# NEW AGRONOMIC MANAGEMENT MODELS IN WINTER WHEAT (*Triticum aestivum L.*) PRODUCTION

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***Abstract***

*Hungary is located in temperate climatic zone of Central-Europe. Agriculture has traditionally important role in Hungarian economy (agriculture has 5% and total agribusiness takes 14% in GDP, respectively). Arable land is about 50% of total territory wich is very high proportion. Climatic and soil conditions generally are favourable for arable field crops especially for small grain cereals and maize (they have about 67% of arable land).*

*Issues of our normal and long-term, small and big plots experiments were carried out to study the effects of agroecological conditions, genotypes and crop management elements on the yield, yield-stability and –quality of winter wheat, to study their interactions on the fertilization of precision agriculture in wheat.*

*According to our results the genotypes of wheat could be classified into 4 groups, regarding nutrient utilization and fertilizer response: type A-modern genotype; type B-extensive genotype; type C-intensive genotype; type D-out-of-date genotype.*

*In our long-term experiment the optimum N-doses (+PK) varied depending on the cropyear (water supply in vegetation period and winter period too) and genotypes (variety-specific fertilization). The optimum N-doses ranged 60-120 kgha$^{-1}$ (+PK) depending on years and variety. Over the optimum N-dose some $NO_3$-N residues remained in the soil which accumulated year by year.*

*In the average of years and varieties fertilization hughly increased the wet gluten content*

*Fertilizer application also had favourable effects on farinograph values.*

*Application of precision fertilization could increase the agronomic efficiency of crop management in wheat production (better yield, baking quality, yield-stability) and could decrease the harmful environmental effects.*

**Key words**: wheat, crop models, yield, baking quality

## INTRODUCTION

Hungarian crop production was characterized by dynamic development in the 1960-1980's. The technical conditions were improved, the introduction of new varieties was accelerated. This intensive phase of crop production has yielded advantageous results and disadvantageous consequences as well.

This development in crop production has decreased the biological, agronomic and economic efficiency and has caused a lot of harmful effects in current agricultural practice.

These problems have resulted in the agricultural policy agenda in West-European and North-American countries being increasingly influenced by concern for various new alternative agricultural production systems (low input, sustainable, ecological, organic, precision etc.) during the past two decades. Governments are becoming increasingly sensitive to the environmental and human-health risks associated with current modes of agricultural production.

Crop science has to deal with several new fields of agricultural activity. Apart from traditional agro-industrial production new target areas have appeared. There are also fields of crop science which are not related to production - such are environmental protection, landscape management, soil amelioration, alleviation and remediation, as well as sport, urban and ornamental vegetation.

Agriculture has traditionally an important role in Hungarian economy and rural development. About 70% of Hungary's total territory is under agricultural land use, which is internationally an outstandingly high proportion. It is an especially large rate of arable land use, which is 50% of our country's area.

Nowdays the modern crop production has to meet the issues of new police agenda, which means sustainability, environmental protection, agronomic and economic efficiency and high quality standards (*Pepó* 2001). For the above mentioned main impacts it is necessary to harmonize the interaction of agroecological, biological and agrotechnical elements (*Pepó* 2002).

Side by side with higher yields and better quality, yield stability has become an ever important factor in the precision production technology of winter wheat. The negative effects of environmental factors on yield fluctuation can be moderated if more intensive and higher level technologies are used (*Pepó* 2003). Wheat varieties need resilience and stability to withstand the effects of the environmental and cultivation factors (*Bradshaw* 1965, *Untila et al.* 1992), i.e. any given genotype has to be in possession of the ability to bring high and stable yields under different conditions of cropping site and management (*Matsuo* 1975, *Lökös Tóth et al.* 1997).

A markedly important future objective of Hungarian wheat growing is the production of quality wheat that can address different demands of both domestic and international markets. The quality of wheat is determined by a complex of factors including biological bases (variety, seed), agro-ecological conditions (weather, soil) and the growing management (fertilization etc.) practices applied (*Erdei and Szániel* 1975, *Bocz et al.* 1983, *Pepó* 1991, *Matuz et al.* 1999, *Pepó* 2000, *Pepó* 2001, *Kertész és Matuz* 2001).

## MATERIALS AND METHODS

Our different normal and long-term experiments were carried out in Hajdúság on chernozem soil (small-plots experiments) and in the eastern parts of Hungary on chernozem, meadow and brown forest soils (big-plots experiments).

In our small experiments different small grain cereals (winter wheat, winter barley, spring barley, triticale) and other cereal (maize) were studied. The most important crop production factors which were studied in our normal and long-term experiments were the followings:

- agroecological factors
- biological-genetic background of wheat production
- individual and interactive effects of different agrotechnical elements on the yield-performance and quality.

In different small and big plots experimental projects yields, different phenological, phenometrical, agronomical traits, quality-parameters, soil physical, chemical and biological characters etc were measured.

**RESULTS AND DISCUSSIONS**

Hungarian crop production is fairly cereal oriented production, which means that cereals (small grains and maize) take about 65-68 % of the arable land. Small grain cereals are grown almost all territory of Hungary, maize production is concentrated on the best soils.

In Hungarian small grain cereal production the growing area of different crops were stable in the 1990 years (except the area of triticale which increased rapidly). Comparing the average yields of the first and second five years of 1990's in Hungarian cereal production there were a dramatic yield-decreasement and hudgely dropped the yield-stability because of the so called „agronomic-erosion" (less use of different industrial inputs, fertilizers, pesticides, energy etc).

In generally Hungary has favourable agroecological conditions for cereal production. In different regions of Hungary the ecological conditions are fairly different for cereal production. [yearly average temperature is 10 $^{o}$C (9,28-10,35 $^{o}$C), yearly average rainfall is 530 mm (450-800 mm)]. In Hungary water is the integrative, key-element from climatic aspects. The ratio of soil types in Hungarian arable land is the following: brown forest soil 34,5 %, meadow soil 18,6 %, chernozem soil 16,1 %, sandy soil 9,8 %, salty soil 8,7 %, others 12,3 %.

There are several problems in all management factors but the most important ones are in nutrient supply, fertilization and crop protection. Because of limited, low fertilizer using the nutrient balance became negative in Hungary (*Table 1.*).

*Table 1*

**Nutrient balance in Hungary**

| **1986-90** | | | **1991-95** | | |
|---|---|---|---|---|---|
| **N** | **$P_2O_5$** | **$K_2O$** | **N** | **$P_2O_5$** | **$K_2O$** |
| +95 | +140 | +45 | -35 | -15 | -30 |
| Total: +280 $kgha^{-1}$ (+56 $kgha^{-1}$/year) | | | Total: -80 $kgha^{-1}$ (-16 $kgha^{-1}$/year) | | |

To build up sustainable, environmentally-friendly, precision fertilization-system of wheat, we have to take not only climatic, soil conditions (site-specific aspects) into consideration, but we have to know the biological responses of different genotypes (variety-specific aspects). Our more than twenty year long-term experiments proved that the following parameters could characterise the nutrient and fertilizer response of different winter wheat genotypes:

- natural nutrient utilization (yield of control treatment)
- efficiency of fertilizer using (yield-surplus/1 kg NPK)
- utilization of genetic yield ability (maximum yield in optimum fertilizer treatment)
- fertilizer demand of genotypes ($N_{opt}$+PK)
- curves of fertilizer response.

The fertilizer response types of winter wheat varieties could be defined by making algorithms of our long-term experimental data. According to our results the genotypes of wheat could be classified into 4 groups, regarding nutrient utilization and fertilizer response (*Figure 1*): type A-modern genotype; type B-extensive genotype; type C-intensive genotype; type D-out-of-date genotype. The appropriate fertilization have a hudge effect on the yield stability (water utilization) and baking quality (wet gluten content, protein content, farinograph value etc) of wheat. The *Table 2.* is showed the variety-specific nutrient utilization and fertilizer response of some characteristic winter wheat varieties.

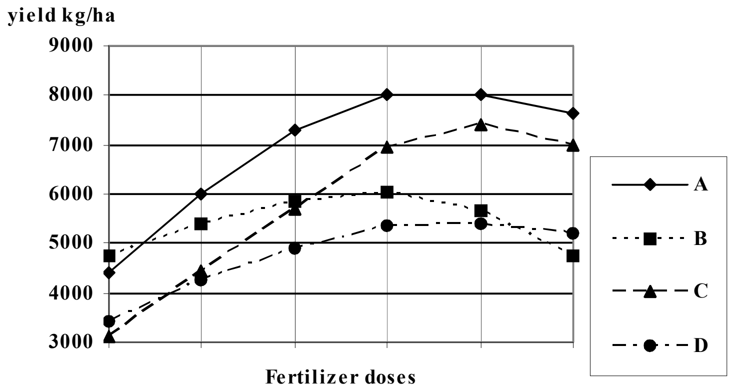


**Figure 1. Fertilizer response types of wheat**
**(chernozem soil, continental climatic conditions**

According to our long-term experimental results we can state that the cropyear strongly modified the maximum yields of varieties. In the average of varieties the maximum yield was 6,5 t $ha^{-1}$ in the average cropyears (in 1999 was 6598 kg $ha^{-1}$, in 2002 was 6555 kg $ha^{-1}$ respectively). In the favourable, good cropyears we obtained much bigger maximum yields, but there were differences between the cropyears characterized by favourable agrometeorological parameters. The maximum yield (in the average of genotypes) were 8296 kg $ha^{-1}$ in 2000, 7226 kg $ha^{-1}$ in 2001, 8583 kg $ha^{-1}$ in 2004 and 8098 kg $ha^{-1}$ in 2005, respectively. The maximum yield differences of varieties were significant in average and good cropyears too. In very dry cropyear (2003) the maximum yields in optimum N+PK treatments were fairly moderated (4387 kg $ha^{-1}$ in average of winter wheat varieties).

The efficiency of fertilizers was determined by the water supply of the cropyears. The yield surpluses by fertilization proved the efficiency of fertilization were better in the favourable cropyears (in 2000, 2001, 2004 and 2005) than in the average cropyears (in 1999 and 2002). The yield-surpluses by fertilization comparing with the control (in average of varieties) were 4255 kg $ha^{-1}$ in 2000, 4033 kg $ha^{-1}$ in 2001, 3860 kg $ha^{-1}$ in 2004 and 3559 kg $ha^{-1}$ in 2005 (good cropyears) and the yield-surpluses were 2556 kg $ha^{-1}$ in 1999 and 2089 kg $ha^{-1}$ in 2002 (average cropyears) on chernozem soil. In very dry cropyear (2003) the yield-surplus of fertilization was very moderated (940 kg $ha^{-1}$) because of water deficit in the soil during the vegetation period of winter wheat (*Table 3.*).

*Table 2*

**Maximum yields of winter wheat varieties and their fertilizer doses (yield kg ha$^{-1}$, $N_{opt.}$ kg ha$^{-1}$, chernozem soil)**

| Variety | 1999 | 2000 | 2001 | 2002 | Average |
|---|---|---|---|---|---|
| *GK Öthalom* | $6572_{(90)}$ | $7658_{(120)}$ | $7562_{(120)}$ | $6247_{(120)}$ | 7010 |
| *Fatima* | $6299_{(90)}$ | $8560_{(90)}$ | $7875_{(90)}$ | $6903_{(90)}$ | 7409 |
| *Mv Kucsma* | - | $8790_{(120)}$ | $7485_{(120)}$ | $7213_{(120)}$ | 7829 |
| *Mv Magvas* | $6697_{(60)}$ | $8640_{(90)}$ | $7460_{(90)}$ | - | 7599 |
| *Mv Emese* | - | - | $6617_{(90)}$ | $5870_{(120)}$ | 6244 |
| *Mv Palotás* | - | - | $7436_{(90)}$ | $6967_{(120)}$ | 7202 |
| *Mv Csárdás* | - | - | $7183_{(120)}$ | $5980_{(90)}$ | 6582 |
| ***Average*** | ***6523*** | ***8412*** | ***7374*** | ***6530*** | ***7125*** |
| ***Yield interval, t ha$^{-1}$*** | ***6,3-6,7*** | ***7,7-8,8*** | ***6,6-7,9*** | ***5,9-7,2*** | ***6,2-7,8*** |
| ***Min-Max, %*** | ***97-103*** | ***91-104*** | ***90-107*** | ***90-110*** | ***88-110*** |
| **Interval of yield fluctuation, %** | **6** | **13** | **17** | **20** | **22** |
| **Interval of $N_{opt.}$ kg ha$^{-1}$** | **60-90** | **90-120** | **90-120** | **90-120** | **80-113** |
| **$LSD_{5\%}$** | **265** | **263** | **353** | **381** | **-** |

*Table 3*

**Effect of cropyear on the control and maximum yield of winter wheat (Debrecen, 1999-2005) (average of varieties)**

| Cropyear | Control yield kgha$^{-1}$ | Maximum yield kgha$^{-1}$ | Yield-surplus kgha$^{-1}$ | Rainfall in veg. period (mm) | Rainfall deviation from 30 year average (mm) |
|---|---|---|---|---|---|
| 1998/1999 | 4042 | 6598 | 2556 | 470,4 | +69,5 |
| 1999/2000 | 4041 | 8296 | 4250 | 312,9 | -88,0 |
| 2000/2001 | 3193 | 7226 | 4033 | 430,2 | +29,3 |
| 2001/2002 | 4466 | 6555 | 2091 | 184,6 | -216,3 |
| 2002/2003 | 3447 | 4387 | 940 | 279,3 | -121,6 |
| 2003/2004 | 4713 | 8573 | 3860 | 376,5 | -24,4 |
| 2004/2005 | 4539 | 8098 | 3559 | 410,4 | +9,5 |

The appropriate fertilization could effectively modify not only the yield quantity but quality as well (*Table 4*.). Our long-term experimental results proved that the fertilization (mainly N and harmonized PK) could strongly increase the wet gluten content and averagely the farinograph indexes and slightly the falling number. Our result proved that the changes of quality parameters were variety-specific. The water supply of cropyears also modified the quality parameters (*Table 4*.). In 2000 cropyear (better water supply in grain filling period) we obtained better quality parameters than in 2002 (very dry periods in spring and early summer in air and soil too).

*Table 4*

**Effect of fertilization and cropyear on the wheat quality parameters (Debrecen, variety: GK Öthalom)**

| Fertilizer doses kg ha$^{-1}$ | 2000 | | | 2002 | | |
|---|---|---|---|---|---|---|
| | wet gluten (%) | farinograph index | falling number (s) | wet gluten (%) | farinograph index | falling number (s) |
| 0 | 26,48 | 56,27 | 344 | 23,23 | 41,93 | 327 |
| $N_{30}$+PK | 26,21 | 57,70 | 336 | 24,26 | 43,58 | 324 |
| $N_{60}$+PK | 31,22 | 59,08 | 320 | 28,08 | 47,73 | 333 |
| $N_{90}$+PK | 31,79 | 58,80 | 341 | 29,34 | 51,65 | 341 |
| $N_{120}$+PK | 34,20 | 59,50 | 350 | 29,93 | 52,15 | 338 |
| $N_{150}$+PK | 34,84 | 59,98 | 362 | 32,13 | 52,75 | 342 |

Our long-term experiments proved that the appropriate, precision, variety- (the demand and response of varieties) and site-specific (adaption to climatic and soil conditions) fertilization (mainly N-fertilization) provides optimum yield, good yield-stability and excellent baking quality, so we could get better agronomic and economic efficiency, less harmful environmental effects in different input-level (extensive, low-input, mid-tech, intensive) crop models of the winter wheat precision management.

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