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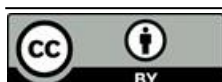
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ABSTRACT

Agricultural utilization of yellow waters associated with cassava wastewater is a sustainable technique, since it allows reduction of costs related to acquisition of industrialized fertilizers and minimizes the environmental pollution caused by the inadequate disposal of these effluents. In this context, this study evaluated the macronutrient macronutrient content and growth of cowpea fertigated with yellow water associated with cassava wastewater and NPK as source of nutrients. The experiment was set up in a greenhouse located at Campus I of the Federal University of Campina Grande. The experimental design was completely randomized, composed of five treatments characterized by: fertigation with mineral fertilizers, in the form of NPK; organic fertigation composed of human urine, cassava wastewater, human urine plus cassava wastewater; and organo-mineral fertigation composed of urine, cassava wastewater and mineral phosphorus, with four replicates. At 36 days after sowing, the following parameters were determined: contents of nitrogen, phosphorus, potassium, sulfur and the variables number of leaves, plant height, stem diameter, leaf area, shoot fresh matter and shoot dry matter. The use of yellow waters promotes significant increases for growth and production variables for nitrogen and potassium contents mainly, as well as for growth and production variables. The contents of nitrogen, phosphorus and potassium were higher than the levels considered as adequate for the cowpea crop. The use of human urine and cassava wastewater have potential to meet the needs for the main macronutrients required by cowpea and the irrigation via fertigation with these biofertilizers positively influences the development of cowpea.

Keywords: agricultural use of wastes, human urine, *vigna unguiculata* (L.) Walp.



Teores de macronutrientes e crescimento do feijão vigna ‘BRS Marataoã’ fertirrigado com água amarela e manipueira

RESUMO

O uso agrícola de águas amarelas associadas à manipueira é uma técnica sustentável, uma vez que possibilita a redução de custos com a aquisição de fertilizantes industrializados e minimiza a poluição ambiental ocasionada pela destinação final inadequada desses efluentes. Neste contexto, objetivou-se com este trabalho avaliar os teores de macronutrientes e o crescimento do feijão vigna fertirrigado com águas amarela associada à manipueira e NPK como fonte de nutrientes. O experimento foi instalado em uma casa de vegetação localizada no Campus I da Universidade Federal de Campina Grande. Utilizou-se delineamento inteiramente casualizado composto por cinco tratamentos caracterizados por fertirrigações com fertilizantes minerais, na forma de NPK; orgânicos compostos por urina humana, manipueira, urina humana mais manipueira e organomineral composto por urina, manipueira e fósforo mineral e quatro repetições. Aos 36 dias após a semeadura foram avaliados os teores de nitrogênio, fósforo, potássio, enxofre e as variáveis: número de folhas, altura de planta, diâmetro caulinar, área foliar, massa fresca e seca da parte aérea. O uso de águas amarelas promove incrementos significativos para os teores de nitrogênio e potássio principalmente, assim como para as variáveis de crescimento e produção. Os teores de nitrogênio, fósforo e potássio apresentam valores superiores aos considerados adequados para o cultivo do feijão vigna. O uso de urina humana e a manipueira apresentam potencialidade para suprir as necessidades dos principais macronutrientes requeridos pela cultura do feijão vigna e a irrigação via fertirrigação com estes biofertilizantes pode influenciar positivamente o desenvolvimento dessa cultura.

Palavras-chave: urina humana, uso agrícola de resíduos, *Vigna unguiculata* (L.) Walp.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.), also known as ‘feijão-fradinho’, ‘feijão-macassar’ or ‘feijão-de-corda’, is a source of income and food for many regions, especially the Brazilian Northeast (Benett *et al.*, 2013). In Brazil, cowpea has undergone great changes, in both the production sector, with expansion of its cultivation to other regions, and in the commercial sector, with the standardization of the best product, beginning of industrial processing and product entry in new markets in the country and abroad (Freire Filho *et al.*, 2011).

The recycling of nutrients contained in biodegradable wastes is a sustainable technique because it minimizes the use of synthetic mineral fertilizers and the negative impacts resulting from lack of environmental management in the exploitation of natural resources to produce fertilizers and pollution of waters due to uncontrolled disposal of wastes in the environment.

The increased costs of mineral fertilizers and increasing environmental pollution make the use of organic wastes in agriculture an attractive alternative from an economic point of view, due to the cycling of C (carbon) and nutrients (Silva *et al.*, 2010).

It is important to make it clear that yellow waters have high concentrations of nitrogen (N), phosphorus (P), potassium (K) and sulfur (S). Human urine has been used as a source of urea and cassava wastewater as a source of potassium since the concentration of these substitute mineral fertilizers (Ranasinghe *et al.*, 2016).

According to Sousa *et al.* (2008), various studies based on the separation of urine and feces have been carried out. Urine separation can provide a “free” hygienic fertilizer which can be used in agriculture (Kvarnström *et al.*, 2006). For Karak and Bhattacharyya (2011), urine is a

highly valuable source of nutrients which has been used in agriculture since ancient times.

Another effluent with great potential for recycling of nutrients through agricultural reuse is cassava wastewater because, according to Conceição *et al.* (2013), like human urine it is rich in macro and micronutrients, and can be used as fertilizer.

Recently, several studies have been conducted to evaluate the agricultural use of human urine. Araújo *et al.* (2015b) studied the cultivation components of hydroponic green fodder of corn fertilized with human urine as source of nutrients. Santos Júnior *et al.* (2015) evaluated grain and phytomass production in millet irrigated with human urine associated with domestic effluent. Bonvin *et al.* (2015) studied N and P absorption by ryegrass fertilized with synthetic urine. Santos *et al.* (2016) tested the use of human urine as source of nutrients for Bermuda grass and Botto *et al.* (2017) evaluated the yield of castor bean, cultivar 'BRS Nordestina', fertilized with human urine.

The human urine is rich in nitrogen in the form of urea, and cassava wastewater is rich in potassium; their use in agricultural production can reduce the use of mineral fertilizers that salinize the soil and water, destroy aquatic and terrestrial life, and which, during the process of manufacture, release into the air and water dioxins, which are highly carcinogenic substances.

The use of wastewater in agricultural production reduces the use of mineral fertilizers, which generate negative impacts for water bodies, soil, air, etc. This happens because of the use of mineral fertilizers. This negatively affects the process of production, releasing POP'S (Persistent Organic Pollutants), as the dioxins, element high carcinogenic and smooth air and hydric flow. Regarding cassava wastewater, in the last seven years studies have been published analyzing the fertilizer potential of this effluent (Santos *et al.*, 2010; Schwengber *et al.*, 2010; Araújo *et al.*, 2012; 2015b; Duarte *et al.*, 2012; Silva Junior *et al.*, 2012; Barreto *et al.*, 2013; 2014; Dantas *et al.*, 2015; Leal *et al.*, 2015; Pessuti *et al.*, 2015). Based on the results obtained in the above-mentioned studies, the authors concluded that the agricultural use of human urine or cassava wastewater had positive effects on the variables of the crops analyzed.

Therefore, considering the lack of studies using yellow water and cassava wastewater in cowpea cultivation, the present study evaluated the contents of nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) and the growth of *Vigna unguiculata* (L.) Walp., cultivar 'BRS Marataoã', fertigated with human urine combined with cassava wastewater as source of nutrients. These sources of organic fertilizer have little to no acquisition cost for small rural producers, and may increase production, particularly that based in family agricultural.

2. MATERIAL AND METHODS

The experiment was conducted in a greenhouse between November and December 2015, at Campus I of the Federal University of Campina Grande (UFCG), in the city of Campina Grande (7°13'50" S, 35°52'52" W, 551 m of altitude), Paraíba state, Brazil.

In the research environment, the experimental units consisted of 15-L plastic pots distributed at spacing of 0.80 m between rows and 0.50 m within the row, supported by a base made of bricks.

Each pot was perforated at the bottom to insert a drain, that is, a 15-cm long hose with nominal diameter of 6 mm, which was attached to a 2.0-L PET bottle to collect the drained effluent, allowing its recirculation in the original pot in order to reduce possible losses of nutrients leached by the excess of water volumes drained from irrigation. The pots were filled with a 0.50-kg layer of crushed stone (nº 0), covering the bottom, and a 15.0-kg layer of a Eutrophic Regolith Neosol with sandy loam texture, properly pounded to break up clods and sieved, from the rural area of the municipality of Esperança, PB. Its analysis showed the following results: pH (H₂O) = 5.58; EC = 0.56 mmhos cm⁻¹; Al = 0.00 cmolc dm⁻³; Mg = 2.78 cmolc dm⁻³; Ca = 9.07 cmolc dm⁻³; K = 0.33 cmolc dm⁻³; Na = 1.64 cmolc dm⁻³;

$P = 3.98 \text{ mg dm}^{-3}$; $S = 13.72 \text{ cmolc dm}^{-3}$; $OC = 1.70\%$; $OM = 2.93\%$ and $d = 1.28 \text{ g cm}^{-3}$.

After the pots were filled, irrigation was applied to bring the soil to field capacity. Then, holes were opened and sowing was carried out by planting five seeds of the cowpea cultivar 'BRS Marataoã' per pot. 10 days after sowing (DAS), thinning was performed to leave two seedlings per pot.

Irrigation water volumes were estimated individually for each experimental plot with 2-day intervals based on water balance (difference between the mean volumes applied and drained sufficient to maintain the soil at field capacity, plus 20%, to meet water losses through evapotranspiration). The water used in irrigation was collected in the public supply network of Campina Grande, PB.

The experimental design was completely randomized, with four replicates and five treatments, totaling 20 experimental plots. Treatments consisted of fertigation with NPK (Treatment 1 - NPK); only human urine (Treatment 2 - U); only cassava wastewater (Treatment 3 - W); human urine plus cassava wastewater (Treatment 4 - U + W) and human urine plus cassava wastewater plus phosphorus (Treatment 5 - U + W + P). Mineral fertilizers consisted of urea (45.9% N), single superphosphate (18.9% P_2O_5) and potassium chloride (60% K_2O).

Treatments 1 and 5, in 10 fertirrigation treatments, were applied differently, because human urine and cassava wastewater must be diluted to soften the toxic effects that these effluents can cause in plants. If the concentrations of effluents applied via fertirrigation exceed the recommended limited by 10%, injuries may be caused to plants, such as burned leaves.

Fertigation began 10 days after sowing (DAS). Each plot received the equivalent of 100 mg N kg^{-1} of soil, 300 mg P kg^{-1} of soil and 150 mg K kg^{-1} of soil, according to the recommendations of Novais *et al.* (1991).

The amounts of human urine and cassava wastewater applied in each plot were estimated based on the concentrations of nitrogen and potassium in the effluents (Table 1) and the dose recommended by Novais *et al.* (1991) (100 mg N kg^{-1} of soil and 150 mg K kg^{-1} of soil).

The pots that received human urine were treated with 224.95 mL of this effluent to supply the nitrogen required by the cultivar, and 561.93 mL of cassava wastewater to supply the necessary potassium. To complete fertilization, phosphorus of mineral origin was applied in a portion of 23.83 g of P_2O_5 per pot.

Table 1. Physicochemical characterization of human urine (U) and cassava wastewater (W) used in the experiment.

Effluents	Parameters								
	TKN	NH ₃ -N	NO ₃	P-PO ₄ ⁻³	K	Na	Ca + Mg	pH	EC
	g L ⁻¹							-	mS cm ⁻¹
U	6.668	5.257	0.002	0.325	1.558	2.509	0.034	9.12	42.7
W	1.199	0.336	0.019	0.338	4.004	0.096	2.800	3.75	11.75

Note: TKN: Total Kjeldahl Nitrogen; NH₃-N: Ammoniacal Nitrogen; NO₃: Nitrate; P – PO₄⁻³: Soluble Orthophosphate; K: Potassium; Na: Sodium; Ca + Mg: total hardness; pH: Hydrogen potential and EC: Electrical Conductivity.

For treatments containing mineral fertilizers (Treatments 1 and 5), fertigation was split into 3 portions and applied at 10, 20 and 28 DAS. For treatments containing human urine (Treatment 2), cassava wastewater (Treatment 3) and human urine plus cassava wastewater (Treatments 4 and 5), fertigation was split into 10 portions and applied at 10, 12, 14, 16, 18, 20, 22, 24, 26 and 28 DAS.

Human urine was subjected to a treatment, which consisted of storage in a hermetically sealed 20-L plastic bucket for 60 days before being used. For cassava wastewater, the treatment

consisted of anaerobic digestion for 90 days in a 85-L plastic bucket, with an empty space of 10 cm inside it. The lid of the bucket was attached to a hose with the other tip immersed in a container with water up to 10 cm in depth, to release the gases generated during the effluent bio-digestion.

Regarding the presence of xenobiotics, everyone carries these in their bodies from food, drink, etc.; so the concentrations of xenobiotics would vary depending on the food habits of the individuals. The human urine utilized was from men who do not smoke and do not take any type of controlled medicine.

In relation to the use of cassava wastewater and human urine, these effluents harm only minimally, because they are a source of organic nutrients, with an easy assimilation into soil and plants. Moreover the applications followed a recommended method of fertilization which does not cause nutritional stress in the crop or eutrophic alterations in the hydric bodies and soil.

After treatment, the effluents were analyzed according to the methodology recommended by the Standard Methods for Wastewater (APHA *et al.*, 2005), and their parameters are presented in Table 1.

Human urine and cassava wastewater were submitted to pre-treatment to reduce the concentration of hydrocyanic acid in cassava wastewater and increase the pH of human urine to eliminate pathogenic microorganisms in the effluent.

It is known that treated cassava wastewater reduces pH (± 3.0), while human urine increases it (± 9.0). In this way, the pH of the soil solution, in an interval between 5.5 and 6.5, promotes high nutrient availability for plants (Malavolta *et al.*, 1989).

At 36 days after sowing (DAS), a period in which plants were at a late vegetative stage and in early flowering, when they assimilate maximum quantities of nutrients, growth variables were evaluated: plant height (PH, cm), stem diameter (SD, mm), number of leaves (NL, leaves plant⁻¹), leaf area (LA, cm²), shoot fresh matter (SFM, g plant⁻¹) and shoot dry matter (SDM, g plant⁻¹).

Plant height was determined using a tape measure graduated in centimeters from the collar to the apical bud. Stem diameter was measured using a digital caliper, graduated in millimeters, at approximately 2.0 cm from the collar. Number of leaves was determined by counting green leaves longer than 3.0 cm, disregarding dry leaves, from the basal leaves to the last open leaf in the plant. Leaf area was estimated by the mathematical model proposed by Lima *et al.* (2008), which consists in the sums of midrib length (L) and maximum width (W) of each leaflet, according to Equation 1:

$$LA = \sum (0.9915 \times (L \times W)^{0.9134}) \quad (1)$$

Where: LA is the leaf area of the cultivar (cm²); W is the maximum width of each leaflet (cm); and L is the midrib length (cm).

To determine shoot fresh matter, one plant from each plot was cut close to the soil and weighed on a precision analytical scale. After weighing, the plants were placed in paper bags previously identified and dried in an oven at a controlled temperature of 65°C for 72 hours to determine SDM.

After SDM determination, plants were ground in a Wiley-type mill and placed in identified packages to determine the contents of nitrogen (N, g kg⁻¹), phosphorus (P, g kg⁻¹), potassium (K, g kg⁻¹) and sulfur (S, mg kg⁻¹). These analyses were conducted following the methodology described by EMBRAPA (2009).

The results of the studied variables were subjected to analysis of variance and means were compared by Tukey test at a 0.05 probability level using the program ASSISTAT v. 7.7 Beta (Silva and Azevedo, 2016).

3. RESULTS AND DISCUSSION

Based on the results presented in Table 2, the analysis of variance showed significant effect ($p < 0.01$) on the contents of nitrogen (N), phosphorus (P) and sulfur (S) and non-significant effect ($p > 0.05$) on the content of potassium (K). Significant statistical difference was also found between the means of N, P and S.

Table 2. Summary of analysis of variance and mean contents of N (g kg^{-1}), P (g kg^{-1}), K (g kg^{-1}) and S (mg kg^{-1}) in the shoot of cowpea fertigated with human urine and cassava wastewater.

SV	Mean square				
	DF	N	P	K	S
Treatments	4	151.29567**	6.46752**	34.12312 ^{ns}	2895.89787**
Residual	15	4.63867	0.20291	13.75016	15.22620
CV%	-	4.39	8.78	11.82	6.53

Treatments	Means			
1 - (NPK)	52.50a	6.41a	36.38a	43.45cd
2 - (U)	52.50a	4.27b	27.60a	35.55d
3 - (W)	36.40b	4.27b	29.21a	51.84bc
4 - (U+W)	51.80a	3.69b	31.15a	54.19b
5 - (U+W+P)	52.27a	6.99a	32.56a	113.76a

Note: SV – Source of variation; DF – Degrees of freedom; CV – Coefficient of variation; NPK – Nitrogen, phosphorus and potassium; U – Human urine; W – Cassava wastewater; U + W – Human urine plus cassava wastewater; U+W+P – Human urine plus cassava wastewater plus phosphorus; (^{ns}, **, *) - Not significant, significant at 0.01 and 0.05 probability levels by F test; Means followed by the same letter in the column do not differ by Tukey test ($p > 0.05$).

For N contents, the means of Treatment 3 (fertigation with cassava wastewater) were different, whereas the means of the other treatments did not differ from one another. The maximum mean of N was 52.5 g kg^{-1} , obtained in plants fertigated with yellow water (Treatment 2 – U) and with mineral fertilizers (Treatment 1 – NPK). The minimum mean of N was 36.40 g kg^{-1} , obtained in plants fertigated with only cassava wastewater (Treatment 3 – W), but this value was still higher than the concentration range considered as adequate for common beans (30 to 35 g kg^{-1}) (Fageria *et al.*, 1996) and for cowpea ($19.7 \pm 1.3 \text{ g kg}^{-1}$) (Freire Filho *et al.*, 2005).

The maximum mean of P was 6.99 g kg^{-1} , obtained in plants fertigated with urine plus cassava wastewater associated with the mineral fertilizer P (5 – U+W+P). This value did not differ statistically from that of the treatment with NPK fertigation (control; 6.41 g kg^{-1}). The means of P also did not differ between Treatment 2 (fertigation with yellow water), 3 (fertigation with cassava wastewater) and 4 (fertigation with yellow water associated with cassava wastewater).

According to the results in Table 2, N and P contents obtained in the present study were higher than those found by Parry *et al.* (2008), who analyzed the contents of macronutrients in cowpea shoots in soil fertilized with two P doses and in different sowing periods and obtained maximum values of 24.5 g kg^{-1} and 1.7 g kg^{-1} , respectively. Means of K did not differ statistically, and the maximum value (36.38 g kg^{-1}) was obtained under fertigation with NPK.

Mean S contents were statistically different between treatments, and the maximum value was approximately $113.76 \text{ mg kg}^{-1}$, obtained under fertigation with human urine associated with

cassava wastewater and mineral fertilizer (5 – U+W+P). This value is within the range are considered as adequate for common beans according to EMBRAPA (2009), from 18 to 50 mg kg⁻¹, and below the adequate value for cowpea, which is 1.5 ± 0.4 g kg⁻¹ according to Freire Filho *et al.* (2005).

Except for S contents, all treatments led to N, P and K contents considered as adequate for common beans (Fageria *et al.*, 1996). For cowpea, Freire Filho *et al.* (2005) state that adequate P and K contents should be 1.4 ± 0.3 and 32.0 ± 3.6 g kg⁻¹, respectively. Thus, according to Table 2, all treatments met the needs for N and P by cowpea plants and Treatments 1 (1 – NPK) and 5 (5 – U+W+P) also met the needs of K, indicating that fertigation management was satisfactory in the present study for the cowpea crop.

In a study carried out by (Upreti *et al.*, 2011) with different crops (onion, potatoes, wheat, radish, rice), using mineral (NPK) and organic fertilizations (human urine), and with distinct spaces, it was observed that human urine positively affected the evaluated crops.

According to the summary of analysis of variance (Table 3), there was significant statistical difference between treatments ($p < 0.05$) for stem diameter (SD), shoot fresh matter (SFM) and shoot dry matter (SDM), whereas the other variables did not differ statistically between treatments, and these results corroborate those found in the literature. Pereira *et al.* (2013) studied the effects of three sources of organic fertilization (bovine manure, goat manure and earthworm humus) on cowpea and found no significant effect on number of leaves and plant height. Sousa *et al.* (2013) evaluated the effect of increasing doses of bovine biofertilizer on cowpea growth at 4 days after sowing and obtained significant statistical difference for stem diameter (SD) and shoot dry matter (SDM). Alves *et al.* (2009), studying the effects of increasing doses of biofertilizer obtained by whey fermentation and applied through fertigation in cowpea, found significant effect on plant height and number of leaves and non-significant effect on stem diameter.

Table 3. Summary of analysis of variance and means for number of leaves per plant (NL, leaves plant⁻¹), plant height (PH, cm), stem diameter (SD, mm), leaf area (LA, cm²), shoot fresh matter (SFM, g plant⁻¹) and shoot dry matter (SDM, g plant⁻¹) of cowpea fertigated with human urine and cassava wastewater.

SV	Mean Square						
	DF	NL	PH	SD	LA	SFM	SDM
Treatments	4	4.55000 ^{ns}	39.59375 ^{ns}	1.21923*	10136.66698 ^{ns}	130.99785*	2.01556*
Residual	15	5.65000	13.03750	0.26424	18187.72725	29.37111	0.49281
CV%	-	12.81	10.82	6.18	16.00	11.45	10.54
Treatments		Means					
1 - (NPK)		17.00a	28.87b	7.95ab	802.24a	47.88ab	6.96ab
2 - (U)		18.75a	37.50a	8.78a	874.18a	47.7ab	6.69ab
3 - (W)		18.00a	32.37ab	7.54b	860.66a	41.85b	5.98b
4 - (U+W)		19.50a	34.50ab	8.80a	898.96a	56.34a	7.67a
5 - (U+W+P)		19.50a	33.62ab	8.50ab	779.28a	42.93b	6.00b

Note: SV – Source of variation; DF – Degrees of freedom; CV – Coefficient of variation; NPK – Nitrogen, phosphorus and potassium; U – Human urine; W – Cassava wastewater; U + W – Human urine plus cassava wastewater; U+W+P – Human urine plus cassava wastewater plus phosphorus; (^{ns}, **, *) - Not significant, significant at 0.01 and 0.05 probability levels by F test; Means followed by the same letter in the column do not differ by Tukey test ($p > 0.05$).

Significant differences were observed for plant height (PH), stem diameter (SD), shoot fresh matter (SFM) and shoot dry matter (SDM).

No statistical difference was found in the means of number of leaves (NL) and leaf area

(LA). Except for the Treatment 5 (5 – U+W+P) for leaf area, the means of number of leaves and leaf area in the other treatments (2 – U, 3 – W, 4 – U+W and 5 – U+W+P) were higher than those in the control (1 – NPK). A probable explanation for that can be related to the supply of other nutrients contained in yellow water and cassava wastewater, which were available to be assimilated by cowpea plants.

The maximum mean of number of leaves was 19.50 leaves per plant, obtained under fertigation with yellow water associated with cassava wastewater (4 – U+W) and these effluents associated with phosphorus (5 – U+W+P). Similar results were found by Silva *et al.* (2010), who obtained on average 20.50 leaves per plant of cowpea fertigated with 30 L ha⁻¹ day⁻¹ of bovine biofertilizer, at 45 days.

For plant height, it can be observed that there were no differences between the means of plants fertigated with only cassava wastewater (3 – W), yellow water associated with cassava wastewater (4 – U+W) and these effluents associated with mineral phosphorus (5 – U+W+P). Minimum mean of PH (28.87 cm) was obtained with NPK fertigation, whereas maximum values (34.50 and 37.5 cm) were found in plants fertigated with yellow water associated with cassava wastewater (4 – U+W) and only yellow water (3 – U), respectively.

The means of stem diameter of plants fertigated with NPK and yellow water associated with cassava wastewater and these effluents associated with mineral P (5 – U+W+P) did not differ statistically, and the same occurred with Treatments 2 (yellow water) and 4 (yellow water associated with cassava wastewater). The minimum mean (7.54 mm) was obtained in plants fertigated with cassava wastewater, whereas the maximum values of 8.78 and 8.80 mm were obtained with fertigation using yellow water (2 – U) and yellow water associated with cassava wastewater (4 – U+W), respectively. Evaluating the effect of cassava wastewater applied by fertigation on cowpea, at 35 DAS, Schwengber *et al.* (2010) observed that the highest value of stem diameter (2.99 mm) was obtained with application of 100 m³ ha⁻¹. Cruz *et al.* (2014), evaluating cowpea at 40 days after emergence under application of 4.0 L m⁻¹ of organic biofertilizer produced by accelerated biodegradation of wastes of coconut straw and inflorescences, neem tree pruning and cashew tree pruning, observed stem diameter of more than 6.0 mm, which is lower than the value found in the present study.

For leaf area (LA), the maximum mean was 898.96 cm², observed in plants fertigated with yellow water associated with cassava wastewater. Studying the growth of cowpea fertigated with wastewater, Rebouças *et al.* (2010) found maximum leaf area of 943.0 cm², which is very close to that observed in the present study.

The values of shoot fresh matter (SFM) were statistically different between the treatments tested. Its minimum (41.85 g plant⁻¹) and maximum (56.34 g plant⁻¹) values were obtained in plants fertigated with cassava wastewater and with yellow water associated with cassava wastewater (4 – U+W), respectively.

For shoot dry matter (SDM), there was a statistical difference between the means of Treatments 3 (cassava wastewater), 4 (yellow water associated with cassava wastewater) and 5 (yellow water associated with cassava wastewater and mineral P), and the results were not significant for the Treatments 1 (NPK) and 2 (yellow water). Minimum and maximum means were 5.98 and 7.67 g plant⁻¹, obtained in plants fertigated with cassava wastewater (3 – W) and yellow water associated with cassava wastewater (4 – U+W), respectively.

In a study by Messa *et al.* (2016) to determine the release of fertilizers in clay soil, it was observed that most of the fertilizers used in the study were released into the soil solution more quickly when at a pH between 4.0 to 5.5.

There probably was influence of the pH of the soil solution; its fluctuation can determine the availability of nutrients for the plants.

Evaluating the use of bovine biofertilizer and treated wastewater in cowpea fertigation,

Sousa *et al.* (2013) and Rebouças *et al.* (2010) obtained positive response with gains in shoot dry matter. Using bovine manure to fertilize cowpea at 35 days after planting, Bastos *et al.* (2012) found fresh shoot matter of 27.30 g per plant.

According to the data in Table 3, although there was no significant statistical difference between the means of number of leaves (NL), plant height (PH) and leaf area (LA), when plants were fertigated with wastewaters the values were higher than those of plants fertigated with chemical fertilizer formulated with NPK. In other words, the nutrients present in the yellow water and cassava wastewater caused positive effects on the cowpea crop. Except for the number of leaves and plant height, fertigation with yellow water associated with cassava wastewater led to maximum means for the variables SD, LA, SFM and SDM. A probable explanation is that the nutrients present in the yellow water and cassava wastewater were well assimilated by the plants, indicating great nutritional potential for the associated use of these effluents in agricultural cultivation.

The fact of effect variables promoted different results for the response variables; this action possibly can be associated with the fact of synergism or nutritional antagonism in the soil.

According to Fageria (2001), excess ions in the soil solution, such as potassium, which is an abundant nutrient in the cassava wastewater, can affect the absorption of other essential nutrients by plants, such as calcium, magnesium, zinc and manganese, due to the antagonism between potassium and these elements.

4. CONCLUSIONS

N, P and S contents, stem diameter, shoot fresh matter and shoot dry matter of cowpea were influenced by the fertigation with yellow water, association between yellow water and cassava wastewater, and these effluents associated with the source of P;

Maximum contents of N, P, K and S were obtained by fertigation with NPK and human urine plus cassava wastewater associated with the mineral source of P;

Human urine and cassava wastewater applied by fertigation have potential to meet the needs of the cowpea crop for N, P and K; and

Maximum means of most growth variables were obtained in plants fertilized with human urine associated with cassava wastewater.

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