EFFECTS OF FERTILIZATION ON SOME QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF WINTER WHEAT IN GREAT CUMANIA

Ágnes CZIMBALMOS – János JÓVÉR – József ZSEMBELI

Karcag Research Institute of University of Debrecen, H-5300 Karcag, Kisújszállási út 166.
czagnes@agr.unideb.hu, jover@agr.unideb.hu, zsembeli@agr.unideb.hu

Abstract

Due to the drastically increasing food prices during the last few years in Europe and also in Hungary, good and medium quality winter wheat varieties produced at low costs with high yield potential came to the front. Although food overproduction is characteristic to one part, while shortage of food to the other part of the world, the newest tendencies show an increasing role of the production and consumption of high quality food that can be produced only from high quality raw materials. When a new variety is certified, the qualitative parameters are more and more important beyond the quantitative ones. Several programmes were started to breed and produce winter wheat varieties with excellent qualitative parameters including the determination of the adequate, variety- and habitat specific agro-techniques and plant nutrition. In Karcag Research Institute plant breeding and long-term fertilization experiments have been carried out separately from one another for several decades. In the vegetation period of 2012/2013 a new series of experiments was started that includes the determination of the fertilizer doses optimal for our high quality winter wheat varieties with high yield potential. The determination of the adequate and optimal fertilizer doses are essential not only from economic point of view and lower environmental loads, but also for the most effective utilization of the genetic potential of our winter wheat varieties without the degradation of the qualitative parameters. After the assessment of the data we established that extreme high doses of fertilizers are needed for the spectacular improvement of the parameters we examined. As the financial possibilities of farmers are limited, the fertilizer cost is a determining factor: they have to consider if the yield or the quality of a given variety can be increased at an affordable fertilizer input. Our goal is to determine the often empiric hence not so accurate fertilizer doses more precisely providing the producers a proper production technology and plant nutrition recipe adequate to the varieties bred by us. Due to the complexity of this topic high number of further examinations is required.

Keywords: winter wheat, fertilization, yield, Falling Number, Zeleny Sedimentation Value

Introduction

The region of Great Cumania is of great importance from the point of view of high quality winter wheat production in Hungary. The main goal of our investigations is to determine how to produce winter wheat varieties bred for the extreme agroecological conditions of the region providing such quantitative and qualitative parameters that make them attractive to the farmers. We used conventional agro-techniques but variety-specific fertilizer doses in our experiment.

One of the most cardinal elements of wheat production is the seeds, as not only their quantity but the quality is very important, therefore seeds must be produced at the highest level as possible (Jolánkai et al., 2006). The main goal of seed production is to gain high quality seeds demanded by the market economically. This goal must be in harmony with the purpose of the actual plant breeding research (Klupács and Tarnawa, 2007).

According to Peterson at al. (1998) environmental factors have significant effect on the quality of winter wheat, but the wheats with different genotypes have different reaction to the environmental effects. The conditions of wheat growing are considerably determined by the soil and climatic features. The effects of these features are cannot or hardly be influenced, even they basically determine the aim of the production, the species and variety of the plant to be produced, the applicable agrotechnical operations and the economy of the activity (Jolánkai et al., 2004).

At the recent level of agriculture plant nutrition (mainly provided in the form of artificial

fertilizers) is of great importance for winter wheat (Ragasits et al., 2000). Wheat is a nutrient-demanding plant with good nutrient reaction. The biggest problem of wheat nutrition (mainly with nitrogen) is the fact that the optimal interval of nutrient supply is narrower compared to other plants, therefore over- or underdosage can happen very easily.

The nutrient demand of wheat is considered similar by wheat growing experts, 25-30 kg N, 10-15 kg P_2O_5 és 15-20 kg K_2O substances are needed for 1 t of grain yield and the accompanying straw and roots as an average (Pepó, 2009).

Not only the detailed examination of species specific-, but variety specific fertilizer reaction is also important, as the N-demand and nutrient reaction of wheat varieties with different genotypes are significantly different (Pepó, 2001).

It is well known from the national and international literature that different doses and rates of nutrients are needed for the optimal plant nutrition at different habitats, hence the importance of differentiated, habitat-specific nutrition is emphasized by several experts (Debreczeniné and Ragasits, 1996).

Materials and methods

The indicator crop was Hunor, a winter wheat variety bred in Karcag Research Institute. It was registered in 1996, but it is still very popular among wheat growers due to its morphologic and agrotechnical features.

It is a waxy variety with medium maturity and short-medium height. It has excellent stem stability, winter- and drought tolerance. It has good fertilizer reaction and yield capacity with Harvest-index of 45-46%. Its Farinograph value is A2 - B1. It has medium sensitivity for most of the well-known diseases of winter wheat.

A small-plot field trial with 4 replications was set on a meadow chernozem soil in the territory of Karcag Research Institute using the data base of the National Long-term Fertilization Experiments and the data of production year of 2012/2013 (Table 1.).

More than 15 quantitative and qualitative parameters were examined during the investigation, among them yield, plant height, thousand grain weight (TGW), hectoliter test weight, Zeleny-index and the falling number are analyzed in this paper.

Table 1. The investigated treatments of the experiment

Treatments (kg ha^{-1})	N_0	N_{50}	N_{100}	N_{150}	N_{200}
P0	x	x	x	x	x
P50		x	x	x	x
P100		x	x	x	x
P150			x	x	x
P200			x	x	x

Methods applied to determine the parameters: quantitative parameters (yield, plant height, TGW, hectoliter test weight) were simply measured by means of a grain counter and a HL-balance. For the flour quality examinations the Zeleny-index was determined according to the relevant Hungarian standard (MSZ ISO 5529:1993). The falling number was determined by means of a Perten system.

The results gained from the experiment were processed by means of Microsoft Excel spreadsheet application and assessed according to Sváb (1973).

Results and discussion

The basic meteorological data of the investigated growing season (2012/2013) are summarized in Table 2.

According to Bocz et al. (1992) the water demand of winter wheat in winter is 140-150 mm, while its total water demand is 400-450 mm. Birkás and Gyuricza (2001) quantified 280-340 mm water that is needed in the period from March to July for winter wheat.

On the base of these data it can be said that the investigated period was sufficient from the point of view of water supply with its 496.7 mm

total amount of precipitation, of which 135.1 mm fell in winter and 302.3 mm in the period from March to July.

The yields have linearly increased parallel to the increase of the fertilizer doses, both in the cases of nitrogen and phosphorus. At the level of 50 kg ha^{-1} P-dose a slight decrease of yield was experienced compared to the plots not treated with P, but this difference was not significant (Fig. 1.).

The effect of fertilization on TGW was less considerable than in the case of yield. Ragasits (2001) had similar experiences on a Ramann type brown forest soil in Keszthely. The increase of TGW due to the higher doses of fertilization is so small that it hardly exceeds the SD level (Fig. 2.).

The highest value was measured at 200 kg ha^{-1} nitrogen and 0 kg ha^{-1} phosphorus level. Nevertheless it can be established that the increasing P-doses resulted in the decrease of TGW – significant difference could be figured out between the plots at P_0-N_{200} level.

Assessing the plant height data, it can be established that the higher fertilizer doses

Table 2. The basic meteorological data of the investigated growing season

	Oct. 2012.	Nov. 2012.	Dec. 2012.	Jan. 2013.	Febr. 2013.	Mar. 2013.	Apr. 2013.	May 2013.	June 2013
Avg.temp. (°C)	11.8	6.9	-0.7	-0.3	2.6	3.8	12.8	17.3	20.4
Precipitation (mm)	40.6	18.7	41.6	42.5	51.0	110.2	47.3	81.9	62.9

Source: Karcag Research Institute of University of Debrecen

Figure 1. Grain yields in the function of N and P fertilization

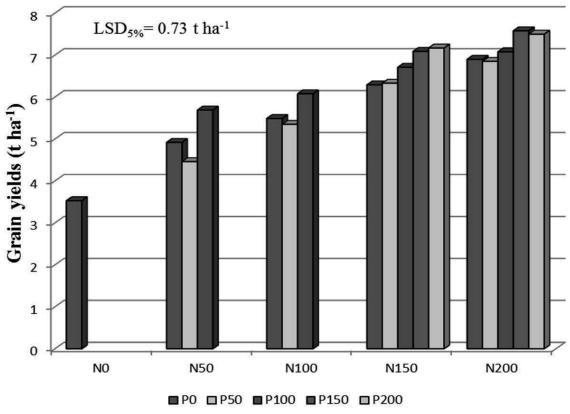


Figure 2. Thousand grain weights in the function of N and P fertilization

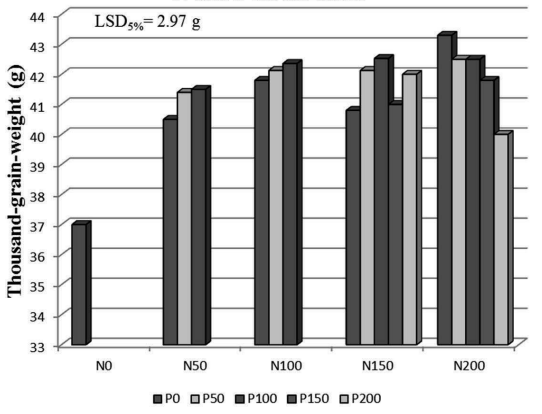


Figure 3. Plant height in the functionof N and P fertilization

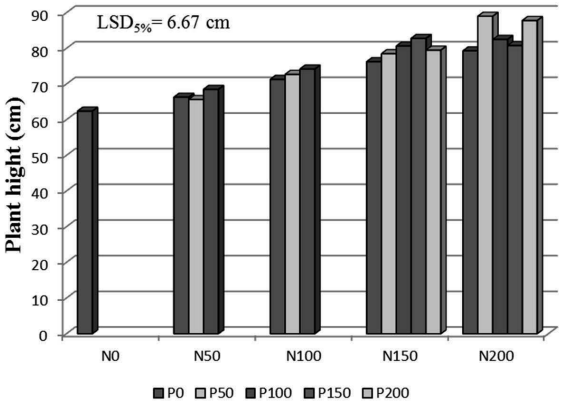


Figure 4. Test weights in the functionof N and P fertilization

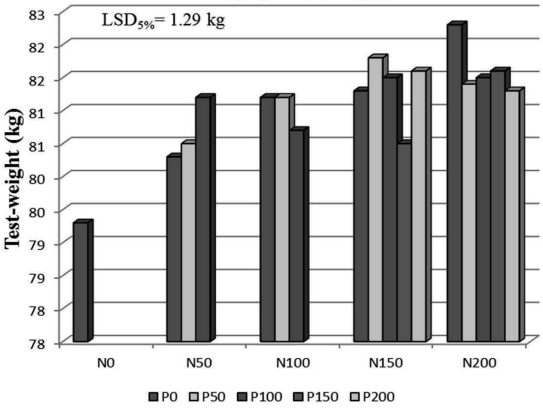


Figure 5. Zeleny value in the function

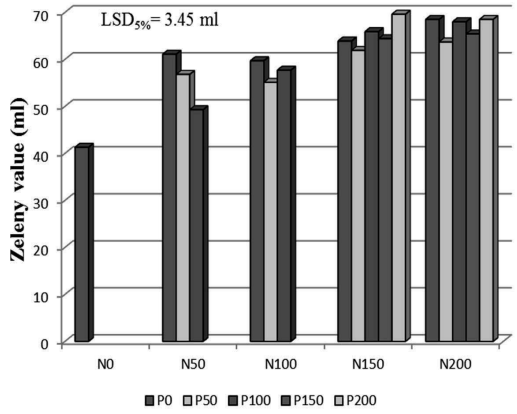
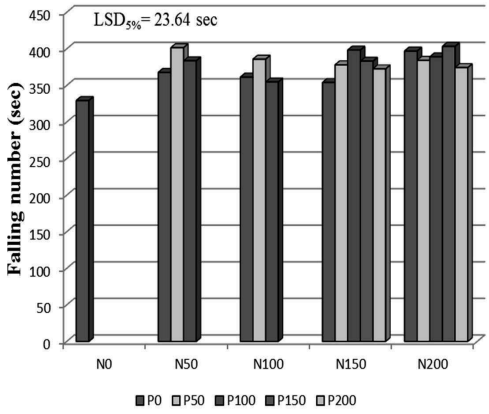


Figure 6. Falling number in the function of N and P fertilization



resulted in significantly higher plant height. The tallest plants were almost 50% taller than the shortest ones (Fig. 3.). Nevertheless the increase of plant height is not desired by the practice as it has several unfavourable effects (especially for the farmers who has no livestock and cannot utilize the higher amount of straw resulting in extra work and costs). The higher the plants, the higher is their sensitivity to lodging due to the less stem stability resulting in harder harvest and lower quality straw. The higher amount of straw also results in lower Harvest-index and drought tolerance.

The test weight of the various wheat varieties is a particularly important parameter for the mill industry as this value characterizes the milling yield very well. On the base of our results it could be established that there is no considerable effect of fertilization on this physical parameter, no correlation could be figured out. Though the higher N-doses resulted in a slight increase of the test weight of wheat, decrease was detected when phosphorus was added too (Fig. 4.).

In the case of the Zeleny sedimentation value definite improvement was detected due to N-fertilization (Fig. 5.).

The higher N-doses resulted in 50% higher values compared to the untreated control. At lower N-doses (50-100 kg ha^{-1}) our experience was the same as Ragasits's (2001), the increase of P-doses resulted in lower Zeleny values.

The Falling Number method is the most popular method for determining sprout damage. It is cited in several national and international papers that the value of falling number is mainly determined by the year effect, beyond the genetic variability of wheat.

Its explanation is that the sprouting germination is caused by damp or rainy weather conditions during the final stage of maturation of the crop; the germination causes an accelerated starch degrading. We also found that fertilization had not a significant effect on the α-amylase activity (Fig. 6.).

Conclusions

Plant nutrition is only one of the several factors of utilizing the genetic potential of wheat varieties. On the base of our experiment it could be established that extreme high doses of fertilizers (150-200 kg ha^{-1} substance) are needed to a considerable increase of the investigated parameters. Environmental protection and economic points of view must be taken into account beyond genetic potential and year effect.

The financial possibilities of the famers are limited, they consider the extra costs needed for the extra yield (marginal cost) when make their decisions about wheat production knowing the

upper limit of fertilization costs that affordable and benefits in higher quantity and quality. Our goals are to specify these empiric and often inaccurate fertilizer doses applied in the practice and to provide a growing technology and plant nutrition recipe adequate to our winter wheat varieties used regularly by the farmers and producers. Due to the complexity of this issue, further examinations are needed to achieve these goals.

References

Birkás M., Gyuricza Cs. (2001): A szélsőséges csapadékellátottság hatása az őszi búza néhány termesztési tényezőjére barna erdőtalajon. Növénytermelés, 50. No. 2-3. 333-344.

Bocz E., Késmárki I., Ruzsányi L., Kováts A., Szabó M. (1992): Szántóföldi növénytermesztés. Budapest. Mezőgazda Kiadó. 887.

Debreczeni B.-né, Ragasits I. (1996): A búza optimális tápanyagellátása eltérő talaj- és ökológiai viszonyok között. Agrofórum. 7, 11: 8-10.

Jolánkai M., Szőllősi G., Szentpétery Zs. (2004): Az őszi búza termesztésnek és minőségének változása különböző évjáratokban. Gyakorlati Agrofórum Extra 6. 6-9.

Jolánkai M., Szentpétery Zs., Hegedűs Z. (2006): Pesticide Residue dischange dynamics in wheat grain. Cereal Res. Commun. 34. 505-509.

Klupács H., Tarnawa Á. (2007): Phosphorus and potassium utilization in a winter wheat nutrition experiment. Cereal Res. Commun. 35. 625-628.

Pepó P. (2001): Újabb adatok az eltérő genotípusú őszi búza fajták trágyareakciójához. Növénytermelés, 50: 2-3. 203-215.

Pepó P.: 2009. Az elővetemény és tápanyagok hatása az őszi búza termésére. Agrofórum, 2009. 09. 14-16.

Peterson, C.J., Graybosch, R.A., Shelton, D.R., Baenziger, P.S. (1998): Baking quality of hard winter wheat: response of cultivars to environment int he Great Plains. Euphytica. 100.1/3. 157-162.

Ragasits I., Kismányoky T. (2000): A búza minőségének alakulása szervestrágyázás és nitrogénműtrágyázás hatására. Növénytermelés, 49: 5. 527-532.

Ragasits I. (2001): A tápanyagellátás hatása az őszi búza termésmennyiségére és minőségére. Növénytermelés, 50: 2-3. 169-176.

Sváb J. (1973): Biometriai módszerek a kutatásban. Mezőgazdasági Kiadó. Budapest