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Grain yield and yield components at triticale under different technological conditions

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Abstract

The aim of this paper is to present the results regarding the yield and the yield components we have obtained at two triticale varieties studied under different preceding crops, different soil tillage conditions, and different nitrogen application conditions. In this respect, two triticale varieties (Tulus and Gorun 1) were studied under the following technological conditions: two preceding crop (sunflower and maize), two soil tillage (ploughing and harrowing), and six nitrogen application variants (0+0+0 kg.ha^{-1}, 40+40+40 kg.ha^{-1}, 40+80+0 kg.ha^{-1}, 0+40+80 kg.ha^{-1}, 0+80+40 kg.ha^{-1}, and 0+120+0 kg.ha^{-1}, respectively first application in autumn, before seedbed preparation, second application in spring, in the tillering growing stage, and third application in spring, in the two nodes growing stage). Researches were performed in a field experiment under rainfed conditions in the agricultural year 2013-2014. The field experiment was located on a reddish preluvosoil within the Experimental Farm Moara Domneasca (44°29'44'' North latitude and 26°15'28.5'' East longitude) belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest. There were determined the yield at 14% moisture content, the number of ears per square meter, the yield components of the ears (ear length; number of fertile spikelets per ear; number of sterile spikelets per ear; number of grains per ear; number of grains per spikelet; grain weight per ear), and the yield quality (thousand grain weight, hectoliter weight, protein contend and starch content of the grains).

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Keywords: triticale; grain yield; yield components; preceding crop; soil tillage; nitrogen fertilization.

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1. Introduction

Being obtained by crossing the wheat with rye, triticale (x *Triticosecale* Wittmack) is a man-made crop designed to combine the good quality and high yielding capacity of the wheat crop with the tolerance to abiotic and biotic stress factors of the rye crop (Epure et al., 2015).

Triticale is characterized by the capacity to resist to some unfavorable biotic and abiotic environmental factors, and as a consequence by the capacity to produce good yield in marginal regions (Martinek et al., 2008). Triticale is a plant species which is characterized by high genetic potential for grain yield, as well as good nutritive properties of its grains (Biberdžic et al., 2012). Especially the new triticale varieties has a great capacity to use the environmental (soil and climatic) and technological conditions. Therefore, triticale can be characterized as a grains species belonging to the future for areas with limiting soil and climate conditions but also for intensive technological conditions (Dumbrava et al., 2014). It is a potential cereal to give better yield under moister stressed condition (Mohammad et al., 2011; Drăghici, 2012), but it has the ability to produce increased grains and biomass yields under various soil and climatic conditions (Ittu et al., 2001; Burdujan et al., 2014). The capacity of triticale crop to perform well under limited growing conditions made possible the cultivation of this plant in the world on more than 3 million hectares every year since 2002, according to FAO database, the tendency being to exceed 4 million hectares in the last years (Ion et al., 2015).

Grain yield is usually positively correlated with all its components (Kozak et al., 2007). A great influence on the grain yield at triticale has the number of ears on square meter. But, a significant influence on the grain yield has also the yield components of the ear, respectively: ear length; number of fertile spikelets per ear; number of sterile spikelets per ear; number of grains per ear; number of grains per spikelet; grain weigh per ear; thousand grain weight. All these yield components are influenced by different environmental and technological factors. Among the technological factors there are counting the preceding crop, soil tillage, and fertilization conditions, especially nitrogen fertilization.

The preceding crop has a great importance on the crop yielding capacity, being essential to be established an appropriate crop rotation.

In modern agriculture a trend is observed to abandon the traditional soil cultivation for different variants of minimum and even zero tillage system (Jaśkiewicz, 2016). Therefore, it is of interest to understand at different crops, including triticale, the interaction of the soil tillage system associated with different preceding crops and different fertilization conditions.

Nitrogen fertilizer application at different plant stages has an essential effect on the grain yield quality (Alaru, 2004). Understanding the fertilization effect has been a continuous endeavor toward improving fertilization technology and strategy to reduce the negative impacts to increase the crop yield (Janušauskaitė, 2013).

The aim of this paper is to present the results regarding the yield and the yield components we have obtained at two triticale varieties studied under different preceding crops, different soil tillage conditions, and different nitrogen application conditions.

2. Materials and Methods

2.1. Experimental design

Researches were performed in the agricultural year 2013/2014 in a field experiment under rainfed conditions. The field experiment was located within the Experimental Farm Moara Domneasca (44°29'44'' North latitude and 26°15'28.5'' East longitude) belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest.

Two triticale varieties (Tulus and Gorun 1) were studied under the following conditions: two preceding crops, respectively sunflower and maize; two soil tillage, respectively ploughing and harrowing; six nitrogen application variants, respectively 0+0+0 $kg.ha^{-1}$, 40+40+40 $kg.ha^{-1}$, 40+80+0 $kg.ha^{-1}$, 0+40+80 $kg.ha^{-1}$, 0+80+40 $kg.ha^{-1}$, and 0+120+0 $kg.ha^{-1}$.

2.2. Crop management

For the variants with ploughing as soil tillage, there was performed one harrowing work at a depth of 12 cm, on 26th of September 2013, which was followed by ploughing performed at a depth of 18 cm two days later, respectively on 28th of September 2013.

For the variants with harrowing as soil tillage, there were performed two harrowing works at a depth of 12 cm, on 26th of September 2013.

Seedbed preparation was performed on 29th of October 2013, by two passages with a seedbed cultivator for the variants with ploughing as soil tillage, and by one passage with a seedbed cultivator for the variants with harrowing as soil tillage.

Sowing was performed in the same day as seedbed preparation, at 12.5 cm row spacing and at a density of 600 germinal seeds per square meter.

Nitrogen applications were performed as follows: first application of nitrogen was in autumn, before seedbed preparation (on 29th of October, 2013); second application of nitrogen was in spring, in the tillering growing stage (on 14th of March, 2014); third application of nitrogen was in spring, in the two nodes growing stage (on 26th of April, 2014).

In the spring, the weed control was performed by the help of herbicide Dicopur Top 464 SL (344 g/l acid 2.4 D from SDMA + 120 g/l dicamba) at a rate of 1 $l.ha^{-1}$. The herbicide application was performed on 2nd of April 2014.

2.3. Soil and climatic data

For the area where the field experiment was performed, the specific soil is reddish preluvosoil, which is characterized by the humus content between 2.2 and 2.8%, a clay loam texture, and a pH between 6.2 and 6.6.

In the studied area, during the nine months of interest for triticale plant growth, respectively from September 2013 to June 2014, the average temperature was 9.5°C, while the multiannual average temperature is 8.5°C. For the same period, the sum of rainfall was 572 mm, while the multiannual average rainfall is 408.9 mm.

2.4. Determinations and data analysis

The yield determinations were performed at fully maturity stage, by cutting and then harvesting the triticale plants by the help of a thrasher. The samples were obtained from four rows of plants on 1 m length, which represents 0.5 m^2 for each experimental variant. The grains were weighted and their mass was reported at hectare and expressed in $kg.ha^{-1}$. For each grain sample, the grain moisture content was determined by the help of a moisture analyzer. Then, the yield was calculated at 14% moisture content.

Also, it was determined the number of ears per square meter. But, for the experimental variants having maize as preceding crop and ploughing as soil tillage, we were not able to take valid samples of plants because of the high plant heterogeneity, which was due to the poor and staggered plant emergence.

For each experimental variant, ten triticale ears were taken and analyzed into laboratory for determining the yield components of the triticale ears, respectively: ear length; number of fertile spikelets per ear; number of sterile spikelets per ear; number of grains per ear; number of grains per spikelet; grain weight per ear.

The grain samples coming from thrasher, after their weighting and moisture analyze, there were used to be determined the yield quality, respectively: thousand grain weight, hectoliter weight, protein contend and starch content of the grains.

The obtained data were statistically processed by analysis of variance (ANOVA).

3. Results and Discussions

3.1. Ear density

The most important factor for high yield is the number of productive stems (number of ears) per area unit (Skuodienė and Nekrošienė, 2009). Regarding this important yielding component, respectively the ear density expressed as number of ears per square meter, the studied varieties reacted differently depending on the preceding crop and soil tillage, regardless of nitrogen fractionation (Figure 1).

Gorun 1 variety achieves higher ear densities than Tulus variety. It can be observed that Gorun 1 variety achieves densities of over 500 ears/m^2 when sunflower is the preceding crop and lower densities after maize as preceding crop, in the same fertilization and soil tillage conditions, respectively harrowing conditions. In case of Tulus variety, the ear density was lower regardless of the preceding crop and soil tillage but with the highest values when the preceding crop was maize and in harrowing conditions.

For the variant without nitrogen application the ear density was below 400 ears/m^2 regardless the preceding crop and soil tillage. The variants with nitrogen applied in the autumn realized the highest values of the ear density.

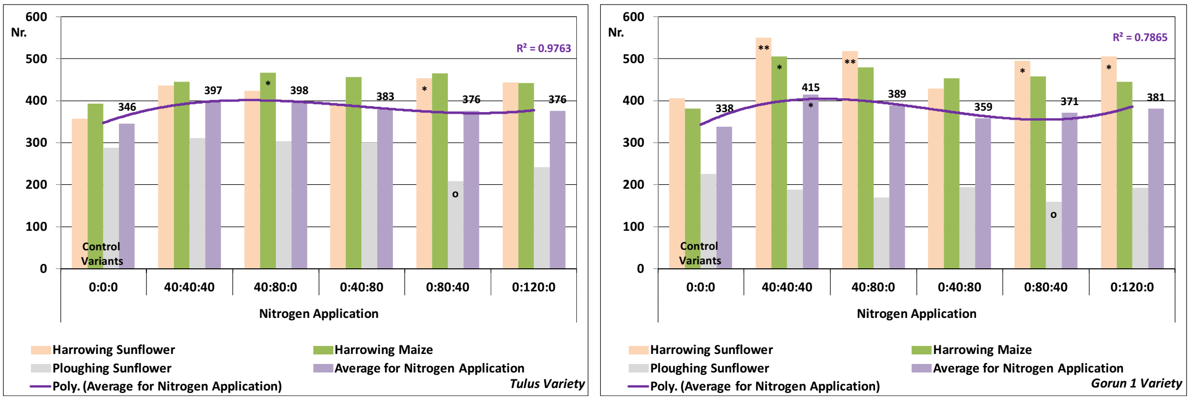

Fig. 1. Ear density at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.2. Ear length

Regarding the ear length it can be observed that Tulus variety achieved longer ears than Gorun 1 variety regardless of preceding crop, soil tillage and nitrogen application, this yield component being correlated negatively with the number of ears/m^2 (Figure 2).

In case of Tulus variety, the ear length has values of over 11 cm for the majority of variants compared with Gorun 1 variety in which the ear length is over 8 cm in the same variants. The increase of ear length can be observed in variants where nitrogen was applied fractionated and in higher doses in the tillering growing stage favoring the yield components at ear level compared with nitrogen applied in three equal fractions or fully applied in the tillering growing stage.

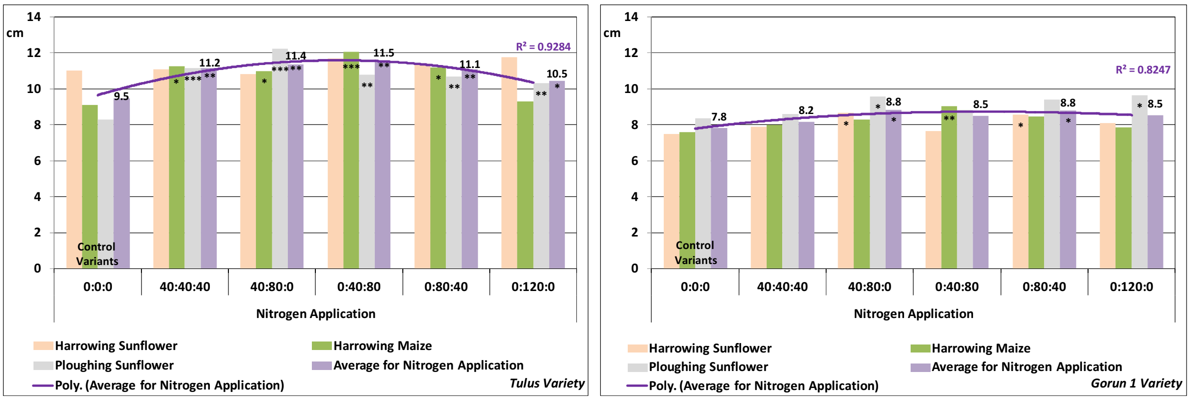

Fig. 2. Ear length at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.3. Number of fertile spikelets per ear

The number of fertile spikelets per ear is higher in case of Tulus variety, which has a lower number of ears/m^2, compared to Gorun 1 variety. The number of fertile spikelets per ear is rising in the variants where the nitrogen was applied at a rate of 80 kg/ha in the tillering growing stage for Tulus variety and in the two nodes growing stage for Gorun 1 variety. A higher number of spikelets per ear (over 30) can be observed when the preceding crop is maize, in harrowing conditions and when applying 80 kg N/ha during differentiation of yield components at ear level (Figure 3).

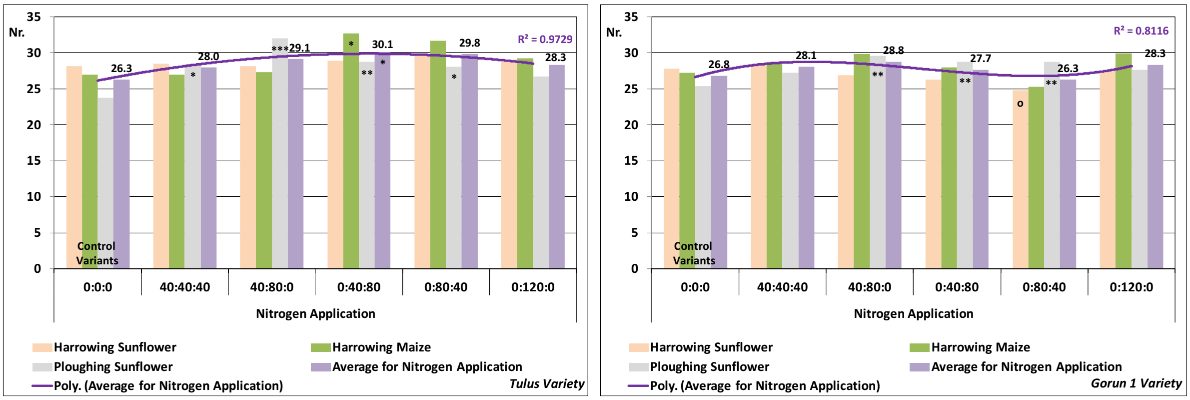

Fig. 3. Number of fertile spikelets per ear at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.4. Number of sterile spikelets per ear

Compared with Gorun 1 variety in which the number of sterile spikelets per ear is relatively homogeneous between the experimental variants, at Tulus variety the number of sterile spikelets per ear is rising when the preceding crop is sunflower and in ploughing conditions and reduces when applying 80 kg N/ha in the early spring (in the tillering growing stage) and at the mid-term of stem elongation, respectively in the two nodes growing stage (Figure 4).

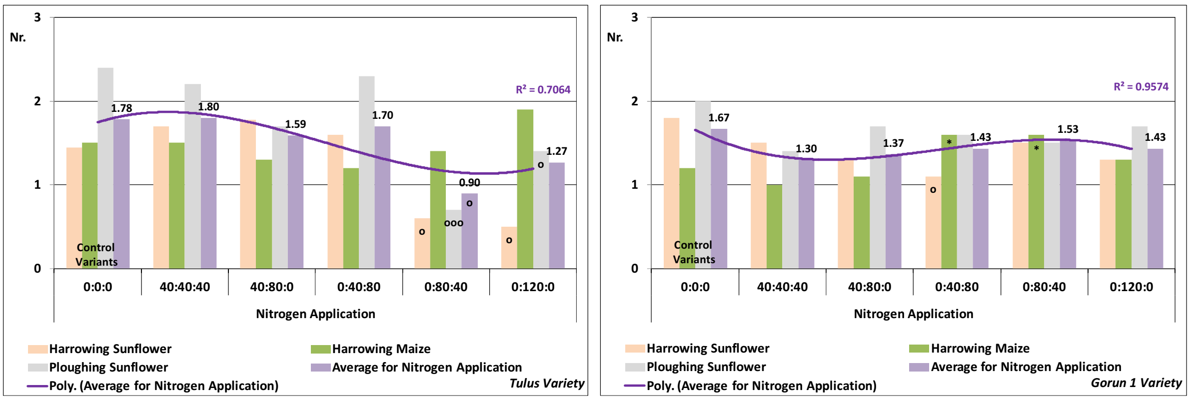

Fig. 4. Number of sterile spikelets per ear at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.5. Number of grains per ear

Compared with Gorun 1 variety, at Tulus the number of grains per ear is higher. The highest number of grains per ear is registered at Tulus variety in ploughing conditions, when applying 80 kg N/ha at the mid-term of stem elongation regardless of the preceding crop. The full application of nitrogen in the early spring reduces considerably the number of grains per ear. At Gorun 1 variety the number of grains per ear is rising in ploughing conditions and when most of the nitrogen was applied in the early spring and at the mid-term of the stem elongation (Figure 5).

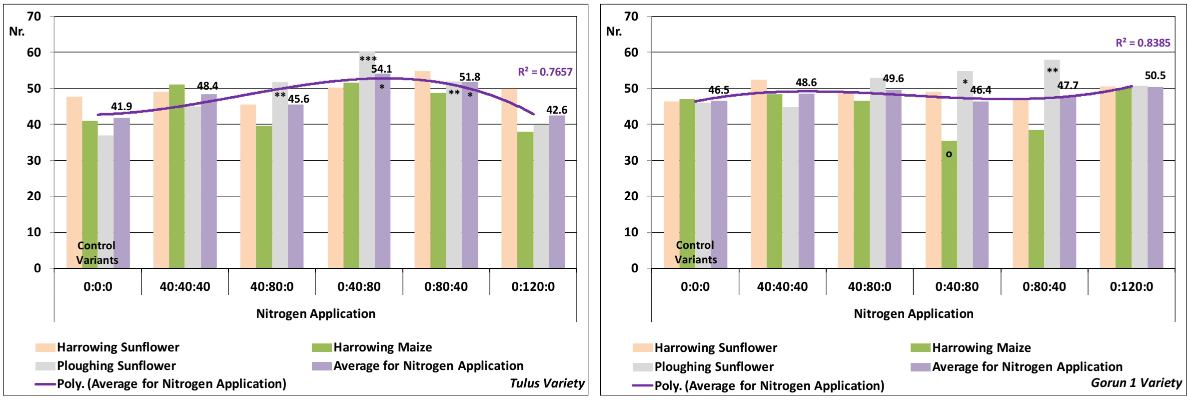

Fig. 5. Number of grains per ear at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.6. Number of grains per spikelet

In case of Tulus variety, the number of grains per spikelet is rising in ploughing conditions, after sunflower and when applying 80 kg N/ha at the mid-term of stem elongation (two nodes growing stage). In case of Gorun 1, this variety capitalizes better the nitrogen applied in the early spring (Figure 6).

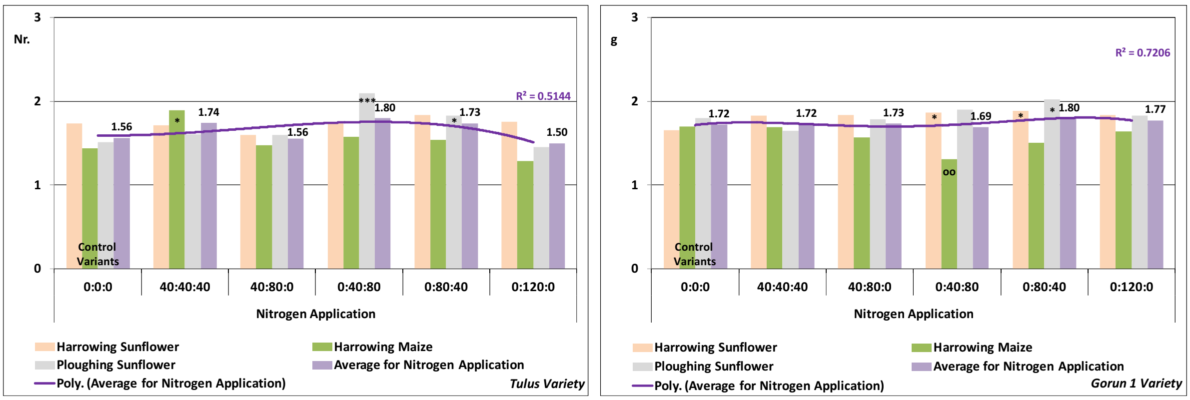

Fig. 6. Number of grains per spikelet at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.7. Grains weight per ear

The grain weight per ear is higher in Tulus variety compared with Gorun 1 variety. At Tulus variety the grain weight per ear increases greatly after sunflower, in ploughing conditions and when applying 80 kg N/ha in the early spring or at the mid-term of stem elongation but reduces in all experimental variants in case of full application of nitrogen in the early spring (Figure 7).

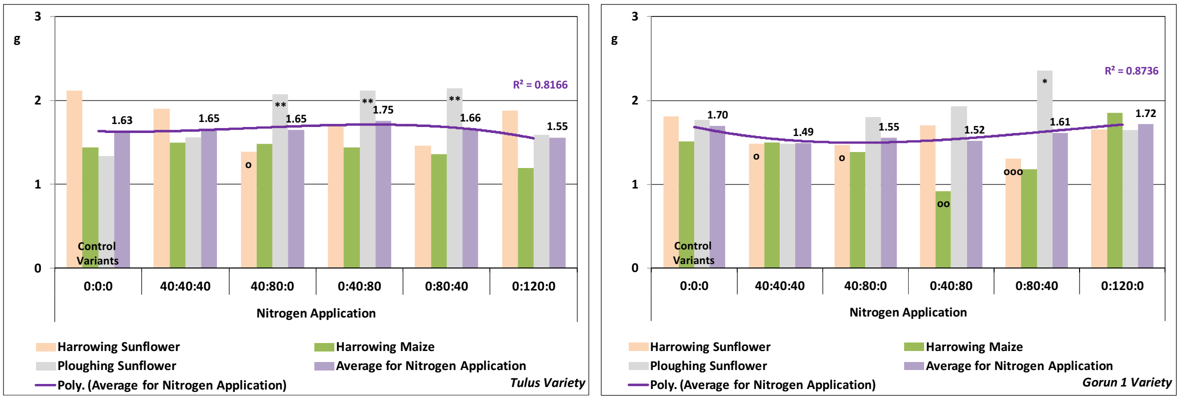

Fig. 7. Grains weight per ear at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.8. Thousand grain weight

The 1000-grain weight is influenced significantly by the number of ears/m^2, the number of grains per ear and the grain weight per ear. The highest values of the 1000-grain weight (TGW) are registered in unfertilized variants on which the number of ears/m^2 and the number of grains per ear are lower. In the variants with high densities of ears/m^2 and high number of grains per ear, TGW has the lowest values (Figure 8).

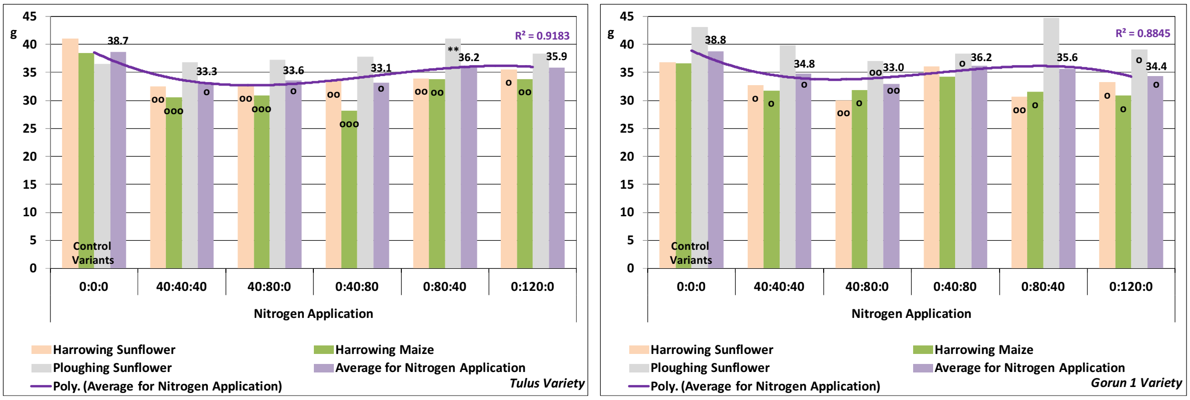

Fig. 8. Thousand grain weight at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.9. Grain yield at 14% moisture content

The grain yield at 14% humidity is higher in case of Gorun 1 variety compared with Tulus variety for most of experimental variants. Gorun 1 variety achieves the highest grain yields in harrowing conditions, regardless of the preceding crop and nitrogen fractionation (Figure 9).

When the preceding crop is sunflower, the grain yield varies between 5500 and 6100 kg.ha^{-1} for most of experimental variants and for Gorun 1 variety. In case of Tulus variety, the grain yield ranges between 4100 and 4500 kg/ha for most of experimental variants, regardless of the nitrogen fractionation. It has to be underlined that good grain yields were achieved in the variants with nitrogen application in the autumn.

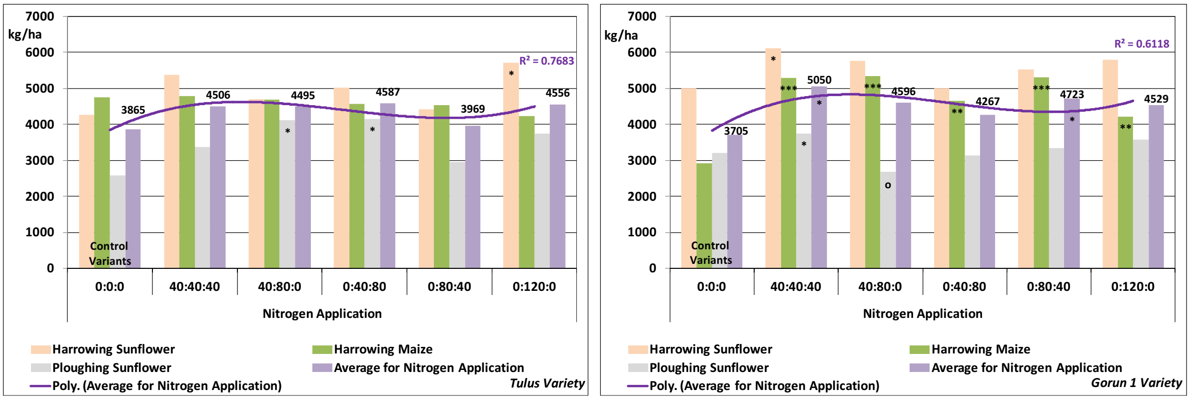

Fig. 9. Grain yield at 14% moisture content at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.10. Hectoliter weight

The hectoliter weight registers large variations according to technological conditions (preceding crop, soil tillage, and nitrogen fertilization conditions). However, the highest values of the hectoliter weight are registered in ploughing conditions regardless of the preceding crop and nitrogen fractionation (Figure 10).

In the unfertilized variant the high values of the hectoliter weight are determined by the small number of ears/m^2 and the small number of grains per ear, which have influenced the apparent density of grains.

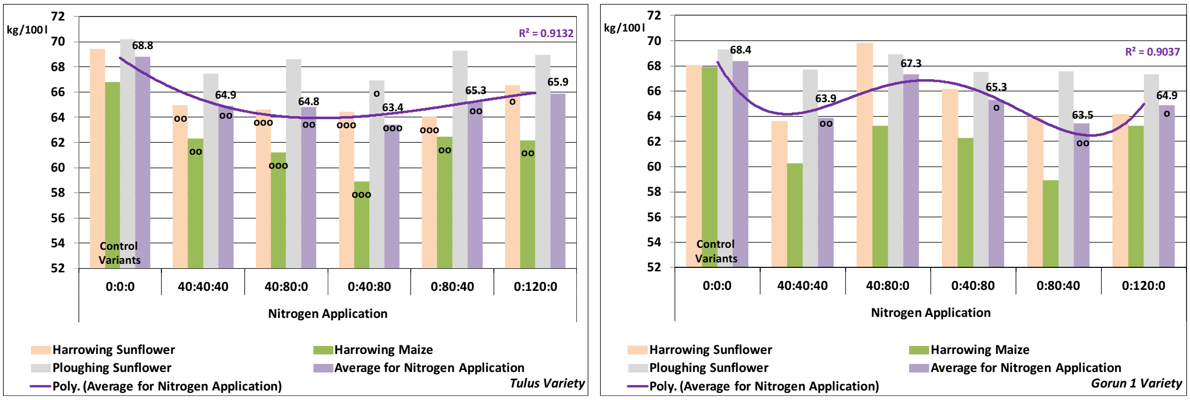

Fig. 10. Hectoliter weight at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.11. Grain protein content

The protein content of the triticale grains was influenced significantly by variety, preceding crop, soil tillage, and nitrogen fertilization (Figure 11).

In case of variants with nitrogen application, the protein content ranges from 11 to more than 14%, while for the unfertilized variants the protein content was below 11%. So, the lowest protein content of the triticale grains was registered at the unfertilized variant.

Gorun 1 has realized higher values of the protein content than Tulus variety. The highest protein content was registered in the case of variants fertilized with nitrogen in spring in both growing stages, respectively in the tillering growing stage and in the two nodes growing stage. Also, the highest protein content was registered in the case of harrowing as soil tillage compared to plowing. But, the differences determined by the preceding crop were small.

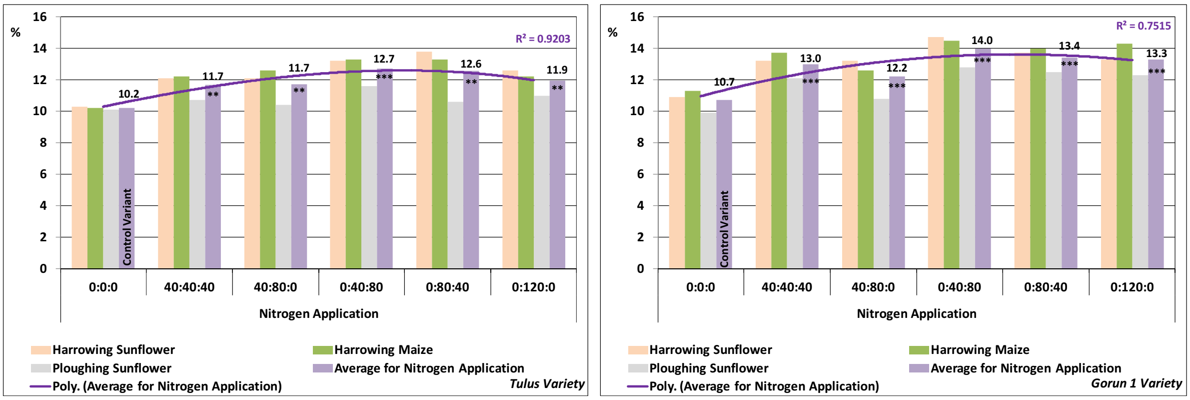

Fig. 11. Grain protein content at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

3.12. Grain starch content

The starch content of the triticale grains correlated negatively with the protein content. Thus, Tulus variety has realized higher values of the starch content then Gorun 1 variety. The highest starch content was registered in the unfertilized variant, regardless of variety, preceding crop and soil tillage. Also, the highest starch content was registered in the variants with plowing as soil tillage (Figure 12).

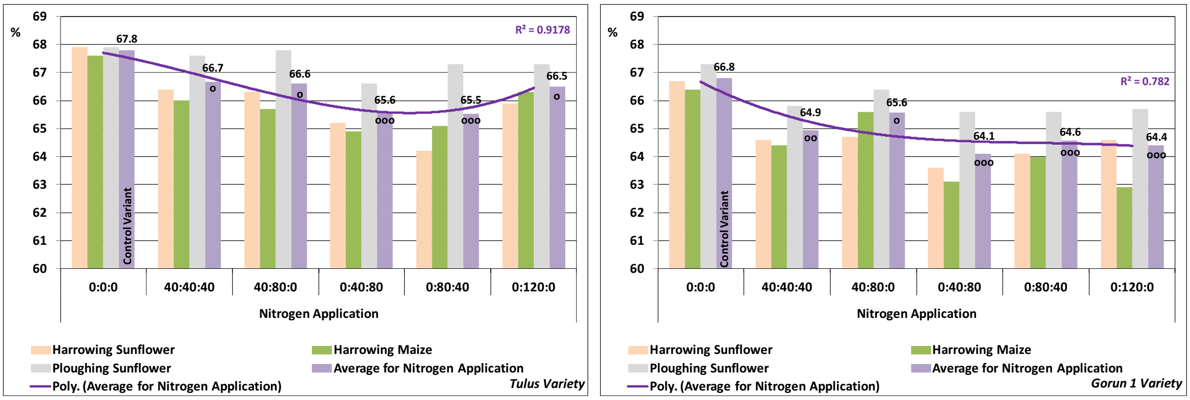

Fig. 12. Grain starch content at at the two triticale varieties studied under different preceding crops, soil tillage and nitrogen fertilization conditions.

4. Conclusions

Triticale is a cereal species with a high ecological plasticity that makes a better use of climatic and soil conditions than other crops.

The studied varieties reacted differently in the specific climatic conditions of 2014 after the preceding crops sunflowers and maize and under the different soil tillage conditions and nitrogen fertilization in the growing stages when the yielding components of the ear are developing.

Tulus variety reacted more favorable when the minimum soil tillage was performed after sunflowers as preceding crop and when nitrogen was applied in spring, in the two nodes growing stage, this being suitable for intensive technologies.

Gorun 1 variety shows rusticity characteristics which are manifested by higher yields in the case of sunflower as preceding crop and in the case of nitrogen application in the growing stages with high nitrogen consumption.

Triticale responds more favorable, with higher yields than those obtained at wheat and maize when intensive technologies are practiced in the limited soil and climatic conditions.

5. Acknowledgements

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