Original Research Article

Initial Development of Cowpea Submitted to Wood Ash Doses

ABSTRACT

Cowpea (*Vigna unguiculata* (L.) Walp.) constitutes one of the principal protein sources for the economically constrained low-income sector. The composition of the wood ash reveals macro and micronutrients, which form an alternative source of high-added value fertilizers, very suitable for low-cost farming systems. The aim of this study was to estimate the use of wood ash as a fertilizer during the early developmental stages of the cowpea. A randomized block design with four replications was selected for the experiment. It was performed in a greenhouse, in pots 1.5 dm^{-3} capacity, to which five wood ash doses (0, 8, 16, 24 and 32 g dm^{-3}) were added. The following variables were analyzed, viz. plant height, stem diameter, number of leaves, chlorophyll index, shoot and root dry masses, mass and number of nodules, water consumption and water use efficiency. Increased values of plant height, stem diameter and number of leaves were observed post the addition of the following doses of wood ash: 24.61, 23.25 and 27.03 g dm^{-3}, respectively. The chlorophyll index, dry shoot and root masses, water consumption and water use efficiency rose to 54.18, 93.83, 90.50, 34.09 and 90.14%, respectively. No significant difference, however, was noted in the values for dry mass and number of nodules. The wood ash was found to promote conditions favorable to the initial development of the cowpea, and can be used as a corrective and a fertilizer for this culture. Based on this improvement in the fertility of the soil, it is safe to assume that there are also gains in sustainability and that the application of vegetal ash can contribute to combating soil degradation.

Keywords: Vigna unguiculata; water use; organic fertilization

1. INTRODUCTION

In spite of the issues discussed in the professional political field, which often seem disconnected from reality, there is a real world with real problems that needs concrete and tangible solutions in the medium and long term, including sustainable soil management.

In this real world, strategies are drawn which, to be carried out, depend not only on changes in management by farmers, foresters, but also on political decisions on rules and regulation, subsidies, and perhaps the problem that deserves more attention, the change public perception.

Ensuring food security for low-income populations is one of the sustainable development goals approved by the UN General Assembly in September 2015. In this way, agricultural research that addresses this target audience should be prioritized [1].

Originally from Africa, the cowpea (*Vigna unguiculata* (L.) Walp.) is a legume which has adapted itself very well to the Brazilian environment [2]. The cultivable regions of Brazil, are restricted to the Northeast, Midwest and North, with the Northeast being the chief producer state [3]. Here, cowpea is a popular cultivar selected by small producers for family agriculture, and forms one of the essential protein sources for the low-income populace [4].

Cowpea shows a high degree of adaptability and tolerance to water stress and poor soil fertility [5]. Although cowpea grows in low-fertility soils, additional fertilization plays a very significant part in increasing the grain productivity and its nutritional quality [6]. Fertilizing involves the addition of agricultural inputs like correctives, conditioners and mineral or organic fertilizers [7]. Therefore, as the high cost of the additives is often a deterrent for the low-income producers, it becomes crucial to use low-cost alternatives, like wood ash as a fertilizer.

Wood ash is the end product of burning plant material to produce energy to run boilers, grain driers and industrial furnaces. Rural properties in proximity to the ash producing locations possess a higher potential for utilization of this residue, as it lowers the transportation charges. Thus, wood ash has been proven to be a good alternative for boosting soil fertility [8]. Wood ash is also useful in lowering the soil acidity, by promoting the neutralization of hydrogen and toxic aluminum, via the release of the soil carbonate content [9]. This residue may also reveal the presence of potassium, phosphorus, calcium, magnesium and micronutrients [10]. Thus, the aim of this study was to estimate the use of wood ash as a fertilizer during the early developmental stages of the cowpea.

2. MATERIAL AND METHODS

The experiment was performed in a greenhouse at the Federal University of Mato Grosso, Campus of Rondonópolis, MT, Brazil, using the soil collected from a region under Cerrado vegetation. The soil composition in the 0.0 to 0.2 m layer of Oxisol included the following chemical and granulometric features: pH ($CaCl_2$) = 4.0; P = 1.4 mg dm^{-3}; K = 23 mg dm^{-3}; Ca = 0.4 cmol dm^{-3}; Mg = 0.2 cmol dm^{-3}; SB = 0.7 $cmol_c$ dm^{-3}; CTC = 6.8 $cmol_c$ dm^{-3}; V = 9.7%; O. M. = 27.1 g dm^{-3}; sand, silt and clay = 423, 133 and 444 g kg^{-1}, respectively.

The treatments followed the randomized complete block design with four replications and involved five doses of wood ash (0, 8, 16, 24 and 32 g dm^{-3}). Post homogenization (soil + wood ash), a 20 day incubation period was enforced for each treatment to enable the soil acidity neutralization reactions to occur. Each experimental unit included a pot of 1.5 dm ^{3} capacity, filled with soil sieved through a 4 mm mesh.

An analysis was made of the wood ash utilized in biomass burning in the ceramic industry boilers as fertilizer to ascertain the nutrients that constituted it (Table 1) [11].

Table 1. Chemical analysis of the wood ash used as fertilizer

pH H_2O	NP*	N	P_2O_5 Total	K_2O	Zn	Mn	B	Ca	Mg	S	Si	Fe
	%	g kg^{-1}										
11.8	25	2.5	48.5	16.6	0.13	0.5	0.2	37.5	28.5	2.8	187	15.3

*NP = Neutralization power

Ten seeds of cowpea were sown per pot. Seven days post emergence the plants were thinned, leaving only two plants per pot. The soil moisture was maintained at 80% of the maximum water retention capacity [12].

After the completion of the experiment, at 30 days post emergence, the plant heights of the two plants, from their base in the soil to the tip of the highest leaf was measured, while the stem diameter was assessed at the plant base using a digital caliper (Fig. 1). The chlorophyll index (SPAD) was recorded using a portable chlorophyllometer from five leaves in the middle one-third of the plants per pot [13].

Fig. 1. Measurements of stem height (A) and stem diameter (B) in cowpea plants fertilized with wood ash doses.

Later, the plants were cut down at ground level and the aerial parts were separated from the roots to estimate the dry mass. The values were recorded after the aerial parts were dried in a forced circulation air oven at 65 Cº temperature until constant mass was reached; root dry mass was estimated by running water through the roots in sieves and drying them in the greenhouse. The number and mass of the nodules was done by counting the nodules taken from the washed roots and weighing them after being oven dried (Fig. 2).

Fig. 2. Cutting (A), root washing (B) and nodule count (C) in cowpea plants fertilized with wood ash doses

The variables concerned with irrigation viz., water consumption - the total irrigations done in each pot and the water use efficiency - the total dry mass ratio of the plants with the water consumption in each pot (eq. 1).

$$\text{Water use efficiency}_{(\text{g L}^{-1})} = \frac{\text{Total dry mass}_{(\text{g})}}{\text{Water consumption per pot}_{(\text{L})}} \quad (1)$$

The analysis of variance was done for the results and the significant variables were further analyzed using the regression test until 5% significance level. The Sisvar statistical program was used [14].

3. RESULTS AND DISCUSSION

According to the analysis of variance all the variables showed significance (P < .001), except for the number and mass of the nodules.

The wood ash doses influenced the cowpea plant growth (Fig. 3A), where the height was adjusted to the quadratic model of regression; the tallest height (24.36 cm) was reached for the wood ash dose of 24.61 g dm^{-3} (Fig. 3B).

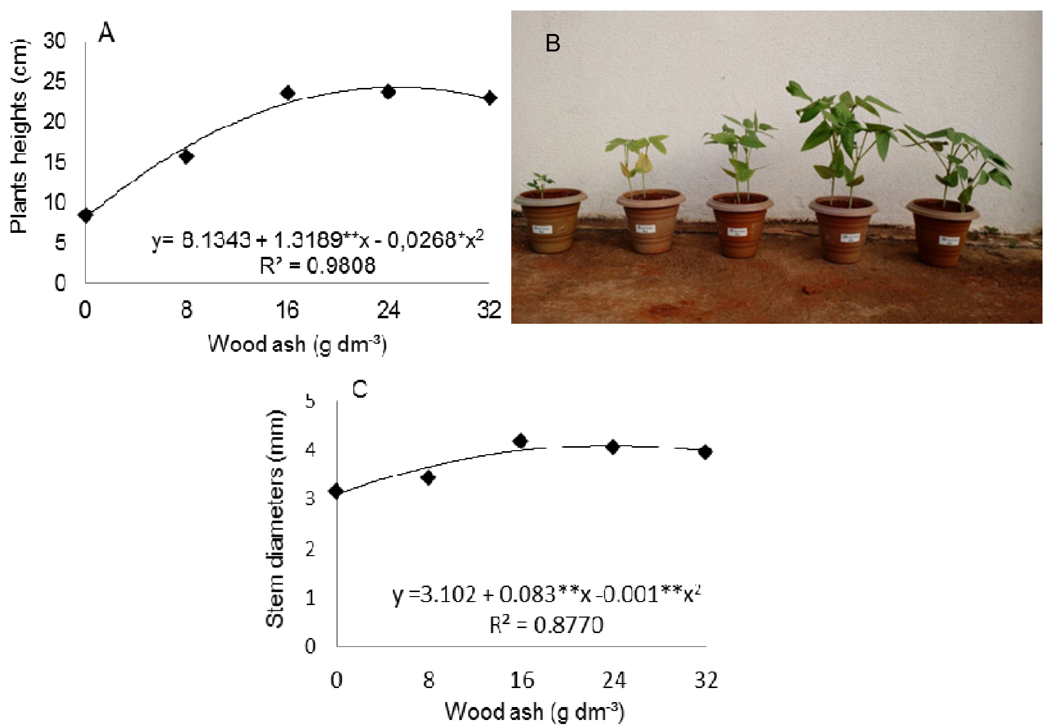

Fig. 3. Plant heights (A and B) and stem diameters (C) of cowpea as a function of the wood ash doses.

** P < 0.05; ** P < 0.001*

Stem diameter also responded to the wood ash dosages, with adjustment to the quadratic model of regression (Fig. 3C). The largest stem diameter (4.08 mm) was observed for the wood ash dose of 23.25 g dm^{-3}.

The nutrients contained in the wood ash applied improved the soil fertility and enabled the development of more robust plants, having greater height and stem diameter. Fertilization with wood ash promote taller plant (*Gossypium hirsutum* L) and thicker stem diameter [15]. The wood ash application raised the soil fertility, providing enhanced plant nutrition and, therefore, improved growth of the *Pinus radiata* trees [16].

The number of leaves was adjusted to the regression model, with the most number of leaves (8.27) being noted for the wood ash dose of 27.03 g dm^{-3} (Fig. 4A).

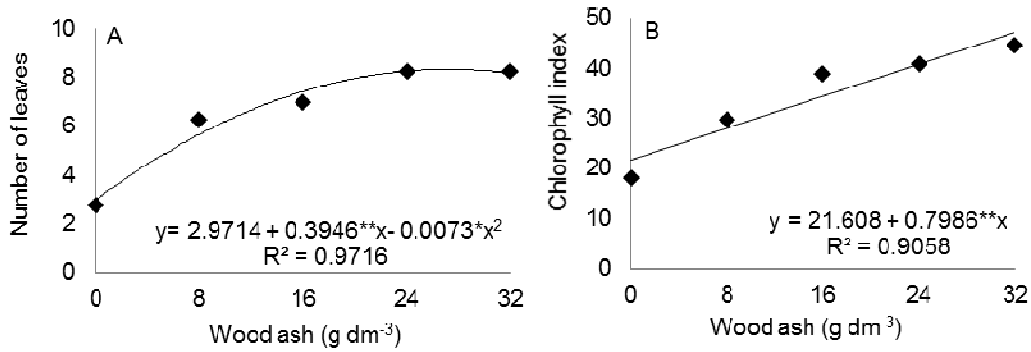

Fig. 4. Number of leaves (A) and chlorophyll index (B) of cowpea as a function of the wood ash doses.

** P < 0.05; ** P < 0.001*

When more nutrients were made available to the plants via fertilization utilizing wood ash the number of leaves was positively affected. Studies on the availability of soil phosphorus have reported that plant ashes are available source of mineral fertilizers, thus highlighting the feasibility of their use [17]. There are rises in the soil macronutrient contents in response to ash application, thus facilitating higher development in lettuce plants [18]. When treated with wood ash doses occurred an increase in the number of crotalaria leaves (*Crotalaria juncea*), because of the higher nutrient availability to the plants [19].

The variable chlorophyll index was adjusted to the linear regression model (Fig. 4B). The increase of the wood ash doses was observed to encourage a boost in the chlorophyll content of the plants, of the order of 54.18%, when compared to a higher dose in the absence of wood ash.

Rise in the chlorophyll indexes was findings in another study with wood ash doses in cotton [15]. In both instances, the increase may be linked to the greater nitrogen absorption, as the ash application may increase the soil nitrification rate and, consequently, the increased availability of nitrogen to the plants. Occur rise in nitrification when soil eucalyptus ash (*Eucalyptus globulus*) was added [20].

The production of the aerial and root dry masses was affected by the plant ash doses, and the data were adjusted to the linear regression model (Fig. 5A and B). An increase of 93.83% was recorded in the dry mass of the aerial portions with the application of the highest wood ash dose, as against the dry mass produced in the absence of such an application.

The increased shoot dry mass production in response to the wood ash doses was attributed to the increased plant height and the greater number of leaves produced, which in turn also raised the photosynthetic leaf area.

Fertilization using wood ash can also enhance the plant nutrient uptake. The wood ash increased the dry mass in the marandu grass (*Brachiaria brizantha*) resulting from the increased nutrient supply provided by the ash used as fertilizer [21].

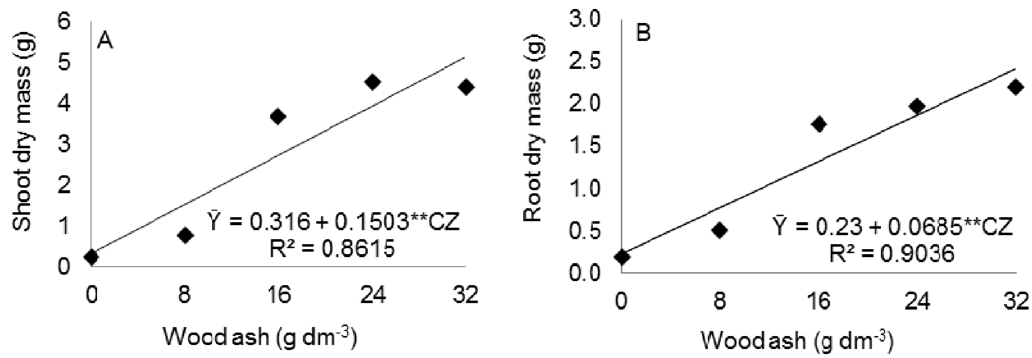

Fig. 5. Shoot dry mass (A) and root dry mass (B) of cowpea as a function of gray doses. Rondonópolis - MT.

*** P < 0.001*

A 90.50% rise in the root yield post fertilization with wood ash was reported, compared with the root production for the highest dose tested without the wood ash fertilization. The increase in the development of the root system of these plants facilitates greater soil volume to be explored, thus encouraging higher water and nutrient absorption, resulting in better plant development. Such increases of the roots were observed in the radish culture [19].

The data collected on water consumption and the efficiency of its use were adjusted to the linear regression model (Fig. 6A and B).

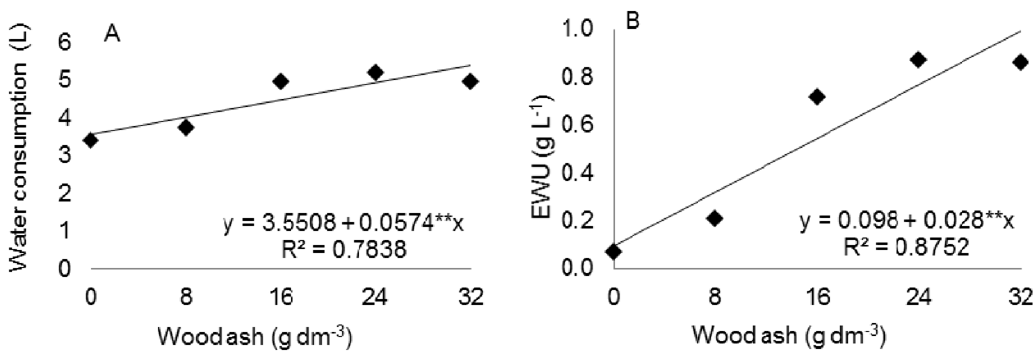

Fig. 6. Water consumption (A) and efficiency of water use (EWU) (B) in cowpea as a function of the doses of wood ash. Rondonópolis - MT.

*** P < 0.001*

Wood ash fertilization was observed to increase the water consumption and efficiency in cowpea by 34.09% and 90.14%, respectively. Water consumption rose in response to improved plant development (Figs. 3, 4 & 5). Plants with better developed aerial parts have greater evapotranspiration, and therefore, better water consumption and nutrient absorption.

The enhanced efficiency of water use is attributed to the higher nutrient concentration made available by the wood ash and the lowered soil acidity levels. The growth and efficiency of water use in the arugula (*Eruca sativa*) plants are improved with the application of wood ash [22].

4. CONCLUSION

The wood ash was found to promote conditions favorable to the initial development of the cowpea, and can be used as a corrective and a fertilizer for this culture. Based on this improvement in the fertility of the soil, it is safe to assume that there are also gains in sustainability and that the application of vegetal ash can contribute to combating soil degradation.

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