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NUTRITIONAL COMPOSITION OF *MERREMIA AEGYPTIA*, *CALOTROPIS PROCERA*, AND *SENNA UNIFLORA* FOR USE AS GREEN MANURE IN DIFFERENT TYPES OF SOILS

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ABSTRACT

We assessed the nutritional composition of *Merremia aegyptia*, *Calotropis procera*, and *Senna uniflora* for use as green manure in different soil types. Soil and plant samples were collected at four sites in the municipality of Natal, Rio Grande do Norte, Brazil, from May to June 2014. The experimental design was a completely randomized factorial design (4 x 3) with four replications. Treatments consisted of four types of soils (I - Red Yellow Acrisol Eutrophic Latosol; II - Vertisol; III - Dystrophic Yellow Red Latosol with sandy texture; and IV - Cambisol) and three weed species (above mentioned). We assessed the following characteristics of soils: N; Organic Matter (OM); pH; P; K^+; Na^+; Ca^{2+} and Mg^{2+}. The following attributes of weed species were evaluated: N; P; K^+; Ca^{2+}; Mg^{2+} and carbon/nitrogen ratio (C/N). We found significant interaction of soil types and weed species for phosphorus, calcium, and magnesium. Levels of nitrogen and potassium were statistically different among weeds, with *M. aegyptia* showing the highest mean values: N (23.8 g kg^{-1}) and K^+ (17.2 g kg^{-1}); *C. procera* with the following averages: N (20.9 g kg^{-1}) and K^+ (15.2 g kg^{-1}); and *S. uniflora* with following averages: N (21.3 g kg^{-1}) and K^+ (10.4 g kg^{-1}). Soil types influenced the nutrient concentration of the weed species.

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INTRODUCTION

Search for healthier food and consolidation of family farming have strengthened the system of agro-ecological vegetable production. In this context, green manures stood out as an economically viable practice, minimizing costs with chemical inputs and facilitating availability to the small farmer in rural properties. Green fertilization uses rotating or intercrop systems of plants that grow naturally in the soil (such as weeds) with plants of economic interest. To improve physical, chemical and biological characteristics of the soil, weeds can be directly incorporated into the soil or plowed under and maintained on the surface (Fernández *et al*., 2007). Green manures show the following benefits to crops: increase of organic matter content; reduction of erosion; protection of soils against heavy rains; increase in water retention; recovery of degraded and compacted soils; reduction of nutrient loss, such as nitrogen; and reduction of invasive plants (Lima; Menezes, 2010; Lima *et al*., 2017). Plant species like *Merremia aegyptia*, *Calotropis procera*, and *Senna uniflora*, are weeds found in the semi-arid region of Brazil. They stood out as green manure in the cultivation of vegetables (Silva *et* *al*., 2011; Silva *et al*., 2011, Linhares *et al*., 2011), presenting positive results in edaphic conditions. According to Fávero *et al*. (2000), weed species can promote the same effects of soil cover, biomass production, and nutrient cycling as introduced species. The use of non-leguminous plants as green manuring is important because they mitigate losses of nitrogen by temporary immobilization of this nutrient in the biomass (Andreola *et al*., 2000) and protect the soil structures (Bortollini *et al*., 2000). Oliveira *et al*. (2011) observed an increase of about 33% in the yield of commercial roots of carrot with the addition of *M. aegyptia*. *C. procera*, an exotic species adapted to soils and climatic conditions of semiarid Brazil, has a well-developed vegetative morphology and thrives throughout the year. It has an average yield of 1.0 t ha^{-1} cut $^{-1}$ $year^{-1}$ of dry matter, providing three annual cuts (EMPARN, 2004), with nitrogen content of 22.6 g kg^{-1} in the dry matter and nitrogen/carbon ratio of 20/1 (Linhares *et al*., 2011). *S. uniflora* is abundant in semi-arid Brazil, with dry biomass production of 7.0 t ha^{-1}. All the features mentioned above makes these species feasible as green manure. Due to the great range of applicability of *M. aegyptia*, *C. procera*, and *S. uniflora* and its potential as green fertilizer in agroecosystem, we aimed to assess the nutritional composition of these weeds grown on different types of soil.

MATERIALS AND METHODS

The experiment was carried out in the municipality of Mossoró, Rio Grande do Norte, Brazil, from April to June 2016. We analyzed four different types of soils, which were collected through opening 0-20 cm depth trenches and chemically characterized in the soil laboratory of UFERSA, according to EMBRAPA methodology (1999). The dominant climate of the region, according to the classification of Köppen, is of the type BSwh', that is, hot and dry semi-arid tropical climate, with a very irregular rainy season, being delayed from summer to autumn and concentrating on the beginning of the year. According to CarmoFilho, EspíndolaSobrinho and Maia Neto (1991), the local characteristics are the average temperature of 27.4 °C, annual rainfall of 673.9 mm and relative humidity of 68.9%. The experimental design was completely randomized in a 4 x 3 factorial scheme, with four replications. Treatments consisted of four types of soils (I - Red Yellow Acrisol Eutrophic Latosol; II - Vertisol; III - Dystrophic Yellow Red Latosol with sandy texture; and IV - Cambisol) and three weed species (*Merremia aegyptia*, *Calotropis procera*and *Senna obtusifolia*). We assessed the nutritional composition of weeds from the Caatinga ecoregion for use as green manure. Plants were collected by hand in four different locations, at the beginning of the flowering period, when the plant shows the highest concentration of nutrients. From each species, we collected a composite sampling; from each composite sample, we tacked simple samples for analysis. The samples were composed of leaves and branches. They were crushed in a conventional forage machine, obtaining segments between 2.0 and 3.0 cm. The material was dried in a forced air circulation oven at 65 ° C. Then, the dry matter was milled in a Wiley mill, packed in 100 g container and sent to the Soil Fertility and Plant Nutrition Laboratory of the Department of Environmental and Technological Sciences of the Federal Rural University of the Semi-Arid (UFERSA). We assessed the following variables: carbon (C), nitrogen (N), phosphorus (P), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}) and carbon/nitrogen ratios. Data were submitted to analysis of variance and the mean values of treatment were compared by Tukey's test at 5% probability. We use the ESTAT software (Kronka and Banzato, 1995).

RESULTS AND DISCUSSION

There was no interaction between weed species and soil types for nitrogen and potassium (Table 1 and 2). However, there was interaction for phosphorus, calcium, and magnesium. In relation to the nitrogen content, *Merremia aegyptia* was statistically superior to *Calotropis procera* and *Senna uniflora*, with average values of 23.8, 20.9, and 21.3 g kg^{-1}, respectively. Potassium showed the mean values of 17.2, 15,2, and 10,4 g kg^{-1}, respectively for *M. aegyptia*, *C. procera*, and *S. uniflora*, the first two weeds were statistically equal (Table 2).

Table 1. Nitrogen and potassium contents of *Merremia aegyptia*, *Calotropis procera*, and *Senna uniflora*used as green manure. UFERSA, 2016

Green manures	Nutritionalcomposition	
	Nitrogen (g kg^{-1})	Potassium (g kg^{-1})
Merremia aegyptia	23.8a*	17.2a
Calotropis procera	20.9b	15.2a
Senna uniflora	21.3b	10.4b
CV (%)	12.0	10.3

* In the columns, averages followed by different letters differ statistically according to the Tukey test, at 5% probability level.

Table 2. Assessment of nitrogen and potassium contents according to different types of soils.UFERSA. 2016

Soil types	Chemical composition	
	N (g kg^{-1})	K^+(mg dm^{-3})
Red Yellow Acrisol Eutrophic Latosol	0.10b	30.0b
Vertisol	0.30b	35.2b
Dystrophic Yellow Red Latosol with sandy texture	0.07c	40.0b
Cambisol	1.05a*	200.0a*
CV (%)	12.0	10.9

* In the columns, averages followed by different letters differ statistically according to the Tukey test, at 5% probability level.

Table 3. Interactions of the *Merremia aegyptia*, *Calotropis procera*, and *Senna uniflora* with soil types as function of the availability of phosphorus, calcium, and magnesium. UFERSA, 2016

Nutrients	Green manure types	Soil types with occurrence weeds			
		I	II	III	IV
P (g kg^{-1})	*Merremia aegyptia*	11.1a	10.5b*	10.6b	10.2b
	Calotropis procera	11.2a	10.6b	10.6b	10.2b
	Senna uniflora	10.2ab	10.5ab	9.9b	10.6b
		CV (%) =11.0			
Ca^{2+} (g kg^{-1})	*Merremia aegyptia*	9.4b	10.0a	10.3a	10.4a
	Calotropis procera	11.3a	11.3a	10.6a	9.4b
	Senna uniflora	10.1b	11.0a	10.5ab	10.6ab
		CV (%) = 9.5			
Mg^{2+} (g kg^{-1})	*Merremia aegyptia*	8.6a	9.7a	8.5a	8.4a
	Calotropis procera	6.5b	7.9a	7.7a	8.2a
	Senna uniflora	5.2a	4.5b	4.1b	4.2b
		CV (%) = 8.5			

* In the columns, averages followed by different letters differ statistically according to the Tukey test, at 5% probability level. Soil I = Red Yellow Acrisol Eutrophic Latosol; Solo II = Vertisol; Soil III = Dystrophic Yellow Red Latosol with sandy texture; Solo IV = Cambisol.

Cavalcante *et al*. (2012), assessing the biomass and nutrient extraction by cover crops, found nitrogen content of 13.0 g kg^{-1} in weed species. On the other hand, in *Crotalaria juncea* and *Canavaliaensiformis*, the authors found levels of 22.0 and

22.2 g kg^{-1}, which were lower values than the nitrogen content found in *M. aegyptia*, *C. procera*. Although they are not legumes, these species have been used as green manure in vegetables crops (Linhares *et al*., 2012), since they show high values of dry matter and nitrogen concentration. All studied species had higher potassium contents than the species *Cajanuscajan*, *C. cajan* (arboreal cultivar), and *Stizolobiumaterrimum*, which were studied by Cavalcante *et al*. (2012). These results suggest a high potential of *M. aegyptia*, *C. procera*, and *S. uniflora* as green manures. Teixeira *et al*. (2005) found similar results, verifying that the species *Pennisetumglaucum* had higher potassium contents than legumes. It is important to emphasize that green soil fertilizer, unlike chemical fertilizers, does not release nutrients readily to plants. Mineralization process depends on factors such as the current physical, chemical and biological condition of the soil, the C/N ratio of the material and meteorological elements acting on the soil (XU; Hirata, 2005, Souza, 2014). Regarding soil types, there was a statistically significant difference for nitrogen and potassium, with Cambisols being statistically superior to other soil types for both Nitrogen and Potassium contents (Table 2). Assessing interactions between soil nutrients and weed species, we found that the phosphorus was not statistically different among weeds, with soil I (Red Yellow Acrisol Eutrophic Latosol), which obtained the highest values, with a mean of 11.1, 11.2, and 10.2 g kg^{-1} for *M. aegyptia*, *C. procera*, and *S. uniflora*, respectively. Calcium showed different result, with soil II (Vertisol), having the highest averages, with concentrations of 10.0, 11.3, and 11.0 g kg^{-1} for *M. aegyptia*, *C. procera*, and *S. uniflora*, respectively. Magnesium differed among soils I, III (Dystrophic Yellow Red Latosol with sandy texture) and IV (Cambisol), with *M. aegyptia* having the highest averages, with values of 8.6, 9.7, 8.5, and 8.4 g kg^{-1} for soils I, II, III, and IV, respectively (Table 3). Studied species were superior in terms of concentration of phosphorus, calcium and magnesium compared to the legumes studied by Cavalcante *et al*. (2012). According to Fávero *et al*. (2000), in terms of nutrients, the weeds show a higher content of K, Mg and P in relation to legumes, which corroborates with our results.

Conclusion

We found interactions among soil types and weed species for phosphorus, calcium and magnesium contents. Nitrogen and potassium contents of the weeds were statistically different. *Merremia aegyptia* showed the highest values of N (23.8 g kg^{-1}) and K^+ (17.2 g kg^{-1}). *Calotropis procera* showed the following mean values: N (20.9 g kg-1) and K^+ (15.2 g kg^{-1}). *Senna uniflora* showed the following mean values: N (21.3 g kg^{-1}) And K^+ of (10.4 g kg^{-1}). Soil types influenced the nutrient concentration of all weed species.

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