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PHOSPHORUS AND POTASSIUM REMOVAL ASSESSMENT IN OMITTED PLOT TRIALS WITH WHEAT AND BARLEY

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Abstract

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"Best agricultural practices for sustainable crop nutrition in Bulgaria" was the topic of an extensive research project supported by International Plant Nutrition Institute (IPNI) during the period 2009-2012. Omission plot trials (control, N, P, K, NP, NK, PK, NPK) were arranged in field, vegetable, fruit crops and wine grapes. Wheat (variety Aglika) and barley (variety Aheloy) were tested in crop rotation on four locations. The paper presents the P and K removal data under two representative for the tested crops conditions of South Bulgaria – Pomorie (Burgas region) and Sadievo (Stara Zagora region). P-removal was more influenced by the factor fertilization and for both wheat and barley was lower under conditions of balanced nutrition (NPK) – 6.0 – 7.0 kg.t^{-1} depending on the site. These lower rates were due to the higher yields obtained under balanced fertilization. K-removal was less influenced by the factor fertilization. Its value was lower for Sadievo – 15.0 kg.t^{-1} for both crops and higher for Pomorie – 17.5 kg.t^{-1} for wheat and 22.3 kg.t^{-1} for barley. The differences occurred in the K-removal values were due to the different level of the exchangeable potassium in the soil. In general both P and K-removal were more influenced by the site specificity and the climate conditions of the year than the nutrition regime.

Key words: phosphorus removal; potassium removal; wheat fertilization; barley fertilization
Abbreviations: N – nitrogen, P – phosphorus, K – potassium, NP – potassium omission, NK – phosphorus omission, PK – nitrogen omission, NPK – balanced nutrition

Introduction

Nutrients uptake is one of the major indicator for evaluation the nutrients use efficiency (Dimova et al., 2005). Its specifying helps to determine the optimal crop nutrition (Bazitov, 1998; Tomov and Manolov, 2009). The results from supervised field trials can be used for calculating, forecasting and adjusting the balance of the main nutrients in agriculture (Dimitrova and Borisova, 1984). Phosphorus and Potassium removal has been analyzed by many Bulgarian authors (Nikolova et al., 1989; Stanchev, 1990; Angelova and Hristov 2003; Tomov, 2004; Dimova et al., 2005; Ivanova et al., 2007; Tomov et al., 2008; Tomov et al., 2008; Ivanova et al., 2010; Kostadinova et al., 2010; Kostadinova and Panayotova, 2012; Koutev, 2013; Yancheva et al., 2013; Landjeva et al., 2014; Tsenov et al., 2014; Valeva and Stamenov, 2016; Nikolova et al, 2017, etc.) demonstrating that for efficient crop production is important to reduce the nutrient expense for unit crop yield. Many factors affect this parameter and for managing sustainable crop nutrition is important to have information about the influence of nutrient interaction.

The aim of the study was to follow the influence of nutrient addition and omission on the P and K removal for wheat and barley in omitted plot trials, carried out under the conditions of South-Eastern Bulgaria, depending on the crops nutrition.

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Materials and Methods

The study was conducted in 2009 – 2012 in Central and Eastern part of South Bulgaria and covered regions with typical for these crops soil and climatic conditions – Pomorie (Vertisol, with very low level of available phosphorus and very good level of exchangeable potassium) and Sadievo, Nova Zagora Municipality (Chromic Luvisols, with low level of phosphorus and good of potassium). Physical-chemical properties and soil nutrients statuse of the sites are presented in Tables 1 and 2.The tested crops were winter wheat (Aglika variety), grown after sunflower and winter barley (Aheloy variety), grown after maize. Eight different treatments with addition and omission of nitrogen, phosphorus and potassium were tested: untreated check; N; P; K; NP; NK; PK; NPK. The nitrogen was applied before the spring vegetation of the crops, while phosphorus and potassium were applied just before the main tillage. Ammonium nitrate, triple superphosphate and potassium chloride were used for the crops fertilization. Weeds, pest and disease control was conducted with proper pesticides, when needed. Harvesting was done at full maturity of the crops. Yield parameters and chemical composition of the main and secondary production were reported every season in order to determine the nutrient efficiency indicators and also P and K removal per unit area and per yield unit (grain). *ANOVA two-way analysis* (Pearson, 1895; Fisher and Ronald, 1925; Tukey, 1977) *of variance for P and K-uptake (wheat) and* their dependence on the factors fertilization and site-specific conditions was applied for the statistical data processing.

Results and Discussions

P-removal per unit wheat grain production in Pomorie was in the range from 6.2 to 7.3 kg.t^{-1} (Figure 1).

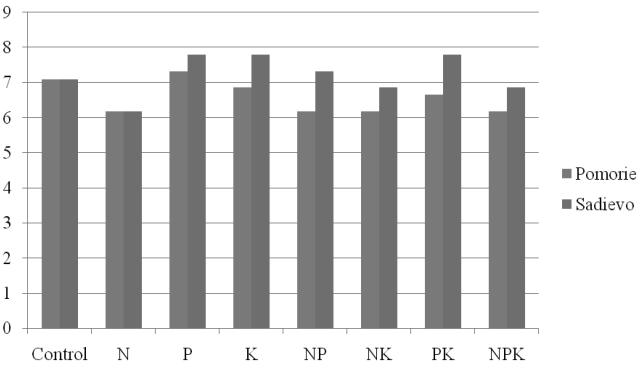

Fig. 1. Phosphorus removal for winter wheat, 2009 – 2012, kg.t^{-1}

Under balanced nutrition (NPK) and nutrition where nitrogen was applied (single addition or in combination with phosphorus or potassium), P removal with unit wheat grain was lower in comparison to the single P and K addition or N omission. Under nitrogen omission due to lower yields, P-removal per unit grain increased with 7 – 18% and reaches 7.3 kg.t^{-1}. For the winter wheat grown in Sadievo, P-removal varied from 6.2 to 7.8 kg.t^{-1} and the same trend as in Pomorie occurred – lower P-removal from the variants with higher yields (N, NP, NK and NPK) and up to 13% higher P-removal from the variants with lower yields (P, K and PK).

Table 1
Physical – chemical properties of the soil

Soil horizon and depth (cm)	Clay content (< 0.01 mm), %		Hygroscopic moisture, %		Hygroscopic moisture, %	
	Sadievo	Sadievo	Pomorie	Pomorie	Pomorie	Sadievo
A^{I} 0 - 28	56.13	56.13	1.63	2.45	2.45	2.06
A^{II} 28-50	64.70	64.70	2.21	2.03	2.03	1.63
AB 50-75	60.10	60.10	2.83	1.51	1.51	1.49
$B_к$ 75-100	61.75	61.75	1.66	0.94	0.94	1.12
$C_к$ 100-130	54.33	54.33	1.58	–	–	0.77

Table 2
Soil nutrient status of the sites

Site	Soil depth cm	pH (H_2O)	P_2O_5 mg.100g^{-1}	K_2O mg.100g^{-1}	NH_4-N mg.100g^{-1}	NO_3-N mg.100g^{-1}
Pomorie	0 - 30	6.7	2.3	33	11.8	4.70
Sadievo	0 - 30	5.9	< 2	24	16.3	14.0

Table 3
Analysis of the variance of the P uptake type III Sums of Squares

Source	Sum of squares	Df	Mean Square	F-Ratio	P-Value
Main effects					
A:Fertilization	17.0759	7	2.43941	1.89	0.0802
B:Site	40.3044	3	13.4348	10.39	0.0000
Interactions					
AB	18.6148	21	0.886417	0.69	0.8379
Residual	124.189	96	1.29363		
Total (correctedD)	200.184	127			

The recorded differences were due to the differences in the obtained yields, and the statistical analysis (Table 3) showed that the P-removal is more influenced by the factor "site" (P-value: 0.0000), while the factor "fertilization" had no influence (P-value 0.0802).

K-removal for Pomorie conditions was with rates from 16.6 to 18.1 kg.t^{-1} (Figure 2).

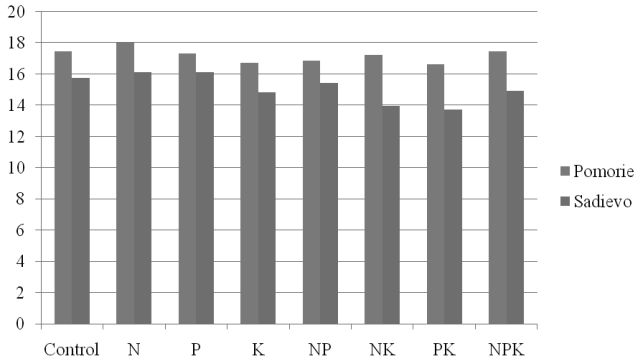

Fig. 2. Potassium removal for winter wheat, 2009 – 2012, kg.t^{-1}

The lowest level of K-removal was under nitrogen omission (PK) and higher at single N addition. In general, the K removal per unit wheat grain in Sadievo was not very changeable. K-removal for Sadievo region was significantly lower in comparison with Pomorie (13.7 to 16.1 kg.t^{-1}) due to the difference of the exchangeable potassium level in the soil, but the trend was the same – lowest K-removal under PK nutrition and highest under N nutrition.

The statistical analysis for K-removal in winter wheat (Table 4) showed the same tendency – influence from the factor "site" (P-value 0.0001) and no influence from the factor "fertilization" (P-value 0.9993).

For winter barley, P-removal was from 6.3 to 9.0 kg.t^{-1} for Pomorie and from 6.3 to 8.2 kg.t^{-1} for Sadievo (Figure 3).

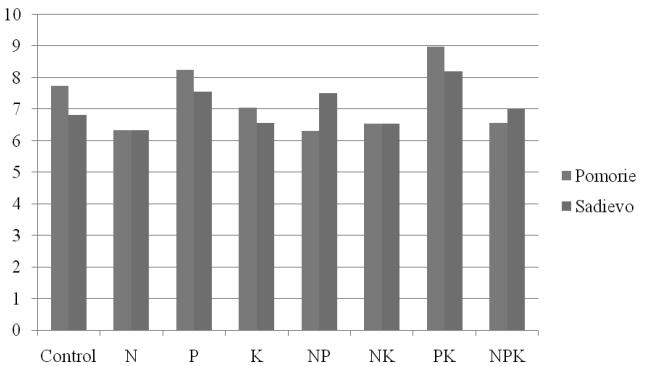

Fig. 3. Phosphorus removal in winter barley, 2009 – 2012, kg.t^{-1}

Based on the results it can be summarized that for both fields, P-removal was higher when P and K were applied single or when N was omitted from the balanced NPK combination and was above 8.0 kg.t^{-1}. Under balanced NPK fer-

Table 4
Analysis of the variance of the K uptake type III Sums of Squares

Source	Sum of squares	Df	Mean Square	F-Ratio	P-Value
Main effects					
A:Fertilization	20.1679	7	2.88113	0.08	0.9993
B:Site	923.336	3	307.779	8.05	0.0001
Interactions					
AB	117.522	21	5.5963	0.15	1.0000
Residual	3671.22	96	38.2419		
Total (correctedD)	4732.24	127			

tilization, P-removal was lower and in the range of 6.5 to 7.0 kg.t^{-1} for both locations.

K-removal for the conditions in Pomorie was from 18.0 to 22.3 kg.t^{-1} (Figure 4).

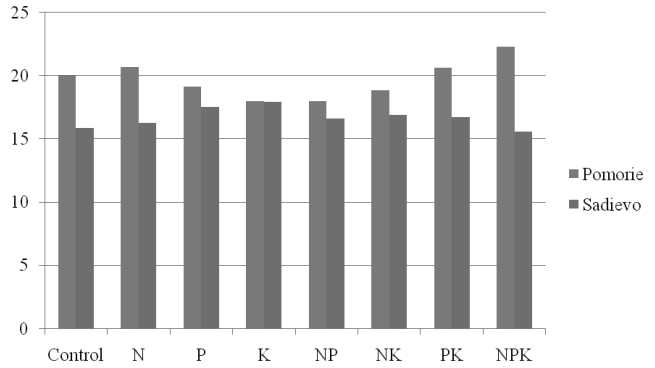

Fig. 4. Potassium removal in winter barley, 2009 – 2012, kg.t^{-1}

The highest value of K-removal was observed under balanced nutrition due to the highest yields obtained during the years, while the lowest K-removal was obtained under single potassium addition, where the yields from the four years of the study were lowest of all nutrition treatments. As for wheat, K-removal for barley was lower in Sadievo than Pomorie – 15.6 – 17.9 kg.t^{-1}. The variations between the different nutrient treatments were not significant, but enough to be summarized that K-removal was lower when Nitrogen was applied and the lowest under balanced NPK nutrition.

Conclusions

P and K-removal per unit wheat and barley yield, grown under the conditions of South-Eastern Bulgaria was more influenced by the site specifics, as well as by the yield magnitude, and less by the nutrition conditions.

Nitrogen was the main nutrient influencing P and K removals due to its higher effect on the yields.

P-removal for both wheat and barley was lower under balanced NPK combination and also under N application due to the higher yields and the so-called "dilution effect" in which the phosphorus content in the grain and straw was lower.

The variation of K-removal was slight and no influence from the factor fertilization occurred. The K-removal was influences by the site specific and was lower for Sadievo, where the exchangeable potassium in the soil was with 10 mg/100 g less than in Pomorie.

P and K fertilization demonstrated very small impact on the removal of these two nutrients. The chemical composition of the crops, esp. the grain, was less influenced by the nutrients than by the yield. Due to this fact, nitrogen influencing the yields in a greater extent was the main factor influencing the P and K removal per unit grain yield.

The P and K removal values for wheat and barley varies in a limited range on both sites and this is prerequisite for unification the data used for preparing fertilizer recommendations.

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