# YIELD AND GRAIN QUALITY OF SPRING BARLEY AS AFFECTED BY SOIL TILLAGE METHOD AND FERTILIZATION

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***Abstract:*** *During 2011-2012, the multifactorial field trial of spring barley variety Kangoo was established at Experimental site of Slovak Agricultural University in Nitra, in south-western Slovakia (E 18º09', N 48º19') with altitude of 175 m above MSL. The location has continental warm and moderate arid climate with an average annual temperature of 9.07°C an average annual precipitation of 561 mm. The mean temperature during the growing season is 16.2°C. The soil type is Orthic Luvisol with a loamy texture, medium humus content of 1.95%-2.60% and a pH of 5.7. The impact of two soil tillage systems (conventional - O1 and minimization - O3 tillage methods were used) and mineral and organic fertilization treatments (H1-zero treatments, H2- mineral fertilizers only, H3- application of both mineral fertilizers and post-harvest residues of the forecrop) on yield and quality parameters of spring barley variety Kangoo was studied. The lack of humidity and above average temperatures reduced the harvest of grains of barley statistically in 2012 on 0.601 t ha$^{-1}$ compared with the yield of spring barley in the year 2011 (3.63 t ha$^{-1}$). The way of tillage highly significantly influences the yield of spring barley. Yield of spring barley under minimization methods was higher (3.48 t ha$^{-1}$) with comparison to 3.19 t ha$^{-1}$ yield in conventional tillage. The application of fertilizers and incorporation of maize aboveground residues as forecrop significantly create the better condition for yield of spring barley (3.84 t ha$^{-1}$). The highly significant relationship between weather condition and quality of selected parameters were determined as follows: TKW (r=0.43$^{++}$), volume weight (r=0.85$^{++}$), percentage proportion of grains above 2.5 mm (r = 0.81$^{++}$) and protein content in grain (r=0.87$^{++}$). High direct relationship between the TKW and percentage proportion of grains above 2.5 mm seed (r=0.37$^{+}$) and protein content (r=0.40$^{+}$) were also determined. The same relationship between content of protein in grain and proportion of grains above 2.5 mm(r=0.70$^{++}$) and between volume weight and proportion of grains above 2.5 mm (r=0.71$^{++}$) were also determined. Variability of yield was statistically influence by all treatments – weather condition, tillage treatments and fertilization.*

***Key words****: crop residues, fertilization, soil tillage, spring barley, yield*

## INTRODUCTION

In Slovakia, the cereals are cultivated on an area of about 780 thousand hectares, and the proportion of barley is 18%. In 2011 and 2012, the yield of barley was 3.87 t ha$^{-1}$and 3.18 t ha$^{-1}$ , respectively. Very favourable conditions for growing barley were in 2014, on an area of 138.9 thousand ha, the average barley yield reached 4.74 t ha$^{-1}$. Barley maintains economically interesting and profitable (JAMBOROVÁ, 2014).

Grain yield of barley can be expressed as a function of spikes per square meter, kernels per spike, and kernel weight, which together referred to as yield components (SINEBO, 2002). Variation in yield components resulting from environmental, and management factors, affects variation in crop yield (KOZAK and MĄDRY, 2006).

The reduced technology, compared to conventional tillage, allow reducing the unit cost by 40 to 50%. In growing condition of central Europe, it is necessary to calculate with a reduction in yield of crops, in the first year by 10-12% in the second year of 5-7% and below.

Introduction of minimize technologies of soil cultivation can help to achieve greater efficiency of production of malting (NOZDROVICKÝ and RATAJ, 2000, KOVÁČ et al., 2010).
Fertilization is crucial factor fo influence the quality and yield of spring barley. Some processes can be managed in a field, but other variables cannot be controlled -temperature, rainfall, or soil texture (SHEJBALOVA et al., 2014)

The aim of the study was to evaluate the effect of soil tillage methods and mineral and organic fertilizer) on grain yield of spring barley and its yield components formation.

## MATERIAL AND METHODS

The polyfactorial field trial was carrying out during 2011-2012 on Experimental site of Slovak Agricultural University in Nitra, in south-western Slovakia (E 18º09' N 48º19') with altitude of 176 m above sea level. The location has continental warm and moderate arid climate with an average annual temperature of 9.07°C an average annual precipitation of 561 mm. The mean temperature during growing season is 16.2°C. Agro-climatic sub-area is characterized as very dry. The soil type is Orthic Luvisol with a loamy texture, medium humus content of 1.95% - 2.60% and a pH of 5.7 (TOBIAŠOVÁ and ŠIMANSKÝ, 2009).

The experiment was designed as long strips with vertically segmented plots. The size of plot was 20 $m^2$ (10 x 2 m), in four replications. Maize as a forecrop was used, after harvest of forecrop mouldboard ploughing to the depth 0.24 m and phosphorus and potassium mineral fertilizers were applied. For seedbed preparation harrow and combinator were used. The spring barley variety Kangoo was tested. Variety Kangoo was released in 2009 with excellent malting quality.

There were three tillage treatments (O1-medium deep ploughing to 0.24 m, O2-shallow ploughing to 0.15 m, O3-disc tools to 0.12 m and fertilization treatments H1 - control treatment, H2 - inorganic fertilizers (P and K on designed yield level), H3-inorganic fertilizers and incorporation of forecrop residues. Nutrients were added on the base of balance method according to nutrient content in soil on yield level of 5 t $ha^{-1}$ spring barley under the normative nutrients withdrawing per 1 ton of crop: 24 kg N, P 5.2 kg, 19.9 kg K (FECENKO AND LOŽEK, 2000). Due to the good phosphorus and potassium stocks in soil, replacing system was used. Dose of phosphorus in form of superphosphate and potassium in form of 40% potassium salt fertilizer was also applied each year.

Sowing periods was as follows: March 16, 2011; March 15, 2012. Dates of harvest were as follows: July 18, 2011; July 21, 2012. Sowing dose was 4.5 million germinable seeds per ha each year.

## RESULTS AND DISCUSSION

In 2011, we note the deficit of rainfall in April (up to 25.8 mm) with comparison to normal, but June 25.1 mm above normal.

In both evaluated years temperature was about normal (Figure 1).

Due to the less suitable moisture condition in 2012, number of plants was 235 pcs per square meter with comparison to 235 pcs of plants in 2011.

Empirical evidence indicates a ranking of plasticity: tillering > grain number > grain size (SADRAS and DENISON, 2009).

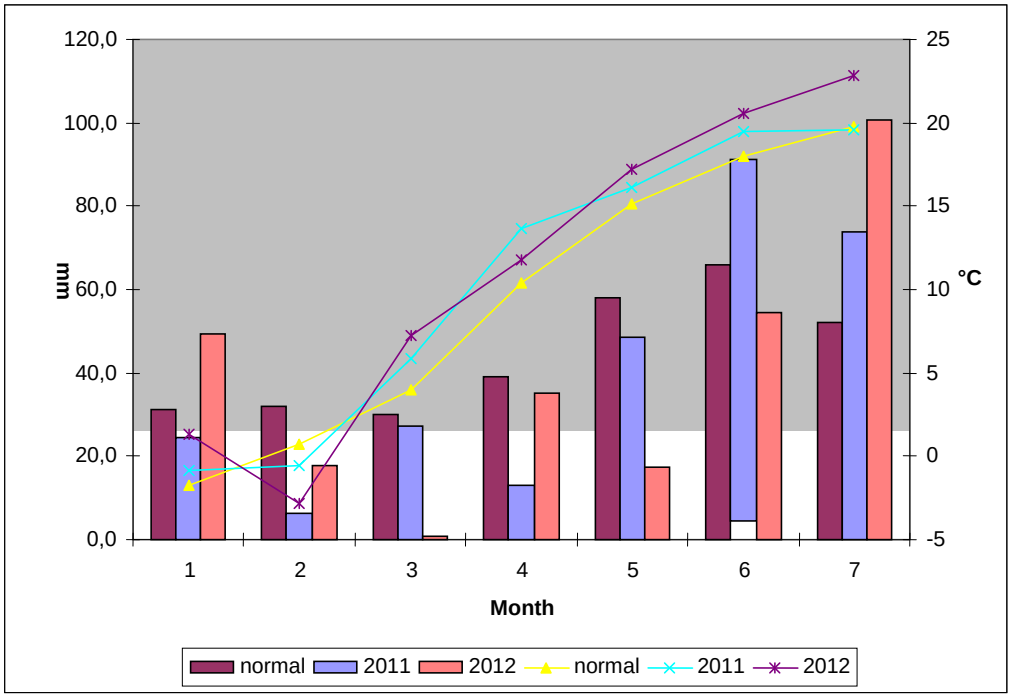


Figure 1 Precipitation and temperature scenarios during 2011 and 2012

But in our condition, number of plants was not compensate by number of tillers, due to number of spike per square meter was very low (304 pcs) in 2012, with comparison to 581 number of tillers in 2011.

Sufficient amount of soil moisture positively reflect the number of germinated plants, and tillering. The highest number of spike and TKW was also noted in 2011. Number of grain per spike was 21.8 in 2011 with comparison to 19.25 in 2012.

*Table 1*

The influence of year, soil cultivation and fertilization on grain yield of spring barley in 2011, 2012

| Factor | Year<br>P 0.05=0.1001<br>P 0.01=0.1380 | | Soil cultivation treatments<br>P 0.05=0.1001<br>P 0.01=0.1380 | | Fertilization treatment<br>P 0.05=0.1500<br>P 0.01=0.1949 | | |
|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | O1 | O3 | H1 | H2 | H3 |
| Yield grain | 3.63b | 3.03a | 3.19a | 3.48b | 2.79a | 3.35b | 3.84c |

Deficit of soil moisture maintain in June 2012 supported only 3.03 t ha$^{-1}$ (Fig. 2) with comparison to 3.63 t ha$^{-1}$ in 2011. All evaluated factors significantly influenced the yield of spring barley. The significantly higher yield was reached in minimum tillage system. Positive influence of mineral fertilizers combined with forecrop biomass incorporation supported significantly higher yield of grain. The suitability of minimize technologies for spring barley also confirm POSPIŠIL et al. (2014). The higher energy gain was on mineral fertilization treatment combine with incorporation of forecrop residues. In our field trial all fertilization treatment significantly increases the yield of spring barley.

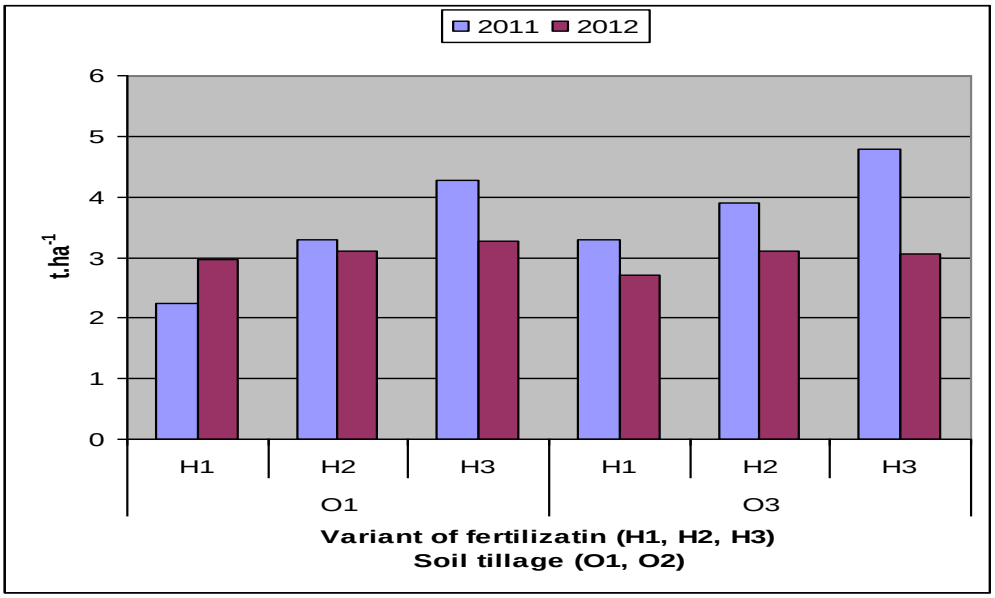


Figure 2 Grain yield of spring barley in 2011-2012

Technological parameters of spring barley (TKW, volume weight, 1st class grain portion) in 2011 were lower than the same parameters in 2012 (Table 2 and 3).

*Table 2*

Technological quality parameters of spring barely in 2011

| Soil cultivation | Fertilization treatments | TKW (g) | Volume weight (g $l^{-1}$) | 1st class grain portion (%) | Protein content (%) |
|---|---|---|---|---|---|
| O1 | H1 | 39.76 | 681.06 | 93.98 | 9.70 |
| | H2 | 40.24 | 680.03 | 94.64 | 9.90 |
| | H3 | 42.68 | 678.10 | 95.57 | 9.60 |
| | $\bar{x}$ | **40.89** | **679.73** | **94.73** | **9.73** |
| O3 | H1 | 41.22 | 685.00 | 94.49 | 9.80 |
| | H2 | 41.43 | 680.19 | 95.77 | 9.60 |
| | H3 | 44.75 | 679.74 | 94.29 | 9.80 |
| | $\bar{x}$ | **42.47** | **681.64** | **94.85** | **9.73** |
| Total average | | **41.68** | **680.69** | **94.79** | **9.73** |

The criteria for protein content in dry matter according Slovak technical standard for higher quality class A is 11% and for B class 12.5%. According quality standards the malting quality of barley was better in 2012 (content of protein 12.58%) and in 2011 only 9.73% of protein

The requirements of malting industry in the crude protein content of grain barley malt vary from 10.5% to 11.5%. ŠOLTÝSOVÁ and DANILOVIČ (2005) found out increasing of crude

protein in year with moisture deficit conditions. The content of crude protein is influenced also by agro ecological growing conditions (ZIMOLKA et al., 2006).

*Table 3*

Spring barley - technological and qualitative parameters of grain in 2012

| Soil cultivation | Variant fertilization | TKW (g) | Volume weight (g $l^{-1}$) | 1st class grain portion (%) | Protein (%) |
|---|---|---|---|---|---|
| O1 | H1 | 45.67 | 730.96 | 97.54 | 12.60 |
| | H2 | 45.27 | 733.22 | 97.39 | 13.40 |
| | H3 | 46.17 | 707.29 | 98.34 | 12.80 |
| | $\bar{x}$ | **45.70** | **723.82** | **97.75** | **12.93** |
| O3 | H1 | 44.00 | 694.73 | 97.87 | 10.20 |
| | H2 | 45.97 | 727.27 | 97.51 | 13.00 |
| | H3 | 46.27 | 715.56 | 98.07 | 13.50 |
| | $\bar{x}$ | **45.41** | **712.52** | **97.82** | **12.23** |
| Total average | | **45.56** | **718.17** | **97.79** | **12.58** |

The main technological parameters of grain barley are TKW, volume weight and uniformity of grain expressed as portion of grain under the sieve 2.5 mm of diameter.

The relationship of evaluated technological factors was evaluated by using correlative analysis are shown in Table 4.

*Table 4*

Correlation coefficients between variables of yield structure and environmental factors and treatments

| Factor | TKW | Volume weight | 1st class grain portion | Protein |
|---|---|---|---|---|
| Year | $0.4294^{++}$ | $0.8513^{++}$ | $0.8114^{++}$ | $0.8751^{++}$ |
| Soil cultivation | 0.1929 | -0.1195 | 0.0401 | -0.1017 |
| fertilization | 0.1374 | -0.0692 | 0.1158 | 0.2118 |
| Yield grain | 0.0305 | $-0.3658^{+}$ | -0.2189 | -0.3183 |
| TKW | - | 0.3140 | $0.3709^{+}$ | $0.4023^{+}$ |
| Volume weight | - | - | $0.7090^{++}$ | $0.9010^{++}$ |
| 1st class grain portion | - | - | - | $0.7070^{++}$ |

P 0.05=0.33 P 0.01=0.42

The highly significant relationship between weather condition and quality of selected parameters were determined as follows: TKW ($r=0.43^{++}$), volume weight ($r=0.85^{++}$), percentage proportion of grains above 2.5 mm ($r = 0.81^{++}$) and protein content in grain ($r=0.87^{++}$). High direct relationship between the TKW and percentage proportion of grains above 2.5 mm seed ($r=0.37^{+}$) and protein content ($r=0.40^{+}$) were also determined. The same relationship between content of protein in grain and proportion of grains above 2.5 mm ($r=0.70^{++}$) and between volume weight and proportion of grains above 2.5 mm ($r=0.71^{++}$) were also determined.

The positive correlation between year condition and evaluated factors confirm also HANÁČKOVÁ and CANDRÁKOVÁ (2013).

## CONCLUSION

All evaluated factors significantly influenced the yield of spring barley. The significantly higher yield was reached in minimum tillage system. Positive influence of mineral

fertilizers combined with forecrop biomass incorporation supported significantly higher yield of grain.

Evaluated cropping years had contrasting conditions for accumulation of nitrates in spring barley grain.

The correlations between weather condition and TKW volume weight, proportion of grains and protein content in grain was determined.

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