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RESPONSE OF SOYBEANS AND WHEAT TO PHOSPHORUS FERTILIZATION ON CALCAREOUS ALLUVIAL SOIL OF SAVA VALLEY AREA IN BOSNIA AND HERZEGOVINA

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Abstract: The stationary field experiment of increasing rates of phosphorus (P) fertilization started in spring 2011 on calcareous alluvial soil of Posavian Canton in Federation of Bosnia and Herzegovina (B&H). The level of plant available P was found to be low by previous soil tests carried on with ammonium-lactate-method (7.06 pH in 1 M KCl; 4.17% organic matter; 3.79% $CaCO_3$; 5.4 mg P_2O_5 in 100 g of soil). Five rates of P fertilizers (monoammonium phosphate: 13% N + 53 % P_2O_5) were applied as follows (kg P_2O_5 ha^{-1}): a = 75 (basic fertilization), b = 225, c = 375, d = 525 and e = 975). The experiment was conducted in four replicates (basic plot 60 m^2). Only basic fertilization was applied in the following years. Crop rotation was as follows: soybean (2011) - winter wheat (2012 + 2013). Soybean yield increased for 20% (2.11 and 2.53 t ha^{-1}, respectively) with P fertilization from 75 to 375 kg P_2O_5 ha^{-1}, whereas further increase of P rates resulted with lower yield compared to the control level. In both years significant differences of wheat yields were found only between basic and each rate of the increased P fertilization. Wheat yields of the control group were 6.21 and 6.44 t ha^{-1}, for the harvest of 2012 and 2013, respectively. P fertilization led to an increase in wheat yields up to 13% in 2012 and 15% in 2013. Mean values of wheat yields of four P treatments (b+c+d+e) were 6.92 and 7.21 t ha^{-1} for 2012 and 2013, respectively.

Key words: Soybean, winter wheat, yield, phosphorus fertilization

Bosna Hersek Sava Vadisi'ndeki Kalkerli Alüvyal Bir Topraktaki Fosfor Gübresi Uygulamalarının Soya Fasulyesi ve Buğday Üzerine Etkileri

Özet: Artan oranlarda fosfor (P) gübrelemesi ile gerçekleştirilen tarla denemelerinin yapıldığı bu çalışma, 2011 yılı bahar döneminde Bosna Hersek Federasyonu (B&H) Posavian Kantonu'ndaki kalkerli alüvyal bir toprakta başlatılmıştır. Amonyum laktat metodu kullanılarak yapılan ön toprak testleri ile bitkiler tarafından kullanılabilir fosfor miktarının düşük olduğu belirlenmiştir. Fosfor gübrelemesi (monoamonyum fosfat: 13% N + 53 % P_2O_5) a= 75 (temel gübreleme), b= 225, c= 375, d= 525 ve e= 975 kilogram olacak şekilde hektar başına P_2O_5 cinsinden gerçekleştirilmiştir. Deneyler 4 tekrar olarak yürütülmüştür (temel parsel yüzey alanı 60 m^2). Takip eden yıllarda yalnızca temel gübreleme işlemine devam edilmiştir. Ürün döngüsü 2011 yılında soya fasülyesi, 2012 ve 2013 yıllarında da kışlık buğday olarak uygulanmıştır. Soya fasülyesi ürün verimi, 75 kg'dan 375 kg'a çıkarılan gübreleme sonucunda %20'lik bir artış gösterirken (hektar başına 2.11 ve 2.53 ton) gübreleme miktarının daha da arttırılması sonucunda kontrol grubuna gore daha az ürün verimi elde edilmiştir. Kışlık buğday ekimi yapılan her iki yılda da sadece temel ve artan gübreleme grupları arasında anlamlı bir ürün farklılığı olduğu tespit edilmiştir. Kontrol grubunun ürün düzeyi 2012 ve 2013 yılları için hektar başına sırasıyla 6.21 ve 6.44 ton olarak hesaplanmıştır. Fosfor gübrelemesi ile buğday veriminde 2012 yılı için %13, 2013 yılı için ise %15'lik bir artış elde edilmiştir. Dört fosfor uygulaması (b+c+d+e) için ortalama buğday verimi 2012 ve 2013 yılları için hektar başına 6.92 ve 7.21 ton olarak belirlenmiştir.

Anahtar kelimeler: Soya fasülyesi, kışlık buğday, verim, fosfor gübrelemesi.

Introduction

Low levels of plant available phosphorus (P) is a limiting factor on soil fertility worldwide. Soils of Bosnia and Herzegovina (B&H) are mainly low supplied with plant available P (Markovic and Supic 2003; Marković et al. 2006, 2008). Although bound P is quite abundant in many soils, it is largely unavailable for plants uptake thus making P the most limiting element for plant growth and development (Vance et al. 2003). P is a major plant essential nutrient which cannot be replaced by another element to sustain plant life and phosphorus fertilization is an important component for high yield achievement (Lott et al. 2011.). P deficiency can affect wheat yield by reducing the number of ears per area due to a poor tiller emergence (Rodriguez et al. 1999).

Application of higher P rates by fertilization is a possible solution to increase field crop yields on Pdeficient soils of B&H (Komljenović et al. 2006, 2008, 2010, 2013; Jovic et al. 2013). The aim of this study was to evaluate effects of P fertilization on grain yields of soybean and winter wheat yields.

Materials and Methods

The stationary field experiment of increasing rates of phosphorus fertilization started in spring 2011 on calcareous alluvial soil of Posavina Canton in Federation of Bosnia and Herzegovina (B&H). Previous soil tests revealed low levels of plant available P as determined by ammonium-lactate-method (7.06 pH in 1 M KCl; 4.17% organic matter; 3.79% $CaCO_3$; 5.4 mg P_2O_5 in 100 g of soil). Five different rates of P fertilizer (monoammonium phosphate: 13% N + 53% P_2O_5) were applied as follows (kg P_2O_5 ha^{-1}): a = 75 (basic fertilization), b = 225, c = 375, d = 525 and e = 975. The experiment was conducted in four replicates (basic plot 60 m^2). In the following years only basic fertilization was applied. Crop rotation was as follows: soybean (2011) - winter wheat (2012 + 2013). Details of materials and methods, soil characteristics and weather characteristics for the first two years of the experiment were given in previous studies (Antunovic et al. 2012; Rastija et al. 2014).

Results and Discussion

The increasing use of P fertilization from 75 to 375 kg P_2O_5 ha^{-1} led to an 20% (2.11 and 2.53 t ha^{-1}, respectively) increase in soybean yield but further increase of P use resulted in lower yield as compared to the control group. In 2012 and 2013, significant differences between wheat yields were found only between basic and each rate of increased P fertilization. Wheat yields were 6.21 and 6.44 t $ha^{-1}$for the control group and for the harvest of 2012 and 2013, respectively. As a result of P fertilization, wheat increased to 13% in 2012 and 15% in 2013. The mean wheat yield value of four P treatments (b+c+d+e) were 6.92 and 7.21 t ha^{-1}, for 2012 and 2013, respectively. Increases seen in grain yield of wheat due to P fertilization were closely related with increases of ear numbers per unit of area. Ear numbers per unit ranged from 756 to 952 in 2012 and from 450 to 570 in 2013 (Table 1).

The growing season 2011 was less favorable not only for soybeans but also for most of the spring crops. For example, precipitation quantity in August (Gradiste: about 20 km distance from the experimental site) was only 4 mm and it was accompanied with a mean air–temperature of 23.4 °C. Also, during the 5–month period from May to September, precipitation quantity was 189 mm or 45% lower and air–temperature was 2.6 °C higher compared to the long-term average (Antunovic et al. 2012). Under drought stress conditions of 2011 grain yield of soybean in B&H was 1.90 t ha^{-1} and was 13% lower compared to relatively normal weather conditions of the growing season in 2009 (FAO 2014).

Table 1. Response of soybeans and winter wheat to ameliorative phosphorus fertilization

Fertilization in spring of 2011 (P_2O_5 kg ha^{-1})	Grain yield (t ha^{-1}) and number of ears per m^2 of area				
	Soybeans 2011*	Winter wheat 2011/2012**		Winter wheat 2012/2013	
	Yield t ha^{-1}	Yield t ha^{-1}	Ears per square m	Yield t ha^{-1}	Ears per square m
75	2.11	6.21	756	6.44	450
225	2.45	6.90	795	7.05	499
375	2.53	6.81	831	7.06	522
525	2.36	6.94	840	7.41	563
975	2.37	7.04	952	7.32	570
$LSD_{0.05}$	0.24	0.54	116	0.51	39
Average	2.36	6.78	835	7.06	521
Yield increase: P effect	+19.9%	+13.4%		+15.1%	

*Antunovic et al. 2012; ** Rastija et al. 2014

The beginning of growing season during early growth was characterized with drought in 2011/2012, followed by a dry and warm March, mild December and January and a very cold February. Total precipitation from October to June was 389 mm or about 20% less than the 30-years mean, while the mean air temperature was slightly higher (Rastija et al. 2014).

The next growing season of winter wheat was characterized by oversupplies of precipitation in winter period and lower precipitation in the last three months, particularly in June. When the temperature values of November, January and April were compared with the 30-years (1961-1990) average based on the data for eight sites of Pannonian region of Croatia, it appeared that the temperature in these three mounts was higher than the average by 3.7 °C, 2.5 °C 2.0 °C, respectively. However, in spite of considerable differences in weather characteristics, response of wheat to P fertilization was similar in both growing seasons (Table 1).

Conclusions

Soybean yield was increased for 20% in 2011, whereas wheat yields were increased up to 13% in 2012 and 15% in 2013. Also, increased wheat yields are mainly a result of high ears density obtained by the fertilization treatments. When soybean and wheat yields are compared individually no significant difference was seen between different P fertilization rates, most probably as a result of less favorable weather conditions during growing seasons. In next years we are expecting residual effects of ameliorative fertilization on the field crops in crop rotation.

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