

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.***

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28 1.0. INTRODUCTION

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

34 Swiss chard forms part of the several leafy green vegetables that are known as 'greens.' It is a
35 biennial plant with large dark leaves. The leaves are large, glossy and crispy and can grow up to
36 37 cm long and 25 cm wide [1]. Stalks of Swiss chard come in a variety of colours depending on
37 the cultivar, they are usually white, yellow, orange or red [2]. The first records of cultivation
38 place the origin of Swiss chard in the Mediterranean region particularly Italy and was first
39 written about by the Greek philosopher Aristotle in 4 B.C [1]. Swiss chard is a short day (SD)
40 plant with critical day length of 12 hours. It grows best at temperatures ranging from 7 to 24 °C.
41 Swiss chard can withstand light frosts but an extended exposure to temperatures less than 5°C
42 induces bolting. In hot weather, the leaves remain small and are of inferior quality [3]. Leaves of
43 Swiss chard are harvested usually within eight weeks from sowing and once they are in good size
44 [2]. Harvesting is done continuously so that the leaves do not stay long and lose their colour or
45 become tough.

46

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

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

56 The main objective of this study was to improve the production of Swiss chard and to contribute
57 towards food security and income generation in Eswatini/Swaziland. The specific objective was
58 to determine the optimum level of chicken manure application on growth, yield and quality of
59 Swiss chard.

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62 **2.0 MATERIAL AND METHODS**

63 **2.1 Experimental site**

64 The experiment was conducted at the Horticulture Department Farm, Faculty of Agriculture and
65 Consumer Sciences, Luyengo Campus of the University of Swaziland. The farm is located at
66 Luyengo, Manzini region, in the Middleveld agro-ecological zone. Luyengo is located at latitude
67 26°4' S and longitude 31°4' E. The average altitude of this area is 750 m above sea level. The
68 mean annual precipitation is 980 mm with most of the rain falling between October and April.
69 Drought hazard is about 40%. The average summer temperature is 27°C and the winter

70 temperature is about 15°C. The soils of Luyengo are classified under Malkerns series. They are
 71 ferrasolic or merely a ferralitic soil integrated to fersialitic soils or typical ultisols. The soil in the
 72 experimental area was a sandy loam [4].

73 2.2 Plant Materials

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

78 2.3 Experimental Design

79 Four chicken manure application rates (10, 20, 40 and 80 t/ha) and a recommended 900 kg/ha,
 80 inorganic basal fertilizer with a 125 kg/ha limestone ammonium nitrate (LAN) top dressing
 81 fertilizer was used as a control (Table 1). The inorganic basal fertilizer used was 232() which
 82 contains two parts nitrogen (N) three parts phosphorus (P) and two parts Potassium (K) while
 83 LAN contains 28% N. A Randomised Complete Block Design (RCBD) with four replicates was
 84 used. Each plot had four rows and there were four plants in each row which gave a total of 320
 85 plants used in the experiment.

86 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)

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.

107 **2.7.3. Leaf area (cm²)unit**

108 The leaf area of the Swiss chard was determined by multiplying the leaf width and leaf length
109 and then multiplying the product by 0.75 (correction factor) [5]. (It was expressed in cm²)

110 **2.7.4. Leaf area index**

111 The leaf area index was determined by dividing the leaf area in cm² by the area occupied by a
112 single plant in cm² [5].

113 **2.7.5. Fresh and dry mass (g) unit**

114 This was determined at the end of the cropping season by weighing the harvested leaves per plot.
115 Five plants per plot were used to determine the fresh and dry mass in this experiment. The plants
116 were randomly selected per plot and their shoot fresh mass was measured using a digital scale
117 balance. They were then oven dried at a temperature of 72°C for 72 hours to determine their
118 shoot dry mass [5].

119 **2.8. Data analysis**

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

123 **3.0 RESULTS**

124 **3.1. Soil analysis**

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

127 Table 2: Soil analysis

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

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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.

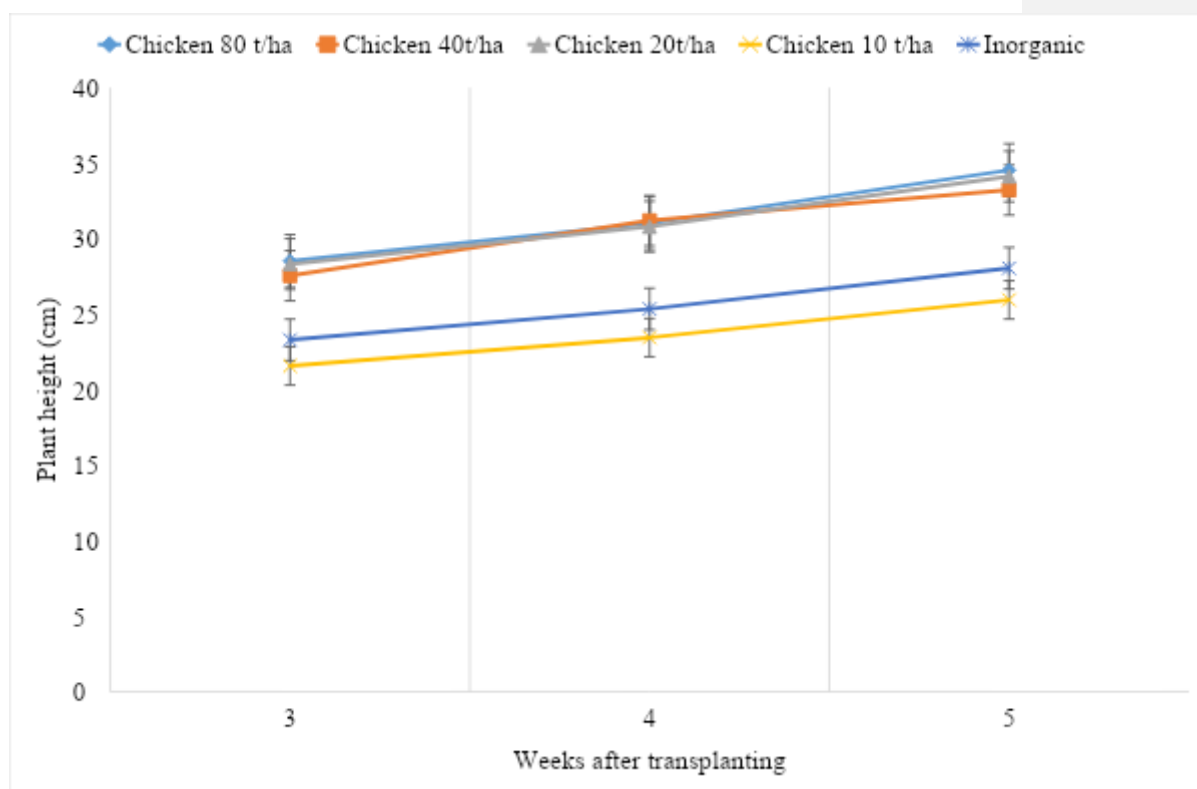
133 Table 3: Chicken manure analysis

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**

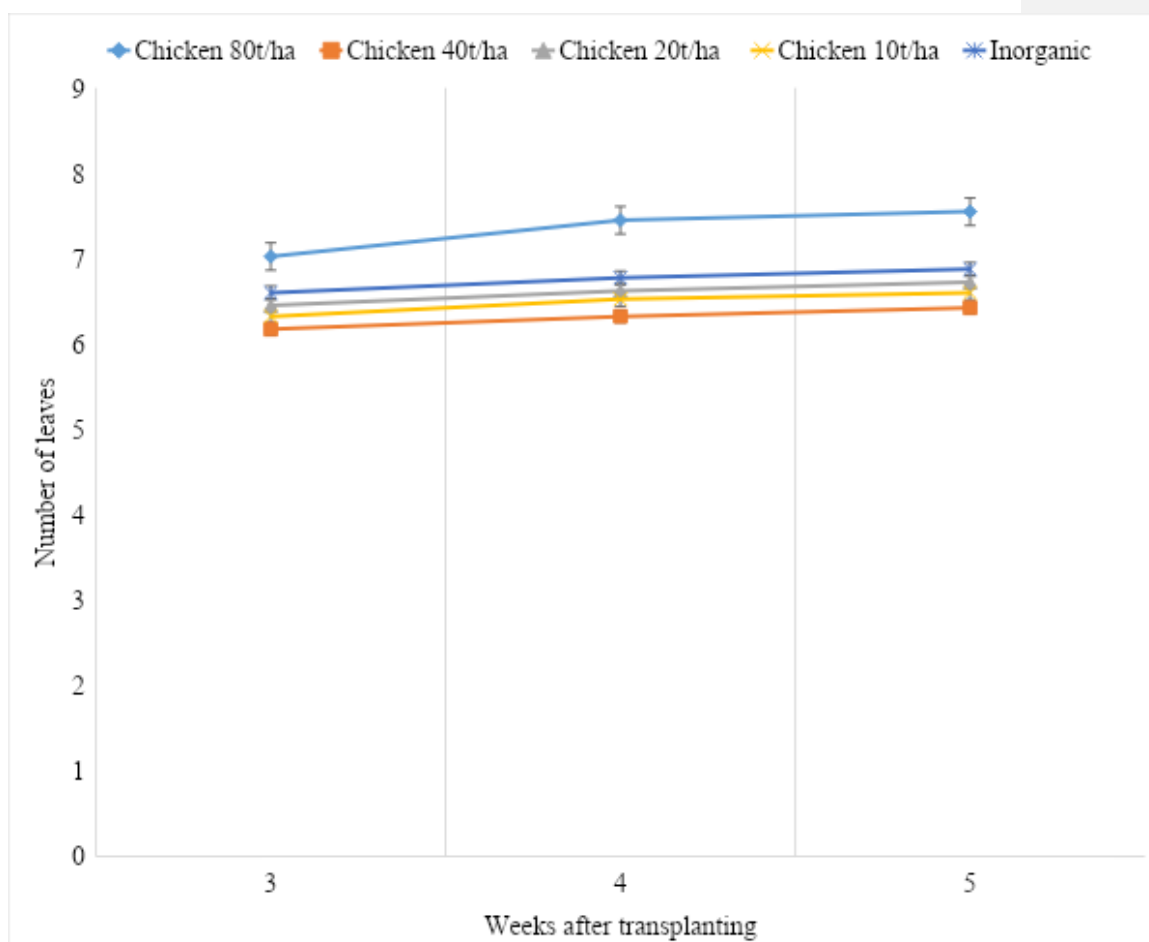
138 plants treated with 10 t/ha of chicken manure (Figure 1). The plant height of **Swiss chard** plants
 139 treated with inorganic fertilizers was higher (28.1 cm) but not significantly ($P>0.05$) different
 140 from those treated with 10 t/ha of chicken manure (26.0 cm) (Figure 1).



141
 142 Figure 1: Effects of chicken manure on **Swiss chard** plant height. Vertical bars are standard
 143 error (se) below and above the mean.

144 3.4. Number of leaves

145 The number of leaves per plant was not significantly ($P>0.05$) different among the **Swiss chard**
 146 plants. The highest number of leaves (7.6) was obtained in plants treated with 80 t/ha of chicken
 147 manure while the lowest number of leaves (6.4) was obtained in plants treated with 40 t/ha of
 148 chicken manure (Figure 2).



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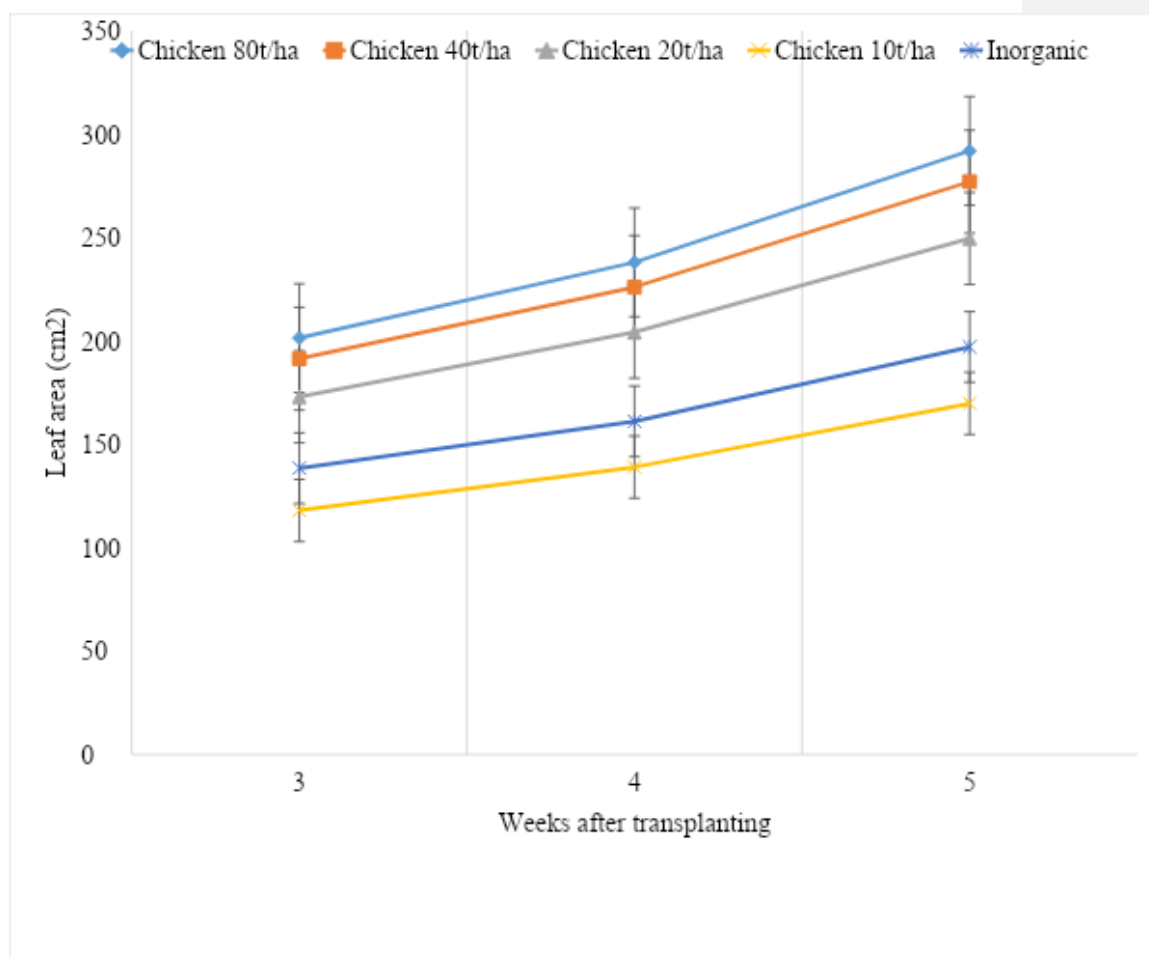
150 Figure 2: Effects of chicken manure on number of leaves of **Swiss chard**. Vertical bars are
 151 standard error (se) below and above the mean.

152

153 3.5. Leaf area

154 The leaf area of **Swiss chard** plants was significantly ($P < 0.05$) different among treatments. The
 155 highest leaf area (291.9 cm^2) was obtained in plants treated with 80 t/ha of chicken manure while
 156 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

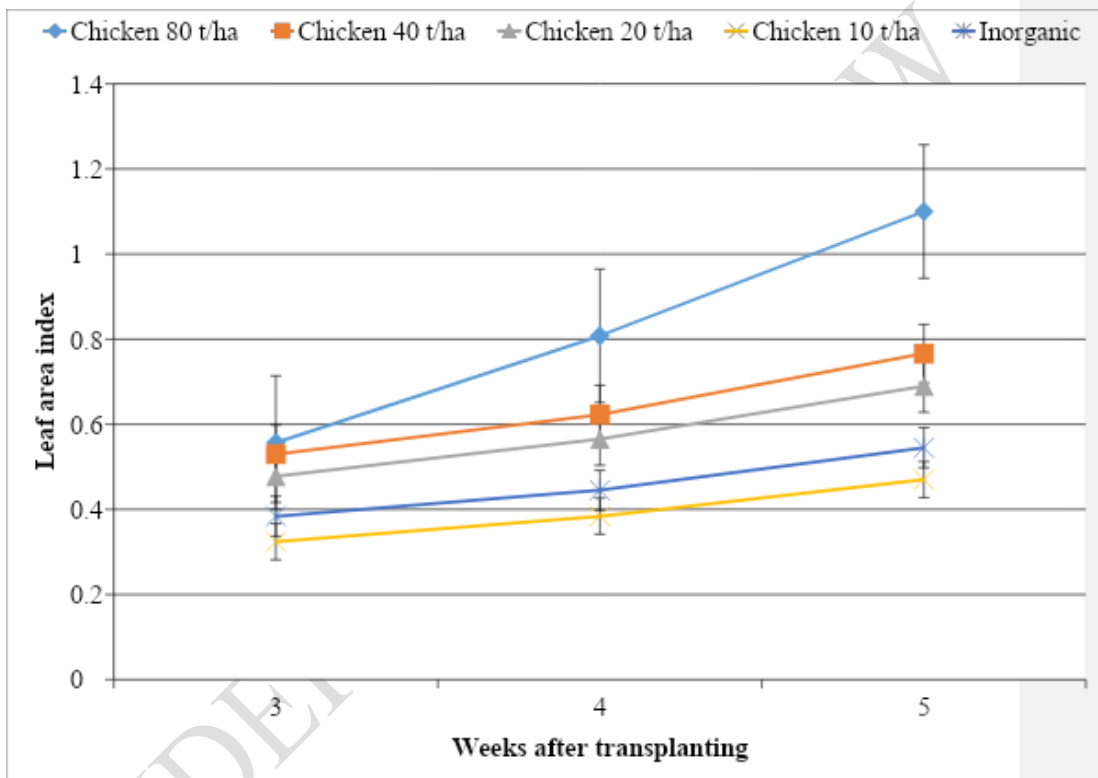
163 The leaf area index (LAI) was significantly ($P < 0.05$) different among treatments. The highest
 164 LAI (1.1) was obtained in plants treated with 80 t/ha of chicken manure while the lowest LAI

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167 (0.5) was obtained in plants treated with 10 t/ha of chicken manure at 5 WAT (Figure 4). The

168 leaf area of **Swiss chard** increased with increasing application rates of chicken manure.



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170 Figure 4: Effects of chicken manure on the LAI per plant of **Swiss chard**. Vertical bars are

171 standard error (se) below and above the mean.

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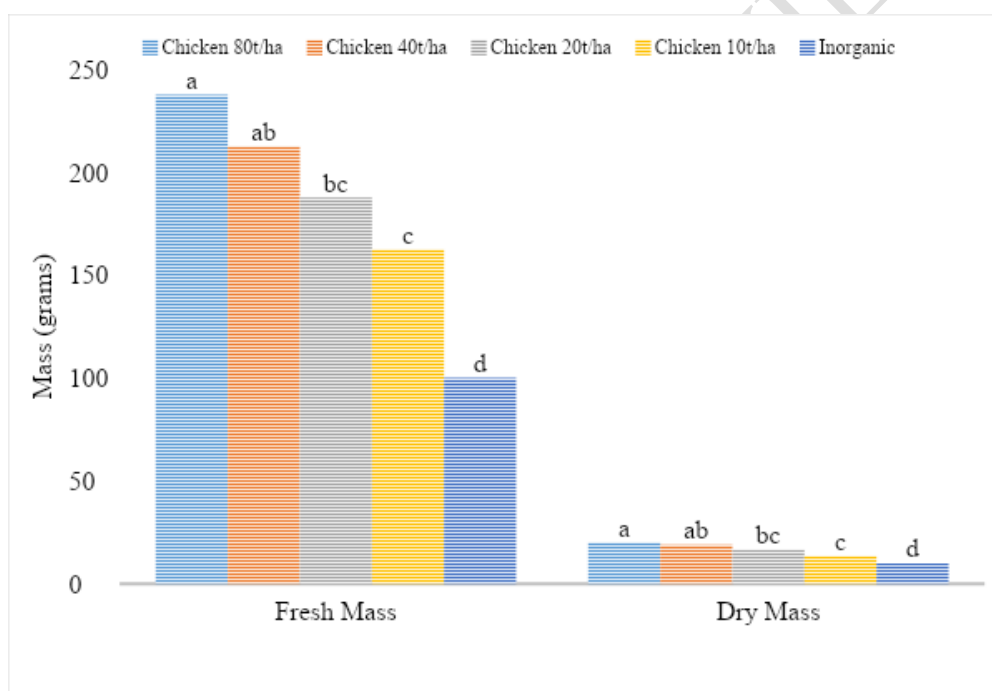
173 3.7. Fresh mass and dry mass

174 There was a significant ($P < 0.05$) difference in the fresh shoot mass of **Swiss chard** plants among

175 treatments (Figure 5). The highest fresh shoot mass (237.5 g) was obtained in plants treated with

176 80 t/ha of chicken manure while the lowest fresh shoot mass (100.0 g) was obtained in plants
 177 fertilized with inorganic fertilizers. There was no significant difference in Swiss chard fresh
 178 mass amended with 40 t/ha or 80 t/ha chicken manure.

179 There was a significant ($P < 0.05$) difference in the dry shoot mass of Swiss chard plants among
 180 the different treatments (Figure 5). The highest dry shoot mass (20.4 g) was achieved at 80 t/ha
 181 of chicken manure while the lowest dry shoot mass (10.1 g) was obtained in Swiss chard plants
 182 treated with inorganic fertilizers.



183
 184 Figure 5: Effects of chicken manure on fresh and dry shoot mass of Swiss chard at week 5 after
 185 transplanting. Bars followed by the same alphabet are not significantly different from
 186 one another at $P = 0.05$. Mean separation by Duncan's New Multiple Range Test.

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188 4.0. DISCUSSION

189 Different application rates of chicken manure had varying effects on growth, yield and quality of
190 **Swiss chard**. Plants treated with 80 t/ha of chicken manure performed better in terms of growth
191 in comparison with the other treatments. These **Swiss chard** plants had the highest plant height,
192 number of leaves, fresh shoot mass, dry shoot mass, leaf area and leaf area index compared to
193 spinach treated with 10, 20, 40 t/ha of **chicken** manure and application of inorganic fertilisers
194 recommended for **Swiss chard** production. **Swiss chard** plants treated with 10 t/ha had the lowest
195 plant height, leaf area and leaf area index. The highest number of leaves of **Swiss chard** plants
196 from the highest application rate of chicken manure must have been as a result of relatively high
197 amounts of nitrogen [8]. It was also noted that plant height, number of leaves, leaf area, leaf area
198 index, fresh and dry shoot mass increased with increasing levels of chicken manure. These
199 results are in agreement with those of [8] who studied the effects of an organic fertilizer (cattle
200 manure) on *Zea mays*. As chicken manure application rate was increased, the availability of plant
201 nutrients in the soil also increased. **This resulted in the increase of plant growth and yield.**

202 Chicken manure at 80 t/ha performed better in comparison with inorganic fertilizers. These
203 findings do not deviate much from those obtained by [9] Owen (2008) who reported that
204 synthetic fertilizers do not have good characteristics in aggregating soil particles. The plants
205 treated with inorganic fertilizers gave a lower yield than those treated with 80 t/ha of chicken
206 manure. Animal manures have beneficial effects on the physical and chemical properties of soil
207 and therefore have the ability to retain water, supply macro- and trace elements absent in
208 inorganic fertilizers. Increased vegetable yield with the use of manure has been previously
209 reported for okra [10]. The benefits of organic fertilizer use in vegetable production have
210 previously been reported [11,12,13] and very recently reported [14,15,16] in the Kingdom of
211 Eswatini.

212 **5.0. CONCLUSION AND RECOMMENDATION**

213

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

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

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