THE IMPACT OF VARIETY AND SOIL MANAGEMENT ON YIELD FORMATION ELEMENTS AND GRAIN YIELD AMOUNT IN SPRING BARLEY

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Abstract
Field polyfactorial trials were conducted in warm corn production area of Slovakia, with three spring barley varieties Annabell, Kompakt, Nitran and two new-breeds KM 2010 and KM 2092, after sugar beet in three repetitions. Four methods of soil cultivation were evaluated: ***A*** *- conventional tillage, with tillage of harvest remains;* ***B*** *– conventional tillage without tillage of harvest remains;* ***C*** *– minimum tillage - without tillage of harvest remains; D – minimum tillage - with tillage of harvest remains. The share of the variety on achieved yield amounts is estimated to 20% till 28% depending on production conditions of growing season. The highest average grain yield of 5.97 tones per hectare was achieved by Annabell with the highest number of plants and spikes. Yield differences in naked and husky barley varieties in single growing seasons were from 0.62 tones per hectare to 1.56 tones per hectare in behoof husky ones. The highest yield amount was recorded in the case of minimum tillage system without tillage of harvest remains (****C*** *soil management system) (5.69 tones per hectare) when also the highest number of plants (233 pieces.m^{-2}) and spikes (577 pieces.m^{-2}) was determined.*

Key words*:* spring barley, conventional tillage, minimum tillage, yield formation elements, grain yield

INTRODUCTION

In order to ensure effective and ecologic production appropriate to malting and food industry demands is important to search and use new biological material and to learn its requirements in production technology (e.g. several soil tillage systems) according to agroecological conditions of the production area.
Fundamental for successful barley production is the correct selection of variety suitable for given site. The share of the variety on achieved yield amounts is estimated to 25% till 40% depending on production conditions of growing season [15, 18, 22].
The influence of tillage systems on the yield amount and spring barley quality was studied by several authors. The way of tillage – either conventional or no tillage system have to match to the given production area [3]. By the selection of tillage system it is important to differentiate the demands for optimal soil process conditions and crop demands for soil environment. Soil cultivation depends on the fore crop, soil type, production potential and physical soil properties [9]. In the future it is important to combine properly the conventional tillage system with no tillage system or several ways of soil protective management systems [20]. No tillage systems where the correct selection of crop rotation is very important are matching to both environmental and economic aspects [9]. Minimum soil management systems are applied especially by cereals, because this group of field crops doesn't respond to the depth cultivation and doesn't demand loose soil [3, 19 and other]. Another plus is that the lower level of mineralization increases the content of organic matter in top soil upper sections [16, 14]. After long-term evaluation of soil protective and conventional technologies in Canada there were stated that grain yield was

for 23 – 27% higher by conventional tillage but the highest yield amount was achieved by soil protective tillage system [4].

On the university in Delaware within the evaluation of several soil management systems (conventional and minimum ones) impact on the grain yield – the highest grain yield was achieved by no-tillage system [23]. According to autor's good results of no-tillage system consist in good management, i.e. selection of proper soil protective technology, fertilization planning, variety selection, sowing rate and herbicide treatment. Statistically significant increase in spring barley yield produced on light sandy soils was achieved by soil protective technology as compared to conventional technology. It relates to soil protective and water-conservation effects of adopted technology which affect the physical soil properties and water saving in the soil [7]. Lower yields in soil protective technologies compare to conventional ones were observed by authors [23, 8, 17]. Lotter et al., [13] based on study of soil protective technologies in extremely dry climatic season in eastern part of U.S.A. have stated that soil protective tillage was for 100 % more effective regarding the soil moisture keeping than conventional soil management. Kulík and Líška [11] have stated that as for the soil cultivation in the case of spring barley production the agro ecological conditions of Slovakia aren't suitable for long term "no-tillage" production systems. They can be used "ad hoc" in cases when they seem to be the most suitable.

Objective of the paper is to point out the impact of different soil management methods and that of varieties on the formation of yield elements and the yield amount in spring barley in climatically different growing seasons.

MATERIAL AND METHODS

Field polyfactorial trials were conducted on experimental plots of the Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra during 2002-2004 with three spring barley varieties Annabell, Kompakt, Nitran and two new-breeds KM 2010 (KM-96) and KM 2092 (KM-98). The fore crop was sugar beet. The size of experimental plots was 14 square meters. Four methods of soil cultivation were evaluated: **A -** conventional tillage up to a 0.18 – 0.20 m depth with tillage of harvest remains; **B –** conventional tillage up to a 0.18 – 0.20 m depth without tillage of harvest remains; **C –** minimum tillage - (disking up to a 0.12 – 0.15 m depth) without tillage of harvest remains; **D –** minimum tillage - (disking up to a 0.12 – 0.15 m depth) with tillage of harvest remains. The yield was re-counted on 14 % moisture content.

Samples of biological material in growing phase BBCH 85 – 89, from area of 1 square m, in all soil management ways and three repetitions were taken in order to determine the accumulation potential. Evaluated were accumulation potential parameters as follows: number of plants per 1 square meter before harvest (pieces per 1 square meter), an average number of productive shoots per 1 square meter (pieces per 1 square meter), an average number of productive shoots per 1 plant (pieces), number of spikes per 1 square meter (pieces per 1 square meter), number of grains per 1 spike (pieces) and the weight of grains per 1 spike (g).

Experiment results were statistically evaluated using the software Statgraphics and Statistica 6.1. Methods as follows were used: multifactorial analysis of variance, multiple comparison test, method of confidence intervals.

For more detailed determination of grain yield data the evaluated factors have been tested by the analysis of variance and by the multiple range test (Tukey test) on 95% and 99% reliability level (α= 0,05; α=0,01).

The trial area is classified and characterized as a warm macro area and a very dry subarea with an average annual precipitations of 561 mm (1951-1980), 333 mm during the

vegetation period and an average year temperature of 9,7 °C (1951 - 1980), 16,3 °C during the vegetation period.
The trial stand is located on brown soil with clay subsoil. The soil is middle supplied in P and well in K. The humus content in topsoil is middle (1.20 – 2.07%). The soil reaction is acid up to subacid (active pH 5.9-6.5; exchange pH 5.0-5.5) [5].

RESULTS AND DISCUSSION

Varieties

Achieved results refer to statistically significant difference in yield amounts of evaluated varieties. For the whole trial the highest average grain yield of 5.97 tones per hectare was achieved by Annabell variety. It gave statistically higher yield compare to Nitran and Kompakt variety.
Statistically significant was also the difference among Annabell, KM- 2092, and KM-2010 varieties (from 0.81 tones per hectare up to 1.56 tones per hectare) in behoof the Annabell variety, and between K- 2092 and KM-2010 new-breeds, too (Figure 1).

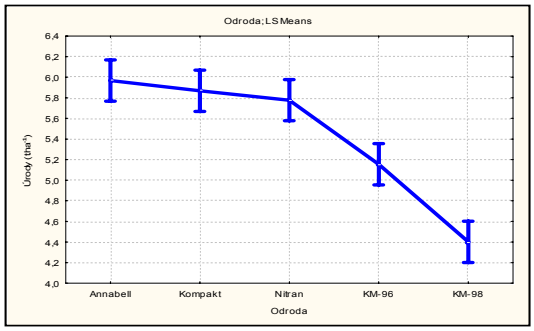


Fig. 1: Average grain yield amount depending on variety.
Averages and 99% confidence intervals.

In average for evaluated growing seasons husky varieties have achieved for 1.08 tones per hectare higher yield amounts compare to evaluated naked new-breeds which is in conformity with Hang et al. [6]. Yield differences in naked and husky barley varieties in single growing seasons ranged from 0.62 tones per hectare up to 1.56 tones per hectare in behoof husky ones.
In term of grain yield interactions the relation between *variety* and *growing season* was highly significant (the highest yield amount was observed by interaction: Nitran variety x 2004 growing season) (Figure 2.). The share of the variety on achieved yield amounts is estimated to 20% till 28% depending on production conditions of growing season. The authors [15, 18, 22] amounts 25% till 40%.

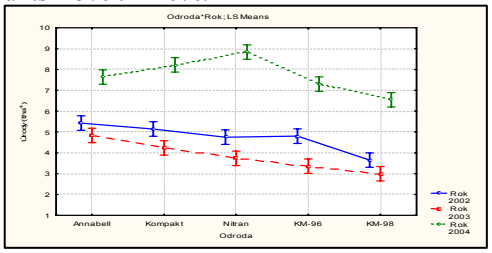
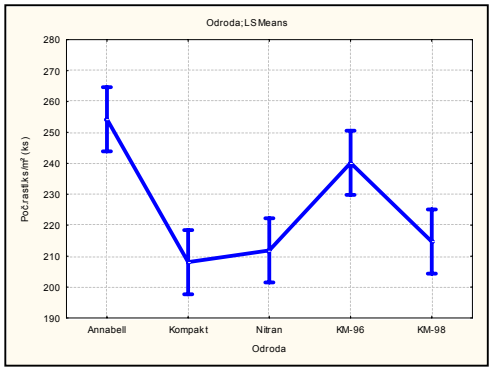


Fig.2: Average grain yield amount depending on variety and growing seasons.
Averages and 99% confidence intervals.

From evaluated husky varieties the highest number of plants and spikes was achieved by the Annabell variety. Compare to other varieties (Nitran a Kompakt) the difference was statistically highly significant. Regarding new-breeds – higher number of plants and spikes was achieved by KM-2010 (Figure 3, 4).



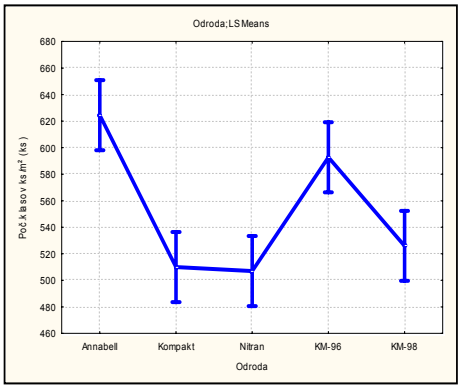
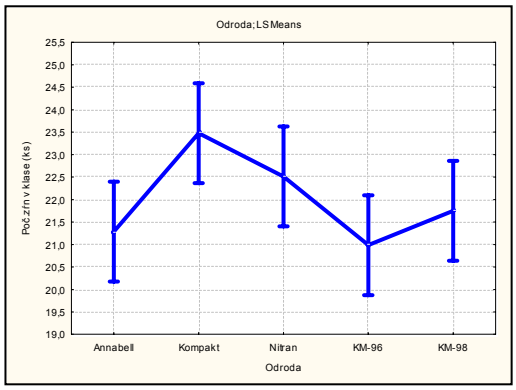


Fig. 3,4: The number of plants and number of spikes depending on variety.
Averages and 99% confidence intervals. Averages and 99% confidence intervals

There were any statistically significant differences in the number of productive shoots in evaluated varieties. The highest number of grains per spike was determined by Kompakt variety (23.47 pieces per spike), between this variety and the KM-2010 new-breed (20.98 pieces per spike) was observed statistically significant difference (Figure 5).



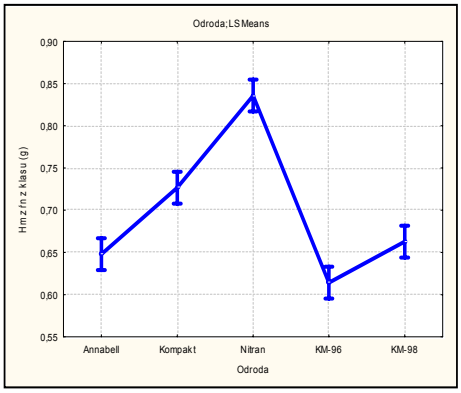


Fig. 5,6: The number of grains per spike and the grain weight per spike depending on varieties.
Averages and 99% confidence intervals. Averages and 99% confidence intervals

In average for evaluated three year period the highest grain weight per spike was determined by the Nitran variety (0.83 g) (Figure 6). The Annabell variety achieved 0.64 g and Kompakt 0.73 g. The grain weight by KM-2010 and KM-2092 new-breeds achieved 0.61 g and 0.66 g. The differences of grain weight per spike in evaluated varieties and new-breeds compare to the Nitran variety were statistically highly significant.

Soil cultivation

The soil management system influenced the yield amount statistically highly significant. In all evaluated soil management cultivation the highest yield amount was observed in the case of minimum tillage system without tillage of harvest remains (**C** soil management system) (5.69 tones per hectare) (Figure 7), when also the highest number of plants and spikes was determined. These results are consistent with conclusions of Walker [23], who achieved the highest grain yield in no tillage soil management system, too. Entz et al. [4], Kitchen et al. [8], Ryan et al. [17], report higher yield amounts by protective soil management, too. Comparing the **C** soil management system (minimum tillage without tillage of harvest remains) and the **A** soil management system (conventional tillage with tillage of harvest remains) statistically significant yield increase (for 0.61 tones per hectare) in behoof the **C** soil management system was determined. Lotter et al. [13] reported that reduced soil management system during extremely dry climatic growing season was more effective in moisture retention than conventional soil management system which is consistent with our results from 2003. The tillage of sugar beet harvest remains haven't caused an yield increase in any evaluated soil management system which is consistent with results of Candráková - Kulík [1].

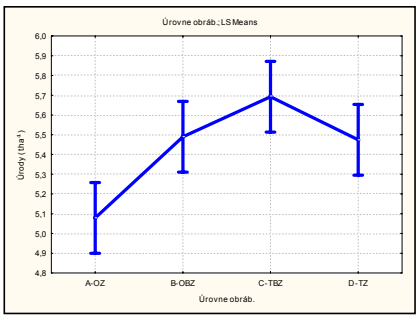
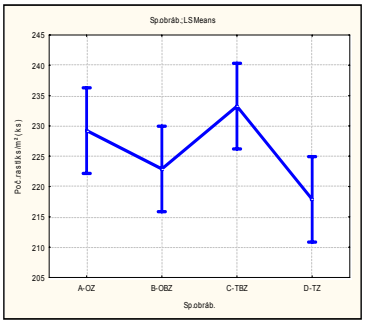


Fig. 7: An average yield amount depending on the soil management level.
Averages and 99% confidence intervals.

The soil management levels have had a significant influence on the number of plants and the number of spikes (Figure 8, 9) in average for three growing seasons. The highest number of plants (233 pieces per square meter) and the number of spikes (577 pieces per square meter) was determined by minimum soil tillage system (C). Statistically significant differences in the number of plants and the number of spikes were determined between the soil management systems C and D.



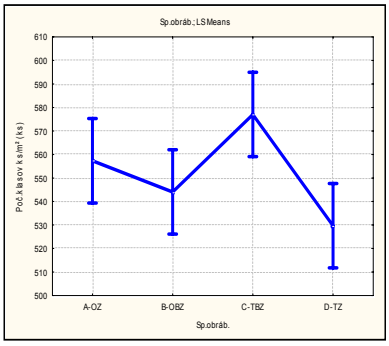


Fig. 8, 9: The number of plants and the number of spikes depending on the soil management level.
Averages and 99% confidence intervals. Averages and 99% confidence intervals

Interactive relations of *variety* x *soil management system* have had highly significant influence on the grain yield (the highest yield amount was achieved in interaction Annabell x C soil management system and the number of spikes (the highest number of spikes was achieved in interaction KM-2010 x C soil management system. Significant influence on the number of plants (the highest number of plants was determined in interaction KM-2010 x C soil management system .

CONCLUSION

Results referred to statistically significant difference in yield amounts among evaluated varieties. The highest average grain yield of 5.97 tones per hectare was achieved by Annabell with the highest number of plants and spikes. Differences in yield amounts of naked and husky varieties ranged in single growing seasons from 0.62 to 1.56 tones per hectare and achieved 1.08 tones per hectare in average for three years to behoof husky varieties. The share of the variety on achieved yield amounts is estimated to 20% till 28% depending on production conditions of growing season. The highest number of grains was noted for Kompakt variety (23.47 pieces per spike). The highest yield amount was recorded in the case of minimum tillage system without tillage of harvest remains (**C** soil management system) (5.69 tones per hectare) when also the highest number of plants (233 pieces.m^{-2}) and spikes (577 pieces.m^{-2}) was determined.
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