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Effects of organic fertilisers on growth, yield and nutritional content of sweet basil (*Ocimum basilicum* L.)

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ABSTRACT

Sweet basil *(Ocimum basilicum* L.) is one of the major essential oil-producing species used in culinary and fragrance applications. However, there is a dearth of information pertaining to its organic production in the country. A field study laid out in a Randomized Complete Block Design (RCBD) was conducted at the Horticulture Farm, Luyengo Campus, University of Eswatini to assess the effects of organic fertilisers on the growth, yield and nutritional content of basil. This study consisted of four treatments replicated four times. The organic fertilisers used were chicken manure, kraal (cattle) manure and compost. The rates of application were 40 t/ha for the manures. Chemical fertilizer 2:3:2 (22) + 0.5 Zinc (Zn) and limestone ammonium nitrate (LAN 28%) were included at application rates of 150 kg/ha basal dressing and 100 kg/ha LAN top dressing, respectively. The results showed that the type of organic fertilizer applied affected the growth and yield of sweet basil. A trend in the superiority of the different types of organic fertilisers was observed as chicken manure exhibited higher values of the number of leaves (134.2), branches (78.6), leaf area (30.2 $cm^{2)}$) and chlorophyll content (68.2 CCI), fresh leaf mass (355 g), and fresh mass of basil plant (691 g). Kraal manure was the second, followed by chemical fertilizer and lastly compost. There were no significant ($P > 0.05$) differences in P, K, Mn, Cu, and Zn content due to the application of different organic fertilisers. Calcium, Mg and Fe showed significant ($p < 0.05$) differences among the treatments. The use of chicken manure in the production of basil should be encouraged because its application resulted in relatively higher growth and yields compared to the other fertilisers.

Keywords: Organic fertilizers, growth, basil, medicinal properties, mineral content.

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INTRODUCTION

Background information

In the mid1800s, Justus von Liebig proposed that mineral salts replace organic amendments as the source of essential plant nutrients needed for agricultural production (Brook, 1997). Application of organic amendments such as compost, chicken manure and kraal manure are effective tools to manage soil fertility in vegetable production (Roe, 1998). These amendments not only supply essential plant nutrients to a crop but by their organic fraction can improve the nutrient holding capacity of soils and can also be beneficial to soil micro-organisms.

Maximum use of locally available resources is an integral part of sustainable vegetable production in the tropics. Composting provides an opportunity to recycle materials that would otherwise add to the amount of waste needing disposal (Valenzuela, 2000).

Excessive use of synthetic fertilisers has resulted in numerous negative effects on the environment including degrading soil quality due to loss of soil organic matter as a result of conventional farming systems and losses of agricultural biodiversity. The usage of chemical fertilisers causes a great impact on the environment and the costs are increasing with the years (Guo et al., 2015). Organic farming can reduce the costs and the burden on the environment hence they are recommended as they are an eco-friendly, non-toxic and recycled biological product. The prolonged over usage of chemicals has, however, resulted in human and soil health hazards along with environmental pollution. At present, people are willing to get vegetables produced organically because they are suffering from serious diseases which are due to toxic substances released by chemical fertilisers (Asaduzzanman et al., 2010).

With continuing consumer concerns related to the environment and chemicals used in food production, and the growing availability of certified organic production, the outlook for the continuing growth of organic production is bright (Dimitri and Greene, 2002). Farm income will also improve when farmers use less money on fertilisers and pesticides for growing crops (Masarirambi et al., 2010; Masarirambi et al., 2012). Eswatini has not reached self-sufficient levels in the production of herbs and spices and has not been able to meet the population's herb requirements. It is, therefore, necessary to increase the production to meet the needs of the increasing population as herbs play a vital role in providing a good source of essential nutrients which are important in human nutrition.

Commercial and conventional farming has been and is still relying on the use of inorganic fertilisers for growing crops (Lampkin, 1990). This is because they are easy to use and quickly absorbed and utilized by crops. As long as organic fertilisers are available and comparable with chemical fertilisers in yield improvement, their use as sources of plant nutrients for growing horticultural crops could assume increasing importance (Ogunlela et al., 2005).

Basil (*Ocimum basilicum* L.) is a popular herb known for its flavourful foliage (Davis, 1995). Basil belongs to the mint family known as Lamiaceace. It is a tender growing herb, grown as a perennial in warm, tropical climates and as an annual in temperate climates. Traditionally, it is used as a medicinal plant in the treatment of coughs, headaches, constipation, diarrhoea and kidney malfunctions hence very useful for human health. Sweet basil is cultivated as a culinary herb for fresh market and as a condiment or spice in the dried or frozen leaf form. It is a source of aromatic essential oil used in foods, flavours and as a pot herb and a bedding plant. The essential oils and oleo-resins may be extracted from leaves and flowers used for flavouring in liqueurs and fragrance in perfumes and soaps. The leaves are used fresh or dried to flavour meats, fish, salads and sauces (Vieira and Simon, 2000; Vieira and Simon, 2005).

Basil has been utilised for its expectorant, carminative and stimulant properties in folk medicine. In addition, it was used as an insecticide, flea and moth repellent (Simon et al., 1999). Fresh and dry leaves of the plant are used in the food and spice industries. The oil of basil is used in food industries, perfumery, dental and oral products. The oil of basil has an antimicrobial effect. Basil produces a range of polyphenolic compounds including rosmarinic acid, a characteristic it shares with herbs in the genus Lamiaceae. Rosmarinic acid is a cinnamic acid derivative with potent antioxidant activity and known antiviral, antibacterial, and anti-inflammatory properties. In addition, several purple cultivars also contain anthocyanins which are powerful antioxidants (Gutierrez-Miceli et al*.,* 2008). The objective of the study was to determine the effects of organic fertilisers on the growth, yield and mineral content of basil.

MATERIALS AND METHODS

Experimental site

The study was carried out at the University of Eswatini, Luyengo Campus, in the Horticulture Department Farm. The site is located at Luyengo, Manzini region, in the Middleveld agro-ecological zone. Luyengo is located at 26° 34' S and 31° 2' E. The average altitude of the 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 approximately 40%. The average summer temperature is 27°C and the winter temperature is about 15°C. The Luyengo soils are classified under Malkerns series. The soils are Ferrasolic or merely Ferrealitic soil intergrades to fersiallitic soils or typic ultisoils (Murdoch, 1970). The experiment was carried out from late December 2019 up until early February 2020.

Planting material

Planting was done on 23rd December 2019 using sweet basil seedlings. The seedlings were bought at Vickery Seedlings which is located at Malkerns, Eswatini. The plants were provided with all cultural practices such as irrigation and weeding which were uniformly carried out on all treatments. Compost used as a treatment in the experiment was bought at Carters Garden Centre in Mbabane, Eswatini. Synthetic fertiliser NPK [2:3:2 (22)] which was used as the control was bought from Khuba Traders in Mbabane.

Experimental design

The experiment was laid in a Randomized Complete Block Design (RCBD). The experiment consisted of four treatments (kraal manure, poultry manure, compost and chemical fertiliser (control) randomly assigned (Gomez and Gomez, 1984). Each treatment was replicated four times which resulted in 16 plots. The treatment codes and descriptions are shown in Table 1.

The land was first ploughed using a tractor, making it ready for planting. After that, forks and rakes were used to till the soil, to a fine tilth. Experimental plots were then marked, 3 m × 3 m and separated by 1 m footpath. Organic manures were applied five weeks before planting and incorporated into the soil so that it got enough time to decompose and be absorbed by the soil. The intra-row plant spacing was 50 cm and the inter-row spacing was 50 cm. That resulted in each plot having six rows. The four inner rows of plants were used for data collection, whilst the two outer rows were used as guard rows

The different fertilisers which were chicken, kraal, compost were applied at the same rate which was 40t/ha. Chemical fertiliser NPK [2:3:2 (22)] + 0.5 Zn was used as the control. Limestone ammonium nitrate (LAN) was used as a top dressing.

Soil sampling was done to a 20-cm depth using the zigzag method (Brady and Weil, 2007). The soil samples were placed in plastic bags labelled inside and outside and transported to the shade house for air drying for a few weeks. Then air-dried soil samples were transported to the Chemistry laboratory of the University of Eswatini. These were screened with a 2 mm together with a 0.5 mm sieve to remove the gravel, stones and roots. Organic manures used in the experiment were taken to Malkerns Research Station for physical and chemical analysis to help in the subsequent interpretation of results.

Table 1. Treatment codes and description.

Treatment code	Treatment description	Rate of application per plot
1	Kraal manure	40 t/ha
2	Poultry manure	40 t/ha
3	Compost	40 t/ha
4	Control, Synthetic fertilizer NPK [(2:3:2 (22)]	150 kg/ha basal dressing and Limestone Ammonium Nitrate (LAN) applied as top dressing at 100 kg/ha

Data collection

Data collection began on the second week after transplanting (WAT) when the basil had fully established. Data collection continued at one-week intervals up until 6 WAT. The data collected included the following parameters:

i. Number of: fully expanded leaves of sweet basil were counted from three tagged plants per plot;
ii. Plant height: on the tagged plants, t was measured using a ruler;
iii. Chlorophyll content: A chlorophyll meter, (CCM 200, OptiSciences, Hudson, New Hampshire, USA) was used to determine the chlorophyll content of the leaves per sampled plants;
iv. Number of flowers were recorded per tagged plants;
v. Number of branches: The branches were counted from the three tagged plants, an average was calculated to get the number of branches per plot;
vi. Leaf area: Leaf area was calculated using the formula: LA = 0.209 (L^2+W^2) + 0.25 (Bazaza et al., 2011). Leaf size was determined by measuring the length and width of 10 leaves that were fully developed per plant, using a ruler;
vii. Fresh and dry mass of roots: The tagged plants were used to determine the fresh and dry mass of basil roots. The fresh mass of roots was measured using an electronic beam balance. The roots were oven-dried at 72°C until constant mass using an oven (Biochrom LTD, Leeds, England). After 72 hours the plants were then reweighed to get the dry mass.
viii. Fresh and dry mass weight of basil plants: The tagged plants were used to determine the fresh and dry mass of basil plants. The fresh mass of basil plants was measured using an electronic beam balance. The plants were oven-dried at 72°C until constant mass using an oven (Biochrom LTD, Leeds, England). After 72 hours the plants were then reweighed to get the dry mass.
ix. Fresh and dry mass of basil leaves of: the tagged plants were used to determine the fresh and dry mass. The fresh mass of basil leaves was measured using an electronic beam balance. The leaves were then oven-dried using an oven (Biochrom LTD, Leeds, England) at 72°C for 72 hours (3 days) until constant mass.
x. Mineral determination: Basil leaves were harvested per plot and transported to the Chemistry Laboratory for leaf nutrient content analysis (Figure 1). The samples were oven-dried for 72 hours at 100°C using an oven (Biochrom LTD, Leeds, England) then oven-dry mass was measured using a scale in grams. Thereafter, samples of leaves and stems were ground in a mill fitted with stainless steel knives and a 42 mm screen. A modification of the method outlined by Thomas et al. (1967) was used for the digestion of plant tissues Potassium was measured by flame photometry using Jenway flame photometer. Minerals, Fe, Mn, Zn, Cu, Mg and Ca were determined following the procedure of Baker and Amacher (1982). Duplicate 0.25 g samples of each tissue were weighed into digesting tubes. Five ml of the concentrated sulphuric acid (H_2SO_4) was added into the digestion tubes and then placed onto a hot plate for an hour to digest. After that, the content in the tubes was slightly cooled and five to six drops of hydrogen peroxide (reagent grade) were added. The tubes were heated on a hot plate for five minutes. The hydrogen peroxide was added at intervals of five minutes and continuously heated till the contents were clear. Upon clearing a final hydrogen peroxide addition was made again and the contents heated up for a further 30 minutes. The tubes were allowed to cool and the solutions were transferred to 100 ml volumetric flasks and topped up to volume with distilled water. The samples were taken for analysis using Atomic Absorption Spectrophotometry using a VarianTechtron Atomic Absorption Spectrophotometer (Model AA 200).

Data analysis

The data collected were subjected to analysis of variance (ANOVA), using the GENSTAT statistical package (Payne, 2009). Mean separation was performed where significant differences were detected using the Least Significance Differences (LSD) test

Figure 1. Testing for K and other nutrients in basil leaves, Chemistry laboratory, University of Eswatini.

(Gomez and Gomez, 1984) at a 5% probability level.

RESULTS

Soil and manure characteristics

Basic properties of the garden soil, kraal manure, chicken manure and compost used in the study

The soil used in the study was slightly acidic with a pH of 5.5. Kraal manure had the highest pH of 8.01, followed by chicken manure (7.45) and compost had the least pH (5.5). Table 2 shows that chicken manure had the highest amounts of both macro and micronutrients.

Temperature during the months of the study

The temperature was relatively high in all the months during the study (Table 3). December had the highest maximum temperature of 37°C and February with the least maximum temperature of 34°C. The minimum temperature (15°C) was experienced in February.

Table 2. Chemical properties of kraal manure, chicken, compost and garden soil.

Type of organic fertiliser	pH	Nutrient (cmol/kg)								µg/kg
		Ca	Mg	K	Mn	Cd	Zn	Cu	Fe	P
Kraal manure	8.01	0.80	4.73	7.9	0.13	0.00	0.23	0.02	0.54	0.03
Chicken manure	7.45	1.4	5.19	9.3	0.17	0.01	0.19	0.03	1.64	1.8
Compost	6.3	0.54	0.9	1.6	0.05	0.02	0.17	0.01	0.27	1.4
Garden soil	5.5	1.48	1.24	0.54						48.05

Table 3. Temperatures experienced during the period of the study.

Temperature	December 2019	January 2020	February 2020
Maximum Temp (°C)	37	35	34
Minimum Temp (°C)	16	19	15

Vegetative growth

Plant height

There were no significant (P > 0.05) differences in plant height among the plants supplied with the different organic manures at 2 WAT. However, significant (P < 0.05) differences were observed at 3, 4, 5 and 6 WAT (Figure 2). The highest plant height (71.2 cm) was observed at 6 WAT, which was obtained from plants supplied with kraal manure. This was followed by 67 cm which was obtained from plants supplied with chicken manure. The lowest plant height (62.3 cm) was from plants supplied with compost manure (Figure 2). The plants are shown in the field (Figure 3).

Number of leaves

The average number of leaves per plant was significantly (P < 0.05) different among treatments. The highest number of leaves (134.2) was from plants supplied with chicken manure at 6 WAT (Figure 4). The lowest number of leaves was from plants supplied with compost (98.2).

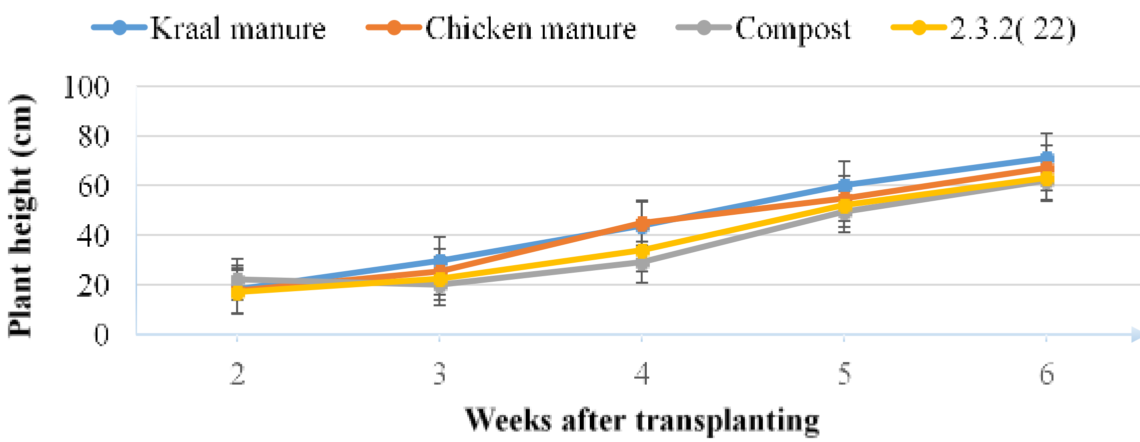

Figure 2. The effects of organic fertilisers on plant height of basil. Vertical bars represent standard error (SE) below and above the mean.

Figure 3. Basil plants showing growth under the application of different types of fertilizers.

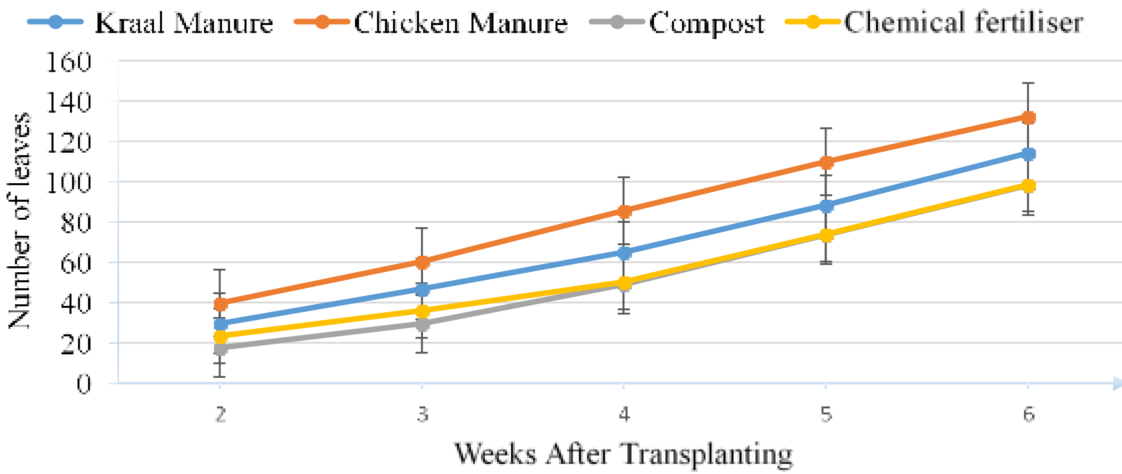

Figure 4. The effects of organic fertilisers on the number of basil leaves. Vertical bars represent standard error (SE) below and above the mean.

Number of branches

The average number of branches per plant was significantly (P< 0.05) different among treatments. The highest number of branches (78.6) was from plants supplied with chicken manure at 6 WAT. The lowest number of branches (54.5) was from plants supplied with compost at 6 WAT (Figure 5).

Leaf chlorophyll content

There were no significant (P>0.05) differences in leaf chlorophyll content among the plants supplied with the different organic manures at 4, 5 and 6 WAT. However, significant (P<0.05) differences were observed at 2 and 3 WAT (Figure 6). The highest chlorophyll content 68.2 CCI at 2 WAT was from leaves of plants supplied with chicken manure (Figure 6). The lowest chlorophyll content 40.7 CCI was obtained from leaves of plants supplied with chemical fertiliser at 6 WAT.

Leaf area

Significant (P < 0.05) differences in leaf area of plants provided with the different organic manures were observed among the treatments. The highest leaf area (30.2 cm$^{2)}$ was obtained from plants supplied with chicken manure at 6 WAT (Figure 7). The lowest leaf area (23.3 cm$^{2)}$ was obtained from plants supplied with compost at 6 WAT.

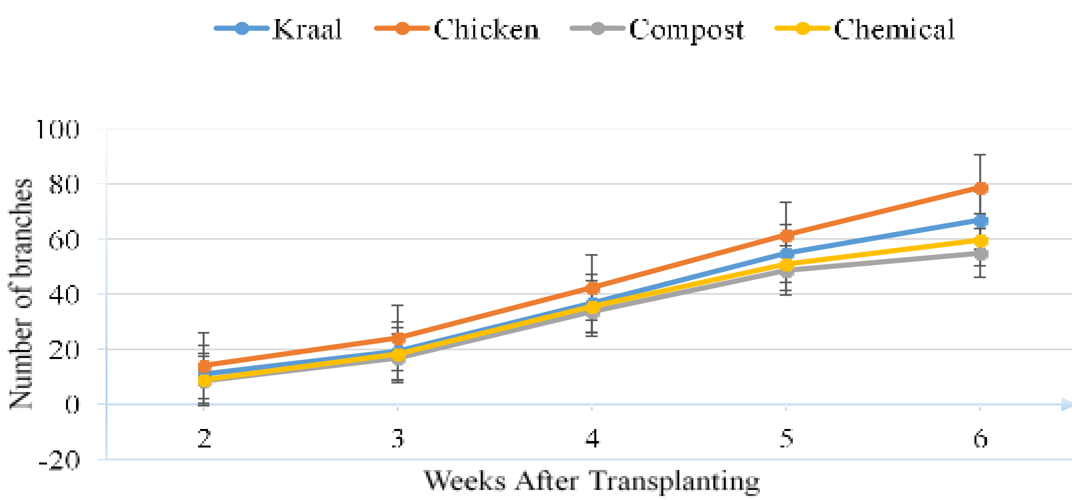

Figure 5. The effects of organic fertilisers on the number of basil branches. Vertical bars represent standard error (SE) below and above the mean.

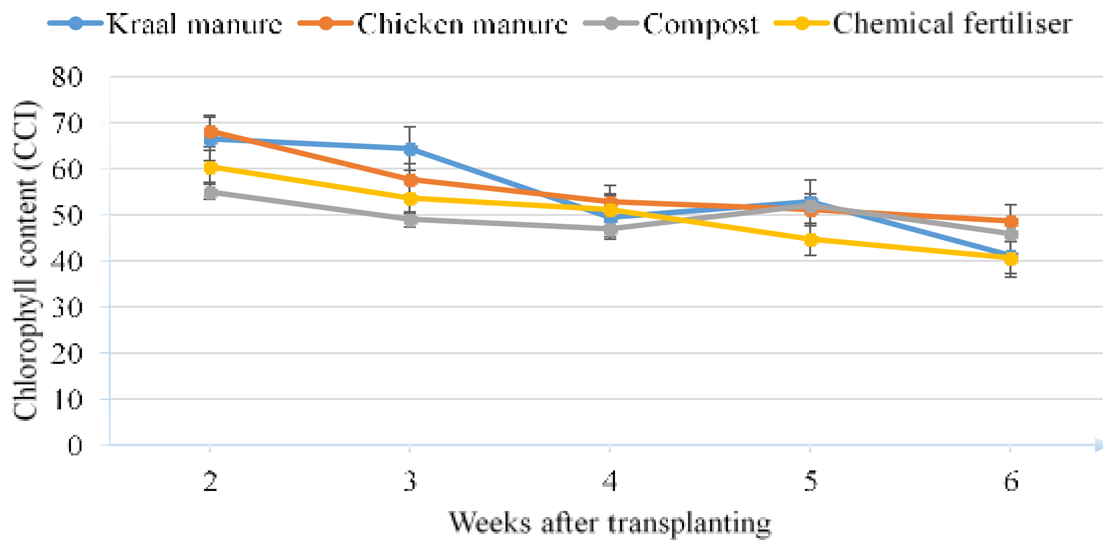

Figure 6. The effects of organic fertilisers on leaf chlorophyll content of basil. Vertical bars represent standard error (SE) below and above the mean.

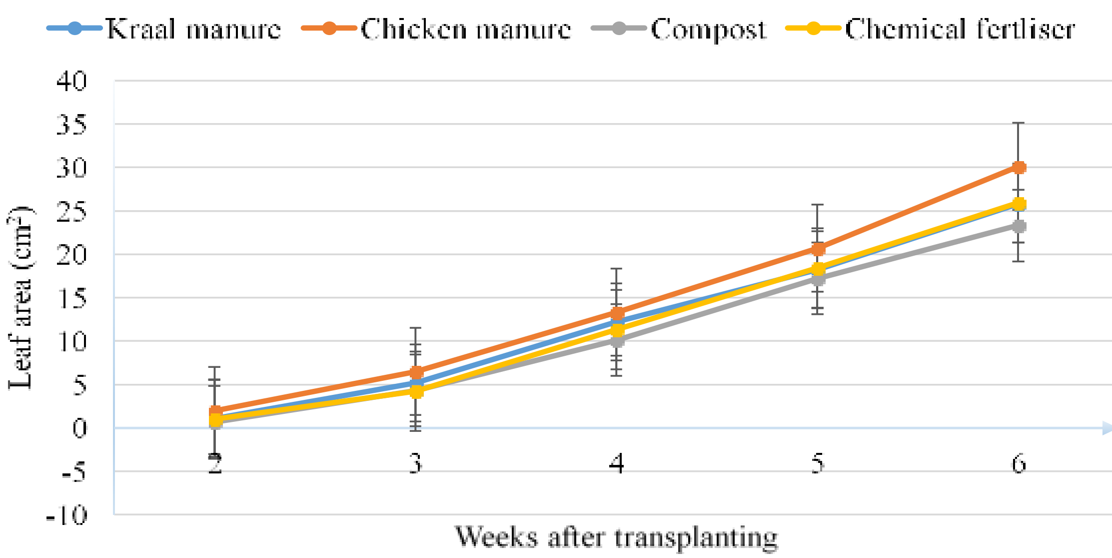

Figure 7. The effects of organic fertilisers on leaf area of basil. Vertical bars represent standard error (SE) below and above the mean.

Yield

Fresh and dry mass of basil plant

There were significant ($P < 0.05$) differences in the fresh mass of basil plants among the different treatments (Figure 8). The highest fresh (691.0 g) mass at 6 WAT was obtained from plants supplied with chicken manure, followed by plants supplied with kraal manure. The lowest fresh mass (477.0 g) was obtained from plants supplied with compost manure at 6 WAT. There were significant ($P < 0.05$) differences in the dry mass of basil plants among the different treatments. The highest dry mass (171.3 g) was obtained from plants supplied with chicken manure, followed by plants supplied with kraal manure. The lowest dry mass (79.4 g) was obtained from plants supplied with compost at 6 WAT (Figure 8).

Fresh and dry leaf mass

Significant ($P < 0.05$) differences in fresh leaf mass of plants provided with the different organic manures were observed among the treatments (Figure 9). The highest

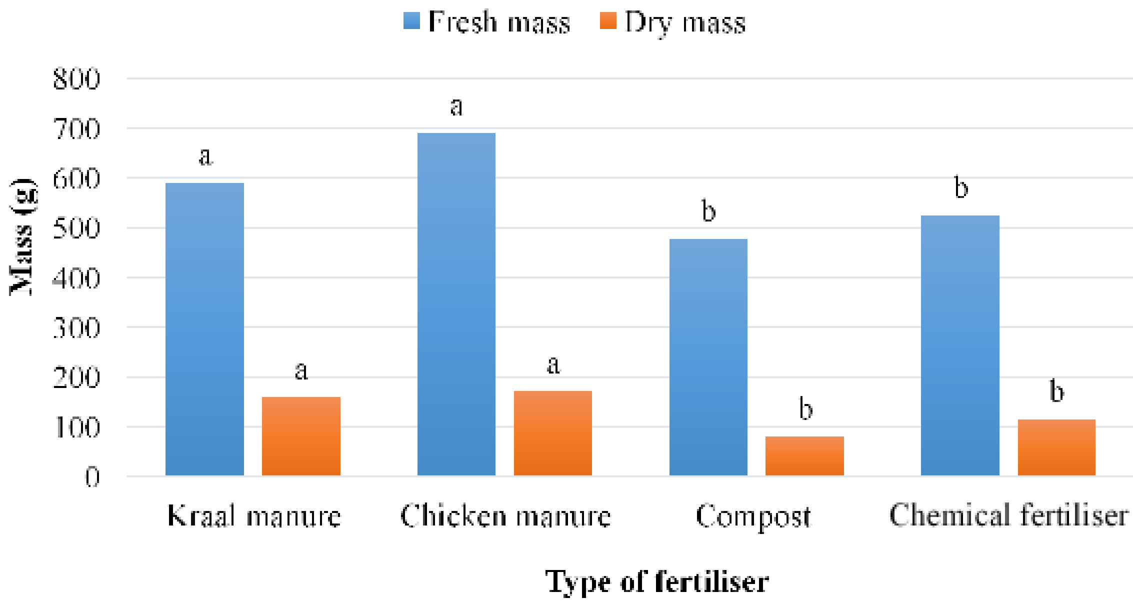

Figure 8. Effects of different types of fertilisers on the fresh and dry mass of basil plants. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

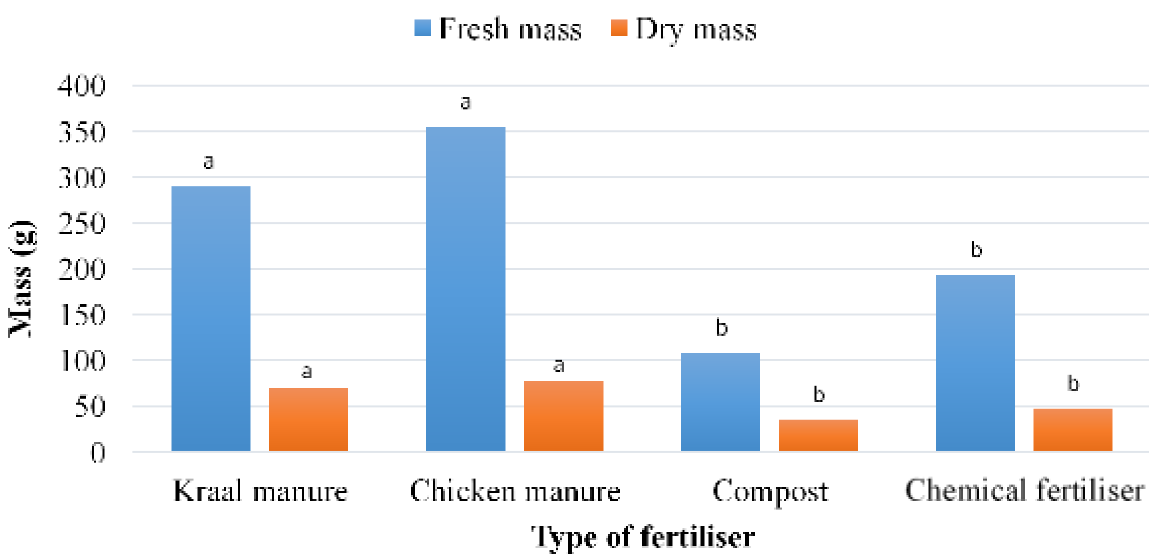

Figure 9. Effects of different types of fertilisers on the fresh and dry mass of basil leaves. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

fresh leaf mass (355.0 g) was obtained from plants supplied with chicken manure. The lowest fresh leaf mass (108.0 g) was obtained from plants supplied with compost. The dry mass of basil leaves also showed significant ($P < 0.05$) differences among the treatments (Figure 9). The highest dry mass (77.3 g) at 6 WAT was obtained from plants provided with chicken manure, while the lowest dry mass (47.1 g) was obtained from plants provided with compost.

Fresh root and dry mass

There were no significant ($P > 0.05$) differences in fresh root mass of basil plants among the different treatments (Figure 10). The highest fresh root mass (13.6 g) at 6 WAT was obtained from plants supplied with kraal manure, followed by plants supplied with chicken manure. The lowest fresh mass (8.25 g) was obtained from plants supplied with compost. There were also no

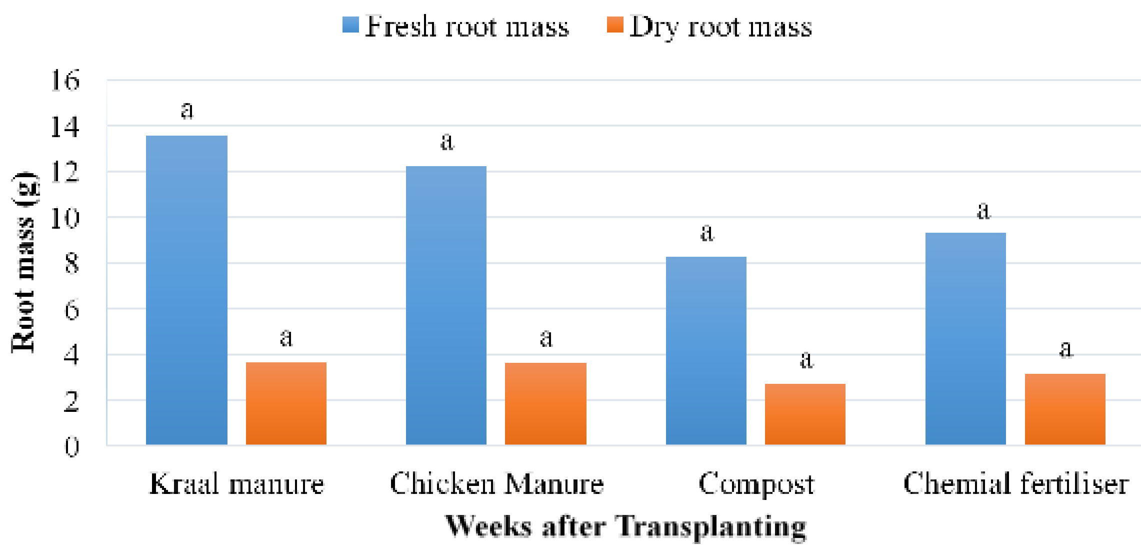

Figure 10. The effects of organic fertilisers on the fresh and dry weight of basil roots. Bars followed by the same letter are not significantly different.

significant differences (p > 0.05) in the dry root mass of basil plants among the different treatments (Figure 10). The highest root mass (3.65 g) was obtained from plants supplied with kraal, followed by plants supplied with chicken manure. The lowest dry mass (2.7 g) was obtained from plants supplied with compost.

Stem fresh and dry mass

There were significant (P < 0.05) differences in fresh stem mass of basil stem among the different treatments (Figure 11). The highest fresh stem mass (416.1g) was obtained from plants supplied with kraal manure, followed by plants supplied with chicken manure. The lowest fresh mass (178.1 g) was obtained from plants supplied with compost. There were also significant (p < 0.05) differences in the dry mass of basil plants among the different treatments (Figure 11). The highest stem mass (87.2 g) was obtained from plants supplied with kraal manure, followed by plants supplied with chicken manure. The lowest dry mass (41.5 g) was obtained from plants supplied with compost.

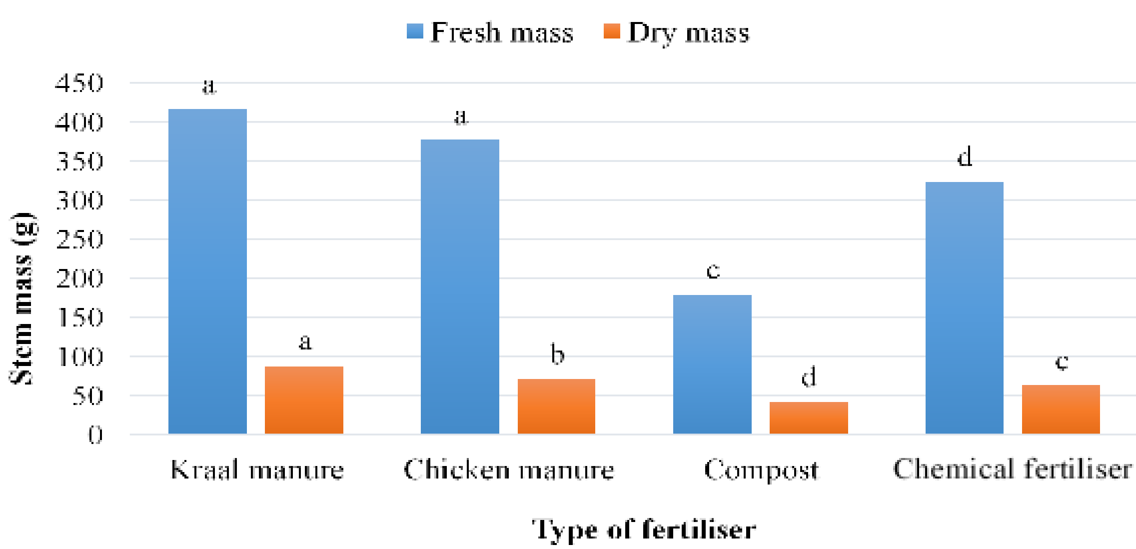

Figure 11. The effects of organic fertilisers on the fresh and dry weight of basil stem. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

Reproductive growth

Number of flowers

There were significant (P < 0.05) differences in the number of flowers on plants among the different treatments of organic manures. The highest number of flowers (66.8) at 5 WAT was obtained from plants supplied with chicken manure. The lowest number of flowers (16.8) was obtained from plants supplied with compost (Figure 12).

Mineral content

Calcium content

There were significant (P < 0.05) differences in the content of Calcium (Ca) among the different treatments (Figure 13). The highest Ca content (3.17%) was obtained from plants supplied with chicken manure. The lowest Ca content (1.82%) was obtained from plants supplied with compost.

Potassium content

There were no significant (P > 0.05) differences in the content of potassium (K) among the different treatments (Figure 14). However, the highest K content (3.04%) was obtained from plants supplied with chicken manure. The lowest K content (1.81%) was obtained from plants supplied with compost.

Phosphorus content

There were no significant (P > 0.05) differences in the phosphorus (P) content of basil leaves between the different fertilisers (Figure 15). Plants provided with chemical fertilisers had the highest content of P (0.79%), followed by those provided with chicken manure. The lowest P content (0.65%) was obtained from plants provided with compost.

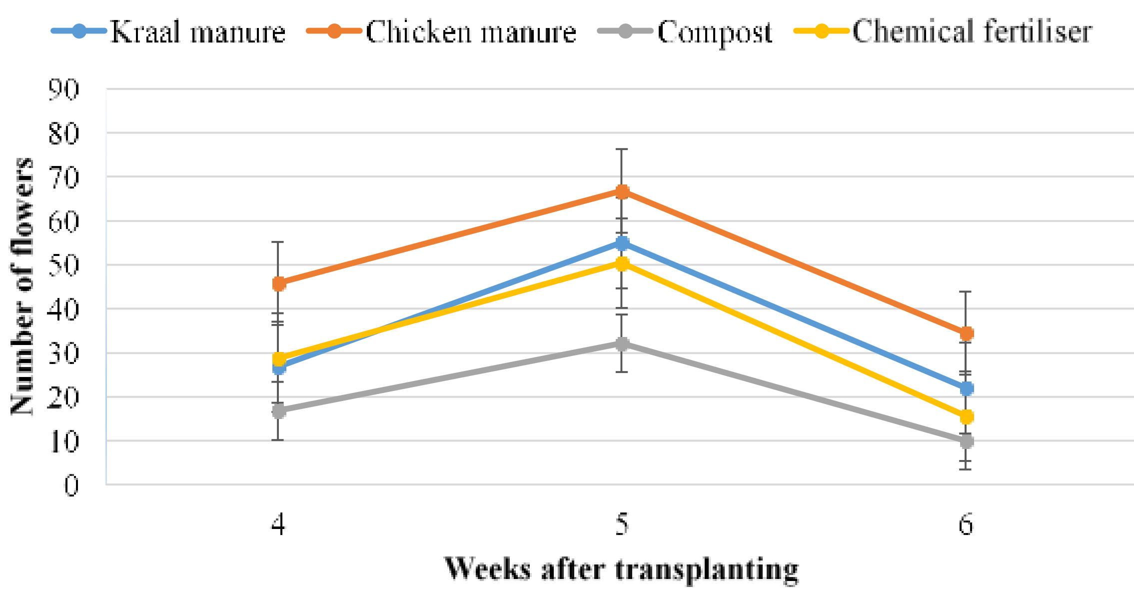

Figure 12. The effects of organic fertilisers on the number of sweet basil flowers. Vertical bars represent standard error (SE) below and above the mean.

Magnesium content

There were significant (P < 0.05) differences in the content of magnesium (Mg) among the different treatments (Figure 16). The highest Mg content (0.79%) was obtained from plants supplied with chemical fertiliser while the lowest Mg content (0.5%) was obtained from plants supplied with compost.

Iron content

There were significant (P < 0.05) differences in the content of iron (Fe) among the different treatments (Figure 17). The highest Fe content (179.5 mg/kg) was obtained from plants provided with chicken manure followed by plants supplied with kraal manure. The lowest Fe content (154.5 mg/kg) was obtained from plants

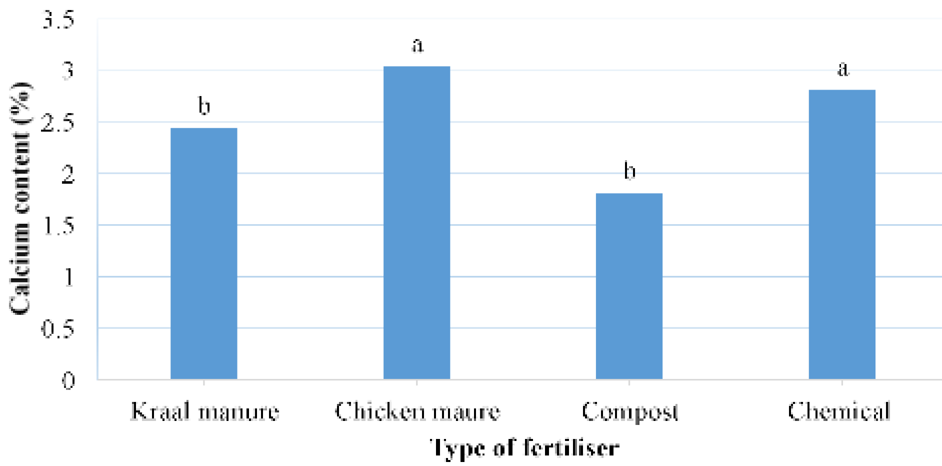

Figure 13. Effects of organic fertilisers on calcium content of basil leaves. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

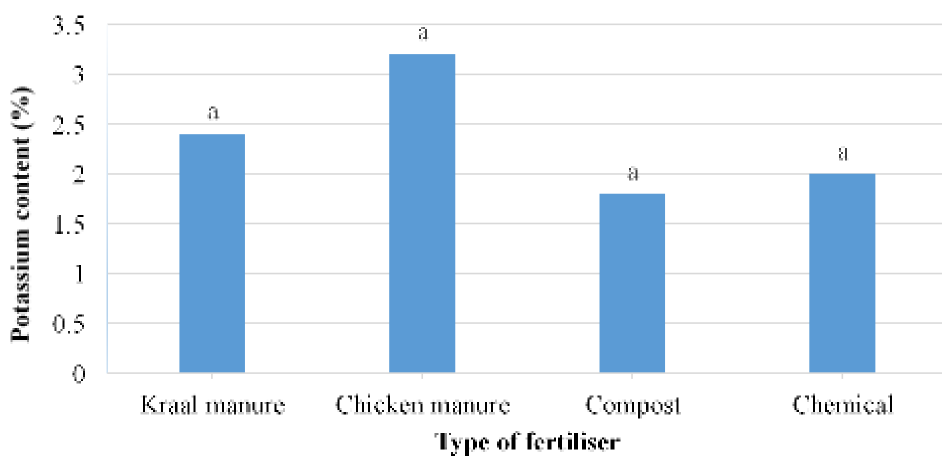

Figure 14. The effects of organic fertilisers on K content of basil leaves. Bars followed by the same letter are not significantly different.

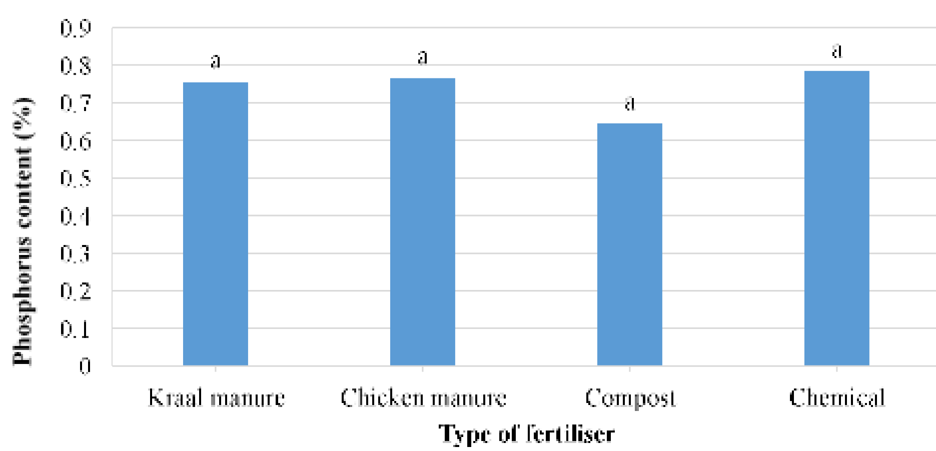

Figure 15. The effects of organic fertilisers on P content of basil leaves. Bars followed by the same letter are not significantly different.

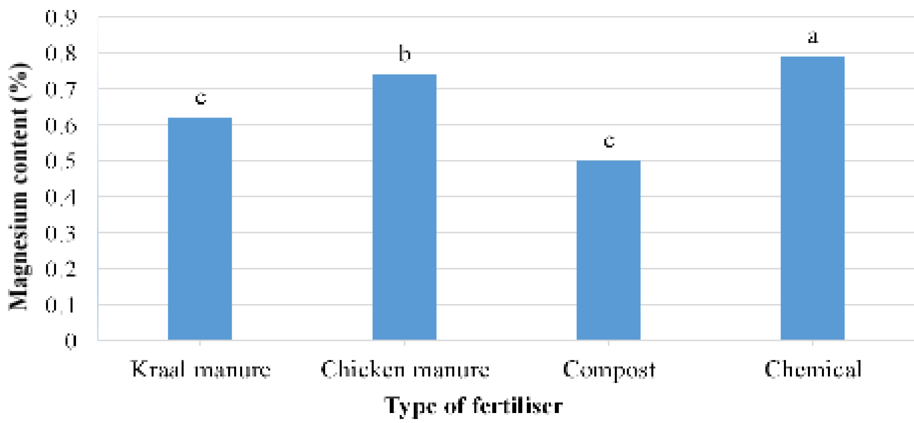

Figure 16. The effects of organic fertilisers on Mg content of basil leaves. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

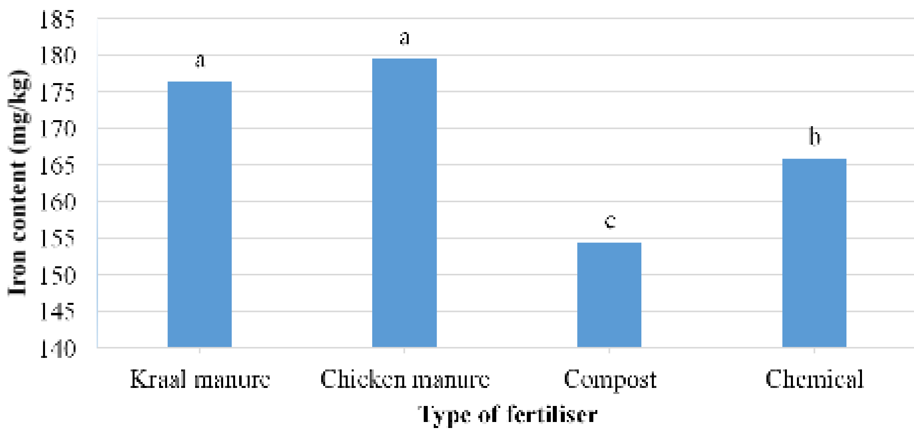

Figure 17. The effects of organic fertilisers on Fe content of basil leaves. Bars followed by the same letter are not significantly different. Mean separation by LSD at 5% probability level.

provided with compost.

Zinc content

There were no significant ($P > 0.05$) differences in the zinc (Zn) content of basil leaves among the different fertilisers (Figure 18). The highest Zn content (48.12 mg/kg) was obtained from plants provided with kraal manure, followed by plants provided with chicken manure. The lowest Zn content (42.83 mg/kg) was obtained from plants provided with compost.

Manganese content

There were no significant ($P > 0.05$) differences in the content of manganese (Mn) among the different treatments (Figure 19). The highest Mn content (52.3 mg/kg) was obtained from plants provided with chicken manure, followed by plants provided with kraal manure. The lowest Mn content (49.1 mg/kg) was obtained from plants provided with chemical fertiliser.

Copper content

There were no significant ($P > 0.05$) differences in the copper (Cu) content of basil leaves between the different fertilisers (Figure 20). The highest Cu content (18.69 mg/kg) was obtained from plants provided with chicken manure, followed by plants provided with kraal manure. The lowest Cu content (17.61 mg/kg) was obtained from plants provided with chemical fertiliser.

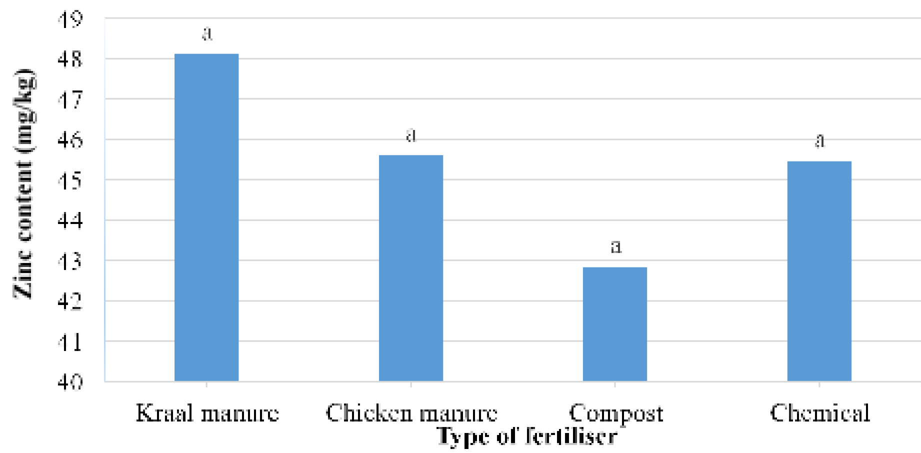

Figure 18. The effects of organic fertilisers on Zn content of basil leaves. Bars followed by the same letter are not significantly different.

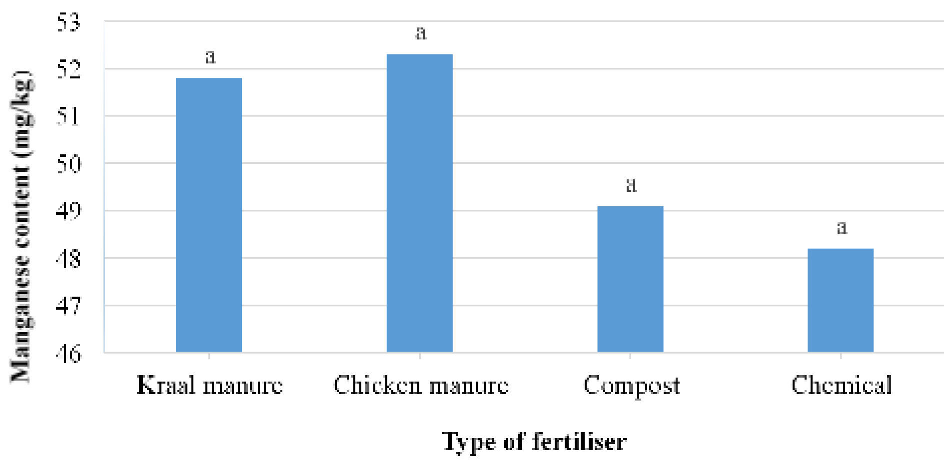

Figure 19. The effects of organic fertilisers on Mn content of basil leaves. Bars followed by the same letter are not significantly different.

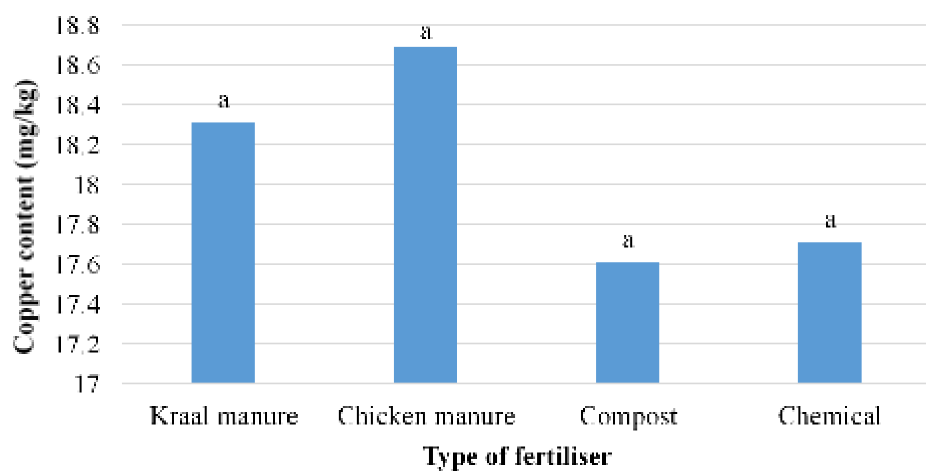

Figure 20. The effects of organic fertilisers on Cu content of basil leaves. Bars followed by the same letter are not significantly different.

DISCUSSION

Different types of organic fertilizers and chemical fertilizers had varying effects on the growth, yield and mineral content of basil. From this study, plants that were supplied with chicken manure exhibited higher growth and yield parameters. This is in agreement with Opara and Asiegbu (1996), who observed that chicken manure increased the yield of eggplant fruit. Cooperband (2002) reported that the positive influence of chicken manure on the growth of the crop was due to the release of the balanced nutrients contained in the organic matter. This also could be attributed to the large quantities of available phosphorus and potassium in the chicken manure. Studies have shown that chicken manure contains many plant nutrients and has been proven to be an effective fertilizer for vegetables with the added potential of improving soil and physical characteristics.

Gopal (1977) reported that among the organic sources of nutrients, chicken 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 analytic values. It has been experimentally proven that a considerable amount of N present in chicken manure consists of uric acid, which is readily available to plants. The C:N ratio of chicken manure was 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 maintains the optimum conditions for micro-organism activity, poultry manure, therefore, gave better results.

Xu et al. (2005) conducted a study on the yield and quality of leafy vegetables grown with organic fertilisers and the results showed that vegetables grown with organic fertilisers grew better and resulted in higher yield than those supplied with chemical fertilisers. This study also proved that basil grown with organic fertilisers resulted in high growth and yield than those grown with chemical fertilisers.

The highest leaf number, number of branches and leaf area were recorded in plants that were supplied with chicken manure, which were significantly different from those supplied with kraal manure. From the chemical analysis, chicken manure showed to have more nutrients than the other organic fertilizers and thus the differences. The lowest plant height, number of leaves, number of branches and leaf area and nutritional contents were obtained from plants supplied with compost.

The differences may also be due to the availability of nutrients as affected by the water holding capacity of the soil. Increased vegetable yield with the use of organic manure has been previously reported for okra (Ogunlela et al., 2005).

Sweet basil plants applied with chicken manure exhibited a relatively higher yield and fresh mass of plants than those that received the other kinds of fertilizers. The study also revealed that chemical fertilisers performed inferiorly as compared to chicken manure in the production of sweet basil. This can be attributed to the lower ability in retention of moisture that is exhibited by the inorganic fertilisers. It has been reported that inorganic fertilisers do not have good characteristics in aggregating soil particles. As a result, the plants supplied with inorganic fertilizer produced a relatively lower yield than those supplied with chicken manure. In studies on the yield and quality of leafy vegetables grown with organic fertilisers, it was shown that vegetables grown with organic fertilisers grew better and resulted in a higher total yield than those grown with chemical fertilisers (Ghanbarian et al., 2008).

The highest dry mass of plants was obtained from basil supplied with chicken manure at 40 t/ha. Similar results were reported by Masarirambi et al (2010), who obtained higher dry mass in lettuce plants amended with organic fertilizers as compared to synthetic fertilisers. Mbatha (2008) also reported that the dry mass of cabbage treated with compost was significantly lower than that treated with chicken manure.

The application of kraal manure had a positive effect on the plant height of basil. According to Xiao et al (2006), soil treated with kraal manure was found to be loose, which probably provided adequate aeration and moisture into the soil and improved soil microbial activities which resulted in higher growth and higher root yield. The highest fresh root mass was obtained from plants supplied with kraal manure while compost recorded the lowest. Similar results were reported by Ayeni and Oye (2017) who reported that the highest fresh root weights were shown in goat and cow dung manure treatments in a study on *Corchorus olitorius*.

Plants amended with kraal manure resulted in a relatively higher stem mass. These results are in agreement with the findings of several researchers, who revealed that organic manuring increased vegetative growth and biomass production effectively (Dinesh et al., 2010). Moreover, it has been found that increment of application of organic manure increased the growth, dry matter accumulation, yield and quality of plants. According to Detpiratmongkok et al. (2014), the stem dry weight of kalmega was higher in plants applied with kraal manure as compared to those applied with compost manure.

The type of fertiliser used resulted in effects on the mineral composition of basil leaves. There was relatively higher Ca, Fe, K, Mn and Cu contents in basil leaves amended with chicken manure. This can be attributed to the balanced quantity of nutrients in the chicken manure. Magkos et al (2003) reported that although a limited number of studies have been published, slightly higher contents of minerals have been obtained in organic vegetables. Most of the evidence, however, revealed no significant difference between organic and inorganically grown vegetables. Chemical fertiliser showed to have a high content of Mg and P. Kraal manure treatment plants on the other hand had relatively higher contents Zn. This could be attributed to the high quantity of zinc content in the kraal manure hence the results.

Conclusion

The results of the study indicated that the highest growth and yield of basil was obtained by using eco-friendly organic fertilisers than chemical fertiliser. It was revealed in this study that organic fertilisers like chicken and kraal manure improved the growth performance of basil but to varying degrees. Chemical fertiliser application resulted in a lower yield compared to chicken and kraal manure in the production of sweet basil. However, the chemical fertiliser performed much better than compost in most cases. Compost is not the best organic fertiliser to use in the production of basil.

RECOMMENDATIONS

Based on the findings of the study, it is recommended that farmers who wish to start a basil production enterprise should use organic fertilisers like chicken and kraal manure since they resulted in relatively higher vegetative growth, yields and mineral contents. It is recommended that similar research should also be carried out in the other agro-ecological zones of Eswatini. It is also recommended that other types of organic fertilisers should be tried to find out which one is the best in the organic production of sweet basil.

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