10.7251/AGSY1303114P

AGRONOMIC EFFICIENCY OF FERTILIZATION AT DURUM WHEAT UNDER CONTRAST CLIMATE CONDITIONES

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Abstract

The agronomic efficiency for nitrogen and phosphorus fertilization at durum wheat varieties „Progress” was studied in a long-term fertilizing experiment in Institute of field crops – Chirpan, Bulgaria. The investigation was established in two field crops rotation cotton – durum wheat under rain conditions for the period 2005 – 2011. The studied fertilizing systems were: single nitrogen (N) and single phosphorus (P_2O_5) fertilization in rates 0; 40; 80; 120 and 160 kg N or P_2O_5 per hectare, and combined nitrogen-phosphorus fertilization in rates: 1). $N_{80}P_{80}$; $N_{120}P_{80}$; $N_{160}P_{80}$; 2). $N_{80}P_{120}$; $N_{120}P_{120}$; $N_{160}P_{120}$; 3). $N_{80}P_{160}$; $N_{120}P_{160}$; $N_{160}P_{160}$. Nitrogen fertilization in the form of NH_4NO_3 was applied before sowing (1/3 of the rate) and at early spring (2/3 of the rate). The phosphorus fertilization was done before sowing in the form of triple superphosphate. According hydrothermal conditions during the wheat vegetation three of the experimental years (2005, 2007 and 2009) were classified as dry and hot. The hydrothermal conditions of the three other experimental years were close to the long term average norms of temperature and rainfall for the region.
It was established that climate conditions during the growing season were the key determinant factor for the agronomic efficiency for nitrogen in wheat. Maximum value of 27.6 kg grain kg N^{-1} was obtained when nitrogen N_{80} was combined with P_{80}. Agronomic efficiency for phosphorus was significantly lower than AE_N. Appling of phosphorus alone in rates higher than 80 kg P_2O_5 ha^{-1} was inefficient at durum wheat, apart from the low content of available phosphates in the soil.
Key words: agronomic efficiency, fertilizing, durum wheat

Introduction

Agriculture is among the sectors most directly exposed to climate variability and change, with consequences for food production and food security (Fuhrer, 2006). Because agricultural systems are often constrained by either temperature or precipitation, their sensitivity depends on the conditions under which they operate today. If a system operates near its optimum, any deviation from the ‘norm’ will limit growth and yield (Gregory and Ingram, 2008). Nitrogen and phosphorus fertilization plays a central role for improving yield in wheat and these two nutrients represent a significant cost of production for the grower (Batten, 1992; Delogua et al., 1998). They may also have environmental impacts through nitrate leaching, use of fossil fuels for manufacture and application, N_2O emissions associated with denitrification and high N and P use efficiency is desired to protect ground and surface waters (Foulkes et al., 2009**)**. Nitrogen and phosphorus are the most crucial nutrients which affect the assimilate production and distribution and affecting directly or indirectly the grain yields (Arduini et al., 2006). Nitrogen can influence the leaf area development and maintenance as well as photosynthetic efficiency and dry matter partitioning to reproductive organs (Gastal and Lemaire, 2002). In

addition, P affects the grain number and yield of wheat (Elliot et al., 1997) and diminishes biomass accumulation in a different fashion than N (Batten, 1992).
The relationship between grain yields and fertilizing rates usually are discussed as yield efficiency or agronomic efficiency. This relationship represents the yields increased per unit of applied nitrogen or other nutrients (Below, 1995; Pervaoz, 2004). There are many factors that can affect the grain yields and efficiency of nutrients of durum wheat including genotype, temperature, rainfall and fertilization (Borras et al., 2007; Miralles and Slafer, 2007). From all of them, the year conditions and fertilizing levels are usually the most important for determining of the agronomic efficiency (Delogua, 1998).

The aim of this study was to analyze the effects of different N and P fertilizer rates and their interaction on the agronomical efficiency of durum wheat grown under contrast hydrothermal conditions.

Materials and methods

A fertilizing experiment with durum wheat variety Progress were conducted under field conditions during 2005 - 2010 growing seasons at the Institute of Field Crops - Chirpan on a eutric vertisols (FAO). The studied fertilizing systems were single nitrogen (N) and phosphorus (P_2O_5) rates 0; 40; 80; 120 and 160 kg ha^{-1}, and combined nitrogen-phosphorus fertilization in rates: 1). $N_{80}P_{80}$; $N_{120}P_{80}$; $N_{160}P_{80}$; 2). $N_{80}P_{120}$; $N_{120}P_{120}$; $N_{160}P_{120}$; 3). $N_{80}P_{160}$; $N_{120}P_{160}$; $N_{160}P_{160}$. The used fertilizers were ammonium nitrate and triple superphosphate. In the present study were used data of two contrast parts of growing seasons According hydrothermal conditions two years (2007 and 2009) were classified as dry and hot. The other two years (2009 and 2010) were characterized with hydrothermal conditions close to the 23-year average of temperature andrainfall. The agronomic efficiency was determined as the ratio (YF – YC)/FR, where: YF is grain yield at given fertilizing rate, YC is grain yield without N and/or P fertilization, and FR is the fertilizing rate (Guarda et al., 2004).

Results and discussion

The obtained results show that agronomic efficiency was decreased with increasing of the nitrogen or phosphorus rates (Table 1). One kilogram applied nitrogen under favourable hydrothermal conditions was increased the durum wheat yields by 25.8 – 14.8 kg grain.

Table 1. Agronomic efficiency of nitrogen (AE_N) and phosphorus (AE_P) at durum wheat in dependence of the climate conditions

AE_N			AE_P		
Year / N rate	Favourable	Unfavourable	Year / P rate	Favourable	Unfavourable
N_{40}	25.8	9.0	P_{40}	2.8	7.3
N_{80}	20.4	6.8	P_{80}	2.5	3.8
N_{120}	19.5	7.8	P_{120}	1.0	-
N_{160}	14.8	2.9	P_{160}	-	-
Average	*20.1*	*6.6*	*Average*	*2.1*	*5.6*

In years with unfavourable conditions average AE_N at durum wheat was 3-fold slower, than AE_N in favourable years. The obtained additional grain yield per kilogram fertilized nitrogen was varied from 9 kg at rate N_{40} to 2.9 kg at rate N_{160}, and then high nitrogen fertilization had very little effect on the grain yields.

Table 2. Agronomic efficiency of nitrogen at durum wheat under different phosphorus fertilization and climate conditions

Fertilization	Favourable			Unfavourable		
	P_{80}	P_{120}	P_{160}	P_{80}	P_{120}	P_{160}
N_{80}	27.6	19.9	25.9	7.7	12.0	11.4
N_{120}	17.8	22.2	21.8	7.0	8.3	7.3
N_{160}	11.8	16.2	16.2	4.1	1.8	2.6
Average	*19.1*	*19.4*	*21.3*	*6.3*	*7.4*	*7.1*

Agronomic efficiency of P (AE_P) was significantly lower than AE_N. Its values under unfavourable conditions were higher at rates P_{40} and P_{80}. Appling phosphorus alone in rates higher than 80 kg P_2O_5 ha^{-1} was inefficient at durum wheat, apart from the low content of available phosphates in the soil.

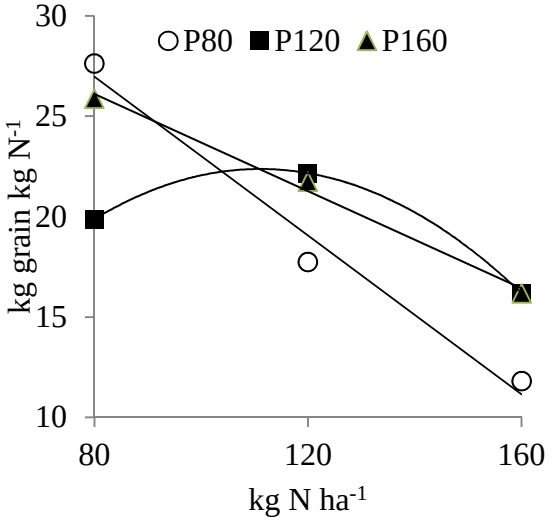

Figure 1. Agronomical efficiency of N (AE_N) at different P fertilization under favourable hydrothermal conditions

Climate conditions during the growing season were the main determinative factor for the agronomic efficiency of applied nitrogen (Table 2). Its effect on the AE_N was similar to the effect of alone nitrogen fertilization. Combination N and P fertilization resulted in week effect on the grain productivity of one kilogram nitrogen. Under favourable conditions among NP rate, maximum AE_N were obtained when N_{80} was applied in combination with P_{80}. Infavourable climate conditions reduced obtained maximum AE_N at durum wheat from 27.6 to 12.0 kg grain per kg applied N.

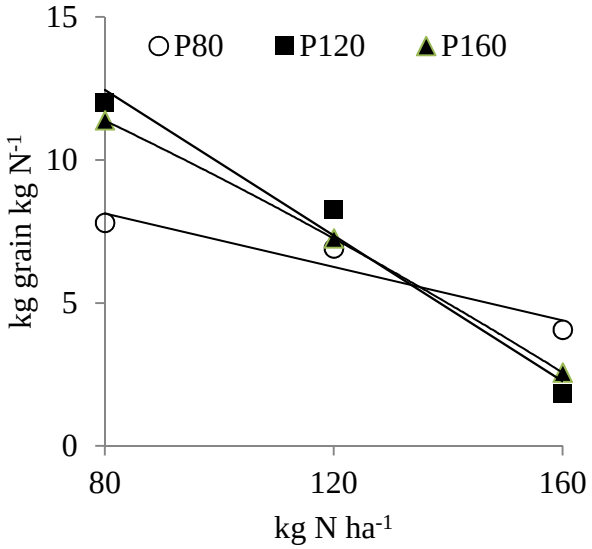

Figure 2. Agronomical efficiency of N (AE_N) at different P fertilization under unfavourable hydrothermal conditions

Agronomic efficiency of nitrogen showed negative relationship with increase in N rates, independently of the applied phosphorus (Fig. 1 and 2). It was observed exception of this relationship when N rates were combined only with 120 kg P_2O_5 ha^{-1}.

Conclusion

Climate conditions during the growing season were the main determinative factor for the agronomic efficiency of applied nitrogen in durum wheat. Maximum AE_N 27.6 kg grain/kg N were obtained when fertilizing rate N_{80} was applied in combination with P_{80}.
Agronomic efficiency of P (AE_P) was significantly smaller than AE_N. Appling of phosphorus alone with rates higher than 80 kg P_2O_5/ha was inefficient at durum wheat, apart from the low content of available phosphates in the soil.

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