Use of rooster tree (*Calotropis procera*) mixed with cattle manure in cowpea productivity in the semi-arid region of Brazil.

ABSTRACT :

The production of cowpea is part of the agricultural activities of farmers in the semi-arid region of Brazil, being important in the aspect of acquiring income and source of food, in this sense, the use of rooster tree (*Calotropis procera*) mixed with cattle manure in cowpea productivity in the semi-arid region of Brazil. The experiment was conducted from August to November 2023 at the Rafael Fernandes experimental farm, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, with an area of 400 hectares. The experimental design used was randomized complete blocks in a 4 x 2 factorial scheme, with three replications. The first factor consisted of four quantities of cattle manure (0.0; 1.1; 2.2 and 4.4 kg m^{-2}), the second factor being the presence and absence of silk flower. Each plot consisted of dimensions of 2.2 m x 1.2 m, with a total area of 2.64 m^2. Each plot had eight holes with three plants, making a population of 90,900 plants ha^{-1}. After harvesting the dried pods, they were stored in plastic bags, identified and taken to the DCAF/UFERSA Post-Harvest laboratory, where the following characteristics were measured: Pod length [twenty pods were measured per treatment, expressed in cm (CV)], Number of pods $plant^{-1}$ [the total number of pods in the experimental plot were counted, divided by the number of plants, expressed in $plant^{-1}$ units (NVP)], weight of five pods [In each experimental plot, five representative pods were removed, weighed on an electronic scale with a precision of 0.001g, expressed in grams (P05V)], weight of 100 grains [It consisted of weighing 100 grains of each experimental plot on a 0.001g precision scale, expressed in grams (P100G)] and dry grain productivity [It consisted of measuring the grain weight of each experimental plot multiplied by ha, expressed in kg ha^{-1})]. The highest cowpea productivity was observed at a dose of 4.4 kg m^{-2}, with a maximum value of 2,858.85 kg ha^{-1}. The presence of rooster tree did not influence any of the characteristics evaluated. The use of cattle manure is an option for farmers in the semi-arid region.

Keywords: *Food production; agroecological agriculture and family farming*.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is an annual legume belonging to the Fabaceae family and native to Central Africa [1], it is cultivated mainly in the dry areas of the tropics in Latin America, Africa and south from Asia [2]. Its grain production worldwide is more than 6.0 million tons in an area of more than 12 million hectares [3]. Its grain production worldwide is more than 6.0 million tons in an area of more than 12 million hectares [3].

This crop is a source of protein for a large number of people living in semi-arid regions, with a chemical composition of 23.4% protein, 1.8% fat and 60.3% carbohydrates, in addition to being an important source of calcium and iron [1]. In Brazil, cowpea cultivation is of paramount importance for agricultural systems, especially family agricultural systems, occupying more than 1.2 million hectares annually [4].

In the Northeast, where agriculture is largely family-based, the crop stands out for its rusticity in the semi-arid climate, cultivated mainly for the production of dry or green grains for human consumption (LIMA, 2014).**????** The use of local varieties has several advantages linked to production sustainability, such as resistance to diseases, pests and climate imbalances, and seeds can be stored for subsequent harvests, which reduces production costs [6].

According to [7] manure is a viable option for cowpea production among farmers in the semi-arid region, as it allows for an increase in organic matter, enabling an increase in productivity. Some research has shown the cultivation of landraces for grain production. [8] obtained values between 10.75 (BRS Itaim) and 14.85 grains per pod (BRS Tumucumaque), with an overall average of 13.04 grains per pod. [9] highlights the BRS xique xique cultivar (13.0 grains/pod) as an option for farmers in rural Paraiba.

Social technologies that promote the obtaining of renewable sources are attractive not only for their environmental advantages, but also for improving social and economic aspects. One of the widespread technologies is the use of biofertilizer, which can alleviate the problems of family farmers in agroecological systems or in conversion, and can be used both as a preventative against insect pests and diseases and as a source of the main nutrients for plants [10].

Given the importance of mixing organic fertilizers in the production of large crops, the objective was to study the use of rooster tree (*Calotropis procera*) with cattle manure in cowpea productivity in the semi-arid region.

The objectives are not clear, you should state the objectives with clear manner

2. MATERIAL AND METHODS

2.1 Experimental area

The experiment was conducted from August to November 2023 at the Rafael Fernandes experimental farm, in the district of Alagoinha (5º03'37 "S, 37º23'50" W), northwest of Mossoró, State of Rio Grande do Norte, Brazil, with an area of 400 hectares [11]. According to [12] and the Köppen classification, the local climate is BSwh', dry and very hot, with a dry season, often from June to January, and a rainy season from February to May, average annual precipitation of 673.9 mm and average relative humidity of 68.9%.

The region's climate, according to the Köppen Geiger classification, is dry and very hot with two seasons: a dry season starting in June and ending in January and a rainy season starting in February and ending in May [13]. The soil in the experimental area was classified as a typical dystrophic red yellow argisol, with a sandy loam texture [14].

Before setting up the experiment, soil samples were collected from the 0-20 cm arable layer, homogenized, and sent to the soil chemistry and fertility laboratory for the following analyses: pH (water) = 6.6; EC = 0.20 dS m^{-1}; O.M. = 1.2 g kg^{-1}; N = 0.15 g kg^{-1}; P = 28.92 mg dm^{-3}; K = 38.17 mg dm^{-3}; Ca= 19.24 cmolc dm^{-3}; Mg = 8.74 cmolc dm^{-3}; Na = 3.27 mg dm^{-3}; Cu = 0.47 mg dm^{-3}; Fe = 2.35 mg dm^{-3}; Mn = 9.41 mg dm^{-3}; and Zn = 2.48 mg dm^{-3}.

2.2 Experimental Design

The experimental design used was randomized complete blocks in a 4 x 2 factorial scheme, with three replications. The first factor consisted of four quantities of cattle manure (0.0; 1.1; 2.2 and 4.4 kg m^{-2}), the second factor being the presence and absence of silk flower.

Each plot consisted of dimensions of 2.2 m x 1.2 m, with a total area of 2.64 m^2. Each plot had eight holes with three plants, making a population of 90,900 plants ha^{-1} (Figure 1).

Figure 1. Representation of the experimental area with cultivation of cowpea (*Vigna uniculata* L.), a Creole cultivar (Canapum), at different stages of development.

The preparation of the area was carried out through manual weeding, followed by marking the experimental plots, opening the pits and adding the irrigation system with 14 mm hoses. Creole cowpea seed (*Vigna uniculata* L.) was used, coming from producer Francisco Vicente Filho from the city of Martins, RN, Brazil. Planting was carried out on August 9, 2023 at the Rafael Fernandes Experimental Farm, belonging to the Universidade Federal Rural do Semi-Árido, Brazil.

Manual weeding was used to remove spontaneous plants that competed with the cowpea crop for water and nutrients at all stages of crop development. Irrigation was carried out by sprinkler, with a daily irrigation shift divided into two applications (morning and afternoon).

2.3 Chemical composition of rooster tree (*Calotropis procera*) and cattle manure

The rooster tree (*Calotropis procera*) was harvested within the campus of the Federal Rural University of the Semiarid (UFERSA), being cut from the apex of the plant to the green insertion of the stem (Figure 2). Samples were taken from the rooster tree for carbon (C) analysis; nitrogen (N); phosphorus (P); potassium (K^+); calcium (Ca^{2+}); magnesium (Mg^{2+}) and carbon/nitrogen ratio. The values observed were: 550 g kg^{-1} C, 20.0 g kg^{-1} N, 11.1 g kg^{-1} P, 15.5 g kg^{-1} K, 10.6 g kg^{-1} Ca, 13.7 g kg^{-1} Mg and a nitrogen/carbon ratio of 28/1.

Figure 2. Rooster tree (*Calotropis procera*) in the vegetative (a) and reproductive (b) phase in a vegetation area within UFERSA.

The cattle manure was collected in the cattle sector at UFERSA, from dairy cows, where they feed roughage and concentrate, whose concentration presented the following values: 7.45 g kg^{-1} of nitrogen (N); 191.15 g kg^{-1} of organic matter (MO); 865.4 mg dm^{-3} of phosphorus (P); 2547.7 mg dm^{-3} of potassium (K^+); 465.9 mg dm^{-3} of sodium (Na^+); 7.14 cmolc dm^{-3} of Ca^{2+}; 0.40 cmolc dm^{-3} of Mg^{2+} and 13.02 cmolc dm^{-3} of cation exchange ability (CTC).

2.4 Evaluated characteristics of Cowpea

Four harvests were carried out in the experimental area with cowpea, starting on October 25, 2023 and ending on November 30, 2023, with the objective of harvesting dry grains (Figure 3).

Figure 3. Cowpea plants in the flowering period and producing dry pods in the semi-arid region of Brazil.

After harvesting the dried pods, they were stored in plastic bags, identified and taken to the DCAF/UFERSA Post-Harvest laboratory, where the following characteristics were measured: Pod length [twenty pods were measured per treatment, expressed in cm (CV)], Number of pods plant^{-1} [the total number of pods in the experimental plot were counted, divided by the number of plants, expressed in plant^{-1} units (NVP)], weight of five pods [In each experimental plot, five representative pods were removed, weighed on an electronic scale with a precision of 0.001g, expressed in grams (P05V)], weight of 100 grains [It consisted of weighing 100 grains of each experimental plot on a 0.001g precision scale, expressed in grams (P100G)] and dry grain productivity [It consisted of measuring the grain weight of each experimental plot multiplied by ha, expressed in kg ha^{-1})].

2.5 Statistical analysis

Statistical analysis was performed according to conventional methods of analysis of variance [15], using ESTAT statistical software [16]. The response curve fitting procedure was performed using the ESTAT Software [16], applying regression analysis and conducting hypothesis testing that helps the researcher accept or reject a statistical hypothesis based on experimental results [17], [18].

3. RESULTS AND DISCUSSION

No significant interaction was observed between the doses of cattle manure and the absence and presence of rooster tree on the agronomic characteristics of cowpea, demonstrating that the factors behaved independently. However, significance was observed at the level of $P<0.01$ probability in the factor cattle manure doses (DE) in the characteristics pod length, number of pod plant^{-1}, weight of 100 grains, weight of 05 pods and productivity of grains.

However, significance was observed at the level of $P<0.01$ probability in the factor cattle manure doses (DE) in the characteristics pod length, number of pod plant-1, weight of 100 grains, weight of 05 pods and productivity of grains. For the factor absence and presence of rooster tree, no statistical difference was observed (Table 1).

The different doses of cattle manure contributed positively to the increase in all characteristics, which is probably due to the increase in organic matter in the soil, with nutrient availability and greater water retention in the 0-20 cm layer.

Table 1. F values for pod length, expressed in cm (CV), number of pods plant^{-1} (NVP), weight of 100 grains, expressed in g (P100G), weight of five pods, expressed in g (P05V), weight of 100 grains (W100G) and dry grain productivity, expressed in kg ha^{-1} (DGP) of cowpea (*Vigna unguiculata* L.) in the semi-arid region of Brazil.

Causes of variation	GL	CV	NVP	P100G	P05V	W100G	DGP
Doses of manure (DE)	3	6.23^{**}	7.34^{**}	10.52^{**}	9.57^{**}	13.65^{**}	15.70^{**}
Absence and presence (AP)	1	2.23^{ns}	1.81^{ns}	0.12^{ns}	1.21^{ns}	0.89^{ns}	3.28^{ns}
DE X AP	3	2.81^{ns}	1.74^{ns}	2.93^{ns}	1.37^{ns}	$1,21^{ns}$	0.70^{ns}
Treatments	7	-------	-------	--------	-------	---------	--------
Block	2	6.85^{**}	8.34^{**}	8.60^{**}	5.24^{*}	4.56^{**}	9.34^{**}
Residue	14	------	-------	---------	--------	---------	---------
Overall average	----	18.27	6.76	26.69	28.66	26.6	2,291.3
CV (%)	---	3.68	10.46	6.29	7.32	8.14	17.0

Non-significant effect by F test (ns); ** Significant effect by F test at 1% probability level; *Significant effect by F test at 5% probability level.

For the pod length characteristic, there was an increase of 1.6 cm between the highest dose 4.4 kg m^{-2} (19.2 cm) due to the absence of fertilization, dose 0 kg m^{-2} (17.6 cm). (Figure 4). Regarding the presence and absence of rooster tree (*Calotropis procera*) there was no statistical difference with values of 18.5 and 18.0 cm per plant respectively (Table 2). [19], studying the cultivation of cowpea using inoculants with organic and mineral fertilizers, found a maximum pod length of 20.5 cm, higher than the aforementioned research. According to [20], agronomic characteristics of beans are affected by increasing amounts of cattle manure.

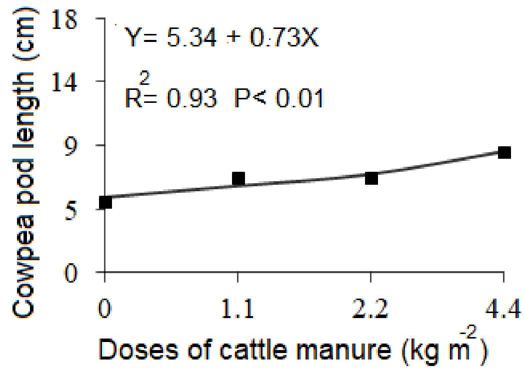

Figure 4. Pod length as a function of different doses of cattle manure incorporated into the soil in the semi-arid region of Brazil.

In the characteristic number of pods per plant there was an increase of 60.6% due to the doses of 4.4 kg m^{-2} (8.5 pods $plant^{-1}$) due to the absence of fertilization (5.3 pods $plant^{-1}$) with a maximum value of 8.5 pods $plant^{-1}$ (Figure 5). For the presence and absence of rooster tree (*Calotropis procera*) factor, no statistical difference was observed with maximum values of 7.3 and 6.2 respectively (Table 2). [21], studying the production of cowpea depending on different dosages and concentrations of biofertilizers, found a number of $plant^{-1}$ pods of 20.75 units, higher than the aforementioned research.

For the characteristic weight of five pods, there was an increase of 2.9g due to the higher dose of 4.4 kg m^{-2} (31.5g) and the absence of fertilization (28.6g). (Figure 6). Regarding the presence and absence of silk flower, no statistical difference was observed with values of 30.3 and 29.3g respectively. (Table 2).

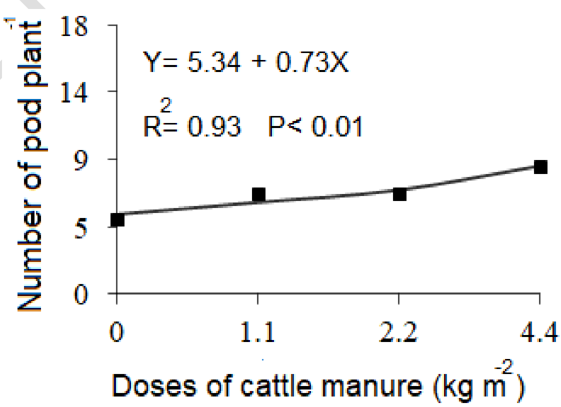

Figure 5. Number of $plant^{-1}$ pods as a function of different doses of cattle manure incorporated into the soil in the semi-arid region of Brazil.

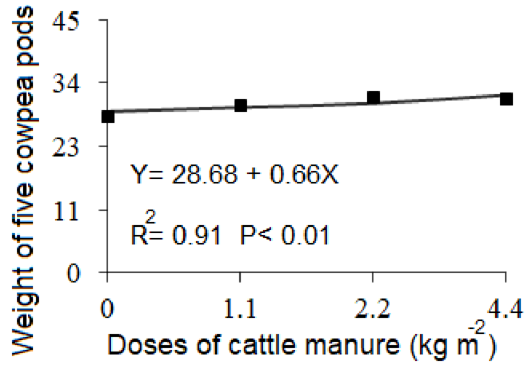

Figure 6. Weight of five pods depending on different doses of cattle manure incorporated into the soil in the semi-arid region of Brazil.

For the weight characteristic of 100 grains, there was an increase of 2.0g due to the dose of 4.4 kg m^{-2} (28.2g) and the absence of fertilization (26.2g) (Figure 7). For the factor presence and absence of rooster tree there was no statistical difference with maximum values of 26.8 and 26.5g, respectively (Table 2). The time of incorporation of the fertilizers probably influenced so that there was no statistical difference. [19], studying the cultivation of cowpea using inoculants with organic and mineral fertilizers, with a weight of 100 g of seeds of 20.88g, lower than the aforementioned research. [21], studying the production of cowpea depending on different dosages and concentrations of biofertilizers, found the weight of 100 seeds to be 17.15g, lower than the aforementioned research. Probably the quality of the biofertilizer contributed greatly to a lower value.

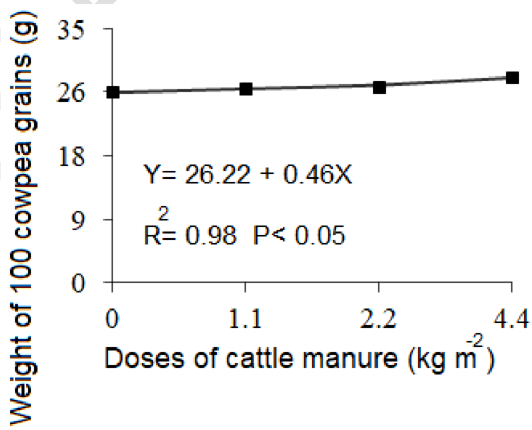

Figure 7. Weight of 100 grains depending on different amounts of cattle manure incorporated into the soil in the semi-arid region of Brazil.

For productivity, there was an increase of 1.1 kg ha^{-1} due to the higher dose of 4.4 kg m^{-2} (2,858.85 kg ha^{-1}) and the absence of fertilization (1,712.78 kg ha^{-1}) (Figure 8) . For the factor presence and absence of rooster tree, no statistical difference was observed with values of 2,288.7 kg ha^{-1} and 2,193.9 kg ha^{-1} respectively (Table 2). [19], studying the cultivation of cowpea using inoculants with organic and mineral fertilizers ound productivity of 840.49 kg ha^{-1}, lower than the aforementioned research. [22] obtained pod bean productivity of 926.3 kg ha^{-1}, with the application of cattle manure biofertilizer, a value below that of the aforementioned research. Probably the quality of the mixture of biofertilizer with cattle manure compromised productivity.

[23], studying the yield of cowpea cultivated with cattle manure and mineral fertilizer, found a dry grain yield of 3.0 t ha^{-1}, equivalent to 3,000 kg ha^{-1}, a value higher than the aforementioned research. Probably, during the growth and development of bean plants, the mixture of cattle manure with mineral fertilizer greatly contributed to a balanced form of the crop's nutritional needs.

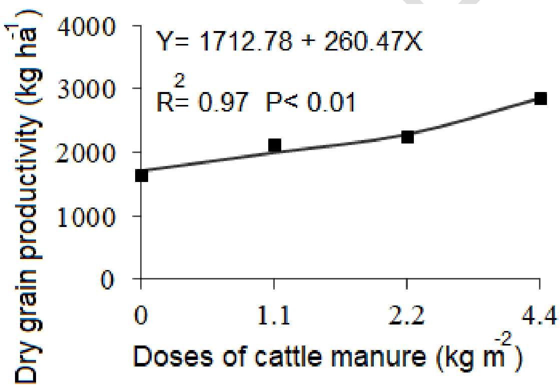

Figure 8. Productivity of dry cowpea grains as a function of different doses of cattle manure incorporated into the soil in the semi-arid region of Brazil.

Table 2. Average values by F test, for pod length, expressed in cm (CV), number of pods plant^{-1} (NVP), weight of 100 grains, expressed in g (P100G), weight of five pods, expressed in g (P05V), weight of 100 grains (W100G) and dry grain productivity, expressed in kg ha^{-1} (DGP) of cowpea (*Vigna unguiculata* L.) in the semi-arid region of Brazil.

Forms of application	CV	NVP	PCV	P100G	PG
Presence of the rooster tree	18.5 a	7.3 a	30.3 a	26.8 a	2,388.7 a
Absence of the rooster tree	18.0 a	6.2 a	29.3 a	26.5 a	2,193.9 a
Average	18.3	6.8	29.8	26.6	2,291.3

Averages followed by the same letter do not differ statistically at the 5% probability level.

CONCLUSION

The highest cowpea productivity was observed at a dose of 4.4 kg m^{-2}, with a maximum value of 2,858.85 kg ha^{-1}.

The presence of rooster tree did not influence any of the characteristics evaluated.

The use of cattle manure is an option for farmers in the semi-arid region.

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