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The Effects of Weed-Crop Competition on Nutrient Uptake as Affected by Crop Rotation and Fertilizers

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Abstract: A field study at the Agricultural University of Timiriazev, Moscow, was conducted to determine the effect of crop rotation and Long-term fertilizer application on differences in the competitive ability of spring barley and weeds to nutrient uptake in 2004 and 2005. Spring barley was cultivated in continuous and in crop rotation with winter rye, potato, clover, flax and fallow, with and without NPK application since 1912. Spring barley, especially in no fertilizer plots grown in crop rotation has greater dry mass than spring barley grown in continuous. While dry weed mass markedly decreased in crop rotation. Decrease dry weeds mass was greater when NPK had applied. The statistical analyses show that when spring barley grew in competition with weeds in the no fertilizer plots, crop rotation significantly increased nutrient content in spring barley, but when fertilizer applied the content of N, P_2O_5 and K_2O in barley did not change. Lowest weeds nutrient content observed where soil fertility was increased by crop rotation and NPK application. Crop rotation significantly increased total nutrient uptake of soils by spring barley, but decreased total nutrient uptake by weeds.

Key words: Spring barley (*Hordeum vulgare* L.), crop rotation, fertilizers, weed, nutrient uptake

INTRODUCTION

Managing crop rotation and fertilizers in cropping systems are important components of integrated weed management programs. In fact, crop rotation is an effective practice for controlling serious weeds, because it affects weed growth and reproduction negatively and as a result reduces dry weed mass (Tulikov and Sugrabov, 1984; Derksen *et al.*, 1993; Blackshaw *et al.*, 1994). Tulikov and Sugrabov (1984) found that crop rotation decrease dry weed mass 3-4 times. Riedell *et al.* (1998) found that corn grown in annual rotation with soybean has greater mineral nutrient content and higher yields than corn grown in continuous.

Information on responses of weeds to various soil fertility levels is required to develop fertilizer management strategies as components of integrated weed management programs. Many studies have shown that fertilizers benefit for weeds more than crops and following the fertilizers application increase weed competitive ability (Alkamper, 1976; Ampong-Nyarko and De Datta, 1993; Patro *et al.*, 1999; Burgos *et al.*, 2006). Burgos *et al.* (2006) shown that rice and weedy rice produced equivalent shoot dry mass when no fertilizer N was added, but weedy rice accumulated more dry mass than rice upon addition of N fertilizer. In the other hand, studies have shown that in low fertility soils weeds were more competitive than crops (Santos *et al.*, 1998; Davis and Liebman, 2001).

In addition of dry mass, fertilizer application affects nutrient uptake by weeds and crops in agrophytocoenoses. Nitrogen uptake efficiency in crops can range from 10 to as high as 80% depending on how the N fertilizer is managed (Ampong-Nyarko and De Datta, 1993; Riedell *et al.*, 1998; Fritschi *et al.*, 2004; Hunt *et al.*, 2004). Ponce and Santín (2003) found that the weed barnyard-grass (*Echinochloa crus-galli*) competes for nitrogen (N) with tomato and pepper crops. Competition was greater in both crops the earlier the weed emerged or the longer it grew with the crops. This competition affected growth attributes, fruit yield and its components and N uptake in both crops. Davis and Liebman (2001) found that in low fertility soils weeds use N more efficiently in compare with crops. Also, at high N application rates, N uptake by weeds is higher than that by crops (Ampong-Nyarko and De Datta, 1993). In continuous crop, weeds which had high dry mass production at high N application rates, were most competitive at low N and thus had least sensitivity to low applied N. Blackshaw *et al.* (2003) shown that shoot and root growth of all weeds increased with added N, but the

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magnitude of the response varied greatly among weed species. Many weeds exhibited similar or greater responses in shoot and root dry mass to increasing amounts of soil N, compared with wheat or canola. Andreasen *et al.* (2006) reported that N and P uptake did not differ much between weeds and barley. They found that weeds grew poorly in competition with barley. The N and P content in barley did not change when they grew in competition with weeds. Ugen *et al.* (2002) found that when N and P were applied, bean nutrient uptake and growth decreased in compare with weed, but the relative competitiveness of bean increased with K application.

This study was performed to compare competitive ability of spring barley and weeds and nutrient uptake in agrophytocoenoses under crop rotation and fertilizer application.

MATERIALS AND METHODS

The research was conducted during 2004 and 2005 at the long-term experimental farm of the Department of Agronomy and Experimental Methods, Agricultural University of Timiriazev, Moscow. Spring barley was cultivated in continuous and in crop rotation with winter rye, potato, barley, clover, flax and fallow, with and without NPK application since 1912. The fertilizers were broadcast before planting at 100 kg N ha^{-1} as ammonium nitrate, 150 kg P_2O_5 ha^{-1} as triple super phosphate and 120 kg K ha^{-1} as potassium chloride. At the wax maturity stage, weeds were cut at ground level in three permanent quadrates measuring 50×50 cm and oven dried at 105°C and weighted. The dried powdered material was analyzed for nitrogen, phosphorus and potassium content. Nitrogen content was estimated by the micro-kjeldahl method, phosphorus by colorimetry using the chloro-stannous reduced molybdo-phosphoric acid blue color method in a sulphuric acid system and potassium by flame photometry. The obtained data were statistically analyzed using SPSS software (SPSS Inc., 1998).

RESULTS AND DISCUSSION

The primary objective of this study was to investigate competition between spring barley and weeds as affected by crop rotation and fertilizer application, therefore, it was important to compare the dry mass production of spring barley and weeds in agrophytoceonoses. Spring barley grown in crop rotation has greater dry mass than spring barley grown in continuous (Table 1). The obtained data show that in no fertilizer plots dry mass of spring barley was 6.7 times greater when grown in crop rotation compared with the continuous. This increase in NPK application plots was lower. This show that crop rotation improves soil fertility and thus reduces necessary to fertilizer application (Riedell *et al.*, 1998; Marenco and Santos, 1999; Hennessy, 2006).

Table 1: Dry mass production (kg ha^{-1}) responses of spring barley and weeds to crop rotation and fertilizer application in Moscow (2004-2005)

	Continuous		Rotation	
	Barley	Weeds	Barley	Weeds
No fertilizer	640.5	1205.0	4220.0	849.5
NPK	4289.0	1796.0	5696.0	448.5

Table 2: Nutrient content (%) of spring barley and weeds as affected by crop rotation and fertilizer application in Moscow (2004-2005)

	Continuous			Rotation		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Barley						
No fertilizer	0.81	0.36	0.99	0.95	0.41	1.02
NPK	1.21	0.36	1.02	1.02	0.37	0.98
Weeds						
No fertilizer	0.73	0.45	2.79	0.96	0.52	3.08
NPK	1.14	0.44	2.61	0.96	0.44	2.40

The results also indicate that crop rotation markedly decrease dry weed mass. Reduction of dry weed mass was greater when NPK had applied. The results also show that fertilizer application differentially promoting competition ability of spring barley more than weeds. Another possibility is that crop rotation decrease weeds density (Tulikov and Sugrobov, 1984; Liebman, 1989; Mohammaddoust *et al.*, 2006). In the continuous cropping system, fertilizer application increased dry weed mass, but in the crop rotation the dry weed mass in plots with NPK was lower than in no fertilizer plots. This probability may be due to greater competition of spring barley result fertilizer application. Studies shown that in low fertile soils weeds were more competitive than crops (Santos *et al.*, 1998; Davis and Liebman, 2001). Results show that spring barley for obtain maximum growth and successfully control of weeds needs to grew in rotation with another crops and to apply 100 kg N ha^{-1} as ammonium nitrate, 150 kg P_2O_5 ha^{-1} as triple super phosphate and 120 kg K ha^{-1} as potassium chloride.

Statistical analysis show that when spring barley grow in competition with weeds in no fertilizer plots, crop rotation significantly increases nutrient content of spring barley, while when fertilizer is applied, the N, P_2O_5 and K_2O content in the barley does not change (Table 2).

The weed nutrient content was greater in no fertilizer plots when barley grown in crop rotation (Table 2). Lowest weed nutrient content observed where soil fertility is increased (crop rotation plus NPK application). The analysis of nutrient content also support that competitive ability of spring barley with weeds is highest when grew in crop rotation and apply NPK fertilizer.

Table 3: Nutrient uptake (kg ha^{-1}) by spring barley and weeds as affected by crop rotation and fertilizer application in Moscow (2004-2005)

	Barley			Weeds			Total			
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total NPK uptake
Continuous										
No fertilizer	5.2	2.2	6.3	8.8	5.4	33.5	18.4	7.6	38.3	64.3
NPK	51.9	15.2	43.0	20.5	7.9	21.9	46.8	18.9	71.0	136.7
Rotation										
No fertilizer	40.8	17.6	43.8	8.2	4.4	26.5	42.8	18.5	49.3	110.6
NPK	58.1	21.1	55.8	4.3	2.0	10.8	62.4	23.1	99.0	184.5

The data show that nutrient uptake by spring barley in crop rotation compared with continuous cropping system significantly increased (Table 3). In plots with no fertilizer, N, P_2O_5 and K_2O uptake by crop in crop rotation was 8, 8 and 7 times greater than continuous, respectively.

Fertilizer application also significantly increased nutrient uptake by spring barley. In the continuous crop, P_2O_5 and K_2O uptake in plots with NPK application was 7 times greater than no fertilizer plots that equal with increase accumulation of dry mass result to NPK application (Table 1). In the crop rotation N uptake in the plots with NPK application was 10 times higher than the plots with no fertilizer.

This result was duo to not only increase dry mass, but also due to by greater N content in spring barley.

The data of Table 3 shows that nutrient uptake of soil by weeds significantly reduced in crop rotation compared with continuous. Reduction nutrient uptake of soil by weeds was greater when NPK was applied. Overall, total NPK uptake by spring barley and weeds was 64.3-184.5 kg ha^{-1} that in continuous crop and no fertilizer plots, weeds uptake 74% of total NPK. This was 36.8% when NPK was applied. In crop rotation, total NPK uptake by weeds reduced, so in the no fertilizer plots the portion of weeds from total NPK uptake was 35% and in the NPK plots was only 9%. Study findings suggest that crop rotation and NPK application results in suppressed weed growth, not by reduced nutrient uptake by weeds but instead by greater nutrient uptake by spring barley that increases its competitiveness with weeds.

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