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MOBILE PHOSPHORUS DYNAMICS AT ASHED BLACK SOILS UNDER PRECISION FARMING

TONKHA O.L., pHD in soilscience
SYCHEVSKYI S.O., postgraduate
National University of life and environmental sciences of Ukraine
E-mail: oksana16095@gmail.com

Abstract. *In article was shown specifics of winter wheat yield formation depend on different levels of available phosphorus in Ashed Black soil. Investigated that soil available phosphorus concentration was between levels along vegetation period even without additional in season application of phosphorus fertilizers, only because of natural or acquired spatial variability. In certain conditions were approved phosphorus influence on winter wheat grain fullness. During grain yield structure determination on test plots, was pointed significant yield difference between plot with medium P level and others test plots. As a factor which occur yield difference between plots was weight of 1000 grains. On this plot plants were form more fullness grain and as a result – higher yield. .*

Keywords: mobile phosphorus, winter wheat, winter hardiness, crop yield.

Problem statement. Phosphorus deficiency impact on winter wheat crop yield (Leartis variety) may not be accompanied with deficiency symptoms of that element during the growing season. Crop yield decrease caused by soil available phosphorus deficiency can reach 10-15 % compered to plots with medium and higher level of supply.

Winter wheat is the main cereal crop of Ukraine. Cultivated area and gross grain amount of this crop is much higher than other cereals crop [9]. Average yield of grain at Left Bank forest steppe zone of Ukraine in last few years had decreasing trend. However, using of modern technologies which are combined in “precision” farming philosophy it is possible to get better yields even under difficult conditions of economic crisis. This technology is able to reduce nutrition management costs and increase yields [1].

Phosphorus is highly important nutrient for winter wheat. Deficiency of it can cause stress for the plant. In certain situation, plants are applying different adaptations. Such adaptations can be divided into next groups: morphological (root:stem ratio increase, root morphology and architecture change, root hairs elongation and proliferation increase, mycorrhiza growth stimulation), physiological (increasing of phosphorus absorption by roots, it mobilization from vacuoles to cytoplasm, organic acids exudation, changes at the process of photosynthesis, nitrogen fixation and respiration), biochemical (phosphorus metabolism ferment activation, enhance phosphatases formation, changes at

protein phosphorylation process), molecular (RNA genes activation, phosphatase, storage proteins, etc.) and genetical (changes in gene expression for P absorption efficiency increase by plants, etc.) [2].

P and K impact on plant mainly consist in providing of resistance to biotic and abiotic stress factors. Plants which are supplied with enough amounts of those elements are less sensitive to stress factors [4].

Phosphorus is the second most important macronutrient in plant grows. Commonly, deficiency of this element is the reason of low cereals yields in Ukraine. Plants need available forms of phosphorus, it deficiency can't be compensated by low soluble P and organic P. Winter wheat plants are absorbing P_2O_5 from $Ca_3(PO_4)_2$, through solving phosphates by it root exudate or mobilized it by intensive consuming of Ca^{++} from soil solution. For spring and winter cereals consumption of available P form is only possible [2].

Importance of this element for plants on early growth stages makes additional application of P necessary. Phosphorus might reduce negative influence of Nitrogen overfeeding and optimize it usage in soil media on late growth stages of winter wheat [2, 4].

Total arable land area of Ukraine with low and medium available P content is around 18 thousand hectares, or 57% [8]. P_2O_5 application with fertilizers gives additional 4-5 kg of grain per kilo of fertilizers with makes it highly profitable because of low natural P availability for plants [4].

The purpose of research was to investigate specifics of winter wheat yield formation depend on different levels of available phosphorus in Ashed Black soil**.**

Research methodology. Scientific data was collected during seasons 2014-2016 from production fields of LLC Lotivka Elit. Test plots were placed in Northern part of Shepetivka region which is North-West Right Bank Forest Steep Zone. This territory is part of North agroclimatic area of oblast. Local soil - Ashed Black soil, with medium clay loam texture, formed on Loess.

Were considered three experiments with different available soil P content and medium exchangeable soil K content: P_mK_m – medium, P_lK_m – low, $P_{vl}K_m$- very low. Winter wheat variety – Leartis. For grows stages determination Zadocs BBCH scale (from "Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie") was used.

Crop rotation system was typical for Forest Steep Zone with next crops: corn for grain – winter wheat - corn for grain – peace – winter wheat.

Soil samples were taken systematically dated to BBCH stages according to ISO 10381-2 [6]. Chemical analysis sample preparation was made according to DSTU ISO 11464-2001. Available Phosphorus content was measured by Chirikov method[7]. Grain harvesting was made by industrial harvesting machines equipped with yield monitoring systems. Scientific data was processed according to Dospechov method of dispersion analysis using Microsoft Excel®. Yeld data was processed in FarmWorks® software.

Results and discussion

In Ukrainian and foreign literature the main reason of soil fertility decrease considered humus level depression as a result of long term land

usage(1). Therefore it phisycal-chamical properties deteriorated. It makes negative effect on crop provision with available forms of nutrients [3]. Next of an important reason of soil fertility decrease is low phosphorus fertilizers rates.

Among grain crops winter wheat is one of the most sensitive to soil available nutrients content. With the grain (yield of 4,5 $t*he^{-1}$) it remove 120kg* he^{-1}, 45-50 kg of Phosphorus and 50-75 kg of Potassium [5].

Phosphorus plays an important role in plant and microorganism life and development. Most of it metabolism processes are passing with compulsory participation of Phosphorus. Particular role of Phosphorus consist in cell energy exchange, acceleration of the transition from vegetative growth to generative development, winter hardiness and lodging resistance increase [2].

The highest physiological need of Phosphorus is observe on the beginning of crop growth. Plants feel Phosphorus deficiency especially on that age when their roots have low sorption ability. That deficiency can't be compensated later in the season by additional fertilizer application. Winter wheat plants become more diseases sensitive, suffering and doesn't coming back to normality [4].

To make any conclusions about soil Phosphorus supply only available forms can be taken to account. That is why soil available phosphates value is so important parameter for rational land usage. To achieve effective P management during growing season we need to determine factors and correlation of it distribution in time and space.

In different grows stages of winter wheat soil P monitoring was done. Soil samples were taken from same spots, using GPS technology. Soil available phosphorus content was determined by Chirikov method. Field data is presented in Table 1.

1. Ashed Black soils' available phosphates content dynamics on different growth stages, mg/100 g

Experiment	Chirikov P_2O_5 test, $mg*100\ g^{-1}$.	BBCH 30/tillering	BBCH 32/node	BBCH 45/boot	BBCH 50/heading	BBCH 60/flowering	Average
P_mK_m	13,3	16,3	18,0	18,7	24,0	17,8	19,0
P_lK_m	8,1	13,3	14,0	22,9	10,5	9,1	13,9
$P_{vl}K_m$	4,6	11,0	9,5	12,6	13,2	6,0	10,5

At test plot with medium soil available phosphorus content (P_mK_m) this parameter had shown stable increase an till BBCH 50/heading. On stage BBCH 60/flowering - soil available phosphorus content had dropped. It might be explained by maximal P consumption by winter wheat plants on stage BBCH 60. At test plot with low soil P (P_lK_m) - on stage BBCH 30 was obtained P content by 13,3 $mg*100\ g^{-1}$ which corresponded to medium level. But in next

grows stages this parameter had dropped to level of 9,1 mg*100 g^{-1} (BBCH 60/flowering). At test plot with very low soil available P ($P_{vl}K_m$) phosphorus content was low on the beginning (4,6 mg*100 g^{-1}), but was increasing with next grows stages until BBCH 60/flowering (13,2 mg*100 g^{-1}). In general, the highest soil available P forms content was at P_mK_m plot (19,0 mg*100 g^{-1}). Little lower – at plot with low available soil P content (P_lK_m). The lowest available soil P dynamics was observed at plot with very low available soil P content ($P_{vl}K_m$).

From our point of view at first (P_mK_m) and third ($P_{vl}K_m$) plots available P content gradual increase with plant development which can be explained by P releasing processes activation. At second plot (P_lK_m) the highest soil P content was observed on stage BBCH 45/boot later on was stable.

During observation plants almost doesn't differed in their development. After winter period wheat plants of all plots had active back to it vegetation. Tillering coefficient was approximately 2,8 tillers per plant. During spring vegetation restoration, we had note slight soil available P concentration reduction on test plot with very low P content level ($P_{vl}K_m$). It could be caused by phosphorus deficiency in the early stages of development. Nevertheless, the level of provision in this element did not go beyond his class up to active growth stages begin.

One of consequence of winter wheat plants growth retardation in Autumn period is accumulation of protective plastic material in plant cells. Its well known that frost protective function in winter period is strongly correlated with the level of soluble carbohydrates accumulated in plant cell. In course of studies was found that number of sugars not always is determined by the presence of nutrients in vegetative period. In Table 2 is presented correlation between sugars accumulation in winter wheat plants and soil available P level.

2. Carbohydrates content in winter wheat plant cell under different soil available P level, mg/g

Exp.	End of Autumn vegetation		Beginning of Spring vegetation вегетації	
	Mono sugars	Total sugars	Mono sugars	Total sugars
$P_{vl}K_m$	77,4	197,2	48,1	113,5
P_lK_m	68,1	188,1	50,0	116,7
P_mK_m	79,7	207,2	52,5	115,9

At test plot with very low soil available P level mono sugars number in winter wheat plants on the beginning of Spring vegetation was on 29,3 less than at the end of Autumn vegetation. Total sugars number was on 83,7 less accordingly. Similar pattern was noted in other experiments too. Experiment with medium soil available P level (P_mK_m) has shown the highest plant sugar content. Experiment with low soil available P level (P_lK_m) has shown the lowest plant mono and total sugar content. That was even less than on plot with very low soil available P level.

Winter wheat yield losses because of hard condition in winter period commonly may reach significant amounts. Wheat winter hardiness is very complicated phenomen. Along with winter wheat cold hardiness, winter

hardiness also includes resistance to stuffiness under ice crust layer and because of long term stay in waterlogged soil [2].

Winter and cold hardiness first of all driven by variety specifics. Winter wheat overwintering essentially depends on weather condition in Autumn-Winter period. Previous crops and soil tillage type make perceivable influence on that as factors which make impact on soil water and nutrition regime [2]. That was confirmed by the results of our research (Table 3).

3. Wheat winter hardiness depending on different soil available P level

Exp.	Winter hardiness, %
$P_{vl}K_m$	76,1
P_lK_m	79,9
P_mK_m	84,0

Direct correlation was investigating between plant winter hardiness and presents of enough amounts of soil nutrients. Plants from the plot with medium soil P level (P_mK_m) had highest winter hardiness - 91,0%, this parameter was decreasing accordingly with the decreasing of soil nutrients level. Winter hardiness at low P plot was 87,9%, very low P – 79,1%.

4. Winter wheat grain yield and quality parameters depending on different soil available P level

Exp.	Nature, g	Proteins content, %	Gluten content in flour , %	Bread volume, sm^3	1000 seed weight, g	Yield, $t*ha^{-1}$
$P_{vl}K_m$	785	12,9	25,7	580	282	7,1
P_lK_m	800	12,6	26,0	582	289	7,4
P_mK_m	820	13,2	26,3	591	299	8,3

At the experiments with low and medium soil P level on stage BBCH 45/boot rapid available soil P concentration increase was noted. We assume that the reason of it phenomena could be weather. Because there was heavy rains 5 days before soil sampling. Warm weather in next days had contributed to active development of soil phosphate mobilizers.

In the end of a season very low soil P plots has shown even less P content that it was on the beginning, which might be an indicator of deficit phosphorus balance at those test plots. Medium soil available P test plot in same conditions has shown positive phosphorus balance.

During grain yield structure determination on test plots, was pointed significant yield difference between plot with medium P level and others test plots. As a factor which occur yield difference between plots was weight of 1000 grains. On this plot plants were form more fullness grain and as a result – higher yield.

Conclusions

Soil available phosphorus concentration might move between levels along vegetation period even without additional in season application of

phosphorus fertilizers, only because of natural or acquired spatial variability. In certain conditions were approved phosphorus influence on winter wheat grain fullness.

Phosphorus deficiency impact on winter wheat crop yield (Leartis variety) may not be accompanied with deficiency symptoms of that element during the growing season. Crop yield decrease caused by soil available phosphorus deficiency can reach 10-15 % compered to plots with medium and higher level of supply. Which is 4080 UAH per hectare, EXW 2016 [10].

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ДИНАМІКА РУХОМОГО ФОСФОРУ ЧОРНОЗЕМУ ОПІДЗОЛЕНОГО ЗА ТОЧНОГО ЗЕМЛЕРОБСТВА

Тонха О.Л., Сичевський С.О.

Анотація. *У статті наведено специфіку формування врожаю пшениці озимої залежно від різних рівнів забезпечення рухомими формами фосфору чорнозему опідзоленого. Встановлено, що за вегетації культури рівень забезпеченості ґрунтів рухомим фосфором чорнозему опідзоленого може зміщатися у класах навіть без внесення фосфорних добрив за рахунок природної або набутої просторової варіабельності. Було підтверджено вплив фосфору на виповненість зерна пшениці озимої. Найвища урожайність і якість зерна пшениці озимої отримана за середньої забезпеченості рухомим фосфором у чорноземі опідзоленому при цьому за вегетації культури цей варіант характеризувався найбільшою кількістю моноцукрів (53-80), сумою цукрів (116-207 мг/г) і зимостійкістю 91%. Негативний вплив дефіциту фосфору на урожайність пшениці озимої сорту Лаертіз, може не супроводжуватись симптомами нестачі даного елементу впродовж вегетації.*

Ключові слова: мобільний фосфор, озима пшениця, зимостійкість, врожайність.

ДИНАМИКА ПОДВИЖНОГО ФОСФОРА ЧЕРНОЗЕМА ОПОДЗОЛЕННОГО ПРИ ТОЧНОМ ЗЕМЛЕДЕЛИИ

Тонха О.Л., Сычевский С.А.

Аннотация. *В статье приведено специфику формирования урожая пшеницы озимой в зависимости от различных уровней обеспечения подвижными формами фосфора чернозема оподзоленного. Установлено, что во время вегетации культуры уровень обеспеченности почв*

подвижным фосфором чернозема оподзоленного может смещаться в классах даже без внесения фосфорных удобрений за счет природной или приобретенной пространственной вариабельности почвы. Было подтверждено влияние фосфора на наполненность зерна озимой пшеницы. Самая высокая урожайность и лучшее качество зерна пшеницы озимой получена при средней обеспеченности подвижным фосфором черноземе оподзоленного при во время вегетации культуры этот вариант характеризовался наибольшим количеством моносахаров (53-80), суммой сахаров (116-207 мг / г) и зимостойкостью 91%. Негативное влияние дефицита фосфора на урожайность озимой пшеницы сорта Лаертиз, может не сопровождаться симптомами недостатка данного элемента в течение вегетации.

Ключевые слова: мобильный фосфор, озимая пшеница, зимостойкость, урожайность