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PHOSPHORUS FARMING OF MORPHOLOGICALLY DIFFERENT PEA (*Pisum sativum*) VARIETIES IN POTASSIUM DEFICIENCY SOIL CONDITIONS

GOSPODARKA FOSFOROWA ZRÓŻNICOWANYCH MORFOLOGICZNIE ODMIAN GROCHU (*Pisum sativum*) W WARUNKACH NIEDOBORU POTASU W PODŁOŻU

Abstract: In a two-year pot experiment the effect of potassium deficiency on the dynamics of the concentration and accumulation of phosphorus in two morphologically different pea varieties – Agra and Bursztyn – was investigated. The experiment was conducted in Mitscherlich pots, in an experimental greenhouse in IUNG-Pulawy. Potassium was applied in the following doses per pot: 0, 500 and 1500 mg K (as K_2SO_4). Phosphorus was applied in equal quantities per pot: 1000 mg P (as $NaH_2PO_4 \cdot 2H_2O$). Other components of mineral nutrients were applied in equal amounts to ensure proper growth and development of plants. Plants were harvested at 5 development stages, and divided into component parts. The percentage content of phosphorus in the dry weight of component parts was then determined. The potassium fertilization applied in the experiment resulted in differences in the concentration and accumulation of phosphorus in particular component organs and in whole plants at analyzed stages of tested pea varieties. Potassium deficiency limited plant growth, distribution and accumulation of phosphorus in comparison with plants which were optimally fertilized with K (the effect was stronger for Agra variety). Regardless of the dose of potassium, plants of Bursztyn variety accumulated more phosphorus and gave of larger biomass yield compared with plants of Agra variety.

Keywords: pea varieties, phosphorus farming, potassium deficit

Pea, like most legumes, has high nutritional requirements, among other things, in relation to phosphorus due to high N_2 symbiotic fixation processes [1–3]. The contents of this element in the various species of leguminous plants, plant parts and varieties is highly variable [4, 5]. There are no data from literature, or are very fragmented, in respect of phosphorus farming of morphologically different new pea varieties. There is also no data on the collection and management of this component in the above-mentioned pea varieties in potassium deficiency soil conditions. As it is known, most

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of the soils of our country have a relative shortage of K [6], so it seems an interesting issue. Some results of studies concerning the collection and management of potassium and yield of plants have already been published by the author [7]. The present work focuses on the phosphorus farming of two pea varieties.

The aim of this work is to investigate the state of phosphorus supply in morphologically different pea varieties and the phosphorus farming during growth, development and maturation of plants in potassium deficiency soil conditions.

Material and methods

The object of research were two morphologically different pea varieties: Bursztyn – a traditional form and Agra – semi-leafless with leaves partially changed at tendrils, growing in different conditions of potassium fertilization. The experiment was conducted in an experimental greenhouse in IUNG – Pulawy, during two years (1998 and 1999), in Mitscherlich pots filled with 6.5 kg of light soil, low in potassium and phosphorus. Seeds of peas were inoculated with *Rhizobium leguminosarum* biotype *viceae* and were sown in early April. Five plants were grown in each pot. Humidity was maintained at the ground level of 60 % field water capacity.

Potassium in the experiment was varied and was used in the following 3 doses per pot: 0, 500 and the optimum dose of K – 1500 mg K (K as K_2SO_4). Plants received equal amounts of phosphorus in all facilities, at a dose of 1000 mg P in pot (as $NaH_2PO_4 \cdot 2H_2O$). Half of the dose was given before sowing to the soil, and half at the 5–6 knots phase. Other components of the mineral nutrient were administered in equal amounts to ensure proper growth and development of plants. Soil reaction in pots was close to pH_1n_{KCl} 6.5.

Plants were collected at five dates in the following phases of development, as defined by BBA scale [8]: I – phase 9 knots (29), II – creation of flower buds (59), III – flowering (65), the development of pods (79), full maturity (95). Collected plant material was divided into organs, dried and weighed to determine dry matter and then analyzed including the content of P. Phosphorus was determined by flow spectrophotometry. Phosphorus determination was made in two parallel repetitions, the relative method error was within 5–8 %. Research results in this paper are averages of two years of research. Yields of dry mass of plants were subjected to statistical analysis using variance analysis Tukey test at the level $\alpha = 0.05$ and have been already published [7].

Results and discussion

The differential in the experiment of potassium fertilization led to differences in concentration and accumulation of phosphorus in various organs and whole plants, as analyzed in the test phases of growth of the pea varieties (Table 1 and 2). Phosphorus in young plants, in the early stages of growth and development of plants in both pea varieties regardless of feeding potassium, was collected in larger quantities and concentrations in roots than in the overground parts of plants. It was only in the generative phase, the phase of full maturity of seed that phosphorus accumulated more in seeds in relation to the roots, leaves and other organs. Location of phosphorus in bodies of peas was strictly dependent on the development phase and the physiological role of this component in the plant [9]. In the young plants to a large extent phosphorus is responsible for the nodule bacteria survival and N_2 symbiotic fixation, hence the high content of this component in the roots [2]. In mature plants the accumulated phosphorus was mainly concentrated in the seeds, at the expense of vegetative organs of which it was phased out (Table 1).

Table 1

Phosphorus content in particular organs of plants, in successive harvests of two varieties of pea in relation to potassium fertilization

Harvest*	Plant organ	Bursztyn variety			Agra variety		
		K dose [mg K · pot^{-1}]					
		0	500	1500	0	500	1500
		P content [% d.m.]					
I (29)	Leaves + stems	0.48	0.44	0.46	0.43	0.48	0.50
	Roots	0.88	0.89	0.86	0.61	0.67	0.65
II (59)	Leaves + stems	0.46	0.41	0.39	0.38	0.37	0.39
	Roots	1.12	1.05	0.98	0.83	0.90	0.91
III (65)	Leaves +stems	0.49	0.43	0.43	0.39	0.40	0.42
	Roots	1.10	1.10	0.91	0.94	0.99	0.96
IV (79)	Leaves + stems	0.30	0.28	0.30	0.32	0.34	0.38
	Flowers + pods	0.49	0.45	0.44	0.55	0.48	0.53
	Roots	0.83	0.75	0.74	0.97	0.87	0.79
V (95)	Leaves + stems	0.38	0.09	0.08	0.31	0.19	0.16
	Seeds	0.60	0.44	0.47	0.56	0.49	0.47
	Hulls	0.43	0.14	0.09	0.41	0.15	0.13
	Roots	0.54	0.27	0.33	0.35	0.30	0.38

* Harvest – development stage (the code according to BBA): (29) – 9 nod stage, (59) – bud formation, (65) – flowering, (79) – pod development, (95) – complete maturity.

Potassium deficiency in soil limited absorption of phosphorus from the soil only in older plants and, despite the high concentration of this component in different organs of plants, the total uptake of P in plants from these objects was lower in both pea varieties in relation to the plants optimally fertilized with that component. In mature plants, there were substantial differences in the concentration and accumulation of phosphorus between K deficiency objects and objects fertilized sufficiently with this component. Both pea varieties unfertilized with potassium (K = 0), despite the generally higher concentration of P in all organs, have accumulated much less of this component, especially in the seeds (Table 2) as compared with the plants optimally fertilized with potassium (K = 1500). Phosphorus in plants from these first objects (K = 0) remained in leaves, hulls and other organs. The shortage of potassium in the soil led to a change in the formulation of distribution and accumulation of phosphorus in plants, compared with plants fertilized optimally with K (objects fed 1500 mg K per pot). Seeds of Agra variety from the latter objects accumulated about 75 % and seeds of Bursztyn variety as much as 85 % of the total pool of phosphorus accumulated in the plant. In contrast plants from deficiency objects, especially where no potassium was given, accumulated significantly less of this element in the seeds, about 52 % (Agra) and only 32 % (Bursztyn) of the total pool of phosphorus accumulated in plants. According to Marshner [5] and Starck [9] in plants sufficiently fed with potassium processes of distribution and redistribution of P are more efficient and the main pool of phosphorus is accumulated in seeds at the expense of the removal of this element from leaves and other organs. P uptaken by plants growing in the potassium deficiency ground could not be sufficiently used as a shortage of K limits growth and yielding of plants [7, 10, 11].

Table 2

Accumulation of phosphorus in particular organs of plants, in successive harvests of two varieties of pea in relation to potassium fertilization

Harvest*	Plant organ	Bursztyn variety			Agra variety		
		K dose [mg K · pot^{-1}]					
		0	500	1500	0	500	1500
		P uptake [mg P · pot^{-1}]					
I (29)	Leaves + stems	41	39	35	18	24	23
	Roots	40	44	33	14	16	14
	Whole plant	81	83	68	32	40	37
II (59)	Leaves + stems	55	52	46	33	37	37
	Roots	57	59	51	32	36	34
	Whole plant	112	111	97	65	73	71
III (65)	Leaves + stems	84	96	84	46	54	57
	Roots	75	81	65	35	39	39
	Whole plant	159	177	149	81	93	96
IV (79)	Leaves + stems	103	109	151	64	93	89
	Flowers + pods	78	93	103	36	53	40
	Roots	59	65	85	47	50	44
	Whole plant	240	267	338	147	197	173
V (95)	Leaves + stems	131	32	30	55	38	37
	Seeds	106	276	368	95	172	181
	Hulls	48	16	13	19	8	8
	Roots	43	11	21	11	8	14
	Whole plant	328	334	432	180	226	240

* explanations under table 1.

The obtained values of P concentration in particular organs at the successive phases of plants development (from all objects) were in range of sufficient value for the pea [4, 12]. Similar results and values, in respect of faba bean, were acquired in their studies by Dietrych-Szostak et al [13] and Labuda [14].

Tested pea varieties showed significant differences in the size of the uptaken and accumulated phosphorus (Table 2). Mature plants of both pea varieties from K deficiency objects accumulated much less P as compared with plants fertilized optimally with potassium. Bursztyn variety, regardless of potassium fertilization, in all development phases accumulated much more P compared with Agra variety. This was due to, first of all, a significant difference in yield of dry weight of plants: traditional Bursztyn variety produced a much greater biomass and seed yield compared with the variety of "tendril-leaves" Agra [7].

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Abstrakt: W dwuletnim doświadczeniu wazonowym badano wpływ niedoboru potasu na dynamikę pobierania i akumulacji fosforu roślin dwóch zróżnicowanych morfologicznie odmian grochu zwyczajnego: Agra oraz Bursztyn. Doświadczenie prowadzono w wazonach Mitscherlicha, w hali wegetacyjnej IUNG-PIB w Puławach. Potas zróżnicowano i zastosowano, w przeliczeniu na wazon, w 3 dawkach: 0, 500 i 1500 mg K (w K_2SO_4). Natomiast fosfor rośliny otrzymały w jednakowych ilościach we wszystkich obiektach, w dawce 1000 mg P/wazon (w postaci $NaH_2PO_4 \cdot 2H_2O$). Pozostałe składniki pożywki mineralnej podawano w jednakowych ilościach zapewniających prawidłowy wzrost i rozwój roślin. Rośliny zbierano w 5 fazach rozwojowych, dzielono na organy i w ich suchej masie oznaczano procentową zawartość fosforu. Zastosowane w doświadczeniu nawożenie potasem prowadziło do różnic w koncentracji i akumulacji fosforu w poszczególnych organach i w całych roślinach, w analizowanych w fazach wzrostu badanych odmian grochu. Niedobór potasu ograniczał wzrost roślin, dystrybucję i akumulację fosforu, w porównaniu z roślinami optymalnie nawożonymi K, bardziej u odmiany Agra. Niezależnie od dawki potasu, rośliny odmiany Bursztyn nagromadziły większą ilość fosforu i wydały większy plon biomasy w porównaniu do roślin odmiany Agra.

Słowa kluczowe: odmiany grochu, gospodarka fosforowa, niedobór potasu