

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

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Authors' contributions

This work was carried out in collaboration among all authors. Author TRK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MTM and PKW managed the analyses of the study. Author TOO managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2019/v11i130043

Editor(s):

(1) Dr. Ali E Sharief, Professor, Department of Agronomy, Faculty of Agriculture, Mansoura University, Mansoura, Egypt.

Reviewers:

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(3) Rahim Foroughbakhch, University of Nuevo Leon, Mexico.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/50769>

Received 11 June 2019

Accepted 29 August 2019

Published 16 September 2019

Original Research Article

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 Eswatini 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 included kraal manure applied at 60 t/ha, [NPK (2:3:2) 37] at 370 kg/ha, chicken manure at 40 t per hectare and the control with no amendment. The results

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showed that growing pepper using the four 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 followed in decreasing order by chicken manure, kraal manure and lastly peppers which did not receive any amendment. There were no significant difference in the growth rate of pepper in the inorganic fertilizer and chicken manure treatments. Similarly, there was no significant difference of pepper grown with chicken manure and chemical fertilizer in the number of days it took the harvested pepper to reach 100% decay stored at room temperature for 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. Although the control had the least decay, the yield was the lowest thus it is not recommended. Kraal manure at 60 t/ha is recommended in the production of pepper with a longer shelf life.

Keywords: *Kraal manure; chicken manure; inorganic fertilizer; Capsicum annum L.; pepper.*

1. INTRODUCTION

Green pepper (*Capsicum annum L.*) is amongst the most important vegetables grown in most countries with warm climate. 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 [1,2].

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. The number and frequency of irrigation will depend on the type of soil, developmental stage of the plant, atmospheric temperature and humidity [1].

Vegetables such as green pepper are very important nutritionally and economically in Eswatini. 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 [1]. The challenges observed though are those of proper nutrition for specific vegetables. It is important to ensure that there is enough 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 Eswatini 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 use commercial (inorganic) fertilizers. Inorganic fertilizers commonly used by farmers in Eswatini 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 [1], but it is wise to test the soil for nutrient status and apply fertilizers/soil amendments as recommended. Previously the use of animal manure in the production of vegetables has been investigated [3,4].

Eswatini 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.

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 [2]. 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. The objective of the study was to find out the effects of different fertilizers on yield and quality of pepper.

2. MATERIALS AND METHODS

2.1 Experimental Site

This experiment was conducted in the lath house of the Horticulture Department, University of Eswatini, 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 [5]. The soil was mixed with sand to create a sandy loam [6].

2.2 Plant Material

Six week old green pepper seedlings of the cultivar 'Mayo' were obtained from Vickery Seedlings, Malkerns. 'Mayo' was chosen because it is a popular green bell pepper cultivar.

2.3 Experimental Design

The seedlings were transplanted on the 2nd November 2012 transplanted in pots (one seedling per pot) 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 treatments, fourpots per row and replicated 4 times. The treatments were of kraal manure applied at 60 t/ha, 2:3:2 (37) at 370 kg/ha and chicken manure at 40 t/ha. The plants were provided with optimal growing conditions, and all cultural practices according to need, for example irrigation, weeding, and pest and disease control.

Three types of nutrition sources were used as treatments, i.e., NPK (2:3:2) (37) was used as a source of inorganic fertilizer. Two types of organic fertilizers were used, which included kraal and poultry manures. The organic and

inorganic soil amendments were applied two weeks after transplanting (WAT).

Chicken and cattle (kraal) manure samples were analysed for pH status at the Malkerns Research Station, Soil Testing Unit. The results were as shown in Tables 1 and 2.

Table 1. Nutrient composition per 1 kg of chicken manure

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

Table 2. Nutrient composition per 1 kg of cattle manure

Nutrient	Concentration per kg of manure
Iron	0.19 mg
Cadmium	0.02 mg
Zinc	0.11 mg
Copper	0.12 mg
Manganese	0.02 mg
Phosphorus	0.18 mg
Potassium	0.14 mg
Magnesium	0.38 mg
Calcium	2.04 mg
pH	6.97

The experiment was laid in a Randomized Complete Block Design (RCBD) with three types of fertilizers for nutrition, the control had no fertilizer applied as what is sometimes practiced by the resource poor farmers. Plant pots were arranged in blocks and were laid down on the ground in the lath house with 80% light transmission.

2.4 Data Collection and Analysis

Data were taken on a fortnightly basis and recorded until harvest and through postharvest. Three plants were randomly selected at the beginning of the experiment in each of the replications and the following parameters were measured: plant height, number of leaves, leaf area index, time to flowering, number of flowers, number of fruits harvested per plant, fruit weight, percentage of non-marketable fruits, and shoot

and root dry mass. Leaf area index (LAI) was calculated as follows: $LAI = \frac{\text{leaf area (cm}^2\text{)}}{\text{land area (cm}^2\text{)}}$.

Data collected were analysed using MSTAT-C [7]. 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) at $P = 0.05$, where the F test showed significant differences [8].

3. RESULTS

3.1 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 (8 cm) was obtained in control plants 9 (WAT) (Fig. 1). There were no significant ($P > 0.05$) differences in plant height of pepper treated with NPK (2:3:2) (37) and chicken manure after 9 WAT, but both were significantly ($P < 0.05$) higher than plants treated with kraal manure or control.

3.2 Number of Leaves

The number of leaves per plant was significantly ($P < 0.05$) affected by the different fertilizers. Plants treated with inorganic fertilizer NPK (2:3:2) (37) had the highest number of leaves while those treated with kraal manure had the lowest number of leaves (22) (Fig. 2). However, there was no significant ($P > 0.05$) difference in the number of leaves produced by green pepper treated with kraal manure or chicken manure at 6 WAT.

3.3 Leaf Area

There were significant ($P < 0.05$) differences in leaf area of green pepper plants for the various fertilizer treatments. Plants treated with inorganic fertilizer NPK (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 (Fig. 3).

3.4 Leaf Area Index

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

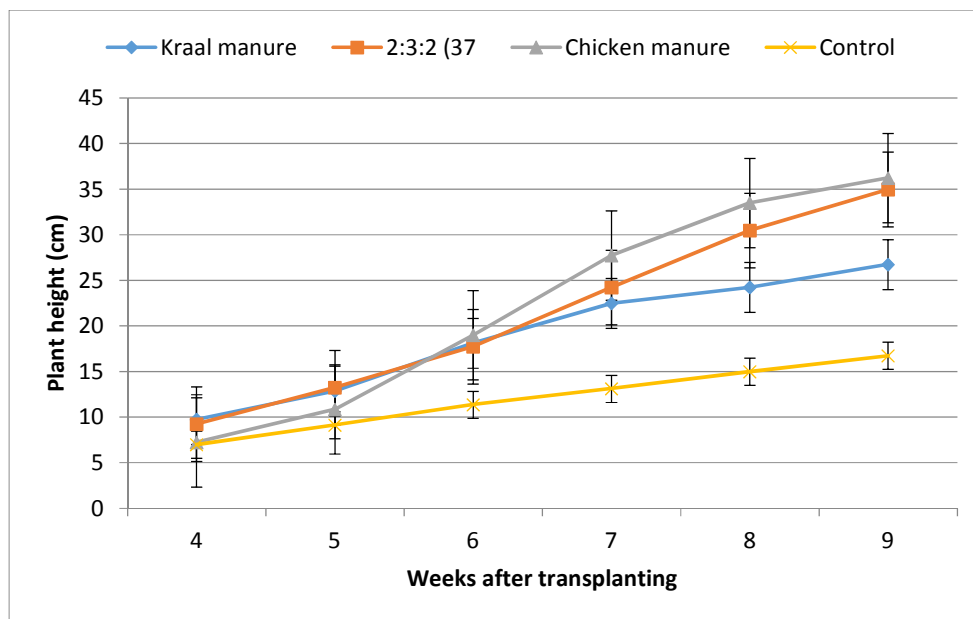


Fig. 1. Effects of different fertilizers on plant height of green pepper
Bars are standard error below and above the mean

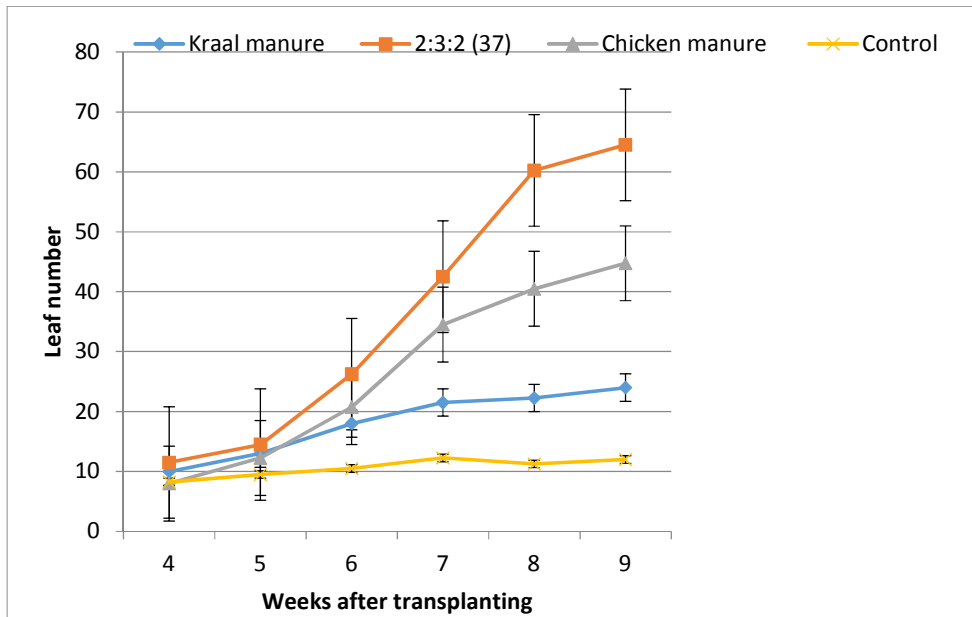


Fig. 2. Effects of different fertilizers on number of leaves of green pepper
Bars are standard error below and above the mean

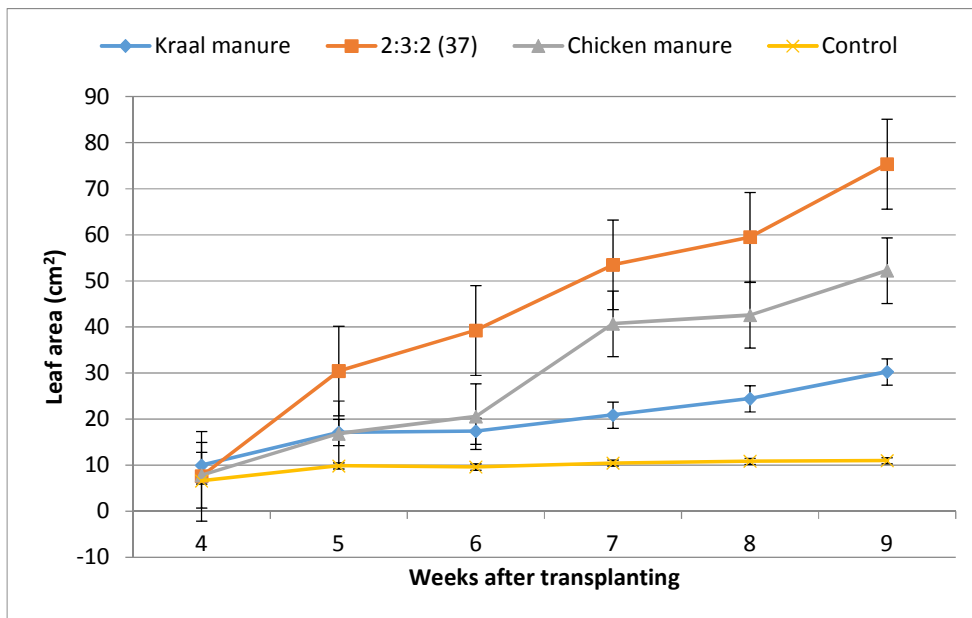


Fig. 3. Effects of different fertilizers on leaf area of green pepper
Bars are standard error below and above the mean

3.5 Number of Flowers

There were significant ($P < 0.05$) differences in number of flowers produced per plant treated with different fertilizers (Fig. 5). Plants treated with inorganic fertilizers NPK (2:3:2) (37) and

chicken manure produced significantly ($P < 0.05$) higher number of flowers (26) than plants treated with kraal manure (17) (Fig. 5). A variation in the flowering dates among the treatments was observed. Plants treated with inorganic fertilizer 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).

3.6 Fruit Number

There were significant ($P < 0.05$) differences in the number of fruits produced by green pepper plants treated with the different fertilizers (Fig. 6). Plants treated with chicken manure produced the highest number of fruits (28) followed by pepper treated with NPK (2:3:2) (37) at (25) while lowest number of fruits were obtained from fruits treated with kraal manure (16) (Fig. 6). However, the number of harvested fruits was significantly ($P < 0.05$) affected by the different fertilizer treatments (Fig. 7). Highest number of harvested fruits (9.8) per sample of three plants 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).

3.7 Change of Colour

The change of colour of fruits stored at room temperature was significantly ($P < 0.05$) affected by the different fertilizer treatments (Fig. 8). The

highest change of fruit colour was observed on fruits from plants previously treated with chicken manure (3) and the lowest was obtained on fruits from plants previously treated kraal manure (2).

3.8 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 NPK (2:3:2) (37) started to shrink 3 days after harvest (DAH) while those treated with chicken manure started to shrink at 6 DAH (Fig. 9).

3.9 Fruit Decay

The different fertilizer treatments significantly ($P < 0.05$) affected the rate of fruit deterioration when stored at room temperature. Fruits fertilized with NPK (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 (Fig. 10).



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

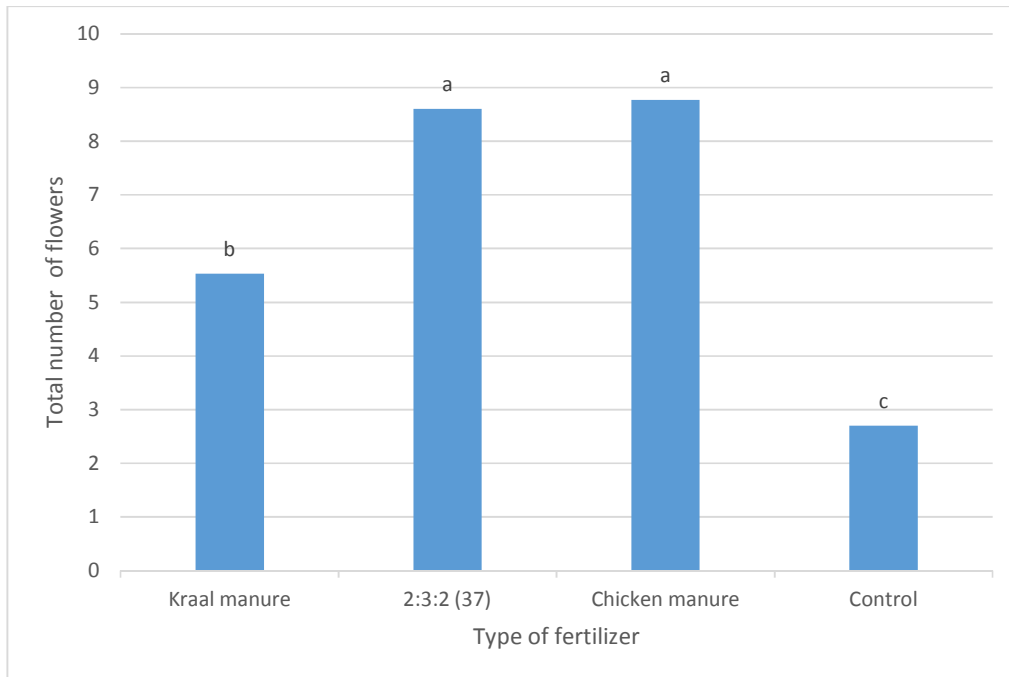


Fig. 5. Total number of flowers on plants from different fertilizer treatments
Bars with the same letters are not significantly different ($P>0.05$) from one another. Mean separation by Duncan's New Multiple Range (DNMRT).

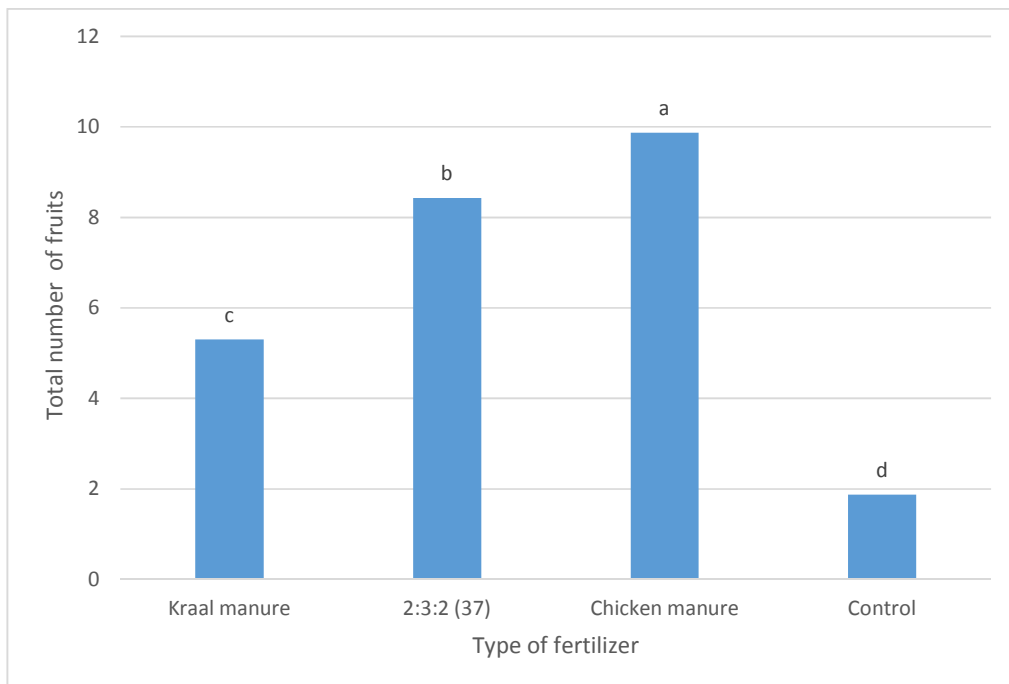


Fig. 6. Total number of fruits produced by plants from different fertilizer treatments
Bars with the same letter are not significantly different ($P>0.05$) from one another. Mean separation by Duncan's New Multiple Range Test (DMRT)

4. 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 inorganic fertilizer applied at recommended rates of 370 kg which was followed in decreasing order by chicken manure applied at 40 t/ha, the kraal manure at 60 t/ha the lowest in plants where was no amendment.

These differences may be due to the fact that the growing 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 inorganic fertilizers had nutrients readily 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 [9]. 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 inorganic fertilizer by organic manures has been reported to enhance soil biological activity, efficiency and the rate of microbial substrate use [10]. Increased vegetable

yield with the use of manure have been previously reported for okra [3].

The mean leaf area and yield between the three treatments showed some variations. Overall inorganic fertilizer applied at 370 kg/ha had the highest leaf area and yield. However yield of pepper fertilized with inorganic fertilizer was not significantly 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 [11,12].

The extent of shrinking of harvested fruits fertilized with inorganic fertilizer was significantly 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 harvesting a 100% rotting of stored fruits was recorded for fruits previously fertilized with chicken manure and 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 [13].

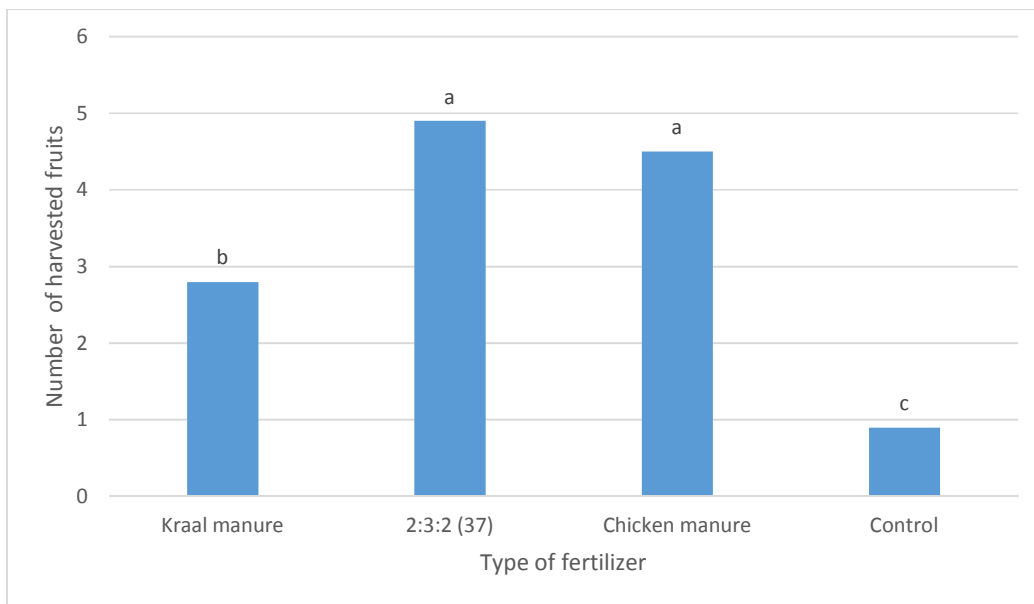


Fig. 7. Effects of different fertilizers on total number of harvested fruits

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)

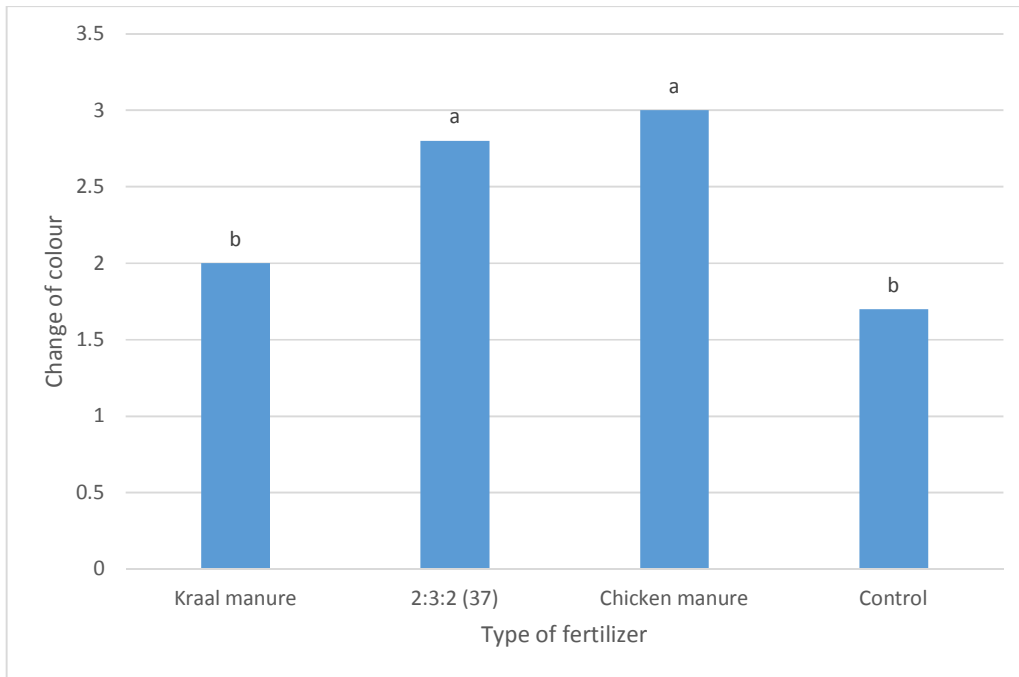


Fig. 8. Effects of fertilizer treatments on colour change of fruits from green to red stored at room temperature

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

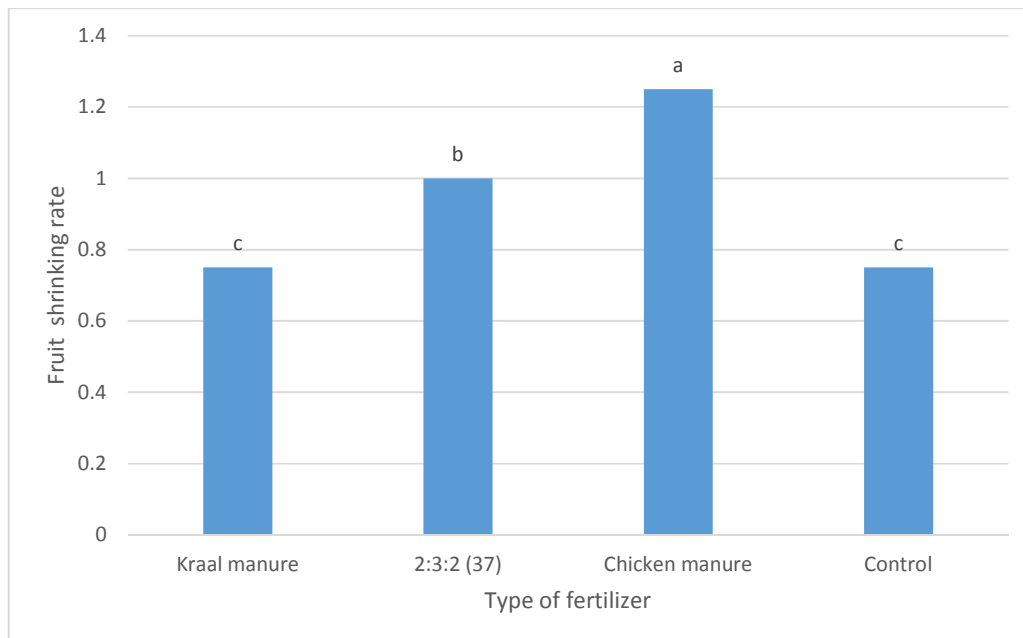


Fig. 9. Effects of the different fertilizers on the rate of shrinking of pepper harvested and stored at room temperature

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)

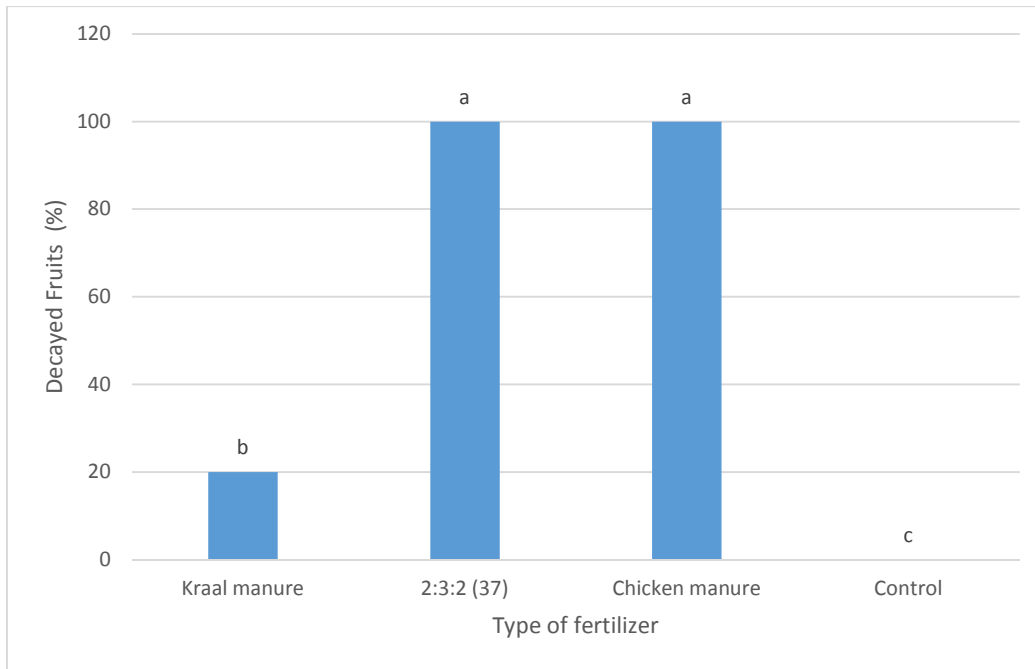


Fig. 10. Percentage of decayed fruits at 21 days after harvest (DAH)
 Bars with the same letters are not significantly different ($P>0.05$) from one another

5. CONCLUSION AND RECOMMENDATION

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) or in the inorganic fertilizer treatment followed by kraal/cattle manure and lastly the control. Chicken manure or inorganic fertilizer treatment resulted in a 100% rot rate after 21 days of storage compared to the 20% in kraal manure treated plants. It is recommended that more research be conducted to establish the optimum period of applying organic fertilizer before planting and to validate the recommendation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

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