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Scientific Article

Potential of wood ash on the production characteristics of peanuts and mitigation of water deficit

Potencial da cinza vegetal nas características produtivas de amendoim e mitigação do déficit hídrico

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ABSTRACT - The application of wood ash in agriculture emerges as a promising technique to enhance agricultural productivity. Its chemical composition can improve soil attributes, acting as a fertilizer, corrective agent, and assisting in water retention. However, studies recommend controlled adoption to avoid adverse impacts. The objective of this article is to evaluate the potential of wood ash as a fertilization strategy in peanut cultivation, with an emphasis on optimizing plant productivity and reducing water deficit. The experiment was carried out in a greenhouse in 5 dm^3 pots; the experimental design applied was randomized blocks, forming a 5x5 factorial scheme, corresponding to five doses of wood ash (0; 8; 16; 24 and 32 g dm^{-3}) and five levels of water availability (25; 50; 75; 100 and 125% of field capacity), with four repetitions. The cultivar used was IAC OL-3. The data were subjected to the normality test to check whether they followed the normal distribution and, subsequently, subjected to analysis of variance and, when significant, subjected to regression analysis, at a 5% probability of error. Wood ash, rich in nutrients, proved to be a viable alternative source of nutrients. Doses between 18.4 and 22.8 g dm^{-3} of wood ash led to the most satisfactory results. The water availability that responded best ranged from 96 to 111.3%. Wood ash, at doses of 22.8 and 19.64 g dm^{-3}, contributed to water consumption and soil water efficiency.

Keywords: *Arachis Hypogaea.* Soil fertility. Water availability.

RESUMO - A aplicação de cinza vegetal na agricultura surge como técnica promissora para potencializar a produtividade agrícola. Sua composição química tem aptidão para aprimorar os atributos do solo, atuando como fertilizante, corretivo e auxiliando na retenção de água. Entretanto, estudos recomendam adoção controlada, para evitar impactos adversos. O objetivo da pesquisa foi avaliar o potencial da cinza vegetal como estratégia de adubação na cultura do amendoim, com ênfase na otimização da produtividade das plantas e na redução do déficit hídrico. O experimento foi conduzido em casa de vegetação em vasos de 5 dm³; o delineamento experimental aplicado foi em blocos casualizados, formando um esquema fatorial 5x5, correspondente a cinco doses de cinza vegetal (0; 8; 16; 24 e 32 g dm³) e cinco disponibilidades hídricas (25; 50; 75; 100 e 125% da capacidade de campo), com quatro repetições. A cultivar utilizada foi a IAC OL-3. Os dados foram submetidos ao teste de normalidade para verificar se seguiram a distribuição normal e, posteriormente, submetidos à análise de variância e, quando significativo, submetidos à análise de regressão, a 5% de probabilidade de erro. A cinza vegetal, rica em nutrientes demonstrou ser uma alternativa viável de fonte de nutrientes. Doses entre 18 e 23 g dm^{-3} de cinza vegetal apresentaram os resultados mais satisfatórios. A disponibilidade hídrica que melhor respondeu foi de 96 a 112%. A cinza vegetal, nas doses de 23 e 20 g dm-³, contribuiu no consumo da água e na eficiência hídrica do solo.

Palavras-chave: *Arachis hypogaea*. Fertilidade do solo. Disponibilidade hídrica.

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a legume consumed worldwide. Brazil's natural and industrialized versions are widely appreciated (SILVA et al., 2020).

In recent years, there has been a notable increase in the consumption of products derived from this legume, thus boosting its production. Given this scenario, concerns about meeting growing demand and ensuring high yields in a competitive manner have gained prominence. Among these concerns are the high costs of chemical fertilizers, which are essential for nutrient availability, and the unpredictability of rainfall, which affects crop efficiency and the availability of water resources for plantations. In addition, research on environmental conservation and the use of natural resources in production has intensified, aiming to preserve the environment and supply the market. Applying techniques that meet this expectation has been valued in this field, especially those that preserve soil, water, and biodiversity. They balance production and conservation and promote agricultural sustainability (SOARES et al., 2020).

In this context, the use of wood ash in agriculture has shown promise. It is a residue that is highly capable of regulating soil acidity and improving its fertility, providing essential nutrients for plants, reducing soil degradation, and improving its chemical, physical, and biological attributes, resulting in increased crop productivity and quality (BONFIM-SILVA; SCHLICHTING; JOSÉ, 2020).

Bonfim-Silva, Schlichting, and José (2020) highlighted that wood ash provides calcium, potassium, phosphorus, and magnesium, neutralizes aluminum toxicity (Al^{3+}), and increases nutrient availability in the soil solution and the cation exchange capacity.

Given the beneficial characteristics of wood ash and its ability to alter aspects of the soil, it is important to stress the need for studies related to water consumption and the efficiency in its use, as part of strategies to tackle water deficit and seek sustainability in the soil-water-plant system (BONFIM-SILVA et al., 2011).

Duarte, Silva, and Bonfim-Silva et al. (2020) showed in their research that introducing wood ash into the soil can trigger various effects on water properties. These effects are intrinsically linked to the interaction between the specific properties of the ash used and the characteristics of the soil, especially its texture.

Given this information, this article aimed to evaluate the potential of wood ash as a fertilization strategy for peanut cultivation, with emphasis on optimizing plant productivity and reducing water deficit.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the Federal University of Mato Grosso, on the Rondonópolis University Campus, geographically located at latitude 16º27'49.39"S, longitude 54º34'46.59"W and altitude of 284 m. The experimental design was randomized blocks, forming a 5x5 factorial scheme, corresponding to five doses of wood ash (0, 8, 16, 24, and 32 g dm^{-3}) and five levels of water availability (25, 50, 75, 100, and 125% of field capacity), making up a total of 100 experimental units.

The soil was collected in an area under Cerrado vegetation, close to the greenhouse, at a depth of 0-20 cm, for chemical and physical analysis (Table 1), classified as *Latossolo Vermelho distrófico* (Oxisol) (EMBRAPA, 2018).

Table 1. Chemical and particle-size characterization of samples at a depth of 0-20 cm* of Oxisol in a Cerrado area in Rondonópolis, MT, Brazil.

pH	P	S	K	Ca	Mg	Al	H+Al	V	m
$CaCl_2$	------------------mg dm^{-3} ------------------			-------------------- cmol dm^{-3} --------------------				------------ % ------------	
4.3	1.5	2.00	18.00	0.50	0.20	0.60	4.80	13.5	44.4
Zn	Mn	Cu	Fe	B	Clay	Silt	Total sand	SB	CEC (T)
------------------------ (mg/dm^3) ------------------------					-------------------------- (g/kg) --------------------------			------- ($cmol_c/dm^3$) -------	
0.70	21.80	0.20	64.00	0.15	330.0	100.0	570.0	0.75	5.55

pH $CaCl_2$= pH in Calcium Chloride; Pmel = Mehlich Phosphorus; S= Sulphur; K= Potassium; Ca= Calcium; Mg= Magnesium; Al = Aluminum; H+Al = Potential Acidity; Zn= Zinc; Mn= Manganese; Cu= Copper; Fe= Iron; B= Boron; SB = sum of bases; CEC= cation exchange capacity; V = Base Saturation; m = Percentage of Aluminum Saturation.

Once the soil had been sieved through a 4 mm mesh, it was incubated with wood ash, using the respective doses (0, 8, 16, 24, and 32 g dm^{-3}), and placed in plastic bags containing 4.5 dm³ of soil for 30 days. Soil moisture was maintained at 60% of the maximum water retention capacity.

The ash used in the experiment came from the food industry in the Rondonópolis-MT region and was analyzed as a fertilizer (Table 2) according to Osaki and Darolt (1991).

Table 2. Chemical characterization of wood ash as a fertilizer.

pH	N	P_2O_5	K_2O	Ca	Mg	Fe	Cu	Mn	B	Zn
$CaCl_2$	--- g kg^{-1} ---									
10.97	4.9	7.9	32.5	49.6	42.0	7.2	0.1	0.4	0.4	0.2

N = Nitrogen; P_2O_5 = Phosphorus in neutral ammonium citrate and water; K_2O = Potassium; Ca = Calcium; Mg = Magnesium; Fe= Iron; Cu = Total copper; Mn= Total manganese; B = Total boron; Zn = Total zinc.

The maximum water retention capacity of the soil or field capacity (FC) was determined in the laboratory using three pots perforated at the bottom. With 4.5 kg of soil in each 5 dm³ pot, they were immersed in water until the soil was saturated (24 hours) and then suspended to drain the excess water (48 hours). After this period, the pots were weighed to obtain the maximum water retention capacity of the soil by the difference in weight (pot capacity) according to the method described by Bonfim-Silva et al. (2011) (Equation 1).

$$\text{Pdrained soil} - \text{Pdry soil} = 100\%\text{FC} \quad (1)$$

The cultivar used was IAC OL3, a variety developed by the Agronomic Institute of Campinas (IAC), which was sown using ten seeds per pot at a depth of 2 cm. Seedling emergence began six days after sowing, and thinning was carried out 20 days after emergence (DAE), leaving three plants per pot, following the criteria of homogeneity, arrangement in the pots, and size. During this same period, the treatments were started with the respective field capacities (25, 50, 75, 100, and 125%) and applied according to the data obtained from the maximum water retention capacity of the soil.

According to the treatments, irrigation was carried out twice a day, once in the early morning and once in the late afternoon, throughout the experimental units to maintain soil moisture. Irrigation management was determined using the gravimetric method (BONFIM-SILVA et al., 2011).

The variables analyzed were shoot dry mass (SDM), root dry mass (RDM), root volume (RV), total water consumption (TWC), and water use efficiency (WUE). The shoot was manually separated from the roots by washing them in running water to remove the soil. The washed roots were placed in a 50 mL beaker containing a known volume of water. The root system of the three plants from each experimental unit was then inserted into the cylinder, where the water level displacement indicated the roots' volume.

The evaluations began 115 days after the crop emerged. During this period, the plant was in phenological stage R8, which was the right time to harvest. The separated material was then placed in paper bags and dried in a forced circulation oven at 65 °C for 72 hours to obtain the SDM and RDM. After drying, the samples were weighed on an analytical scale for evaluation.

Total water consumption was determined by the total amount of water consumed by each treatment during the experiment.

In turn, water use efficiency (WUE) was determined by the ratio between the amount of shoot dry mass (SDM) and the total water consumption (TWC) of each treatment (Equation 2):

$$WUE=\frac{SDM}{TWC} \quad (2)$$

The data were subjected to the normality test to assess whether it followed a normal distribution. Then, an analysis of variance was carried out, and if the results were significant, the data were subjected to a regression analysis, both up to a 5% probability of error. All statistical analyses were carried out using R Studio software (R DEVELOPMENT CORE TEAM, 2018).

RESULTS AND DISCUSSION

The chemical composition of wood ash (Table 2) reveals a significant concentration of nutrients crucial to the growth and development of peanuts, such as phosphorus, potassium, calcium, and magnesium. These components play a vital role in crop production and productivity, highlighting wood ash as a viable alternative source of fertilizer for plants since the elements contained in its composition are relevant to various physiological processes linked to plant development (CAVALCANTE et al., 2018).

In this context, it is possible to observe that wood ash has a variety of important nutrients in a production system, which, as presented by Cavalcante et al. (2018), offer advantages in the context of its application in agriculture.

The variables had satisfactory normality and did not need to be transformed. The data from the variance analysis in Table 3 refer to shoot dry mass, root dry mass, and water use efficiency. These showed results with isolated effects ($p < 0.05$) for the factors wood ash doses and water availability, with the quadratic regression model best explaining these results.

Table 3. Summary of the analysis of variance for shoot dry mass, root dry mass, and water use efficiency.

SV	DF	p-value		
		Shoot dry mass	Root dry mass	Water use efficiency
Wood ash doses	4	< 0.05*	< 0.05*	< 0.05*
Water availability	4	< 0.05*	< 0.05*	< 0.05*
Dose * water availability	16	0.0686 ns	0.0892 ns	0.0626 ns
Error	72			
CV%		31.28	55.27	30.68

Significant: *p ≤ 0.05; * by F test; ns – non-significant difference. SV – source of variation; DF – Degrees of freedom; CV – Coefficient of variation.

In the shoot dry mass variable, the results showed that the best response was obtained with a dose of 19.72 (g dm^{-3}) of wood ash, resulting in an average production of 33.18 g per pot^{-1} (Figure 1A). Compared to the treatment without fertilization, the results showed a significant increase of 67.6% in the production of shoot dry mass. This indicates that the application of this specific dose of wood ash had a significant impact on increasing the shoot dry mass of peanuts.

Regarding the composition of this residue, calcium, one of the most abundant elements, played a crucial role in the effects observed. According to Bonfim-Silva et al. (2019b), the presence of this element is fundamental in various functions of plant growth and development.

Magnesium, also found in a significant quantity in wood ash, contributed to the plant's performance, as this nutrient performs various functions that promote growth, and its role in enzyme activation is particularly noteworthy (PEREIRA et al., 2020).

Considering the results observed and the fact that these nutrients are of paramount importance for the metabolic processes of plants, it is possible to deduce that they contributed to the increase in the shoot dry mass of peanuts observed in this study.

The results also showed that the shoot dry mass of peanuts increased significantly with increased water availability. The greatest response was observed when the crop received a supply of 96% of field capacity (Figure 1B), resulting in a dry mass of 29.86 g pot^{-1}. This represented an increase of more than 92% compared to the lowest water availability offered.

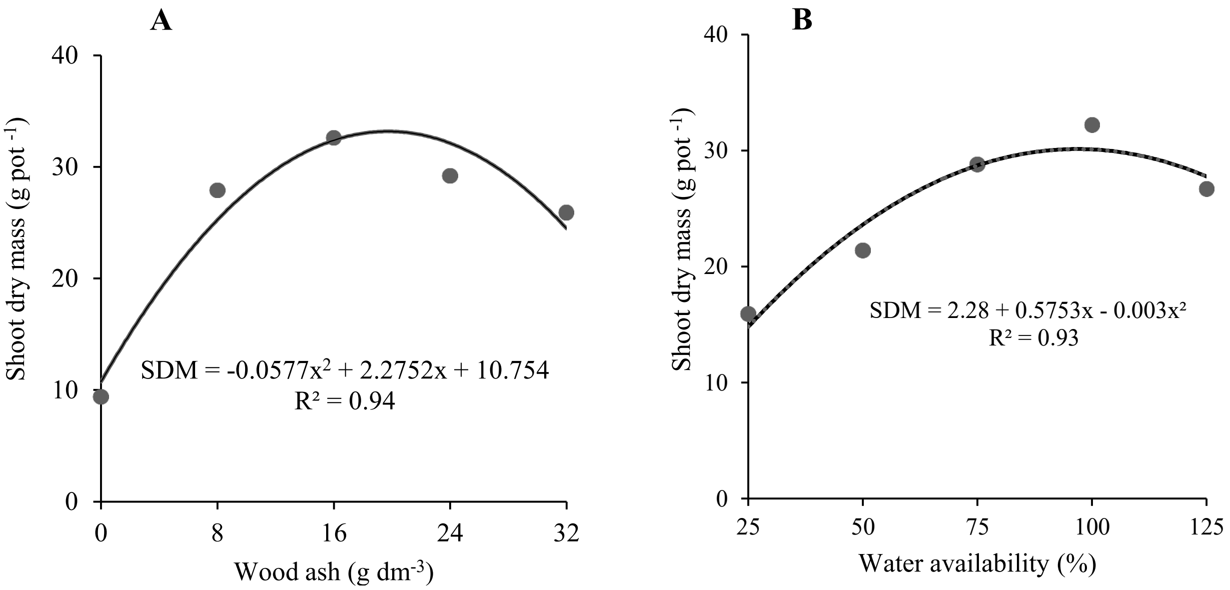


Figure 1. Shoot dry mass g (pot^{-1}) of peanut as a function of wood ash (g dm^{-3}) (A) and water availability (%) (B). Significant at 5% probability.

These results corroborate the study conducted by Pinto et al. (2020), highlighting the authors' significant contribution by emphasizing the importance of fertilization and the positive influence of water availability on peanut crop productivity.

At this stage of development, from vegetation to flowering, the crop needs good water availability, reaching close to 100% of field capacity. This is essential to support its metabolism and guarantee the fundamental synthesis of organic compounds necessary for growth.

Bonfim-Silva et al. (2019a) demonstrated in their studies the beneficial interaction of combinations of wood ash doses with soil water tension, obtaining productive yields of Paiaguás grass and reducing the effect of drought stress.

Bang et al. (2020) highlighted in their research the benefit of potassium for the plant, which is one of the nutrients made available by wood ash, playing a crucial role as a regulator of stomatal movements, contributing to the regulation of transpiration and, consequently, to the water balance of plants.

Agricultural productivity is conditioned on determining factors that allow it to reach its maximum potential, and soil moisture is one of these key elements that affect the physiological development of plants.

For peanut root dry mass production, the dose that benefited this variable was 18.4 g dm^{-3} of wood ash (Figure 2A), reaching a total of 25.6 g pot^{-1}, a 64.18% increase in production compared to the absence of fertilization. This same result was achieved with 111.3% water availability, but the increase was 126% compared to 25% water availability for the plant (Figure 2B).

Wood ash is composed of nutrients that promote changes in the soil's chemical composition, neutralizing aluminum (Al^{3+}) and making nutrients available (PEIXOTO et al., 2019) in order to favor root growth (DAYRELL et al., 2020).

As a result, calcium and magnesium in this residue enhance soil acidity correction, making essential nutrients available for growth, such as phosphorus, calcium, and magnesium, among others. These nutrients are crucial in root development and overall plant health (KORZUNE et al., 2021).

Soil moisture also has a significant influence on root development. The results of this study show that the conditions that provide the greatest water availability led to the best results, as illustrated in Figure 2B.

Silva et al. (2017) found a decrease in root dry mass under conditions of lower water retention capacities (WRC), specifically at the WRCs of 50% and 70%, differing significantly from the results obtained at the WRC of 90%, under which higher values of root dry mass were observed. The authors stress the importance of soil moisture in the production system context, as it plays an important role in plant development and directly influences the development of root dry mass.

Due to the peanut crop's demand for water, lower root dry mass values were observed as water availability decreased. In this context, water availability is an abiotic factor that directly influences plant development and causes morphological changes (CAMPOS; SANTOS; NACARATH, 2023).

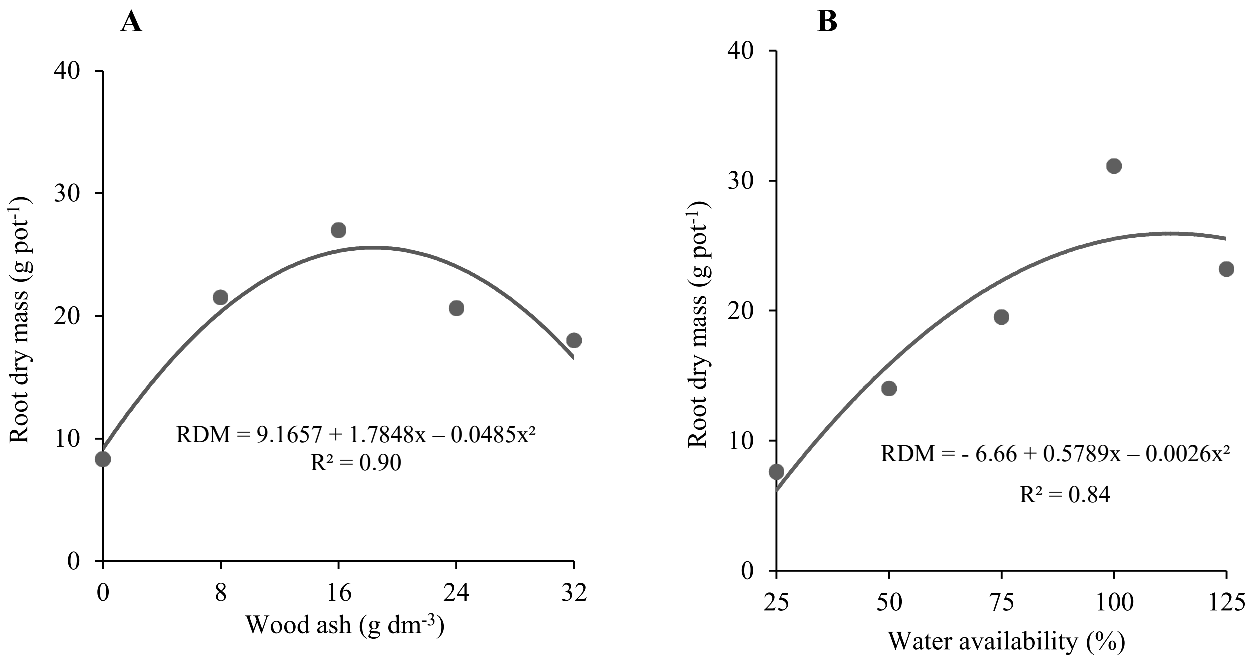


Figure 2. Root dry mass (g pot^{-1}) of peanut as a function of wood ash doses (g dm^{-3}) (A) and water availability (%) (B). Significant at 5% probability.

Despite the chemical alteration of the soil caused by wood ash, Mezzomo et al. (2020) pointed out in their study that plants under water deficit absorb fewer nutrients, as this process occurs through mass flow in the soil solution, and when the amount of water found in the soil is not sufficient to meet the plant's demand, this whole process is affected. In cases of waterlogging, the plant's stomatal conductance is impaired, affecting plant development, both in the shoot and in the root (BONFIM-SILVA et al., 2011).

The variables that showed a significant interaction were root volume and total water consumption (Table 4), i.e., the interaction results reached a significance level of <0.05.

Table 4. Summary of analysis of variance for root volume and total water consumption.

SV	DF	p-value	
		Root volume	Total water consumption
Wood ash doses	4	<0.005*	<0.005*
Water availability	4	<0.005*	<0.005*
Dose * Water availability	16	0.005*	<0.005*
Error	72		
CV%		36.01	15.16

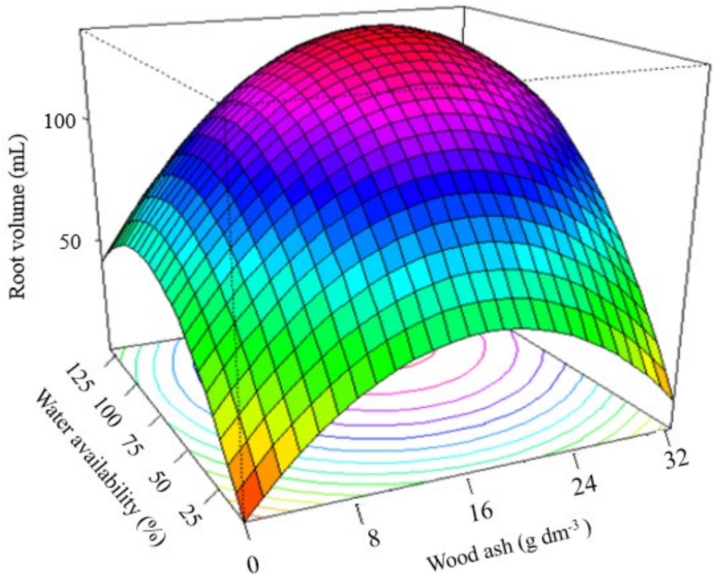
Significant: $^{*}p \leq 0.05$; * by F test; ^{ns} – non-significant difference. SV – source of variation; DF – Degrees of freedom; CV – Coefficient of variation.

The maximum value of root volume was 134.18 cm³ at the wood ash dose of 20.48g dm^{-3} associated with 98.74% water availability (Figure 3). Bonfim-Silva et al. (2019b) obtained similar results for cowpea and attributed this to the pH value, corrected by fertilization, and the availability of essential nutrients for root development and growth, such as K, P, Ca, and Mg, present in this residue.

These elements play a crucial role in the growth and development of plants, besides increasing their productivity. As highlighted in the study carried out by Santiago and Rosseto (2009), the authors considered that these nutrients played a significant role in the growth of plant roots since their presence can increase the breadth of the area to be explored, which consequently results in greater absorption of water and nutrients, resulting in greater productivity.

The neutralization of toxic aluminum that the ash promotes, as already highlighted in this study, emerges as a crucial determinant in optimizing biomass production, as evidenced in the study by Abdalla et al. (2022).

In the absence of wood ash and under 100% water availability in the treatment, a decrease of more than 50% in root volume production was observed compared to the more optimized results obtained with the presence of wood ash. This chemical change in the soil substantially improves the efficiency of nutrient assimilation in the system and enhances the search for water, which in turn alleviates concerns related to water scarcity (SCALON et al., 2011).

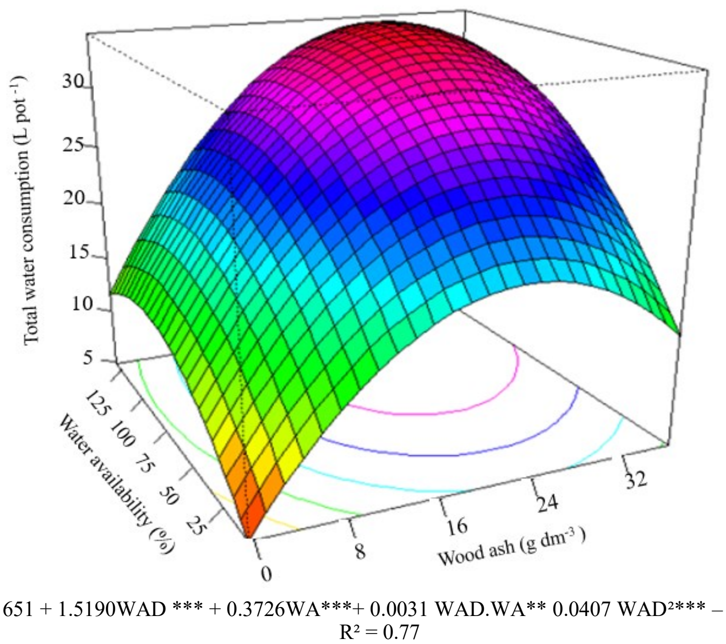


RV = -55.4036**+ 5.6087WAD*** + 2.6768 WA*** + 0.0167 WAD.WA*** - 0.1772 WAD²*** – 0.0153WA²***
$R^2 = 0.54$

Figure 3. Root volume (mL) of peanut as a function of wood ash doses and water availability; RV – Root volume, WAD - Wood ash doses, WA - Water availability. **, ***, Significant at 1% and 0.1% probability, respectively.

The interconnection between the soil-water-plant components showed intrinsic effectiveness after the application of wood ash as a soil improvement strategy. We can validate this information based on the study conducted by Bonfim-Silva et al. (2015) on the satisfactory rate of root volume produced, where the authors highlighted that the addition of this residue not only benefits soil fertility and water absorption but also favors the system's empty spaces and allows for a better flow of oxygen, therefore stimulating a more vigorous rooting process.

For total water consumption, the maximum value was 34 mL (Figure 4), promoted by the wood ash dose of 22.8 g dm^{-3} associated with water availability of 108.8%. Research carried out by Bonfim-Silva et al. (2017) on water consumption and use efficiency corroborates the results of this study, in which wood ash contributed with 34.09% to water consumption, improving plant development and nutrient absorption. The data show that higher water use efficiency is associated with higher concentration of nutrients provided in the fertilization with wood ash.



TWC = -3.1651 + 1.5190WAD *** + 0.3726WA***+ 0.0031 WAD.WA** 0.0407 WAD²*** – 0.0020WA²***
$R^2 = 0.77$

Figure 4. Total water consumption (L pot^{-1}) of peanut as a function of wood ash doses and water availability; TWC - Total water consumption, WAD - Wood ash doses, WA - Water availability. **, ***, Significant at 1% and 0.1% probability, respectively.

Soil fertility contributed to water consumption. According to Moraes, Bonetti, and Cherubin (2020), healthy plants generally have a more stable demand for water, while plants stressed by disease, pests, or other factors may have altered water consumption.

As these are compounds rich in organic matter and with greater variability of essential elements (BONFIM-SILVA et al., 2019a), wood ash favors the preservation of organic matter and enzymatic activity, promoting an improvement in moisture retention capacity and adequate drainage.

The potassium (K) provided by wood ash also played a crucial role in total water consumption. Bang et al. (2020) point out that the presence of this element is essential for the occurrence of photosynthetic activity, the maintenance of cell turgor, the regulation of stomatal movements, and the promotion of water uptake by plants.

In addition, the authors mentioned above state in their study that potassium is very important in regulating the translocation of nutrients within the plant, stimulating the transport and storage of carbohydrates, increasing nitrogen absorption, and promoting protein synthesis.

Another element in wood ash, not presented in this study but identified in other studies, is silicon. Bonfim-Silva et al. (2020) found a concentration of 187 g kg^{-1} of this element. Mauad et al. (2016) state that silicon plays a crucial role in plants' biochemical, physiological, and photosynthetic processes, helping to mitigate the stress caused by water scarcity.

However, it is important to note that a plant's total water consumption depends on several factors, such as the type of plant, environmental conditions, growth stage, and plant health, as these factors directly influence this consumption (MORAES; BONETTI; CHERUBIN, 2020).

Water use efficiency showed the best response (34 g DM L^{-1}) (Figure 5A) at the wood ash dose of 19.64 g dm^{-3}, with an increase of 65.92% compared to the absence of fertilization. Concerning water availability (Figure 5B), the best water use efficiency (31.52 g DM L^{-1}) was observed at 98.48%, with an increase of 92.33% compared to the lowest water supply.

The presence of nutrients in the soil due to wood ash can influence water retention, improving its use efficiency. As mentioned above, this relationship is linked to increased organic matter. This, in turn, increases the hydration capacity and improves the soil's physical and hydraulic characteristics (FERREIRA; FAGERIA; DIDONET, 2012).

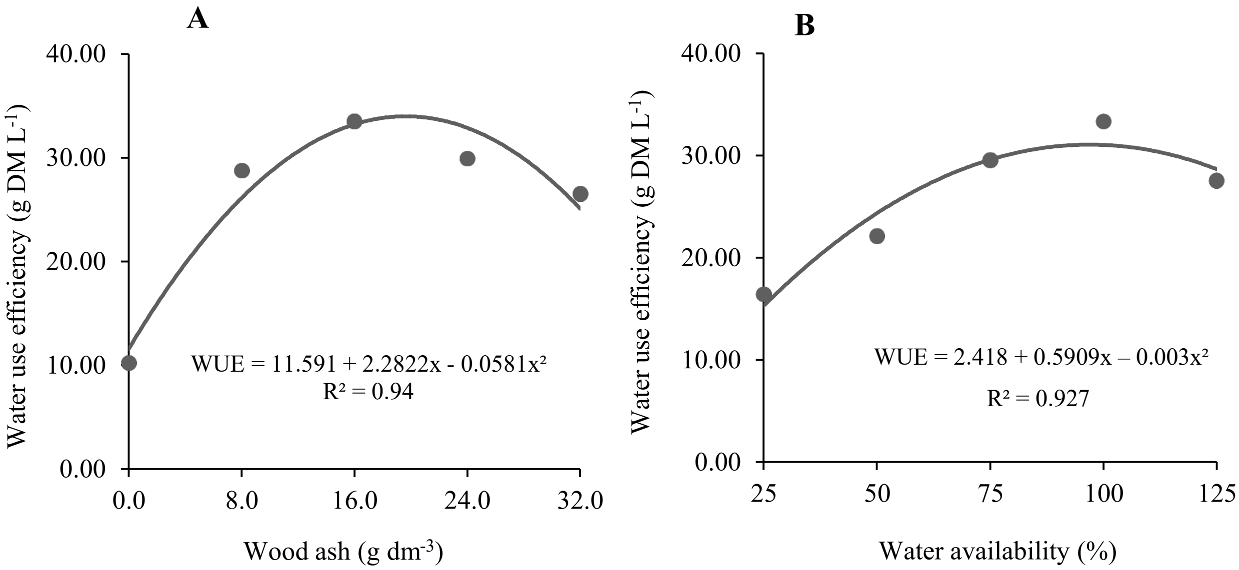


Figure 5. Water use efficiency (g DM L^{-1}) of peanut as a function of wood ash doses (g dm^{-3}) (A) and water availability (%) (B). DM – Dry mass. Significant at 5% probability.

A beneficial result can also be observed in plants of the Brassicaceae family, and Bonfim-Silva et al. (2011) point out that the application of wood ash fertilizer had a beneficial impact on increasing production, as well as promoting significant improvements in water consumption and water use efficiency by arugula.

Due to these facts, we can associate that the addition of wood ash promoted a nutritional balance in the plants, allowing them to use water more efficiently. Since wood ash can create a more porous and stable surface layer in the soil, it reduces the rate of water evaporation, helping to conserve soil moisture (BONFIM-SILVA et al., 2019b).

Corroborating these results, Sousa et al. (2017) identified an increase in the water use efficiency of papaya in treatments with wood ash, with a positive response in terms of productivity when compared to treatments without it.

However, we can see that wood ash in the soil can alter the dynamics of water retention, which can contribute to irrigation practices to avoid excess or lack of water for plants.

However, sufficient information must be available to determine the WUE of a crop in order to plan which treatment or planting time will provide the best amount of water for the plants and the economic viability of the activity. Further research is therefore needed to assess this factor in order to contribute to the entire agricultural system, avoiding unnecessary expenditure and waste of this resource.

CONCLUSIONS

Wood ash is a viable alternative as a source of fertilizer due to its rich composition of essential nutrients. Doses between 18 g dm^{-3} and 23 g dm^{-3} proved to be more effective in promoting the development of peanut shoot dry mass, root dry mass production, and root volume.

The water availability level that optimized the production of shoot dry mass, root dry mass production, and root volume of this oilseed crop was between 96% and 112%.

The addition of wood ash promoted improvements in water consumption and use efficiency, with the doses of 22.8 and 19.64 g dm^{-3} being the most effective. The water availability levels associated with these doses, 108.8% and 92.33%, respectively, were the most favorable. The presence of minerals such as calcium and magnesium in the wood ash correlated positively with increased cation exchange capacity in the soil, favoring nutrient availability and water retention, contributing to water deficit mitigation.

REFERENCES

ABDALLA, M. et al. A calagem das pastagens aumenta a produtividade da biomassa sem causar impactos prejudiciais nas emissões líquidas de gases de efeito estufa? **Revista Poluição Ambiental**, 300: 1-15, 2022.

BANG, T. C. et al. The molecular-physiological functions of mineral macronutrients and their consequences for deficiency symptoms in plants. **Tansley Review**, 229: 2446-2469, 2020.

BONFIM-SILVA, E. M.; SCHLICHTING, A. F.; JOSÉ, J. V. Cinza vegetal como corretivo e fertilizante. In: BONFIM-SILVA, E. M. (Eds.). **Cinza vegetal e biochar na agricultura**. Maringá, PR: Uniedusul, 2020. v. 1, cap. 1, p. 7-30,

BONFIM-SILVA, E. M. et al. Características fitométricas e índice de clorofila de cultivares de amendoim adubado com cinza vegetal. **Brazilian Journal of Development**, 6: 13468-13482, 2020.

BONFIM-SILVA, E. M. et al. Wood ash and water availability in the production of Paiaguás-grass. **Revista Ambiente & Água**, 14: 1-15, 2019a.

BONFIM-SILVA, E. M. et al. Growth and development of cowpea under wood ash doses and liming. **Brazilian Journal of Development**, 5: 28701-28718, 2019b.

BONFIM-SILVA, E. M. et al. Initial Development of Cowpea Submitted to Wood Ash Doses. **International Journal of Plant & Soil Science**, 17: 1-7, 2017.

BONFIM-SILVA, E. M. et al. Características produtiva do rabanete submetido a doses de cinza vegetal. **Enciclopédia Biosfera, Centro Científico Conhecer**, 11: 421-432, 2015.

BONFIM-SILVA, E. M. et al. Características produtivas e eficiência no uso de água em Rúcula adubada com cinza vegetal. **Enciclopédia Biosfera, Centro Científico Conhecer**, 7: 178-186, 2011.

CAMPOS, A. J. M.; SANTOS, S. M.; NACARATH, I. R. F. F. Water stress in plants: a review. **Research, Society and Development**, 10: 1-7, 2023.

CAVALCANTE, A. C. P. et al. Physiology of Paluma guava plants fertilized with potassium and calcium. **Idesia**, 36: 163-172, 2018.

DAYRELL, L. H. S. et al. Productivity of peanut grown on Urochloa brizantha straw as a function of liming. **Revista Agrária Acadêmica**, 3. 89-102, 2020.

DUARTE, T. F.; SILVA, T. J. A.; BONFIM-SILVA, E. M. Cinza vegetal nos atributos físicos do solo. In: BONFIM-SILVA, E. M. (Ed.). **Cinza vegetal e biochar na agricultura**. Maringá, PR: Uniedusul, 2020. v. 1, cap. 3, p. 42-61.

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária. **Sistema Brasileiro de Classificação de Solos**. 5 ed. rev. ampl. Brasília, DF: EMBRAPA, 2018. Available at: <https://www.embrapa.br/solos/busca-de-publicacoes/-/publicacao/1107206/sistema-brasileiro-de-classificacao-de-solos>. Access on: Apr. 6, 2022.

FERREIRA, E. P. B.; FAGERIA, N. K.; DIDONET, A. D. Chemical properties of an Oxisol under organic management as influenced by application of sugarcane bagasse ash. **Revista Ciência Agronômica**, 43: 228-236, 2012.

KORZUNE, M. et al. Crescimento e produção de matéria seca da raiz e da parte aérea em mudas de Poncirus trifoliata (L.) Raf. sob efeitos de gesso e calagem. **Pesquisa, Sociedade e Desenvolvimento**, 10: 1-10, 2021.

MAUAD, M. et al. Effects of silicon and drought stress on biochemical characteristics of leaves of upland rice cultivars. **Revista Ciência Agronômica**, 47: 532-539, 2016.

MEZZOMO, W. et al. Produção forrageira e eficiência de utilização da água do capim sudão submetido a diferentes lâminas de irrigação. **Revista Irriga**, 25: 143-159, 2020.

MORAES, M. T.; BONETTI, J. A.; CHERUBIN, M. R. Relações da água com parâmetros físicos e crescimento radicular das plantas. In: BONETTI, J. A.; FINK, J. R. (Eds.). **Manejo e conservação da água e do solo**. Lavras, MG: UFLA. 2020. cap. 3, p. 39-54.

OSAKI, F. M. R. DAROLT, M. R. Estudo da qualidade de cinzas vegetais para uso como adubos na região metropolitana de Curitiba. **Revista Setor Ciências Agrárias**, 11: 197-205, 1991.

PEIXOTO, D. et al. Atributos químicos de solo após incubação com produtos com cálcio e magnésio. **Acta Iguazu**, 8: 62-68, 2019.

PEREIRA, E. G. et al. O metabolismo de nitrogênio em plantas de arroz é severamente afetado pela deficiência de cálcio e magnésio. **Brazilian Journal of Development**, 6: 15351-15362, 2020.

PINTO, A. A. et al. Cultivo de amendoim em função da adubação e do espaçamento entre plantas em sistema de sequeiro e irrigação complementar. **Colloquium Agrariae**, 16: 27-36, 2020.

R Development Core Team. **R**: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing. Vienna. Austria, 2018. Disponível em: <Disponível em: https://www.r-project.org/ >. Acessado em: 08 de mar. de 2022.

SANTIAGO, A. D.; ROSSETTO, R. **Árvore do conhecimento Cana- de-Açúcar.** Agência Embrapa de Informação Tecnológica (Ageitec). 2009. Available at: <https://www.agencia.cnptia.embrapa.br/gestor/cana-de-acucar/arvore/CONTAG01 _19_711200516716.html>. Access on: Jan. 20, 2020.

SCALON, S. P. Q. et al. Water stress in metabolism and initial growth of mutambo (Guazuma ulmifolia Lam.) seedlings. **Ciência Florestal**, 21: 655-662, 2011.

SILVA, F. E. V. et al. Análise De Viabilidade Econômica De Uma Agroindústria Processadora De Amendoim. **Revista Interface Tecnológica**, 17: 376-387, 2020.

SILVA, R. C. D. et al. Nutrition with boron in soybean as function of soil water availability. **Revista Scientia Agraria**, 18: 155-165, 2017.

SOARES, J. P. G. et al. Agricultura orgânica e agronegócio: análise e impactos de tecnologias sustentáveis. In: GARNIERI, P.; GUIMARÃES, M. C.; THOMÉ, K. M. (Eds.). **Agronegócios: perspectivas**. Brasília, DF: Universidade de Brasília, 2020. v. 3, cap. 4, p. 108-149.

SOUSA, P. G. R. et al. Produtividade do mamoeiro cultivado sob aplicação de cinzas vegetais e bagana de carnaúba. **Revista Brasileira de Agricultura Irrigada**, 11: 1201-1212, 2017.