

1 The Effects of Chicken Manure Application Rates on Growth and Yield of Swiss Chard

2 (*Beta vulgaris* var. *cicla* L.)

4 ABSTRACT

5 Swiss chard (*Beta vulgaris* var. *cicla*) is a leafy vegetable that belongs to the *Chenopodiaceae*
6 family. The leaves are cooked, if still tender they are used in salads. Over the years, Emawati has
7 adopted the use of inorganic fertilizers as they are easy to apply and come with recommended
8 application rates. However, their main drawback is that they are environmentally unfriendly
9 especially when washed into rivers, streams and other water bodies. For this cause, the use of
10 animal manures has been promoted. Four-week-old Swiss chard seedlings were transplanted on
11 the 4th of February, 2016 in 1.5 x1.5 m plots with an inter and intra row spacing of 45 cm and
12 they were irrigated twice a day during the first week and every second day from the second week
13 until the end of the experiment. The experiment was conducted at the Horticulture Department
14 Farm, Faculty of Agriculture and Consumer Sciences, Luyengo Campus of the University of
15 Swaziland to determine the effects of chicken manure application rates on growth, yield and
16 quality of Swiss chard. Four chicken manure application rates (10, 20, 40 and 80 t/ha) and a
17 recommended 900 kg/ha, inorganic basal fertilizer with a 125 kg/ha LAN top dressing fertilizer
18 used as a control. A Randomised Complete Block Design (RCBD) with four replicates was used.
19 The study showed that the application of 80 t/ha of chicken manure improved the growth and
20 yield of Swiss chard. It is recommended that farmers may use 80 t/ha of chicken manure because
21 it gave the best results compared to the other treatments. The highest fresh shoot mass (237.5 g)
22 was obtained in plants treated with 80 t/ha of chicken manure while the lowest fresh shoot mass
23 (100.0 g) was obtained in plants fertilized with inorganic fertilizers. The study concluded that 80

24 t/ha was best for under the conditions of this study and it was found that fresh mass at the end
25 was the most important parameter to consider.

26 **Keywords:** Swiss chard, manure, organic fertilizer, growth and yield, production

27 **1.0. INTRODUCTION**

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

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

45

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

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

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

59

60

61 **2.0 MATERIAL AND METHODS**

62 **2.1 Experimental site**

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

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

72 **2.2 Plant Materials**

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

77 **2.3 Experimental Design**

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

85 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) |

86

87 **2.4. Soil analysis**

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

90 **2.5. Manure analysis**

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

93 **2.6. Data collection**

94 Data were collected weekly, from the second week after transplanting. Five plants were
95 randomly selected in each plot for data recording. Data was collected on the following growth
96 parameters: plant height, number of leaves and leaf area while the leaf area index was calculated.

97 The fresh mass and dry mass of the Swiss chard were measured after harvesting.

98 **2.7. Growth parameters**99 **2.7.1. Plant height**

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

102 **2.7.2. Number of leaves per plant unit**

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

106 **2.7.3. Leaf area (cm²)unit**

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

109 **2.7.4. Leaf area index**

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

112 **2.7.5. Fresh and dry mass (g) unit**

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

118 **2.8. Data analysis**

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

122 **3.0 RESULTS**

123 **3.1. Soil analysis**

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

126 Table 2: Soil analysis

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

127

128 3.2. Manure analysis

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

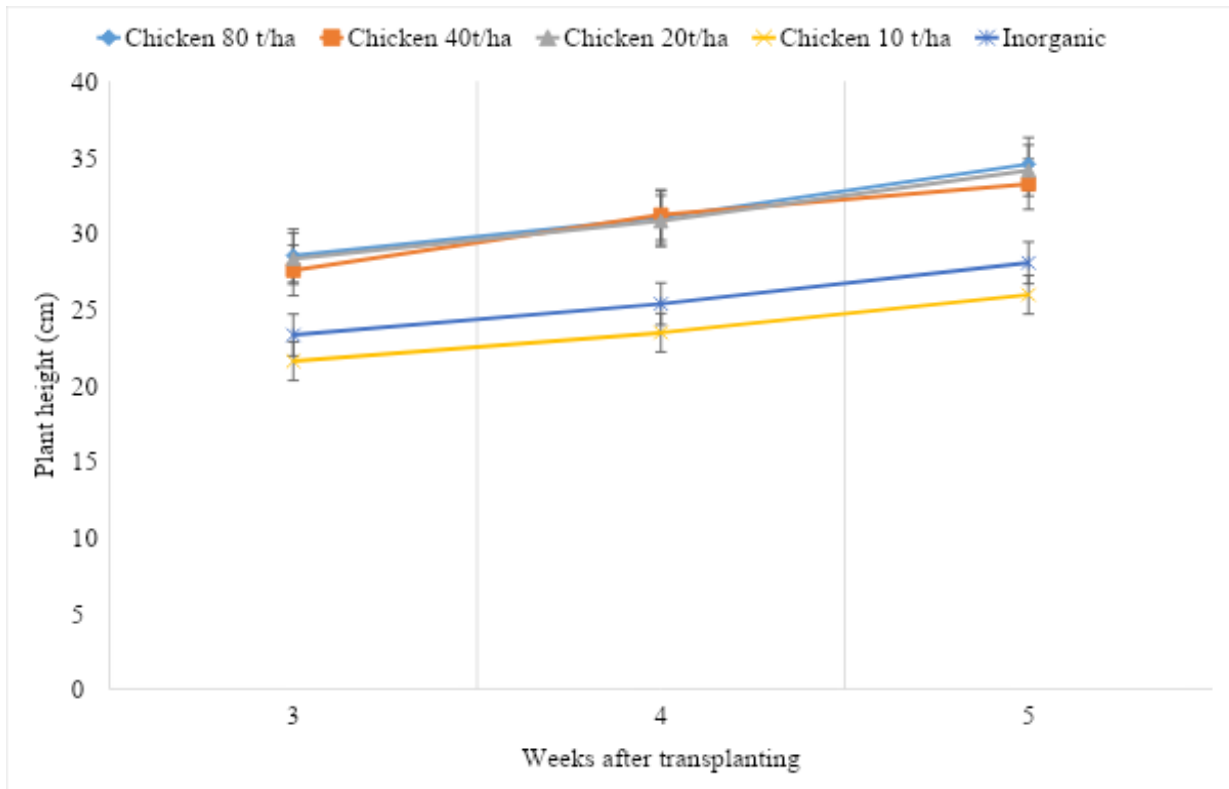
132 Table 3: Chicken manure analysis

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

133 3.3. Plant height

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

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

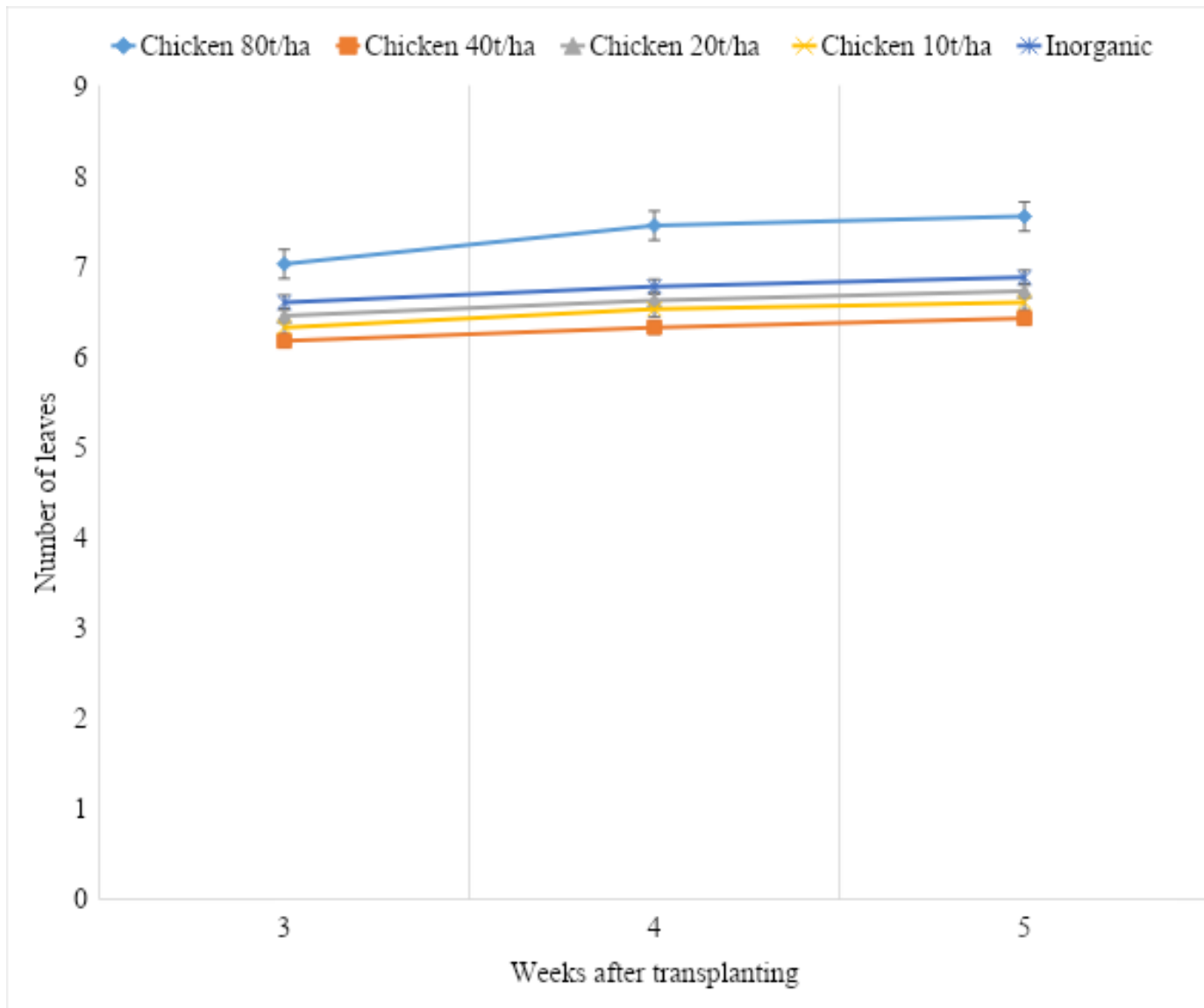


140

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

143 3.4. Number of leaves

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



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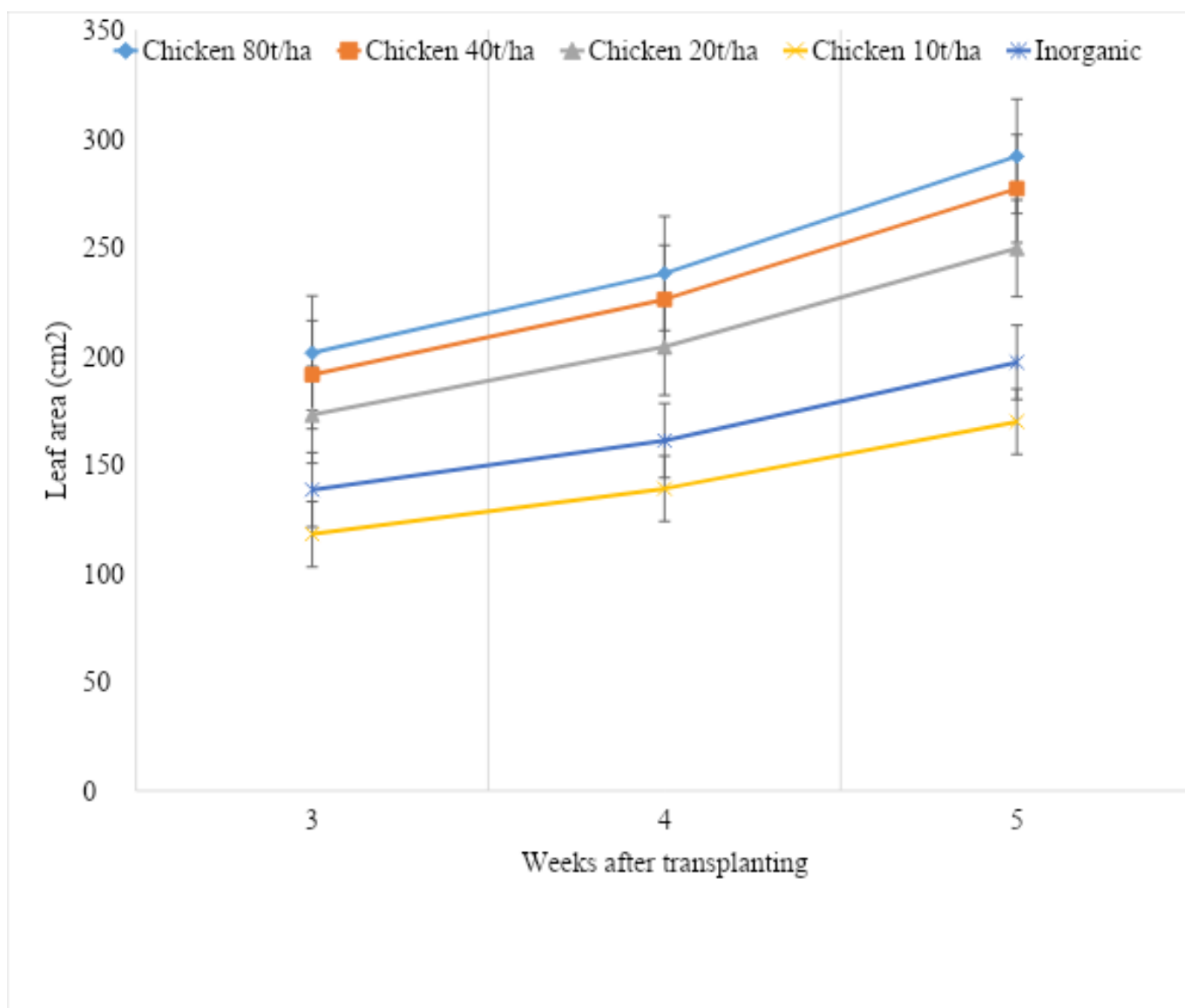
149 Figure 2: Effects of chicken manure on the number of leaves of Swiss chard. Vertical bars are
 150 standard error (SE) below and above the mean.

151

152 3.5. Leaf area

153 The leaf area of Swiss chard plants was significantly ($P < 0.05$) different among treatments. The
 154 highest leaf area (291.9 cm^2) was obtained in plants treated with 80 t/ha of chicken manure while
 155 the lowest leaf area (169.8 cm^2) was obtained in plants treated with 10 t/ha of chicken manure at

156 5 WAT (Figure 3). The leaf area of Swiss chard increased with increasing application rates of
 157 chicken manure.



158
 159 Figure 3: Effects of chicken manure on the leaf area per plant of Swiss chard. Vertical bars are
 160 standard error (SE) below and above the mean.

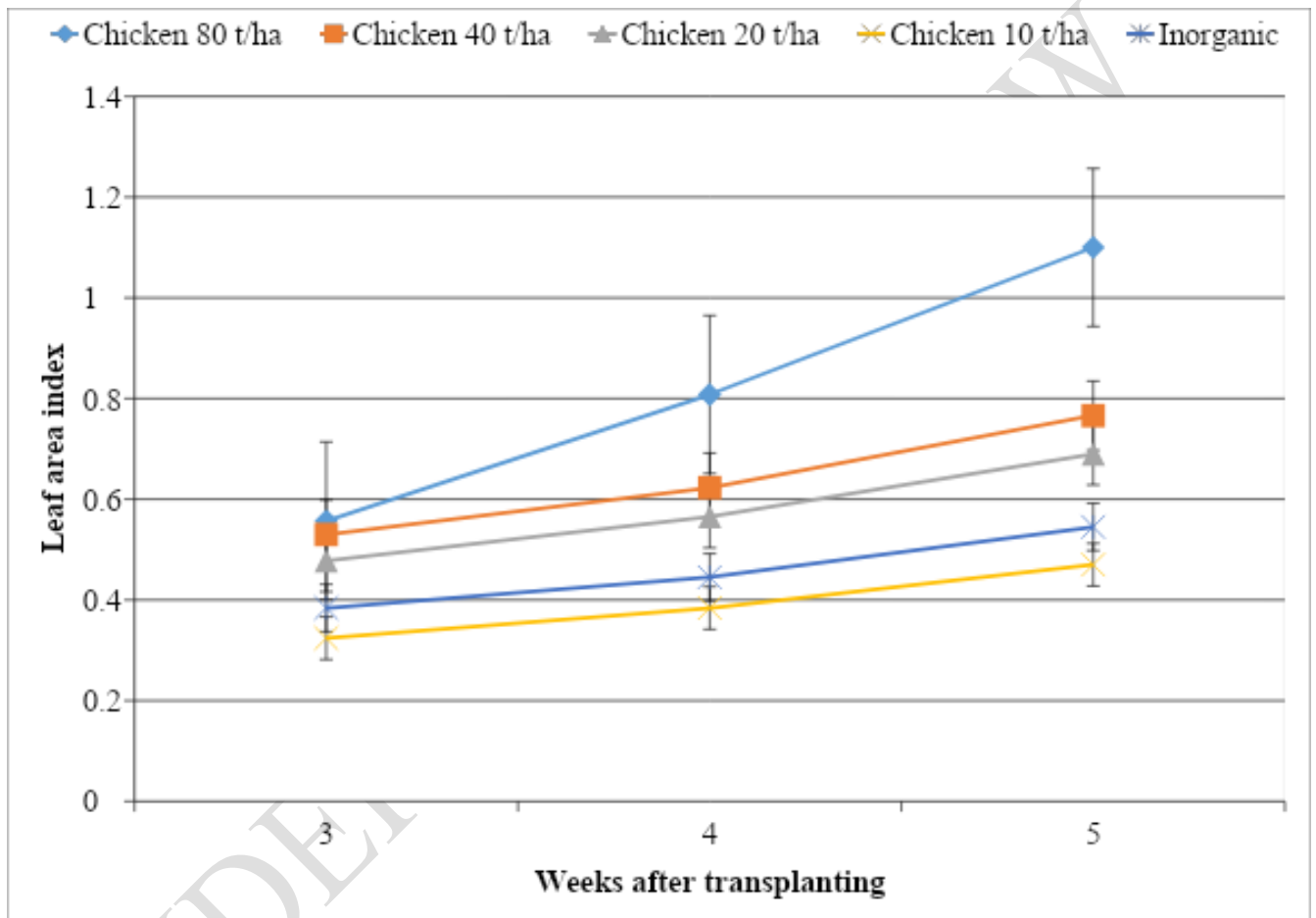
161 3.6. Leaf area index

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

164

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166 (0.5) was obtained in plants treated with 10 t/ha of chicken manure at 5 WAT (Figure 4). The
 167 leaf area of Swiss chard increased with increasing application rates of chicken manure.



168

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

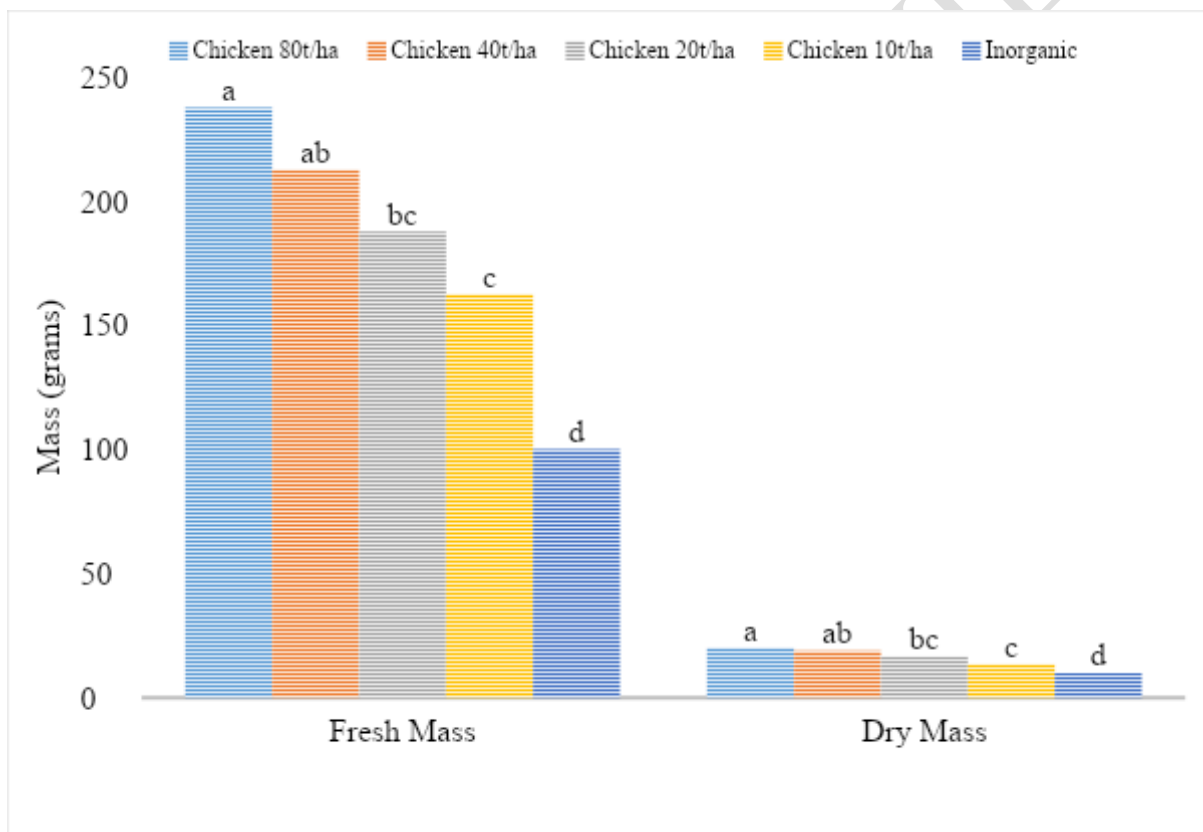
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172 3.7. Fresh mass and dry mass

173 There was a significant ($P < 0.05$) difference in the fresh shoot mass of Swiss chard plants among
 174 treatments (Figure 5). The highest fresh shoot mass (237.5 g) was obtained in plants treated with

175 80 t/ha of chicken manure while the lowest fresh shoot mass (100.0 g) was obtained in plants
 176 fertilized with inorganic fertilizers. There was no significant difference in Swiss chard fresh
 177 mass amended with 40 t/ha or 80 t/ha chicken manure.

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



182

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

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187 **4.0. DISCUSSION**

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

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

210 **5.0. CONCLUSION AND RECOMMENDATION**

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

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

219 Consent: NA

220 Ethic: NA

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