A N N A L E S
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LIX, Nr 4 SECTIO E 2004

Department of Agricultural Chemistry, Belarusian State Agricultural University
213410 Gorki, Mogilev Region, Belarus

Alexander Tsyganov, Olga Vildflush

The influence of microfertilizers on productivity and quality of peas grain on sward-podzolic soils

ABSTRACT. The research was carried out in 2001–2003 on sward-podzolic light-loamy soil of an experimental farm of the Belarusian State Agricultural University. The aim of the research was to establish the influence of non-root additional fertilization of peas in the budding phase by boron, molybdenum, cobalt, and complex microfertilizer "Mikom" containing boron, molybdenum, copper, and zinc on productivity and quality of peas grain, removal and coefficients of nutrients usage. Application of boron on the background of $N_{50}P_{50}K_{90}$ increased peas grain productivity during 3 years on average by 0.33 t, molybdenum – by 0.26 t, cobalt – by 0.28 t, and complex microfertilizer "Mikom" – by 0.43 t/ha. Under the influence of cobalt and molybdenum the content of crude protein in peas grain increased by 1.0 and 1.1%. Peas non-root additional fertilization by boron, cobalt, molybdenum and complex microfertilizer "Mikom" increased the output of crude protein from 1 hectare in comparison with the background of $N_{50}P_{50}K_{90}$ by 89, 94, 103, and 0.98 kg/ha, correspondingly. Under the influence of molybdenum, complex microfertilizer "Mikom" coefficients of fertilizers phosphorus usage increased.

KEY WORDS: peas, productivity, quality, boron, molybdenum, cobalt, complex microfertilizer, removal

Grain-leguminous crops have great importance all over the world. They are an important source of protein for man feeding and animal feeding. At present the world population satisfies its need for proteins by 16% by means of grain-leguminous crops [Shpaar et al. 2000]. Grain-leguminous crops positively affect soil fertility. Thanks to the activity of nodule bacteria they can fix nitrogen from the air. So, it was established that depending on growing conditions pea can fix 50-500 kg/ha of nitrogen (mean 150 kg/ha) from the air. The share of nitrogen fixed from the air makes up 70% of the total absorption [Trepachev 1999].

Pea, just as other grain-leguminous crops, requires a lot of microelements. Boron, molybdenum, and manganese are of special importance for pea. Their getting into plants gets worse at increased (boron, manganese) or low (molybdenum) indices of pH and during droughts [Anspok 1989; Fedushkin 1989].

There is a promising tendency in microfertilizers application, that of using multi-component fertilizers as well as complexonants (chelates) which contain biologically active microelements necessary for plants (Zn, Cu, B, Mo, Co, Mn). These fertilizers are applied for pre-sowing treatment of seeds, and for soil application and non-root additional fertilization [Lapa, Bosak 2002].

METHODS

The aim of the research is the influence of non-root additional fertilization by microelements boron, molybdenum, cobalt, and complex microfertilizer Mikom on productivity and quality of pea grain.

Experiments with fodder pea of Agat variety were conducted in 2001–2003 on the test field "Tushkovo" of the Belarusian State Agricultural University experimental farm on sward-podzolic soil developing on loess-type loam with a sub-layer or moraine loam at the depth of about of 1 m. General area of the plot – 54 m^2, recording – 43.8 m^2, test repetition rate – 4. The rate of sowing was 1.2 million per ha of germinating seeds. The method of yield recording was complete, by-the plot. Determination of humus in the soil was conducted according to Turin's method, mobile forms of phosphorus and potassium according to Kirsanov's method, boron in water extract by photocalorimetric method with azometin H, copper and zinc in extract 1 mol HCl by method of atomic-absorption spectrophotometer [Vildflush et al. 1998].

The soil of the experimental field in the years of research had low-acid and close to neutral reaction (pH_{KCl} 5.7–6.2), low and not sufficient content of humus (1.40–1.70%), increased content of mobile phosphorus (150–186 mg/kg) and medium content of mobile potassium (160–176 mg/kg of soil). The content of the mobile forms of boron (0.28–0.42 mg/kg) and copper (1.21–1.74 mg/kg) in the years of research fluctuated from low to medium levels; the content of zinc was low (2.49–2.61 mg/kg of soil).

We applied the following mineral fertilizers: carbamid, ammonized superphosphate and potassium chloride. Non-root additional fertilization of pea by microelements was conducted in the phase of budding at the rate of 200 g of boric acid, 150 g of molybdenum-acid ammonium, 100 g of sulfate cobalt, and 2.5 l/ha of complex microfertilizer “Mikom” for 200l of water. Mikom contains microelements in chelate form (pH 7.95, bulk density 1.25 g/cm^3); in the preparation the weight share of zinc – 3.22%, copper – 1.58%, boron – 0.28%, and molybdenum – 0.1%.

RESULTS

Application of nitrogen-potassium fertilizers ($N_{30}K_{60}$) during the years 2001–2003 increased pea grain productivity by 0.6 t/ha, and complete mineral fertilizer ($N_{30}P_{40}K_{60}$) by 0.85 t/ha on average (Tab. 1). Further increase of doses of mineral fertilizers ($N_{50}P_{50}K_{90}$) increased pea grain productivity only insignificantly (0.17 t/ha). Non-root additional fertilization by microelements helped to increase pea grain productivity. The highest pea grain productivity increase from microfertilizers application was obtained in 2002 and 2003, the years more favorable for grain productivity forming than 2001 in moteorological terms. On average during 2001–2003 pea grain productivity compared with the background of $N_{50}P_{50}K_{90}$ increased with molybdenum application by 0.26, cobalt by 0.28 and boron by 0.33 t/ha (Tab. 1).

Table 1. Influence of microfertilizers on pea grain productivity

Treatment	Productivity, t/ha				Increase from control t/ha	Compensation rate of 1 kg of NPK kg of grain
	2001	2002	2003	Mean		
Without fertilizers	2.10	2.98	3.33	2.80	-	-
$N_{10}P_{40}K_{60}$	2.66	3.43	3.87	3.32	0.52	4.8
$N_{30}K_{60}$	2.52	3.59	4.06	3.40	0.60	6.7
$N_{30}P_{40}K_{60}$	2.85	3.83	4.26	3.65	0.85	6.5
$N_{50}P_{50}K_{90}$	3.22	3.87	4.38	3.82	1.02	5.4
$N_{50}P_{50}K_{90}$ +B	3.33	4.41	4.70	4.15	1.35	7.1
$N_{50}P_{50}K_{90}$ +Co	3.50	4.12	4.67	4.10	1.30	6.8
$N_{50}P_{50}K_{90}$ +Mo	3.34	4.13	4.78	4.08	1.28	6.7
$N_{50}P_{50}K_{90}$ +Mikom	3.62	4.25	4.87	4.25	1.45	7.6
$LSD_{0.05}$	1.7	1.8	2.1	1.1		

LSD Least significant difference

The positive influence of boron on pea productivity is connected, it seems, with the fact that boron has great importance for the development of roots nodules of leguminous plants. Molybdenum goes into ferments nitratreductaza and nitrogenaza and increases the activity of dehydrogenazas – ferments ensuring a continuous flow of hydrogen, which is necessary for fixing atmospheric nitrogen [Yagodin et. al 2002]. Cobalt takes part in the biosynthesis of leghaemoglobin, changes the ultra-structure of nitrogen-fixing apparatus, activizes the functioning of bacteroids, positively influences the reproduction of nodule bacteria [Tsyganov et al. 1988; Anspok 1989].

The highest pea grain productivity increase (0.43 t/ha) was obtained with non-root additional fertilization of pea crops by complex microfertilizer "Mikom" (Tab. 1). Under the influence of microfertilizers the compensation rate of 1 kg of NPK for kg of grain increased. Thus, in comparison with the background of $N_{50}P_{50}K_{90}$ it increased by 1.3 kg, cobalt – 1.4 kg, boron – 1.7 kg, and complex microfertilizer "Mikom" – 2.2 kg. When microfertilizers are applied, there is a tendency for an increase of 1000 grains weight (Tab. 2).

Molybdenum and cobalt increased crude protein content in the grain in comparison with the background of $N_{50}P_{50}K_{90}$ by 1.0 and 1.1%, correspondingly. Under the influence of microelements crude protein output increased. When molybdenum was applied, the crude protein output increased by 103 kg in comparison with the background of $N_{50}P_{50}K_{90}$, cobalt – 94 kg, boron – 89 kg, and complex microfertilizer "Mikom" – 98 kg/ha. Non-root additional fertilization by microelements also helped to increase the supply of 1 f. u., g of degistible protein (Tab. 2).

Table 2. Influence of microfertilizers on pea grain quality (mean for 2001–2003)

Treatment	Mass of 1000 grains g	Crude protein, %	Crude protein output kg/ha	Supply of 1 f. u., g digestible protein
Without fertilizers	207.3	23.1	586	153.6
$N_{10}P_{40}K_{60}$	210.8	25.5	733	162.5
$N_{30}K_{60}$	210.3	23.5	705	152.3
$N_{30}P_{40}K_{60}$	209.9	24.5	781	157.3
$N_{50}P_{50}K_{90}$	215.8	25.3	836	160.8
$N_{50}P_{50}K_{90}$ + B	217.4	25.7	925	163.7
$N_{50}P_{50}K_{90}$ + Co	217.9	26.3	930	166.6
$N_{50}P_{50}K_{90}$ + Mo	219.8	26.4	939	169.3
$N_{50}P_{50}K_{90}$ + Mikom	222.6	25.4	934	162.2

Calculation of the removal of nutrients showed that when fertilizers were applied, the general removal of nitrogen, phosphorus, and potassium increased (Tab. 3). Input of nutrients for getting 1 t of pea grain with a corresponding quantity of straw also increased in fertilizer treatments of the test.

Table 3. Removal of basic nutrients depending on microfertilizers application (mean 2001–2003).

Treatment	General removal of nutrients kg/ha			Removal of nutrients in kg for 1 t of grain with corresponding quantity of straw		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Without fertilizers	121.6	36.1	58.3	43.4	12.9	20.8
$N_{10}P_{40}K_{60}$	157.5	38.9	73.4	47.4	13.9	22.1
$N_{30}K_{60}$	152.5	39.1	78.3	44.8	11.7	23.0
$N_{30}P_{40}K_{60}$	170.8	44.1	85.1	46.8	12.1	23.4
$N_{50}P_{50}K_{90}$	184.0	49.7	86.2	48.2	13.0	22.6
$N_{50}P_{50}K_{90}$ + B	197.4	52.7	92.8	47.6	11.0	22.4
$N_{50}P_{50}K_{90}$ + Co	197.4	49.5	89.9	48.1	12.1	21.9
$N_{50}P_{50}K_{90}$ + Mo	197.7	55.8	89.4	48.5	13.7	21.9
$N_{50}P_{50}K_{90}$ + Mikom	206.7	53.3	93.5	48.6	12.5	22.0

Table 4. Influence of microelements on nitrogen index and coefficients of phosphorus and potassium fertilizers usage (mean 2001–2003)

Treatment	Coefficients of usage, %		Nitrogen index
	P_2O_5	K_2O	
Without fertilizers	-	-	0.74
$N_{10}P_{40}K_{60}$	7.8	25.2	0.75
$N_{30}K_{60}$	-	33.3	0.73
$N_{30}P_{40}K_{60}$	20.5	44.7	0.73
$N_{50}P_{50}K_{90}$	27.2	31.0	0.75
$N_{50}P_{50}K_{90}$ + B	33.2	38.3	0.75
$N_{50}P_{50}K_{90}$ + Co	26.8	35.1	0.75
$N_{50}P_{50}K_{90}$ + Mo	39.4	34.6	0.75
$N_{50}P_{50}K_{90}$ + Mkom	34.4	39.1	0.71

According to generalized data, removal of 1 t of grain with a corresponding quantity of pea straw, depending on variety peculiarities of pea growing conditions, is within 45–60 kg for nitrogen, phosphorus (P_2O_5) – 11–20 kg, and potassium (K_2O) – 20–40 kg [Shpaar et al. 2000]. In our test with pea specific removal of nitrogen was in the middle of the given interval, of phosphorus and potassium – at the lower level. Application of microfertilizers did not essentially affect the removal of nutrients of 1 t of pea grain with a corresponding quantity of straw as well as the value of nitrogen index (relation between nitrogen accumulated in the grain and general removal of nitrogen with the yield).

At the same time under the influence of molybdenum and complex microfertilizer Mikom, containing B, Cu, Zn, and Mo, in comparison with the background of $N_{50}P_{50}K_{90}$, the coefficient of fertilizer phosphorus usage increased. This fact seems to be connected with the positive character of interaction between phosphorus and molybdenum [Yagodin et al. 2002]. Microfertilizers application did not essentially affect the coefficients of fertilizers potassium usage.

CONCLUSIONS

1. Non-root additional fertilization of pea by boron in the phase of budding on the background of $N_{50}P_{50}K_{90}$ increased pea grain productivity on average during 2001–2003 by 0.33 t, molybdenum – by 0.26 t, cobalt – by 0.28 t, and complex microfertilizer Mikom, containing boron, molybdenum, zinc, and copper – by 0.43 t/ha.

2. Cobalt and molybdenum helped to increase the content of crude protein in pea grain on average during three years by 1.0 and 1.1%, correspondingly. The output of crude protein from 1 ha on the background of $N_{50}P_{50}K_{90}$ with boron application increased by 89 kg, cobalt – 94, molybdenum – by 103, and complex microfertilizer Mikom by 98 kg/ha.

3. Molybdenum and complex microfertilizer Mikom on the background of $N_{50}P_{50}K_{90}$ helped to increase the coefficients of fertilizers phosphorus usage. The coefficients of fertilizers potassium usage by pea with the application of the examined microfertilizers did not essentially change in comparison with the background treatment.

REFERENCES

Shpaar D., Elmer F., Postnikov A., Taranuho G. 2000. Grain-leguminous crops. Minsk. (in Russian)

Trepachev E.P. 1999. Agrochemical aspects of biological nitrogen in modern farming. Moscow. (in Russian)

Fedushkin B. F. 1989. Mineral fertilizers with microelements. Leningrad. (in Russian)

Anspok P.I. 1989. Microfertilizers. Leningrad. (in Russian)

Lapa V.V., Bosak V.N. 2002. Mineral fertilizers and ways of increasing their efficiency. Minsk. (in Russian)

Vildflush I.R., Kukresh S.P., Shekunova S.F. 1998. Practical work in agrochemistry. Minsk. (in Russian)

Yagodin B.A., ZhukovY.P., Kobzarenko V.I. 2002. Agrochemistry. Moscow. (in Russian)

Tsyganov A.R., Persikova T.F., Reutskaya S.F. 1988. Microelements and microfertilizers. Minsk. (in Russian)