Scientific Papers. Series A. Agronomy, Vol. LVII, 2014
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESULTS REGARDING BIOMASS YIELD AT SUNFLOWER UNDER DIFFERENT PLANTING PATTERNS AND GROWING CONDITIONS

Viorel ION[1], Georgeta DICU[2], Marin DUMBRAVĂ[1], Adrian Gheorghe BĂŞA[1], Georgeta TEMOCICO[1], Daniel STATE[2], Lenuța Iuliana EPURE[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Agriculture
59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania
[2]SC Procera Agrochemicals Romania SRL
47 Muncii Street, 915200, Fundulea, Călăraşi, Romania

Corresponding author email: viorelion@agro-bucuresti.ro

Abstract

There are several annual crops suitable to supply important biomass yields to be used as raw material for producing different kinds of energy, including the possibility to be used as substrate for biogas production. Sunflower is counted among these crops of great importance. Producing biomass in an efficient way become possible by using the most appropriate cultivation techniques and sunflower hybrids according to specific growing conditions.
The aim of this study was to identify how the row spacing and plant population, associated with different soil and climatic conditions and cultivated sunflower hybrids are influencing the above-ground biomass yield at sunflower.
Researches were performed in field experiments in 2013, in two locations from South Romania, respectively Fundulea (44°28' N latitude and 26°27' E longitude) from Călăraşi County, and Moara Domnească (44°29' N latitude and 26°15' E longitude) from Ilfov County. 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}). Determinations were performed in the early dough - dough plant growth stage taking into account that the biomass yield in this growth stage of the sunflower plants is of importance as raw material for biogas production.

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

INTRODUCTION

Growing biomass is among the cheapest options for CO_2 emissions reduction, particularly if that biomass is used for energy production (Roman et al., 1998). Biomass is a unique fuel and has the potential to play a significant role in the future energy; unlike other renewables, biomass can provide continuous electricity generation, and is the only widespread source of renewable heat (Komlajeva et al., 2012). There are several annual crops suitable to supply important biomass yields to be used as raw material for producing different kinds of energy, including the possibility to be used as substrate for biogas production. Sunflower is counted among these crops of great importance.

Sunflower (*Helianthus annuus* L.) is one of the most important oil crops in the world, because it offers advantages in crop rotation systems, such as high adoption capability, suitability to mechanization and low labour needs (Kazemeini et al., 2009).

Romania has favourable conditions for growing sunflower (*Helianthus annuus* L.), this being the most important oil crop (Ion et al., 2013).

The above-ground dry biomass yield which a sunflower crop could supply is usually of 10-15 tons ha^{-1}, but it can reach 20 tons ha^{-1} (Stefan et al., 2008).

Cultivated sunflower could be used as a source of lignocelluloses biomass. Research is needed to determine the best agricultural practices, which are targeted at maximizing yield in the field (biomass/hectare) (Ziebell et al., 2013).

The most important yield limiting factors are heavy weed infestation and improper production technology particularly row spacing producing proper nutritional area to exploit available resources judiciously (Nawaz et al., 2001). Apart the row spacing, of great importance is also the plant population, as well as the cultivated hybrid.

Widely spaced sowing dates provide differences in soil water, temperature and radiation regimes, and these factors are further compounded by differences in vapour pressure deficits in the different seasons of planting (Agele, 2003).

Diepenbrock et al. (2001) found in 1996 and 1998 that the aboveground biomass increased significantly with increasing row spacing, but in 1997, however, the differences between the row spacings were small. These data prove the importance of performing this kind of studies and the necessity to be continued these studies concerning the relation between row spacing and aboveground biomass.

Plant population based on row and plant spacing is a major part of agronomic practices (Beg et al., 2007).

Producing biomass in an efficient way become possible by using the most appropriate cultivation techniques and sunflower hybrids according to specific growing conditions.

The aim of this study was to identify how the row spacing and plant population, associated with different soil and climatic conditions and cultivated sunflower hybrids are influencing the above-ground biomass yield at sunflower.

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' E longitude) from Călăraşi County, and Moara Domnească (44°29' N latitude and 26°15' E longitude) from Ilfov County.

In the period September 2012 – August 2013, from a climatic point of view Fundulea area was characterised by the average temperature of 12.0°C and the sum of rainfall of 700.6 mm, while Moara Domnească was characterised by the average temperature of 12.6°C and the sum of rainfall of 288.0 mm.

The specific soil from Fundulea area is chernozem (cambic chernozem soil), while the specific soil from Moara Domnească area is reddish preluvosoil.

The studied sunflower hybrids were the followings: Pro 111, LG56.62, P64LE19, and 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. Each variant consisted in four lines with a length of 10 m.

The sowing was performed on 17th of April at Fundulea and on 25th of April at Moara Domnească. The preceding crop was maize. The fertilization was performed with 106 kg ha^{-1} of nitrogen and 40 kg ha^{-1} of phosphorus. The weed control was performed by the help of herbicides and through one manual hoeing.

In each location and from each variant the sunflower plants from one square meter were cut at soil level and were weighed immediately for determining the fresh biomass yield (above-ground biomass). One sunflower plant for each variant was taken into the laboratory for determining the dry biomass by oven drying at 80°C for 24 hours.

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 Domnească (reddish preluvosoil). Determinations were performed in the early dough - dough plant growth stage taking into account that the biomass yield in this growth stage of the sunflower plants is of importance as raw material for biogas production. Analysis of variance (ANOVA) was performed for the obtained data.

RESULTS AND DISCUSSIONS

Biomass yield at sunflower at different row spacing (Figure 1)

On chernozem soil, the narrow rows decreased the fresh and dry biomass yields compared to row spacing of 75 cm, the differences being negative distinct significant.

The highest biomass yield was obtained at row spacing of 75 cm, respectively 91.60 tons ha^{-1} of fresh biomass and 18.07 tons ha^{-1} of dry biomass. The smallest biomass yield was obtained at row spacing of 50 cm, respectively 74.91 tons ha^{-1} of fresh biomass and 15.25 tons ha^{-1} of dry biomass.

Narrow rows decreased the moisture content compared to the row spacing of 75 cm, but without significant differences. The plants were the driest at row spacing of 50 cm (79.6%).

On reddish preluvosoil, the narrow rows increased the fresh and dry biomass yields compared to row spacing of 75 cm, the differences being statistically significant.

The highest biomass yields were obtained at twin-rows of 75/45 cm, respectively 80.19 tons ha^{-1} of fresh biomass and 15.61 tons ha^{-1} of dry biomass. The smallest biomass yields were obtained at row spacing of 75 cm, respectively 63.48 tons ha^{-1} of fresh biomass and 13.00 tons ha^{-1} of dry biomass.

Narrow rows also determined the increasing of the moisture content compared to the row spacing of 75 cm. The plants were the driest at row spacing of 75 cm (79.5%), but without significant differences. The moisture content was the highest at twin-rows of 75/45 cm (80.5%).

Under favourable growing conditions, the row spacing of 75 cm seems to be more suitable for sunflower plants. Under less favourable growing conditions, the twin-rows of 75/45 cm seems to be more suitable for sunflower plants. In fact, the narrow rows provided better growing conditions for sunflower plants than row spacing of 75 cm.

Biomass yield at sunflower at different plant population (Figure 2)

On chernozem soil, the highest biomass yields were obtained at 70,000 plants ha^{-1}, which was followed by the biomass yields obtained at 50,000 plants ha^{-1}, and the smallest biomass yields were obtained at 60,000 plants ha^{-1}.

Compared to biomass yield obtained at 50,000 plants ha^{-1}, only the dry biomass yield obtained at 70,000 plants ha^{-1} registered a difference statistically significant.

The increasing of plant population decreased the moisture content of the sunflower plants, the differences being negative distinct significant.

On reddish preluvosoil, the increasing of plant population increased the dry biomass yield, but without significant differences. The highest dry biomass yield, as well as the highest fresh biomass yield was obtained at 70,000 plants ha^{-1}.

The increasing of plant population decreased the moisture content of sunflower plants, but without significant differences. It has to be underlined the fact that the driest biomass yield was obtained at 60,000 plants ha^{-1}.

Biomass yield at different sunflower hybrids (Figure 3)

The biomass yield, both fresh and dry biomass, was different according to hybrid and growing conditions.

On chernozem soil, the highest fresh and dry biomass yield was obtained by Pro 111 hybrid (90.25 tons ha^{-1} of fresh biomass and 17.46 tons ha^{-1} of dry biomass), which had also the highest moisture content (80.7%). The smallest fresh and dry biomass yield was obtained by LG 56.62 hybrid (74.97 tons ha^{-1} of fresh biomass and 16.04 tons ha^{-1} of dry biomass), which had also the smallest moisture content (78.6%).

On reddish preluvosoil, the highest fresh biomass yield was obtained by Pro 111 hybrid (77.51 tons ha^{-1}), but the highest dry biomass yield was obtained by P64LE19 hybrid (15.25 tons ha^{-1}).

As in the case of chernozem soil, the smallest fresh and dry biomass yield was obtained by LG 56.62 hybrid (63.54 tons ha^{-1} of fresh biomass and 13.84 tons ha^{-1} of dry biomass), which had also the smallest moisture content (78.2%).

The highest moisture content of the biomass yield was obtained at Pro 953 hybrid (81.5%), with a difference statistically significant compared to the average moisture content of the four studied sunflower hybrids.

Average biomass yield at different growing conditions (Figure 4)

In our study, chernozem soil was associated with favourable growing conditions for sunflower plants, while reddish preluvosoil was associated with less favourable growing conditions for sunflower plants with much less rainfall.

The fresh biomass yield obtained on chernozem soil was of 81.36 tons ha^{-1}, while that on reddish preluvosoil was of 72.52 tons ha^{-1} representing 89.1% of the fresh biomass obtained on chernozem soil.

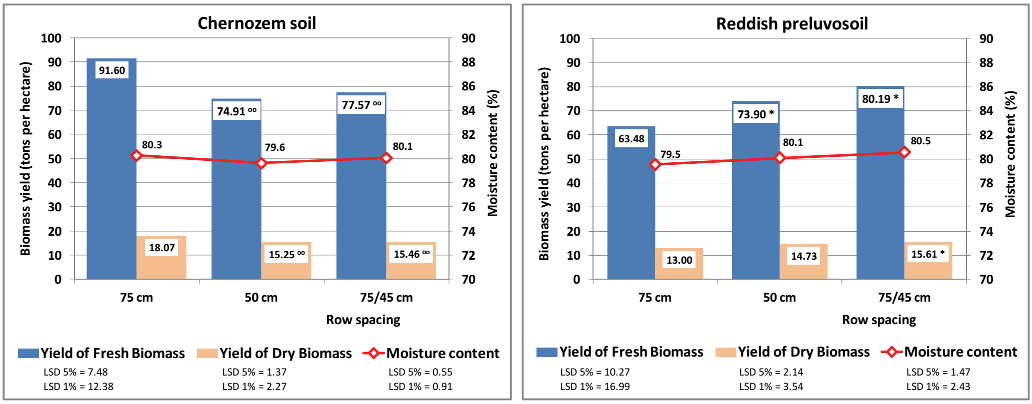

Figure 1. Biomass yield at sunflower at different row spacing and on different growing conditions from South Romania, in the early dough-dough plant growth stage of sunflower plants

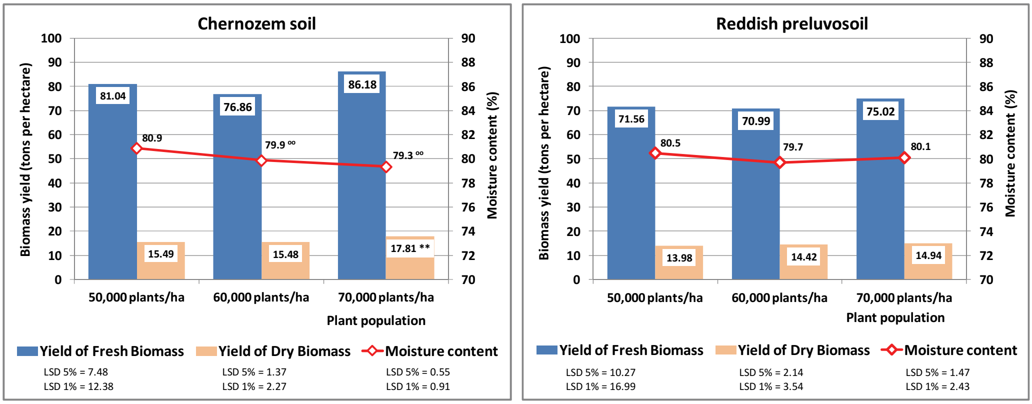

Figure 2. Biomass yield at sunflower at different plant population and on different growing conditions from South Romania, in the early dough-dough plant growth stage of sunflower plants

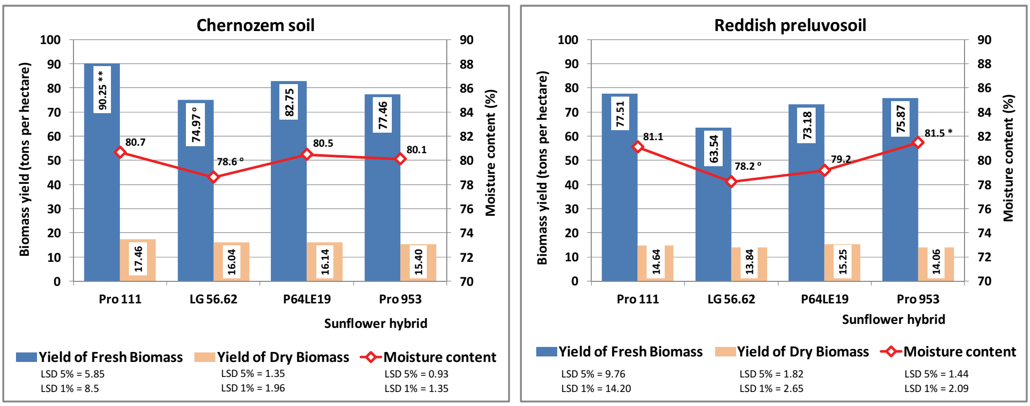

Figure 3. Biomass yield at different sunflower hybrids and on different growing conditions from South Romania, in the early dough-dough plant growth stage of sunflower plants

The dry biomass yield obtained on chernozem soil was of 16.26 tons ha^{-1}, while that on reddish preluvosoil was of 14.45 tons ha^{-1} representing 88.9% of the fresh biomass obtained on chernozem soil.
Under less favourable growing conditions on reddish preluvosoil, with much less rainfall than on chernozem soil in 2013 in South Romania, the fresh and dry biomass yield was of about 89% of those on chernozem soil. The moisture content of the biomass yield was very slightly different on the two growing conditions, being of about 80%.

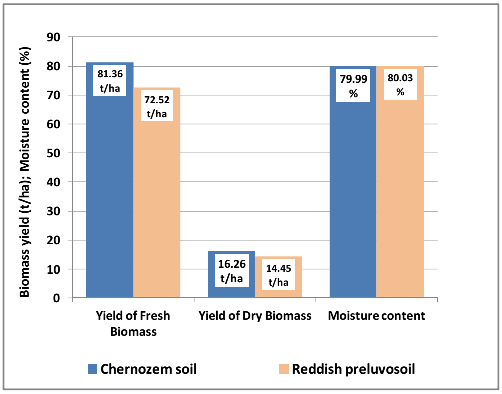

Figure 4. Average biomass yield at different growing conditions from South Romania, in the early dough-dough plant growth stage of sunflower plants

CONCLUSIONS

The fresh and dry biomass was different according to sunflower hybrid and growing condition.
Compared to row spacing of 75 cm in our study, narrow rows decreased the fresh and dry biomass yield under favourable growing conditions and increased the fresh and dry biomass yield under less favourable growing conditions. Thus, the highest fresh and dry biomass yield was obtained at row spacing of 75 cm under favourable growing conditions and at twin-rows of 75/45 cm under less favourable growing conditions.
The highest fresh and dry biomass yield was obtained at the plant population of 70,000 plants ha^{-1} whatever the growing conditions.
The increasing of plant population decreased the moisture content of sunflower plants.
The less favourable growing conditions in 2013 in South Romania, respectively less rainfall, led to fresh and dry biomass yields of about 89% of those on favourable growing conditions, with much more rainfall.
The moisture content of the biomass yield was about 80% in the early dough - dough plant growth stage.

ACKNOWLEDGEMENTS

The researches carried out for the elaboration of the present paper were financed by Romanian Program “Partnerships for Priority Domains”, project PN-II-PT-PCCA-2011-3.2-1778 “OPTImization of BIOMass and Approach to Water conservation” (OPTIBIOMA-W), Contract no. 45/2012.
The experiments in the field were performed with the support from SC Procera Agrochemicals Romania SRL.

REFERENCES

Agele S.O., 2003. Response of sunflower to weather variations in a tropical rainforest zone. African Crop Science Conference Proceedings, Vol. 6, p. 1-8.
Beg A., Pourdad S.S., Alipour S., 2007. Row and plant spacing effects on agronomic performance of sunflower in warm and semi-cold areas of Iran. Helia, 30, nr. 47, p. 99-104.
Diepenbrock W., Lang M., Feil B., 2001. Yield and quality of sunflower as affected by row orientation, row spacing and plant density. Die Bodenkultur, 52 (1):29-36.
Kazemeini S.A., Edalat M., Shekoofa A., 2009. Interaction effects of deficit irrigation and row spacing on sunflower (*Helianthus annuus* L.) growth, seed yield and oil yield. African Journal of Agricultural Research, vol. 4 (11):1165-1170.
Komlajeva L., Adamovičs A., Poiša L., 2012. Comparison of different energy crops for solid fuel production in Latvia. Renewable Energy and Energy Efficiency, Growing and processing technologies of energy crops, p. 45-50.
Ion V., Ion N., Roman Gh.V., Bucata L.I., Dumbrava M., Istoc V.A., 2004. Behavior of Romanian sunflower hybrids in the meteorological conditions of 2002, on the reddish-brown soil from Moara Domnească. Scientific Papers. Series A. Agronomy, vol. XLVI, p. 114-121.

Nawaz R., Ahmad R., Cheema Z.A., Mehmood T., 2001. Effect of Row Spacing and Sorgaab on Sunflower and its Weeds. International Journal of Agriculture & Biology, Vol. 3, No. 4, p. 360-362.

Roman Gh.V., Hall D.O., Gosse G., Roman A.M., Ion V., Alexe Gh., 1998. Researches on Sweet-Sorghum Productivity in the South Romanian Plain. Proceedings of AFITA (The Asian Federation for Information Technology in Agriculture) Conference, Japan, p. 183-188.

Stefan V., Ion V., Ion N., Dumbrava M., Vlad V., 2008. Floarea-soarelui. Editura ALPHA MDN Buzău.

Ziebell AL., Barb J.G., Sandhu S., Moyers B.T., Sykes R.W., Doeppke C., Gracom K.L., Carlile M., Marek L.F., Davis M.F., Knapp S.J., Burke J.M., 2013. Sunflower as a biofuels crop: An analysis of lignocellulosic chemical properties. Biomass and Bioenergy, xxx, 1-10, http://dx.doi.org/10.1016/j.biombioe.2013.06.009.