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CONSEQUENTIAL EFFECT OF FEEDING RED CLOVER SEED CROP WITH BORON AND MOLYBDENUM ON THE CONTENT OF ORGANIC AND MINERAL COMPONENTS IN PLANTS

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A b s t r a c t. Samples of plants of red clover cv. Dajana were collected from a strict field experiment carried out in 2005-2006. Two factors were considered: 1. Seeds originating from plantation of red clover, foliar fed with boron and molybdenum at the following rates: 0; B – 0.3; Mo – 0.01; B – 0.3 + Mo – 0.01; B – 0.45; Mo – 0.015; B – 0.45 + Mo – 0.015 kg ha^{-1}; 2. Two cuts of red clover. A consequential impact of feeding the seed red clover with boron and molybdenum was observed; it considerably diversified the contents of N, P, K, Ca, Mg, specific protein, crude fibre, NDF, ADF, and microelements (B, Cu, Mn, Mo) in the plants. Better effects were most often recorded for seeds fed at the following rates: B – 0.45; Mo – 0.015, and B – 0.45 + Mo – 0.015 kg ha^{-1}. Great variability of above components and zinc in the plants resulted from the weather during particular seasons. From the point of view of red clover as a fodder, better results were noted for plants from 2006 and from the 2nd cut.

K e y w o r d s: red clover, boron, molybdenum, organic components, minerals

INTRODUCTION

Red clover (*Trifolium pratense* L.) is one of the major fodder crops. The nutritive value of the species depends on the genetic properties, time of harvest, cut number, mineral fertilisation and feeding with microelements (Ćwintal 2011, Shelp 1993, Wilczek and Ćwintal 2008, Wilczek *et al.* 1999). Foliar feeding with boron and molybdenum affects the yield structure and increases the yield of seeds (Ma 1993, Wilczek and Ćwintal 2008, 2010), and improves the chemical composition of clover from the viewpoint of its use as fodder. Apart from that, boron and molybdenum have a favourable effect on the enzymatic activity of the soil environment (Bielińska *et al.* 2008, Ma 1993, Shelp 1993).

In the study presented here an attempt was made at the determination of the consequential effect of foliar feeding of seed red clover with B and Mo on the content of organic components and the major macro- and microelements in plants from the first and second cut in the year of sowing.

The objective was to provide an answer to the question: does better supply of seeds with boron and molybdenum cause a change in the chemical compositions of plants grown from them? The sense of undertaking such a study was fully justified by the deficiency of those elements, especially in the case of red clover plants grown in the year of sowing.

MATERIAL AND METHODS

Samples of plants of red clover cv. Dajana were taken at the beginning of the blooming phase from a strict field experiment realized in the years 2005-2006 at the Experimental Farm in Felin with the method of completely randomised blocks, in four replicates, on plots with area of 1 m^2.

The experiment was situated on a grey-brown podzolic soil classified in the good wheat complex (class III b), with humus content of 16.5 g kg^{-1} and pH in 1 mol KCl dm^{-3} = 6.3. In 1 kg of the soil the following amounts of available components were assayed: 156 mg P_2O_5, 142 mg K_2O, 60 mg Mg, 1.1 mg B and 0.02 mg Mo. The experiment included two experimental factors:

1st factor: seeds from a plantation of red clover foliar fed with boron and molybdenum at the following doses: 0; B-0.3; Mo-0.01; B-0.3 + Mo-0.01; B-0.45; Mo-0.015; B-0.45 + Mo-0.015 kg ha^{-1}. Boron and molybdenum were applied in the form of water solution prepared from the preparations Borvit and Molibdenit in the amount of 300 dm^3 ha^{-1}, on plants from the second re-growth (the seed re-growth), prior to budding.

2nd factor: two cuts of red clover in the year of sowing.

Under the effect of feeding with those elements, the content of boron and molybdenum in the seeds varied from 10.41 to 13.80 and from 1.18 to 1.54 mg kg of dry matter, respectively (Ćwintal *et al.* 2010).

The following determinations were made in dry matter of red clover from two cuts – nitrogen content (with the Kieldahl method), true protein (with the method of Motehs and Engel), crude fibre (gravimetric method), phosphorus (with the method of flow spectrophotometry), potassium (with the method of flame emission spectroscopy), calcium, magnesium, copper, manganese and zinc (with the method of electrothermal atomic absorption spectroscopy – cuvette). In addition, the following dietary fibre fractions were assayed: NDF – neutral detergent fibre, and ADF acid detergent fibre (with the method of Van Soest). The analyses were

performed at the Central Laboratory of Chemical Analyses, Institute of Soil Science and Plant Cultivation in Puławy.

A detailed presentation of the methodological assumptions and meteorological data is given in the papers by Ćwintal *et al.* (2010) and Ćwintal (2011).

The results were processed statistically using the analysis of variance and $LSD_{0.05}$ in accordance with the Tukey test.

RESULTS AND DISCUSSION

Nitrogen content in dry matter of red clover was significantly differentiated by supplementary feeding with boron and molybdenum and by the cuts (Tab. 1).

Table 1. Percentage content of macro nutrients and true protein in dry matter of red clover

Object	N	P	K	Ca	Mg	True protein
Microelements						
0	2.75	0.22	1.80	1.89	0.43	11.6
B	2.96	0.26	1.89	1.95	0.45	12.1
Mo	2.93	0.27	1.78	2.27	0.50	14.5
B + Mo	2.93	0.30	2.00	1.92	0.48	13.6
1.5 B	2.92	0.28	1.85	2.02	0.46	14.4
1.5 Mo	3.11	0.27	1.68	2.36	0.51	15.1
1.5 B + 1.5 Mo	3.11	0.29	2.09	2.00	0.49	14.6
$LSD_{0.05}$	0.28	0.03	0.18	0.22	0.05	1.10
Years						
2005	2.87	0.24	1.70	1.97	0.43	12.3
2006	3.04	0.30	2.05	2.15	0.52	15.1
$LSD_{0.05}$	n.s.	0.02	0.14	0.16	0.04	0.9
Cut						
I	2.82	0.21	1.59	2.00	0.42	11.9
II	3.10	0.33	2.16	2.13	0.53	15.5
$LSD_{0.05}$	0.23	0.02	0.14	n.s.	0.04	0.9

The best results were obtained at the increased dose of molybdenum and of molybdenum plus boron. This is understandable, as molybdenum participates in nitrogen transformations, being included in nitrogenase and reductase (Shelp 1993, Starck 2002, Zimmer and Del 1999). Moreover, a higher concentration of

nitrogen was noted in plants from the 2nd cut, when the stems are shorter but the plants have a higher leaf area index. It is the leaves that contain more total proteins than the stems (Wilczek *et al.* 1999).

The levels of phosphorus, potassium and magnesium were significantly affected by the cuts, the years, and by the feeding with the microelements (Tab. 1). Significantly higher amounts of those components were assayed in plants from the 2nd cut, compared to those from the 1st, which corresponds with results of other research (Ćwintal and Sowa 2006, Żuk-Gołaszewska 2010). Only in the case of calcium the difference between the cuts was insignificant. The highest content of phosphorus was assayed at feeding with B and Mo, of potassium – at 1.5 B + 1.5 Mo, and of calcium and magnesium at the dose of 1.5 Mo. These relations indicate that seeds richer in boron and molybdenum modify the content of macroelements in plants grown from them.

The concentration of true protein was significantly higher relative to the control treatment, in all the variants of supplementary feeding, with the exception of the 0.3 kg ha^{-1} dose of B. In the particular years of the study the weather significantly differentiated the content of true protein in dry matter. It was notably higher (15.1%) in 2006, when over the period from April till September the mean air temperature was higher by 0.69°C compared to that of 2005, and lower rainfalls by 65.2 mm (Ćwintal 2011). Likewise, a high concentration of true protein was noted in plants from the 2nd cut (15.5%). Results at such a high level are rarely encountered in the literature (Graham 1991, Wilczek *et al.* 1999).

Table 2 presents the effect of feeding with the microelements on the content of crude fibre and its fractions. The content of crude fibre in the plants was significantly lower under the effect of both doses of molybdenum (Mo and 1.5 Mo). The fractions of dietary fibre behaved in a similar manner. The cuts significantly differentiated the content of crude fibre, ADF, cellulose and lignin. Their levels were higher in red clover from the 1st re-growth. A higher level of crude fibre and its fractions was noted in plants in 2005, a year that in the vegetation period (from April to September) was characterised by lower air temperature (14.9°C) and higher rainfalls (409.0 mm) compared to 2006, though from the second decade of August till the end of September the sum of rainfalls was only 22.0 mm (Ćwintal 2011). Between the level of crude fibre and its fractions, and the concentration of true protein in the clover there appeared the known relation which was manifested between the years and the cuts. With an increase of the level of protein in the plants the content of crude fibre and its fractions decreased, and the other way round (Sheaffer *et al.* 2000, Wilczek *et al.* 1999).

Feeding with B and Mo significantly increased their level in clover (Tab. 3). Copper concentration decreased significantly relative to the control treatment, at the base doses of boron and molybdenum and at B dose increased by 50%, and

increased at combined feeding with B+Mo and 1.5B+1.5Mo, but insignificantly. The level of manganese was significantly higher only in the variant with 1.5 B and 1.5 Mo. Feeding with boron and molybdenum did not cause any significant consequential effect on the content of zinc in red clover. A greater variability in the levels of microelements in the plants was caused by the weather in the years of the study, while the cuts significantly differentiated the levels of Cu, Mo, Zn. Higher concentrations of boron, manganese and zinc were noted in 2006, and of copper and molybdenum – in 2005. Clover plants from the 2nd cut had significantly higher contents of molybdenum and zinc.

Table 2. Percentage of crude fibre and its particular fractions in dry matter of red clover

Object	Fibre	NDF	ADF	Hemicellulose	Cellulose	Lignin
Microelements						
0	26.9	41.8	30.6	11.0	24.4	6.21
B	24.4	40.0	29.2	10.5	24.0	5.25
Mo	21.6	36.8	25.8	10.7	20.7	5.13
B + Mo	26.2	38.8	29.2	9.4	23.0	6.18
1.5B	22.8	39.4	28.0	11.2	22.5	5.49
1.5 Mo	20.1	36.2	25.4	9.5	20.0	5.38
1.5 B + 1.5 Mo	24.4	38.6	28.2	10.1	21.7	6.47
$LSD_{0.05}$	2.2	3.7	2.0	1.0	1.9	0.51
Years						
2005	25.3	40.6	29.3	11.3	23.2	6.22
2006	22.2	36.6	27.3	9.3	22.1	5.25
$LSD_{0.05}$	2.0	3.2	1.7	1.0	n.s.	0.46
Cut						
I	24.9	40.0	30.0	9.8	23.9	6.11
II	22.7	37.1	26.6	10.2	21.3	5.36
$LSD_{0.05}$	2.0	n.s.	1.7	n. s.	1.5	0.46

NDF – Neutral Detergent Fibre, ADF – Acid Detergent Fibre.

The contents of microelements in red clover resented in this experiment enhanced, in certain cases, the quality of the fodder, or maintained it on a good level (Falkowski *et al.* 1990, Sheaffer *et al.* 2000). Moreover, the consequential effects of red clover feeding with boron and molybdenum was manifested in the fact that plants grown from seeds supplied with those elements were characterised by significant changes in the content of mineral and organic components relative to the

control treatment. A consequential effect of boron and molybdenum on the emergence and yield structure of red clover in the year of sowing was observed by Ćwintal (2011).

Table 3. Content of microelements in red clover (mg kg^{-1} d. m.)

Object	B	Cu	Mn	Mo	Zn
Microelements					
0	32.3	10.20	78.0	0.40	37.2
B	46.3	8.50	80.3	0.42	40.3
Mo	43.6	8.97	79.4	0.46	38.2
B + Mo	31.9	11.21	72.2	0.42	37.0
1.5 B	45.1	9.02	90.2	0.44	40.1
1.5 Mo	42.5	9.38	89.1	0.48	37.9
1.5 B + 1.5 Mo	31.1	11.16	84.5	0.47	37.7
$LSD_{0.05}$	4.9	1.09	8.1	0.06	n.s.
Years					
2005	34.2	12.16	64.8	0.55	35.9
2006	43.7	7.40	99.1	0.33	40.8
$LSD_{0.05}$	4.1	0.92	6.7	0.04	3.6
Cut					
I	38.3	11.08	80.0	0.27	33.8
II	39.6	8.48	83.9	0.61	42.9
$LSD_{0.05}$	n.s.	0.92	n.s.	0.04	3.6

CONCLUSIONS

1. A consequential effect of seed red clover feeding with boron and molybdenum was observed that significantly differentiated the contents of nitrogen, phosphorus, potassium, calcium, magnesium, true protein, crude fibre, NDF, ADF and microelements (boron, copper, manganese, molybdenum) in plants. Better fodder quality effects were obtained from seeds of clover fed with the doses of 0.015 kg ha^{-1} Mo, 0.45 kg ha^{-1} B, and in the case of combined application of both microelements in those doses.

2. A notable variation in the levels of the abovementioned components and zinc in the plants was caused by the weather in the particular years, and by the cuts. From the view point of fodder use of red clover, better results were obtained in 2006 and in the case of plants from the second cut.

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NASTĘPCZY WPŁYW DOKARMIANIA NASIENNEJ KONICZYNY CZERWONEJ BOREM I MOLIBDENEM NA ZAWARTOŚĆ SKŁADNIKÓW ORGANICZNYCH I MINERALNYCH W ROŚLINACH

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S t r e s z c z e n i e. Próbki roślin koniczyny czerwonej, odmiany Dajana, pobrano ze ścisłego doświadczenia polowego, prowadzonego w latach 2005-2006. Uwzględniono w nim dwa czynniki: 1. nasiona pochodzące z plantacji koniczyny czerwonej dokarmianej dolistnie borem i molibdenem

w następujących dawkach: 0; B – 0,3; Mo – 0,01; B – 0,3 + Mo – 0,01; B – 0,45; Mo – 0,015; B – 0,45 + Mo – 0,015 kg·ha^{-1}. 2. dwa pokosy koniczyny czerwonej. Stwierdzono następczy wpływ dokarmiania nasiennej koniczyny czerwonej borem i molibdenem, który istotnie zróżnicował zawartość: N, P, K, Ca, Mg, białka właściwego, włókna surowego, NDF, ADF oraz mikroelementów (B, Cu, Mn, Mo) w roślinach. Najczęściej lepsze efekty uzyskano z nasion koniczyny dokarmianej dawkami: B – 0,45; Mo – 0,015 i B – 0,45 + Mo – 0,015 kg·ha^{-1}. Dużą zmienność wymienionych wyżej składników i cynku w roślinach spowodowała pogoda w poszczególnych latach. Lepsze wyniki, z punktu widzenia paszowego koniczyny czerwonej dotyczyły 2006 roku i roślin z II pokosu.

S ł o w a k l u c z o w e: koniczyna czerwona, bor, molibden, składniki organiczne, składniki mineralne