LEAF APPLICATION OF MOLYBDENUM RATES IN CRAMBE PLANTS

Adriana Maria Meneghetti[1], Daniele Medida Rosa[1], Márcia Mauli[1], Claudia Tatiana Araújo da Cruz Silva[1], Thaisa Pegoraro[1], Fabiana Garcia Papani[1], Francieli Helena Bernardi[1] e Tiago Roque Benetoli da Silva[2*]

[1]Universidade Estadual do Oeste do Paraná (UNIOESTE), *Campus* Cascavel, PR. Programa de Pós-Graduação em Engenharia Agrícola (PGEAGRI). Rua Universitária, 85819-110, Cascavel, PR. E-mails: adri@innet.com.br, danimrosa@yahoo.com.br, marcia.m.mauli@gmail.com, claudia_petsmart@hotmail.com, thaisapegoraro@gmail.com, fgarciapapani@gmail.com, bernardifrancieli@gmail.com

[2]Universidade Estadual de Maringá (UEM), *Campus* Umuarama, PR. Departamento de Ciências Agronômicas. Estrada da Paca, São Cristóvão, 87501-970, Umuarama, PR. E-mail: trbsilva@uem.br
*Corresponding author

ABSTRACT: Because molybdenum (Mo) is associeated with the nitrogen (N) metabolism in plants, the aim of this study was to evaluate the leaf application of Mo rates effect in crambe. The experiment was conducted in a greenhouse in pots filled with soil. The cultivar used was crambe FMS-Brilhante. Seven days after emergence, foliar Mo was applied at rates of 0, 20, 40, 60 and 80 g ha^{-1}. On pre-flowering, the chlorophyll index was measured in leaves of all three plants per plot, dry mass of shoots and N content. The experimental design was completely randomized, and analyzes of variance at 5% probability. The results showed that the leaf application of Mo did not affect the N content, dry matter and chlorophyll.

KEY WORDS: *Crambe abyssinica* Hochst., nitrogen, micronutrient

APLICAÇÃO FOLIAR DE MOLIBDÊNIO EM CRAMBE

RESUMO: O objetivo deste trabalho foi avaliar o efeito de doses de molibdênio (Mo) em aplicação foliar na cultura do crambe uma vez que Mo está associado com o metabolismo de Nitrogênio em plantas. O experimento foi conduzido em casa de vegetação, em vasos preenchidos com solo. A cultivar de crambe utilizada foi a FMS-Brilhante, adubada com 3,4 t ha^{-1} da fórmula 2-22-18 (NPK). Aos sete dias após a emergência, foi aplicada a dose de 0,03 t ha^{-1} de nitrogênio na forma de ureia e Mo via foliar nas doses 0, 20, 40, 60 e 80 g Mo ha^{-1}. No pré-florescimento, foi medido o índice de clorofila em três folhas de todas as plantas da parcela, massa seca da parte aérea e teor de nitrogênio. O delineamento experimental foi o inteiramente casualizado, sendo realizada análise de variância e teste de Tukey a 5% de probabilidade. Os resultados mostraram que a aplicação de Mo foliar não interferiu no teor de nitrogênio, massa seca e clorofila foliar quando comparadas ao controle.

PALAVRAS-CHAVE: Crambe abyssinica Hochst., nitrogênio, micronutriente

INTRODUCTION

Crambe (*Crambe abyssinica* Hochst.) is an annual plant cycle from Brassicaceae family, can reach a heigh between 70 and 90 cm, flowering at 35 days after sowing, with 35 to 60% of oil (Pitol et al., 2010).

With the discovery of the high potentical of oil production, research ended up directing crambe use as a feedstock for biodiesel, which recently was only used as forage in crop rotation and soil cover (Varisco and Simonetti, 2012). Characteristics of high stability and low melting point represent an important advantage for the biodiesel production chain, because it allows greater flexibility for transport and product storage (Pitol et al., 2010).

Nutrients are essential for the plant to complete its life cycle, have specific function and are directly involved in plant metabolism. Among these elements, the required large quantities are called macronutrients and those required in small quantities characterize the micronutrients (Raven et al. 2007; Kerbauy, 2008; Taiz and Zeiger, 2009). Micronutrient molybdenum (Mo) occurs in plants in the form of molybdate anion. The functions of Mo are related to electron transfer reactions (Kerbauy, 2008). Most important role of Mo in plants is associated with the nitrogen (N) metabolism (Dechen et al., 1991), being the basic component and nitrogenase enzyme nitrate reductase (Santos, 1991).

Mo participates as a cofactor in enzyme nitrogenase, nitrate reductase and sulfite oxidase and it is closely related to the transport of electrons during biochemical reactions (Sfredo; Oliveira, 2010). Nitrate and nitrite reduction is catalyzed by the enzyme nitrate reductase adaptive, which requires the presence of flavin (NAD) and Mo during the reaction. Plants growing in nitrate have higher concentrations of Mo than nourished with ammonium. This difference in concentration is due, almost entirely, to the Mo present in the nitrate reductase (Gupta and Lipsett, 1981). The nitrogenase also contains Mo and is the enzyme necessary for N_2 fixation.

Because Mo can be rapidly adsorbed and has high mobility in plant, it may be added in solutions and applied to the leaf, without the risk of reducing the fixation when it is added to the soil (Moraes et al. 2008). Leaf fertilization is an agricultural technique that consists in supplying nutrients to plants through their leaves through use of leaf fertilizers. Leaf application is intended to correct nutritional deficiencies in a prompt manner, while maintaining or even increasing the nutrients concentration, serving as a complement of soil fertilization (Wille and Silva, 2012).

The first indication of Mo deficiency is yellowing between the veins and necrosis of older leaves. In some plants like cauliflower and broccoli, leaves can not become necrotic, but may appear twisted and die afterwards (Taiz and Zeiger, 2009).

In leaves with Mo deficiency the activity of the enzyme nitrate reductase can drop significantly and as a result, it occurs an increase in the soluble N concentration compounds and an increase of ribonuclease activity. The decreasing of protein concentration and the activity of alanine aminotransferase, which can explain the pronounced effect of Mo deficiency in the chlorophyll, the chloroplast structure, and in the growth, delay in flowering and formation pollen. Symptoms of N deficiency are common in plants with Mo deficient (Kerbauy, 2008), since the lack of Mo can cause a N deficiency if the plant depends on symbiotic N fixation (Taiz and Zeiger, 2009).

There is no technical recommendations for Mo application in crambe, and the lack of information effects negatively in the plant species. Therefore, the objective of this study was to evaluate the leaf application of Mo on crambe crop.

MATERIAL AND METHODS

Experiments were conducted in two greenhouses with controlled temperature of 22ºC during 51 days at the Western Paraná State University (UNIOESTE) on 24º 59’ 20 west longitude and 53º 26’ 59 south latitude and altitude of 756 meters, located in Cascavel, Paraná, Brazil. Crambe was sown in pots occupied by 4 dm^3 of soil classified as Dystrophic Oxisol Udic (USA, 1998) whose chemical characteristics are presented in Table 1.

Table 1 - Chemical characteristics of the soil used in the experiments with crambe crop

pH	**P**	**OM**	**Ca**	**K**	**Mg**	**Al**	**CEC**	**BS**
$CaCl_2$	**mg dm^{-3}**	**g dm^{-3}**	**---------------------$cmol_c$ dm^{-3}---------------------**					**%**
6.2	2.20	13.42	4.55	0.11	1.38	0.0	8,58	70.4

OM = organic matter. CEC = cationic exchange capacity. BS = basis saturation

Based on soil analysis (Table 1), it is observed that the soil pH was high, which agrees with the result of aluminum and the organic matter content. It is observed that the phosphorus contente is low, as well as potassium content. Calcium and magnesium, on the other hand, are high. Therefore, the value of basis saturation (high) probably shows an imbalance among the three elements, indicated by the deficiency of potassium. The cation exchange capacity is at an intermediate level, indicating that the soil is potentially fertile.

The fertilization was conducted according to the soil analysis data (Table 1) and in each vessel it was applied the amount corresponding to 2.5 kg ha^{-1} of N (urea) at the base and 10 kg ha^{-1} for covering performed at 14 days after sowing. It was also applied 75 kg ha^{-1} of K_2O (potassium chloride) and 75 kg ha^{-1} of P_2O_5 (superphosphate triple) in the base.

In each pot were planted ten seeds, which seven days after emergence were thinned down in order to keep two plants per pot. The weed control was done manually. Two experiments were carried out simultaneously, labeled First crop and Second Crop. The cultivar used was crambe FMS-Brilhante.

Experimental design was the completely randomized, with five treatments based on Mo rates (0, 20, 40, 60 and 80 g ha^{-1}), with 25 plots (vases) per crop. At seven days after emergence (DAE), was applied 30 kg ha^{-1} of N (urea). The Mo source was the ammonium molybdate (54% of Mo).

In the pre-flowering, 50 days after sowing, it was determined chlorophyll content (SPAD) using clorofiLog Falker ® measured at the first and second leaf of each plant. After 51 days the plants were collected, dry mass (g) and shoots N content (g kg^{-1}) were determined. To determine the dry mass, the samples were dried in a forced ventilation oven from 55°C to 65°C for 48 hours. After that, samples were weighed, getting dry mass. The dried plants were ground and sieved in order to procede N analyzis that were performed in triplicate and according to the methodology proposed by Tedesco et al. (1995).

The results were submitted to ANOVA and linear regression at 5% probability using the software R (R Development Core Team, 2012).

RESULTS AND DISCUSSION

Chlorophyll index showed no statistically significant difference between the two crops of Mo applied (Table 2).

Table 2 - Chlorophyll index, dry matter and nitrogen (N) shoots of crambe (*Crambe abyssinica*) in two crops

	---------------- First crop --------------			**---------------- Second crop-------------**		
Molybdenum rates ($g\ ha^{-1}$)	**Chlorophyll index**	**Dry matter (g)**	**Nitrogen ($g\ kg^{-1}$)**	**Chlorophyll index**	**Dry matter (g)**	**Nitrogen ($g\ kg^{-1}$)**
0	34.56	11.13	30.4	36.53	12.24	29.1
20	36.10	11.66	29.3	38.00	11.39	28.8
40	35.60	11.61	29.7	37.50	11.03	32.4
60	34.56	11.25	29.4	36.53	12.83	28.1
80	34.64	11.04	32.9	37.48	12.43	29.5
VC	5.79	9.17	14.02	6.44	7.79	2.96
F value	0.57^{ns}	0.32^{ns}	0.63^{ns}	0.28^{ns}	4.62^{ns}	0.44^{ns}

ns: not significative; VC: variation coeficient

Variables did not have any difference among the average which may indicate that the Mo was in appropriate concentration in the soil. However, it was found that the average dry matter rates between 40 and 60 g ha^{-1} in the second crop are different.

Mello and Minami (1999) evaluated Mo rates (0, 13.5, 27 and 54 g kg^{-1}) to treat seeds of cauliflower, which belongs to the same Family of crambe crop, and they also found that the productivity parameters and development were not affected by Mo rates.

Other nutrients rates were already evaluated by some authors in crambe crop and showed other behaviors. According to Rogerio et al. (2013), phosphorus levels (0, 15, 30, 60 and 90 kg ha^{-1}) resulted in higher grain yield of crambe, but did not affect the oil content of the seeds. Santos et al. (2013) studied the potassium effects (0, 15, 30, 60 and 90 kg ha^{-1}) on the yield, oil, oil content and plant population of crambe and observed that the higher K_2O levels the higher was the yield, however, the oil content and plant population were not affected in that study.

CONCLUSION

The different leaf application rates of Molybdenum did not affect the crambe initial development.

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