ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1994, z. 413, 41-46

THE INFLUENCE OF MINERAL FERTILIZATION AND LIMING ON PHOSPHORUS UPTAKE BY SPRING BARLEY FROM VARIOUS SOIL PHOSPHORUS FORMS

W. Bednarek, W. Lipiński

Departament of Agricultural Chemistry, University of Agriculture
Akademicka 15, 20-033 Lublin, Poland

A b s t r a c t. During the two years of pot experiment held in a very acid, nutrient deficient podzolic soil, the influence of differrentiated mineral fertilizing and liming on phosphorus uptake by spring barley from its various forms was tested. It was stated that nitrogen fertilization caused significant increase in aluminium phosphate fraction content and decrease in easily soluble phosphate fractions. The phosphorus fertilization contributed to the increase of all determined forms of phosphorus, on the other hand potassium fertilizing did not influence in a statistically proved mode the concentration of the examined P forms. The phosphorus uptake by the vegetative parts was significantly and positively dependent on the amount of aluminium phosphate fraction amount in soil and iron phosphate fractions easily soluble by grain.

K e y w o r d s: spring barley, fertilization, liming, phosphorus uptake, soil phosphorus forms

INTRODUCTION

The soil fertility in mineral phosphorus compounds depends on various factors, its type among other, fertilization and liming [1-4,7-12]. Except from the dose, a certain influence on the content of some phosphorus forms, the kind of applied phosphorus fertilizer [2,13] can have certain influence. Liming of acid soils and mineral fertilizing (phosphorus one) causes in general the increase of P forms easily available for plants [2,3,8,9]. The plants uptake phosphorus mainly from easily soluble aluminium fractions [3,10].

Calcium and iron phosphates may be a good phosphorus source [13] in the cultivation of chosen plant species at applying various phosphorus fertilizers in specific soil conditions. Available phosphorus, determined with various methods, can also supply plants with this component [1,3,5,6,10-12].

The aim of the experiment was to determine the influence of differentiated mineral fertilizing and liming of very acid podzolic soil on phosphorus uptake by spring barley from various soil phosphorus forms.

MATERIALS

The research was made on the basis of pot experiment, laboratory analyses and statistic calculations. The experiment was carried out on podzolic soil which, before fertilizing, had been limed with oxide type calcium with a dose calculated according to 1 Hh. Its characteristic features are 50 % silt particles, 27 % of fine particles and pH_{KCl} - 4.4. It contained 26 mg P kg^{-1} determined according to Enger-Riehm method and 1.5 mg P kg^{-1} easily soluble phosphate fractions, 86.0 mg P kg^{-1} aluminium phosphate fractions, 81.0 mg P kg^{-1} iron phosphate fractions and 14.2 mg P kg^{-1} calcium phosphate fractions. Pre-sowingly in each of the two years of the experiment two levels of NPK fertilizing (for 6 kg of soil) was applied: N_1-0.9 g N,

N_2-1.8 g N; P_1-0.393 g P, P_2-0.786 g P; K_1-0.9g K, K_2-1.8g K.

Ammonium nitrate, potassium salt and dicalcium phosphate were used for fertilizing.

The barley harvesting (leaves, stems, roots and grain) was made in the full ripeness and at the same time soil samples were taken for analyses. Phosphorus in plant material was determined with vanadate-molybdate method, in soil samples pH_{KCl}, available phosphorus according to Egner-Riehm and mineral phosphorus fractions according to Chang and Jackson. Barley yelding, phosphorus content in soil and plant was evaluated with variance analysis method using Tukey's half-interval of credibility. Relationships occurring between phosphorus forms in soil and yelding, P content and phosphorus uptake by spring barley were also determined.

As NPK fertilizing was applied on limed soil, as a control I very acid soil fertilized with single doses of these components was used, and as control II this soil without mineral fertilization, only limed before starting the experiment.

RESULTS

The result of liming a very acid soil was the change of its reaction to neutral. Phosphorus and potassium fertilizing did not cause significant differences in pH, on the other hand applying double dose of nitrogen contributed to statistically proved soil acidification (Table 1). Double-dose nitrogen fertilization, through soil acidification, effected in a statistically proved way the contact of aluminium phosphate fraction (increase) and easily soluble phosphate fractions (decrease).

Phosphorus fertilizing caused significant increase of easily soluble, aluminium phosphate fractions, the sum of fractions and phosphorus determined with Egner-Riehm method. Iron and calcium phosphate fractions contents were not differentiated in a statistically proved way although in this case one can observe certain tendency of the increase concentration of these fractions. Potassium fertilizing did not influence significantly the content of any determined phosphorus forms.

Liming caused distinct increase of available phosphorus content and easily soluble phosphate fractions (in comparison to control I), on the other hand mineral fertilizing additionally caused the increase of aluminium, iron and mineral phosphate amounts (control II).

Spring barley yelding, its vegetative parts and grain, did not significantly depend on mineral fertilization applied. It may prove the

Table 1. pH_{KCl} and content of various forms of phosphorus in soil (mg P/100 g)

Fertilization	pH_{KCl}	P-acc. to Egner-Riehm	P-easily soluble	P - Al	P - Fe	P - Ca	Sum of fractions
N_1	6.4	12.8	6.0	13.6	14.3	2.2	36.1
N_2	5.9	11.2	3.9	14.7	14.1	2.3	35.0
LSD p = 0.05	0.1	*	1.1	0.8	*	*	*
P_1	6.1	8.0	2.0	11.9	13.4	2.2	29.5
P_2	6.2	16.0	7.8	16.4	15.0	2.3	41.6
LSD p = 0.05	*	1.9	1.1	0.8	*	*	2.5
K_1	6.2	12.1	4.9	14.1	14.3	2.3	35.6
K_2	6.2	11.9	4.9	14.2	14.2	2.2	35.5
LSD p = 0.05	*	*	*	*	*	*	*
Control							
I	4.4	7.0	1.0	13.2	13.2	1.9	29.2
II	6.4	2.4	0.3	5.8	10.9	1.9	18.8

* - not significant differences.

fact that already single dose fully covered the needs of the plant, double dose applying did not differentiate its biomass (Table 2). The liming of very acid soil and mineral fertilizing caused the significant increase in barley yields, a plant very sensitive to soil acidification and insufficient nutrient supply (especially easily available phosphorus forms).

In comparison to control, soil liming as well as mineral fertilization caused distinct increase of P content in plants and phosphorus uptake by barley (Table 3). However, no significant differences in the amount and uptake of this component by vegetative parts and grain within the applied doses of NPK were found.

Spring barley yelding depended significantly on the easily soluble aluminium (positive correlation), as well as on iron (negative correlation) phosphate fraction content in soil. With the increase of easily soluble phosphates fractions in soil by one unit, the harvest of vegetative parts will increase by 0.9 g per pot, however, if iron phosphate concentration increases by one unit, the harvest mass of these parts will decrease by 1.3 g per pot (in comparison to average harvest mass of vegetative parts of the plant).

It was found that positive correlation exists between aluminium phosphates fractions and the amount of P in the vegetative parts of the plant, and similar dependence between iron phosphates fraction concentration and the amount of phosphorus in barley stems and grain.

However, the increase in aluminium phosphate fractions in soil by one unit will cause the increase in phosphorus amount in the vegetative parts of the plant by 0.02-0.03 % d.m., and iron phosphates fractions by 0.01 % d.m. of stems and grain.

The phosphorus uptake by barley proved positive correlation with the aluminium phosphates content in soil as well as those easily soluble (vegetative parts) and iron phosphates content (grain). Together with the increase of those fractions by one unit, the phosphorus uptake by vegetative parts will increase subsequently by 4.7 and 2.4 mg P from one pot, and 6.8 mg P by grain.

Table 2. Yields and the content and uptake of phosphorus by spring barley

Fertilization	Yield (g/pot)			Content of P (%)			Uptake of P (mg/pot)	
	vegetative parts	grain	stems	leaves	roots	grains	vegetative parts	grains
N_1	32.1	37.0	0.34	0.34	0.17	0.46	85	177
N_2	31.8	33.5	0.41	0.37	0.21	0.49	84	166
LSD p=0.05	*	*	*	*	*	*	*	*
P_1	30.4	33.8	0.35	0.31	0.18	0.45	76	158
P_2	33.4	36.7	0.40	0.38	0.20	0.50	93	185
LSD p=0.05	*	*	*	*	*	*	*	*
K_1	30.8	34.1	0.36	0.33	0.19	0. 46	84	161
K_2	33.0	36.4	0.39	0.36	0.20	0.49	85	183
LSD p=0.05	*	*	*	*	*	*	*	*
Control								
I	25.7	26.6	0.31	0.26	0.17	0.39	21	106
II	14.7	12.6	0.05	0.08	0.07	0.50	12	68

*not significant differences.

T a b l e 3. The dependence of yield, phosphorus content in plant and phosphorus uptake by spring barley on the occurrence of various phosphorus forms in soil (n=108)

Phosphorus forms in soil	Correlation coefficient								Regression coefficient							
	Yield		P content				P uptake		Yield		P content				P uptake	
	vege-tative parts	grains	roots	leaves	stems	grains	vege-tative parts	grains	vege-tative parts	grains	roots	leaves	stems	grains	vege-tative parts	grains
P easily soluble	0.23	*	*	*	*	*	0.20	*	0.94	*	*	*	*	*	2.42	*
P - Al	*	0.47	0.47	0.49	0.38	*	0.29	*	*	0.02	0.02	0.03	0.03	*	4.66	*
P - Fe	-0.45	*	*	*	0.27	0.76	*	0.77	-1.32	*	*	*	0.01	0.01	*	6.77
P - Ca	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
P - acc. to Egner-Riehm	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

* - lack of significant dependencies at P=0.05.

DISCUSSION

The results pertaining to the influence of mineral fertilizing on various phosphorus content in soil found their confirmation in the works of other authors [2,4,7,9,12]. At the same time Bednarek [3] stressed that easily soluble and aluminium phosphates play a significant role in the influence on the crop of Italian ryegrass and on supplying it with phosphorus. However, other authors inform that no positive correlation was noted between the soil availability in phosphorus determined with Egner-Riehm method and its content in the vegetative mass of grain crops grown mainly on light textured soil [5]. Czuba also states that there is a significant correlation between the content of available phosphorus in soil and its content in grain and straw of spring wheat [6]. It is also noticed that significant correlations exist between available phosphorus content, determined with various methods, and plant indices (relative plant yield and phosphorus uptake) [1]. At the same time, it is stated that AL and DL Egner methods and Olsen's method should be considered the best of the tested ones allowing to evaluate the actually available and reserve content of phosphorus forms.

Moskal [11] also states that phosphorus uptake by barley and corn had significant and positive correlations with the content of this element in soil, determined among others by Egner-Riehm method. Plants absorb phosphorus mainly from easily soluble and aluminium fractions [10], but they can also effectively absorb iron and aluminium fractions, especially when they are fertilized with various phosphorus fertilizers [13].

CONCLUSIONS

The following conclusions can be formulated from the above presented research:

1. Nitrogen fertilizing caused a significant increase in the aluminium phosphate content in soil and the decrease in easily soluble phosphate content (through the influence on its acidification). The fertilization with phosphorus contributed to the increase in the amount of all determined phosphorus forms, and fertilizing with potassium did not affect significantly the concentration of determined P forms.

2. The fertilizing of soil with double NPK dose did not cause significant increase in the plant yield, phosphorus content in it and its uptake by barley. This may prove the fact that a single dose of NPK applied in neutral soil fully covered the nutritive needs of the plant. However, liming of a very acid soil and its mineral fertilizing contributed to the increase of the content of determined phosphorus forms in soil, barley yielding and phosphorus uptake by plant in comparison to the control.

3. Spring barley yielding was significantly dependent on the content of easily soluble and aluminium phosphate fractions' content in soil (subsequently vegetative parts and grain - positive correlation) and of iron phosphate content (vegetative parts - negative correlation). The phosphorus content in the vegetative parts of the plant was positively correlated with the amount of aluminium phosphate fractions in soil and in grain with the amount of iron phosphate fraction. The uptake of P by vegetative parts was significantly and positively correlated with the amount of aluminium and easily soluble phosphate fractions in soil and by grain with the amount of iron phosphate fractions.

REFERENCES

1. **Adamus M., Fotyma M., Gosek S., Kęsik K.:** Wartości progowe testów określających zawartość przyswajalnych form fosforu w glebie. Pam. Puł., 76, 79-95, 1981.
2. **Bednarek W.:** Wpływ nawożenia fosforowego na zawartość różnych form w glebie. Prace Nauk. Akad. Ekon., Wrocław, 200, 1982.
3. **Bednarek W.:** Pobranie fosforu przez życicę wielokwiatową w zależności od zawartości mineralnych form tego składnika w glebie. Polish J. Soil Sci., 20(2), 25-30, 1987.
4. **Chmielewska B., Myszka A., Kupisz E.:** Wpływ jednorazowych zróżnicowanych dawek fosforu na zawartość jego różnych frakcji mineralnych oraz P - przyswajalnego w brunatnej glebie lessowej. Prace Nauk. Akad. Ekon., Wrocław, 159, 191-202, 1980.
5. **Chojnacki A., Filipiak K., Ponikiewska A.:** Zależność między zawartością przyswajalnych form składników pokarmowych w glebie a ich zawartością w materiale roślinnym zbóż. Pam. Puł., 76, 77-105, 1981.
6. **Czuba R.:** Badania nad pobieraniem składników po-

karmowych przez pszenicę ozimą. Rocz. Nauk Roln., A, 96(1), 5-28, 1969.
7. **Czuba R., Murzyński J.**: Formy fosforu w glebie po ośmioletnim stosowaniu wzrastających dawek azotu i potasu. Prace Nauk. Akad. Ekon., Wrocław, 159, 93-108, 1980.
8. **Deleczewa-Walewa D., Moskal S.**: Wpływ długoletniego zróżnicowanego nawożenia na zawartość różnych fosforanów w glebie. Roczn. Glebozn., 18(2), 523-535, 1968.
9. **Kęsik K., Fotyma M.**: Wpływ wapnowania na stan fosforowy gleb. Prace Nauk. Akad. Ekon., Wrocław, 267, 90-97, 1984.
10. **Kęsik K., Pietrasz-Kęsik G.**: Wykorzystanie mineralnych frakcji P z gleb nawożonych tym składnikiem. Roczn. Glebozn., 32(3), 123-130, 1981.
11. **Moskal S.** : Chemiczne i izotopowe metody oznaczania łatwo dostępnych dla roślin fosforanów w glebie. Roczn. Nauk Roln., A, 96(1), 57-82, 1969.
12 **Myszka A., Ginalski J.**: Wpływ poziomu i sposobu nawożenia fosforowego w płodozmianie na zawartość różnych frakcji mineralnego fosforu i przyswajalnego DL w glebach lessowych. Ann. UMCS, E, 38/39, 231-240, 1983.
13. **Smith A.N.**: The uptake of phosphorus by wheat and clover from four inorganic soil phosphate fractions after the addition of contrasting types of phosphate fertilizer. Plant Soil, 29(1), 144-155, 1969.

WPŁYW NAWOŻENIA MINERALNEGO I WAPNOWANIA NA POBRANIE FOSFORU PRZEZ JĘCZMIEŃ JARY Z RÓŻNYCH FORM TEGO SKŁADNIKA WYSTĘPUJĄCEGO W GLEBIE

W dwuletnich doświadczeniach wazonowych założonych na bardzo kwaśnej, ubogiej w składniki pokarmowe glebie bielicowej, badano wpływ zróżnicowanego nawożenia mineralnego i wapnowania na pobranie fosforu przez jęczmień jary z jego różnych form.

Stwierdzono, że nawożenie azotem powodowało istotny wzrost zawartości w glebie frakcji fosforanów glinowych i zmniejszenie frakcji fosforanów łatwo rozpuszczalnych. Nawożenie fosforem przyczyniło się do zwiększenia ilości wszystkich oznaczanych form fosforu, natomiast nawożenie potasem nie oddziaływało w sposób udowodniony statystycznie na koncentrację badanych form P. Pobranie fosforu przez części wegetatywne było istotnie i dodatnio uzależnione od ilości w glebie frakcji fosforanów glinowych i łatwo rozpuszczalnych, przez ziarno - frakcji fosforanów żelazowych.

S ł o w a k l u c z o w e: jęczmień jary, nawożenie mineralne, wapnowanie, pobieranie fosforu.