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THE EFFECT OF GOAT MANURE ON PERFORMANCE OF VEGETATIVE GROWTH OF CACTUS (*NOPALEA COCHENILLIFERA SALM-DYCK*)

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ABSTRACT: *The study aims to evaluate the effect of goat manure application on the growth performance of cactus. The research was conducted at Bunda Campus of the Lilongwe University of Agriculture and Natural Resources, Malawi. The plots were prepared in February 2018, applying four measures of goat manure: T1, which was a control had 0 ton / ha of application; T2, with 10 ton / ha; T3, with 20 ton / ha; and T4, with 30 ton / ha. The data collected at 1, 2 and 3 months included the number of buds per treatment, number of racquets per plant, number of primary racquets per plant, height measurement and diameter which were used to evaluate the number of buds per treatment and to verify the performance of plant growth. Data was analysed using SPSS version 22, with the Tukey multiple comparison procedure being employed to separate the means of treatments. The results showed a significant influence (P <0.05) on the buds with no effect (P> 0.05) on the number of tiller (T1, T2, T3 and T4) of rackets per plant, number of primary rackets per plant, plant length and diameter. These results revealed that the high amounts of fertilizer application increased the percentage of buds. The study confirmed that the application of high quality goat manure as fertilizer may increase cactus growth performance in terms of racket numbers per plant, number of primary rackets per plant, height and diameter.*

KEYWORDS: Buds percentage, cactus, diameter measurement, goat fertilizer, Number of rackets, number of rackets per plant, plant length

INTRODUCTION

In Mozambique and Malawi, the main livestock species are goats raised on natural pasture. Because of their location (tropics), these countries face serious problems caused by poor quality pasture during the dry season (July - December) every year. In order to overcome the crisis, there are strategies used to maintain the performance of ruminants and consequent production of meat and milk throughout the lactation period, which include production of forage plants, adapted to the conditions during this dry period, among which the cactus plant stands out. The cactus (*Nopalea cochenillifera Salm-Dyck*) provides energy; it is palatable and supplies water in ruminants during the dry weather (Souza *et al.*, 2008).

Cactus pear is cactaceous exotic plant originating from Mexico, but has a wide geographical distribution, being cultivated in South America, Europe and Africa (Souza *et al.,* 2008). In recent years, the plant has been cultivated on a large scale by dairy farmers, especially in Pernambunco and Alagoa, in Brazil (Nobel and Bobich, 2002). Brazil has the largest planted area in the world, approximately 600 thousand hectares (Soares, 2017). In these zones today cactus has become one of the main forages for ruminants during the dry season (Nobel and Bobich, 2002) because it is a low-cost energy alternative (Santos, 2006).

It is considered one of the best options for the production of fodder in a semi-arid dry land system, with a capacity to reach high biomass yields per area, being the crop more stable over time (Sousa, *et al.*, 2013). The success of cactus propagation depends on its shoots capacity and ability to survive and grow (Meiado, 2016). The manure utilisation is a widely adopted alternative to provide nutrients to plants (Silva, *et al*. 2007). In some cases, when exaggerated the application rate may be excessive, and excess nutrients as well as nutrient deficiency may have negative effects on plant growth (Khan *et al.*, 2010).

On the basis of what has been described above, the present study was carried out, with the aim of evaluating the percentage of shoots per treatment, vegetative growth and the adaptability of the small cactus applied with different levels of goat manure.

MATERIAL AND METHODS

Study Area

The trials were conducted in Central region of Malawi, at Lilongwe University of Agriculture and Natural Resources (LUANAR) - Sakhula Small Ruminant Farm. Malawi has a sub-tropical climate, which is characterized by wet (November to April) and dry (May to October) conditions. The area is between latitudes 12.5°S to 14.5°S and longitudes 33°E and 34.7°E. The area has favourable climate for crop production. Its temperature ranges from 16 to 26 °C, 154 mm with annual average rainfall between 900 to 1,200 mm, mainly concentrated in the period from November to April. The monthly reference evapotranspiration ranges between 90 to156 mm in winter (May, June and July) to a peak of 180 mm in October (Fiwa, *et al.* 2014).

The soil of the experimental station was characterized as sandy clay loam. In terms of soil texture, the soils was in good condition for the cultivation of cactus according to the recommendation by Almeida *et al.* (2012) who used soils of light texture, preferably the Sandy clay loam since such soils are not subject to waterlogging, with the slopes gently at 5%, resulting in a good vegetative and productive development.

Soil samples from the experimental area were collected before application of the organic fertilizer (tanned goat manure) in the topsoil layer of 0 – 20 cm depth to evaluate the chemical characteristics of the soil. The characterization of the manure was also carried out. The analyses were conducted in the Soil Laboratory of LUANAR, according to the Standard Methods, methodology

recommended by the crop science sector (Chilimba, 2007). The data were entered in MS Excel and analyzed for inferential statistics using SPSS version 22. Analysis of variance was performed to assess whether there were significant differences between sample means and Tukey test was used to separate the means.

The organic fertilization was composed of four treatments of goat manure in the proportion of 0.0; 1.0; 2.0 and 3.0 kg per meter, equivalent to 0, 10, 20 and 30 t / ha. It was applied 1.5 meters between parcels, 1 meter between rows and 0.09 meters between rackets.

Planting and Handling

Soil preparation for planting was in a traditional system with a short rope hoe. Regarding the cultural treatments, manual weeding was performed to control spontaneous plants. According to Farias *et al.* (2005) for the best performance of the cactus, it is necessary to consider the best cultivation practices. Therefore, the more adequate its management, the greater its production. To prepare the soil, it is recommended to do plowing, subsoiling, and harrowing and furrow depths of approximately 20 cm (Silva *et al.*, 2013).

Racket Selection

Seedlings were cut from the central part of the plant; the base are very cellulosic and difficult to bud. Rackets with good vigor and free from pests or diseases were placed in the shade for 15 days to lose excess moisture and allow healing of the cut injuries thus reduce the possibility of contamination by microorganisms.

Image1: Suassuna, 2008 - Brazil

After the fall, the rackets were left in the shade for a period of 15 days. This activity promotes the healing of the cuts caused by the plunge, besides favoring buds and increasing the index of grip of the rackets decreasing replanting. In order to guarantee the efficiency of the sprouting of the racquets, called the curing period, before planting, the rackets remained in the shade for 15 days also to lose excess moisture, allowing healing of injuries and thus reduce the possibilities of disease incidences.

Spacing

The experimental design was completely randomized with spacing of 1.0 m x 0.09 m in 16 plots. Each plot had 3 rows of 1.5 m in length and 2.0 m in width, totaling 4 useful partners per treatment, containing 39 plants per plot. The experiment was replicated 4 times. The planting was carried out in February 2018. Mature rackets found in the residential area around the campus (LUANAR), served as an ornamentation plant, consisted the small cactus variety (Nopalea cochenilliphera Salm Dyck) aged approximately 5 years and were planted vertically and spaced 1.0 x 0.09 m.

Image2: planting of the experimental unit at Bunda campus (LUANAR, 2018)

The organic fertilization were done at the same time of planting, with a depth of 30 cm. The arrangement was 7 cm by dry grass, 3 cm occupied by goat manure, 5 cm by sand, at the end the rackets buried half way their length, which corresponded approximately to 15 cm. The cut side faced the ground, deep enough for half of the cladode length buried. To sow the rackets the soil was excavated to an average depth of 30 cm to allow the best development of the roots. The plant spacing of the cactus is a management strategy, because it is important in establishing the cactus. It varies according to the soil fertility, rainfall, purpose of exploitation and its use or not in consortium with other crops. As Farias et al. (2005) had noticed, the spacing is directly associated with the interception of light by the plant. Therefore, denser plantings promote higher productivity, due to greater efficiency in the interception of solar radiation.

Measured variables

Measurement of cactus agronomic parameters was done every thirty days after planting the rackets to evaluate the number of sprouts in the first month, in the second month the development of the cactus measured the height and diameter of the plant, number of rackets per plant, primary, secondary, length and width of rackets per treatment until ninety days. A tape measure was used to determine the height of the plant and the dimensions of the rackets.

For the plant height measurement, the length of the end of the largest article to the ground were considered. The width and length of the plant were measured considering the region of greater width and length of the plant, both with the aid of a tape measure. The number of racets (primary and secondary) were counted per plant and per treatment. The weeding to eliminate weeds was carried out each month.

Precipitation conditions during the experimentation period

In the experimentation period (three month), the total accumulated precipitation was 900 mm,

characterized as follows: 1,200 mm in February, 400 mm in March, 180 mm in April and 156 mm in May 2018. These values represent a high monthly variability of water provision for the study plants. In this period there was also predominantly rainy, with as high intensity as registered in February 1,200 mm, possibly more than the water retention capacity of the soil, which means high benefit from the rain water by the cactus.

The vegetative growth is highly related to water content of the soil, due to water dependence of the main physiological and biochemical processes, such as photosynthesis, respiration, transpiration and nutrient absorption (Sampaio, *et al.* 2005).

However, the forage cactus root system is characterized by thin mesh roots, located close to superficial layer of the soil (up to 10 - 20 cm), adapted to absorb water from tenuous rain or moisture. This would be very beneficial in zones of low rainfall index, giving rise to quick absorption of rainwater, associated with metabolism, and high benefit from rainwater, despite the irregular rainfall.

RESULTS

Table 1 shows that the soil had very low levels of nitrogen and low pH. However, there were high levels of calcium and magnesium.

Table 1: chemical properties of the soil and manure used in the experiment

Chemical property	**Soil (0 – 20 cm)**	**Manure**
Soil Texture	Sandy clay loam	N/A
P (mg/kg)	34.389	661.7
K(cmol/kg)	0.356	2.106
Ca (cmol/kg)	2.532	11.16
Mg (cmol/kg)	2.061	13.56
N (%)	0.055	4.475
OC (%)	1.307	3.385
OM (%)	2.253	5.835
pH	5.223	9.55

Table 2. Mean number of shoots per treatment of cactus applied with varying levels of goat manure after one month.

Treatment	Number of shoots
0kg no manure	17.35 ± 1.56
1kg of manure per meter	25.75 ± 5.13
2kg of manure per meter	26.20 ± 5.16
3kg of manure per meter	29.60 ± 6.42

Table 3. Mean number of racquets per plant of cactus applied with varying levels of goat manure after one, two and three months.

	Number of rackets and primary rackets per plant		
Treatment	One month	Two months	Three months
0kg no manure	3.55 ± 0.37[b]	4.25 ± 0.43[b]	4.85 ± 0.33[b]
1kg of manure per meter	4.25 ± 0.27[b]	5.30 ± 0.28[b]	8.90 ± 0.69[a]
2kg of manure per meter	6.55 ± 0.31[a]	6.95 ± 0.48[a]	10.15 ± 0.88[a]
3kg of manure per meter	6.95 ± 0.30[a]	7.65 ± 0.26[a]	11.70 ± 0.32[a]

[ab]Means having the same letters in any given column are not significantly different at 5% level of significance.

Table 4. Mean racket length in centimeters of cactus applied with varying levels of goat manure after one, two and three months

Length of racket in cm			
Treatments	One month	Two months	Three months
0kg no manure	1.60 ± 0.16[b]	14.63 ± 0.58[b]	18.91 ± 0.69[b]
1kg of manure per meter	3.28 ± 0.26[ab]	16.27 ± 1.36[ab]	21.49 ± 0.73[ab]
2kg of manure per meter	3.40 ± 0.20[ab]	16.62 ± 0.43[ab]	21.84 ± 1.11[ab]
3kg of manure per meter	4.66 ± 0.18[a]	18.39 ± 0.82[b]	23.34 ± 0.18[a]

[ab]Means having the same letters in any given column are not significantly different at 5% level of significance.

Table 5. **Mean racket diameter in centimeters of cactus applied with varying levels of goat manure after one, two and three months**

diameter of racket in centimeters			
Treatments	One month	Two months	Three months
0kg no manure	0.81 ± 0.05[b]	6.40 ± 0.20	8.26 ± 0.31
1kg of manure per meter	1.43 ± 0.09[a]	6.22 ± 0.39	8.70 ± 0.18
2kg of manure per meter	1.38 ± 0.07[a]	6.30 ± 0.12	8.26 ± 0.29
3kg of manure per meter	1.51 ± 0.10[a]	6.74 ± 0.33	9.15 ± 0.18

[ab]Means having the same letters in any given column are not significantly different at 5% level of significance.

Table 6. Mean plant length and plant diameter in centimeters of cactus applied with varying levels of goat manure after three months

	Plant length (cm)	Plant diameter (cm)
Treatments	Three months	Three months
0kg no manure	27.07 ± 1.26[c]	25.92 ± 0.83[c]
1kg of manure per meter	38.50 ± 1.43[b]	38.84 ± 2.83[b]
2kg of manure per meter	41.24 ± 0.45[ab]	41.26 ± 2.29[ab]
3kg of manure per meter	43.59 ± 1.11[a]	48.39 ± 1.52[a]

[abc]Means having the same letters in any given column are not significantly different at 5% level of significance.

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DISCUSSION

The soil used in this experiment had very low levels of nitrogen and low pH. The goat manure on the other hand had very high levels of all parameters analyzed (Table 1). With the results of the soils, there was a need to apply goat manure to increase the levels of nitrogen and pH. This finding agrees with Felker (2015) who recommend nitrogen application at a rate of 40 $kgha^{-1}$ to sustain productivity of Cactus as low N levels place a low ceiling of sustainable productivity for the plant in arid regions. The lower pH contradicts with the recommended pH of 6.0 by Burleigh et al (2008) who alluded to the fact that cactus grows slowly at higher soil pH values.

The results in Table 3 above present the values for total number of forage cactus cladodes and the fertilizing using goat manure during the experimental period. From the experimentation, it was found out that the number of cactus per treatment (NCT) increased linearly ($P<0.05$) within the time as it was expected, because when the plant grows the number of cladodes increases too. The organic fertilization caused the increase of NCT, providing more NCT in treatments with 10, 20 and 30T/ha dosages. The fertilization probably created conditions for essential nutrients absorption for cactus development, increasing the capacity of infiltration and retention of water in the soil, and this in turn increased the capacity of cationic exchange providing favorable aeration conditions to the soil. It was found that the NCT behavior did not change in all fertilizing dosages, until 30 days after planting (DAP) with the average of 8.65 cladodes per plant. This behavior could relate to the excess of moisture in the soil, considering the fact that there was intense rainfall at 30 DAP cactus. The number of cladodes reported in the current study are far below those reported in India by Kauthale et. Al (2017) who reported between 15 to 37 cladodes per plant.

At 30 DAP the dosages of 10, 20 and 30t/ha of manure increased significantly and the cladodes came out when there was increased goat manure application in the treatment. The portions without treatment (0t/ha) the cladodes average was 4.22, which gave rise to increase of 6.15% of NCT at 90 DAP when manure dosage was used at the proportion of 10t/ha. From the proportion of 20t/ha, the result was 7.88% and from 30t/ha, 8.77%. These results could be well explained considering the fact that the composition of the soil contained nutrients in considerable values, where the quantity of median dosages was enough to overcome the demand. Dubex, *et al.* (2006) found out that the lack of mineral fertilization caused a variation in plant cladodes from 4.1 (in stands of 4000 plants ha^{-1}) to 7 cladodes per plant (in stands of 5000 plants ha^{-1}). Fertilizing with 75 kg of N and 33 kg of P_2O_5 ha^{-1}, they found 12.3 cladodes in the first and 5.9 in the second stand. These results show that forage palm responds positively to fertilization.

Cunha *et al*. (2012), assessing the effect of nitrogen fertilization, observed that the nitrogen caused linear effect and positive effect in terms of number of cladodes, whose values raised from 27.75 to 36.08 cladodes per plant, without fertilization and for the dosage of 300 kg/ha of N respectively. However, Dubex *et al*. (2010), while assessing the effect of phosphorus and

potassium in forage palm IPA 20 clone, at six months of age, did not find significant effect of phosphorus nor of potassium in the number of cladodes, which may suggest that the cactus does not have a high need of the two nutrients until six months, requiring many quantity of nitrogen to expand new tissues and produce new cladodes.

The means and general linear model effect of organic fertilization and DAP and height of forage palm (AP) are found in Table 3. It was observed that there was a significant effect (P<0,05) in the height due to fertilization, with the mean of 11.71; 13.68; 13.95; e 15.46 (cm) in dosages and 0, 10, 20, 30t/ha of goat manure respectively at 90 DAP. The plant height is important because it is a characteristic normally correlated with production characteristics. This fact is related also to other characteristics, such as soil texture, nitrogen, phosphorous and potassium incorporation, which contribute to plant development. In Table 3 it is observed that for all rates of goat manure, the cactus exhibited similar growth in 10t/ha and 20t/ha treatments and inversely in portions where there was no fertilization the cactus height was less, calling attention for manure application. Aside from the fact that goat manure is rich in potassium, it is important to underline that the experimentation area was characterized by the lack of fertility, presenting insignificant percentage of nutrients. Thus, considering that nutrients are highly required by the forage cactus, it explains the higher need of nutrients in non-treated portions than in those where goat manure was applied.

Silva *et al*. (2010) stated that the correlation coefficient for forage cactus height variable indicated that bigger height plants display bigger diameter and large and long primary and secondary articles, and dense tertiary articles.

Tables 4 and 5 illustrates goat manure application rate effect on length and diameter of forage cactus cladodes. It was found that both application rates had a linear increase in variables until a certain point and after which it stabilized. According to Alvarez (1985), this means the answer of LRP type (Linear Response-Plateau), which defines two segments, as follows: one of them is adjusted to linear regression and the other is represented by dependent variable mean. The majority of cultivated plants follow sigmoid growth model, which means that at the beginning of cycle the growth is slow, increasing gradually until it reached a plateau, when it stabilizes (Almeida *et al*., 2003).
This model, also known as linear discontinuous, showed a high adjustment to simple linear model. Adopting the LRP model, one may infer that the width reached a plateau in less days (30 to 90 days) in 10 and 20t/ha manure dosages, with 20.25 and 20.62 cm, respectively.

The vegetative growth of forage cactus, expressed in number of cladodes per plant, plant height, cladode length and width, is increased through organic fertilization. The utilization of cladode length and width maximization as cactus management and weed reveals the determined time for cactus collection, after plantation.

CONCLUSION

The results showed a significant influence (P <0.05) on the buds with no effect (P> 0.05) on the number of tiller (T1, T2, T3 and T4) of rackets per plant, number of primary rackets per plant, plant length and diameter. These results revealed that the high amounts of goat manure application increased the percentage of buds. The study confirmed that the application of high quality goat manure could increase cactus growth performance in terms of racket numbers per plant, number of primary rackets per plant, height and diameter.

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