The effects of chicken manure application rates on growth, yield and quality of Swiss chard (*Beta vulgaris* var. *cicla* L.)

ABSTRACT

Swiss chard (*Beta vulgaris* var. *cicla*) is a leafy vegetable that belongs to the *Chenopodiaceae* family. Only the fresh young leaves can be used raw in salads as the mature leaves are bitter. Over the years, Swazis have adopted the use of inorganic fertilisers as they are easy to apply and come with recommended application rates. However, their main drawback is that they are environmentally unfriendly especially when washed to river streams and other water bodies. For this cause, the use of animal manures has been promoted. The experiment was conducted at the Horticulture Department Farm, Faculty of Agriculture and Consumer Sciences, Luyengo Campus of the University of Swaziland to determine the effects of chicken manure application rates on growth, yield and quality of Swiss chard. Four chicken manure application rates (10, 20, 40 and 80 t/ha) and a recommended 900kg/ha, inorganic basal fertiliser with a 125kg/ha LAN top dressing fertiliser was used as a control. A Randomised Complete Block Design (RCBD) with four replicates was used. The study showed that the application of 80 t/ha of chicken manure improved the growth and yield of spinach. It is recommended that farmers may use 80 t/ha of chicken manure because it gave the best results compared to the other treatments.

1.0. INTRODUCTION

Swiss chard is leafy vegetable that belongs to the *Chenopodiaceae* family and is scientifically known as *Beta vulgaris var*. *cicla.* It belongs to the same family as beetroot and mangel-wurzel. Unlike beetroot and mangel-wurzel, Swiss chard lacks the large bulbous tape root. It is one of the most nutritious vegetable crops in the world. Swiss chard may be grown in Swaziland all year round, in all the ecological zones.

Swiss chard forms part of the several leafy green vegetables that are known as 'greens.' It is a biennial plant with large dark leaves. The leaves are large, glossy and crispy and can grow to 37 cm long and 25 cm wide (Pierce, 1987). Stalks of Swiss chard come in a variety of colours depending on the cultivar, they are usually white, yellow, orange or red (Hadfield, 1960). The first records of cultivation place the origin of Swiss chard in the Mediterranean region particularly Italy and was first written about by the Greek philosopher Aristotle in 4 B.C (Pierce, 1987).

Swiss chard is a short day (SD) plant with critical day length of 12 hours. It grows best at temperatures ranging from 7 to 24 ºC. Swiss chard can withstand light frosts but an extended exposure to temperatures less than 5ºC induces bolting. In hot weather, the leaves remain small and are of inferior quality (Gilbert and Hadfield, 1996).

Leaves of Swiss chard are harvested usually within eight weeks from sowing and once they are in good size (Hadfield, 1960). Harvesting is done continuously so that the leaves do not stay long and lose their colour or become tough.

The use of inorganic fertilisers has resulted in residual toxicities and degradation of the soil structure. These inorganic fertilisers become an environmental threat to aqua life when washed to river streams and other water bodies. They are expensive such that not all farmers afford them. As a result farmers produce Swiss chard below the expected optimum level.

The main objective of this research is to improve the production of Swiss chard and to contribute towards food security and income generation in Swaziland. The specific objective was to determine the optimum level of chicken manure application on growth, yield and quality of Swiss chard.

2.0 MATERIAL AND METHODS

2.1 Experimental site

The experiment was conducted at the Horticulture Department Farm, Faculty of Agriculture and Consumer Sciences, Luyengo Campus of the University of Swaziland. The farm is located at Luyengo, Manzini region, in the Middleveld agro-ecological zone. Luyengo is located at latitude 26°4‟ S and longitude 31°4‟E. The average altitude of this area is 750 m above sea level. The mean annual precipitation is 980 mm with most of rain falling between October and April. Drought hazard is about 40%. The average summer temperature is 27°C and winter temperature is about 15°C. The soils of Luyengo are classified under Malkerns series. They are ferrasolic or merely a ferralitic soil integrated to fersialitic soils or typical ultisols. The soil in the experimental area was a sandy loam (Murdoch, 1970).

2.2 Plant Materials

Four weeks old Swiss chard seedlings were obtained from Greenhouse Seedlings, Ezulwini. They were transplanted on the 4th of February, 2016 in 1.5 x1.5 m plots with an inter and intra row spacing of 45 cm respectively and they were irrigated twice a day during the first week and every second day from the second week until the end of the experiment.

2.3 Experimental Design

Four chicken manure application rates (10, 20, 40 and 80 t/ha) and a recommended 900kg/ha, inorganic basal fertiliser with a 125kg/ha LAN top dressing fertiliser was used as a control (Table 1). A Randomised Complete Block Design (RCBD) with four replicates was used. Each plot had four rows and there were four plants in each row which gave a total of 320 plants used for the experiment.

Table 1: Treatment descriptions.

Treatment code	**Treatment**
1	80 t/ha
2	40 t/ha
3	20 t/ha
4	10 t/ha
5	900 kg of 2:3:2 (22) and 125 kg of LAN (28)

2.4. Soil analysis

Soil chemical properties were analysed at the Soil Chemistry laboratory of the University of Swaziland, Luyengo Campus.

2.5. Manure analysis

Soil chemical properties were analysed at the soil Chemistry laboratory of the University of Swaziland, Luyengo Campus.

2.6. Data collection

Data was collected weekly, from the second week after transplanting. Five plants were randomly selected in each plot for data recording. Data was collected on the following growth parameters: plant height, number of leaves and leaf area while leaf area index was calculated. The fresh mass and dry mass of the Swiss chard were measured after harvesting.

2.7. Growth parameters

2.7.1. Plant height

Five plants were randomly selected per plot and plant height was measured from the base of the plant to the leaf apex (tip).

2.7.2. Number of leaves

The number of leaves per plant was determined by physically counting all the leaves on each selected plant. Five plants were selected per plot and it was done on a weekly basis, which was at week 3, 4, and 5 after transplanting.

2.7.3. Leaf area

The leaf area of the Swiss chard was determined by multiplying the leaf width and leaf length and then multiplying the product by 0.75 (correction factor), it was expressed in cm^2.

2.7.4. Leaf area index

The leaf area index was determined by diving the leaf area in cm^2 by the area occupied by a single plant in cm^2.

2.7.5. Fresh and dry mass

This was determined at the end of the cropping season by weighing the harvested leaves per plot. Five plants per plot were used to determine the fresh and dry mass in this experiment. The plants were randomly selected per plot and their shoot fresh mass was measured using a digital scale balance. They were then oven dried at a temperature of 72°C for 72 hours to determine their shoot dry mass.

2.8. Data analysis

The data collected was subjected to analysis of variance (ANOVA) using MSTAT-C statistical package, Version 1.4 (Nissen, 1989). Where significant differences were detected mean separation were performed using Duncan's New Multiple Range Test (DNMRT) at 5 % probability level (Gomez and Gomez, 1984).

3.0 RESULTS

3.1. Soil analysis

Soil chemical properties were analysed at the Chemistry Laboratory of the University of Swaziland, Luyengo Campus. The results of the soil chemical properties are shown in Table 2.

Table 2: Soil analysis

Soil parameter	Value
Soil pH	5.8
Phosphorus (mgP/kg)	39.56
Potassium (cmolc/kg)	1.54

3.2. Manure analysis

Chemical properties of the chicken manure were analysed at the Chemistry Laboratory of the University of Swaziland, Luyengo Campus. The results of chemical properties of chicken manure are shown in Table 3.

Table 3: Chicken manure analysis

Manure parameter	Value
pH	7.2
Phosphorus	17 mg/kg
Potassium	1 895 mg/kg
Magnesium	-

3.3. Plant height

Plant height of spinach was significantly ($P<0.05$) different among the different treatments. The highest plant height (34.6 cm) was obtained in spinach treated with 80 t/ha of chicken manure while the lowest plant height (26.0 cm) was obtained in spinach plants treated with 10 t/ha of chicken manure (Figure 1). The plant height of spinach plants treated with inorganic fertilizers was higher (28.1 cm) but not significantly ($P>0.05$) different from those treated with 10 t/ha of chicken manure (26.0 cm) (Figure 1).

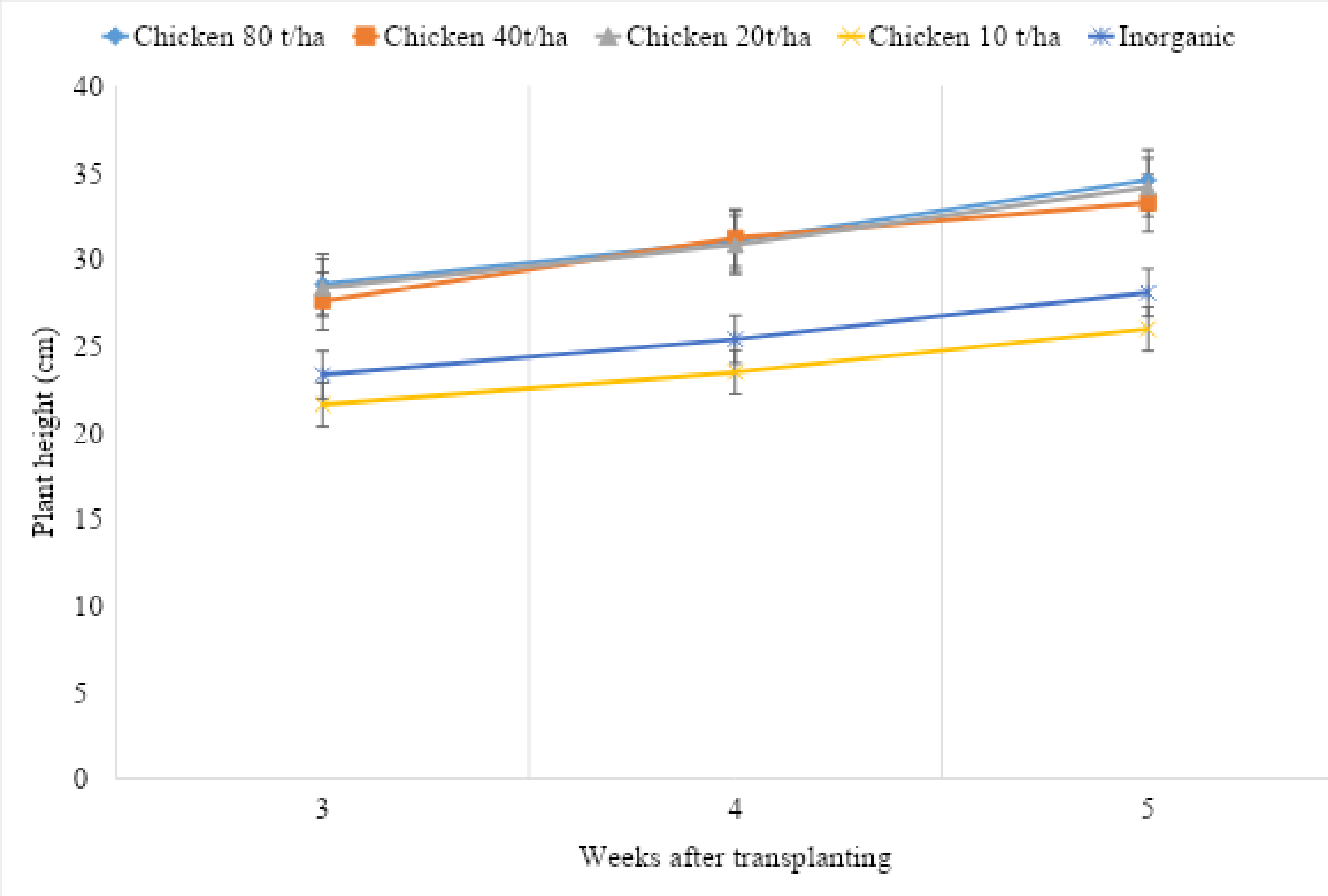

Figure 1: Effects of chicken manure on spinach plant height. Vertical bars are standard error (se) below and above the mean.

3.4. Number of leaves

The number of leaves per plant were not significantly (P>0.05) different among the spinach plants. The highest number of leaves (7.6) was obtained in plants treated with 80 t/ha of chicken manure while the lowest number of leaves (6.4) was obtained in plants treated with 40 t/ha of chicken manure (Figure 2).

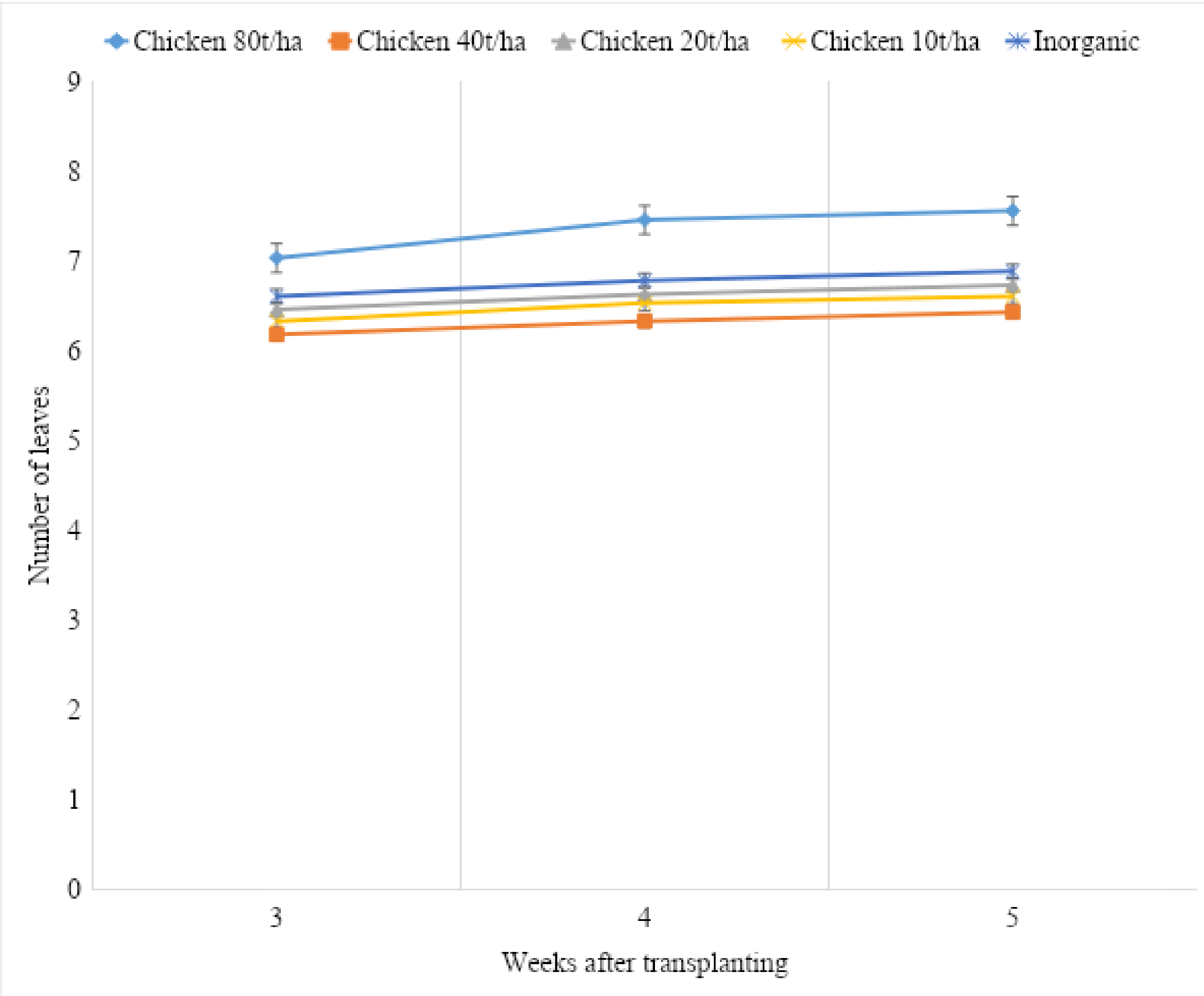

Figure 2: Effects of chicken manure on number of leaves of spinach. Vertical bars are standard error (se) below and above the mean.

3.5. Leaf area

The leaf area was not significantly (P>0.05) different among the spinach plants. The highest leaf area (291.9 cm^2) was obtained in plants treated with 80 t/ha of chicken manure while the lowest leaf area (169.8 cm^2) was obtained in plants treated with 10 t/ha of chicken manure at 5 WAT

(Figure 3). The leaf area of spinach increased with increasing application rates of chicken manure.

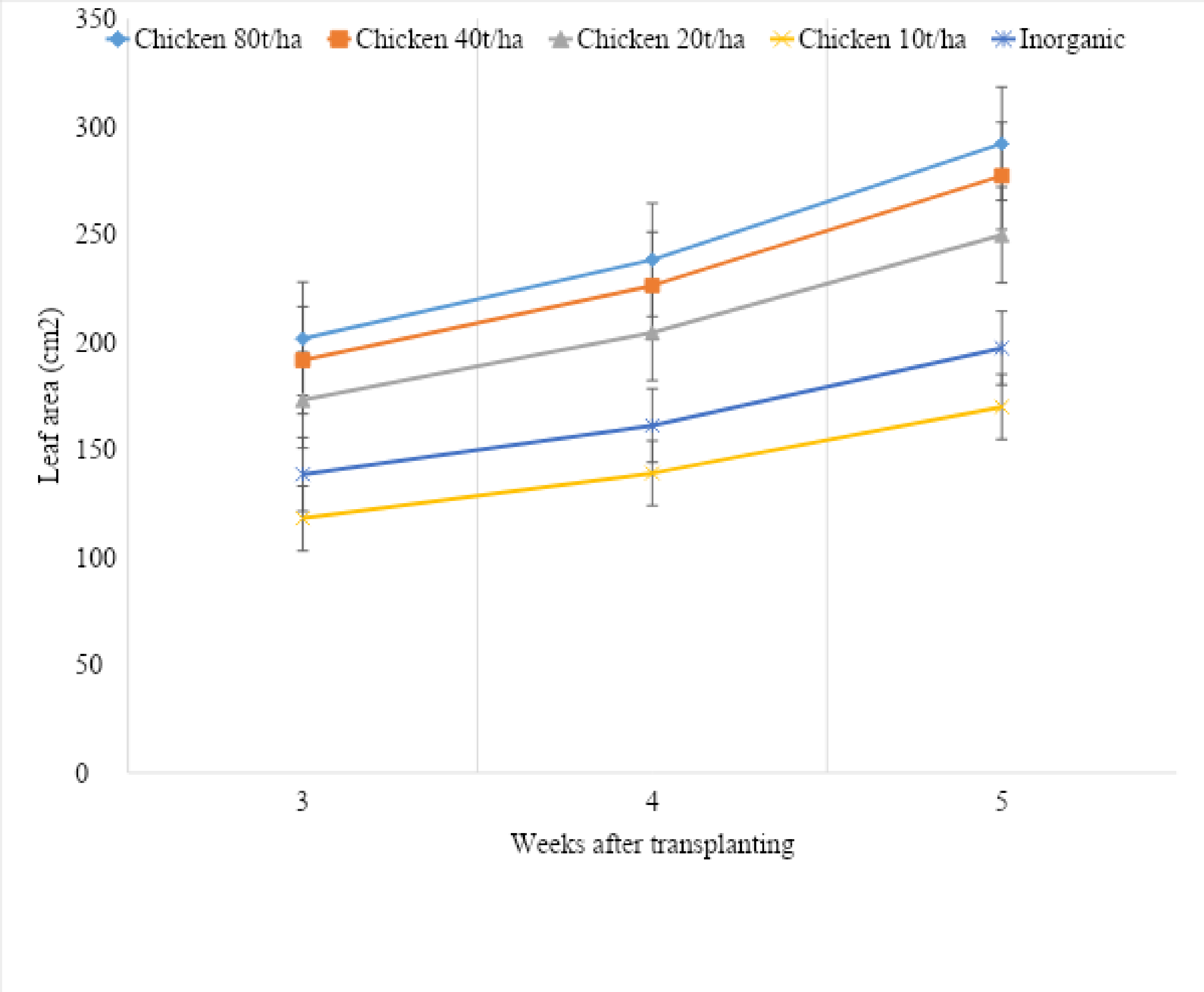

Figure 3: Effects of chicken manure on the leaf area per plant of spinach. Vertical bars are standard error (se) below and above the mean.

3.6. Leaf area index

The leaf area index was not significantly (P>0.05) different among the spinach plants. The highest leaf area index (1.1) was obtained in plants treated with 80 t/ha of chicken manure while the lowest leaf area index (0.5) was obtained in plants treated with 10 t/ha of chicken manure at 5

WAT (Figure 4). The leaf area of spinach increased with increasing application rates of chicken manure.

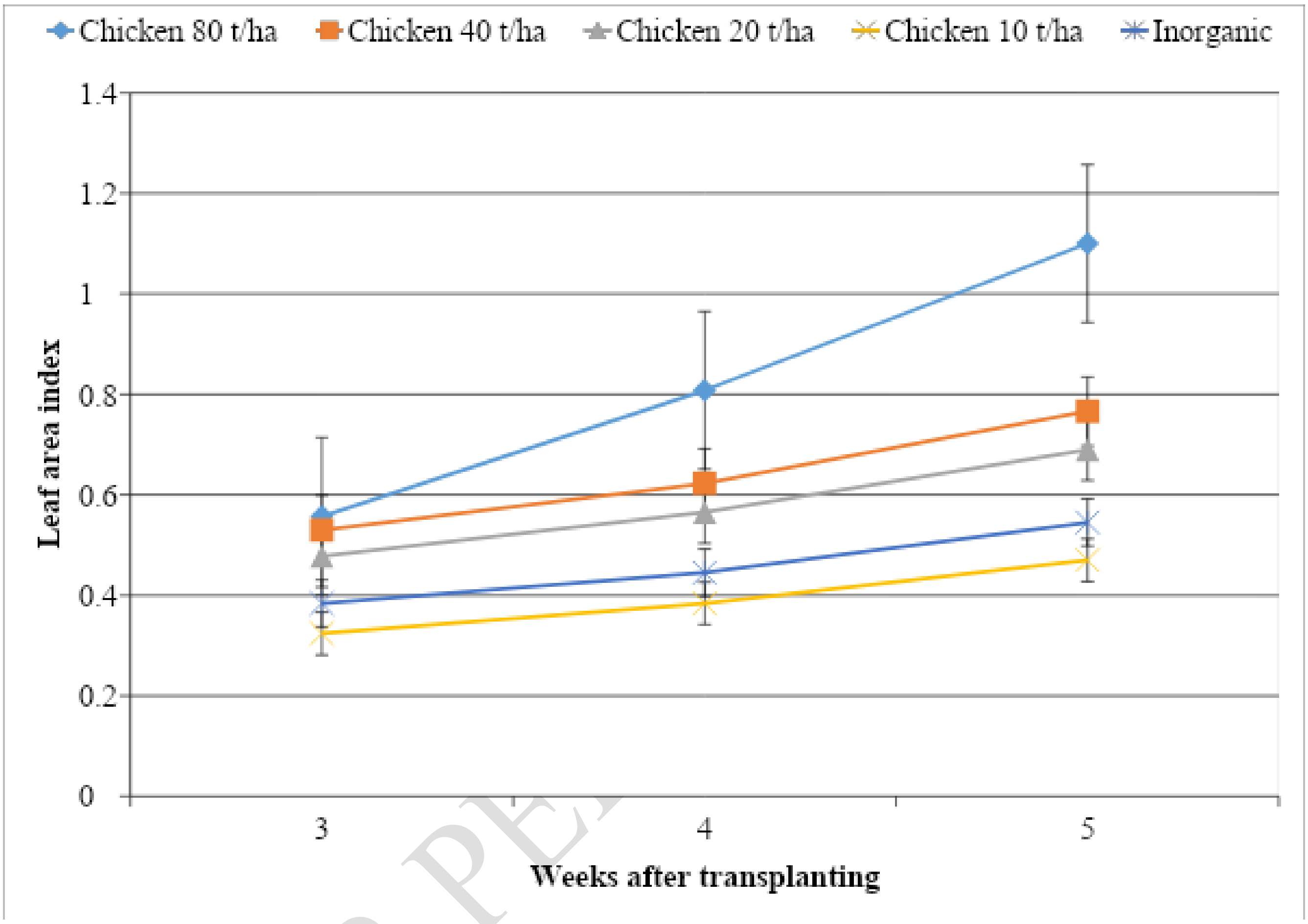

Figure 4: Effects of chicken manure on the leaf area per plant of spinach. Vertical bars are standard error (se) below and above the mean.

3.7. Fresh mass and dry mass

There was a significant ($P<0.05$) difference in the fresh shoot mass of spinach plants (Figure 5). The highest fresh shoot mass (237.5 g) was obtained in plants treated with 80 t/ha of chicken manure while the lowest fresh shoot mass (100.0 g) was obtained in plants fertilised with inorganic fertilisers.

There was a significant (P<0.05) difference in the dry shoot mass of spinach plants in the different fertilisers (Figure 5). The highest dry shoot mass (20.4 g) was achieved at 80 t/ha of chicken manure while the lowest dry shoot mass (10.1 g) was obtained in spinach plants treated with inorganic fertilisers.

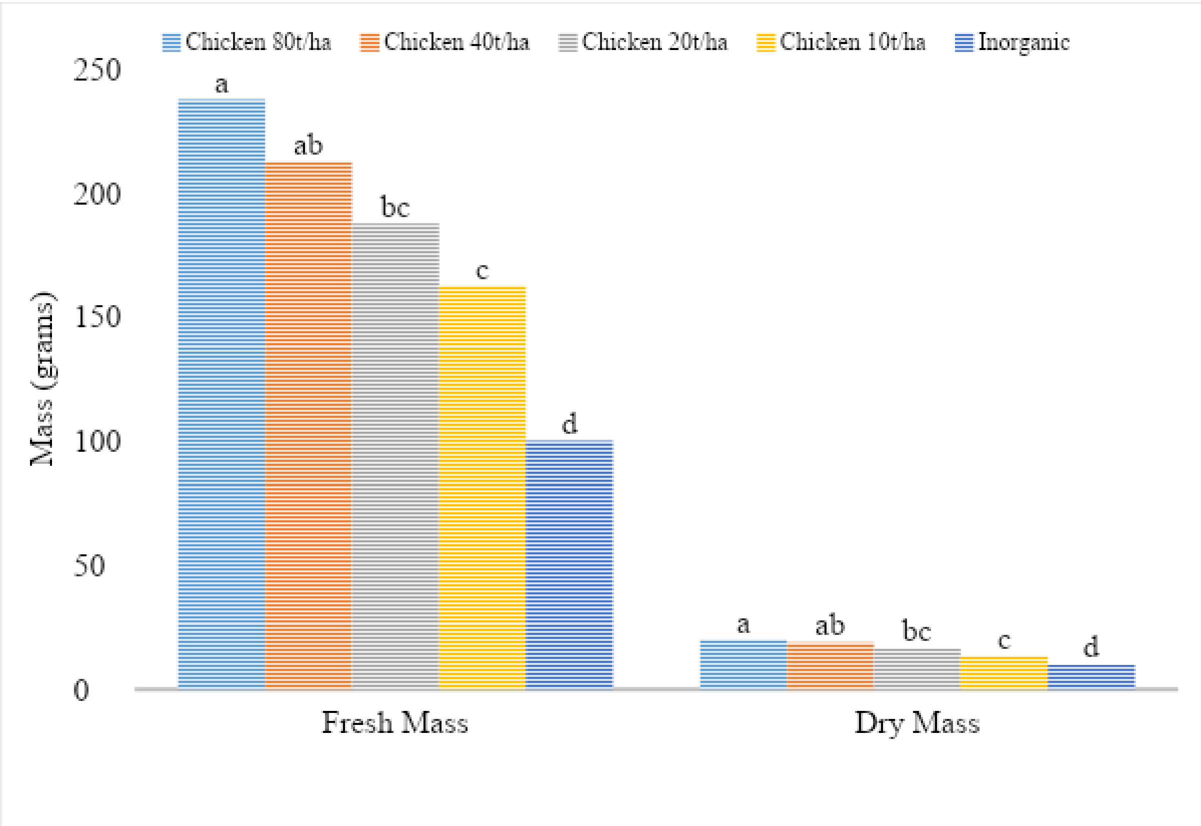

Figure 5: Effects of chicken manures on fresh and dry shoot mass of spinach at week 5 after transplanting. Bars followed by the same alphabet were not significantly different from one another at P = 0.05. Mean separation by Duncan's New Multiple Range Test.

4.0. DISCUSSION

Different application rates of chicken manure had varying effects on growth, yield and quality of spinach. Plants treated with 80 t/ha of chicken manure performed better in terms of growth in comparison with the other treatments. These spinach plants had the highest plant height, number of leaves, fresh shoot mass, dry shoot mass, leaf area and leaf area index compared to spinach treated with 10, 20, 40 t/ha of goat manure and application of inorganic fertilisers recommended for spinach production. Spinach plants treated with 10 t/ha had the lowest plant height, leaf area and leaf area index. Spinach plants treated with 80 t/ha had the highest plant height, number of leaves, leaf area, leaf area index, fresh and dry shoot mass. The highest number of leaves of spinach plants from the highest application rate of chicken manure must have been as a result of relatively high amounts of nitrogen (Lungu and Chirwa, 1993).

It was also noted that plant height, number of leaves, leaf area, leaf area index, fresh and dry shoot mass increased with increasing levels of chicken manure. These results are in agreement with those of Lungu and Chirwa (1993) who studied the effects of an organic fertilizer (cattle manure) on *Zea mays.* As chicken manure application rate was increased, the availability of plant nutrients in the soil also increased. This resulted in the increase of growth and yield.

Chicken manure at 80 t/ha performed better in comparison with inorganic fertilizers. These findings do not deviate much from those obtained by Owen (2008) who reported that synthetic fertilisers do not have good characteristics in aggregating soil particles. The plants treated with inorganic fertilisers gave a lower yield than those treated with 80 t/ha of chicken manure. Animal manures have beneficial effects on physical and chemical properties and therefore have the ability to retain water, supply macro- and trace elements absent in inorganic fertilisers. Increased vegetable yield with the use of manure have been previously reported for okra (Ogunlela *et al*., 2005).

5.0. CONCLUSION AND RECOMMENDATION

The study showed that the application of 80 t/ha of chicken manure improved the growth and yield of spinach. From these findings, it can therefore be concluded that 80 t/ha was best for spinach under the conditions of this study.

It is recommended that farmers may use 80 t/ha of chicken manure because it gave the best results compared to the other treatments.

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