RESEARCH ON THE LEAF AREA THROUGH THE PRISM OF HYBRID X DENSITIES X MOMENT OF DETERMINATION INTERACTION TO AN ASSORTMENT OF THE SUNFLOWER TESTED ON THE CHERNOZEM FROM CARACAL

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ABSTRACT

At ARDS Caracal, on chernozem type soil, for two years (2018 and 2019), 9 sunflower hybrids were tested to study the interaction between hybrid, sowing density and moment of leaf area determination. The hybrids were: Euromis, Generalis, Terramis, Neoma, Diamantis, Subaro, Performer, FD15C27, FD116M1. The densities of which hybrids were: 43000 pl / ha, 57000 pl / ha and 71000 pl / ha and the moment of determining the leaf area was placed 32 days, 43 days, 54 days and 66 days after emergence. The leaf area was determined on all the leaves on the plant, on 3 plants on each replication, using Schneiter's (1978) formula: S = (L * l * 0.6683) -2.45 where S = leaf area, L = length of the leaf, l = width of the leaf. Compared to the first determination, in the other three, the leaf area showed very significant increases in all densities and all hybrids. At medium and high densities, only Neoma and FD15C27 hybrids had fast leaf surface growths. The leaf area was lush at low density in Neoma and FD116M1 hybrids while Euromis and Performer hybrids showed the same leaf area in both densities: low and medium.

INTRODUCTION

The sunflower culture, an oleic plant of global interest, has developed progressively and has gone through several stages, determined by the progress made in the genetic improvement of this noble plant (Bonciu et al., 2020). Sunflower continues to be (after soybean) a world leader of the plants with high nutrition value, as it is considered a miraculous source of food and a therapeutic miracle in the treatment of many diseases (Bonciu, 2019).

On the other hand, through the vegetable residues (leaves, stems and calatids) that remain after harvest, the sunflower returns to the soil appreciable quantities of mineral elements and organic matter estimated in the case of a yield of 3500 kg / ha, at: 65 kg N, 30 kg P_2O_5, 300 kg K_2O and about 7 tons of dry matter equivalent to 1200-1500 kg of humus (Hera et al., 1989).

In terms of sunflower hybrids, Romania was the first country in the world where they were created. In Romania, in addition to the local populations cultivated before the Second World War, there were also three local varieties: Măslinica, Uleioasă de Tg. Frumos, Neagră de Cluj. After cultivating sunflower varieties for a long time, in 1968, the first hybrids based on nuclear androsterility, genetically marked and then based on cytoplasmic androsterility and pollen fertility restoration were created at the Fundulea National Institute for Agricultural Research and Development. In 1973, simple hybrids such as: Romsun 52 (Fundulea 52) and Romsun 53 (Fundulea

53) are approved and put into production. (Vrânceanu, 2000).

Leaf area (LA) is associated with many agronomic and physiological processes including growth, photosynthesis, transpiration, photon interception, and energy balance (Goudriaan and Van Laar 1994).

Simple, accurate, and non-destructive methods for determining leaf area (LA) of plants are important for many experimental comparisons. Determining the individual LA of sunflower (Helianthus annuus L.) involves measurements of leaf parameters such as length (L) and width (W), or some combinations of these parameters. Validation of the equation having W^2 of leaves measured in the 2004 experiment showed that the correlation between calculated and measured areas was very high (Rouphael et al., 2007).

The effects of genotype and environment on canopy development of sunflower (*Helianthus annuus* L.) have been the subject of much research.

Between emergence and anthesis, total leaf area per plant (TPLA) was determined as a logistic function of TPLA at anthesis and thermal time from emergence (TT). Total leaf area per plant at anthesis was linearly related to total leaf number for a range of cultivars and hybrids. Total leaf number was estimated as the product of the duration of the period emergence to head visible (in days) and the average leaf initiation rate in that period. Leaf initiation rate was related to the average temperature during this period (Chapman et al, 1997).

The aim of study made by Firouzabadi and all (2015) was to estimate leaf area across different water regime treatments using a combination of leaf mass and leaf dimensions of sunflower (*Helianthus annuus* L.). For this purpose, different leaf sizes were collected from plants during the growing season on different time intervals. Experiment was conducted during 2012 summer time in Sari Agriculture Sciences and Natural Resources University, Iran. On field leaf dimension measurements were carried out, and leaves sketches were put on paper, scanned and then areas were measured using AutoCAD software. Multivariate linear and non-linear regression models were constructed between leaf area and other leaf components measured. All constructed models provided highly significant correlations (r = 0.90–0.99) between leaf area and different leaf components. In conclusion, the simple and quick models developed in this study could predict the sunflower leaf area and leaf area index with high precision (Firouzabadi et al., 2015).

The leaf area index of sunflower was lower during early growth period, with a gradual increase over the time and achieved maximum value at flowering stage (Sarwar et al., 2013). Similarly, Mirallas et al. (1997) also observed that there was a gradual increase in LA1 with the advance in the age of the crop, the greatest value reached during full flowering.

The differences in leaf areas among the hybrids at 10 to 60 days after emergence (DAE) during both seasons (spring and autumn) were statistically significant, in another study. The effect of differences in years among hybrids was also to be significant ($p < 0.05$) at 10 and 60 DAE during spring and at 10, 40 to 60 DAE during autumn. The effect of interactions (hybrids x years) among the hybrids was also statistically significantly different ($p < 0.05$) at 10 to 60 DAE during both seasons, except at 50 DAE during autumn (Kaleem et al.2010).

MATERIAL AND METHOD

At ARDS Caracal, on chernozem type soil, for two years (2018 and 2019), 9 sunflower hybrids were tested to study the interaction between hybrid, seed density and moment of leaf area determination. The hybrids were: Euromis (1), Generalis (2), Terramis (3), Neoma (4), Diamantis (5), Subaro (6), Performer (7), FD15C27 (8), FD116M1 (9). The densities of which hybrids were: 43000 pl

/ ha (D1), 57000 pl / ha (D2) and 71000 pl / ha (D3) and the moment of determining the leaf area was placed 32 days (m1), 43 days (m2), 54 days (m3) and 66 days (m4) after emergence.

The experiment was placed in randomized blocks, in 3 replications. The length of the plot was 10 m and the width - 2.8 m, the equivalent of 4 rows from which the marginal ones are removed.

The leaf area was determined on all the leaves on the plant, on 3 plants on each replication, using Schneiter's (1978) formula: S = (L * l * 0.6683) -2.45 where S = leaf area, L = length of the leaf, l = width of the leaf (Matei, 2013).

The yield was determined by harvesting the two middle rows of the 10 m long plot (harvestable area = 14 m^2), the seeds were weighed, the humidity was determined and the yield was calculated to the STAS humidity of 9%.

The aim of the experiment was to characterize each hybrid from an assortment of sunflower regarding the dynamics of the leaf area at different seed densities depending on the moment of determination. This aspect is closely related to the recommended technology and the adaptability of the hybrid to a set of pedo-climatic conditions.

RESULTS AND DISCUSSIONS

The hybrid x seed density x the moment of determination the leaf area interaction is the most complex of the interactions that can be determined by this experiment and the one that expresses a complete vision of the development of the sunflower plant.T

The leaf area reaches its peak at the plant blooms when the growth of the leaves stops.

The assimilation surface to sunflower is reduced after the second half of July, by drying the leaves at the base of plant.

The first control was the moment of determination the leaf area 32 days after emergence (ct1) and the second control - the moment of determination the leaf area at 43 days after emergence (ct2).

Compared to the first determination of the leaf area, at 32 days after emergence, the other three (at 43, 54 and 66 days after emergence) show very significant increases at all seed density and all hybrids (Table 1).

The situation changes when the reporting is made to the determined leaf area 43 days after emergence. At the first seed density the increase from 43 to 54 days, in all hybrids is ensured statistically: significant (Generalis); distinctly significant (Terramis, Diamantis, Subaro, FD15C27, FD116M1); very significant (Euromis, Neoma and Performer). From 54 to 66 days after emergence, at low seed density, hybrids: Generalis, Subaro, Performer, FD116M1 no longer shows significant increase in leaf area.

At 57,000 plants / sqm, in the hybrids Terramis, Neoma, FD15C27, FD116M1, the increase of the leaf surface does not show significance from 43 to 54 days, on the one hand and from 43 to 66 days, on the other hand. And at 71000 pl / sqm, the Neoma and FD15C27 hybrids keep the same behavior.

In conclusion, at medium and large seed densities, the Neoma and FD15C27 hybrids have a rapid growth of the leaf area.

Table 1

Hybrid x seed density x moment of determination of the leaf area interaction at sunflower on the chernozem from Caracal (average 2018 and 2019)

Hybrid	Moment	Yield(kg/ha)	Diff.ct.1	Significance	Diff.ct.2	Significance
D1 = 43000 pl/sqm						
1	**m1**	1378	ct 1		-4529	ooo
	m2	5907	4529	***	ct 2	
	m3	8044	6666	***	2137	***
	m4	8639	7261	***	2732	***
2	**m1**	2248	ct 1		-4125	ooo

	m2	6373	4125	***	ct 2	
	m3	7865	5617	***	1492	*
	m4	6556	4308	***	183	
3	**m1**	1633	ct 1		-4424	ooo
	m2	6057	4424	***	ct 2	
	m3	8067	6434	***	2010	**
	m4	7391	5758	***	1334	*
4	**m1**	1970	ct 1		-4694	ooo
	m2	6664	4694	***	ct 2	
	m3	10067	8097	***	3403	***
	m4	8129	6159	***	1465	*
5	**m1**	1623	ct 1		-4624	ooo
	m2	6247	4624	***	ct 2	
	m3	8002	6379	***	1755	**
	m4	7611	5988	***	1364	*
6	**m1**	1797	ct 1		-4494	ooo
	m2	6291	4494	***	ct 2	
	m3	7998	6201	***	1707	**
	m4	6703	4906	***	412	
7	**m1**	1651	ct 1		-4582	ooo
	m2	6233	4582	***	ct 2	
	m3	8978	7327	***	2745	***
	m4	5894	4243	***	-339	
8	**m1**	1274	ct 1		-2918	ooo
	m2	4192	2918	***	ct 2	
	m3	5958	4684	***	1766	**
	m4	6593	5319	***	2401	***
9	**m1**	2390	ct 1		-4403	ooo
	m2	6793	4403	***	ct 2	
	m3	8722	6332	***	1929	**
	m4	6906	4516	***	113	
D2 = 57000 pl/sqm						
1	**m1**	1342	ct 1		-4268	ooo
	m2	5610	4268	***	ct 2	
	m3	8924	7582	***	3314	***
	m4	8115	6773	***	2505	***
2	**m1**	1588	ct 1		-2836	ooo
	m2	4424	2836	***	ct 2	
	m3	5836	4248	***	1412	*
	m4	4153	2565	***	-271	
3	**m1**	2118	ct 1		-2609	ooo
	m2	4727	2609	***	ct 2	
	m3	5749	3631	***	1022	
	m4	4723	2605	***	-4	
4	**m1**	1823	ct 1		-4225	ooo
	m2	6048	4225	***	ct 2	
	m3	7089	5266	***	1041	

	m4	7259	5436	***	1211	
5	**m1**	1637	ct 1		-3124	ooo
	m2	4761	3124	***	ct 2	
	m3	6365	4728	***	1604	**
	m4	5818	4181	***	1057	
6	**m1**	1639	ct 1		-2812	ooo
	m2	4451	2812	***	ct 2	
	m3	5778	4139	***	1327	*
	m4	6172	4533	***	1721	**
7	**m1**	2304	ct 1		-4482	ooo
	m2	6786	4482	***	ct 2	
	m3	8800	6496	***	2014	**
	m4	10029	7725	***	3243	***
8	**m1**	2533	ct 1		-2849	ooo
	m2	5382	2849	***	ct 2	
	m3	6394	3861	***	1012	
	m4	5715	3182	***	333	
9	**m1**	1982	ct 1		-2442	ooo
	m2	4424	2442	**	ct 2	
	m3	5328	3346	**	904	
	m4	4967	2985	**	543	
D3=71000 pl/sqm						
1	**m1**	1674	ct 1		-2653	ooo
	m2	4327	2653	***	ct 2	
	m3	5611	3937	***	1284	*
	m4	4662	2988	***	335	
2	**m1**	1518	ct 1		-2577	ooo
	m2	4095	2577	***	ct 2	
	m3	5553	4035	***	1458	*
	m4	5358	3840	***	1263	*
3	**m1**	1751	ct 1		-3246	ooo
	m2	4997	3246	***	ct 2	
	m3	6784	5033	***	1787	**
	m4	7458	5707	***	2461	***
4	**m1**	1328	ct 1		-3879	ooo
	m2	5207	3879	***	ct 2	
	m3	6420	5092	***	1213	
	m4	5603	4275	***	396	
5	**m1**	2475	ct 1		-3844	ooo
	m2	6319	3844	***	ct 2	
	m3	8001	5526	***	1682	**
	m4	5444	2969	***	-875	
6	**m1**	2763	ct 1		-3399	ooo
	m2	6162	3399	***	ct 2	
	m3	7918	5155	***	1756	**
	m4	5478	2715	***	-684	
7	**m1**	1942	ct 1		-2620	ooo

	m2	4562	2620	***	ct 2	
	m3	5831	3889	***	1269	*
	m4	5534	3592	***	972	
8	**m1**	1986	ct 1		-2106	
	m2	4092	2106	***	ct 2	
	m3	4642	2656	***	550	
	m4	3910	1924	**	-182	
9	**m1**	1608	ct 1		-2625	ooo
	m2	4233	2625	***	ct 2	
	m3	5457	3849	***	1224	
	m4	6529	4921	***	2296	***

DL 5% **1249 kg/ha**
DL 1% **1648 kg/ha**
DL 0.1% **2124 kg/ha**

The attached graphs highlight the traits of each hybrid as a function of seed density and the moment of determination regarding the dynamics of growth of the leaf area.

In the Euromis hybrid, the leaf area is reduced to high seed density (figure 1).

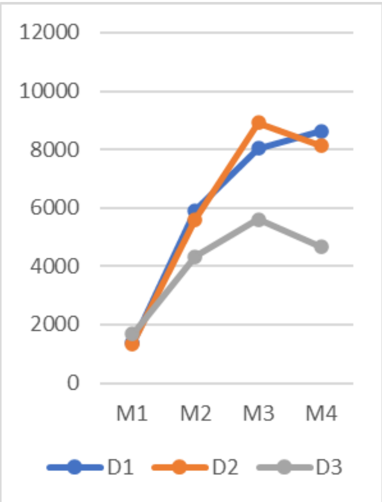

Figure 1. Leaf area dynamics in the Euromis hybrid by interaction with seed density and moment of determination

In the Generalis hybrid, the leaf area is reduced to medium and high seed density (figure 2).

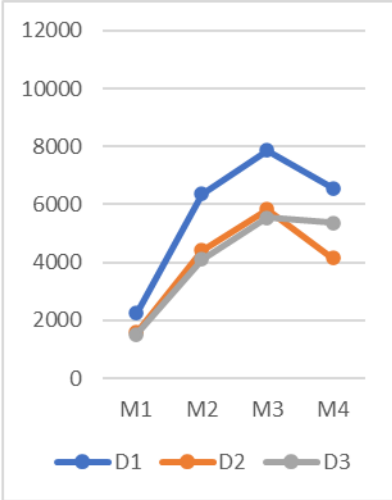

Figure 2. Leaf area dynamics in the Generalis hybrid by interaction with seed density and moment of determination

In Terramis, the difference between the values of the leaf area is relatively equal from one seed density to another (figure 3).

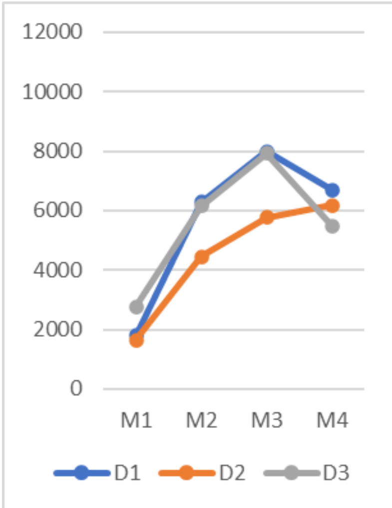

Figure 3. Leaf area dynamics in the Terramis hybrid by interaction with seed density and moment of determination

In Neoma hybrid, practically at none moment of determination and at any of the densities, the values of the leaf surface do not intersect, being perfectly delimited. The leaf area on low seed density has the highest values (figure 4).

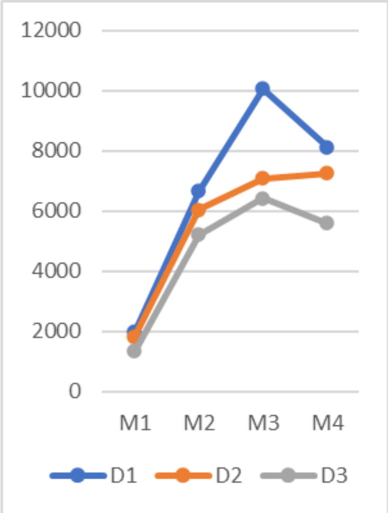

Figure 4. Leaf area dynamics in the Neoma hybrid by interaction with seed density and moment of determination

Diamantis is the first hybrid in which the values of the leaf area at the first and third seed density are practically equal to the first 3 determinations (figure 5).

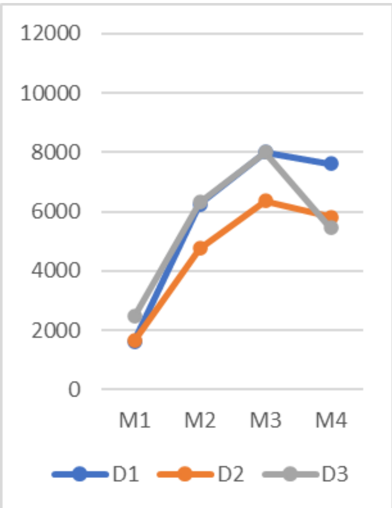

Figure 5. Leaf area dynamics in the Diamantis hybrid by interaction with seed density and moment of determination

The graph representing the Subaro hybrid is almost identical to the previous one (figure 6).

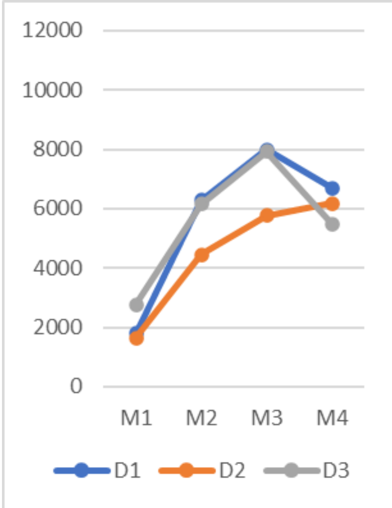

Figure 6. Leaf area dynamics in the Subaro hybrid by interaction with seed density and moment of determination

In Performer, the leaf areas at the first two seed density and at the first 3 moments of determination are equal. The development of the plant in the Performer hybrid is greatly influenced by sowing at high density (figure 7).

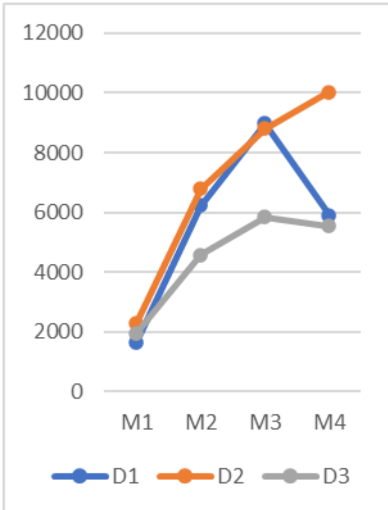

Figure 7. Leaf area dynamics in the Performer hybrid by interaction with seed density and moment of determination

The FD15C27 hybrid is the first and only one in which the foliar development is much reduced indifferent of the seed density, it being around 6000 cm^2 (figure 8).

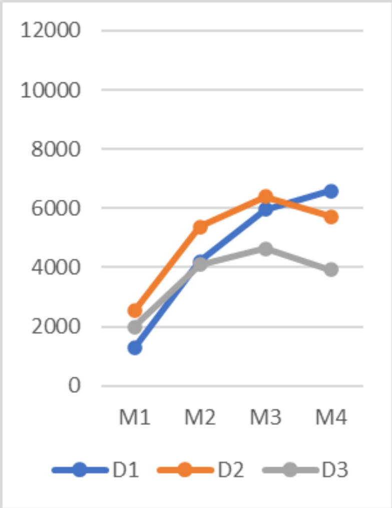

Figure 8. Leaf area dynamics in the FD15C27 hybrid by interaction with seed density and moment of determination

In the FD116M1 hybrid, the leaf development was explosive at the first seed density, at the other two being practically equal (figure 9).

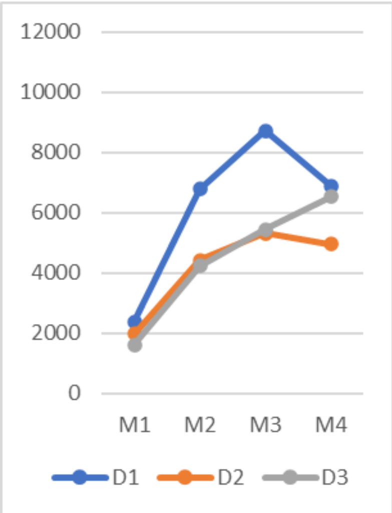

Figure 9. Leaf area dynamics in the FD116M1 hybrid by interaction with seed density and moment of determination

In conclusion, the leaf area is lush at low seed density in the Generalis, Neoma and FD116M1 hybrids while the Euromis and Performer hybrids have the same leaf area in the first and second seed density.

CONCLUSIONS

Compared to the first determination, in the other three, the leaf area showed very significant increases in all densities and all hybrids. At medium and high densities, only Neoma and FD15C27 hybrids had fast leaf surface growths. The leaf area was lush at low density in Neoma and FD116M1 hybrids while Euromis and Performer hybrids showed the same leaf area in both densities: low and medium.

At Neoma, the graph is different from all the others. Practically at none of moments of determination and at any of the seed densities, the values of the leaf surface do not intersect as they are perfectly delimited.

In Performer, the leaf areas at the first two seed density and at the first 3 moments of determination are equal.

The FD15C27 hybrid is the only one in which the foliar development is much reduced indifferent of the seed density, it being around 6000 cm^2.

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