BIOMASS YIELD AT MAIZE UNDER DIFFERENT SOWING AND GROWING CONDITIONS

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Abstract

Maize is known as being one of the most important and most used energy crops for obtaining biomass as substrate for producing biogas. In this respect, the maize crop is important for biogas production taking into account the methane produced by one unit of dry matter, but also taking into account the high biomass yields provided by the crop. However, the high yields are possible to be obtained using the appropriate cultivation techniques according to the growing conditions. The aim of this paper is to present the biomass yield obtained at different maize hybrids under different sowing conditions (different row spacing and plant densities) and under different growing conditions (different soil and climatic conditions) from South Romania. Also, it is intended to identify the average repartition of the biomass on maize plant components under different sowing and growing conditions. Researches were performed in field experiments under rainfed conditions in the years 2013 and 2014, and in two places in South Romania. In both experimental locations and both experimental years, a number of four maize hybrids were studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and under three plant densities (60,000, 70,000, and 80,000 plants ha\textsuperscript{-1}). The determinations of fresh and dry biomass were realized in the early dough - dough plant growth stage. In the specific growing conditions from South Romania, as average values for 2013 and 2014, the highest biomass yields were registered at narrow rows, especially at twin-rows of 75/45 cm, and at plant density of 80,000 plants ha\textsuperscript{-1}. 

Key words: maize, biomass yield, row spacing, plant density, growing conditions.

Introduction

Maize (\textit{Zea mays} L.) is considered as one of the most suitable crops for biomass production which can be used as substrate for producing biogas (Balodis et al., 2011; Basa et al., 2013). Most efficient utilization of maize is supply of green maize biomass directly to biogas plants for heat and power energy production (Dubrovskis et al., 2010). The maize crop is important for biogas production taking into account the methane produced by one unit of dry matter, but also the high biomass yields provided by the crop. The biomass of maize plant is depending on a sum of growth factors among which the cultivated hybrid, plant population, row spacing and soil conditions have a significant influence on the accumulation of the above-ground biomass and its repartition between plant components (Ion et al., 2014).

Selection of hybrids and FAO maturity group is of great importance in order to obtain satisfactory yield of biomass in the optimal stage of maturity even in a shorter growing season (Dubljević et al., 2013).

Row spacing and plant density are among cultivation techniques that could contribute to the production of biomass in an efficient way. Through these cultivation techniques, it is intended to reduce the intraspecific and even interspecific plant competition for acquiring the growing factors in view to be maximized the biomass production.

Maize produced in narrow rows can increase yields and result in a quicker canopy closure (Satterwhite et al., 2006). Twin-row planting systems in maize have been proposed as an...
alternative spatial arrangement that should theoretically decrease plant-to-plant competition, alleviate crop crowding stress and improve yields (Robles et al., 2012). Yields of dry biomass increase with increases in planting density (Averbeke and Marais, 1992; Yılmaz et al., 2007; Nik et al., 2011). However, this is expected to happen up to a level which could be defined as optimum plant density beyond which the dry biomass yield will start to decrease.

The aim of this paper is to present the biomass yield obtained at different maize hybrids under different sowing conditions (different row spacing and plant densities) and under different growing conditions (different soil and climatic conditions) from South Romania. Also, it is intended to identify the average repartition of the biomass on maize plant components under different sowing and growing conditions.

Materials and methods

Researches were performed in field experiments located in two places in South Romania, respectively at Fundulea (44°28' N latitude and 26°27' E longitude) and Moara Domneasca (44°29' N latitude and 26°15’ E longitude). The field experiments were performed under rainfed conditions in the years 2013 and 2014. The soil from Fundulea area is chernozem, with humus content of 2.8-3.2%, loam to clay loam texture, and pH of 6.4-6.8, while the soil from Moara Domneasca area is reddish preluvosoil, with humus content of 2.2-2.8%, clay loam texture, and pH of 6.2-6.6.

For the period April-August and at Fundulea area, the average temperature was 20.1°C in 2013 and 18.9°C in 2014, while the multiannual average temperature for this period is 18.6°C. For the same period (April-August), the sum of rainfall was 381.1 mm in 2013 and 399.0 mm in 2014, while the multiannual average rainfall is 327.9 mm.

For the period April-August and at Moara Domneasca area, the average temperature was 20.5°C in 2013 and 18.8°C in 2014, while the multiannual average temperature for this period is 18.5°C. For the same period (April-August), the sum of rainfall was 115.0 mm in 2013 and 408.0 mm in 2014, while the multiannual average rainfall is 313.2 mm.

In both experimental locations (Fundulea and Moara Domneasca) and in both experimental years (2013 and 2014), four maize hybrids were studied, respectively: Cera 450 (FAO precocity group 450), Flanker (FAO precocity group 450), PR35T36 (FAO precocity group 500), and ES Feria (FAO precocity group 550). Every hybrid in each location and in each experimental year was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and at three plant densities (60,000, 70,000, and 80,000 plants ha⁻¹). Each variant consisted in four lines with a length of 10 m.

In 2013, the sowing was performed on 17th of April at Fundulea location (chernozem soil) and on 26th of April at Moara Domneasca location (reddish preluvosoil). In 2014, the sowing was performed on 8th of May at Fundulea location and on 25th of April at Moara Domneasca location.

The preceding crop was sunflower in both locations and experimental years. 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, which were completed by one manual hoeing.

In each location, in each experimental year, and from each variant the maize plants from one square meter were cut at soil level and were weighed immediately in view to be determined the fresh biomass yield, respectively the yield of above-ground biomass. One average maize plant for each variant was taken into the laboratory and dried in the oven at 80°C for 24 hours in view to be determined the dry biomass yield.

Determinations were performed in the early dough - dough plant growth stage, respectively in the growth stage when the maize biomass is of importance to be used as substrate for
producing biogas. The data are presented and analyzed as average values for the four studied maize hybrids.

**Results and discussion**

**Biomass yield at maize under different row spacing conditions.** On chernozem soil, the highest biomass yields were registered at narrow rows. Thus, in average for 2013 and 2014 it was obtained 72.82 tons.ha\(^{-1}\) of fresh biomass at 50 cm between rows (Figure 1.a) and 20.71 tons.ha\(^{-1}\) of dry biomass at twin-rows of 75/45 cm (Figure 1.b). The same tendencies were registered also on reddish preluvosoil, where the highest yields were 55.59 tons.ha\(^{-1}\) of fresh biomass at 50 cm between rows (Figure 1.a) and 20.15 tons.ha\(^{-1}\) of dry biomass at twin-rows of 75/45 cm (Figure 1.b).

The biomass yields were higher on chernozem soil conditions respectively at Fundulea location, which was characterised by more rainfalls and smaller values of temperatures compared to the conditions registered on reddish preluvosoil at Moara Domneasca location. In average for 2013 and 2014 and in average for the three variants of row spacing, the fresh biomass yield was of 69.84 tons.ha\(^{-1}\) on chernozem soil and of 53.36 tons.ha\(^{-1}\) on reddish preluvosoil, while the dry biomass yield was of 19.89 tons.ha\(^{-1}\) on chernozem soil and of 19.28 tons.ha\(^{-1}\) on reddish preluvosoil (Figure 1). The smallest variations between the two experimental years regarding the yield of dry biomass at different row spacing were registered on reddish preluvosoil.

![Figure 1. Fresh (a) and dry (b) biomass yield at maize under different row spacing conditions, on different types of soils from South Romania, as average values and limits of variations in 2013 and 2014 climatic conditions](image)

**Biomass yield at maize under different plant density conditions.** Increasing of plant density from 60,000 to 70,000 and further to 80,000 plants ha\(^{-1}\) determined the increasing of fresh and dry biomass yield (Figure 2). In average for 2013 and 2014, the highest yields of dry biomass were registered at plant density of 80,000 plants ha\(^{-1}\) both on chernozem soil (20.32 tons.ha\(^{-1}\)) and reddish preluvosoil (20.18 tons.ha\(^{-1}\)), while the highest yield of fresh biomass was registered at 80,000 plants ha\(^{-1}\) on chernozem soil (70.35 tons.ha\(^{-1}\)) and at 70,000 plants ha\(^{-1}\) on reddish preluvosoil (55.53 tons.ha\(^{-1}\)).

In average for the two experimental years (2013 and 2014) and for the three variants of plant density (60,000, 70,000 and 80,000 plants ha\(^{-1}\)), the fresh and dry biomass yields were higher on chernozem soil then on reddish preluvosoil. As in the case of fresh and dry biomass yields registered at different row spacing, the smallest variations between the two experimental years were registered on reddish preluvosoil (Figure 2).
Share of dry biomass on plants components at different row spacing. Regarding the share of dry biomass on stalks (including leaf sheaths and tassels), leaves (leaf blades), ears and husks in the early dough - dough plant growth stage, the highest ration were registered by the ears both on chernozem soil and reddish preluvosoil and both at different row spacing and plant densities (Figures 3 and 4).

On chernozem soil, the narrow rows increased the share of dry biomass on ears and leaves and decreased the share of dry biomass on stalks and husks (Figure 3.a). On reddish preluvosoil, compared to the shares registered at 75 cm between rows, the row spacing of 50 cm increased the share of dry biomass on stalks, leaves and husks, while the twin-rows of 75/45 cm increased the share of dry biomass on ears and husks (Figure 3.b).

In average for the two experimental years (2013 and 2014) and for the three variants of row spacing (75 cm, 50 cm and twin-rows of 75/45 cm), on chernozem soil the shares of dry biomass on plant components were the following: 44.8% for ears, 32.7% for the stalks, 15.0% for the leaves, and 7.6% for the husks (Figure 3.a). On reddish preluvosoil, the average shares of dry biomass on plant components were the following: 48.7% for ears, 29.5% for the stalks, 14.8% for the leaves, and 7.0% for the husks (Figure 3.b). So, on reddish preluvosoil in average it increased the share of dry biomass on ears and decreased the share of dry biomass on all other plant components compared to the values registered on chernozem soil.

Share of dry biomass on plants components at different plant densities. On chernozem soil, the increasing of plant density from 60,000 to 70,000 and further to 80,000 plants ha⁻¹ increased the share of dry biomass on stalks and leaves and decreased the share of dry biomass of ears and husks (Figure 4.a).

On reddish preluvosoil, the increasing of plant density increased the share of dry biomass on ears and leaves and decreased the share of dry biomass of stalks and husks (Figure 4.b).

In average for the two experimental years (2013 and 2014) and for the three variants of plants densities (60,000, 70,000, and 80,000 plants ha⁻¹), on chernozem soil the shares of dry biomass on plant components were the following: 44.9% for ears, 32.6% for the stalks, 15.0% for the leaves, and 7.5% for the husks (Figure 3.a). On reddish preluvosoil, the average shares of dry biomass on plant components were the following: 48.8% for ears, 29.5% for the stalks, 14.8% for the leaves, and 7.0% for the husks (Figure 3.b).
Figure 3. Percentage of dry biomass on maize plant components under different row spacing, on different types of soils (a - chernozem soil; b - reddish preluvosoil) from South Romania, as average values in 2013 and 2014 climatic conditions.

Figure 4. Percentage of dry biomass on maize plant components under different plant densities, on different types of soils (a - chernozem soil; b - reddish preluvosoil) from South Romania, as average values in 2013 and 2014 climatic conditions.

**Conclusion**

In the specific growing conditions from South Romania, as average values for 2013 and 2014, the highest biomass yields were registered at narrow rows, especially at twin-rows of 75/45 cm, and at plant density of 80,000 plants ha$^{-1}$.

The biomass yields were higher on chernozem soil conditions, which were associated with more rainfalls and smaller values of temperatures compared to the conditions registered on reddish preluvosoil.

Among the plant components, the highest ration of dry biomass were registered by the ears both on chernozem soil and reddish preluvosoil conditions, as well as under different row spacing and plant densities.

On chernozem soil, the narrow rows increased the share of dry biomass on ears and leaves, while on reddish preluvosoil the row spacing of 50 cm increased the share of dry biomass on stalks, leaves and husks, and the twin-rows of 75/45 cm increased the share of dry biomass on ears and husks.
On chernozem soil, the increasing of plant density increased the share of dry biomass on stalks and leaves. On reddish preluvosoil, the increasing of plant density increased the share of dry biomass on ears and leaves.

Compared to the average values registered on chernozem soil, on reddish preluvosoil the share of dry biomass on ears increased while the share of dry biomass on all other plant components decreased.

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