplanting and every two weeks thereafter. Five randomly selected plants were used in each plot for data collection. The data collected included plant height, number of cut flower stems, length of cut flowers, fresh and dry masses, plant nitrogen, phosphorus and potassium content. Data collected was subjected to analysis of variance (ANOVA) in a Randomised Completely Blocked Design, using MSTAT-C statistical software to analyse the collected data (Nissen, 1989). Where significant differences were observed among treatments, the Duncan New Multiple Range Test (DNMRT) was used to separate means at 5% level of significance (Gomez and Gomez, 1984).

RESULTS

Plant height

Plant height increased with each increase in levels of organic manures (Figure 1 and 2). The highest plant height was obtained from plants provided with 40 t/ha of chicken manure throughout the experiment. At 10 weeks after transplanting (WAT), the highest plant height (54.7 cm) was obtained from plants supplied with 40 t/ha of chicken manure (Figure 2) followed by plants supplied with 80 t/ha kraal manure with a value of 52.6 cm (Figure 1). The lowest plant height of 38.4 cm was obtained from the control plants.

There was a significant ($P < 0.05$) difference in plant height at 4 WAT between 20 and 40 t/ha application rates of chicken manure (Figure 2). Although there were no significant ($P > 0.05$) differences, plant height of gypsophila was higher in chicken manure as compared to kraal manure treated plants. At 10 WAT, chicken manure treated plants had the highest plant height value as compared to kraal manure and synthetic fertilisers (Figure 1 and 2).

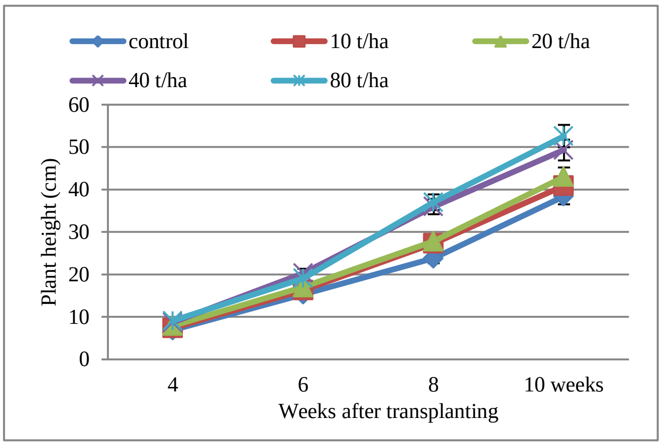

Figure 1: The effects of kraal manure application rates on plant height at 4, 6, 8 and 10 weeks after transplanting (WAT)

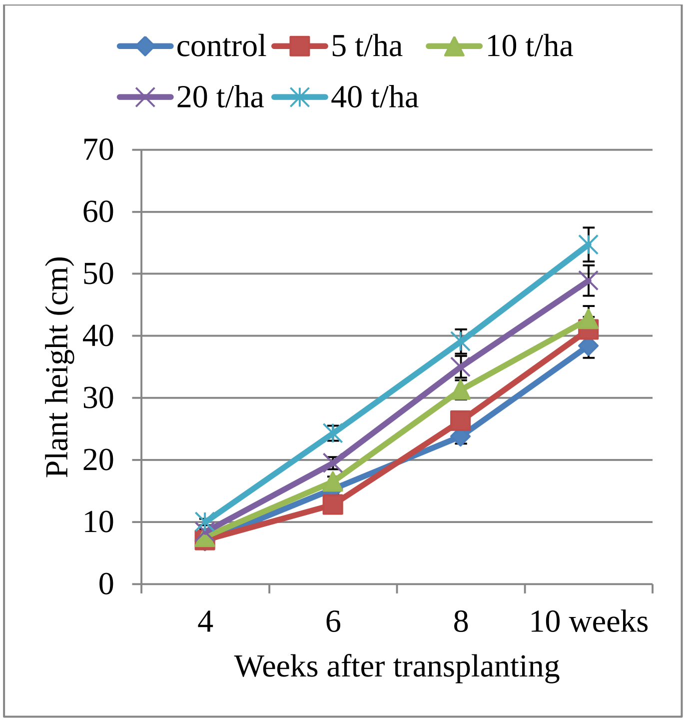

Figure 2: The effects of chicken manure application rates on plant height at 4, 6, 8 and 10 weeks after transplanting (WAT).

Cut flower stem length

There was no significant ($P > 0.05$) difference in cut flower stem lengths in plants treated with synthetic fertiliser and those treated with kraal manure at 5 t/ha. Similarly, no significant ($P > 0.05$) difference was observed in gypsophila cut flower stem length between the plants applied with 20 and 40 t/ha of kraal manure (Figure 3). However, significant ($P < 0.05$) differences in cut flower stem length were observed between kraal manure treatments of 40 and 80 t/ha (Figure 3).

There was a significant ($P < 0.05$) difference in cut flower stem length between the control and chicken manure at 5 t/ha applied gypsophila plants (Figure 4). No significant ($P > 0.05$) difference in cut flower stem length was observed between plants provided with 5 and 10 t/ha of chicken manure but there were significant differences ($P < 0.05$) between 10, 20 and 40 t/ha chicken manure (Figure 4). The longest cut flowers were obtained from plants applied with 40 t/ha chicken manure (53.9 cm) as shown in Figure 4 followed by those supplied with 80 t/ha kraal manure (48.6 cm) as shown in Figure 3. At 10 WAT, the plants from the control had the lowest cut flower length of 37.5 cm. The cut flower stem length of gysophila plants applied with chicken manure was relatively higher than those treated with kraal manure (Figure 3 and 4).

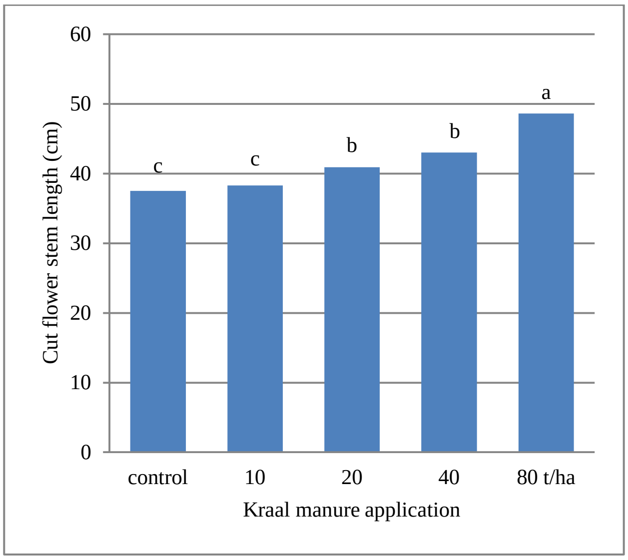

Figure 3: The effects of kraal manure at different application rates on cut flower stem length. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

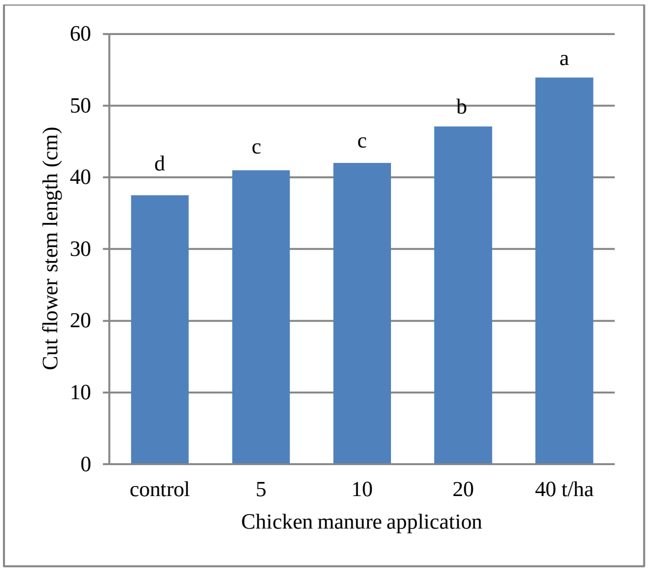

Figure 4: The effects of chicken manure at different application rates on cut flower stem length. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

Number of marketable cut flowers

The number of cut flower stems increased with increasing organic manure application rates (Figure 5 and 6). Significant ($P < 0.05$) differences in the number of marketable cut flowers per plant were observed between plants treated with 20, 40 and 80 t/ha kraal manure (Figure 5). The highest number of marketable cut flowers (6.7) was observed in plants supplied with 80 t/ha of kraal manure while the lowest (5.0) was observed in control plants (Figure 5).

Significant ($P < 0.01$) differences in number of marketable cut flowers per plant were observed across all chicken manure application rates (Figure 6). The highest number of marketable cut flowers (7.1) was observed in gypsophila plants applied with 40 t/ha chicken manure followed by those applied with 80 t/ha kraal manure (6.5) (Figure 6). The lowest number of marketable cut flowers (5.0) was observed in the control plants. The number of marketable cut flowers was relatively higher in plants supplied with chicken manure as compared to those provided with kraal manure (Figure 5 and 6).

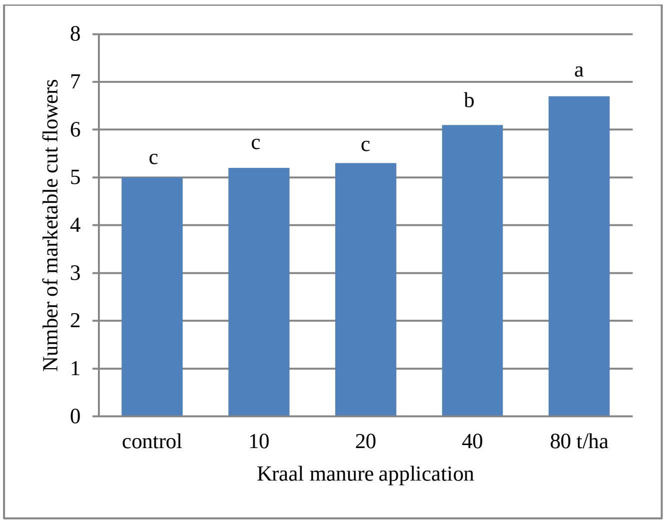

Figure 5: The effects of kraal manures at different application rates on the number of marketable cut flowers. Bars followed by same letter not significantly different. Mean separation by DNMRT at P = 0.05.

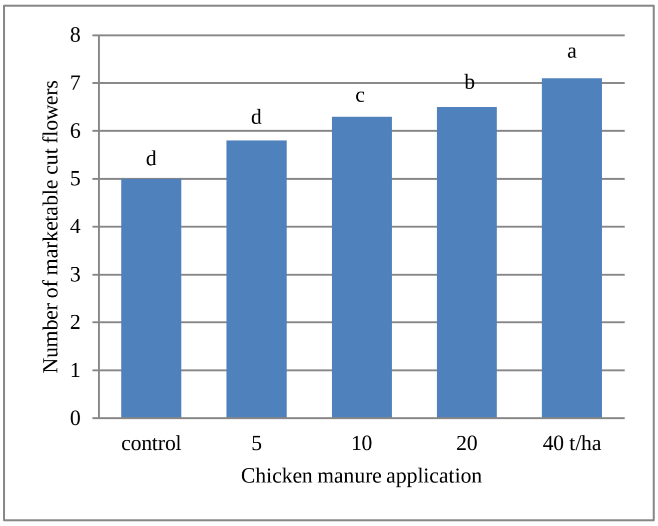

Figure 6: The effects of chicken manure at different application rates on the number of marketable cut flowers. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

Nitrogen content

There were no significant (P > 0.05) differences in nitrogen content in gypsophila plants between all the organic manure application rates (Figure 7 and 8). The highest plant nitrogen content was recorded in plants treated with 40 t/ha of chicken manure (1.964% N) followed by plants applied with 20 t/ha chicken manure (1.888%) (Figure 7). Plants applied with kraal manure at 80 t/ha had a nitrogen content of 1.735% whilst the lowest was recorded in the control plants (1.499% N) (Figure 8). Plants provided with chicken manure had relatively higher nitrogen contents as compared to those supplied with kraal manure (Figure 7 and 8).

Phosphorus content

There were no significant (P > 0.05) differences in phosphoropus content in gypsophioloa plants due to the different organic manure application rates (Figure 9 and 10). The highest leaf phosphorus content (0.016 µg/kg) was recorded in plants applied with 40 t/ha chicken manure followed by 20 t/ha chicken manure (0.015 µg/kg) as shown in (Figure 10). The lowest phosphorus content (0.012 µg/kg) was recorded in the control plants (Figure 9). Higher phosphorus contents was obtained in plants provided with chicken manure as compared to those supplied with kraal manure (Figure 9 and 10).

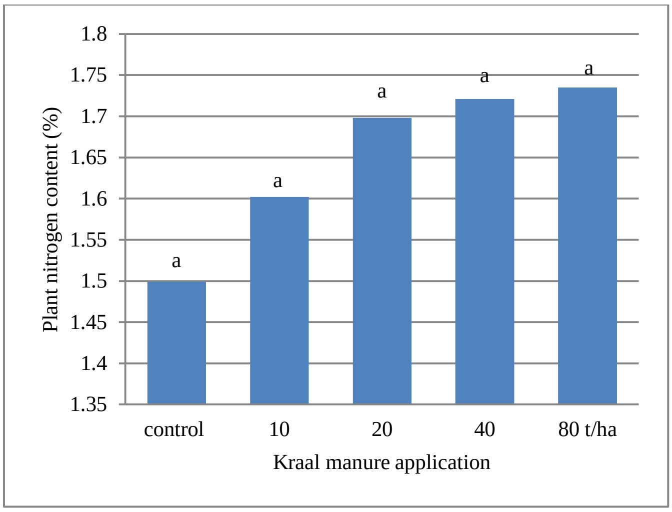

Figure 7: Effects of organic manures at different application rates on the leaf nitrogen content. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

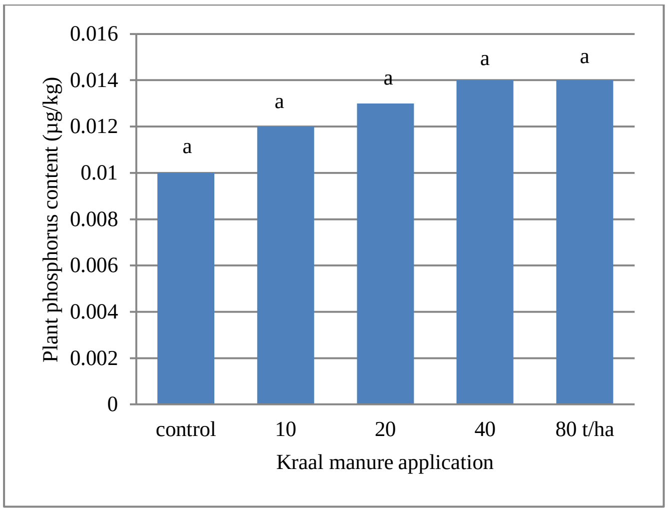

Figure 9: Effects of kraal manure manures applied at different rates on phosphorus content in plants. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

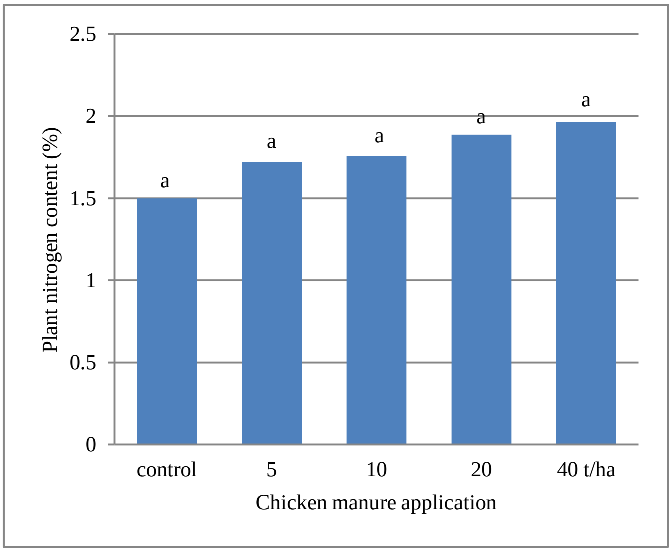

Figure 8: Effects of chicken manure at different application rates on the plant nitrogen content. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

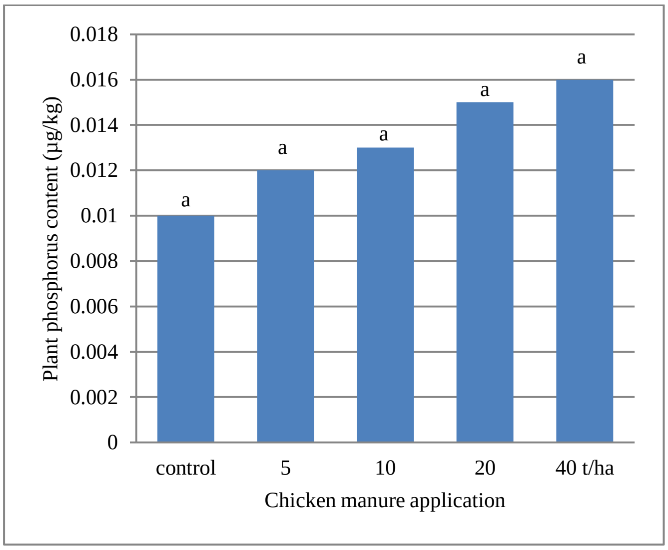

Figure 10: Effects of chicken manure manures applied at different rates on phosphorus content in plants. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

Potassium content

There were no significant (P > 0.05) differences in potassium content in leaves of gypsophila plants applied with different organic manure rates (Figure 11 and 12). The highest potassium content (0.090 cmol/kg) was observed in plants applied with chicken manure at 40 t/ha (Figure 12) followed by 80 t/ha kraal manure (0.087 cmol/kg) (Figure 11). The lowest potassium content (0.064 cmol/kg) was recorded from the control plants (Figure 11). Higher potassium contents were obtained in plants provided with chicken manure as compared to those provide with kraal manure (Figure 11 and 12).

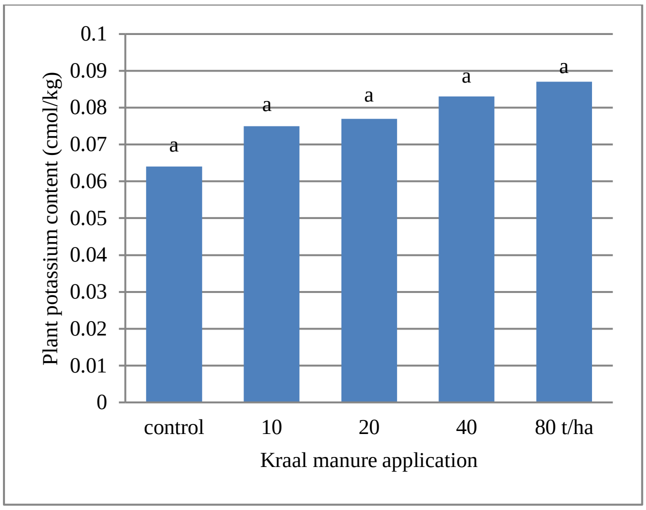

Figure 11: Effects of different application rates of kraal manure on plant potassium content. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

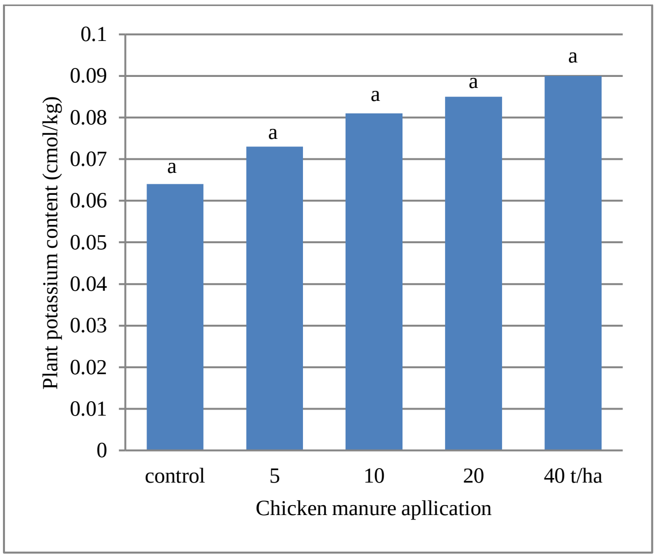

Figure 12: Effects of different application rates of kraal manure on plant potassium content. Bars followed by same letter are not significantly different. Mean separation by DNMRT at P = 0.05.

DISCUSSION

Plant height increased as the organic manure application rates increased. Gypsophila plants treated with 40 t/ha chicken manure had the highest plant height whilst the control plants recorded the lowest plant height. Work done by Mbatha (2008) in two seasons (2005 and 2006), in Bloemfontein, South Africa, on the influence of different organic fertiliser rates, which were chicken manure at 0, 6.25, 12.5, and 25 kg/10 m^2, kraal manure at 0, 12.5, 25, 50 kg/10 m^2 and compost at 0, 25, 50 and 100 kg/10 m^2 showed that different organic fertilisers did not significantly influence plant height of cabbage during the first eight weeks after transplanting in 2005, but in 2006 it was significantly influenced during the first four weeks after transplanting. Organic fertiliser application rates significantly influenced plant height during the first eight weeks after transplanting in both 2005 and 2006.

Plant height is the result of biochemical changes in the plant. It was observed that the soil alone presented very low comparatively to other media. It clearly indicated that different media (manures) in different combinations have different qualitative and quantitative effects on plant height (Anwar *et al*., 2013). Ozcelik *et al.* (1999) observed that a positive mineralisation in organic amendment of soil, adds nitrogen to it, which enhance plant growth and number of branches.

In this investigation, the number of cut flowers increased as the organic manure application rates increased. The highest number of cut flowers were observed in plants supplied with 40 t/ha chicken manure whilst the lowest value was obtained on control plants. These results are in agreement with the results obtained by Idan *et al*. (2014) on the effects of organic manures (which were applied at 10 and 20 t/ha) on flower yield of African marigold. Results showed that the different treatments of organic manures significantly affected the number of flowers per plant. It was evident that among the different treatments, the maximum number of flowers (39.75), was recorded with plants applied with 20 t/ha poultry manure followed by plants applied with 20 t/ha farmyard manure (FYM) [36.67] then vermin-compost at 20 t/ha (34.33). The minimum number of flowers per plant was recorded in control plants was 22.15 (Idan *et al*., 2014). Idan *et al*. (2014) attributed such results to the fact that plant nutrients supplied through organic sources had profound effect on growth and productivity of the crop either by acceleration of respiratory processes with increasing cell permeability and hormonal growth action or by combination of all these processes. Through their biological decomposition processes the organic sources supply nutrients to the plants in the available form. They are also rich in micro-nutrients besides having plant growth promoting substances like hormones, enzymes and humus forming beneficial microbes. Organic sources, on application to the soil, improve the physical properties of soil such as aggregation, aeration, permeability and water holding capacity which promote growth and development of plants.

Gopal (1997) reported that among the organic sources of nutrients, poultry manure proved to be the best source of organic manure which helped in improving physio-chemical properties (pH, electrical conductivity, organic carbon, macro and micro-nutrients) of soil because of its higher analytical values. It has also been experimentally proved that considerable amount of N present in poultry manure consist of uric acid, which is readily available to the plants. The C: N ratio of poultry manure reported to be narrower than others, which attenuates the release of nitrogen (Chadwick *et al*., 2000). Poultry manure when supplied to soil improves texture which makes the soil loose, increase water holding capacity, and uplift humus status which maintain the optimum conditions for micro-organism activity. In this investigation, poultry manure gave better result in all vegetative and flowering parameters.

Plants treated with 40 t/ha of chicken manure had the longest cut flower stem length followed by plants supplied with 80 t/ha kraal manure. The lowest stem length was obtained by control plants. According to Kabir *et al*. (2011), tuberose floral characters such as spike length and diameter, rachis length, number of florets and flower yield both per plant and per hectare of tuberose were significantly increased by the application of different organic fertilisers. Results revealed that flower yield was greater in organic fertilisers than chemical fertiliser treatments. These results indicate that use of organic fertiliser is important for tuberose production. However, among the organic fertilisers, poultry litter performed the best in respect of flower characters and flower yield followed by cow dung and vermin-compost. The plants that were applied with chemical fertilisers performed worst in flower yield due to inferiority in flower characters. These results are consistent with Padaganur *et al.* (2005) in tuberose who reported that poultry litter performed better in flower yield than cow dung. On the other hand, Shankar *et al*. (2010) and Mitra (2010) reported that among the organic manures, the highest spike length and diameter, rachis length and number of floret spikes were recorded in poultry manure treatments at 20 t/ha which resulted in highest flower yield both per plant and per hectare followed by cow dung at 20 t/ha treatment. The lowest flower yield was recorded in chemical fertiliser treatment due to production of fewer floret spikes.

According to Suseela *et al*. (2016), spike length, number of florets, number of spikes per clump per plot and per hectare of tuberose was significantly increased by the application of poultry manure. This was attributed to slow and sustained release of nutrients from poultry manure. Ranjan *et al*. (2014) indicated that poultry manure is a good source of nitrogen and other nutrients. The C: N ratio of poultry manure is narrower than others which could help to release nitrogen at slower rate which is helpful for plant growth at later stages of development. These organic sources contain nitrogen in complex organic form which requires the mineralization process to be executed for bringing nitrogen in available form. This process is essentially a soil micro-biological process carried out by the soil heterotrophic micro-flora which is a slow process. As a result, the entire nitrogen becomes available to the plants over an extended period of time. These results are in conformity with the findings of Jat *et al*. (2006) in fenugreek and Singh *et al*. (2006) in rose, and Padaganur *et al*. (2005) in tuberose.

Mbatha (2008) reported that chicken manure significantly increased the nitrogen content of cabbage heads. There were no significant differences between all the treatments in the accumulation of nitrogen in gypsophila plants in this investigation. The highest nitrogen content was recorded in plants supplied with 40 t/ha of chicken manure whilst the lowest was recorded in control plants. There was no significant difference in phosphorus content that was observed across all the treatments. The highest phosphorus content was recorded in plants applied with 40 t/ha chicken manure whilst the lowest was recorded in control plants. Similarly, there was no significant difference in potassium content that was observed in all treatments. The highest potassium content was obtained from plants that were applied with chicken manure at 40 t/ha and the lowest from control plants.

Mohamed *et al*. (2007) found out that application of organic manures registered fairly higher uptake of NPK that might be due to greater availability of nutrients. Added organic manures not only acted as a source of nutrients but also had influenced their availability. Cumulative effect of these treatments seemed to be adequate supplier of nutrients slowly and steadily throughout the crop growth. Similarly, Sabanyangam (1982) observed an increase in the uptake of N and P due to application of organic manures.

Higher uptake of nutrients in composted poultry manure might be due to increased availability of nutrients. Increase in available nitrogen due to application of poultry manure and FYM was reported by Rayar (1984). Reddy *et al*. (1980) reported that application of poultry manure decreased the adsorption capacity and increased the soluble phosphorus and phosphorus absorption.

CONCLUSION

From the results of the study it is clear that the organic fertilisers which were used in the experiment enhanced the growth and yield of the gypsophila cut flower. Chicken manure applied at 40 t/ha yielded the highest cut flower stem length and was followed by kraal manure applied at 80 t/ha. The highest number of marketable cut flowers were obtained from gypsophila provided with chicken manure at 40 t/ha. Generally, the results of the study showed that the yield increased as the organic fertiliser application rates increased. There were no appreciable differences in the content of N, P and K due to the type or rate of organic manure applied. Plants provided with chicken manure performed better in most of the parameters determined as compared to those applied with kraal manure. Based on the results of the study, it is recommended that farmers who wish to venture into gypsophilla cut flower production should use chicken manure at 40 t/ha or kraal manure at 80 t/ha are the best yield and quality of gypsophila cut flowers.

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