

COBALT AND MOLYBDENUM CONCENTRATED SUSPENSION FOR SOYBEAN SEED TREATMENT⁽¹⁾

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ABSTRACT

The concentrated suspension (CS), the basis of Mo trioxide, allows high Mo concentrations and is therefore a technical advance for seed treatment, since it allows the recommendation of the Mo at lower dosage than with the liquid solution formulations (LS). The purpose of this research was to evaluate the efficiency and doses of fertilizer with Mo and Co in concentrated suspension in comparison with liquid solution as well as fertilizers associated with phytohormones, applied in seed treatments, and their effect on soybean yield. Two experiments were carried out in the growing seasons of 2004/2005 and 2005/2006 at the Universidade Federal de Uberlândia (UFU). The first was conducted in an experimental area on the Fazenda Capim Branco, with six treatments and four replications: (1) Mo and Co (CS) - 22 g ha⁻¹ + 1.08 g ha⁻¹; (2) Mo and Co (CS) - 22 g ha⁻¹ + + 1.08 g ha⁻¹ + phytohormone -200 mL ha⁻¹; 3) Mo and Co (LS), 20.7 g ha⁻¹ + 4.13 g ha⁻¹; 4) Mo and Co (LS), 20.7 g ha⁻¹ + 4.13 g ha⁻¹ + phytohormone -200 mL ha⁻¹; (5) + control phytohormone-200 mL ha⁻¹; and (6) control (free of Mo and Co in the seed treatment). The phytohormone consisted of: auxin (11 mg L⁻¹) and cytokinin (0.031 mg L⁻¹). The soybean cultivar Monsoy 8004 was used and a fertilization of 400 kg ha⁻¹ of 02-20-20 NPK fertilizer was applied at sowing. Based on the results of the first experiment, the second was conducted on the Fazenda Floresta do Lobo, in Uberlândia, MG, evaluated in a randomized block design with nine treatments and four replications. The treatments consisted of Mo and Co (g ha⁻¹) doses applied to soybean seeds, as CS formulation (15, 25, 35, 45, 60 and 0.74; 1.23; 1.72; 2.21; 2.95) and LS- (15; 20; 25 and 3.18; 4.25; 5.31), respectively, and the control (free of Mo and Co in the seed treatment). The variety Monarch was used, fertilized

⁽¹⁾ Work carried out with financial support from the Compo do Brazil S.A. Received for publication in November 2007 and approved in July 2009.

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with 300 kg ha⁻¹ of NPK fertilizer (03-32-06) at sowing; and 78 kg ha⁻¹ (K₂O) in topdressing 30 days after soybean emergence. The Mo and Co doses in the seed treatment with LS and CS resulted in higher soybean yields than in the control, from 20 g ha⁻¹ Mo and 4.25 g ha⁻¹ Co in liquid solution and 35 g ha⁻¹ Mo and 1.72 g ha⁻¹ Co in the concentrated suspension.

Index terms: *Glycine max*, micronutrients, fertilizer technology, nutrition.

RESUMO: COBALTO E MOLIBDÊNIO EM SUSPENSÃO CONCENTRADA NO TRATAMENTO DE SEMENTE EM SOJA

A formulação suspensão concentrada (SC), que é à base de trióxido de Mo, permite altas concentrações de Mo por unidade de volume; é, portanto, um avanço tecnológico no tratamento de semente, pois há condições de obedecer à recomendação de Mo da Embrapa em volumes de dosagens menores que os produtos em formulação solução líquida (LS). Objetivou-se avaliar a eficácia de doses de fertilizantes contendo Co e Mo em formulação suspensão concentrada (CS) em comparação com a formulação solução líquida (LS), bem como a associação dos fertilizantes com fitormônio aplicados no tratamento de semente e o desempenho na produtividade da soja. Foram realizados dois experimentos, em dois anos consecutivos, nas safras de 2004/2005 e 2005/2006. O primeiro foi conduzido na área experimental da Fazenda Capim Branco, com seis tratamentos e quatro repetições: (1) Mo e Co (CS) – 22 g ha⁻¹ + 1,08 g ha⁻¹; (2) Mo e Co (CS) – 22 g ha⁻¹ + 1,08 g ha⁻¹ + fitormônio – 200 mL ha⁻¹; (3) Mo e Co (LS) – 20,7 g ha⁻¹ + 4,13 g ha⁻¹; (4) Mo e Co (LS) – 20,7 g ha⁻¹ + 4,13 g ha⁻¹ + fitormônio – 200 mL ha⁻¹; (5) fitormônio – 200 mL ha⁻¹; e (6) testemunha (ausência de Mo e Co no tratamento de sementes). A composição do fitormônio é à base de auxina (11 mg L⁻¹) e citocinina (0,031 mg L⁻¹). A cultivar de soja utilizada foi a Monsoy 8004, e a adubação de semeadura foi realizada com 400 kg ha⁻¹ da formulação 02-20-20. De posse dos resultados obtidos no primeiro experimento, foi realizado outro experimento na Fazenda Floresta do Lobo, localizada no município de Uberlândia, MG. O delineamento experimental foi de blocos casualizados, com nove tratamentos e quatro repetições. Foram aplicados, em tratamento de semente, nas doses em g ha⁻¹ de Mo e Co: formulação CS - (15, 25, 35, 45, 60 e 0,74; 1,23; 1,72; 2,21; 2,95), respectivamente formulação LS - (15; 20 e 25 e 3,18; 4,25; 5,31), respectivamente; e a testemunha (ausência de Mo e Co no tratamento de sementes). Utilizou-se a cultivar Monarca, com a adubação de semeadura de 300 kg ha⁻¹ do formulado 03-32-06; e adubação de cobertura com 78 kg ha⁻¹ de K₂O, aos 30 DAE. As doses de Mo e Co no tratamento de semente com solução líquida e suspensão concentrada, aumentaram o rendimento de grãos de soja. A produtividade da soja foi superior à da testemunha a partir das doses de 20 g ha⁻¹ de Mo e 4,25 g ha⁻¹ de Co na solução líquida e de 35 g ha⁻¹ de Mo e 1,72 g ha⁻¹ de Co na suspensão concentrada.

Termos de indexação: *Glycine max*, micronutrientes, tecnologia de fertilizantes, nutrição.

INTRODUCTION

The process of biological N₂ fixation (BNF) is characterized by the conversion of atmospheric N₂ into plant-available ammonia. Thus, according to (Embrapa, 2007), BNF is the main N source to soybean and can, depending on its efficiency, supply at least part of the soybean N demand.

Although plants require only small quantities of Mo, according to Gupta & Lipsett (1981), this nutrient participates in plant growth and development by influencing N metabolism. It is a cofactor in the nitrogenase and nitrate reductase enzymes. Nitrogenase is essential for the symbiotic fixation of atmospheric

N₂ and nitrate reductase is indispensable for the recovery of nitrate uptake by plants.

Cobalt in soybean is considered important for the N₂-fixing microorganisms. It is a component of vitamin B12, taking part in the formation of the coenzyme cobamide which is essential in the process of FBN as a precursor of leghemoglobin. As a result, Co deficiency inhibits leghemoglobin synthesis and, therefore, BNF (Lopes & Leonel Junior 2000).

According to Pessoa et al. (1999), since soybean requires only small amounts of Mo, application by seeds seems practical. Campo & Hungria (2002) also recommend Co and Mo application via seeds, due to the efficiency, low cost and ease of application.

Several studies have demonstrated the effectiveness of Mo-treated seeds. In experiments at three locations in Parana State, Sfredo et al. (1996) obtained increased yields on average 18 - 37 %, compared to a treatment that contained the inoculant only. They concluded that an addition of Mo to the commercial formulations resulted in higher yields. Furthermore, according to Campo & Hungria (2002), even in highly fertile soils the response to the addition of Co and Mo was positive.

The following Co and Mo sources are used: Co chloride, Co sulfate, Co nitrate, sodium molybdate, ammonium molybdate, and Mo trioxide. Several commercial products on the market contain these elements at varying concentrations, but more commonly, in formulations with a 10:1 Mo/Co ratio. The results of supplying Mo and Co by these commercial products to the seed or by foliar application have been good (Campo & Hungria, 2002).

In the seed treatment, the amount of liquid to be applied is restricted. According to Embrapa (2007), pesticides and nutrients in liquid form may be applied at up to 300 mL of fluid per 50 kg of seeds. Larger amounts of fluid can destroy the seed coat and hinder germination.

Currently, Co and Mo are used in liquid solution (LS) formulation, where Mo is derived from sodium molybdate, ammonium or K and Co from nitrate or chloride. These products are completely soluble and, with their physical and chemical characteristics, are not harmful to seeds and N_2 fixing bacteria. However, the nutrient concentrations in liquid formulations require volumes ranging from 100 to 200 mL ha⁻¹, which may cause an excess of fluid for soybean seeds. Moreover, phytosanitary treatments and the application of inoculants to the seeds may be necessary (Lantmann, 2002).

New technologies such as concentrated suspension are being developed to establish formulations with high Co and Mo concentrations for applications at lower doses without causing problems related to liquid excess. The aqueous concentrated suspension contains a stable suspension of active ingredient, wetting agent, dispersant and suspensor. It is applied diluted in water.

Therefore, the aim of this study was to evaluate the efficacy and doses of fertilizers containing Co and Mo in concentrated suspension (CS) formulation and liquid solution (LS), as well as of the association of the fertilizer with phytohormone applied in the seed treatment, on soybean yield.

MATERIALS AND METHODS

Two experiments were conducted in 2004/2005 and 2005/2006. The first was a field experiment carried

out in a no-till system on the Experimental Farm Capim Branco, in Uberlândia, State of Minas Gerais, with gentle slopes and 850 m altitude, 1523 mm rainfall, from November 2004 to April 2005.

The soil in the experimental area, analyzed prior to the experiment, was classified as Red Latosol. The chemical characteristics were pH (2:1) = 6.5, available P = 2.6 mg dm⁻³, available K = 96.3 mg dm⁻³, available S = 9.0 mg dm⁻³, Ca = 2.5 cmol_c dm⁻³ and Mg = 1.4 cmol_c dm⁻³, organic matter (OM) = 250 g kg⁻¹; CEC at pH 7.0 (T) = 6.28 cmol_c dm⁻³ and base saturation (V) = 67.0 %. The following extraction methods were used: P, K = (HCl 0.05 mol L⁻¹ + H₂SO₄ mol L⁻¹), S-SO₄²⁻ = Ca (H₂PO₄)₂ 0.01 mol L⁻¹; Ca²⁺, Mg²⁺ = (KCl 1 mol L⁻¹), MO = Colorimetric method. The micronutrient levels in the soil were determined as follows: Mn = 2.1 mg dm⁻³, B = 0.14 mg dm⁻³, Zn = 0.7 mg dm⁻³, Fe = 17 mg dm⁻³ and Cu = 7.1 mg dm⁻³, and the methods of extraction were: B = [BaCl₂.2H₂O 0.125 % hot], Cu, Fe, Mn, Zn = [DTPA 0.005 mol L⁻¹ + CaCl 0.01 mol L⁻¹ + TEA 0.1 mol L⁻¹ at pH 7.3].

The experimental design consisted of randomized blocks with six treatments and four replications. The fertilizers for seed treatment with Co and Mo were used in two formulations: liquid solution (LS) based on salts (sodium molybdate and Co sulfate) and concentrated suspension (CS) based on Mo trioxide. The fertilizers had the following characteristics: Mo and Co in the CS formulation (m/m % - 34.5 % Mo and 1.7 % Co), density 1.6 g cm⁻³, Mo and Co in the LS formulation (m/m % - 10 % Mo and 2 % Co), density 1.38 g cm⁻³, and phytohormone based on auxin (11 mg L⁻¹) and cytokinin (0.031 mg L⁻¹). The doses of Mo and Co in the seed treatment in g ha⁻¹ were: (1) Mo and Co (CS) - 22 g ha⁻¹ + 1.08 g ha⁻¹, (2) Mo and Co (CS) - 22 g ha⁻¹ + 1.08 g ha⁻¹ + phytohormone - 200 mL ha⁻¹, (3) Mo and Co (LS) - 20.7 g ha⁻¹ + 4.13 g ha⁻¹, (4) Mo and Co (LS) - 20.7 g ha⁻¹ + 4.13 g ha⁻¹ phytohormone - 200 mL ha⁻¹; (5) phytohormone - 200 mL ha⁻¹; and (6) control (absence of Mo and Co in seed treatment).

Each plot consisted of six 6 m row, spaced 45 cm. The cultivar Monsoy 8004 was used, sown by hand on 28 November 2004. Fertilizer was applied at an amount of 400 kg ha⁻¹ NPK fertilizer 02-20-20, according to Embrapa (2004).

Based on the results of the first experiment, the second part was carried out on the Fazenda Floresta do Lobo, owned by the company Pinusplan in Uberlândia-MG, at an altitude of 900 m, with 1531 mm rainfall. The experiment took place from October 2005 to April 2006.

The soil in the experimental area was classified as Red Yellow Latosol with clay texture. Soil analysis prior to the experiment determined the chemical properties in the top layer of 0-20 cm as follows: pH

(2:1) = 5.3, available P = 22.6 mg dm⁻³, available K = 100 mg dm⁻³, available S = 38 mg dm⁻³, Ca = 1.8 cmol_c dm⁻³, and Mg = 0.6 cmol_c dm⁻³, organic matter = 280 g kg⁻¹; CEC at pH 7.0 (T) = 6.9 cmol_c cm⁻³ and base saturation (V) = 39.0 %. The soil micronutrients levels were measured as follows: Mn = 2.3 mg dm⁻³, B = 0.07 mg dm⁻³, Zn = 2.7 mg dm⁻³, Fe = 63 mg dm⁻³ and S = 1.3 mg dm⁻³. The soil was analyzed using the same methods as in the previous experiment.

The experimental design consisted of randomized blocks with nine treatments and four replications. Seeds were treated with Mo and Co in doses of g ha⁻¹ with: CS formulation (15, 25, 35, 45, 60 and 0.74, 1.23, 1.72, 2.21; 2.95), LS formulation (15, 20, 25 and 3.18, 4.25, 5.31) and control (no Mo and Co in the seed treatment). The plots consisted of 6 m long rows spaced 0.50 m apart and 1 m between the blocks; the four central rows were considered in the evaluations.

For the seed treatment with Co and Mo two fertilizer formulations were applied: liquid solution (LS) based on salts (Na molybdate and Co sulfate) and concentrated suspension (CS), based on Mo trioxide. The LS was applied as recommended by Embrapa (2007) for seed treatments, at doses of 2–3 g ha⁻¹ Co and 12–25 g ha⁻¹ Mo. A concentrated suspension (CS) can contain high Mo concentrations, which represents a technological breakthrough in seed treatment. With concentrated suspension, the recommendation of Embrapa for Mo can be met, using lower doses than with the standard products in LS.

The fertilizers had the following properties: Mo and Co in the CS formulation (m/m % - 34.5 % Mo and 1.7 % Co), density 1.6 g cm⁻³ and Mo and Co in LS formulation (m/m % - 10 % Mo and 2 % Co), density 1.38 g cm⁻³. Cultivar Monarca was used, sown on 14 November 2005. The seeds were treated with fungicide Vitavax in doses from 0.2 - 0.3 L per 100 kg of seeds. Fertilization was applied according to the CFSEMG recommendation, using 300 kg ha⁻¹ of 03-32-06, (1999). Fertilization took place 30 days after soybean emergence with 78 kg ha⁻¹ (K₂O) KCl. Weeds, pests and diseases were controlled as required by the crop.

To assess the foliar N and micronutrients concentration, samples were collected by removing the third leaf from the apex of the main plant stem with the petiole during soybean flowering. These leaves were analyzed according to Bataglia et al. (1983) at the Soil Laboratory of the Institute of Agricultural Sciences of the UFU. The following variables were evaluated: yield, leaf N, other nutrients and 1000 grain weight.

The variance of data for yield, 1000 grain weight, N and other nutrient contents were analyzed using the Program for Statistical Analysis - SANEST and the means compared by the Tukey test (significance 5 %). Yield data were also submitted to regression analysis.

RESULTS AND DISCUSSION

The differences between the treatments and the control were significant, whereas the treatments did not differ significantly from each other (Table 1). The application of 22 g ha⁻¹ Mo + 1.08 g ha⁻¹ Co in CS resulted in a yield of 5,905 kg ha⁻¹ soybean - 32 % more than of the control (4,442 kg ha⁻¹) - while the application of 20.7 g ha⁻¹ Mo + 4.13 g ha⁻¹ Co in LS resulted in a 19 % higher grain yield than of the control (Table 1).

A linear model of increasing soybean yield shows the effect of Mo and Co after treating seeds with concentrated suspension (Figure 1). For each 1 g ha⁻¹ Mo and 0.05 g ha⁻¹ Co applied, an increase of 20.74 kg ha⁻¹ of soybean is expected, up to a dose of 60 g ha⁻¹ Mo.

The response of soybean to seed treatment by doses of liquid solution shows a linear increase (Figure 2). For each 1 g ha⁻¹ Mo and 0.2 g ha⁻¹ Co applied, an increase of 42.54 kg ha⁻¹ of soybean is expected, up to a dose of 25 g ha⁻¹ Mo.

Table 1. Mean grain yield of soybean treated with molybdenum in concentrated suspension formulation, liquid solution and phytohormone at different levels in 2004/2005

Treatment	Productivity
	kg ha ⁻¹
22 g ha ⁻¹ of Mo + 1,08 of Co CS ⁽¹⁾	5,905a
22 g ha ⁻¹ of Mo SC ⁽¹⁾ + 1,08 of Co + phytohormone (200 mL ha ⁻¹)	5,754a
20,7 g ha ⁻¹ of Mo + 4,13 of Co SL ⁽²⁾	5,301a
20,7 g ha ⁻¹ of Mo + 4,13 of Co SL ⁽²⁾ + phytohormone (200 mL ha ⁻¹)	6,008a
Phytohormone (200 mL ha ⁻¹)	5,620a
Control	4,442b
LSD 5 %	804.06
CV (%)	6.25

⁽¹⁾ CS: concentrated suspension formulation. ⁽²⁾ LS: Liquid solution formulation. Averages followed by the same letter in the column do not differ significantly by the Tukey test at 5 %.

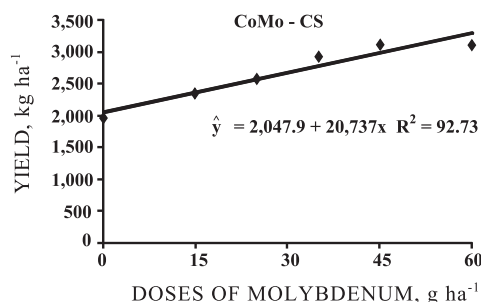


Figure 1. Soybean grain yield as related to seed treatments with Mo and Co doses in concentrated suspension.

There is difference in productivity of soybean treated with LS and CS formulation due to the application of different Mo doses (Table 2). The yield of the control was lowest - 1,967 kg ha⁻¹ - indicating the importance of Co and Mo application to soybean. According to Campo & Hungria (2002), even fertile soil showed a positive response to the addition of Co and Mo. According to Pessoa et al. (1999), the Mo quantities required for soybean are small, favoring an application of this element along with a seed inoculant. The occurrence of N₂ fixation in soils with optimum fertility conditions results in high soybean yields. In this context, the influence of Mo, which also participates in nitrate reductase, is remarkable. It is responsible for the reduction of NO₃⁻ for N plant assimilation (Marschner, 1986).

Yields were highest in the treatments with concentrated suspension at doses of 45 and 60 g ha⁻¹ Mo - 3,114 kg ha⁻¹ and 3,112 kg ha⁻¹, respectively (Table 2). The control yield did not differ regarding the application of 15 g ha⁻¹ Mo in concentrated suspension. The responses to Mo fertilization in Brazil are not consistent. Several experiments with soybean did not show yield increases (Lám-Sanchez & Awad, 1976; Kolling et al., 1981). However, significant increases were reported by Buzetti et al.

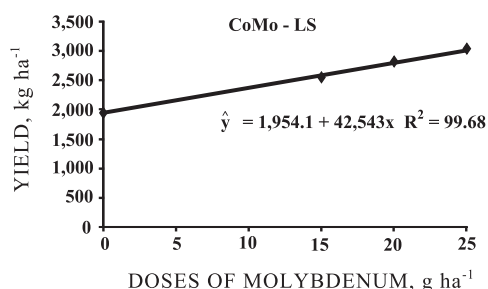


Figure 2. Soybean yield as related to seed treatments with Mo and Co doses in liquid solution in 2005/2006.

(1981) and Bellintani Neto & Lám-Sanchez (1974) in response to fertilization with 400 g ha⁻¹ of Na molybdate on Dark Red Latosol. Similarly, Vitti et al. (1984) reported increases of up to 32.7 % with doses of a commercial product containing 10 % Mo and 1 % Co.

Treatments with liquid solution showed an increase at rates of 20 g ha⁻¹ Mo and more (Table 2). Treatments with concentrated suspension resulted in a better performance at rates of 35 g ha⁻¹ Mo and higher (Table 2).

A comparison of the performance between the formulations at the same doses (15 and 25 g ha⁻¹) showed differences between them: yields were higher with application of liquid solution at 25 g ha⁻¹ Mo (Table 2). The mean weight of 1,000 grains (Table 2) did not differ between treatments.

There were no differences between treatments in N and nutrient content (Table 3).

Table 2. Mean yield of soybean and mean weight of 1000 grains (PMG) at different Mo and Co doses in concentrated suspension and liquid solution in 2005/2006

Treatment	Productivity	
	kg ha ⁻¹	MWG g
15 g ha ⁻¹ of Mo + 0,74 g ha ⁻¹ of Co CS ⁽¹⁾	2,340 cd	129.01 a
25 g ha ⁻¹ of Mo + 1,23 g ha ⁻¹ of Co CS ⁽¹⁾	2,570 bc	129.80 a
35 g ha ⁻¹ of Mo + 1,72 g ha ⁻¹ of Co CS ⁽¹⁾	2,917 ab	132.76 a
45 g ha ⁻¹ of Mo + 2,21 g ha ⁻¹ of Co CS ⁽¹⁾	3,114 a	128.44 a
60 g ha ⁻¹ of Mo + 2,95 g ha ⁻¹ of Co CS ⁽¹⁾	3,112 a	132.90 a
15 g ha ⁻¹ of Mo + 3,18 g ha ⁻¹ of Co SL ⁽²⁾	2,553 bc	127.20 a
20 g ha ⁻¹ of Mo + 4,25 g ha ⁻¹ of Co SL ⁽²⁾	2,819 abc	130.50 a
25 g ha ⁻¹ of Mo + 5,31 g ha ⁻¹ of Co SL ⁽²⁾	3,030 ab	132.48 a
Control	1,967 d	129.28 a
LSD	531.66	15.29
CV (%)	8.15	4.88

⁽¹⁾ CS: concentrated suspension formulation. ⁽²⁾ LS: Liquid solution formulation. Means followed by the same letter in a column do not differ significantly by the Tukey test at 5 %.

Table 3. Mean leaf nitrogen and micronutrients in soybean after application of different Mo and Co doses in concentrated suspension and liquid solution in 2005/2006

Treatment	N	B	Cu	Fe	Mn	Zn
15 g ha ⁻¹ of Mo + 0,74 g ha ⁻¹ of Co CS ⁽¹⁾	35.8 a	31.5 a	10.0 a	141.0 a	29.8 a	24.5 a
25 g ha ⁻¹ of Mo + 1,23 g ha ⁻¹ of Co CS ⁽¹⁾	40.0 a	30.8 a	9.5 a	130.8 a	39.8 a	23.8 a
35 g ha ⁻¹ of Mo + 1,72 g ha ⁻¹ of Co CS ⁽¹⁾	40.3 a	33.5 a	10.3 a	143.8 a	37.5 a	26.3 a
45 g ha ⁻¹ of Mo + 2,21 g ha ⁻¹ of Co CS ⁽¹⁾	37.1 a	30.0 a	10.3 a	163.8 a	32.0 a	27.0 a
60 g ha ⁻¹ of Mo + 2,95 g ha ⁻¹ of Co CS ⁽¹⁾	39.3 a	30.8 a	10.3 a	119.8 a	38.8 a	25.0 a
15 g ha ⁻¹ of Mo + 3,18 g ha ⁻¹ of Co SL ⁽²⁾	39.1 a	32.0 a	10.5 a	161.8 a	39.0 a	28.0 a
20 g ha ⁻¹ of Mo + 4,25 g ha ⁻¹ of Co SL ⁽²⁾	44.3 a	30.3 a	9.3 a	141.8 a	32.0 a	26.0 a
25 g ha ⁻¹ of Mo + 5,31 g ha ⁻¹ of Co SL ⁽²⁾	39.1 a	29.8 a	10.3 a	167.8 a	31.8 a	24.5 a
Control	38.2 a	28.8 a	10.0 a	146.3 a	40.0 a	28.3 a
LSD	14.92	8.86	1.71	62.41	20.45	6.85
CV (%)	15.81	11.97	7.08	17.74	23.88	10.99

⁽¹⁾ CS: concentrated suspension formulation. ⁽²⁾ LS: Liquid solution formulation. Means followed by the same letter in the column did not differ significantly by the Tukey test at 5 %.

The leaf N content was below the level recommended by CFSEMG (1999) for soybean in all treatments. Moraes (2006) states that foliar or seed applications of Co and Mo showed no positive effects on the N concentrations in soybean leaves. Yet, according to CFSEMG (1999), the concentrations of nutrients are appropriate, indicating an adequate nutritional status of soybean, with exception of the treatments with application of 25 g ha⁻¹ Mo with CS and 20 g ha⁻¹ Mo with LS for Cu.

CONCLUSIONS

1. The doses of Mo and Co in the seed treatment with liquid solution and concentrated suspension increased soybean grain yields.

2. Soybean yields in the treatments were higher than of the control from rates of 20 g ha⁻¹ of Mo and 4.25 g ha⁻¹ of Co in liquid solution and 35 g ha⁻¹ Mo and 1.72 g ha⁻¹ of Co in concentrated suspension and higher.

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