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ABOVE-GROUND BIOMASS OF SUNFLOWER PLANT UNDER DIFFERENT PLANTING PATTERNS AND GROWING CONDITIONS

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Abstract

Studies regarding the effect of different planting patterns are of great interest and importance, especially when they are performed in different growing conditions. Plant growth, plant biomass and plant yield are conditioned by factors such as row spacing and plant population, which are of great importance.
The aim of this study was to identify how the planting patterns, respectively row spacing and plant population, associated with diferent soil and climatic conditions, and sunflower hybrid are influencing the above-ground dry biomass of the whole plant and of the plant components. Also, the objective was to identify the share of dry biomass on different plant components, as well as the moisture content of the whole plant and its components. The determinations were performed in the early dough - dough growth stage of the sunflower plants.
Researches were performed in field experiments in the year 2013, in two locations from South Romania, respectively Fundulea (44°28' N latitude and 26°27'56" E longitude), and Moara Domneasca (44°29' N latitude and 26°15' E longitude). The studied sunflower hybrids were the followings: Pro 111, LG56.62, P64LE19, Pro 953. Each hybrid in the two locations was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and three plant populations (50,000, 60,000, and 70,000 plants ha^{-1}).

***Key words**: sunflower, plant biomass, row spacing, plant population, soil conditions.*

INTRODUCTION

Plant growth, plant biomass and plant yield are conditioned by different factors, amoung which the planting patterns are of great importance, respectively row spacing and plant population. Thus, Barros et al. (2004) revealed that uniform adjustment of the crop spacing in the field is one of the most important factors determining yield and quality of sunflower (Asghar et al. 2007).
Plant population based on row and plant spacing is a major part of agronomic practices (Beg et al., 2007). Increasing of plant population from 35,000 to 65,000 plants ha^{-1} led to the diminishing of dry biomass of sunflower plant (Ion et al., 2004; Stefan et al., 2008).
Barros et al. (2004) revealed that the highest plant density presented a significantly lower mean seed weight, probably this behaviour may be the result of a lower dry matter weight per plant in this plant density with the consequence of a reduced assimilate translocation during the seed filling period.
Romania has favourable conditions for growing sunflower (*Helianthus annuus* L.), this being the most important oil crop (Ion et al., 2013). From this perspective, studies regarding the effect of different planting patterns are of great interest and importance.
The aim of this study was to identify how the planting patterns, respectively row spacing and plant population, associated with diferent soil and climatic conditions, and sunflower hybrid are influencing the above-ground dry biomass of the whole plant and of the plant components. Also, the objective was to identify the share of dry biomass on different plant components, respectively leaves, stalk, and head, as well as to identify the moisture content of the whole plant and its components.

MATERIALS AND METHODS

Researches were performed in field experiments in 2013, in two locations from South Romania, respectively Fundulea (44°28' N latitude and 26°27'56" E longitude), Calarasi County, and Moara Domneasca (44°29' N latitude and 26°15' E longitude), Ilfov County. The soil from Fundulea area is chernozem (cambic chernozem soil), and the soil from Moara Domneasca area is reddish preluvosoil.

From September 2012 to August 2013, in Fundulea area the average temperature was of 12.0°C and the sum of rainfall of 700.6 mm, and in Moara Domneasca area the average temperature was of 12.6°C and the sum of rainfall of 288.0 mm.

The studied sunflower hybrids were the followings: Pro 111, LG56.62, P64LE19, Pro 953. Each hybrid in the two locations was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and three plant populations (50,000, 60,000, and 70,000 plants ha^{-1}).

The field experiments were performed in four replications, with a number of variants of 36. The sowing was performed on 17th of April at Fundulea and on 25th of April at Moara Domneasca. The cultivation technology was a regular one for South Romania, under rainfed conditions.

In each location and from each variant a number of three sunflower plants were cut at soil level and analyzed for determining the fresh biomass (above-ground biomass). The plants were weighed directly into the field as total and plant components, respectively leaves, stalk, and head. The components of one sunflower plant for each variant were taken into the laboratory for determining the dry biomass by oven drying at 80°C for 24 hours. The determinations were performed in the early dough - dough plant growth stage, respectively on 2nd of August at Fundulea (chernozem soil), and on 1st of August at Moara Domneasca (reddish preluvosoil).

Based on dry biomass of the plant components, it was established the share of the dry biomass on these components, respectively leaves, stalk, and head. Also, based on fresh and dry matter values, moisture content of the whole plant and plant components was calculated.

The obtained data were statistically processed by analyses of variance.

RESULTS AND DISCUSSIONS

1. **Dry biomass of sunflower plant.**
   a. **Dry biomass of sunflower plant at different row spacing.**

On chernozem soil, which was associated in our study with favourable growing conditions for sunflower plants, compared to the row spacing of 75 cm, the dry biomass of sunflower plant at narrow rows (50 cm and twin-rows of 75/45 cm) registered negative differences statistically significant (Figure 1.a). The most negative significant difference was registered at row-spacing of 50 cm. This situation is found out at all sunflower plant components, respectively leaves, stalk, and heat.

On reddish preluvosoil, which was associated in our study with less favourable growing conditions for sunflower plants, compared to the row spacing of 75 cm, the dry biomass of sunflower plant at narrow rows (50 cm and twin-rows of 75/45 cm) registered positive differences (Figure 1.b). The differences were statistically significant at twin-rows of 75/45 cm, both for the whole plant and its components (leaves, stalk, and heat).

Under favourable growing conditions, it seems to be more suitable the row spacing of 75 cm, while under less favourable growing conditions, the sunflower plants are using better the growth factors at narrow rows, especially at twin-rows of 75/45 cm.

   b. **Dry biomass of sunflower plant at different plant population.**

On chernozem soil, compared to the plant population of 50,000 plants ha^{-1}, the increasing of plant population determined the decreasing of dry biomass of sunflower plant (Figure 2.a). The differences were negative statistically significant at plant population of 70,000 plants ha^{-1}. Concerning the sunflower plant components, only the dry biomass of leaves registered negative differences statistically significant at 70,000 plants ha^{-1}.

On reddish preluvosoil, compared to the plant population of 50,000 plants ha^{-1}, the increasing of plant population determined the decreasing of dry biomass of sunflower plant, but without registering any differences statistically significant (Figure 2.b). So, it can be concluded that once with less favourable growing conditions, the increasing of plant population is determining a less important decreas of dry biomass of sunflower plant. But, less favourable growing conditions is associated with smaller values of dry biomass of sunflower plant compared to the favourable growing conditions. Thus, i.e. the dry biomass of sunflower plant registered at plant population of 50,000 plants ha^{-1} under favourable growing conditions was of 300.97 g (Figure 2.a), while under less favourable growing condition the value was of 233.25 g (Figure 2.b).

c. Dry biomass of plant at different sunflower hybrids.

On chernozem soil, compared to the average value of the four studied sunflower hybrids, the hybrid Pro 111 registered positive differences statisticaly significant for plant dry biomass, this being due to the dry biomass of leaves and stalk (Figure 3.a). Negative differences statisticaly significant for plant dry biomass were registered at hybrid Pro 953, this being due mainly to the dry biomass of head.

On reddish preluvosoil, because of the less favourable growing conditions, the values of dry biomass of sunflower plant were smaller and without differences statisticaly significant (Figure 3.b).

It can be concluded that differences concerning plant dry biomass between sunflower hybrids are more evident under favourable growing conditions, which give to the sunflower plants the possibility to express their genetic potential.

2. Share of dry biomass on sunflower plant components.

a. Share of dry biomass at different row spacing.

On chernozem soil, the narrow rows determined an increase of the share of dry biomasss of stalk from the whole sunflower plant biomass, the highest value being obtained at twin-rows of 75/45 cm (39.34%) (Figure 4.a). Also, the highest value of the share of dry biomass of leaves was registered at twin-rows of 75/45 cm (19.37%). But, the highest value of the share of dry biomass of head was registered at row spacing of 50 cm (43.65%).

On reddish preluvosoil, the highest value of the share of dry biomass of stalk was registered at row spacing of 75 cm (38.31%) (Figure 4.b). As in the case of chernozem soil, the highest value of the share of dry biomass of leaves was registered at twin-rows of 75/45 cm (22.93%), while the highest value of the share of dry biomass of head was registered at row spacing of 50 cm (42.76%).

b. Share of dry biomass at different plant population.

On chernozem soil, the increasing of plant population determined an increase of the share of dry biomass of head, but a decrease of the share of dry biomass of leaves from the whole sunflower plant biomass (Figure 5.a). The highest values of the share of dry biomass of leaves and stalk were registered at 50,000 plants ha^{-1}. The highest value of the share of dry biomass of head was registered at 70,000 plants ha^{-1}. Even the share of dry biomass of stalk registered the highest value at 50,000 plants ha^{-1}, the values at 60,000 and 70,000 plants ha^{-1} are slightly different.

On reddish preluvosoil, the increasing of plant population determined an increase of the share of dry biomass of stalk, but a decrease of the share of dry biomass of leaves from the whole sunflower plant biomass (Figure 5.b). The highest value for the share of head was registered at 60,000 plants ha^{-1}.

c. Share of dry biomass at different sunflower hybrids.

On chernozem soil, the highest value of the share of dry biomass of leaves was registered at hybrid Pro 953, the highest value of the share of dry biomass of stalk was registered at hybrid Pro 111, and the highest value of the share of dry biomass of head was registered at hybrid P64LE19 (Figure 6.a).

On reddish preluvosoil, the highest values of the share of dry biomass of leaves and stalk were registered at hybrid Pro 111, while the highest value of the share of dry biomass of head was registered at hybrid P64LE19 (Figure 6.b).

3. Moisture content of the sunflower plant.

a. Moisture content of the sunflower plant at different row spacing.

On chernozem soil, the narrow rows determined a decrease of the moisture content of sunflower plant (Figure 7.a). The smallest moisture content was registered at row spacing of 50 cm (80.14%), this being determined especialy by the moisture content of the head (76.92%).

On reddish preluvosoil, the narrow rows determined an increase of the moisture content of sunflower plant (Figure 7.b). The highest values of the moisture content of sunflower plant were registered at row spacing of 50 cm (80.99%), this being determined especialy by the moisture content of the stalk (83.64%).

b. **Moisture content of the sunflower plant at different plant population.**

On chernozem soil, the increasing of plant population decreased the moisture content of the sunflower plant (Figure 8.a), this being due to the decreasing of moisture content of all the plant components (leaves, stalk, and head). The smallest values for the moisture content of the sunflower plant and its components were registered at 70,000 plants ha^{-1}.

On reddish preluvosoil, opposite the situation found on chernozem soil, the increasing of plant population increased the moisture content of the sunflower plant, the differences being statisticaly significant (Figure 8.b), both for the whole sunflower plant and its components. The highest values for the moisture content of the sunflower plant and its components were registered at 70,000 plants ha^{-1}.

c. **Moisture content of the plant at different sunflower hybrids**.

On chernozem soil, the highest value of the moisture content of the sunflower plant was registered at hybrid Pro 111, this being due to the moisture content of the stalk and head (Figure 9.a). The smallest value of the moisture content of the sunflower plant was registered at hybrid LG56.62, this being also due to the moisture content of the stalk and head, which registered negative differences statistically significant compared to the average values of the four studied sunflower hybrids.

On reddish preluvosoil, opposite the situation found on chernozem soil, the highest value of the moisture content of the sunflower plant was registered at hybrid Pro 953, this being due to the moisture content of the stalk (Figure 9.b). As in the case of the chernozem soil, the smallest value of the moisture content of the sunflower plant was registered at hybrid LG56.62, this being due to the moisture content of the head and leaves, which registered negative differences statistically significant compared to the average values of the four studied sunflower hybrids.

4. Average values of share of dry biomass on sunflower plant components.

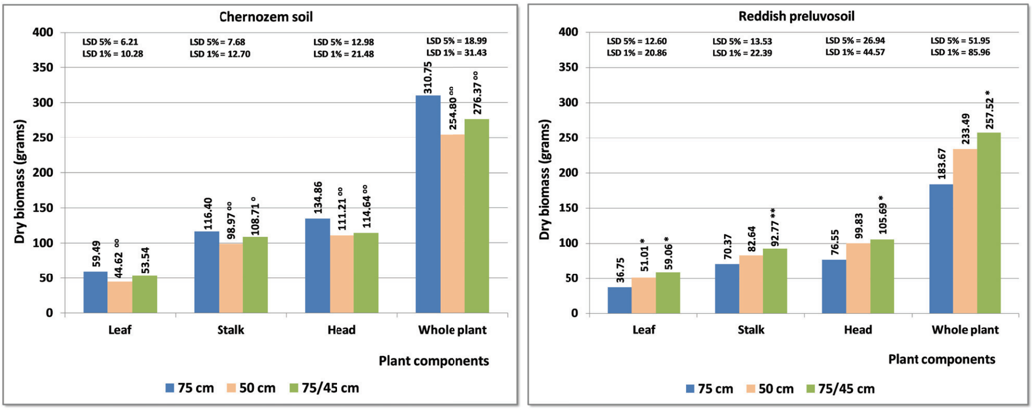
On chernozem soil, respectively on favourable growing conditions for sunflower plants, the average share of the dry biomass of the stalk and head (as average values for all the row spacing, plant population, and sunflower hybrids) registered higher values than on reddish preluvosoil, respectively on less favourable growing conditions for sunflower plants. But, the average share of the dry biomass of leaves registered higher values on less favourable growing conditions for sunflower plants (Figure 10.a).

The average values for the share of the dry biomass for all the experimental conditions, including the soil and climatic conditions, were the followings: 20.16% for leaves, 37.47% for stalk, and 42.36% for head.

5. Average values of moisture content of the sunflower plant components.

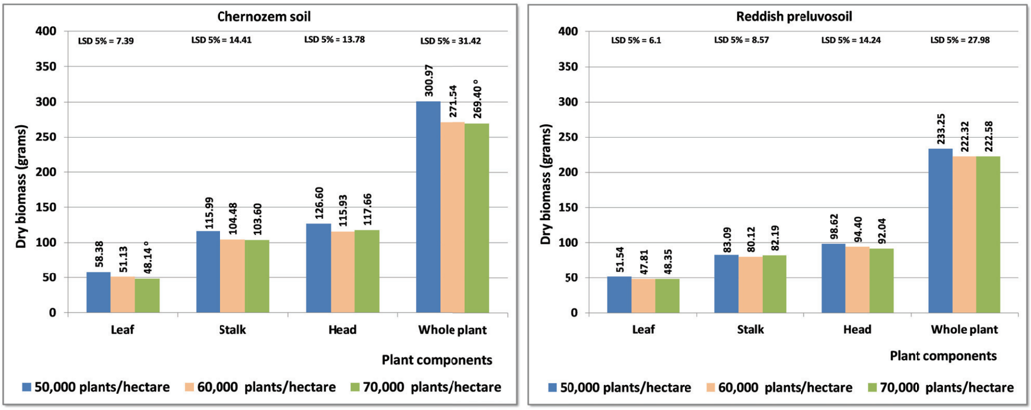
The average values of the moisture content of the whole sunflower plant were practicaly the same on chernozem soil and reddish preluvosoil, respectively 80.2% (Figure 10.b). On chernozem soil, respectively on favourable growing conditions for sunflower plants, the average moisture content of the stalk and leaves (as average values for all the row spacing, plant population, and sunflower hybrids) registered higher values than those on reddish preluvosoil, respectively on less favourable growing conditions for sunflower plants. But, the average moisture content of head registered higher values on less favourable growing conditions for sunflower plants (Figure 10.b).

The average values for the moisture content for all the experimental conditions, including the soil and climatic conditions, were the followings: 77.5% for leaves, 82.44% for stalk, and 78.8% for head.



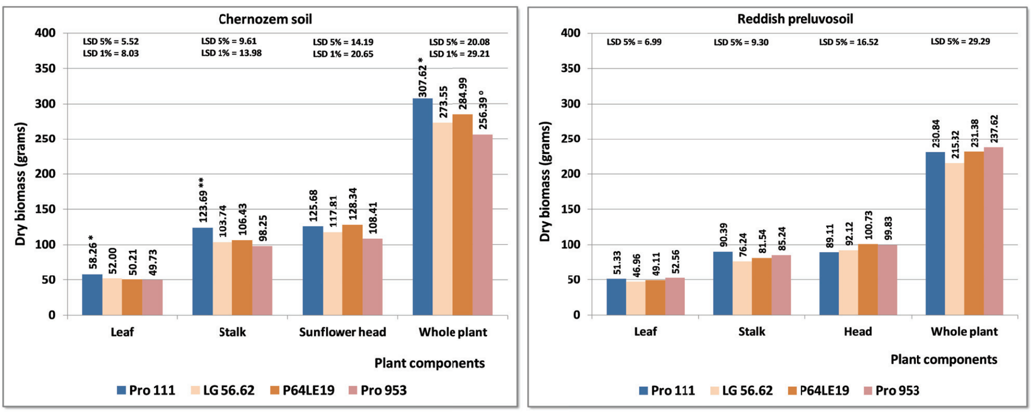
a) b)

Figure 1. Dry biomass on sunflower plant components at different row spacing and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



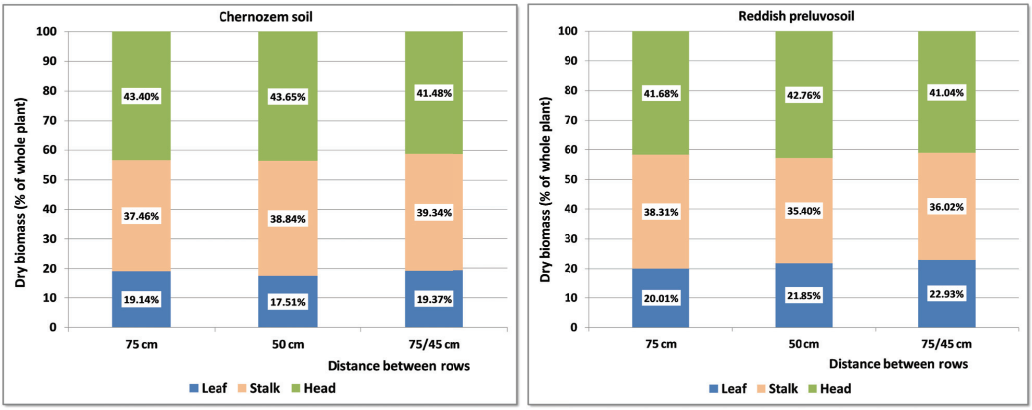
a) b)

Figure 2. Dry biomass on sunflower plant components at different plant population and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



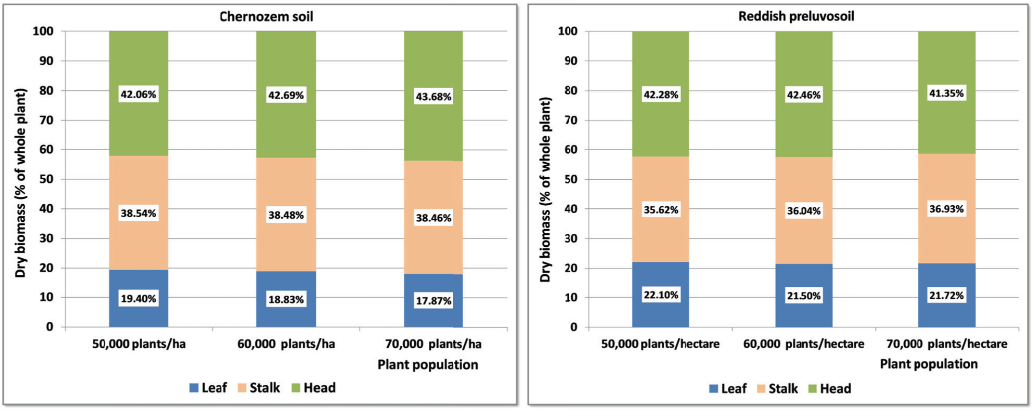
a) b)

Figure 3. Dry biomass on plant components at different sunflower hybrids and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



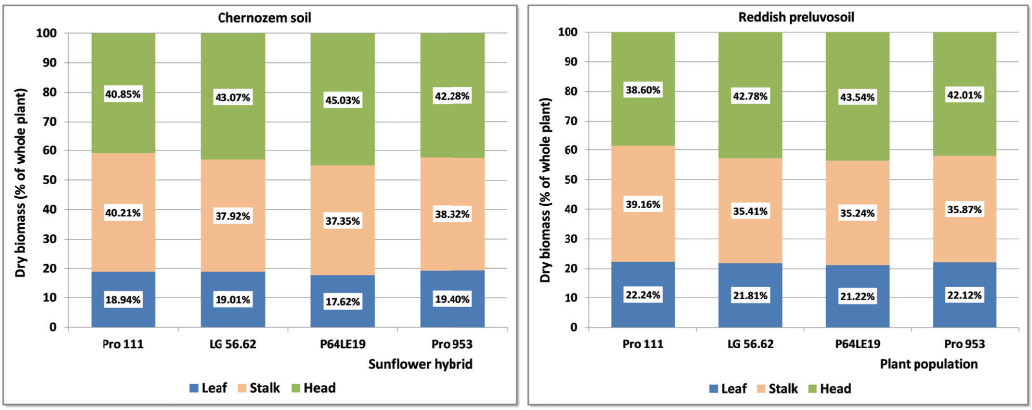
a) b)

Figure 4. Share of dry biomass on sunflower plant components at different row spacing and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



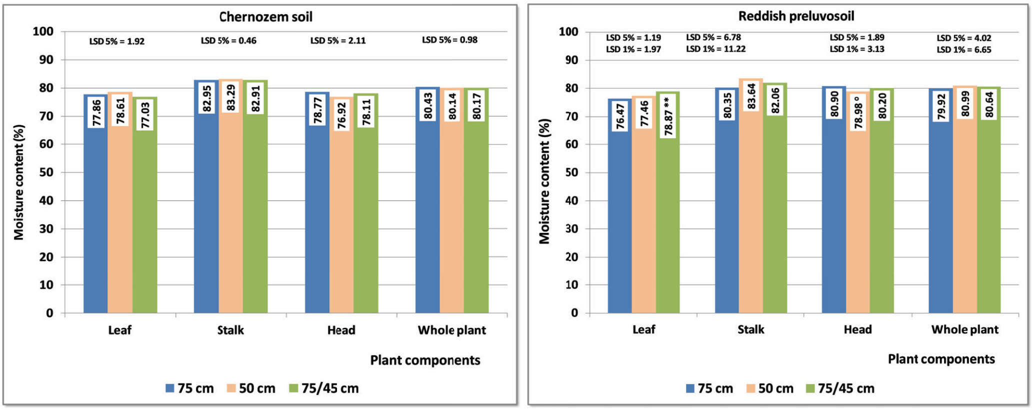
a) b)

Figure 5. Share of dry biomass on sunflower plant components at different plant population and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



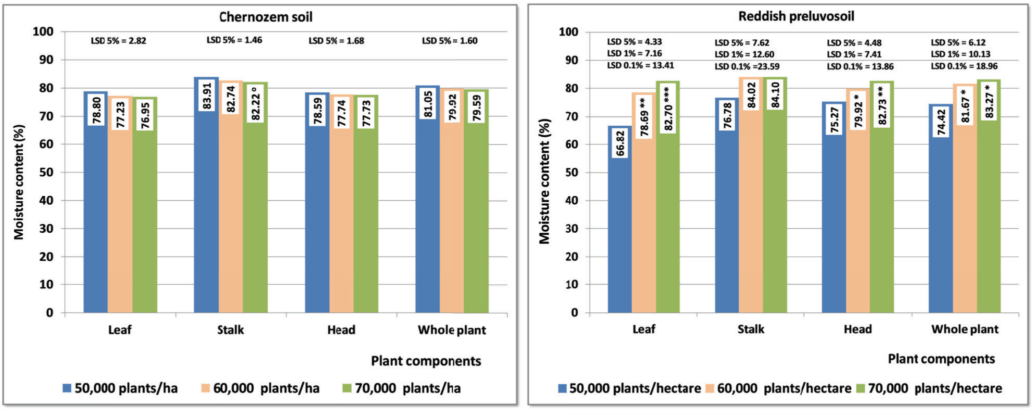
a) b)

Figure 6. Share of dry biomass on plant components at different sunflower hybrids and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



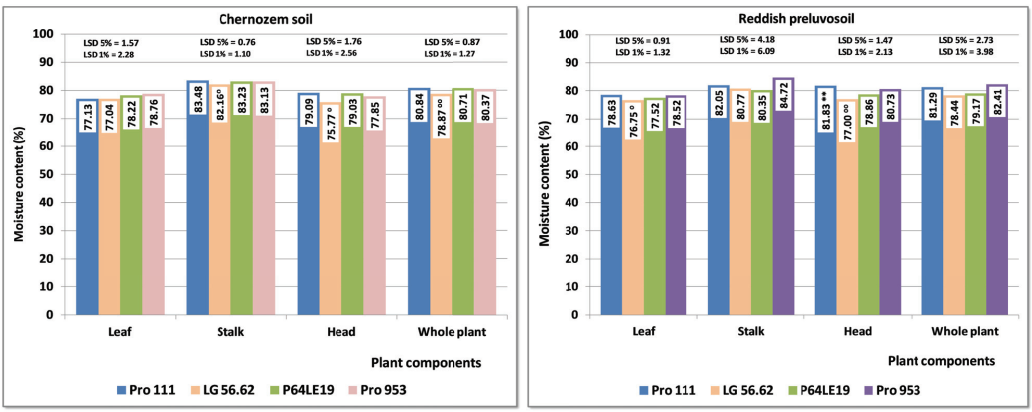
a) b)

Figure 7. Moisture content of the sunflower plant components at different row spacing and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



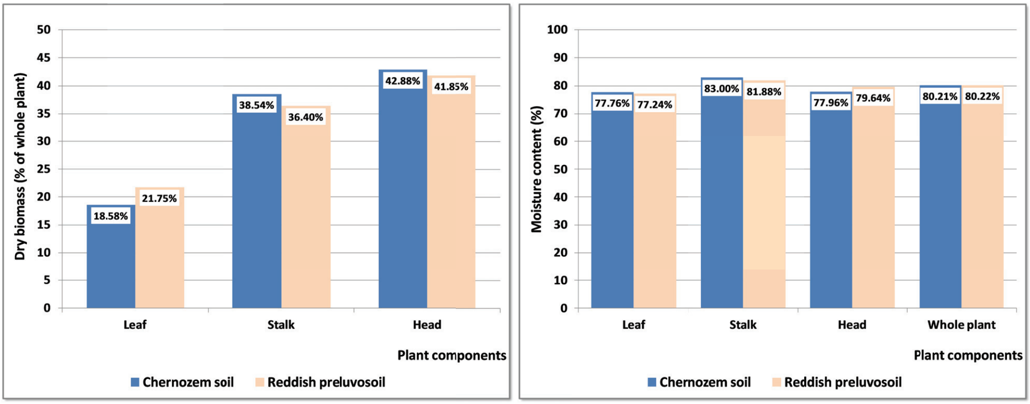
a) b)

Figure 8. Moisture content of the sunflower plant components at different plant population and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



a) b)

Figure 9. Moisture content of the plant components at different sunflower hybrids and in different soil and climatic conditions in South Romania, in the early dough-dough plant growth stage



a) b)

Figure 10. Average values of share of dry biomass on sunflower plant components (a) and moisture content of the sunflower plant components (b) in different soil and climatic conditions in South Romania, in the early dough-dough growth stage of the sunflower plant

CONCLUSIONS

The dry biomass of the sunflower plant in the early dough-dough growth stage was positively influenced by wide rows (75 cm) under favourable growing conditions, and by narrow rows under less favourable growing conditions (especially twin-rows of 75/45 cm).

The increasing of plant population decreased the dry biomass of the sunflower plant in the early dough-dough growth stage.

Differences between sunflower hybrids concerning the dry biomass of the plant in the early dough-dough growth stage are more evident under favourable growing conditions. This is due to the fact that the sunflower plants have the possibility to express better their genetic potential.

The row spacing of 50 cm determined the highest share of dry biomass of head from the whole dry biomass of the sunflower plant, and the twin rows of 75/45 cm determined the highest share of dry biomass of leaves, both under favourable and less favourable growing conditions.

The plant population of 50,000 plants ha^{-1} determined the highest share of dry biomass of leaves. The increasing of plant populations determined the highest share of dry biomass of stalk and head, especially under less favourable growing conditions.

Under favourable growing conditions for sunflower plants, the share of the dry biomass of the stalk and head registered higher values than under less favourable growing conditionsm, while for the dry biomass of leaves is on the contrary.

The narrow rows and the increasing of plant population determined a deacreas of the moisture content of sunflower plant in the early dough-dough growth stage under favourable growing conditions, and an increase of the moisture content of sunflower plant under less favourable growing conditions.

The average moisture content of the whole sunflower plant in the early dough-dough growth stage was almost the same (80.2%) in different growing conditions. But, under favourable growing conditions for sunflower plants, the moisture content of the stalk and leaves registered higher values than those under less favourable growing conditions, while for the moisture content of head is on the contrary.

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