DROUGHT EFFECTS ON GROWTH STAGES AND YIELD COMPONENTS OF SUNFLOWER HYBRIDS

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Abstract

In 2003, in order to emphasize the way that drought has acted on sunflower growth and development; we have studied 20 hybrids registered in Romania. Hydrological and pedological drought during the growth period had significant influence on sunflower growth and development, duration of phenological phase and, implicitly on yield. The heliothermic index for the growth stage was 5.1, ascertaining the dryness of year 2003. The sprouting ratio was between 70.2 % (HS-2521) and 88.1 % (HS-PI-2000). The growth rate was low, hybrid height being lower compared to normal years. The variation limits of this trait were between 102 cm (HS-PI-2000) and 147 cm (HS-2442). The stem diameter indicated a thin stem (1.5-3 cm) until the first anthesis and a strong stem at maturity (3-5 cm). The leaf area and limb had registered maximum values in early and semi-late hybrids, the average of the group being 519.29 cm sq. and 528 cm sq. respectively. High temperatures resulted in early button formation, anthesis and physiological maturity; the growth period in most of hybrids was less than 100 days. The values registered by hybrids for productivity elements certified adaptability of the sunflower to long-term water and thermic stress. The sunflower yield was between 2738 kg/ha (HS-2521, early hybrid) and 4320 kg/ha (HS-2449, late hybrid created at the Institute of Fundulea). Compared to the check hybrid, higher yields (1-16%) were recorded for the hybrids Performer, Minunea, Splendor, TOP-75, HS-PI-2001, HS-2527, HS-2442 and HS-2606, proving their higher stability under excessive drought. High self-fertility (25-59 %) in some hybrids ensured a greater stability in sunflower yield.

Introduction

One of the objectives of sunflower research in the world is to study damaging action and resistance mechanisms to thermic and water stress (Andrei, 2000; Baldini et al., 1991; Khalifa et al., 2000; Vanozzi et al., 1999; Vranceanu, 2000). Sunflower is adapted to different environmental conditions according to cultivar growth period, resistance to drought and temperature variations (Andrei, 1997; Laiu and Andrei, 2000). When thermic and water stress occur early and over a long period, there are changes in sunflower development processes (Merrien, 1992).

This paper presents a study of ecophysiological response of some sunflower hybrids to the drought of 2003, in the area of the Agricultural Research and Development Station of Podu-Iloaiei, Iasi County, Romania.

Materials and Methods

Investigations were conducted on 20 hybrids registered in Romania. The evolution of climatic conditions was estimated according to daily fluctuations of some parameters: temperature (from air and soil), water (rainfall and air humidity) and light (duration of sunny and cloudy weather) during sunflower growth stages. For a climate characterization which takes into account more climatic elements typical of the year 2003, we have used the heliothermic index proposed by Domuta (1995). The ecophysiological response was evaluated by the analysis of phenological phases for the development cycle of aerial organs (vegetative and reproductive), pollen amount, degree of self-compatibility, oil content and pericarp. The plant growth was evaluated by using the FAO scale (growth rate and plant vigor) and by biometrical determinations (stem length and thickness, petiole length, limb area, leaf area per plant and head diameter).

Sunflower yield was determined at maturity for each hybrid and was calculated at 11% humidity. NMR (Newport Instrument) was used for seed oil content analyses. The pericarp ratio was determined on samples of 5g achenes and the results were expressed by reference to 100 g of seeds.

Results and Discussion

The climatic factors (temperature, humidity, and light) recorded in northeastern Romania during the sunflower growth period of 2003 revealed a very severe drought and hot conditions. The heliothermic index for the sunflower growth period was 5.1, emphasizing the dryness of the year 2003, and it was 17.7 during 2002-2003, confirming the humidity aspect. The lack of rainfall in the period before and after sowing, at which high air and soil temperatures were added, had a negative influence on plant sprouting, growth and development. The growth rate was slow, plant height having lower values for all hybrids under study, between 102 and 147 cm, compared to plant height during the normal climatic years. The stem diameter showed thinner stems until the first anthesis (1.5-3 cm), but recovered by maturity (3-5 cm). The head presented a slow growth until the beginning of flowering, and then the growth was faster, caused by a slight improvement in the water factor. The head diameter was between 20 and 31 cm. The number of leaves (25-34) and bracts (57-86) was less affected by water stress and hot conditions, showing a stronger stability of these traits. The limb area had maximum values of over 519 cm sq.. The leaf area per plant varied greatly among hybrids, between 8756.88 cm sq. (HS-PI-2000) and 21440.70 cm sq. (HS-2606).

With regard to the main phenological stages of the sunflower hybrids under study, the interval from sowing to emergence was longer by 4-5 days as a result of the drought which appeared in the first 10 days of April. The water reserves of soil from winter had an important role in the germinating and sprouting processes.

The high minimum, maximum and mean air temperatures resulted in an early button formation, anthesis and physiological maturity and a shorter period passing through phenological phases by the hybrids: sprouting-button formation in 26-36 days; button formation-first anthesis in 19-27 days; button formation-last anthesis in 27-36 days; last anthesis-physiological maturity in 27-40 days, and sprouting-last anthesis in 56-67 days. The growth period up to physiological maturity of most of the hybrids was below 100 days.

The water stress in the period of floral button formation to last anthesis resulted in a greater number of aborted tubular flowers. The thermal stress associated with drought affected pollination and fecundation, justifying the presence of empty seeds. The number of empty seeds per head varied from 34 (HS-2521) to 992 (Splendor) with the greatest number in hybrids with a flat shape to the back of the head. The pollen amount per head varied from 0.72 g (HS-2606, early group) to 1.36 g (TOP-75, late group).

In Table 1 the values of the productivity elements are presented. The number of achenes per head and their weight showed the different productive potential of hybrids. In the early group, the number of achenes had as extremes HS-2521 with 1235 achenes per head and HS-PI-2001, where the number was 2674. In semi-early hybrids, the values were between 1118

Table 1. Productivity elements and achene yield (Agricultural Research and Development Station of Podu-Iloaiei, 2003).

Hybrid	Achenes per head		Weight of 1000 seeds (g)	Hectoliters mass kg/hl	Pericarp rate	Self fert. %	Yield	
	number	weight					Kg/ha	%
Early group (87-90 days)								
HS – 2524	2668	155.03	65.50	46	22.0	3	3146	98
HS – 2606	2353	194.09	70.40	42	18.1	2	3716	116
HS – 2521	1235	137.45	75.50	44	16.5	15	2738	86
HS-PI-2000	1541	167.86	56.50	42	20.0	40	2781	87
HS-PI-2001	2674	179.76	64.70	43	22.0	43	3598	112
Average of the group	2094	166.84	66.54	43	19.7	21	3196	100
LSD 5 %	596	19.57	6.33	1	2.16	23	402	12
Semi-early group (92-96 days)								
HS-2615	2052	166.21	62.25	46	18.3	3	3223	95
HS-2527	1808	164.96	70.00	40	16.3	32	3815	112
VENUS	1548	124.20	68.75	46	16.0	30	2970	87
SPLENDOR	1118	108.12	74.50	42	14.6	40	3561	104
Average of the group	1632	140.87	68.87	43	16.3	26	3392	100
LSD 5 %	943	29.14	5.03	3	1.52	22	370	10
Semi-late group (99 days)								
HS-2442	2193	188.30	72.25	43	20.5	16	3942	113
PERFORM-ER	1599	139.42	79.75	42	24.3	59	3540	101
MINUNEA	1876	194.14	76.00	43	17.6	37	3624	104
ALCAZAR	2634	140.11	57.50	46	23.1	2	3171	91
TRAJANO	1680	138.15	74.50	44	22.4	51	3350	96
FAVORIT	1678	132.45	75.75	45	18.2	13	3338	95
Average of the group	1943	155.43	72.62	44	21.0	30	3494	100
LSD 5 %	327	22.82	7.09	1	2.2	23	223	6

Late group (102–104 days)								
HS-2449	1642	127.88	73.50	40	22.0	55	4320	114
TOP-75	1951	154.26	66.50	46	18.4	2	4076	107
FLORINA	2247	207.08	76.00	44	18.2	3	3473	91
JUSTIN	2085	164.12	66.75	42	22.1	13	3128	82
SELECT	1862	117.46	68.25	44	16.5	6	3142	83
Average of the group	1958	154.16	70.20	43	19.4	16	3628	100
LSD 5 %	203	34.42	10.83	2	2.2	26	487	13

(Splendor) and 2052 (HS-2615). The semi-late hybrid Alcazar had the highest number of achenes per head with 2634, and in the Performer hybrid belonging to the same group, it was 1599. The late hybrids achieved a number of achenes per head between 1642 (HS-2449) and 2247 (Florina).

The weight of achenes per head varied between 155.03 g and 194.09 g (early group); between 108.12 g and 166.21 g (semi-early group); between 132.45 g and 194.14 g (semi-late group) and between 117.46 g and 207.08 g (late group). The weight of 1000-seeds, which directly affects the yield together with the number of achenes per head and the number of plants per area unit, has shown significant differences among hybrids. Extreme mean values were seen in the early hybrid HS-PI-2000 (56.50 g), and in the semi-late hybrid Performer (79.75 g). The results also indicated variations in seed yield among hybrids as well as among the averages of the maturity groups used and the check. The seed yield varied between 2738 kg/ha (HS-2521, early hybrid) and 4320 kg/ha (HS-2449, late hybrid). Compared to the check, higher yields of 1-16% (Performer, Minunea, Splendor, TOP-75, HS-2527, HS-2442 and HS-2606) prove that the new hybrids are more tolerant to water stress and hot conditions.

The high self-fertility (25-59%) of some hybrids correlated well to high seed yields. The test weight was quite high, so this trait was less influenced by these environmental conditions. The pericarp content was between the extreme values of 14.6% (Splendor, semi-early hybrid) and 24.3% (Performer, semi-late hybrid).

In Table 2 correlation coefficients between seed yield and different traits of sunflower hybrids under study are presented. Most of these correlations are similar or close to those reported previously.

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Table 2. Correlation coefficients (r) between yield (kg/ha) and different characteristics of sunflower hybrids (2003, dry)

Characteristics	Group			
	Early P 5% = 0.75	Semi-early P 5% = 0.75	Semi-late P 5% = 0.58	Late P 5% = 0.75
Sowing to emergence (days)	0.47	0.30	-0.16	0.04
Emergence to budding (days)	0.40	0.74	0.55	-0.61
Budding to first anthesis	0.42	0.22	-0.19	0.61
First anthesis to last anthesis	0.57	-0.54	0.34	0.37
Budding to last anthesis	**0.96*** **	-	-0.11	0.50
Last anthesis to physiological maturity	**-0.86***	-0.72	-0.46	-0.19
Physiological maturity to technical maturity	**0.88****	**-0.76***	-	-0.51
Emergence to last anthesis	**0.83***	0.42	0.46	**-0.78***
Emergence to physiological maturity	0.36	-	-	**-0.82***
Emergence to technical maturity	**0.75***	-0.58	-	**-0.90****
Achenes per head (no.)	**0.83***	0.14	-0.22	**-0.80***
Total leaf area per plant (cm^2)	**0.95*** **	-0.24	0.37	-0.35
Amount of pollen produced per head (g)	0.11	-	-	-
Weight achenes per head (g)	**0.83***	0.23	**0.79****	-0.17
Mass of 1000 seeds (g)	0.14	0.44	0.44	0.19
Self-fertility degree (%)	-0.15	0.40	0.15	0.59
Head diameter (cm)	0.66	-0.20	**0.80****	0.52
Plant height (cm)	-0.13	-	0.56	-0.49
Stem diameter (cm)	0.17	-0.39	0.54	0.10
Tubular flowers per head (no.)	**0.84***	0.13	0.24	**-0.77****
Days when tubular flowers appeared (no.)	-	**-0.78***	0.56	-