Influence of Kraal Manure, Chicken Manure and Inorganic Fertilizer on Growth, Yield and Post-harvest Quality of Pepper (C*apsicum annuum l.*) in a Sub-tropical Environment

ABSTRACT

The excessive unjustified use of some kinds of fertilizers has seen some farmers realizing poor quality fruit that does not appeal to the final consumer, thus negatively affecting the effort of alleviating poverty in the Kingdom of Eswatini. This experiment was carried out at the Horticulture Department Lath House, Faculty of Agriculture, Luyengo campus of the University of Swaziland to determine the growth, yield and shelf life of green pepper when fertilized with kraal manure, poultry manure and inorganic fertilizer. The experiment was conducted to find the optimum levels of fertilizers that promotes the growth of pepper and to find the effects of different fertilizers on yield and quality of pepper. The treatments were of kraal manure applied at 60tones/hectare, 2:3:2 (37) at 370 kg/ha and chicken manure at 40 tonnes per hectare. The results showed that growing pepper using the three treatments significantly affected its growth rate, leaf number, fruit number and its (fruit) shelf life. Pepper grown using inorganic fertilizer had the highest leaf number as compared to chicken manure and the least was recorded in kraal manure. There were no significant (P>0.05) difference in the growth rate ~~of~~ due to the inorganic fertilizer and chicken manure treatments. There was also no significant (P>0.05) difference of pepper grown with chicken manure and ~~chemical~~inorganic fertilizer in the number of days it took the harvested pepper to 100% decay stored at room temperature at 21 days. Yet pepper grown with kraal manure was significantly different from the two as it showed 20% decay rate in the same number of days. Kraal manure at 60 t/ha is recommended in the production of pepper with a longer shelf life.

Comment [D1]: It may give the best agronomic effect, but what about the availability, cost and application labor compare to the other sources of fertilizer?

INTRODUCTION

Green pepper (*Capsicum annuum L.*) is amongst the most important vegetables grown in most countries with warm climate. ~~Recently large scale production of pepper for export has been undertaken under irrigation in Southern Africa (Norman, 1992).~~ Green pepper originated from Central and Tropical America. The fruit is berry like tomato but with large locules without the gel with its seeds tightly compressed to the central stalk (Norman, 1992).

Green pepper is a warm season crop and its growth and development is similar to that of tomato but requires relatively higher temperatures. Soils preferred are sandy soils or loamy soils with a lot of organic matter well drained soils and pH ranging from 5.5 - 6.8 is best for its successful production. The crop may be directly seeded or transplanted to the field. Soil moisture must be relatively uniform throughout the growing season for optimal production. Recently large scale production of pepper for export has been undertaken under irrigation in Southern Africa (Norman, 1992). The number and frequency of irrigation will depend on the type of soil, developmental stage of the plant, atmospheric temperature and humidity (Norman, 1992).

Vegetables such as green pepper are very important nutritionally and economically in Swaziland. Pepper is used as a vegetable, salad or to add flavour in stews. It is also used for medicinal purposes to cure fever and colds (Norman, 1992). The challenges observed though are those of proper nutrition for specific vegetables. It is important to ensure that there ~~is~~are enough soil nutrients to hasten the plant growth so that flowering fruit setting does not occur whilst the plant structure is still small to carry the load of fruits.

Farmers in Swaziland normally use both inorganic and organic fertilizers in vegetable production. The question is the amount and effects of the fertilizer of choice on yield and product quality.

Most local farmers apply kraal manure (Boma) on their plots, some use chicken manure and most of them use commercial (~~synthetic~~ inorganic) fertilizers. Synthetic fertilizers commonly used by farmers in Swaziland include 2:3:2 (22), 2:3:2 (38) and straight fertilizers such as Lime Ammonium Nitrate (LAN) or Urea but the latter is rarely used. A general recommendation is to apply 250 kg 15-15-15 NPK prior to planting (Norman, 1992), but it is wise to test the soil for nutrient status and apply fertilizers/soil ~~ammendments as~~amendments as recommended.

Comment [D2]: Is not better to use inorganic fertilizer as it is in the title of the paper?

Comment [D3]: Give the details of what these stand for, N-P-k-(?) or what?

Swazis enjoy their meals with vegetables. The challenges observed are that farmers that produce the vegetables use all types of fertilizers without exactly knowing the benefits and demerits of the various fertilizers. The amount applied is also another challenge that needs to be addressed. Product quality is also a point of concern, including nutritional status and shelf life of the final product. However, growth response of plants differs with different fertilizers due to their differences in nutrient and other element composition. Therefore, the determination of the best source of nutrition is one of the fundamentals for effective plant production to meet consumer satisfaction. Cost effective means of production are a necessity to effectively produce safe, healthy and adequate food thereby alleviating poverty and building a healthy nation.

~~To find out the effects of different fertilizers on yield and quality of pepper.~~

Since the use of fertilizers has been introduced in horticulture, different fertilizer sources have been used which have different compositional properties that causes differences in

growth rate and yield of plants and quality of the final product. The excessive unjustified use of some kinds of fertilizers has seen farmers realizing poor yields of poor quality fruit that does not appeal to the final consumer, thus negatively affecting the effort of alleviating poverty in the Kingdom of Eswatini.

Need a sentence that gives the objective (s) of the present study.

To find out the effects of different fertilizers on yield and quality of pepper.

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MATERIALS AND METHODS

Experimental site: This experiment was conducted in the lath house of the Horticulture Department, University of Swaziland, Luyengo Campus during the summer from November 2012 to February 2013. It is located at Luyengo between latitude 26˚34 'S and 31˚12' E at 750m above sea level with an average of temperature 21˚C and receives about 800mm of rainfall per annum. The soil at the experimental site is classified under Malkerns series, deep red loam. Ferrasolic or merely a ferralitic soil intergrades to fersialitic soils or typical utisols. The soil was mixed with sand to create a sandy loam (Brady and Weil, 2007).

Plant Material: Six week old green pepper seedlings of the cultivar 'Mayo' obtained from Vickery Seedlings, Malkerns. They were transplanted on the 2nd November 2012. The pepper seedlings were transplanted in pots in medium that was prepared in advance. The medium comprised of top-soil obtained from the campus farm, river sand and sawdust at the ratio 1:1:1. The medium was steam sterilized to kill unwanted microorganism and soil borne diseases like bacterial wilt. The pots were arranged into four blocks with 4 treatment, 4 pots per row and replicated 4 times. The plants were provided with optimal growing conditions, and all cultural practices according to need, for example irrigation, weeding, and pest and disease control.

Treatments – how many?; show all the treatments here

Nutrient Sources: Three types of nutrition sources were used as treatments. 2:3:2 (37) was used as a source of inorganic fertilizer. Give the calculation that gives the quantity per pot from the kg/ha rate. Two types of organic fertilizers were used, kraal manure was sourced from the Luyengo animal dairy section while chicken manure was sourced from the poultry section of the Luyengo campus.

The organic and inorganic soil ~~ammendments~~amendments were applied 2 weeks after transplanting (WAT).

Comment [D4]: Why this cultivar? Give its characteristics.

Comment [D5]: It is important to give the details of the cultural practices, so that the experiment can be tested elsewhere, and the pest and disease control may affect the quality of the product.

Comment [D6]: Give more detail of the nutrients and the amount or rates used. How is compare to the recommended 250 kg/ha 15-15-15?

Comment [D7]: It is important to give the quantity or rates used and why these rates? In the abstract a recommendation of 60t/ha is given. It is expected to see in this section what the quantity used.

Samples were analysed for pH status at the Malkerns Research Station Soil Testing Unit. It was found that adjustments were necessary at the rate of 1 tonne per hectare. The pH was below the acceptable level as it was found to be 5.1. The pH had to be raised to acceptable levels of 5.5 – 7.0.

Comment [D8]: What is the nature of the material used? What the quantity per pot, and how did you calculate it?

Table 2: Nutrient composition per 1kg of poultry manure

Comment [D9]: The nitrogen level is not given, why?

Comment [D10]: What is the source? Did you analyse samples or it come from literature, if so give the reference.

Nutrient	Concentration per kg of manure
Iron	256mg
Cadmium	20mg
Zinc	72mg
Copper	96mg
Manganese	20mg
Phosphorus	180mg
Potassium	84mg
Magnesium	240mg
Calcium	1372mg
pH	6.92

Comment [D11]: Is it P_2O_5 or P?

Comment [D12]: Is it K_2O?

Table 3: Nutrient composition per 1kg of cattle manure

Comment [D13]: I suggest to check these composition as the difference with the poultry manure is very high.

Nutrient	Concentration per kg of manure

Iron	0.19mg
Cadmium	0.02mg
Zinc	0.11mg
Copper	0.12mg
Manganese	0.02mg
Phosphorus	0.18mg
Potassium	0.14mg
Magnesium	0.38mg
Calcium	2.04mg
pH	6.97

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Experimental Design: The experiment was a 1x3 factorial experimental laid in a randomized complete block design (RCBD) with three types of fertilizers for nutrition. Plant pots were arranged in blocks and were laid down on the ground in the lath house with 80% light transmission.

Comment [D14]: Factorial treatment structure will have at least two factors, you cannot call have a 1 have 1 x3 factorial.

Data Collection and Analysis: Data were taken on a fortnightly basis and recorded until harvest and through postharvest. Three plants per pot? were randomly selected at the beginning of the experiment in each of the replications and the following parameters were measured from 4 WAT to 9 WAT at one week interval ? : plant height, number of leaves, leaf area index, time to flowering, number of flowers, number of fruits harvested per plant, fruit weight(g), percentage of nonmarketable fruits, shoot and root dry mass determined at harvest time?. Explain how leaf area and leaf area index have been calculated.

Data collected were analysed using MSTAT-C (Nissen, 1989). Analysis of variance (ANOVA) was done on plant height, number of leaves, leaf area, leaf area index, number of flowers, number of fruits produced, number of harvested fruits, fruit weight, percentage of non-marketable fruits, and shoot to root ratio. Mean separation was done using Duncan's New Multiple Range Test (DNMRT) where the F test showed significant differences (Gomez and Gomez, 1994).

RESULTS

First give the ANOVA table that give the significance level of the effect for each measured variable at a given time.

Plant height: Plant height increased steadily in the different fertilizer treatments with plant growth up to 9 WAT. Plant height was significantly ($P<0.05$) affected by the different fertilizers. The highest plant height of 46 cm was obtained in chicken manure treatment whilst the lowest (8cm) was obtained in control 9 (WAT) (Figure 1). There was no significant difference ($P<0.05$) in plant height of pepper treated with 2:3:2(37) and chicken manure in block 2 after 9 WAT, but both were significantly higher than plants treated with kraal manure and control.

Comment [D15]: The results must be the average of all the blocks. You can show from in the ANOVA table that there were significant difference among blocks.

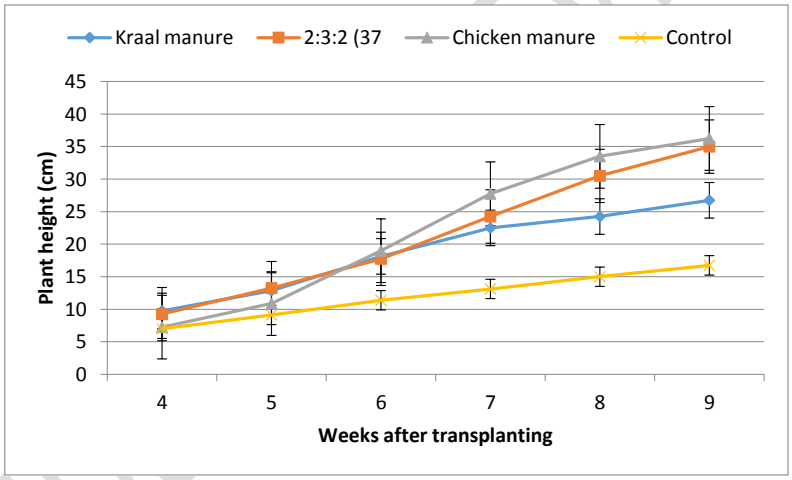

Figure 1: Effects of different fertilizers on plant height of green pepper. Bars are standard error below and above the mean.

Number of leaves: The number of leaves per plant was significantly (P<0.05) affected by the different fertilizers. Plants treated with synthetic fertilizer (2:3:2 (37) had the highest number of leaves while those treated with kraal manure had the lowest number of leaves (22) (Figure 2). However there was no significant (P > 0.05) difference in the number of leaves produced by green pepper treated with kraal manure and chicken manure (15 and 17 respectively) at 6 WAT.

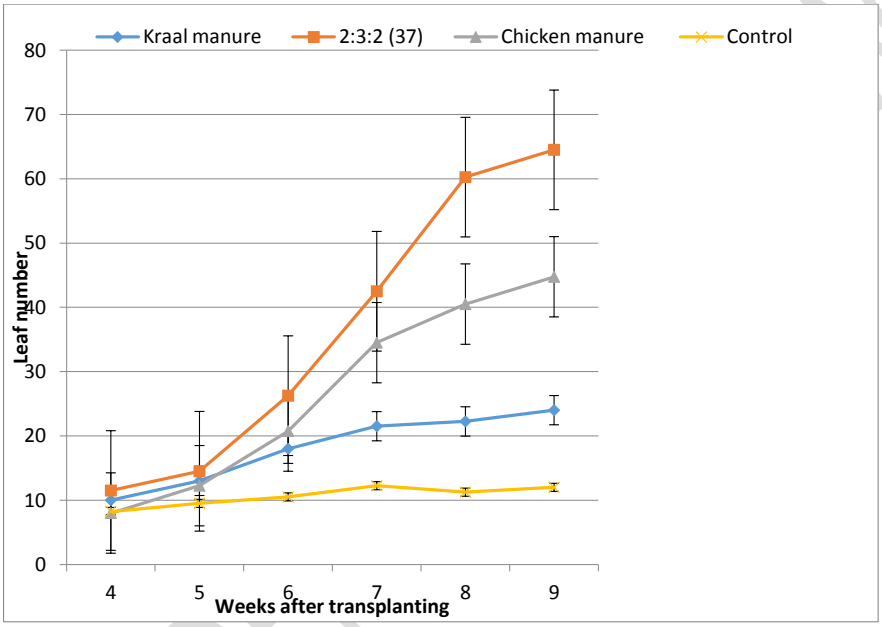

Figure 2: Effects of different fertilizers on number of leaves of green pepper. Bars are standard error below and above the mean.

Leaf area: There were significant (P<0.05) differences in leaf area of green pepper plants for the various fertilizer treatments. Plants treated with synthetic fertilizer (2:3:2 (37) had the highest leaf area than in kraal manure but not significantly (P>0.05) higher from pepper treated with chicken manure at 9 WAT (Figure 3).

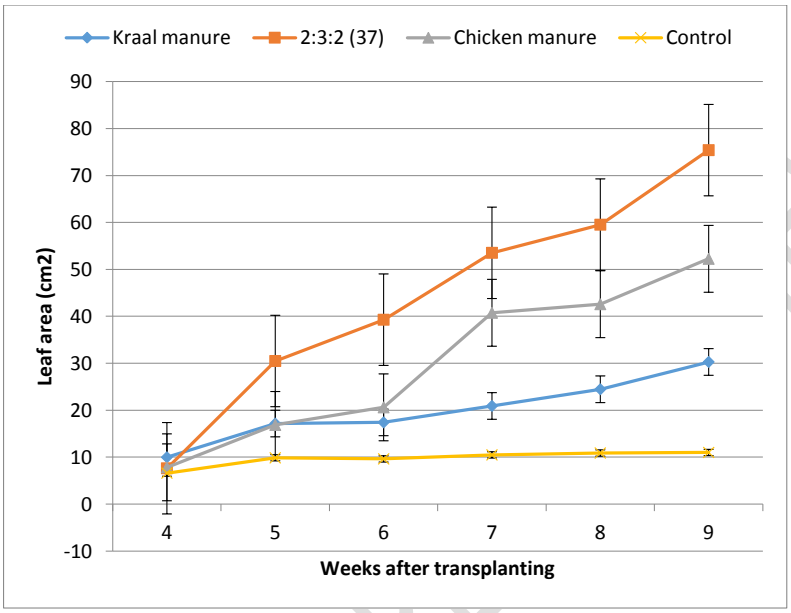

Figure 3: Effects of different fertilizers on leaf area of green pepper. Bars are standard error below and above the mean.

Leaf area index: The leaf area index (LAI) was significantly (P<0.05) affected by the different fertilizers. Plants treated with synthetic fertilizer (2:3:2 (37) had the highest LAI (13.6 cm) cm than those treated with kraal manure and chicken manure. Plants treated with kraal manure had the lowest LAI (6.7cm) (Figure 4).

Comment [D16]: Is this true for all the measurements time?

Comment [D17]: In the Materials and Methods section, show how leaf area index is calculated and what it is the unit? LAI is not the ration leaf area to soil surface/ground ?

Figure 4: Effects of different fertilizers on LAI of green pepper plants. Bars are standard error below and above the mean.

Number of flowers: There were significant (P<0.05) differences in number of flowers produced per plant treated with different fertilizers. Plants treated with ~~synthetic~~ inorganic fertilizers (2:3:2 (37) and chicken manure produced significantly (P<0.05) higher number of flowers (26) than plants treated with kraal manure (17) (Figure 5). A variation in the flowering dates among the treatments was observed. Plants treated with 2:3:2(37) flowered first at 35 days after transplanting (DAT), followed by plants treated with chicken manure (39 DAT) and green pepper treated with kraal manure flowered last at (42 DAT).

Comment [D18]: What about the date of 50% flowering? When did the plants reached this for all the treatments?

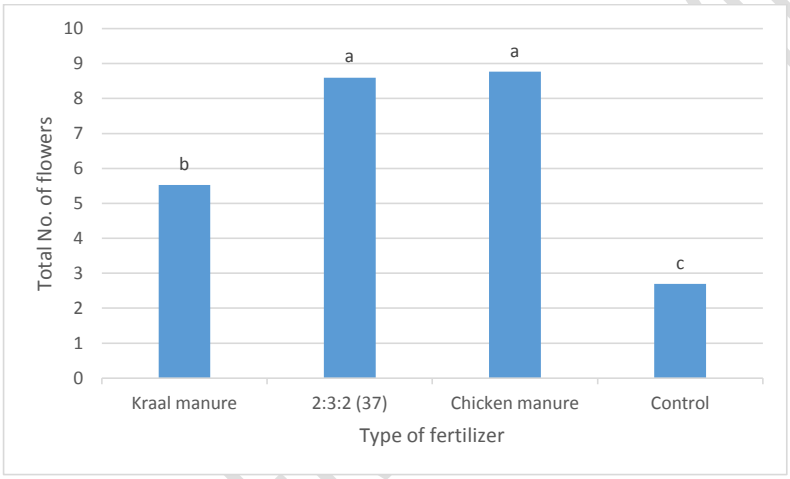

Figure 5: Total number of flowers on plants from different fertilizer treatments

Bars with the same letters are not significantly different (P>0.05) from one another. Mean separation by Duncan's New Multiple Range (DNMRT).

Fruit number: There were significant (P<0.05) differences in the number of fruits produced by green pepper plants treated with the different fertilizers. Plants treated with chicken manure produced the highest number of fruits (28) followed by pepper treated with 2:3:2 (37) at (25) while lowest number of fruits were obtained from fruits treated with kraal manure (16) (Figure 6). However the number of harvested fruits was significantly (P<0.05) affected by the different fertilizer treatments (Figure 7). Highest number of harvested fruits- per plant or per pot? (9.8) was obtained in pepper treated with 2:3:2(37) and chicken manure and the lowest were obtained in pepper treated with kraal manure (3.5).

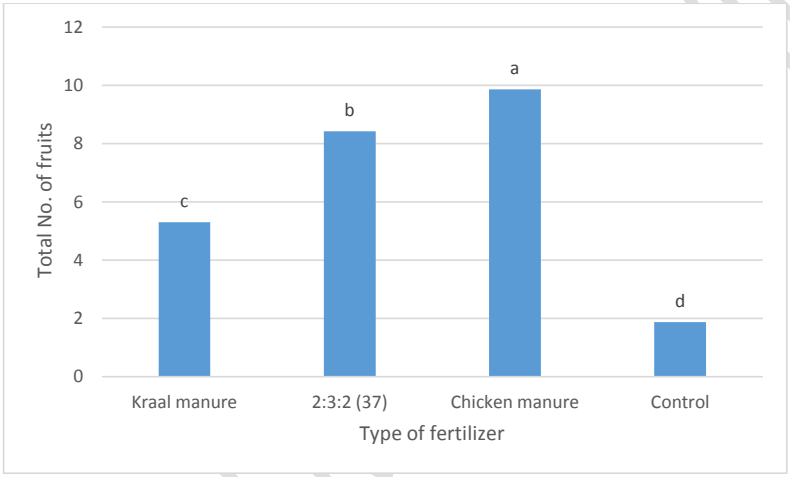

Figure 6: Total number of fruits produced by plants from different fertilizer treatments

Bars with the same letter are not significantly different (P>0.05) from one another. Mean separation by Duncan's New Multiple Range Test (DMRT).

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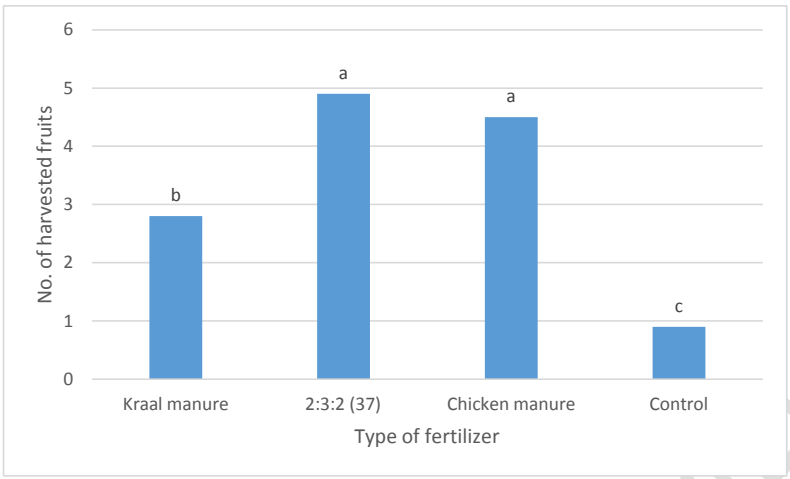

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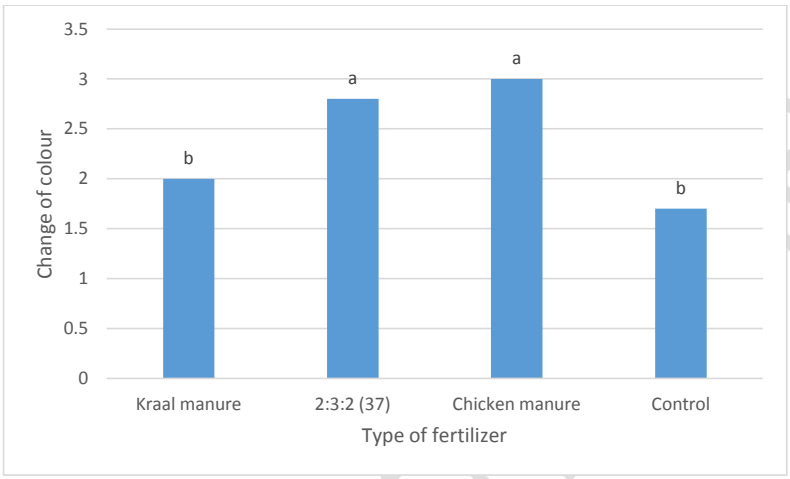
210 Figure 7: Effects of different fertilizers on total number of harvested fruits

211 Bars with the same letter are not significantly different (P>0.05) from one another. Mean

212 separation by Duncan's New Multiple Range Test (DNMRT).

213 **Change of colour:** The change of colour of fruits stored at room temperature was
214 significantly (P<0.05) affected by the different fertilizer treatments (Figure 8). The highest
215 change of fruit colour was observed on fruits from plants previously treated with chicken
216 manure (3) and the lowest was obtained on fruits from plants previously treated kraal manure
217 (2)



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219 Figure 8: Effects of fertilizer treatments on colour change of fruits from green to red stored at
220 room temperature. Bars with the same letters are not significantly different (P> 0.05) from
221 one another. Mean separation by Duncan's New Multiple Range Test (DN MRT).

Fruit Shrinking: The different fertilizer treatments significantly (P<0.05) affected the shrinkage of fruits during storage. Fruits harvested from chicken manure and synthetic fertilizer (2:3:2 (37) showed a significant difference in the number of fruit shrinking. Fruits treated with 2:3:2(37) started to shrink 3 days after harvest (DAH) while those treated with chicken manure started to shrink at 6 DAH (Figure 9).

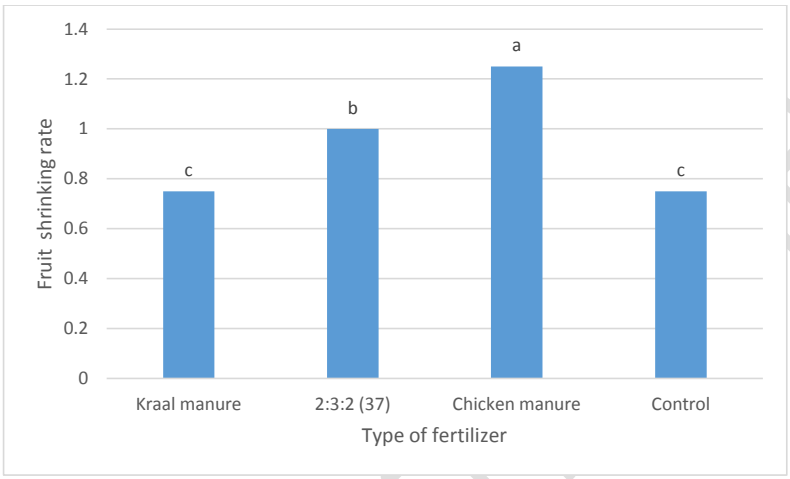

Figure 9: Effects of the different fertilizers on the rate of shrinking of pepper harvested and stored at room temperature. Bars with the same letter are not significantly different (P>0.05) from one another. Mean separation by Duncan's New Multiple Range Test (DNMRT).

Fruit Decay: The different fertilizer treatments significantly (P<0.05) affected the rate of fruit deterioration when stored at room temperature. Fruits fertilized with 2:3:2 (37) and chicken manure had a 100% fruit decay/ rot at 14 days after harvest (DAH), while fruits from plants fertilized with kraal manure started to rot 21 DAH (Figure 10).

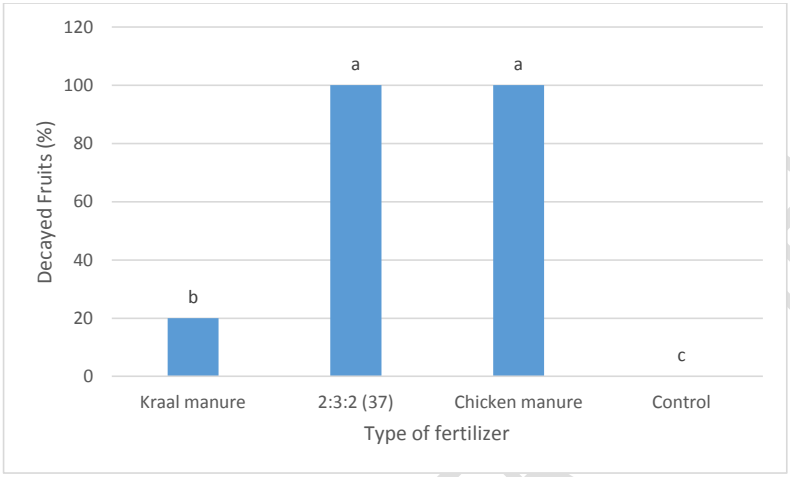

Figure 10: Percentage of decayed fruits at 21 days after harvest (DAH). Bars with the same letters are not significantly different (P>0.05) from one another.

DISCUSSION

Different types of organic and inorganic fertilizers had varying effects on the growth and yield of green pepper. The highest leaf number was recorded in plants grown from ~~chemical~~inorganic~~-~~ inorganic fertilizer applied at recommended rates of 370kg which was significantly (P<0.05) different from chicken manure applied at 40 t/ha and the lowest was obtained from the kraal manure at 60t/ha.

These differences may be due to the fact that the growth medium of all the treatments were added with the same amounts of sawdust that ensured the same water holding capacity in all blocks and that the treatments of ~~chemical~~inorganic~~-~~inorganic fertilizers had nutrients readily

Comment [D20]: You did not compare the fertilizer treatment with the control.

Comment [D21]: This must be given in the Materials and Methods section with indication of the rate per pot.
In the introduction line 53 the recommended rate is 250kg/ha 15-15-15.

Comment [D22]: This must be given in the Materials and Methods section with indication of the rate per pot.

Comment [D23]: This must be given in the Materials and Methods section with indication of the rate per pot.

available for uptake by plants. The other two treatments had to undergo organic matter breakdown by micro-organisms before nutrients were released for plant uptake thus delaying the availability of nutrients (Jacobs *et al*., 2003). As the number of weeks increased a steady increase was obtained from the organic fertilizer treatments. Most probably as the manure decomposed the nutrient availability was increased and that the water holding capacity increased in the manure treatments. Replacement of ~~chemical~~inorganic fertilizer by organic manures has been reported to enhance soil biological activity, efficiency and the rate of microbial substrate use (Van Averbeke and Yoganathan, (2003). Increased vegetable yield with the use of manure have been previously reported for okra (Ogunlela *et al*., 2005).

The mean leaf area and yield between the three treatments showed some variations. Overall ~~chemical~~inorganic~~–~~ inorganic fertilizer applied at 370kg/ha had the highest leaf area and yield. However yield of pepper fertilized with ~~chemical~~inorganic fertilizer was not significantly ($P>0.05$) different from that of chicken manure fertilizer plants. Kraal manure fertilized plants had the lowest mean leaf area and yield compared to the other treatments. These results showed that the release of nutrients for plant utilization was delayed. If the organic fertilizers were given enough time to decompose before planting the results would possibly have been different as reported by (Gandy *et al*., 2002).

The rate of shrinking of harvested fruits fertilized with ~~chemical~~inorganic manure was significantly ($P<0.05$) different from those grown with chicken manure and the least affected was kraal manure fertilized plants. This trend was also evident in the total number of days it took the fruits to start rotting when stored at room temperature.

After 21 days after transplanting a 100% rotting of stored fruits was recorded for fruits previously fertilized with chicken manure and ~~chemical~~inorganic fertilizers. This may be due

to the increased content of elements than in kraal manure which recorded 20% at the same number of days (Ferguson and Ziegler, 2004)

CONCLUSIONS AND RECOMMENDATIONS

The results of this study showed that the highest growth rate and yield of green pepper was obtained in plants treated with chicken manure (60 t/ha) but the highest yield was obtained in the ~~chemical~~inorganic fertilizer treatment followed by chicken manure which both had a 100% rot rate at 21 days of storage compared to the 20% of kraal manure in the same number of storage days.

Comment [D24]: You did not compare the fertilizer treatments with the control which seems to be the best in term of storage?! The control treatment needs to be considered in all the comparisons.

The applications of kraal manure at 60 t/ha are recommended for farmers to obtain products with a higher shelf life. Consumers who do not have the necessary storage means will benefit by just storing their vegetables at room temperature. The results suggest that it is possible to produce higher vegetables yield with longer shelf life through organic farming than that of conventional farming with inorganic fertilizer. It is recommended that more research be conducted to establish the optimum period of applying organic fertilizer before planting and to validate the recommendation.

The study was conducted using pots (not a field study) one season and in a single site, not repeated in space (in other locations) and in time (other season), and in the Materials and Methods section you did not give indication on how representative is the site (soil conditions) and how representative of the season (climate) for pepper production conditions, draw recommendation from this study will be to too pretentious.

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