CONCENTRATIONS OF THE MAIN NUTRIENTS (N, P, K, B, ZN) IN FLAX SEED, STEMS AND CHAFF

Galvēno barības elementu (N, P, K, B, Zn) koncentrācija sēklās, stiebros un pelavās

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Abstract

During 1996-1998 experiments were carried out at the Lithuanian Institute of Agriculture's Upyte Research Station to measure the contents of the main nutrients (N, P, K, B, Zn) accumulated in flax plants (seeds, stems and chaff) at harvesting on the following backgrounds: not fertilized, fertilized with P_{20} and $N_{15}P_{20}K_{60}$; applied with $ZnSO_4$ at the rates from 0,35 to 4,0 kg ha^{-1}.

It was determined that fibre flax seeds accumulated 3.30–4.06 % of N, 0.55–0.78 % of P, 0.69–1.15 % of K, 39.5–68.5 mg kg^{-1} of Zn, 10.00–27.00 mg kg^{-1} of B, the stems – 0.32–0.88 % of N, 0.04–0.15 % of P, 0.38–1.45 % of K, 5.0–18.0 mg kg^{-1} of Zn, 5.16–30.84 mg kg^{-1} of B, the chaff – 0.94–2.34 % of N, 0.20–0.38 % of P, 0.18–1.40 % of K, 14.5–57.0 mg kg^{-1} of Zn, 8.55–38.19 mg kg^{-1} of B.

The obtained data could be used for calculating the amount of main nutrients removed from the soil with flax yield as well as for fixing fertilizer rates more precisely.

Keywords: *concentration, fibre flax, fertilizers, nutrients, seed, stem, chaff.*

Introduction

In order to calculate fertiliser rates, it is necessary to know the contents of main nutrients accumulated in plants. For cereals amount of nitrogen, accumulated in the reproductive parts of plants (seeds) is 2.5-5.0 times higher than that in the vegetative parts (stems). Accumulation of phosphorus in plant seeds is 3-6 times higher than in the vegetative parts. Concentration of potassium in the vegetative parts of plants is higher than that in the reproductive parts /1/. So what is the situation with flax?

According to the investigation of Tichomirova V.J. (Russia), the amount of potassium accumulated in flax seed is in average 1.4 times lower than that of phosphorus and 2.8 times lower than that of nitrogen. At the stage of early yellow ripeness, 3.66 % of N, 1.76 % of P, 1.30 % of K were accumulated in flax seeds, 0.84 % of N, 0.32 % of P, 1.61 % of K in flax stem, 1.07 % of N, 0.46 % of P, 2.21 % of K in the chaff /2/.

According to Belarussian researchers the amount of nitrogen in flax stems at early yellow ripeness stage is 0.50-0.65 %, but could vary from 0.30 to 0.95 %. Their experimental evidence suggests that the concentration of nitrogen in the stems when growing flax without nitrogen was 0.25-0.29 % and 0.32 % when adding N_{15} nitrogen fertilizers, 0.39 % - when adding N_{30} nitrogen fertilizers. When applying PK fertilizers, N concentration in the stems was lower /3/.

Canadian flax researchersin flax seeds found following contents of minerals: 622 mg 100 g^{-1} (0.622 %) of phosphorus, 831 mg 100 g^{-1} (0.831 %) of potassium, 5 mg 100 g^{-1} (50 mg kg^{-1}) of zinc /4/.

In Lithuania some investigations were done with linseed. Linseed (cv. 'Lu 5') accumulated in the seeds 3.06-3.93 % of total nitrogen, 0.50-0.84 % of phosphorus, 0.75-0.95 % of potassium; in the stems: 0.39-0.84 % of N, 0.04-0.13 % of P, 0.66-1.41 % of K; in the chaff: 1.34-2.15 % of N, 0.30-0.36 % of P, 0.42-2.26 % of K /5, 6/.

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References about the concentrations of micronutrients in flax are very scarce. Some researchers identified high contents of zinc (44.5-54.7 mg kg^{-1}) in flaxseeds /7, 8/, French researchers found 50 mg kg^{-1} of zinc in flaxseeds /9/. No evidence is available on the content of zinc in flax stems and chaff.

The content of boron (at flax yellow maturity stage) in flax seeds was found to be 5.1-18.7 mg kg^{-1}, when growing flax without boron application and 6.5-31.0 mg kg^{-1} when applying boron fertilisers, the amount in the stems was 8.2-20.6 and 10.0-30.0 kg kg^{-1}, respectively /7/. Again we did not any evidence about boron content in flax stem and chaff.

Thus the aim of our investigation was to estimate the contents of the main flax nutrients (N, P, K, Zn, B) accumulated in flax plants, and to determine whether these contents are affected by different fertilisation.

Methods

The trial was carried out during 1996-1998 at the Upyte Research Station. In the field rotation, flax followed winter wheat. The trial was conducted on a sod gleyic sandy loam soil. Granulated superphosphate on phosphorus background and ammonium nitrate, granulated superphosphate, potassium chloride on NPK background were applied before sowing. The size of a record plot was 20 m^2. The experiment included 4 replications. Randomised plot design was used. Flax cv. Baltučiai was sown by a sowing machine SNL-16 at a seed rate of 22 million viable seed per hectare with 10 cm interrow spacings. Zinc sulphate was applied when flax was 2-4 cm tall.

Flax was pulled at the stage of early yellow ripeness /10/. The concentration of total nitrogen, phosphorus, potassium, zinc and boron was determined in flax seed, stems and chaff: total nitrogen amount – by Kjeldahl method, phosphorus – by the method of vanadate-molybdate, potassium – flame photometry, zinc - by atomic adsorption spectrophotometer, boron - calorimetrically with azometin H.

The numbers 1-21 in the figures 2-6 denote treatments: 1. Without zinc; 2. Spraying at flax seedlings stage 0,35 kg ha^{-1} of $ZnSO_4$; 3. - 0,35 kg ha^{-1} of $ZnSO_4$+citowett 0,04 %; 4.- 1,0; 5. - 2,0; 6. - 3,0 and 7. - 4,0 kg/ha of $ZnSO_4$ – all treatments without NPK fertilising; 8.- 14. – the same Zn treatments on P_{20} background; 15.-21. - the same Zn treatments on $N_{15}P_{20}K_{60}$ background.

Meteorological conditions during the experimental years were diverse. The largest amount of precipitation was in 1998 (especially in July), and the least in 1997 (Fig. 1).

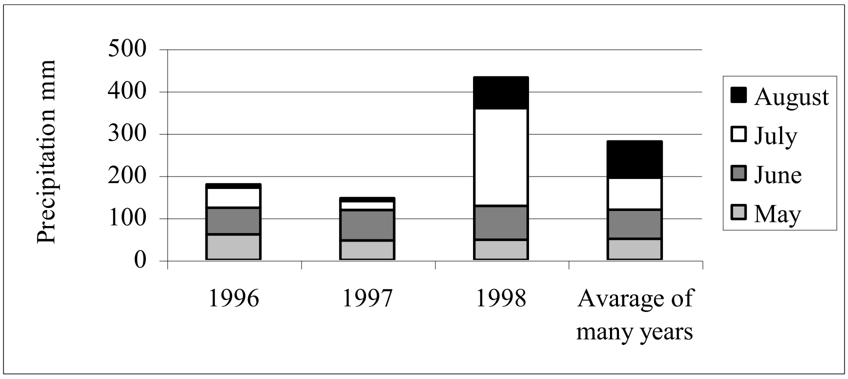

Figure 1. Amount of precipitation in Upyte, 1996-1998.

Results and discussion

Nitrogen. Data analysis suggests that a slightly higher nitrogen concentration in the flax seeds was identified in a very dry year of 1999, but the data were very similar each experimental. Nitrogen content, accumulated in seeds, was lower in the plots without zinc and

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without any fertilisation (3.57 %, Treatment 1.) and was higher when adding phosphorus P_{20} (3.69 %, Treatment 8.) or nitrogen, phosphorus and potassium ($N_{15}P_{20}K_{60}$) (3.74 %, Treatment 15.). This trend persisted all three years. According to three years' averaged data, an insignificantly higher accumulation of nitrogen in the seeds was found when applying NPK fertilisers, but the effect of increased zinc rates was not determined (Figure 2). Nitrogen concentration in flax stems was 6-7 times lower than that in flax seed. A slightly lower content of nitrogen in flax stems was found in 1997, the amount of nitrogen in the soil in that year was lower also, besides, the weather conditions were dry. However, neither the influence of fertilisation backgrounds nor increased zinc sulphate rates on the concentration of nitrogen in flax stems were established in the trial. Nitrogen concentration in the chaff was twice lower than that in flaxseed and two-three times higher than that in flax stem. The amount of nitrogen in the chaff varied from 0.94 % to 2.34 % and was similar in all three years.

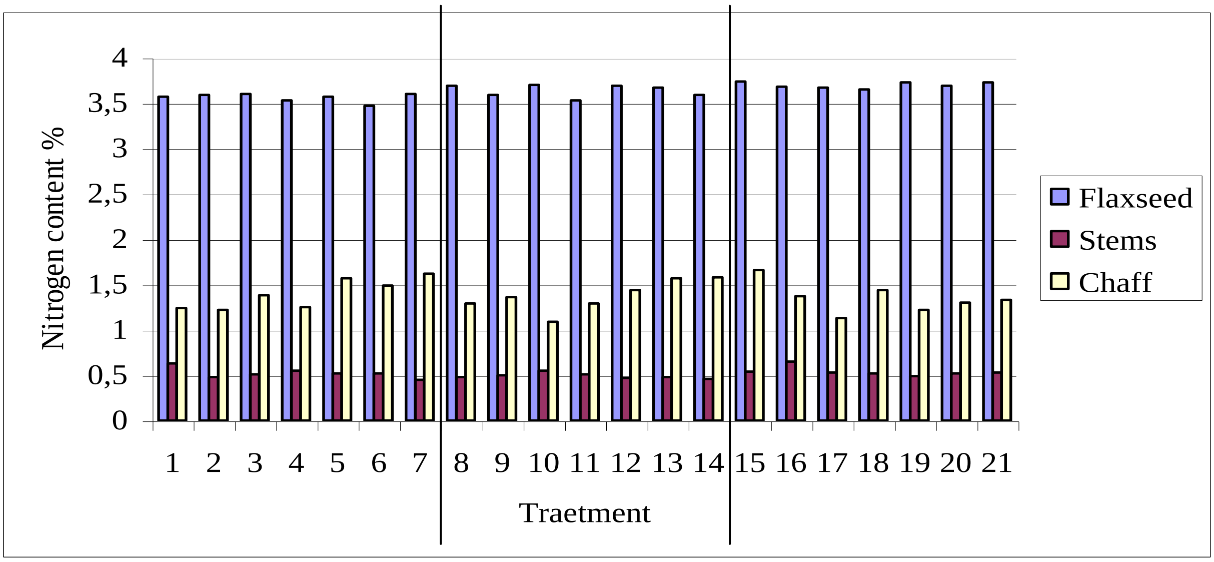

Figure 2. Nitrogen concentration (%) in flax seeds, stems and chaff, 1996-1998 average.

Phosphorus. The lowest content of phosphorus (0.55 %) in seeds was found in 1998. According to averaged data of 3 years, the amount of phosphorus in the seeds was within the limits of 0.61-0.67 % (Figure 3). Neither the influence of fertilisation backgrounds nor increased zinc sulphate rates on the concentration of phosphorus in flax seed were established. Content of phosphorus in the stems was 5-10 times lower than that in the seeds. The amount of phosphorus in the chaff was 2-3 times lower than that in the seeds, but 2-4 times higher than that in the stems. Variation of phosphorus content in chaff was very low - from 0.24 to 0.30 %.

Potassium. Potassium concentration of in flax seeds was very similar each experimental year, the influence of fertilisation was not established (Figure 4). The amount of potassium in the stems was similar to that in the seeds. Higher concentration (up to 1.30 %) was in 1996, lower (up to 1.0 %) in 1997. It was noticed that lower concentration of potassium in the stems was on the not fertilised background (0.54-0.78 %), it was higher (0.63-0.76 %) when adding phosphorus P_{20} or nitrogen, phosphorus and potassium ($N_{15}P_{20}K_{60}$) (0.68-0.95 %). Averaged three years' data revealed a similar trend.

The amount of potassium in the chaff was by one third higher than that in the seeds and stems (but not in all cases). The amount of potassium in the chaff differed within experimental years: the highest concentration (0.94-1.40 %) was in 1996 and the lowest (0.18-0.38 %) in 1997.

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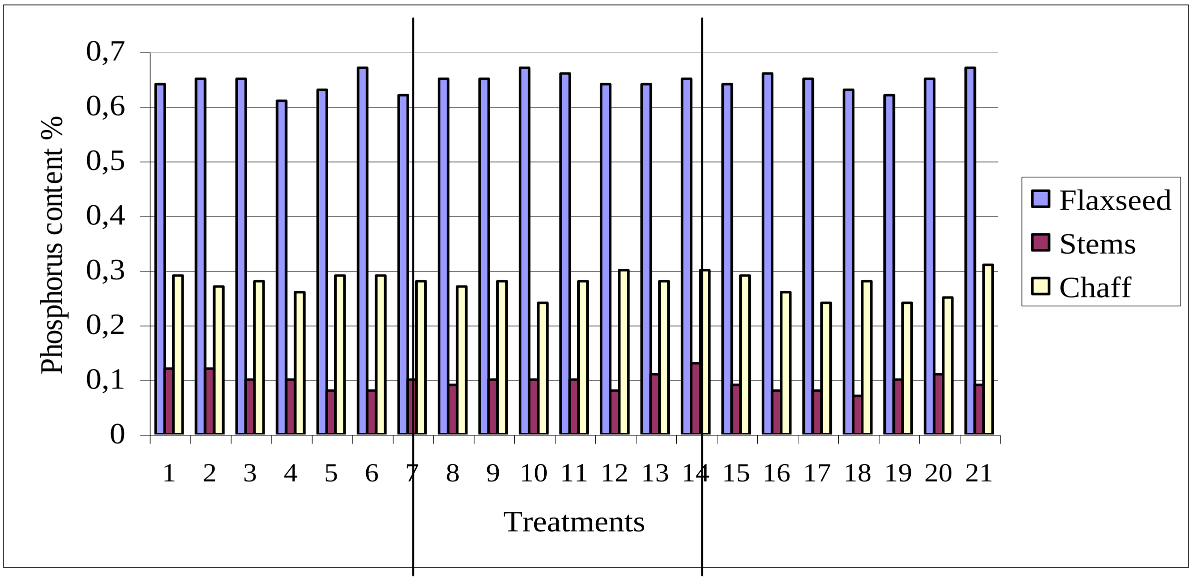

Figure 3. Phosphorus concentration (%) in flax seeds, stems and chaff, 1996-1998 average.

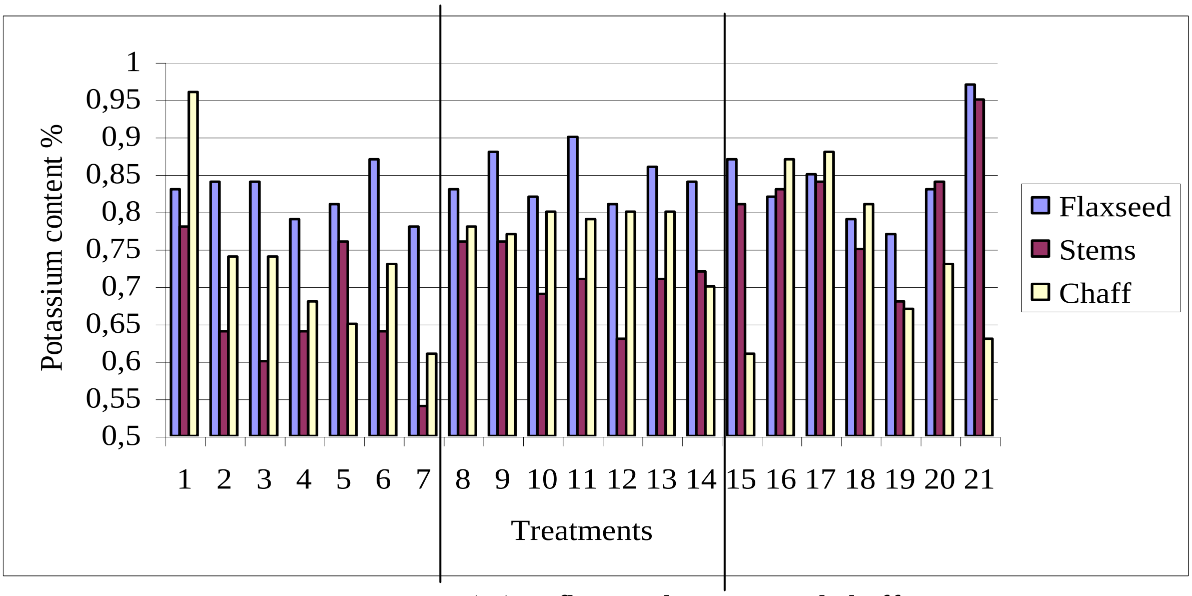

Figure 4. Potassium concentration (%) in flax seeds, stems and chaff, 1996-1998 average.

Zinc. The amount of zinc, identified in the seeds, was close to that (50 mg kg^{-1}) described in the literature sources presented above. In some cases concentration of zinc in the seeds was even higher than 68 mg kg^{-1}. A slightly higher concentration of zinc (0.46-0.88 %) was found in the wet year of 1998 and lower (0.32-0.64 %) in the dry year of 1997. furthermore, in 1997 the ratio between the amount of available phosphorus and available zinc was low in the soil (only within the range of 3-4). Neither the influence of fertilisation backgrounds nor increased zinc sulphate rates on the concentration of zinc in flax seed was established.

Concentration of zinc in the stems was much lower than that in flax seeds (Figure 5). A slightly higher concentration of zinc in the stems was found in the wet year of 1998. The influence of increased zinc sulphate rates or fertilisation backgrounds was established. The amount of zinc in the chaff was by one third lower that that in the seeds, but approximately 3-

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5 times higher than in the stems. A lower concentration of zinc was found in the dry year 1997.

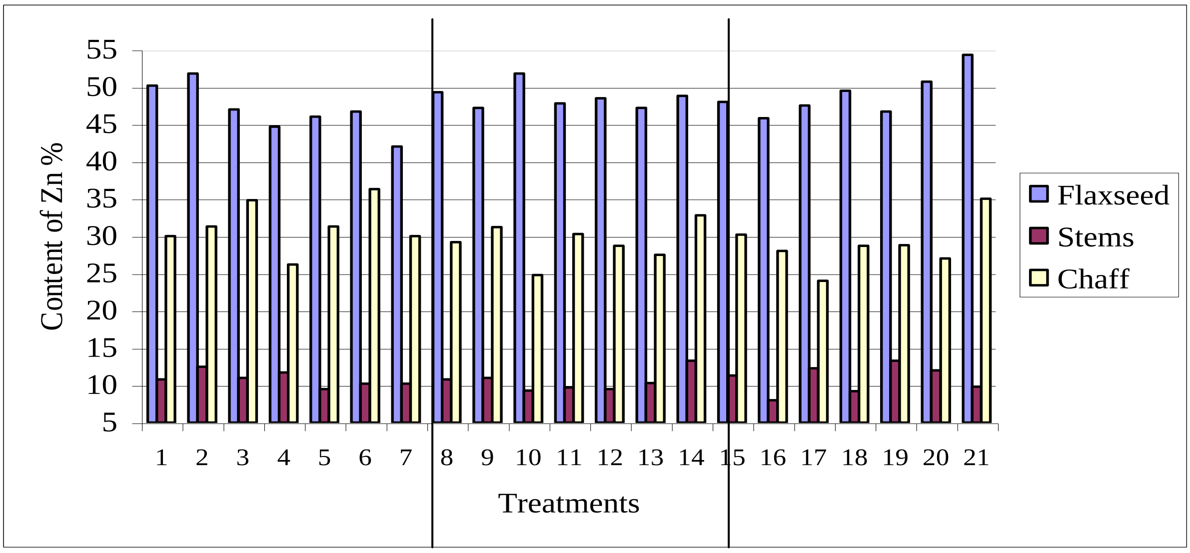

Figure 5. Zinc concentration (%) in flax seeds, stems and chaff, 1996-1998 average.

Boron. Boron concentration in seeds was also lower (10.00-17.58 mg kg^{-1}) in the dry year of 1997 and higher (16.15-27.00 mg kg^{-1}) in the wet year of 1998. The influence of fertilisation was not established, but besides meteorological conditions, concentration of boron in the seeds could be influenced by the level of available boron in the soil, which was lower (1.20-1.88 mg kg^{-1}) in 1997 and higher (2.02-2.58 mg kg^{-1}) in 1998. The amount of boron concentrated in stems was approximately the same as that in the seeds (Figure 6). Much lower concentration of boron in the stems (4.22-13.19 mg kg^{-1}) was found in 1997, higher (15.14-30.84 mg kg^{-1}) – in 1998.

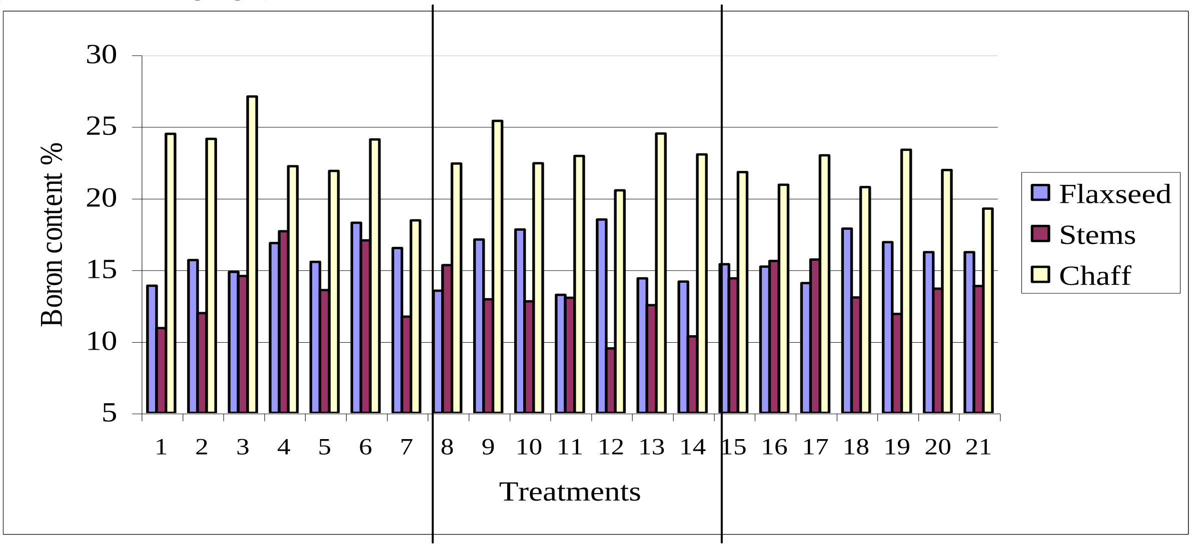

Figure 6. Boron concentration (%) in flax seeds, stems and chaff, 1996-1998 average.

The amount of boron found in the chaff was higher than that accumulated in the seeds and twice as high as that in the stems. Concentration of boron in the chaff varied during the years of trials. The lowest of boron concentration in the chaff (8.55-18.41 mg kg^{-1}) was identified in 1997 as in seeds and stems also.

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Conclusions

1. Accumulation of the main nutrients in flax was as follows: 3,30–4,06 % of N, 0,55–0,78 % of P, 0,69–1,15 % of K, 39,5–68,5 mg kg^{-1} of Zn, 10,00–27,00 mg kg^{-1} of B - in the seeds, 0,32–0,88 % of N, 0,04–0,15 % of P, 0,38–1,45 % of K, 5,0–18,0 mg kg^{-1} of Zn, 5,16–30,84 mg kg^{-1} of B – in the stems, 0,94–2,34 % of N, 0,20–0,38 % of P, 0,18–1,40 % of K, 14,5–57,0 mg kg^{-1} of Zn, 8,55–38,19 mg kg^{-1} of B – in the chaff.

2. Nitrogen content, accumulated in seeds, was lower in the plots without zinc and without any fertilisation (3.57 %) and was higher when adding phosphorus P_{20} (3.69 %) or nitrogen, phosphorus and potassium ($N_{15}P_{20}K_{60}$) (3.74 %).

3. Lower potassium concentration in the stems was identified on not fertilised background (0.54-0.78 %), the concentration was higher (0.63-0.76 %) when adding phosphorus P_{20} or nitrogen, phosphorus and potassium ($N_{15}P_{20}K_{60}$) (0.68-0.95 %).

4. Concentration of boron in flax (seeds, stem, chaff) was lower in the dry year of 1997 when the content of available boron was lower, and higher in the wet year of 1998 when the soil was rich in available boron.

5. Concentration of zinc in the seed and chaff was lower in 1997, concentration of zinc in the seeds and stems was higher in 1998.

6. No effect of increased rates of zinc sulphate was established on the concentration of the main nutrients (N, P, K, Zn, B) in flax seed, stems and chaff.

References

1. Кулик М.С. Погода и минеральные удобрения, Ленинград, 1966, с.6.
2. Тихомирова В.Я. “Физиологическая роль и агрономическая эффективность калийных удобрений на посевах льна-долгунца при разной обеспеченности почвы калием” Селекция, семеноводство, агротехника, экономика и первичная обработка льна-долгунца, научные труды ВНИИЛ, Торжок, 2002, вып.30, т.1, с.207-213.
3. Справочник льновода (Под редакцией М.И. Афонина), Минск: Уроджай, 1973, с. 41-49.
4. Vaisey-Genser M., Morris D. H. Flaxseed. Health, nutrition and functionality, Canada, Manitoba, 1999, p. 17.
5. Jankauskienė Z. “Makroelementų ir riebalų kiekiai sėmeninių linų sėklose” Augalininkystės ir bitininkystės dabartis ir ateitis (The present and future of crop science and bee keeping), Kaunas, Akademija, 1998, p. 180-186.
6. Jankauskienė Z. “Azoto, fosforo ir kalio koncentracija sėmeninių linų derliuje” Žemdirbystė /LŽI, LŽŪU mokslo darbai, t. 72, Akademija, 2000, p. 148-159.
7. Анспок П.И. Микроудобрения, Ленинград: Агропромиздат, 1990, с. 59, 75.
8. Lietuvos dirvožemių agrocheminės savybės ir jų kaita. Monografija (sudarė. J. Mažvila), Kaunas, 1998, p. 167.
9. Eyssautier A. “Carence en zinc sur lin” La France Agricole, 1992, 7 Fevrier, p. 51.
10. Методические указания по проведению полевых опытов со льном-долгунцом, Торжок, 1987, 72 с.

ISBN 9984 – 585 – 68 – 9