Application of wood ash, organomineral and mineral fertilizers to increase the growth of Arugula (*Eruca sativa* Miller) at different base saturation on Oxisol

ABSTRACT

The objective of this study was evaluating the production of arugula fertilized with wood ash, organomineral fertilizer (wood ash + mineral fertilizer) and mineral fertilizer in function of the base saturation levels in Oxisol.The experiment was performed in a greenhouse using the completely randomized experimental design with eight treatments, as follows: T1 - wood ash at 50% of BS; T2 - wood ash at 80% of BS; T3 - wood ash + mineral fertilizers at 50% of BS; T4 - wood ash + mineral fertilizers at 80% of BS; T5 - mineral fertilizers at 50% of BS; T6 - mineral fertilizers at 80% of BS; T7 - control (limed for 50% of BS) and T8 - control (limed for 80% of BS) and four replications.The experimental units consisted of a 2 dm^3 soil pot. pH of the soil 30 days after incubation with limestone and wood ash was evaluated for all treatments.At 30 days after emergence of plants the chlorophyll index, fresh and dry mass of shoot, dry mass of root and evapotranspiration of the arugula were evaluated.The highest values of pH of the soil were observed in the treatments at 80% of BS. Generally, the higher of shoot fresh and dry mass were obtained by application of mineral and wood ash combined with mineral fertilizers (organomineral fertilizer). The higher of root dry mass was obtained by minerally fertilized plots at 80% ofBS. Compared to wood ash fertilized plots only, the minerally fertilized plots followed by the wood ash and mineral treated plot provided the highest of chlorophyll index, shoot fresh and dry mass and root dry mass of the arugula plants.For the mineral or organomineral fertilizer, arugula could be grown at a base saturation of 80% and 50%, respectively.

Keywords: *Eruca sativa* Miller, wood ash, organomineral, alternative fertilizers, root development, waste vegetal.

1.INTRODUCTION

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

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

For the good development of the plants it is necessary, among other factors, a soil with good fertility. Researchesaffirm that for the cultivation of vegetables crops a soil with good fertility and base saturation (BS) between 70 and 80% is required [3], which does not is the reality of the most of soils in Brazil territory.

Oxisol are predominant soil class in the Cerrado, characterized by the low natural fertility, high aluminum saturation, acid pH and low levels of calcium and magnesium [4], needing of fertilizer complementation. Therefore, to make these soils more productive, it is essential to use agricultural practices such as liming and supplementary fertilization.

Nutrient replenishment through mineral fertilizers is interesting, since these can be rapidly absorbed by the roots of plants, due to high concentration and high solubility. However, the

process of leaching and acidification of the soil can be increased easily [5], make the rational management and assembly of fertilization necessary, and the incorporation of alternative fertilizers to the system.

With the necessity for new fertilization alternatives emerged the organomineral composts, originating from the mixture of mineral fertilizers with solid residues of burned organic compounds, such as wood ash.This fertilizer is used as a soil conditioner (ameliorant), stimulating the development of plant roots and enhancing the absorption of water and nutrients. Thus, increases in crop production, stimulating agricultural sustainability[6], specifically by family farming, since the greenery crops are greatly exploited in organic farming [7]and have increased aggregate value.

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

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

2. MATERIAL AND METHODS

The experiment was conducted at greenhouse in theFederal University of Mato Grosso, *Campus* of Rondonópolisbetween February and April of 2014.The Oxisol [10]it was collected

at the layer of 0.0-0.2 m deep in area under Cerrado vegetation.The chemical and granulometric characteristics of the soil (Table 1) [11].

Table1 -Chemical analyses and granulometric of the Oxisolat 0.0-0.2 layer

pH		P	S	K	Ca	Mg	Al	H	SB	CEC	V	m
H_2O	$CaCl_2$											
		-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 (H_2SO_4 0,025N + HCl 0,05N); S - calcium phosphate; B - hot water; BS - Sum of Bases; CEC - Cation Exchange Capacity; V - Base Saturation

The entirely randomized design experimental was used,with eight treatments and four repetitions. The treatments were the following: T1 - wood ash at 50%of BS; T2 - wood ash at 80% of BS; T3 - wood ash + mineral fertilizersat 50% of BS; T4 - wood ash + mineral fertilizers at 80% of BS; T5 - mineral fertilizers at 50% of BS; T6 - mineral fertilizers at 80% of BS; T7 - control (limed for 50% of BS) and T8 - control (limed for 80% of BS).

The culture used was the arugula, cultivated in pots with a capacity of 2 dm^3, each potwas considered asexperimental unit (plot).The treatments with mineral fertilization were applied 80 mg dm^{-3} of N, 200 mg dm^{-3} P_2O_5 and 90 mg dm^{-3} of K_2O, using as fonts: urea, single superphosphate and potassium chloride, respectively[12].

In the treatments with wood ash, the 20 g dm^{-3}rate of ash was used(equivalent to 40 Mg ha^{-1}), which was established through previous experiments (pilots) with same type of soil and

culture, also applied 80 mg dm^{-3} of N, using theureaas font of N,because the low nitrogen content in wood ash. The treatments with inorganic fertilization were composed of 50% of the rate of mineral fertilization and 50% of the rate of wood ash.

After the liming with dolomitic limestone,the soil was incubated for 30 days, to neutralize the acidity of the soil and elevate at 50% and 80% BS, respectively. At the time of the application of the limestone, the ashrates were added, in the two treatments with wood ash (5.82 Mg ha^{-1} at 50% SB and 10.02 Mg ha^{-1} at 80% SB of dolomitic limestone).

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

N	P_2O_5	K_2O	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 30 days after incubation with limestone and wood ash evaluated for all treatments. At 30 days after emergence of plants the chlorophyll index (reading SPAD), shoot fresh and dry mass, root dry mass and evapotranspiration of the arugula were evaluated. The pH of the soil was obtained through the pH meter in water solution and $CaCl_2$[11].

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

The results were submitted to the ANOVA and Scott-Knott test (*P*=.05), in the statistical program SISVAR.

3. RESULTS AND DISCUSSION

There was significant difference between treatments in all variables analyzed (*P*=.05).

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

Table 3 - Chlorophyll Index (CI), Shoot Fresh Mass(SFM), Shoot Dry Mass (SDM), Root Dry Mass (RDM), Evapotranspiration of culture (ETc) and pH of the soil ($CaCl_2$), of arugula culture in function of rates fertilizers in Oxisol

Fertilizers	CI	SFM	SDM	RDM	ETc	pH
	SPAD	---------g vaso^{-1}---------			L vaso^{-1}	
Wood Ash 50% BS	10.53 b	0.38 b	0.06 b	0.07 b	2.78 a	5.84 b
Wood Ash80 BS	17.65 b	0.83 b	0.12 b	0.02 b	2.31 b	6.44 a
Mineral50 BS	45.93 a	3.80 a	0.51 a	0.06 b	2.20 b	5.48 b
Mineral 80 BS	41.20 a	6.88 a	1.31 a	1.45 a	2.65 a	6.38 a
Organomineral 50% BS	50.80 a	3.80 a	0.89 a	0.51 b	2.57 a	5.78 b
Organomineral 80% BS	29.55 a	5.00 a	0.74 a	0.37 b	2.52 a	6.38 a
Control50% BS	-	-	-	-	-	5.90 b
Control80% BS	-	-	-	-	-	6.36 a
CV%	53.90	75.86	109.04	105.79	12.35	4.51

Mean valuesfollowed by the same letter within the column are not differentsignificantly (Scott-Knott test *P*>.05).

The chlorophyll index in the leaf has a positive relationship with the chlorophyll content [14] that influenced 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, another study [15]on cottons plants evaluating rates of wood ashin Oxisol, observed increases 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 ashrates in the culture of the radish (*Raphanussativus*), 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 in studies with rates of wood ash in the marandu-grass, in which there was an increase in the chlorophyll content with the increase in the ash rates [17].

In the shoot fresh and dry masses,the mineral fertilizer (50% and 80% BS) and organomineral (50% and 80% BS) have provided greater increments in mass production, in relation to the application of ash and control (Table 3). In the treatment control, there was no mass production because the death of the plants.

The use of mineral fertilizers and organomineral were more efficient in relation to wood ash, due to a better nutrient availability for the arugula culture, resulting in greater production of shoot fresh and dry masses.Studies with mineral fertilization have reported increases in the productions of shoot dry mass and shoot fresh massof the arugula [2] [18].

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

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

The largest ETc by the arugula plants was observed in the 50% BS wood ash treatments, mineral fertilization 80% BS, organomineral 50% BS and organomineral 80% BS, respectively (Table 3). The increase in water consumption is associated with mineral fertilization treatments and organomineral, which produced greater shoot dry mass. The largest nutrient intake in the soil resulted in greater vegetative development and consequently raised water consumption by the arugula.

The treatments with 80% BS had pH higher than the 50% BS at 30 days after incubation, regardless of the rate of wood ash (Table 3). This effect was due to the use of limestone to elevate the base saturation(50% and 80% BS) and even though the ash increases the pH, such effect was not observed in the present study.

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

4. CONCLUSION

Application of mineral fertilizers or combination of wood ash with mineral fertilizers (organomineral) give the significant and positive effect on the development of chlorophyll index, shoot fresh and dry mass and root dry mass in the arugula culture. For the mineral or organomineral fertilizer, arugula could be grown at a base saturation of 80% and 50%, respectively.

COMPETING INTERESTS

Authors declared that no competinginterests exist.

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