The Effects of Chicken Manure Application Rates on Growth and Yield 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. The leaves are cooked, if still tender they are used in salads. Over the years, Emawati have adopted the use of inorganic fertilizers 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 into rivers, streams and other water bodies. For this cause, the use of animal manures has been promoted. Four-week old Swiss chard seedlings 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 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. 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 900 kg/ha, inorganic basal fertilizer with a 125 kg/ha LAN top dressing fertilizer 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 Swiss chard . It is recommended that farmers may use 80 t/ha of chicken manure because it gave the best results compared to the other treatments. 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 fertilized with inorganic fertilizers.

UNDER PEER REVIEW

1.0. INTRODUCTION

Swiss chard is a 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 Eswatini/ 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 up to 37 cm long and 25 cm wide [1] Stalks of Swiss chard come in a variety of colours depending on the cultivar, they are usually white, yellow, orange or red [2]. 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 [1]. 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 [3. Leaves of Swiss chard are harvested usually within eight weeks from sowing and once they are in good size [2]. Harvesting is done continuously so that the leaves do not stay long and lose their colour or become tough.

UNDER PEER REVIEW

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

Organic fertilizers are an environmentally friendly alternative to inorganic fertilizers. Organic fertilizers are materials that result from natural processes like compost. Organic ferilizers can be derived from animal excreatments like chicken, goat or cattle manure. Organic fertilizers release nutrients relatively slowly and are known to improve soil structure.

The main objective of this study was to improve the production of Swiss chard and to contribute towards food security and income generation in Eswatini/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 the rain falling between October and April. Drought hazard is about 40%. The average summer temperature is 27°C and the winter

UNDER PEER REVIEW

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 [4].

2.2 Plant Materials

Four-week 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 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 900 kg/ha, inorganic basal fertilizer with a 125 kg/ha limestone ammonium nitrate (LAN) top dressing fertilizer was used as a control (Table 1). The inorganic basal fertilizer used was 232( ) which contains two parts nitrogen (N) three parts phosphorus (P) and two parts Potassium (K) while LAN contains 28% N. 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 in the experiment.

Table 1: Treatment descriptions.

Treatment code	Treatment
1	80 t/ha
2	40 t/ha
3	20 t/ha

UNDER PEER REVIEW

4	10 t/ha
5	900 kg of 2:3:2 (22) and 125 kg of LAN (28)

87

88 **2.4. Soil analysis**

89 Soil chemical properties were analyzed at the Soil Chemistry laboratory of the University of
90 Swaziland, Luyengo Campus.

91 **2.5. Manure analysis**

92 Chicken manure chemical properties were analyzed at the soil Chemistry laboratory of the
93 University of Swaziland, Luyengo Campus.

94 **2.6. Data collection**

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

99 **2.7. Growth parameters**

100 **2.7.1. Plant height**

101 Five plants were randomly selected per plot and plant height was measured from the base of the
102 plant to the leaf apex (tip) using a 30 cm ruler.

103 **2.7.2. Number of leaves per plant unit**

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

UNDER PEER REVIEW

2.7.3. Leaf area (cm^2)unit

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) [5]. (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 [5].

2.7.5. Fresh and dry mass (g) unit

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 [5].

2.8. Data analysis

The data collected was subjected to analysis of variance (ANOVA) using MSTAT-C statistical package, Version 1.4 [6]. Where significant differences were detected mean separation was performed using Duncan's New Multiple Range Test (DNMRT) at 5 % probability level [7].

3.0 RESULTS

3.1. Soil analysis

Soil chemical properties were analyzed 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

UNDER PEER REVIEW

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

128

129 **3.2. Manure analysis**

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

133 Table 3: Chicken manure analysis

Manure parameter	Value
pH	7.2
Phosphorus (mgP/kg)	17
Potassium (cmolc/kg)	1 895
Magnesium	Not determined-

134 **3.3. Plant height**

135 The plant height of Swiss chard spinach was significantly ($P<0.05$) different among the different
136 treatments. The highest plant height (34.6 cm) was obtained in Swiss chard spinach treated with
137 80 t/ha of chicken manure while the lowest plant height (26.0 cm) was obtained in Swiss chard

UNDER PEER REVIEW

plants treated with 10 t/ha of chicken manure (Figure 1). The plant height of Swiss chard 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).

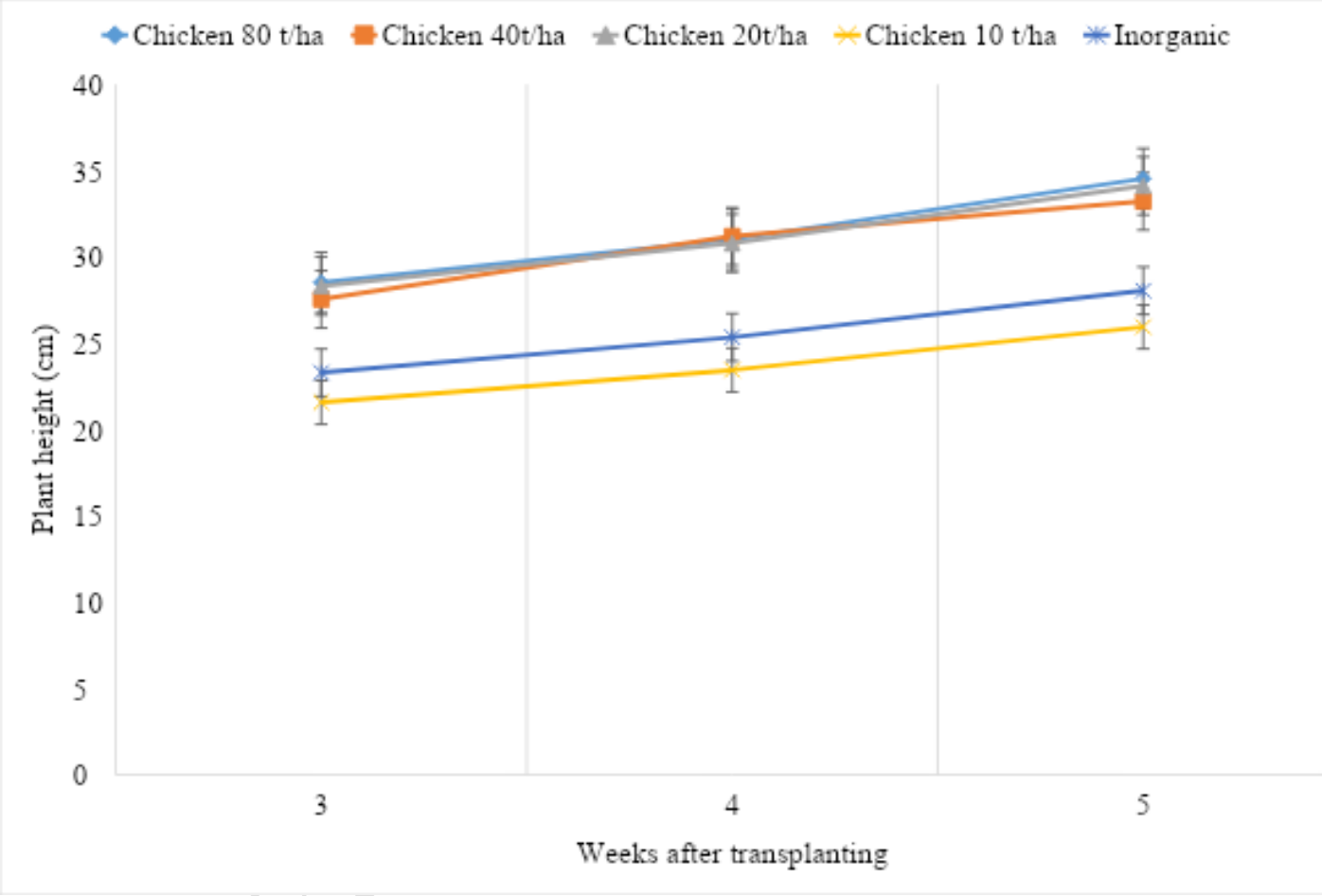


Figure 1: Effects of chicken manure on Swiss chard plant height. Vertical bars are standard error (se) below and above the mean.

3.4. Number of leaves

The number of leaves per plant was not significantly (P>0.05) different among the Swiss chard 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).

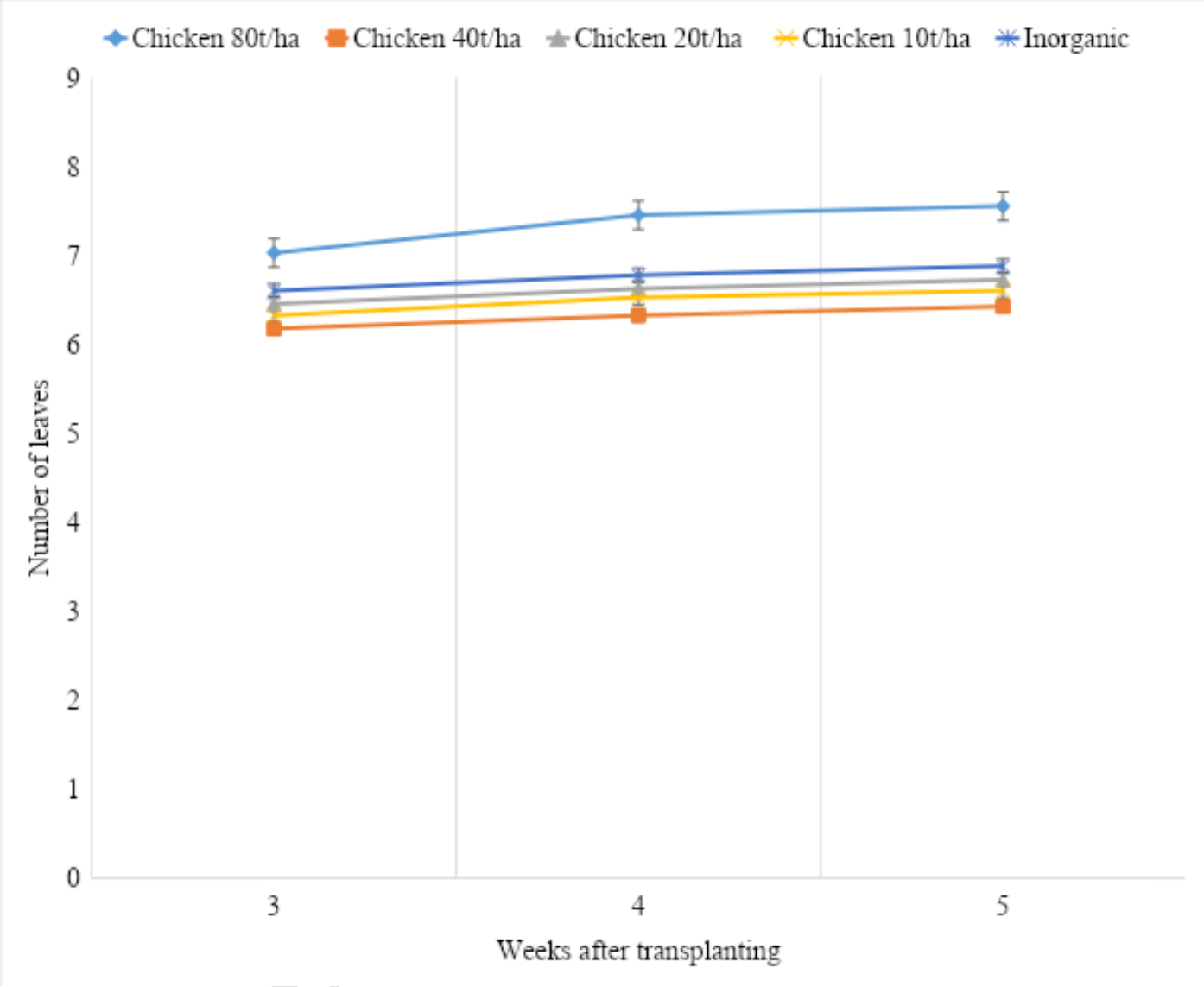


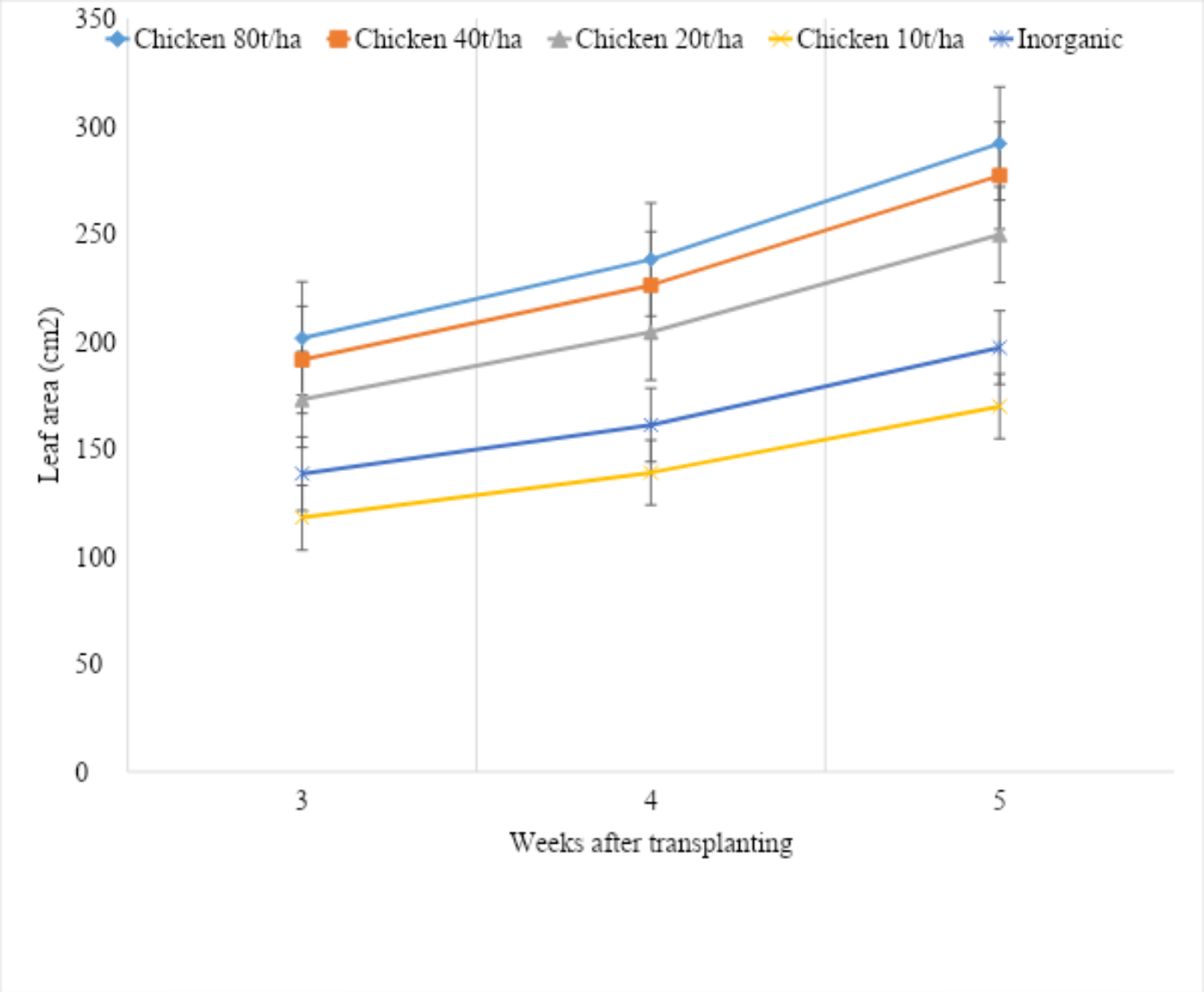
Figure 2: Effects of chicken manure on number of leaves of Swiss chard. Vertical bars are standard error (se) below and above the mean.

UNDER

3.5. Leaf area

The leaf area of Swiss chard plants was significantly ($P<0.05$) different among treatments. 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

157 5 WAT (Figure 3). The leaf area of Swiss chard increased with increasing application rates of
158 chicken manure.



159

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

162 **3.6. Leaf area index**

163 The leaf area index (LAI) was significantly ($P<0.05$) different among treatments. The highest
164 LAI (1.1) was obtained in plants treated with 80 t/ha of chicken manure while the lowest LAI

(0.5) was obtained in plants treated with 10 t/ha of chicken manure at 5 WAT (Figure 4). The leaf area of Swiss chard increased with increasing application rates of chicken manure.

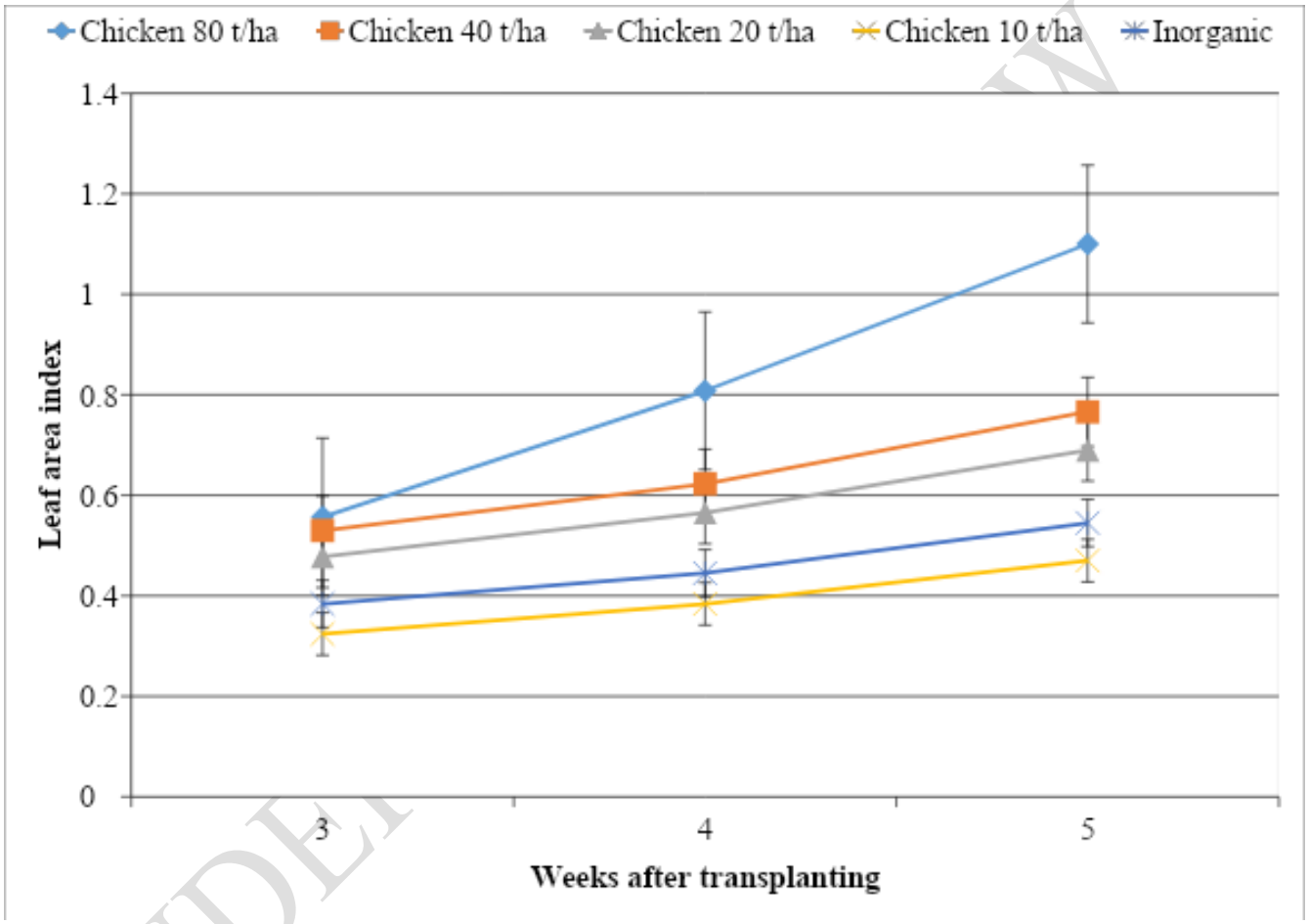


Figure 4: Effects of chicken manure on the LAI per plant of Swiss chard. Vertical bars are standard error (se) below and above the mean.

3.7. Fresh mass and dry mass

There was a significant ($P<0.05$) difference in the fresh shoot mass of Swiss chard plants among treatments (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 fertilized with inorganic fertilizers. There was no significant difference in Swiss chard fresh maas amended with 40 t/ha or 80 t/ha chicken manure.

There was a significant (P<0.05) difference in the dry shoot mass of Swiss chard plants among the different treatments (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 Swiss chard plants treated with inorganic fertilizers.

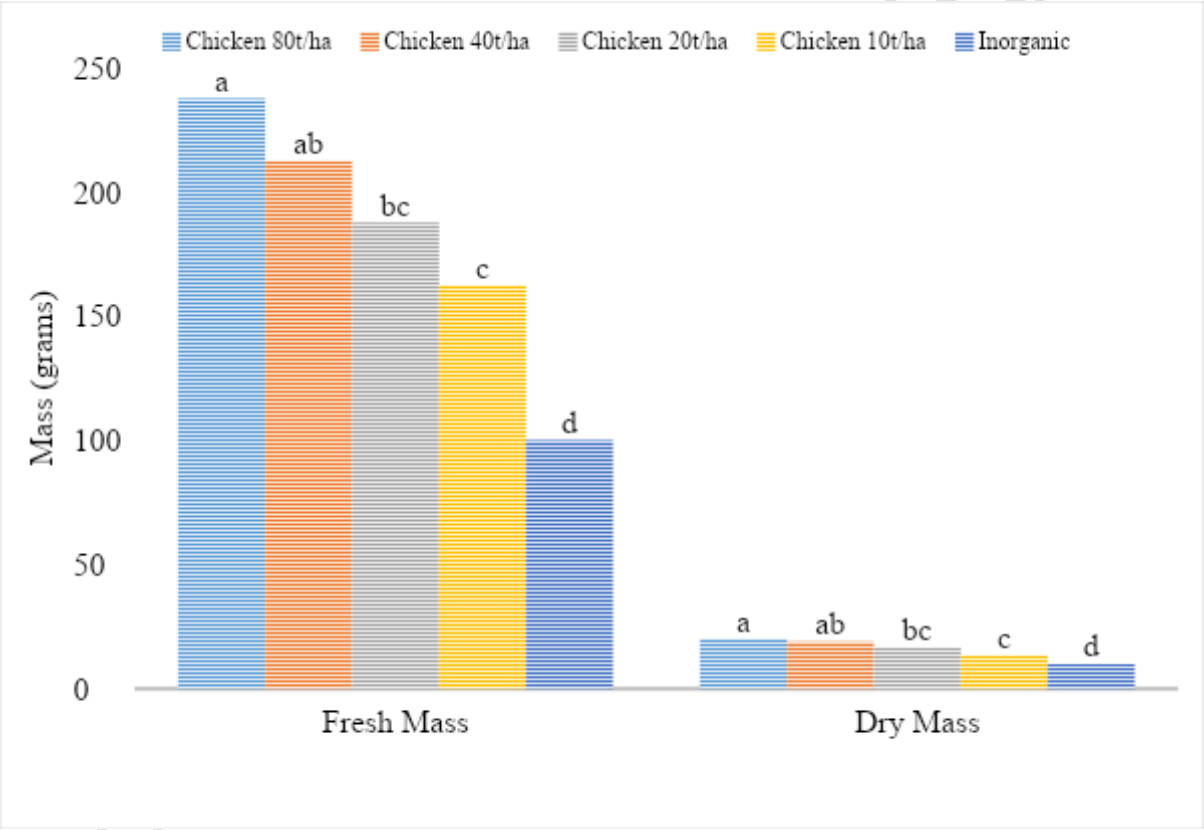


Figure 5: Effects of chicken manure on fresh and dry shoot mass of Swiss chard at week 5 after transplanting. Bars followed by the same alphabet are not significantly different from one another at P = 0.05. Mean separation by Duncan's New Multiple Range Test.

4.0. DISCUSSION

Different application rates of chicken manure had varying effects on growth, yield and quality of Swiss chard. Plants treated with 80 t/ha of chicken manure performed better in terms of growth in comparison with the other treatments. These Swiss chard 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 chicken manure and application of inorganic fertilisers recommended for Swiss chard production. Swiss chard plants treated with 10 t/ha had the lowest plant height, leaf area and leaf area index. The highest number of leaves of Swiss chard plants from the highest application rate of chicken manure must have been as a result of relatively high amounts of nitrogen [8]. 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 [8] 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 plant 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 [9] Owen (2008) who reported that synthetic fertilizers do not have good characteristics in aggregating soil particles. The plants treated with inorganic fertilizers gave a lower yield than those treated with 80 t/ha of chicken manure. Animal manures have beneficial effects on the physical and chemical properties of soil and therefore have the ability to retain water, supply macro- and trace elements absent in inorganic fertilizers. Increased vegetable yield with the use of manure has been previously reported for okra [10]. The benefits of organic fertilizer use in vegetable producion have previously been reported [11,12,13] and very recently reported [14,15,16] in the Kingdom of Eswatini.

UNDER PEER REVIEW

5.0. CONCLUSION AND RECOMMENDATION

The study showed that the application of 80 t/ha of chicken manure improved the growth and yield of Swiss chard. From these findings, it can, therefore, be concluded that 80 t/ha was best for [8] under the conditions of this study. If fresh mass at the end is the most important parameter farmers could as well use 40 t/ha because there was no significant difference in plants amended with 80 t/ha.

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

REFERENCES

1. Pierce LC. Vegetables: Characteristics, Production, and Marketing. John Wiley and Sons. New York, New York, USA. . 1987.

2. Hadfield J. Vegetable Gardening in Central Africa. Purnell and Sons. Johannesburg, South Africa. 1960.

3. Gilber, Z, Hadfield J. Down-to- Earth Fruit and Vegetable Gardening in South Africa. Struik Publishers. Cape Town, South Africa. 1987.

4. Murdoch G. Soils and Land Capacity in Swaziland. Swaziland Ministry of Agriculture. Mbabane, Swaziland. 1970.

5. Edje OT, Ossom EM. Crop Science Handbook. Blue Moon Publishers. Manzini, Swaziland. 2009.

UNDER PEER REVIEW

6. Nissen,O. MSTAT-C. A micro Computer Program Design for Management and Analysis of Agronomic Research Experiments. Michigan State University. East Lansing, Michigan, USA. 1989.

7. Gomez KA, Gomez A A. Statistical Procedures for Agricultural Research. John Wiley and Sons 2nd Edition. Singapore. (1984).

8. Lungu O I,. Chirwa B. Effect of lime and farmyard manure on soil acidity from and maize growth on alfisoils from Zambia. Tropical Agric (Trinidad) 1993; 70; 309-315.

9. Owen P. Origin and distribution of lettuce. (2008).http://www.calettuceresearchboard.org/Origin.html. 10/04/2016

10. Ogunlela VB, Masarirambi MT, Makuza SM. Effects of cattle manure application on pod yield and yield indices of Okra (*Abelmoschus esculentus L. Moench*) semi-arid and subtropical environment. J Food, Agric Environ. 2005;3 (1):125-129

11. Masarirambi MT, Hlawe MM, Oseni TO, Sibiya TE. Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (*Luctuca sativa* L.) 'Veneza Roxa'. Agric and Biol J North America 2010; 1 (6):1319-1324

12. Masarirambi M T, Dlamini P., Wahome PK, Oseni TO. Effects of chicken manure on growth, yield and quality of lettuce (*Lactuca sativa* L.) 'Taina' under a lath house in a semi-arid sub-tropical environment. American Eurasian J Agric Environ Sci, 2012;12 (3): 399-406

13. Msibi, B.M., Mukabwe WO, Manyatsi AM, Mhazo N Masarirambi MT. Effects of liquid manure on growth and yield of spinach (*Beta vulgaris* var cicla) in a sub-tropical environment in Swaziland. Asian J Agric Sci, 2014; 6(2): 40-47

UNDER PEER REVIEW

14. Kunene TR, Masarirambi MT, Wahome PK, Oseni TO. Infuence of kraal manure, chicken manure and inorganic fertilizer on growth, yiels and post-harvest quality of pepper (*Capsicum annum* L.) in a sub-tropical environment. .Asian J Advances Agric Res, 2019;11(1):1-11

15. Mabuza TZ, Masarirambi M.T. Nxumalo KA, Wahome PK. Effects of different rates of cattle manure on growth, yield and quality of pepper (*Capsicum annuum* L.) in a sub-tropical environment of Eswatini (Swaziland). Asian J Advances Agric Res, 2019; 11(1):1-7

16. Dlamini SN, Masarirambi MT, Wahome P K, Oseni. T.O. The effects of organic fertilizers on the growth and yield of amaranth (Amaranthus hybridus L.) grown in a lath house. Asian J Advances Agric Res, 2020;12(1):1-10

UNDER PEER REVIEW