Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 2, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE DYNAMICS OF THE GREEN BIOMASS AND HER RELATIONSHIP WITH THE YIELD, ACCORDING TO HYBRID AND PLANT DENSITY AT AN ASSORTMENT OF SUNFLOWER PLANT, TESTED ON THE CHERNOZEM OF CARACAL

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Abstract

On the ARDS Caracal chernozem, in the last two years, 2018 and 2019, were tested a number of nine sunflower hybrids (Performer, Euromis, Generalis, Terramis, Neoma, Diamantis, Subaro, FD15C27 and FD116M1) sown at three different plant density: 43,000 pl/ha, 57,000 pl/ha and 71,000 pl/ha. The green biomass was determined at 3 different moments: at 44 days, 54 days and 68 days after emergence. The interactions studied showed that the hybrids have a vegetative growth (green biomass) differentiated according to the plant density, hybrid and the moment of determination. As much as the plant density increases, the biomass decreases very significantly. Also, green biomass, regardless of the time of determination, is significantly correlated with production. There are very significant differences between the green biomass determined at the first and the second plant density, at the first and the third plant density, but disappears between the second and the third plant density, at each moments of determination.

Key words*: sunflower, green biomass, plant density, time of determination, chernozem.*

INTRODUCTION

Helianthus annuus L. (sunflower) is one of the 67 species of Helianthus (from the Greek "helios" - sun; "anthus" - flower). Of these, only two species, *H. annuus* and *H. tuberosum*, are cultivated for food, remaining species being ornamentals species, weeds or wild plants. Originally from the United States and Mexico, the sunflower was introduced in Europe in the 16th century, initially in Spain and later in England and France (Azania et al., 2008).

Sunflower (*Helianthus annuus* L.) is an important oil crop which provides more than 13% of the total amount of oil produced globally (Rauf S., 2008).

The sunflower presents one of the most profitable crops for agriculture, which determines significant growth of the sown areas and increased market demands regarding the created hybrids. The breeding of competitive commercial sunflower hybrids for the European seed market is achievable by diversifying the sunflower germplasm. A major importance in the improvement process is the knowledge of the development phases and the analysis of the transformations that the plants suffers during each phenological phase, determined by a complex of interactions between the genetic and environmental factors, such as temperature, photoperiodicity, rainfall quantity.

The phenological data analysis allowed to highlight the irregularity of the growth and development process and a different speed of interphase growth genotype dependent (vegetative growth - from seedling to button appears; reproductive growth - from button appears to flowering; maturing stage - from flowering to full maturation) (Cucereavîi, 2017).

Detailed research on sunflower biomass was conducted by Tingyue (2013) in order to improve its yield and quality as an alternative to the production and implementation of new energies.

Daugthry et al (1992) showed that the green biomass can be estimated by spectrometry. Wanjura and Hartfield (1985) found that a linear combination between NIR and red ratio was correlated with biomass by the ratio of

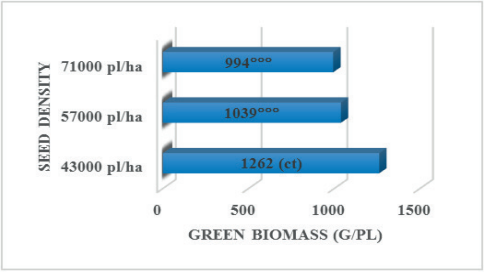
biomass = a + b (NIR/red). At sunflower a = 0.24 and b = 0.69 compared to soybean where a = 0 and b = 1.02.
Serrano et al. (2000) found a strong correlation between biomass and harvested yield.

MATERIALS AND METHODS

On the ARDS Caracal chernozem, in the last two years, 2018 and 2019, were tested a number of nine sunflower hybrids (Performer, Euromis, Generalis, Terramis, Neoma, Diamantis, Subaro, FD15C27 and FD116M1) sown at three different plant density: 43,000 pl/ha, 57,000 pl/ha and 71,000 pl/ha. The green biomass was determined at 3 different moments: at 44 days, 54 days and 68 days after emergence.
The plots were placed in randomized blocks, in 3 repetitions. The length of the plot was 10 m and the width was 2.8 m, the equivalent of 4 rows, two of them, the marginal rows, being eliminated.
The first step in the preparing the land was to make the ploughting at a depth between 25 and 30 cm. In the spring the works continued with the soil disking in 2 passes, process executed using a heavy disc. The last work in preparing the seedbed was performed using a combiner before sowing the sunflower crop.
Fertilization was administered manually in the NPK form, before sowing, and the nitrogen difference was applied in vegetation under the type of ammonium nitrate
In 2018 the sowing was done on 23.04.2018 and the emergence took place on 8.05.2018. In 2019 the sowing was done on 22.04.2019 and the emergence took place on 6.05.2019.
After sowing, the land was pre-emergent herbicidated with Dual Gold 960 EC herbicide (active substance S-metolachlor 960 g/l) in a dose of 1.2 l/ha.
At the stage of 4-6 leaves of the sunflower crop, Select Super 120 EC herbicide (active substance Clethodim 120 g/l) for the annual and perennial monocotyledon weeds was used in a dose of 1.5 l/ha. In the 8-10 leaf phase, a treatment made of 0.6 l/ha Reveller fungicide (active substances Cyproconazole 80 g/l + Picoxystrobin 200 g/l) and 0.15 l/ha Decis Mega 50 EW insecticide (active substance Deltamethrin 50 g/l) was applied to prevent foliar diseases and the attack of pests.
The green biomass was determined at 3 plants from the marginal rows, entirely removed, including roots, at each variant and repetition. The plants were immediately chopped and weighed and then were used to determinate the analysis at three different moments in dynamics: at 44, 54 and 68 days after emergence. Between time 1 (T1) and time 2 (T2) the interval was 10 days and between time 2 (T2) and time 3 (T3) the interval was 14 days. The biomass was then reported in g/pl. The harvested production from the surface of 10 square meters has been reported to the number of plants on the same surface, resulting the yield per plant reported in g/pl.

RESULTS AND DISCUSSIONS

The density at sunflower influences the green biomass, it being very significantly lower at 57,000 pl/ha and 71,000 pl/ha plant density compared to 43,000 pl/ha. The influence of density was analysed without taking into account the hybrid and the time of determination (Figure 1).

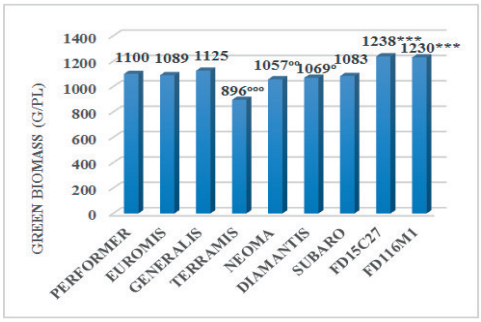


DL 5% = **29 g/pl**; DL 1% = **48 g/pl**; DL 0.1% = **89 g/pl**

Figure 1. Plant density influence on green biomass at sunflower

The green biomass has oscillated to the tested hybrids, irrespective of density and time of determination, between 1,238 g/pl in the Romanian hybrid FD15C27 and 896 g/pl in the hybrid Terramis. Compared to the Performer hybrid, the most wide-spread Romanian hybrid in the country, the FD15C27 and FD116M1 Romanian hybrids are very significantly higher in terms of green biomass. In contrast, the Terramis, Neoma and Diamantis hybrids have a lower vegetative mass with statistical assurance compared to the control hybrid (Figure 2).
Similar results which show that biomass production depends on the hybrid but also on

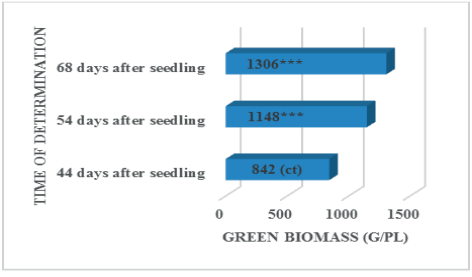
the level of water supply, were obtained by other researchers (Merrien, 1992; Rodriguez et al., 2002).



DL 5% = **26 g/pl**; DL 1% = **35 g/pl**; DL 0.1% = **45 g/pl**

Figure 2. Hybrid influence on green biomass at sunflower

Depending on the time of determination, the results obtained suggest that the green biomass increases very significantly from the first time of the determination (44 days after emergence) to the second time (54 days after emergence) and from the first time of determination (44 days after emergence) to the third time (68 days after emergence). In Caracal conditions it is observed that the biomass grows in the first 10 days from emergence much faster than it grows in the next 14 days (Figure 3).



DL 5% = **45 g/pl**; DL 1% = **60 g/pl**; DL 0.1% = **79 g/pl**

Figure 3. Time of determination influence on green biomass at sunflower

Similar results were presented by Moriondo et al. (2003) who observed that the accumulation of biomass in the sunflower decreases especially in pre-anthesis.

Interaction between plant density, hybrid and the time of determination shows that, at all three density, all hybrids have a very significantly increased biomass at time 2 versus time 1 and at time 3 versus time 1, but with a few exceptions.

If, in a rare crop, this tendency is uniformly maintained, at a density of 57,000 pl/ha and 71,000 pl/ha, the Performer hybrid records a decrease in vegetative mass at the time 2 of the determination in relation to the first one, which suggests that this hybrid does not grow up well under the conditions of a dense crop.

At the density of 57,000 pl/ha, this decrease is even very significantly lower. It is not excluded that this hybrid also has a deficiency because of the applied herbicide which, under high density conditions, acts as a growth inhibitor (Table 1).

At a density of 71,000 pl/ha the hybrid FD15C27 did not showed an increase of green biomass between 44 and 54 days after emergence.

A smaller but still significant increase has recorded the Diamantis hybrid at the density of 57,000 pl/ha between the time 1 and time 2 of determination, the conclusion being that this hybrid has a more pronounced growth over the 54 days after emergence.

The relationship between the 10 days vegetative growth interval (T2-T1) and respectively 14 days (T3-T2) is negative and it is not significant. Only about 5% of growth variability in the first 10 days is associated with vegetative growth in the next 14 days.

Starting from the green biomass value of 182.21 g/pl, an increase in vegetative mass by 1 g/pl in the first 10 days interval is associated with a decrease with 0.0793 g/pl in the following 14 days (Figure 4).

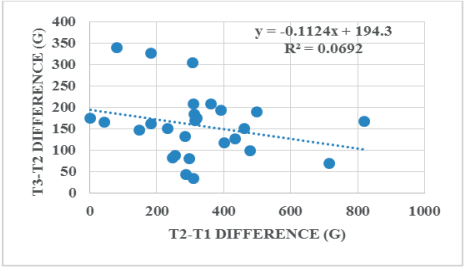


Figure 4. The relationship between the 10 days vegetative growth interval (T2-T1) and respectively 14 days (T3-T2)

However, the hybrids are distinguished from each other also according to their density. The vegetative biomass average between 44 and 54 days after emergence is 305 g/pl and the green biomass average between 54 and 68 days after emergence is 158 g/pl.

Thus, under the cultivation conditions from Caracal, the Generalis hybrid had an above-average increase in both intervals studied at all plant densities. The Diamantis hybrid had an above-average increase only at the 43,000 pl/ha and 71,000 pl/ha plant densities and the Subaro hybrid at 57,000 pl/ha and 71,000 pl/ha plant densities. Growth above-average also registered Euromis hybrid but only at the plant density of 43,000 pl/ha and the FD116M1 hybrid at 71,000 pl/ha plant density.

Table 1. Interaction between plant density, hybrid and the time of determination and its influence on green biomass at sunflower

HYBRIDS	TIME OF DETERMINATION	43,000 pl/ha			57,000 pl/ha			71,000 pl/ha		
		GREEN BIOMASS (G/PL)	DIF. CT (G)	SIGNIFICANCE	GREEN BIOMASS (G/PL)	DIF. CT (G)	SIGNIFICANCE	GREEN BIOMASS (G/PL)	DIF. CT (G)	SIGNIFICANCE
PERFORMER	44 d.a.s.*	1,150	ct		1,029	ct		964	ct	
	54 d.a.s.	1,405	255	***	806	-223	ooo	961	-3	
	68 d.a.s.	1,492	342	***	955	-74		1,135	171	***
EURAMIS	44 d.a.s.*	768	ct		654	ct		738	ct	
	54 d.a.s.	1,078	310	***	1,370	716	***	1,172	434	***
	68 d.a.s.	1,286	518	***	1,439	785	***	1,298	560	***
GENERALIS	44 d.a.s.*	719	ct		724	ct		792	ct	
	54 d.a.s.	1,539	820	***	1,041	317	***	1,112	320	***
	68 d.a.s.	1,706	987	***	1,210	486	***	1,286	494	***
TERRAMIS	44 d.a.s.*	823	ct		701	ct		539	ct	
	54 d.a.s.	1,121	298	***	949	248	***	827	288	***
	68 d.a.s.	1,201	378	***	1,030	329	***	869	330	***
NEOMA	44 d.a.s.*	1,102	ct		749	ct		762	ct	
	54 d.a.s.	1,252	150	***	1,035	286	***	945	183	***
	68 d.a.s.	1,398	296	***	1,166	417	***	1,106	344	***
DIAMANTIS	44 d.a.s.*	930	ct		878	ct		614	ct	
	54 d.a.s.	1,292	362	***	959	81	*	922	308	***
	68 d.a.s.	1,499	569	***	1,297	419	***	1,226	612	***
SUBARO	44 d.a.s.*	934	ct		648	ct		693	ct	
	54 d.a.s.	1,336	402	***	961	313	***	1,194	501	***
	68 d.a.s.	1,453	519	***	1,145	497	***	1,383	690	***
FD15C27	44 d.a.s.*	1,049	ct		1,098	ct		911	ct	
	54 d.a.s.	1,528	479	***	1,409	311	***	956	45	
	68 d.a.s.	1,626	577	***	1,443	345	***	1,121	210	***
FD116M1	44 d.a.s.*	1,105	ct		887	ct		781	ct	
	54 d.a.s.	1,567	462	***	1,072	185	***	1,174	393	***
	68 d.a.s.	1,717	612	***	1,398	511	***	1,367	586	***

d.a.s.* = days after seedling
DL 5% = 78 g/pl; DL 1% = 103 g/pl; DL 0.1% = 133 g/pl

The second category contains hybrids who had increases below average at both intervals. Thus, the Terramis hybrid highlighted this aspect at all plant densities, while the Neoma and Performer hybrids only at the first and second plant densities.

The hybrids with a significant increase within the 10 days interval and then a decrease within the 14 days interval, depending on the average, were: the Euromis hybrid at the second and third density, the FD15C27 hybrid at the first two densities and the Subaro and FD116M1 hybrids at 43,000 pl/ha.

The last category includes hybrids that had a smaller growth within the 10 days interval and then a more pronounced growth within the next 14 days interval. These hybrids (Neoma, Diamantis, Performer, FD15C27, FD116M)

show this aspect at at one single density, either 57,000 pl/ha or 71,000 pl/ha.
The ratio between the biomass growth within the 14 days interval and the biomass growth within the 10 days interval, showed that the Diamantis and FD116M1 hybrids, at 57,000 pl/ha plant density, and the Performer and FD15C27 hybrids, at 71,000 pl/ha plant density, grow much faster between 54 and 68 days after seedling, the growth being 2 to 4 times higher.
For the rest of the hybrids, at all densities, and even for those hybrids mentioned above, but at other densities than those recorded, the growth is stronger within the 44-54 days interval after emergence.
The correlation between the aquenes production obtained at the sunflower and the green biomass, both expressed in g/pl, is a positive and significant correlation.
As the density increases, the production and the green biomass decrease, as shown in the figure below, taking as landmark the control hybrid Performer (Figure 5).

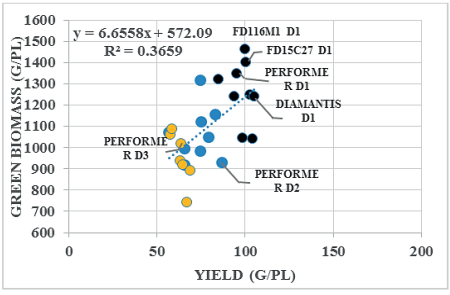


Figure 5. The relationship between production and green biomass at sunflower, without the influence of the time of determination

Published studies have shown that the biomass and the harvest index were strongly correlated with the amount of radiation intercepted during the filling of the grain, which, in turn, were correlated with the duration of the grain filling and the surface of the green leaf at sunflower (Vega and Hall, 2002).

CONCLUSIONS

The density at sunflower influences the green biomass of the sunflower plant, it being very significantly lower at 57,000 pl/ha and 71,000 pl/ha plant density compared to 43,000 pl/ha.
Compared to the Performer hybrid, the most wide-spread Romanian hybrid in the country, the FD15C27 and FD116M1 Romanian hybrids are very significantly higher in terms of green biomass. In contrast, the Terramis, Neoma and Diamantis hybrids have a lower vegetative mass with statistical assurance compared to the control hybrid.
Depending on the time of determination, the results obtained suggest that the green biomass increases very significantly from the first time of the determination (44 days after emergence) to the second time (54 days after emergence) and from the first time of determination (44 days after emergence) to the third time (68 days after emergence).
In Caracal conditions it is observed that the biomass grows in the first 10 days from emergence much faster than it grows in the next 14 days.
Under the cultivation conditions from Caracal, the Generalis hybrid had an above-average increase in both intervals studied at all plant densities. The Diamantis hybrid had an above-average increase only at the 43,000 pl/ha and 71,000 pl/ha plant densities and the Subaro hybrid at 57,000 pl/ha and 71,000 pl/ha plant densities. Growth above-average also registered Euromis hybrid but only at the plant density of 43,000 pl/ha and the FD116M1 hybrid at 71,000 pl/ha plant density.
Hybrids that had increases below average at both intervals were: the Terramis hybrid at all plant densities and the Neoma and Performer hybrids only at the first and second plant densities.
The relationship between the 10 days vegetative growth interval (T2-T1) and respectively 14 days (T3-T2) is negative and it is not significant. Only about 5% of growth variability in the first 10 days is associated with vegetative growth in the next 14 days.

ACKNOWLEDGEMENTS

The experiments in the field were carried out with the support of Agricultural Research and Development Station Caracal.
The foliar fertilizer was provided by AgriTecnoFertilizantes and the Neoma hybrid by Syngenta Company.

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