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Content of microelements in crops of long-fibred flax depending on forms and microfertilizers applied

ABSTRACT. On the basis of field tests and laboratory analyses we have determined the influence of different forms of mineral fertilizers on the microelements content of long-fibred flax during all its vegetation. Thus, non-root additional fertilization of flax by microfertilizers is a quick-acting highly-efficient method of regulating plants microelements content with the aim of creating optimal conditions for their growth and development at the early stages of life, as well as controlling phyto-pathological situation on the flax field. The obtained facts about regularities of microelements getting into plants of long-fibred flax have not only theoretical but also practical importance. They can be the basis for the development of rational system of microfertilizers application for this crop.

KEY WORDS: long-fibred flax, field tests, macro- and microfertilizers, plant development stage, seeds

There are data that show significant fluctuations of microelements content in long-fibred flax. According to Katalymov [1965], the content of boron is within 8.0–26.0, copper – 5.6–23.3, and zinc – 38–116 mg/kg of absolutely dry matter. Anspok [1965] gives wider fluctuations: boron in the straw – 8.2–30.0 and in seeds – 5.1–31.0; cooper – 6.5–31.8 and 8.7–37.8; molybdenum – 0.11–0.52 and 0.13–0.56 correspondingly, and zinc in seeds – 44.5–54.7 mg/kg of absolutely dry matter.

Microelements entering into plants depend on their kind (in large quantities Zn, Co, Ni, Mo can accumulate; Cu, Pb, Cr, Hg accumulate slowly), on their

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forms in the soil (free ions, complex compounds, insoluble compounds, etc), on the total of absorbed bases, the degree of saturation of soils by bases and absorption capacity, content of organic matter, pH of soil, and oxidizing-restoring potential [Shkolnik 1974]. Besides, microelements entering into plants depend on doses, forms, and methods of application of macro- and microfertilizers. In the process of absorption of feeding elements by plants there exists a close relation between these elements, which has not been examined thoroughly. As a rule, application of microfertilizers positively affects the concentration of microelements in plants, but within admissible limits [Stepanova 1974; Yagodin, Tischenko 1978]. Increase of agricultural crops yield on account of mineral fertilizers application and microfertilizers application, and increase of microelements concentration in plants causes increase of the output of chemical elements from the soil, making the soil poor in them. This fact stresses the importance of the issue of enriching the soil by microelements and increasing its fertility on the account of additional application of microfertilizers.

Different chemical elements are not equally used by plants. Elements belonging to quick migrants in the system “soil-plant” include zinc (from 2 to 21% and more) and boron (from 1 to 31%) [Panasin 1986]. On soils with low content of mobile zinc and boron the highest need for microelements in long-fibred flax can be seen from the moment of corn-shoots to blossoming [Milosta 1984]. Zinc gets into flax most intensively at the beginning of vegetation period.

According to Vlasuk [1969], zinc, intensively absorbed by young plants, gets into young leaves and accumulates there, net being used the second time. According to Peive [1980], in cellular sap of leaf tissue there is up to 80% of zinc, which is in ion form or in the form of complexes with low-molecular organic compounds. Zinc forms buffer system for supporting necessary concentration in physiologically active cell centres, and its low-molecular compounds in cytoplasm directly participate in biochemical processes. One notes the ability of this microelement to keep longer on a high level the leaf viability.

METHODS

The research was conducted on the test field of the Department of Agrochemistry of the Belarusian State Agricultural University on sward-middle-podzolic light-loamy soil, developing on loess-type loam with a sublayer of moraine loam on the depth of more than 1 metre, which had the following agrochemical characteristics: pH in KCl 5.9–6.1; P_2O_5 160–196; K_2O 167–187; B 0.3–0.45; Zn

Table 1. The influence of feeding conditions on accumulation of zinc and boron in long-fibred flax in the development stage, mean 2000–2002

Variant	Development stage												Seeds	
	"fir"		intensive		budding		blossoming		green ripeness		early yellow ripeness			
	Zn	B	Zn	B	Zn	B	Zn	B	Zn	B	Zn	B	Zn	B
	mg/kg of dry matter													
1. Control without fertilizers	17.3	18.4	16.3	15.0	15.3	10.8	13.5	9.6	12.4	7.1	11.3	5.6	38.3	9.1
2. $P_{60}K_{90}$	18.3	18.8	18.4	15.5	16.1	10.7	12.8	9.4	11.9	7.0	11.2	6.0	41.3	9.4
3. $N_{30}P_{60}K_{90}$ standard forms	19.8	21.0	17.6	17.6	16.9	12.7	14.2	11.8	13.1	9.2	12.3	7.2	45.0	9.0
4. N_{30}(s) + $P_{60}K_{90}$	18.7	23.3	18.0	16.4	17.0	12.5	14.6	11.4	13.0	9.1	12.1	7.0	46.9	9.2
5. $N_{30}P_{60}K_{90}$ + K_{90} (s) with Zn	24.9	22.6	21.7	17.8	18.6	12.2	14.3	9.2	13.0	7.0	12.6	5.8	58.3	9.0
6. $N_{30}P_{60}K_{90}$ + Zn (intrasoil equivalent $ZnSO_4$) var. 5	25.4	24.5	22.7	17.3	17.3	14.4	12.2	9.8	11.4	7.2	10.9	5.1	54.1	9.2
7. $N_{15}P_{48}K_{105}$ standard forms	19.3	21.5	20.9	17.1	15.7	12.4	12.6	11.6	10.5	9.4	9.6	7.0	49.0	9.5
8. $N_{15}P_{48}K_{105}$ with Zn and B – complex fertilizer	25.3	26.9	21.2	18.9	16.5	13.4	13.9	12.7	12.8	8.9	12.1	6.8	61.7	14.8
9. $N_{30}P_{60}K_{90}$ + $Zn_{1,0}$ ($CH_3C(OH)(PO_3H_2)_2$) full shoots	30.6	19.2	26.5	15.3	13.7	11.6	12.0	9.7	9.8	7.5	9.4	5.6	57.4	9.7
10. $N_{30}P_{60}K_{90}$ + $Zn_{2,0}$ ($CH_3C(OH)(PO_3H_2)_2$) full shoots	37.8	20.3	33.6	15.9	15.6	11.2	14.1	10.2	11.0	7.8	10.1	5.9	62.5	10.3
11. $N_{30}P_{60}K_{90}$ + $Zn_{1,0}$ ($ZnSO_4$) full shoots	44.2	18.6	22.6	14.8	14.5	12.3	11.6	9.0	9.9	7.2	8.7	5.4	56.9	10.1
12. $N_{30}P_{60}K_{90}$ + $Zn_{2,0}$ ($ZnSO_4$) full shoots	47.3	22.5	29.8	16.2	17.6	12.0	12.9	9.8	10.6	8.1	9.5	6.0	60.9	9.6
13. $N_{30}P_{60}K_{90}$ + $Zn_{2,0}$ $B_{1,0}$ (polilignol) full shoots	57.6	39.4	47.0	27.5	16.3	16.4	12.5	15.5	12.2	11.9	9.3	7.9	67.7	14.2
14. $N_{30}P_{60}K_{90}$ + $Zn_{2,0}$ $B_{1,0}$ $(HOOCH_2C)_2N(CH_2)_2N(CH2COOH)2$	46.1	35.7	28.3	28.8	14.7	18.6	11.3	14.7	10.9	10.3	9.1	7.4	63.3	14.5
15. $N_{30}P_{60}K_{90}$ + $Zn_{2,0}$ ($ZnSO_4$) + $B_{1,0}$ (H_3BO_3) full shoots	50.3	30.8	30.2	29.7	16.8	18.1	13.0	15.8	11.3	10.7	9.2	7.3	59.4	13.9
16. $N_{30}P_{60}K_{90}$ + $Zn_{1,0}$ ($CH_3C(OH)(PO_3H_2)_2$) + emistim C full shoots	28.9	25.8	20.5	22.1	12.6	12.9	12.0	11.3	10.7	8.8	9.4	6.2	64.5	11.3
17. $N_{30}P_{60}K_{90}$ + $Zn_{1,0}$ ($CH_3C(OH)(PO_3H_2)_2$) + epi-brassinolide – full shoots	24.0	21.7	15.9	18.4	13.4	12.5	10.8	11.9	9.8	9.1	9.1	6.5	58.9	12.4
$LSD_{0.05}$	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.5	0.3	0.4	0.3

1) s – slow-acting mineral fertilizers with additives of growth-regulator phenomelan
2) complex compounds of microelements – emistim C and epibrassinolide – were used in non-root treatment of crops in the form of solutions.

2.02–3.55 mg/kg; and humus 1.62–1.68%. The field test was repeated four times on plots with the area of 64.8 m^2. The predecessor – spring grains, rate of sowing – 22 million of seeds capable of germinating per hectare. Mineral fertilizers – ammonium sulfate, double superphosphate and chloride potassium – were applied broadcast in pre-sowing cultivation on the depth of 10–12 cm. In the tests we applied complexonates of zinc and boron with the following acids: polilignol, $(CH_3C(OH)(PO_3H_2)_2$ and $(HOOCH_2C)_2N(CH_2)_2N(CH_2COOH)_2$ as well as in organic compounds (zinc sulfate and boric acid). Their doses are shown in the test scheme (Tab. 1). As growth regulators we used epibrassinolide ($C_{28}H_{48}O_6$ – EB) and emistim – a bio-preparation on the basis of N-oxides of piridin derivatives. Agro-technical methods of flax cultivation were generally accepted for the conditions of Mogilev region. Yield recording was complete and by-the-plot. In plant samples we established: zinc – by the method of atomic-absorption spectro-photometry; boron – spectrophotocalorimetrically. Basic numerical data obtained in the tests were processed by the statistical method.

RESULTS

According to the conducted research, the content of zinc in flax plants (leaf + stem) until the middle of vegetation (budding-blossoming stage) decreased sharply, which shows its intensive absorption by young plants; from the middle to the end of vegetation – changed insignificantly, within the limits of test error. At maturing stage the basic amount of zinc concentrated in seeds. The content of boron during all the vegetation of flax from "fir" to early yellow ripeness decreased gradually (Tab. 1).

Anspok [1965] thinks that determining the amount of boron in plants, one can establish the need for boron-containing fertilizers in these plants. Thus, the content of 15–25 mg/kg of absolutely dry matter usually shows lack of boron, 25–100 mg/kg – sufficient amount, and more than 200 mg/kg – surplus of boron.

In our tests the absolute amount of boron and zinc in control plants from the "fir" stage to green and early yellow ripeness was lower than in plants fertilized by microelements. Application of zinc as a component of slow-acting KCl (variant 5) and $ZnSO_4$ (variant 6) really increased the concentration of this element in young tissues, during the following stage of flax growth and development the content of zinc in control and test variants became equalized, the differences being within the limits of test error. Analogous cases were noted by Sorokina [1996], which shows that on soils with low content of mobile boron end zinc the highest need for microelements in long-fibred flax appears from the moment of germinating to blossoming.

It should be noted that from KCl slow-acting zinc got into plants more slowly during the beginning periods of their growth, but more steadily during the whole vegetation. Beginning with the budding stage, the differences in zinc content in plants increased, to the favour of increasing on the background of slow-acting KCl, and remained until the end of the vegetation.

From all the methods of microelements application non-root additional fertilization affected most substantially the content of zinc and boron in long-fibred flax in the stage of full shoots, which were treated by solutions of inorganic salts and complexonates of the examined microelements. Thus, by the application of zinc in the content of $ZnSO_4$ for vegetating plants its content in the stage of "fir" amounted to 44.2–47.3 mg/kg of absolutely dry matter, which is 2.2–2.4 times higher than the background variant ($N_{30}P_{60}K_{90}$). With an increase of the dose of zinc as a component of complexonates, its content in plants increased at the beginning stage of development up to 30.6–57.6 mg/kg of absolutely dry matter, that is more than 2.9 times higher than the background.

With the growth and development of flax, the content of zinc in plants decreased; however, general positive tendencies to the favour of complexonates and inorganic salts remained until harvesting (Tab. 1). According to Panasin [1986], non-root additional fertilization by zinc-containing microfertilizers not only increased photosynthesis in day hours (when control plants had midday depression), but also lengthened the time of assimilation, which was an important condition of high-quality yield formation.

Boron from slow-acting complex fertilizer, applied intra-soil before sowing, got into plants most intensively in the stages of "fir"-budding (25.3 and 16.5 mg/kg of absolutely dry matter); in the following periods of flax growth and development there was a tendency of its content decreasing with its minimal concentration (6.8 mg/kg of absolutely dry matter) before harvesting. In ripe seeds of flax the content of boron was 2.2 times higher and amounted to 14.8 mg/kg of absolutely dry matter on average (according to the results of the analyses for 2000–2002).

Application of boron as a component of complexonates and inorganic salts really increased its content in plants during all the vegetation, especially at the beginning stages of development. The most favourable influence on the plants and flax seeds microelements content was exercised by complexonates of zinc and boron on the basis of polilignols and $(HOOCH_2C)_2N(CH_2)_2N(CH_2COOH)_2$.

CONCLUSIONS

1. Thus, non-root additional fertilization of flax by microfertilizers is a quick-acting highly-efficient method of regulating plants microelements content with the aim of creating optimal conditions for their growth and development at the beginning stages of life as well as controlling phyto-pathological situation on the flax field.

2. The obtained facts about regularities of microelements getting into plants of long-fibred flax have not only theoretical but also practical importance. They can be the basis for development of a rational system of microfertilizers application for this crop.

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