

4 Abstract

24 **Keywords:** *Eruca sativa* Miller, wood ash, organomineral, alternative fertilizers, root
25 development.

26 1. Introduction

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28 The arugula (*Eruca sativa* Miller), is cultivated mainly in small and medium properties
29 throughout the Brazilian territory, in the system we know as family farming. It is a short cycle
30 crop, herbaceous hardwood and fast growing vegetative, originating from southern Europe
31 and the western part of Asia. The leaves are very appreciated in the form of salad, mainly in
32 São Paulo and in the South region of Brazil [1].

33 Throughout the years, this culture has been highlighting itself in the national market. Due
34 to this appreciation in the scale of production, arugula obtains advantages over other crops,
35 due to its nutritional value in relation to the low cost per unit of production [1]. This bitter and
36 spicy vegetable is rich in iron, potassium and sulfur also contains elevated levels of proteins
37 and vitamins A and C [2].

38 For the good development of the plants it is necessary, among other factors, a soil with
39 good fertility. Reference [3] states that for the cultivation of vegetables crops a soil with good
40 fertility and base saturation between 70 and 80 % is required. The predominant soil class in
41 the Cerrado is Oxisol, characterized by low natural fertility, high aluminum saturation, acid
42 pH and low levels of calcium and magnesium [4]. Therefore, to make these soils productive,
43 it is essential to use agricultural practices such as liming and fertilization.

44 Nutrient replenishment through mineral fertilizers is interesting, since these can be rapidly
45 absorbed by the roots of plants, due to high concentration and high solubility. However, the
46 process of leaching and acidification of the soil can be increased easily [5], make the rational
47 management and assembly of fertilization necessary, and the incorporation of alternative
48 fertilizers to the system.

49 With the need for new fertilization alternatives emerged the organomineral compost,
50 originating from the mixture of mineral fertilizers with solid residues of organic compounds,

51 such as wood ash. This fertilizer is used as a soil conditioner, stimulating the development of
52 plant roots and enhancing the absorption of water and nutrients. Thus, increases in crop
53 production, stimulating agricultural sustainability [6], specifically by family farming, since
54 the greenery crops are greatly exploited in organic farming [7] and have increased aggregate
55 value.

56 The importance of organic fertilizers is due to the maintenance and improvement of the
57 soil's physical, chemical and biological properties, reflecting on the performance of crops [8].
58 Nutrient releases by organic fertilizers occur by the contact of soil micro-organisms with
59 organic matrix that will reduce size and gradually releasing nutrients to the plant, effect
60 known as controlled release [9].

61 The challenge is to elaborate practices that can demonstrate that solid residues of organic
62 compounds, applied in the soil, improve the availability of nutrients for plants and at the same
63 time reduce impacts to natural resources. In this context, it was aimed at evaluating the effect
64 of fertilizers with wood ash, organomineral fertilizers, in function the bases saturations in the
65 culture of the arugula in Oxisol.

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67 **2. Material and Methods**

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69 The experiment was conducted at greenhouse in the Federal University of Mato Grosso,
70 *Campus* of Rondonópolis. The Oxisol [10] it was collected at the layer of 0.0 - 0.2 m deep in
71 area under Cerrado vegetation. The chemical and particle size characteristics of the soil
72 (Table 1) followed the methodology of [11].

73

74 Table 1 - Chemical analyses and granulometric of the Oxisol collected at the layer of 0.0 - 0.2
75 m in area under Cerrado vegetation, Rondonópolis, MT, Brazil

pH		P	S	K	Ca	Mg	Al	H	SB	CTC	V	m
H ₂ O	CaCl ₂											
		-mg dm ⁻³ -	-----cmol _c dm ⁻³ -----						-----%-----			
4.7	4.0	1.7	6.8	0.06	0.2	0.2	0.8	4.4	0.46	5.66	8.13	63.49
Zn	Cu	Fe	Mn	B					O. M.	Sand	Silt	Clay
		-----mg dm ⁻³ -----							-----g kg ⁻¹ -----			
0.9	0.5	194	13.4	0.26					20.6	507	116	337

Extraction Zn, Cu, Fe, Mn - Mehlich - 1 (H₂SO₄ 0,025N + HCl 0,05N); S - calcium phosphate; B - hot water.

76
77 The experimental design used was entirely randomized with eight treatments and four
78 repetitions. The treatments were the following: i - wood ash and base saturation at 50 %; ii -
79 wood ash and base saturation at 80 %; iii - fertilization with organomineral (wood ash +
80 mineral fertilizer) and base saturation to 50 %; iv - organomineral (wood ash + mineral
81 fertilizer) and base saturation 80 %; v - mineral fertilization and base saturation 50 %; vi -
82 mineral fertilization and base saturation 80 %; vii - control (no fertilization) and base
83 saturation 50 % and viii - control (no fertilization) and base saturation 80 %.

84 The culture used was the arugula, being cultivated in pots with a capacity of 2 dm³, each
85 pot being an experimental unit. The treatments with mineral fertilization were applied 80 mg
86 dm⁻³ of N, 200 mg dm⁻³ P₂O₅ and 90 mg dm⁻³ of K₂O, using as sources: urea, single
87 superphosphate and potassium chloride, respectively, according to [12].

88 In the treatments with wood ash, the 20 g dm⁻³ rate of ash was used, being that the rate was
89 established through previous experiments (pilots) with same type of soil and culture, also

applied 80 mg dm⁻³ of N, using as a source to urea, due low nitrogen content in wood ash. The treatments with organomineral fertilization were composed of 50 % of the rate of mineral fertilization and 50 % of the rate of wood ash.

After the liming with limestone dolomitic, the soil was incubated for 30 days, to neutralize the acidity of the soil and elevate the base saturation 50 and 80 %, respectively. At the time of the application of the limestone, the ash rates were added, in the two treatments with wood ash (base saturation 50 % and 80 %).

The wood ash used, from wood burning in food industries boilers, was analyzed as fertilizer and the composition is presented in Table 2.

Table 2 - Chemical composition of burned wood ash in boiler

N	P ₂ O ₅	K ₂ O	Ca	S	Zn	Cu	Mn	B	pH (CaCl ₂)
-----g kg ⁻¹ -----									-
5.6	16.7	27.2	27.0	14.9	0.1	0.1	0.0	0.2	10.9

Soluble in CNA + water.

It was sown 10 arugula seeds (*Eruca sativa* Miller) per pot. After the establishment, the thinning was carried out by leaving two plants per pot. For irrigation of plants it was adopted as a criterion for the replacement of evapotranspiration by means of the gravimetric method, maintaining the soil at 80 % of the maximum water retention capacity [13].

The variables evaluated were: pH of the soil at 30 days after incubation; chlorophyll index on the leaf (reading SPAD); Fresh and dry matter of shoot; dry matter of root and evapotranspiration of the arugula, at 30 days after the emergence of plants. The pH of the soil was obtained through the pH meter in water solution and CaCl₂, according to methodology proposed by the [11].

112 The chlorophyll index in the leaf (reading SPAD - Soil plant analysis development) was
 113 obtained by the average reading in five sheets using the indirect reading method of
 114 chlorophyll with the Chlorophyll meter SPAD - 502. The fresh mass of the air and the roots
 115 were determined in a semi-analytic and subsequently, packed in an air forced circulation kiln
 116 to obtain dry mass at 65 °C until constant mass. The evapotranspiration was determined by
 117 the sum of the water repositions in each pot.

118 The results were submitted to the ANOVA and Scott-Knott test up to 5 % probability, in
 119 the statistical program SISVAR.

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121 **3. Results and Discussion**

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123 There was significant difference of treatments in all variables analyzed ($P = .05$).

124 The largest values of the chlorophyll index in the leaf were with the use of mineral
 125 fertilizer (V50 % and V80 %) and organomineral (V50 % and V80 %), not differing
 126 statistically among themselves, but presenting greater values in relation to the treatments with
 127 wood ash and control (Table 3).

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Table 3 - Chlorophyll index (CI), Fresh Matter of Shoot (FMS), Dry Matter of Shoot (DMS), Dry Matter of Root (DMR), Evapotranspiration of culture (ETc) and pH of the soil (CaCl₂), in the culture of arugula according to the application of sources of fertilizers in Oxisol, Rondonópolis - MT

Fertilizers	CI	FMS	DMS	DMR	ETc	pH
	SPAD	-----g vaso ⁻¹ -----			L vaso ⁻¹	
Wood Ash V50 %	10.53 b	0.38 b	0.06 b	0.07 b	2.78 a	5.84 b
Wood Ash V80 %	17.65 b	0.83 b	0.12 b	0.02 b	2.31 b	6.44 a
Mineral V50 %	45.93 a	3.80 a	0.51 a	0.06 b	2.20 b	5.48 b
Mineral V80 %	41.20 a	6.88 a	1.31 a	1.45 a	2.65 a	6.38 a
Organomineral V50 %	50.80 a	3.80 a	0.89 a	0.51 b	2.57 a	5.78 b
Organomineral V80 %	29.55 a	5.00 a	0.74 a	0.37 b	2.52 a	6.38 a
Control V50 %	-	-	-	-	-	5.90 b
Control V80 %	-	-	-	-	-	6.36 a
CV %	53.90	75.86	109.04	105.79	12.35	4.51

Averages followed by the same letter, in the column, do not differ from each other by the

Scott-Knott test to 5% probability.

The chlorophyll index in the leaf has a positive relationship with the chlorophyll content [14] being influenced by the absorption of nutrients, mainly of nitrogen. The organomineral fertilizer presented similar efficiency to mineral fertilizer, showing that the constituent ash of the organomineral fertilizer contributed to the best utilization of the nitrogen applied, providing nutrients, such as magnesium, constituent of the chlorophyll molecule. Corroborating with the results of this work, [15] evaluating rates of wood ash in cotton plants in Oxisol, observed increase in the chlorophyll content with the application of vegetable ash, attributing this effect to an improvement in nitrogen absorption due to the applications of wood ash.

Studies with wood ash rates in the culture of the radish, presented influence in the chlorophyll index, effect provided by the availability of nutrients, which participate in the synthesis of chlorophyll and photosynthetic processes [16]. Related results were also observed

155 by reference [17] in studies with rates of wood ash in the marandu-grass, in which there was
156 an increase in the chlorophyll content with the increase in the ash rates.

157 In the fresh and dry matter of shoot the mineral fertilizer (V50 % and V80 %) and
158 organomineral (V50 % and V80 %) have provided greater increments in mass production, in
159 relation to the application of ash and control (Table 3). In the treatment control, there was no
160 mass production due to the death of the plants.

161 The use of mineral fertilizers and organomineral were more efficient in relation to wood
162 ash, due to a better nutrient availability for the arugula culture, resulting in greater production
163 of fresh and dry matters. Surveys with mineral fertilization have presented increases in the
164 productions of fresh and dry matters shoot of the arugula [2] [18].

165 However, [19] in experiment on lettuce and arugula associations in different spatial
166 arrangements, under organic and mineral fertilizer observed better productivity of arugula
167 performance under organic fertilization. Confronting, [20] reported that the organomineral
168 fertilization was more efficient in the increase in agricultural production which was isolated
169 from a mineral or organic fertilizer. According to the authors, the association of these
170 fertilizers can complement the lack of some nutrient of isolated fertilizer.

171 There was significant difference between the fertilization used for the dry matter root of
172 the arugula plants (Table 3). The largest dry matter root was obtained with mineral
173 fertilization V80 %, since fertilization and soil correction contributed to the best development
174 of the root system. Also, it was found that this same treatment provided the largest dry matter
175 of shoot, indicating that there is a positive relationship in the productivity of the aerial part
176 with the root development of the plant.

177 The largest water consumption by the arugula plants was observed in the V50 % wood ash
178 treatments, mineral fertilization V80 %, organomineral V50% and organomineral V80 %,
179 respectively (Table 3). The increase in water consumption is associated with mineral

180 fertilization treatments and organomineral, which produced greater dry matter of shoot, as the
181 largest nutrient intake in the soil resulted in greater vegetative development and consequently
182 raised water consumption by the arugula.

183 The treatments with V80 % had pH higher than the V50 % at 30 days after incubation,
184 regardless of the rate of wood ash (Table 3). This effect was due to the use of limestone to
185 elevate the base saturation (V50 % and V80 %) and even though the ash provides a pH
186 increase in the soil, it was not observed that effect.

187 However, several works showed the increase in the pH of the soil with the addition of
188 wood ash [21] [22] [15] [23] [24]. This effect is due to the reaction of ash on the soil,
189 releasing potassium carbonate (K_2CO_3) and reacting with the soil H^+ [25].

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191 **4. Conclusions**

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193 The mineral fertilization followed by the organomineral provided the largest chlorophyll
194 index, fresh and dry matters of shoot and root in the arugula plants in comparison to
195 fertilization with only wood ash.

196 It is recommended to use the base saturation of 80 % for mineral fertilizer and 50 % when
197 applied to the organomineral fertilizer.

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199 **5. Competing interests**

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201 Authors declared that no competing interests exist.

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205 **6. References**

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