RESPONSE OF BEANS TO RATES OF MOLYBDENUM APPLIED ON FOLIAGE AND PERFORMANCE OF THE SEEDS HARVESTED

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Introduction. Among the micronutrients that are essential for plant growth, molybdenum (Mo) is required in the smallest amounts. It is a constituent of the enzymes nitrate reductase and nitrogenase. Thus, the symptoms associated with deficiency of Mo are closely related to metabolism of N. In many parts of Brazil, response of common beans to Mo application is reported, and when nitrogen is not used as a side dressing, yield has been increased up to 200% due to foliar Mo application. Despite of these advantages of using Mo on common beans, many Brazilian farmers have no access to that technology because they are unaware of it and/or there is no molybdenum fertilizer available on local commerce. One possible solution to this problem is to provide farmers with seeds with high Mo content. The objective of this study was to test in field trial the feasibility of producing bean seeds with high Mo content from plants sprayed with Mo and then verify the effects of sowing these seeds in field without N as a side dressing.

Material and Methods. The field study was divided in two phases. In the first, the effects of high Mo rates (and split) on yield and seed Mo content were studied. In the second, seeds with four Mo contents were tested either with or without foliar Mo application. Both trials were sprinkler irrigated.

First trial

The trial was conducted during summer-fall in Viçosa, Minas Gerais State. The soil had a pH of 6.1. A randomized complete block design with four replications was used. Each plot had four 5m-long rows. Bean cultivar Ouro Negro was sown in rows spaced 0.5m apart with 15 seeds per meter. Each seed contained 0.028 μg Mo seed^{-1}. The rates (and split) of Mo tested are presented in Table 1. Ammonium molybdate was sprayed on foliage with 225 L ha^{-1} of water. All plants received basal N, P, and K at rates of 24, 37, and 40 kg ha^{-1}, respectively. Urea application (100 kg ha^{-1}) as a side dressing was performed 20 days after emergence (DAE).

Second trial

The trial was installed in winter in Coimbra, Minas Gerais State. The soil had a pH of 6.1. Treatments were four seed sources (0.30±0.068, 1.81±0.320, 2.23±0.914, and 3.01±0.216 μg Mo seed^{-1}), with or without Mo application (factorial 4 x 2). Mo application was made at 23 DAE using sodium molybdate and 225 L ha^{-1} of water. The trial was laid out on a randomized complete block design with five replications. Each plot had five 4m-long rows with 15 seeds per meter. All plants received basal N, P, and K of 24 of 24, 37, and 40 kg ha^{-1}, respectively. Leaves nitrogen status was monitored with a chlorophyll meter Minolta SPAD 502.

Results and Discussion. There were no significant differences in grain yield and 100-seed weight as Mo rates increase from zero (recommended rate) to 1500 g ha^{-1}, but μg of Mo seed^{-1} increased from 0.298 to 3.008 (Table 1). Split the rate of 1000g ha^{-1} of Mo was not advantageous to increase Mo content of seed. In the second trial, there were no significant differences between treatments on leaves N status at 26 and 34 DAE (Table 2). However, when no Mo was applied, N status at 40 DAE was higher in plants from seeds with 3.01 μg Mo $seed^{-1}$ than form seeds with 0.30 and 1.81 μg Mo $seed^{-1}$ (Table 3). Plants from seeds with 1.81 μg Mo $seed^{-1}$ gave the highest yield, which differed significantly from those originated from seeds with 0.30 μg Mo $seed^{-1}$. Mo applied on foliage did not affect leaves N status, yield, and 100-seed weight. This investigation shows that is possible to produce enriched seeds by foliar application of high Mo rates without yield reduction, and plants raised from these seeds have higher yield potential.

Table 1. Effects of Mo rates (split or not) applied on bean foliage on yield, 100-seed weight, and Mo content of seed

Molybdenum treatment	Yield ($kg\ ha^{-1}$)	100-seed weight (g)	Mo content[1] ($\mu g\ seed^{-1}$)
Without Mo	1715*	27.2*	0.298 c**
90 at 20 DAE	2075	28.2	0.790 c
250 at 20 DAE	1703	27.5	1.813 b
500 at 20 DAE	1703	27,5	2.227 ab
750 at 20 DAE	2128	27.1	2.361 ab
500+500 at 20 e 30 DAE	1794	28.4	3.008 a
1.000 at 20 DAE	1921	28.3	2.725 a
500+500+500 at 20, 30 and 40 DAE	1668	27.7	2.926 a
CV(%)	18.9	4.7	17.1

[1] 100-seed weight was used for this calculation.

*Average of four replications. No significant.

**Average of four replications. Means separation by Tukey test at 5%.

Table 2. Effects of Mo content of seed and Mo treatments on chlorophyll readings, yield and 100-seed weight

Mo content of seed ($\mu g\ seed^{-1}$)	Mo application[1]	Chlorophyll readings 26 DAE	Chlorophyll readings 34 DAE	Yield ($kg\ ha^{-1}$)	100-seed weight (g)
0.30		36.2*	35.4*	1843 b**	22.0*
1.81		37.3	36.6	2127 a	22.4
2.23		37.3	36.0	2003 ab	21.1
3.01		37.5	35.7	2030 ab	21.7
	Yes	37.2^{ns}	36.2^{ns}	1975^{ns}	21.6^{ns}
	No	37.0	35.6	2027	22.0
CV (%)		4.8	7.2	11.0	6.3

[1] Mo applied (90 g/ha) on foliage at 23 DAE with 225 liters/ha of water.

*Average of four replications. No significant.

**Average of four replications. Means separation by Tukey test at 5%.

ns = no significant.

Table 3. Interaction of seed Mo content and foliar Mo treatments on chlorophyll readings at 40 DAE

Mo content of seed ($\mu g\ seed^{-1}$)	Mo treatment[1] With	Mo treatment[1] Without
0.30	36.2 a*	33.6 c
1.81	38.0 a	35.6 bc
2.23	35.3 a	37.8 ab
3.01	36.7 a	38.9 a

[1] Mo applied (90 g/ha) on foliage at 23 DAE with 225 liters/ha of water.

* In columns, means separation by Tukey test at 5%.