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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)

Tandzisile Z. Mabuza[1], Michael T. Masarirambi[1*], Kwanele A. Nxumalo[1] and Paul K. Wahome[1]

[1]Department of Horticulture, Faculty of Agriculture, University of Eswatini, P.O. Luyengo M205, Luyengo, Eswaini, Eswatini.

Authors' contributions

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

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ABSTRACT

Green pepper (*Capsicum annuum* L.) is an important vegetable in the Kingdom of Eswatini. However, there is rare information on pepper production using cattle manure. The experiment was conducted at the University of Swaziland, Luyengo Campus, in the Horticulture Department Lath-house to determine the effects of different rates of cattle manure on the growth and yield of green pepper in order to come up with a suitable application rate for green pepper. Cattle manure was applied at different rates of 20, 40, 60 and 80 tons/ha in a Randomized Complete Block Design, while 2:3:2 which was used as a control was applied at 150 kg/ha. For every increase in the application level/rate of the cattle manure, there was a considerable increase in the growth

**Corresponding author: Email: mike@uniswa.sz;*

parameters that were measured. Results obtained from this experiment indicate that applying cattle manure at 80 tons/ha gave relatively higher yields. This cattle manure rate can be used by farmers in green pepper production.

Keywords: Cattle manure; application rate; Capsicum annum L; sub-tropical environment.

1. INTRODUCTION

According to Norman [1], green pepper (*Capsicum annuum* L.) is a herb or sub-shrub which has white corolla and produces only one pedicel per node. Green pepper belongs to the family, Solanaceae. The erect branching stems may attain a height of 30 to 150 cm [1,2,3,4]. Mature green sweet peppers contain about 93% moisture content. Sweet peppers are used as a vegetable either raw in a salad or cooked in stews and soups [1].

Green pepper is not affected by photoperiod but it does not tolerate high temperatures that is why it grows well in regions between 400-600 m in altitude and coastal regions especially during the cool, dry season [5]. The day temperatures should be between 21 and 25ºC, while the night temperatures should be 18 and 20ºC [6].

Hegde [7] reported that the continuous application of chemical fertilisers alone without the use of organic manures has deteriorated soil health in terms of chemical, physical and biological characters resulting in a decline in crop yield. On the other hand, organic manures such as farmyard manure, sheep manure, poultry manure and compost are known to have beneficial effects on soil health but their limited nutrient content and their availability in large amounts is a constraint for their wider usage [7,8].

Maintenance of soil fertility has been established as a prerequisite for sustainable crop production and increased yield and organic manure has been reported to play a vital role in this regard [8-13].

Most farm inputs especially fertilisers have become very expensive for local farmers to purchase and also there have been concerns of residual effects of the chemical or synthetic fertilisers which have resulted in farmers shifting back to using cattle manure which is an organic fertiliser and is readily available. The international market standards have changed because consumers now prefer organically produced vegetables. However, farmers are not sure of the rate of cattle manure to apply for relatively better growth and yield of specific crops. Therefore, this research provides the basis for assessing the effects of different application rates of cattle manure on green pepper production under sub-tropical conditions.

Organic fertiliser application rate is one of the difficult decisions to be taken by farmers in communities, especially the small scale farmers in rural areas. Farmers are always willing to increase their yield but at the same time, they want to use relatively cheaper and environmentally friendly fertilisers. Hence, this study attempted to determine the appropriate application rate of cattle manure which produces the highest yield in green pepper.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out in the lath-house of the Horticulture Department, Faculty of Agriculture and Consumer Sciences, Luyengo Campus of the University of Swaziland. Luyengo is under Manzini Region in the Middleveld agro-ecological zone. Luyengo is located at 26º34 S and 31º12 E. The average altitude of this area is 750 m above sea level, rainfall 800 mm/year and the average temperature is 21ºC [14]. The net for the lath-house was purchased in South Africa and has 70% shading.

2.2 Plant Material

Green pepper seedlings of the cultivar 'California Wonder' were bought from Vickery seedlings (Malkerns, Swaziland). The seedlings were eight weeks old.

2.3 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD). Cattle manure was applied at 20, 40, 60, and 80t/ha four weeks before transplanting of seedlings with the control being inorganic fertiliser 2:3:2 (22) applied at 150 kg/ha as basal dressing and 350 kg/ha top dressing of limestone ammonium nitrate four weeks after transplanting. The control was equally split and applied at 2 and 6 weeks after transplanting (WAT). Cattle manure was taken from Mafutseni area which is in the Middleveld of

Swaziland and analysed in the chemistry laboratory at Luyengo Campus.

Soil analysis for pH, exchangeable acidity, phosphorus, potassium, and magnesium was done in the Chemistry laboratory. After that soil, heat treatment was done and finally, the soil was mixed with cattle manure in plastic bags. This was done four weeks before planting to give it time to decompose. The total treatments were five including the control and also four replications of thirty-five plants each (Table 1).

Table 1. Treatments used in this experiment

Treatment code	Growth Media
1	Inorganic fertilizer (control)
2	20t/ha cattle manure
3	40t/ha cattle manure
4	60t/ha cattle manure
5	80t/ha cattle manure

All leaves of five randomly selected plants were measured. Leaf area was calculated using the formula used by Pandey & Singh [15].

LA= α (LW)

Leaf Area= 0.690(leaf length × leaf width)

Where α= Correction factor

2.4 Data Collection

Data were collected after every two weeks on five randomly selected plants, starting from 3 WAT till harvesting on the number of leaves, plant height, leaf length, leaf width, stem girth, and fruit diameter. A measuring tape was used to measure plant height while for leaf length and width a 30 cm ruler was used and veneer callipers for stem girth. Pepper fruits were harvest in March after 75 days to maturity.

2.5 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using the statistical package GEN-STAT [16]. Where significant differences were detected, the mean separation was done by Duncan's New Multiple Range Test (DNMRT) [17].

3. RESULTS

3.1 Soil Analysis Results

The results of the soil analysis are shown in Table 2.

Table 2. Chemical composition of soil used in the experiment

Parameters	value
pH	5.90
Exchangeable acidity (meq/100 g)	0.45
P (mg P/kg)	20.70
K (Cmol c^{-}/ Kg)	1.21
Mg (Cmol c^{-}/ Kg)	0.58

3.2 Cattle Manure Analysis

The results of the cattle manure analysis are shown in Table 3.

Table 3. Chemical properties of cattle manure used in the experiment

Parameter	Value
pH	8.04
Ca (Cmol c/kg)	0.90
Mg (Cmol c/kg)	5.80
K (mg K/kg)	7.85
Mn (Cmol c/kg)	0.04
Cd (Cmol c/kg)	0.00
Cu (Cmol c/kg)	0.04
Zn (Cmol c/kg)	0.02
Fe Cmol c/kg)	1.57
P (mgP/kg)	0.01

3.3 Growth and Development

Growth parameters of pepper plants were measured as previously reported. The results are presented for each growth parameter.

3.4 Height

There were significant ($P<0.05$) differences in plant height across the levels of cattle manure applied. The height of the plants increased as the application rate of cattle manure increased (Fig. 1). Plants supplied with cattle manure at the rate of 80 tons/ha showed the highest plant height and the lowest plant height was observed in those supplied at 20 tons/ha at 9 (WAT). There were no significant ($P>0.05$) differences in height between plants supplied with 2:3:2 (22) and plants supplied with cattle manure at 80 tons/ha at 3 WAT and 5 WAT, however there were significant ($P<0.05$) differences of plant height between the two treatments at 7 and 9 WAT.

3.5 Leaf Area

There were significant ($P<0.05$) differences in leaf area of the green pepper supplied with the different cattle manure rates (Fig. 2). Plants

grown with 2:3:2 (22) had the highest leaf area while plants grown with 20 tons/ha had the lowest leaf area among the different treatments at 9 WAT. There were no significant (P>0.05) differences between leaf area of plants supplied with 20, 40 and 60 tons/ha at 3 WAT. However, there were significant (P<0.05) differences from 5 to 9 WAT.

3.6 Number of Leaves

The results showed that there were significant (P<0.05) differences in the number of leaves across the five treatments. The number of leaves increased with an increased application rate of cattle manure (Table 4). The highest number of leaves was obtained in green pepper supplied with 2:3:2 (22) followed by 80 tons/ha and the lowest in plants supplied with 20 tons/ha. There were no significant (P>0.05) differences between all treatments at 3 WAT, but there were significant (P>0.05) differences from 5 to 9 WAT.

3.7 Stem Girth

There were significant (P<0.05) differences in stem girth of green pepper supplied with different rates of cattle manure (Fig. 3). Plants provided with 20 tons/ha of cattle manure had the lowest stem girth and highest stem girth was observed in plants supplied with 2:3:2 (22). There were no significant (P>0.05) differences in stem girth of plants supplied with 80 tons/ha of cattle manure and plants supplied with 2:3:2 (22) at 3 and 7 WAT, but there were significant (P<0.05) differences at 5 and 9 WAT. There were significant (P>0.05) differences in stem girth of plants supplied with 20, 40 and 60 tons/ha from 3 to 9 WAT.

3.8 Fruit Yield

There were significant (P<0.05) differences in fruit yield of green pepper among treatments. An increase in cattle manure application rate

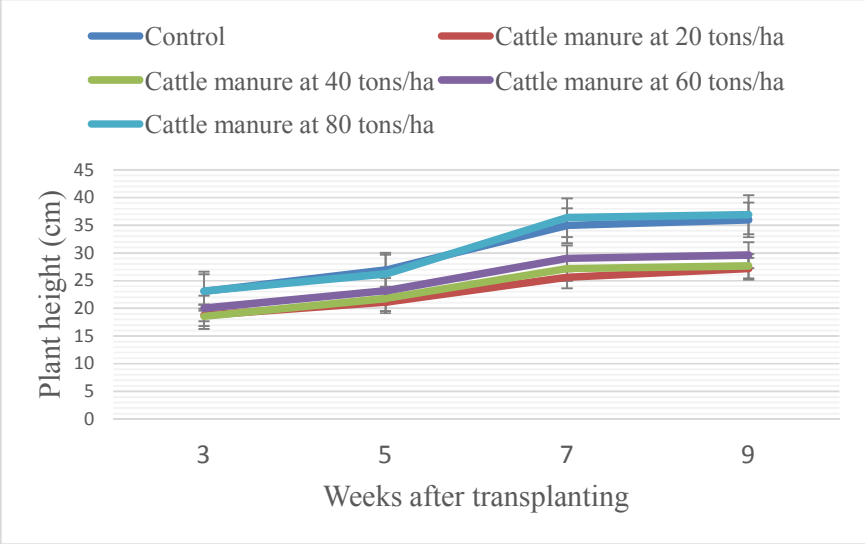

Fig. 1. Effects of different levels of cattle manure on plant height of green pepper. Bars are the standard error (SE) bars above and below the mean

Table 4. Effects of different levels of cattle manure on number of leaves of green pepper

Treatment code	Treatment description	3 WAT	5 WAT	7 WAT	9 WAT
1	Control	7.00a	9.75a	15.75a.	20.00a
2	20 tons/ha	6.25a	7.75b	10.75c	11.00c
3	40 tons/ ha	7.25a	8.50ab	11.50bc	12.50c
4	60 tons/ ha	6.50a	8.75ab	12.50b	14.25b
5	80 tons/ ha	6.50a	9.25ab	14.75a	17.50a
	C.V%	11.00%	14.50%	6.70%	6.70%
	LSD	1.13	1.97	1.36	1.55

Means followed by the same letter in the same column are not significantly different from one another at P = 0.05. Mean separation by Duncan's New Multiple Range Test (DNMRT)

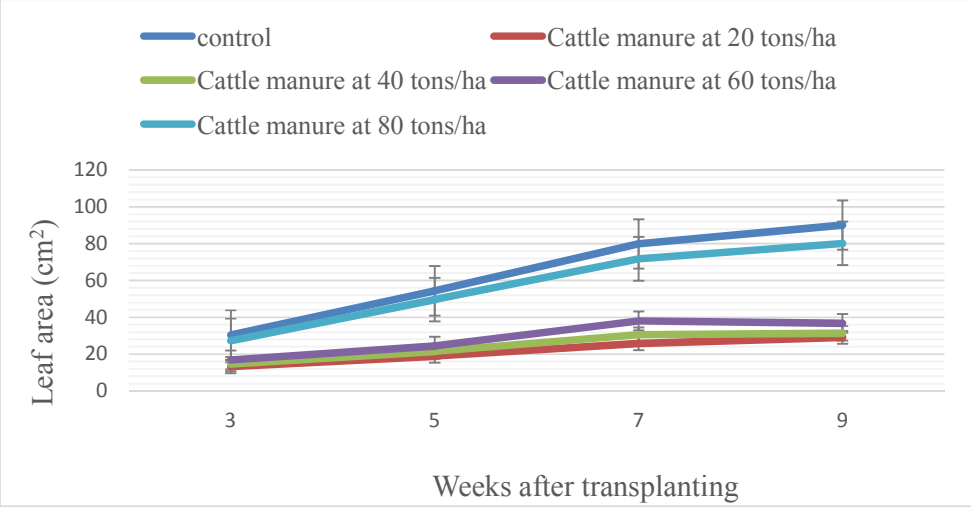

Fig. 2. Effects of different levels of cattle manure on the leaf area of green pepper. Bars are standard error (SE) bars above and below the mean

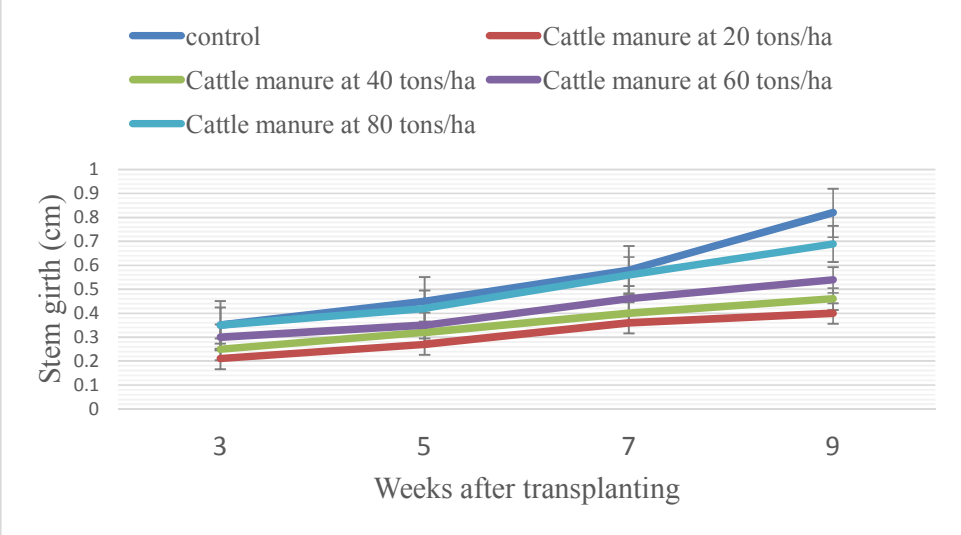

Fig. 3. Effects of different levels of cattle manure on stem girth of green pepper. Bars are the standard error (SE) bars above and below the mean

increased the fruit yield (Fig. 4). The highest fruit yield value was obtained in green pepper supplied with cattle manure at 80 tons/ha and the lowest fruit yield value was obtained in green peeper provided with 20 tons/ha of cattle manure. There were no significant ($P<0.05$) differences between fruit mass of plants supplied with cattle manure at 60 tons/ha and plants supplied with 40 tons/ha cattle manure.

4. DISCUSSION

Increasing the rate of cattle manure increased the growth of measured parameters over time. This was probably because cattle manure contains all the nutrients a plant needs but in low content, thus significantly large volume is required [18]. The lowest plant height was observed in green pepper supplied with cattle manure at 20 tons/ha while the highest was observed in those grown with 80 tons/ha cattle manure.

Plants that were grown using 2:3:2 (22) grew more vegetative but yielded low compared to those where cattle manure was applied at 80 tons/ha. This may probably be because the nutrients in inorganic fertilisers are readily

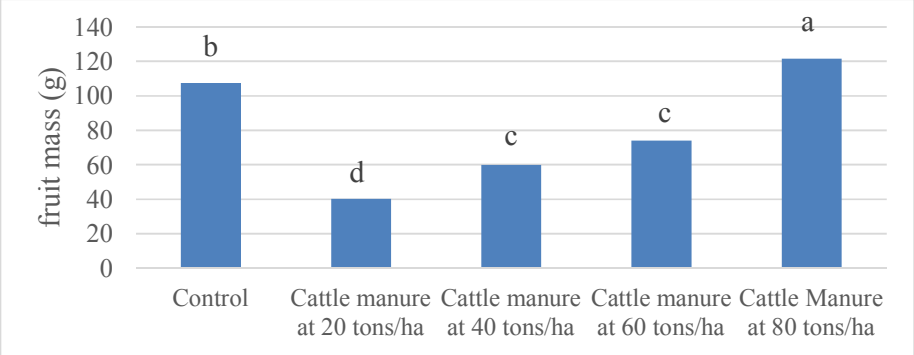

Fig. 4. Fruit weight of green pepper produced at different levels of cattle manure. Bars followed by the same letter not significantly different. Mean separation by DNMRT at P=0.05

available and hence are at higher risk of being leached as reported by Hadfield [18]; [12,13], while with cattle manure the release of nutrients occurs over a relatively long time. Green pepper responds well to added N which is in ample amounts in inorganic fertilisers but it encourages vegetative growth and delays flowering i.e. rank growth.

There were no significant (P>0.05) differences in number of leaves among the treatments at 3 WAT, there was, however, a significant difference after 5 WAT. This could probably be because the cattle manure was still decomposing releasing the nutrients slowly to the plants [12,13]. The results showed that the highest fruits mass was obtained in green pepper grown with cattle manure at the rate of 80 tons/ha.

Plants supplied with 2:3:2 (22) showed vigorous vegetative growth, this was because nutrients in inorganic fertilisers are readily available and in relatively higher amounts. These findings are in agreement with those of Aliyu [8,12,13] who reported that organic manures contain low quantities of plant nutrients which means that N which is required for vegetative growth is in relatively small amounts in cattle manure. Recent studies in the country have shown that animal manures promoted the growth of pepper [19].

5. CONCLUSION AND RECOMMENDATION

Increasing the rate of cattle manure resulted in increased yield of green pepper. Green pepper supplied with cattle manure at 80 tons/ha yielded the most while plants supplied with 2:3:2 (22) which was the control, showed the highest growth in most of the parameters measured.

Based on the results, it is recommended that farmers can use the rate of 80 tons/ha cattle manure when growing green pepper. In future researches, other parameters such as fruit quality and dry mass of plants can be added so that much reliable information is available for farmers in Eswatini.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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