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RESULTS REGARDING YIELD COMPONENTS AND GRAIN YIELD AT SUNFLOWER UNDER DIFFERENT ROW SPACING AND NITROGEN FERTILISATION CONDITIONS

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Abstract

The elements that are participating in the yield formation, respectively the so called yield components, and the yielding capacity are specific features to the cultivated variety, but these are influenced by the growing conditions which are given by the environmental and technological factors. From this perspective, the aim of this paper is to present the results regrading yield components and grain yield obtained at two sunflower hybrids cultivated at different row spacing and nitrogen fertilisation conditions. In this respect, a field experiment was performed in the climatic condition of 2016 on a reddish preluvosoil from South Romania. The field experiment consisted in sowing two sunflower hybrids under four nitrogen fertilisation conditions (N_0; N_{50}; N_{100}; N_{50+50}) and at two row spacing conditions (70 and 50 cm). The following yield components were determined: head diameter, number of grains per head, grain weight per head, and thousand grain weight (TGW). The grain yield was calculated at 9% moisture content and was expressed in kg.ha^{-1}. Under the specific experimental growing conditions, nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg.ha^{-1} increased the grain yield and the yield components, except TGW which tended to be more related to the sunflower hybrid. The average grain yield was higher for row spacing of 70 cm than that registered at row spacing of 50 cm. The two studied sunflower hybrid reacted in their own way to the nitrogen fertilisation conditions as well as to the row spacing conditions.

Key words*: sunflower, yield components, grain yield, nitrogen fertilisation, row spacing.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a temperate zone crop, which can perform well under a variety of climatic and soil conditions (Canavar et al., 2010), and fits well into various cropping systems (Pattanayak et al., 2016). Combining a high yield potential with a great adaptation capacity (Agele, 2003), this is one of the most important oil crop in the world, with a harvested area which increased from 6.6 million ha in 1961 to 26.2 million ha in 2016, according to FAO data (FAOSTAT database).

For Romania, sunflower represents the most important oil crop, with a harvested area which increased spectacularly over the last century, respectively from 672 ha in 1910, when sunflower appeared for the first time in statistics in Romania, to about one million ha per year in the period 2012-2017. In present, Romania has the highest sunflower harvested area in European Union. This is explaining by the favourable growing conditions Romania has for sunflower crop, with a real potential for developing further this crop by increasing first of all the yield (Ion et al., 2013).

The elements that are participating in yield formation, respectively the so called yield components, and the yielding capacity are specific features to the cultivated variety, but these are influenced by the growing conditions which are given by the environmental and technological factors.

The yield of a sunflower hybrid is conditioned by its capacity to use efficiently the environmental variables in different phenophases (Gonzáles et al., 2013). From this perspective, sunflower seed yield is a very complex trait and it is very dependent on environmental conditions (Jockovic et al., 2015).

Agronomic practices in addition to high yielding varieties are important items for higher productivity of the sunflower crop (Beg et al., 2007). Among the technological factors with an important contribution upon the values of the yield components and, finally, on the grain yield, there are counted the nitrogen fertilisation conditions, respectively the nitrogen rate and eventually its splitting in different moments of application, and row spacing which for a given plant population is determining the shape of the nutritional space.

Sunflower yield could be increased by fertilizer application, particularly nitrogen, which is an essential major mineral nutrient for plant growth and development (Ali et al., 2012), which has the greatest impact on seed size, leaf size and number of leaves, test weight and yield (Toosi, Azizi, 2014).

Nitrogen fertilisation and increasing of nitrogen rate increase the sunflower yield due to the increasing of the values of yielding components (Gholinezhad et al., 2009). However, sunflower yield response to increasing nitrogen rate varies with different environmental variables, including weather, soil type, residual fertility (especially nitrate), soil moisture, and cultivar (Killi, 2004).

Sunflower crop can be grown over different row spacing conditions. The experimental results show that different planting patterns sometimes produced higher yield, but not always (Zarea et al., 2005). Narrow rows make sunflower plants able to use in an efficient way the growing resources, respectively the solar radiation, water and nutrients, but this seems to be influenced by the specific environmental factors (Ion et al., 2015).

The aim of this paper is to present the results regrading yield components and grain yield obtained at two sunflower hybrids cultivated at different row spacing and nitrogen fertilisation conditions.

MATERIALS AND METHODS

Researches were performed in a field experiment under rainfed conditions in the year 2016. The field experiment was located within Moara Domnească Experimental Farm (44°29' N latitude and 26°15' E longitude), belonging to the University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania.

The field experiment was performed on a reddish preluvosoil with the following characteristics: humus content between 2.2 and 2.8%; clay loam texture; pH between 6.2 and 6.6.

The year 2016 was characterised by the following climatic conditions for the period April-August: 20.1°C the average temperature; 284 mm the sum of rainfall. As multiannual average values, the climatic conditions for the period April-August are the following: 18.5°C the multiannual average temperature; 313.2 mm the multiannual average rainfall. By reporting the climatic conditions of the year 2016 to the multiannual average values in the studying area, it results that the year 2016 can be characterised as being warmer and drier than normal years.

The field experiment consisted in sowing two hybrids which are representative for sunflower cultivation in Romania (Performer and P64LE19) under the conditions of two row spacing (70 cm and 50 cm) and four nitrogen conditions (N_0 = 0 kg ha^{-1}; N_{50} = 50 kg ha^{-1}; N_{100} = 100 kg ha^{-1}; N_{50+50} = 50+50 kg ha^{-1}). Nitrogen fertilisation was performed immediately after sowing (1st of April 2016), except for the experimental variant N_{50+50}, which consisted in applying half of nitrogen rate (50 kg ha^{-1}) just after sowing and the other half of nitrogen rate (50 kg ha^{-1}) in the growth stage of six leaves, respectively the BBCH code 16 (27th of May 2016). The used fertilizer was the ammonium nitrite with a nitrogen content of 33.5%.

The field experiment was organised in split plots with 16 experimental variants (2 hybrids x 2 row spacing x 4 nitrogen fertilisations). Each experimental variant consisted in six lines with a length of 8 m.

The preceding crop was maize. The soil tillage consisted in ploughing performed on 30th of October 2015, one harrow work performed on 18th of March 2016 followed by one combinator work performed on 28th of March 2016. Sowing was performed by the help of a manual planter on 1st of April 2016, and the plant density was of 60,000 plants ha^{-1}. The weed control was performed by two manual hoeing.

In the stage of full maturity, the heads (capitulum) from one square meter (six heads) in each experimental variant were analysed. There were performed the following determinations of the yield components: head diameter (cm), number of grains (achenes) per head, grain weight per head (g), thousand grain weight - TGW (g). The grain moisture content was determined using a moisture analyser. Based on average grain weight per head, plant population and grain moisture content, the grain yield was calculated at 9% moisture content and was expressed in kg.ha^{-1}. Obtained data were statistically processed using the analysis of variance (ANOVA). The variants with the nitrogen rate of 0 kg ha^{-1} were taken as control variants for each row spacing and sunflower hybrid.

RESULTS AND DISCUSSIONS

Head diameter. In the studied area and in the climatic conditions of 2016, the head diameter registered values between 11.2 and 14.4 cm, according to sunflower hybrid, row spacing and nitrogen fertilisation conditions (Figure 1).

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the head diameter, but statistically differences compared to N_0 variant were registered only for the variant N_{100} at Performer hybrid.

Splitting the nitrogen rate of 100 kg ha^{-1} in two applications of 50 kg ha^{-1} leaded to a further increase in the head diameter for Performer hybrid at row spacing of 70 cm, while for P64LE19 hybrid this leaded to an important decrease of the head diameter regardless the row spacing, respectively it determined the smallest values of the head diameter.

Regarding the row spacing, the average head diameter was 12.9 cm for the row spacing of 70 cm and 12.7 cm for the row spacing of 50 cm. As concerning the hybrid, the average head diameter was 13.1 cm for the Performer hybrid and 12.5 cm for P64LE19 hybrid.

Number of grains per head. In the studied area and the climatic conditions of 2016, the number of grains per head registered values between 674 and 1252, according to sunflower hybrid, row spacing and nitrogen fertilisation conditions (Figure 2).

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the number of grains per head, with statistically differences compared to N_0 variant registered for the variant N_{100} as well as for the variant N_{50+50} regardless hybrid and row spacing. Moreover, statistically differences were registered also for variant N_{50}, but only for row spacing of 70 cm at P64LE19 hybrid and only for row spacing of 50 cm at Performer hybrid.

Splitting the nitrogen rate of 100 kg.ha^{-1} in two applications of 50 kg.ha^{-1} leaded to a decrease in the number of grains per head for Performer hybrid regardless the row spacing, while for P64LE19 hybrid this leaded to a decrease in the number of grains per head for row spacing of 70 cm and to an increase in the number of grains per head for row spacing of 50 cm.

Regarding the row spacing, the average number of grains per head was 965 for the row spacing of 70 cm and 936 for the row spacing of 50 cm. As concerning the hybrid, the average number of grains per head was 844 for the Performer hybrid and 1056 for P64LE19 hybrid.

Grain weight per head. In the studied area and the climatic conditions of 2016, the grain weight per head registered values between 41.5 and 72.7 g, according to sunflower hybrid, row spacing and nitrogen fertilisation conditions (Figure 3).

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the grain weight per head, but statistically differences compared to N_0 variant were registered only for the variant N_{100} regardless row spacing and sunflower hybrid.

Splitting the nitrogen rate of 100 kg ha^{-1} in two applications of 50 kg ha^{-1} leaded to a further increase in the grain weight per head except for variant with row spacing of 50 cm at Performer hybrid.

Regarding the row spacing, the average grain weight per head was 59.9 g for the row spacing of 70 cm and 57.3 g for the row spacing of 50 cm. As concerning the hybrid, the average grain weight per head was 55.6 g for the Performer hybrid and 61.6 g for P64LE19 hybrid.

Thousand grain weight (TGW). In the studied area and the climatic conditions of 2016, TGW registered values between 54.1 and 74.6 g, according to sunflower hybrid, row spacing and nitrogen fertilisation conditions (Figure 4).

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased

TGW in the case of Performer hybrid and decreased TGW in the case of P64LE19 hybrid. There was registered a negative statistically difference compared to N_0 variant for P64LE19 sunflower hybrid at nitrogen rate of 50 kg ha^{-1} and row spacing of 70 cm.

Splitting the nitrogen rate of 100 kg ha^{-1} in two applications of 50 kg ha^{-1} leaded to a further increase in TGW in the case of variant with row spacing of 70 cm regardless the hybrid.

Regarding the row spacing, the average TGW was 62.1 g for the row spacing of 70 cm and 61.6 g for the row spacing of 50 cm. As concerning the hybrid, the average TGW was 65.2 g for the Performer hybrid and 58.5 g for P64LE19 hybrid.

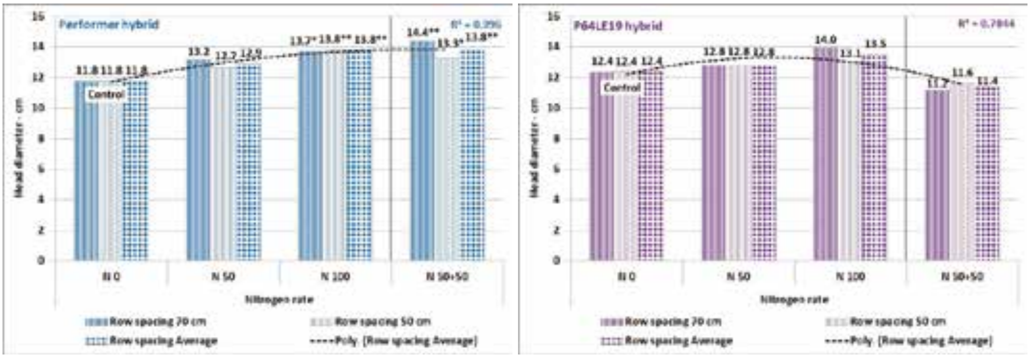

Figure 1. Head diameter at different sunflower hybrids, row spacing and nitrogen fertilisation conditions

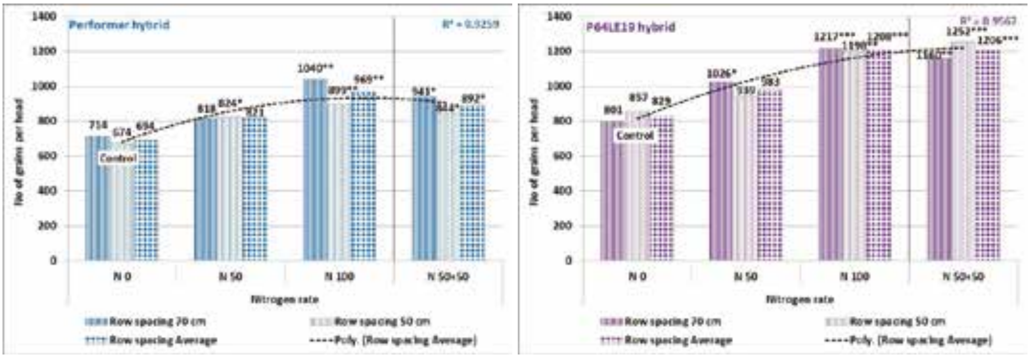

Figure 2. Number of grains per head at different sunflower hybrids, row spacing and nitrogen fertilisation conditions

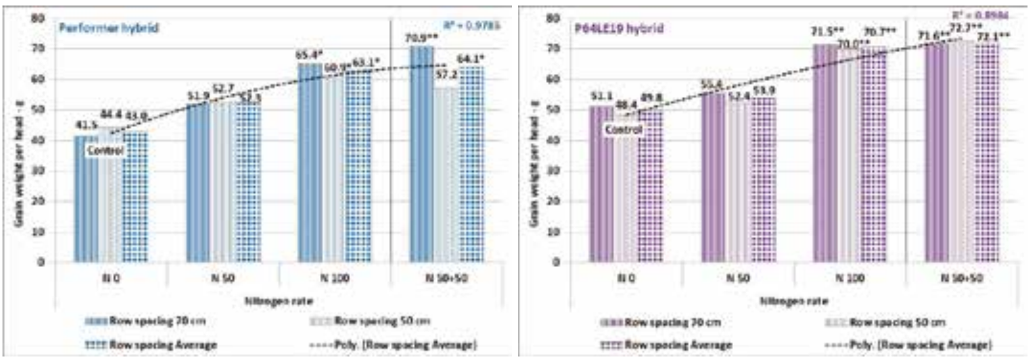

Figure 3. Grain weight per head at different sunflower hybrids, row spacing and nitrogen fertilisation conditions

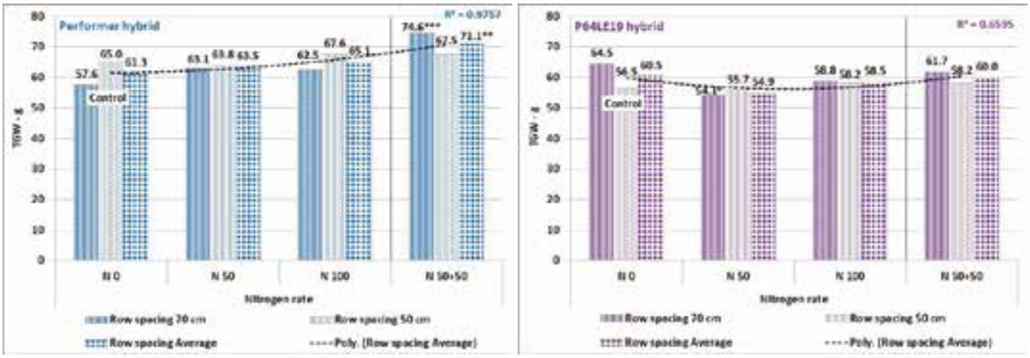

Figure 4. Thousand grain weight (TGW) at different sunflower hybrids, row spacing and nitrogen fertilisation conditions

Grain yield at 9% moisture content of grains. In the studied area and the climatic conditions of 2016, the grain yield registered values between 2585 and 4501 kg ha^{-1}, according to sunflower hybrid, row spacing and nitrogen fertilisation conditions (Figure 5).

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the grain yield with statistically differences compared to N_0 variant registered for the variant N_{100} for both hybrids and row spacing (Figures 5 and 6.a).

Splitting the nitrogen rate of 100 kg ha^{-1} in two applications of 50 kg ha^{-1} leaded to a further increase in grain yield in the case of variant with row spacing of 70 cm at Performer hybrid and in the case of variant with row spacing of 50 cm at P64LE19 hybrid, this experimental variant giving the highest grain yield, with statistically differences compared to N_0 variant (Figure 5).

In average for the field experiment, the highest grain yield was registered in the case of splitting the nitrogen rate of 100 kg ha^{-1} in two applications of 50 kg ha^{-1} (Figure 6.a).

Regarding the row spacing, the average grain yield was 3710 kg ha^{-1} for the row spacing of 70 cm and 3556 kg ha^{-1} for the row spacing of 50 cm (Figure 6.b). As concerning the hybrid, the average grain yield was 3450 kg ha^{-1} for the Performer hybrid and 3816 kg ha^{-1} for P64LE19 hybrid (Figure 6.b).

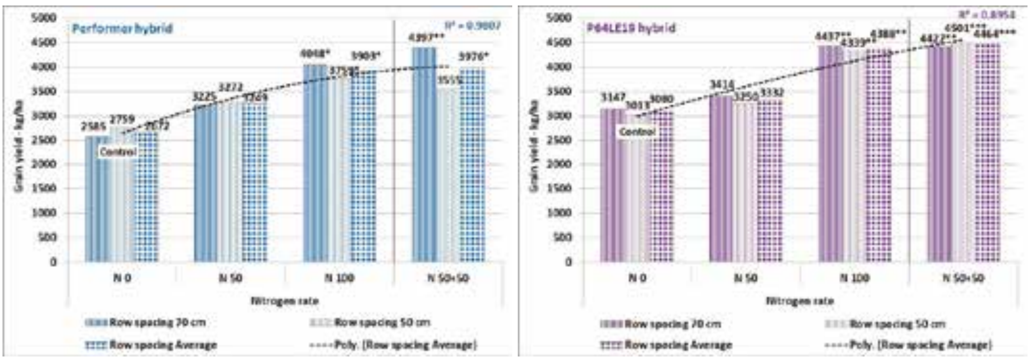

Figure 5. Grain yield at 9% moisture content of grains at different sunflower hybrids, row spacing and nitrogen fertilisation conditions

The values of the yield components and grain yield are smaller for the studied area because of the climatic conditions of the year 2016, which can be characterised from this point of view as being warmer and drier than normal years. Also, it has to be mentioned that the plant density of 60,000 plants ha^{-1} is at the upper threshold for the rainfed conditions in the studied area.

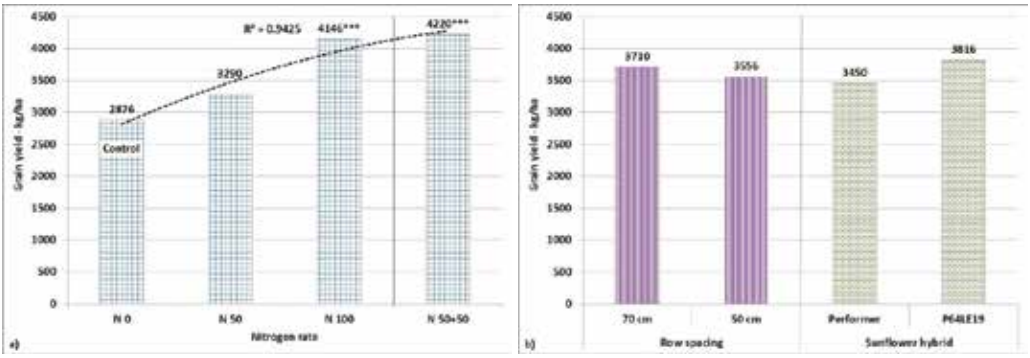

Figure 6. Average grain yield at different nitrogen fertilisation conditions (a)
and at different row spacing and sunflower hybrids (b)

Nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the grain yield and the values of the following yield components: head diameter, number of grains per head, grain weight per head.

These findings are according to those find out of other authors. Thus, Escalante Estrada et al. (2015) found in a field experiment, which was performed at sunflower in Montecillo in Mexico, that grain yield, grain number and the capitulum area showed significant increases due to nitrogen application. Ali et al. (2012) found in a field experiment, which was performed at sunflower in the years 2010 and 2011 at Sargodha in Pakistan, that nitrogen application markedly enhanced growth and yield by affecting plant height, head diameter and thousand grains weight. Baig et al. (2016) found in a field experiment, which was performed at sunflower in the years 2012 and 2013 at Islamabad in Pakistan, that the number of achenes per head, thousand grains weight, and achene yield increased with increased nitrogen application. Similar results were found out at confectionary sunflower in field experiments performed in Turkey by Killi (2004) as well as by Day and Kolsarici (2016).

Unlike that Ali et al. (2012), Baig et al. (2016), Killi (2004), and Day and Kolsarici (2016) found that nitrogen increased the thousand grains weight (TGW), our results showed that nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg.ha^{-1} increased TGW in the case of Performer hybrid and decreased TGW in the case of P64LE19 hybrid. So, in our study, the sunflower hybrids registered different reactions of the yield components and grain yield, but specially concerning the TGW. Ali et al. (2012) found also that sunflower hybrids showed significant differences in case of head diameter.

In fact, each sunflower hybrid is defined by specific traits which determine a specific reaction to a certain growing factor. In our case, Performer hybrid is a mid-late hybrid while P64LE19 is a mid-early hybrid, each of them reacting in its own way to the nitrogen fertilisation conditions as well as to the row spacing conditions.

Despite the fact that Performer hybrid had larger heads than P64LE19 hybrid, the number of grains (achenes) per head was smaller for Performer hybrid than P64LE19 hybrid. That means that the P64LE19 hybrid had a better central area of head filled with grains. Also, the Performer hybrid had TGW with higher values than P64LE19 hybrid, which could be explained by the negative correlation between the number of grains per head and TGW value, which means that for smaller number of grains per head the TGW value is higher. But, despite the P64LE19 hybrid has smaller TGW values, because of the higher number of grains per head it registered higher grain weight per head, which leaded finally, for the same plant population, to a higher grain yield expressed in kg ha^{-1}.

The two experimented sunflower hybrids reacted quite different at splitting the nitrogen rate of 100 kg ha^{-1} in two applications, respectively 50 kg ha^{-1} nitrogen rate applied just after sowing and 50 kg ha^{-1} of nitrogen rate applied in the growth stage of six leaves. Splitting the nitrogen rate of 100 kg ha^{-1} in two applications leaded to the highest grain yields, but while the highest grain yield at Performer hybrid was registered at the row spacing of 70 cm, for the P64LE19 hybrid the highest grain yield was registered at the row spacing of 50 cm. In average for the whole field experiment, the highest grain yield was registered in the case of splitting the nitrogen rate of 100 kg ha^{-1} in two applications.

As concerning the row spacing, generally the yield component values were in favour of row spacing of 70 cm compared to row spacing of 50 cm, which leaded to an average grain yield higher for row spacing of 70 cm than that registered at row spacing of 50 cm. As in the case of the nitrogen fertilisation conditions, the two sunflower hybrids reacted in a specific way to the row spacing conditions.

In the same area, in the field experiments performed in 2013 and 2014, the results showed that the optimal row spacing depended on growing conditions, the highest yields being obtained at row spacing of 75 cm under favourable growing conditions and at narrow rows under less favourable growing conditions, especially at row spacing of 50 cm (Ion et al., 2015). Taking into account these findings and the results we have obtained in 2016, one makes us conclude that there are necessary further studied and experiments related to the effect of row spacing upon grain yield and yield components at sunflower.

There are authors who obtained higher grain yields at row spacing of 75 cm than at row spacing of 50 cm (Diepenbrock et al., 2001; Kazemeini et al., 2009) or obtained higher grain yields at row spacing of 60 cm than at row spacing of 45 or 30 cm (Nawaz et al., 2001), while other authors obtained higher grain yields at narrow rows (Zarea et al., 2005).

CONCLUSIONS

For the specific growing conditions from South Romania, in the climatic conditions of 2016 and on a reddish preluvosoil, nitrogen fertilisation and increasing the nitrogen rate from 50 to 100 kg ha^{-1} increased the grain yield and the values of the head diameter, number of grains per head, and grain weight per head, while TGW tended to be more related to the sunflower hybrid (TGW tended to increase at Performer hybrid and to decrease at P64LE19 hybrid).

Splitting the nitrogen rate of 100 kg ha^{-1} in two applications leaded to the highest grain yields for the two studied sunflower hybrids, but according to row spacing, respectively at row spacing of 70 cm for Performer hybrid and at row spacing of 50 cm for P64LE19 hybrid.

Generally, the yield component values were in favour of row spacing of 70 cm compared to row spacing of 50 cm, which leaded to an average grain yield higher for row spacing of 70 cm than that registered at row spacing of 50 cm, but these studies need further experiments for clarifications.

The two studied sunflower hybrids reacted in their own way to the nitrogen fertilisation conditions as well as to the row spacing conditions.

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