VARIABILITY OF SUNFLOWER RESISTANCE TO DROUGHT

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In order to develop new sunflower hybrids both drought resistant and with high yields of seeds and oil, eight inbred lines of different origins and with various phenotypic characteristics were studied in view of their characterization and for explaining the variability of their drought resistance potential (fig. 1).

These inbred lines were developed at the Research Institute for Cereals and Industrial Crops-Fundulea, and the investigations were carried out during the 1972—1973 period in the Physiology and Biochemistry Laboratory.

While the check variant was maintained at a permanent optimum moisture level (70% of the saturation capacity of the soil), in all the other variants controlled drought at the 40% level was maintained for ten days during flowering period. Our previous experiments showed that drought is the most harmful in this phase, affecting the metabolic activity of plants and decreasing both yields and oil content significantly. These effects were investigated at the end of drought and further during the various stages of vegetation until full maturation. Check plants grown under optimum moisture regime were also analysed for comparison.

During these moments of the growing period, a large number of determinations were performed in order to establish the resistance to drought of the experimented material, knowing that drought resistance is a complex, dynamic and variable characteristic.

MORPHOLOGICAL REACTIONS OF THE STUDIED MATERIAL, BOTH IN SOIL NORMAL MOISTURE CONDITION AND UNDER MOISTURE STRESS

Depending on the biological feature of the inbred line, drought significantly decreased plant height, root length and the diameter of heads (fig. 2).

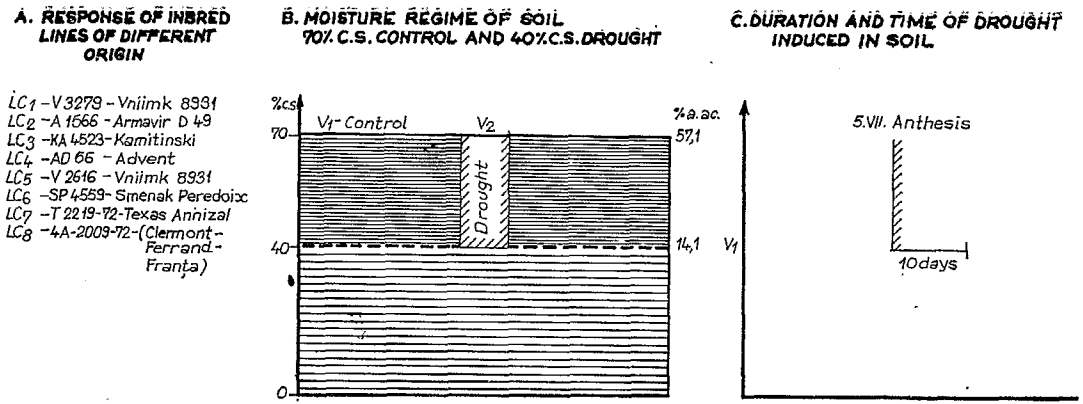

Fig. 1 — Experimental scheme (grouth house).

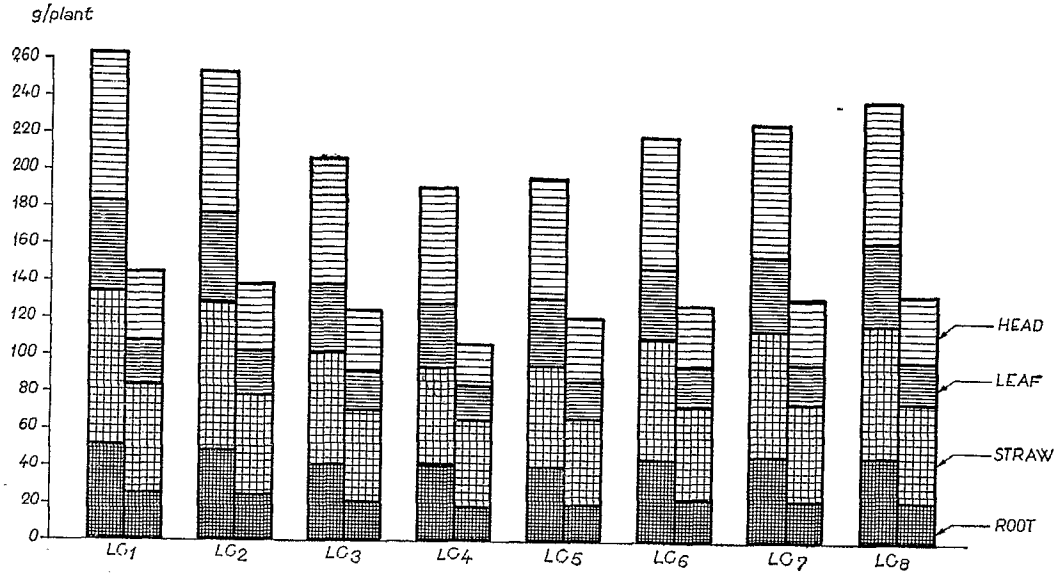

Fig. 3 — Detrimental effect of drought on the accumulation of organic substances in plants.

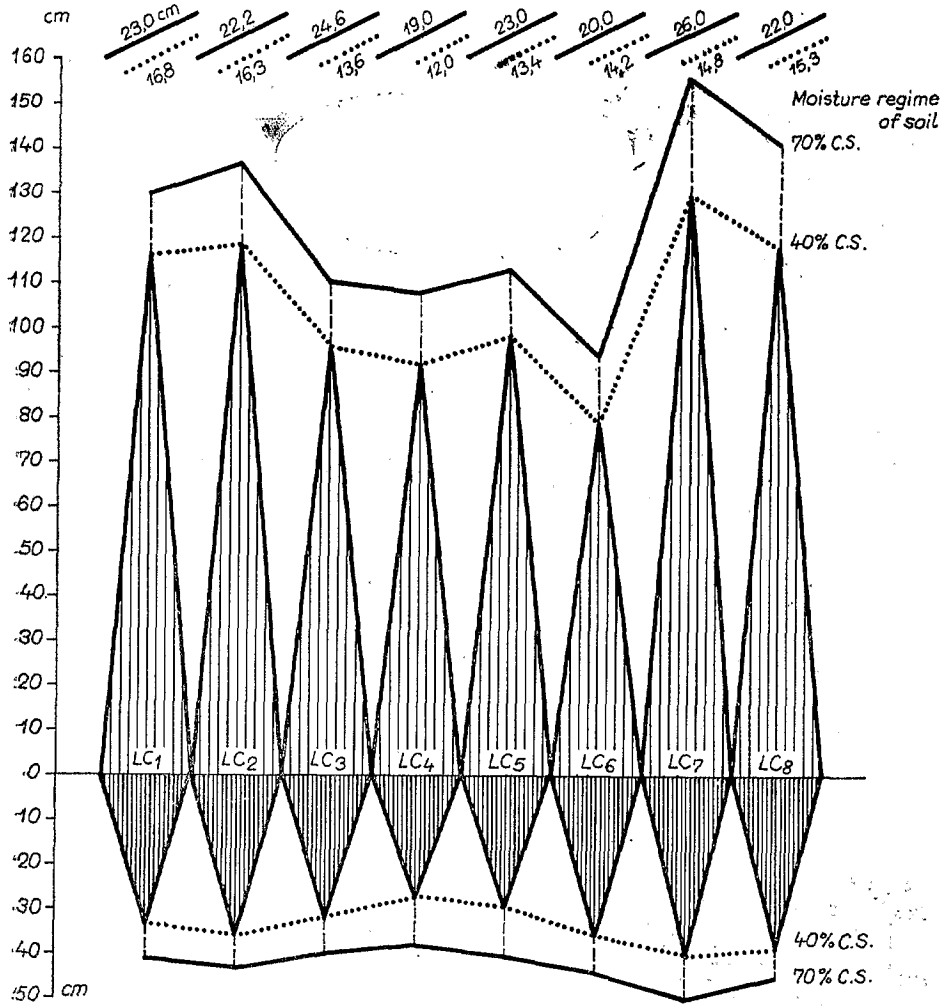

Fig. 2 — Plant height, root length, head diameter, in an optimum moisture regime and in drought conditions.

Dry matter accumulation in roots, stalk leaves and heads was seriously hampered by drought. In stressed variants, the volume of stored assimilates is small (fig. 3). Thus, in drought conditions during flowering period, the weight of stored substances decreases on an average with 42% as compared to checks. It appeared however that both in check and stressed variants, values for dry matter stored in various plant organs were higher in inbred lines 1, 2, 8 and 7, showing that in these lines synthetic activity was less affected and that the capacity of recovery of normal activity is higher.

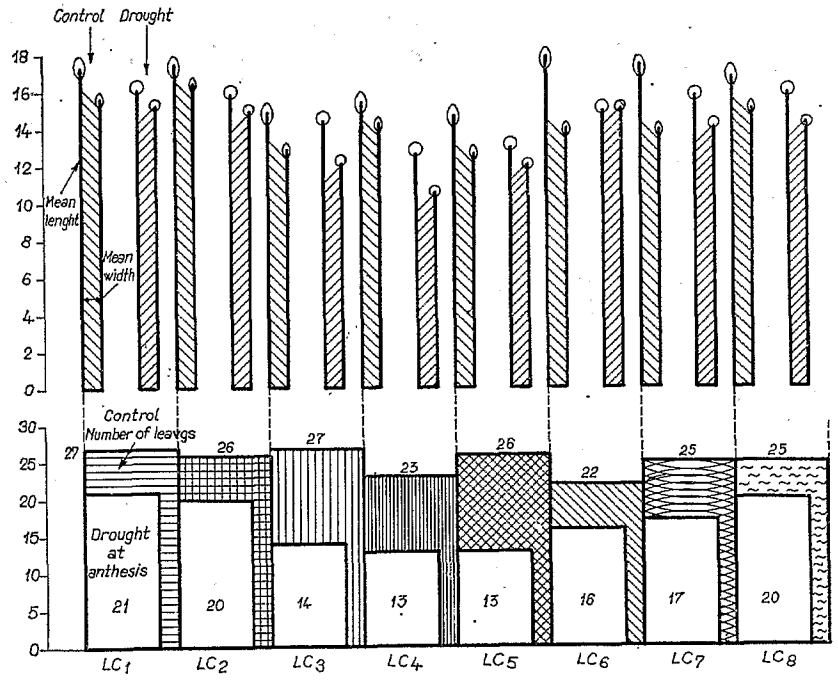

Fig. 4 — Number and size of leaves.

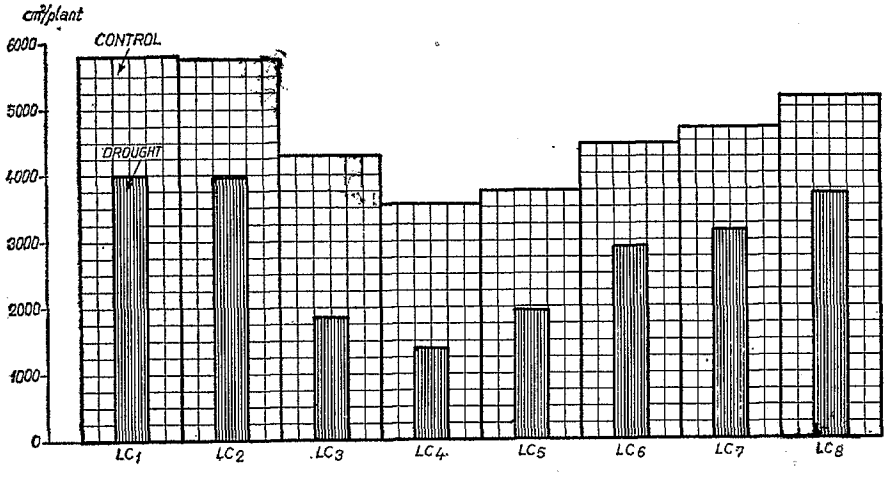

Fig. 5 — Leaf area.

It appears that in these inbred lines, the number and size of leaves were higher for the check as compared to the stressed variants. On the other hand check plants kept their leaves longer while in the others the rate of wilting was higher (fig. 4).

Drought caused a decrease of leaf area by about 61% as compared to the total leaf area, affecting seriously the physiological activity (fig. 5).

PHYSIOLOGICAL REACTIONS

Water dynamics in plants. Water regime in plants is an important factor, as it controls the main physiological and biochemical processes. Daily determinations of water consumption by means of evapotranspiration during the 1 June and 20 August time interval (fig. 6) show that water absorption was lowest in plants of the inbred line 1 (634 g) and highest (726 g) in those of inbred line 4. In soil moisture stress conditions, daily water consumption decreases to about 61% of that of the check. Water absorption capacity is least affected in inbred lines 1

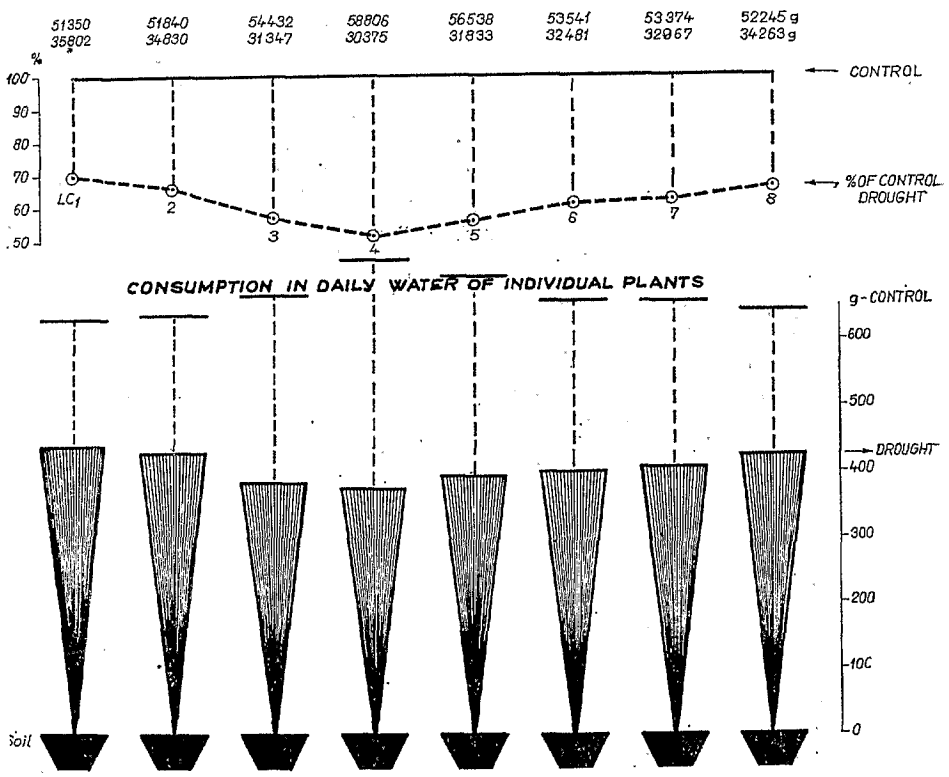

Fig. 6 — Water consumption through evapotranspiration during 1.VI — 20.VIII period.

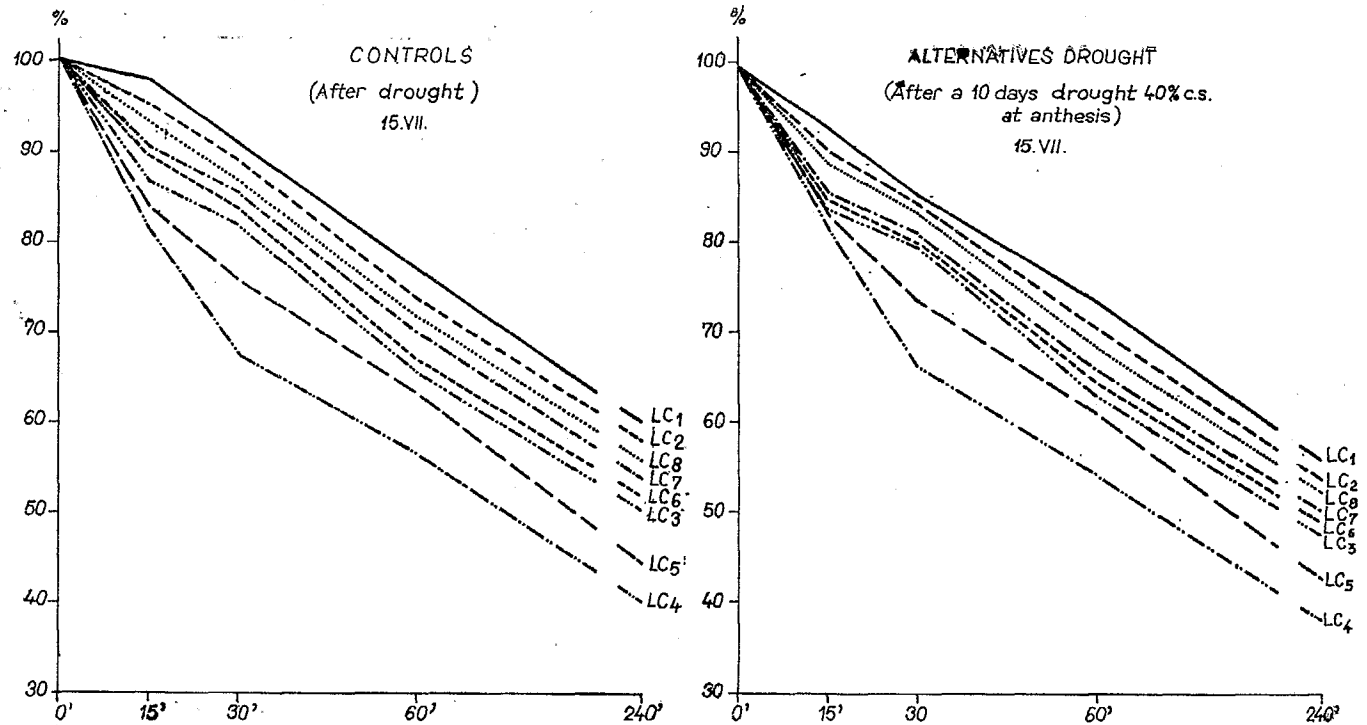

Fig. 7 — Deshydratation rate of leaf tissue and differences between inred lines concerning free water losses.

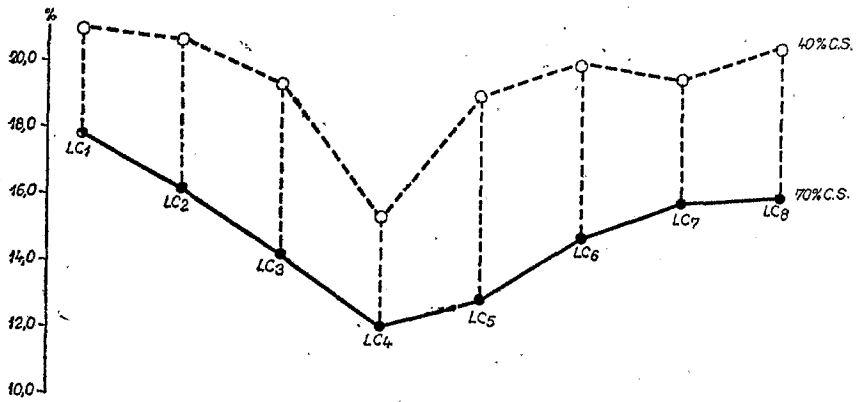

Fig. 8 — Cellular sap concentration after 10 days of soil drought at anthesis.

and 2, their physiological functions becoming normal again as soon as the optimum moisture regime is restored, due to their higher potential of recovering the metabolic activity.

The trend of water loss by dehydration is weaker in inbred lines 1, 2, 8 and 7, while lines 5 and 4 exhibit a marked intercellular dehydration both in normal moisture and in stress conditions (fig. 7).

The study of the cellular juice concentration along the growing period shows that the values of this index increase after a drought period (fig. 8). The lowest values found in lines 4, 5 and 3 may be

Table 1

Content of various water forms and dry matter in a normal moisture regime and after 10 days drought at flowering (g/100 g fresh matter)

Inbred lines	Moisture regime of soil	Total water	Free water	Bound water	Dry matter	Free water/ bound water ratio	Hydric coefficient
LC 1	70% c.s.	63.77	59.38	4.39	36.23	13.52	1.76
2		65.46	61.60	3.86	34.57	15.95	1.89
3		72.35	70.50	1.85	27.65	38.10	2.61
4		74.58	72.99	1.59	25.42	45.90	2.93
5		72.64	70.89	1.75	27.36	40.50	2.65
6		71.47	70.55	1.92	28.53	36.74	2.50
7		69.08	66.18	2.90	30.92	22.08	2.23
8		67.69	64.44	3.25	32.31	19.82	2.09
LC 1	40% c.s.	72.47	70.61	1.86	28.53	37.96	2.64
2		74.36	72.58	1.78	25.64	40.77	2.90
3		79.37	77.97	1.40	20.23	55.69	3.92
4		81.75	80.60	1.15	18.25	70.08	4.47
5		80.20	78.85	1.35	19.80	58.40	4.05
6		78.79	77.20	1,59	21.21	48.55	3.71
7		77.09	75.59	1,50	22.91	50.39	3.36
8		75.78	74.16	1,62	24.22	45.77	3.12

explained by the smaller quantity of the stored assimilates, owing both to a lower intensity of photosynthesis and a smaller leaf area, as compared to inbred lines 6, 7, 8, 2 and 1.

Table 1 presents the changes of water forms in plants after a period of stress.

It appears that in inbred lines 1 and 2, both check and stressed variants, the percentage of bound water and dry matter has increased, the free water/bound water is higher for the latter and the values of the cellular hydric coefficient are lower. These facts are due to the higher drought resistance of these lines, which retain less water to synthetize 1 gram of dry matter.

METABOLIC CHANGES OCCURING IN SUNFLOWER PLANTS

The rate of photosynthesis and respiration as well as other physiological indexes taken into consideration underwent significant changes during growing period, as affected by the hydric regime. After a 10 days stress period during flowering, inbred lines 1 and 2 exhibit a favourable photosynthesis/respiration ratio, while in lines 4 and 5 this ratio is less favourable (fig. 9).

Catalase activity, a compound of the oxide-reducing system also helps to characterize the vital activity of each inbred line, as it depends on water supply conditions. Thus lines 1, 2 and 8 exhibited the highest rate of catalase activity in normal moisture conditions and the lowest during the stress period (fig. 10).

In normal moisture conditions, the ascorbic acid content increases until full blooming and beginning of seed formation. Inbred lines 1, 2 and 7 exhibit higher ascorbic acid content and higher recovery capacity than lines 5, 3 and particularly 4, after a period of stress (fig. 11).

Chlorophyll content is strongly affected by drought and its level remains low even when normal moisture conditions are restored. However, whatever moisture conditions are, chlorophyll content is highest in the same inbred lines as above (fig. 12).

Production data complete the results of morphologic and physiologic determinations and emphasize the differences between grain yields caused by the moisture factor (table 2). Simultaneously, yields represent

Table 2

Effect of drought on seed yield and oil content of different sunflower inbred lines

Inbred lines	Yield g/pot		% oil in kernel	
	control	drought	control	drought
LC1 — V 3279	35.6	22.1	47.4	43.1
LC2 — A 1566	31.3	18.5	51.5	47.6
LC3 — KA 4523	22.6	13.5	42.9	38.2
LC4 — AD 66	20.5	10.3	47.5	38.6
LC5 — V 2616	21.5	11.8	51.4	43.9
LC6 — SP 4559	23.1	14.0	52.2	46.3
LC7 —T 2219-72	25.3	14.7	49.5	45.1
LC8 — AS 20009-72	28.6	16.2	44.7	40.6

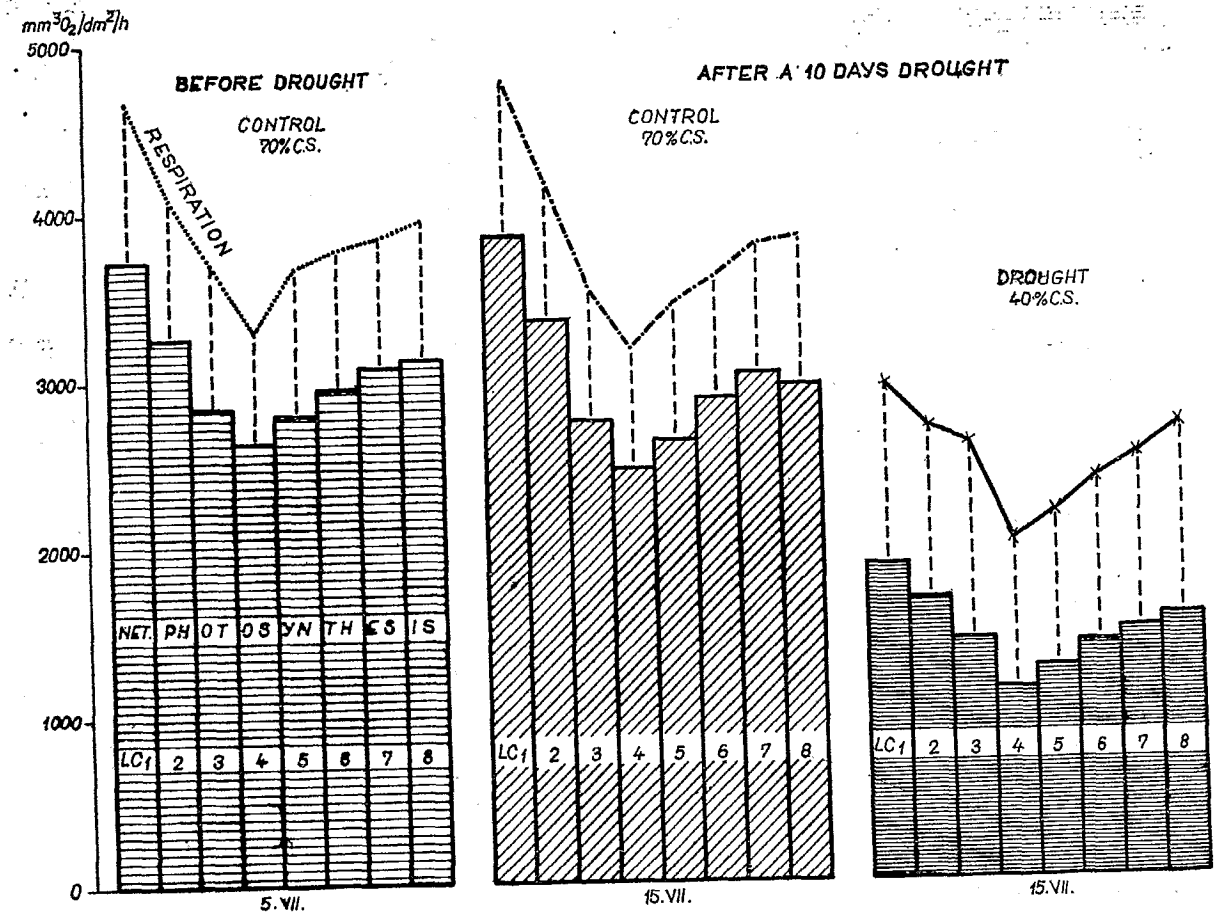

Fig. 9 — Photosynthesis and respiration rates.

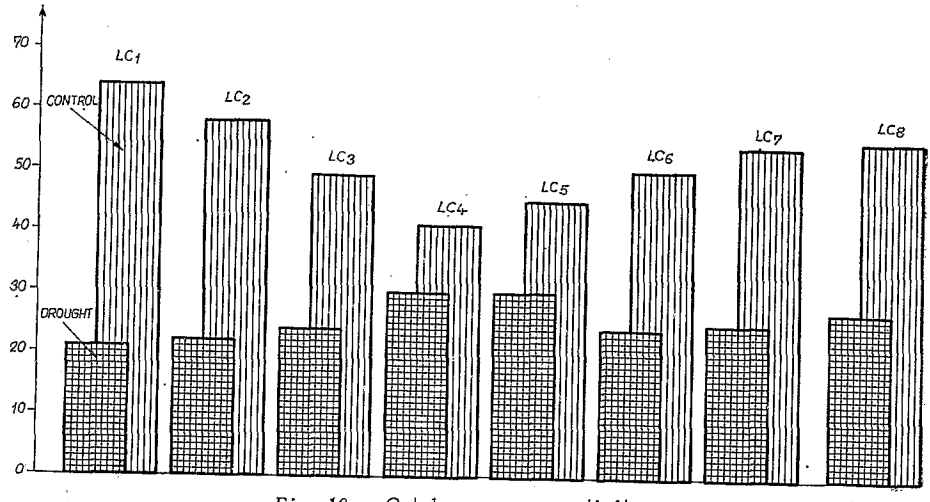

Fig. 10 — Catalase enzyme activity.

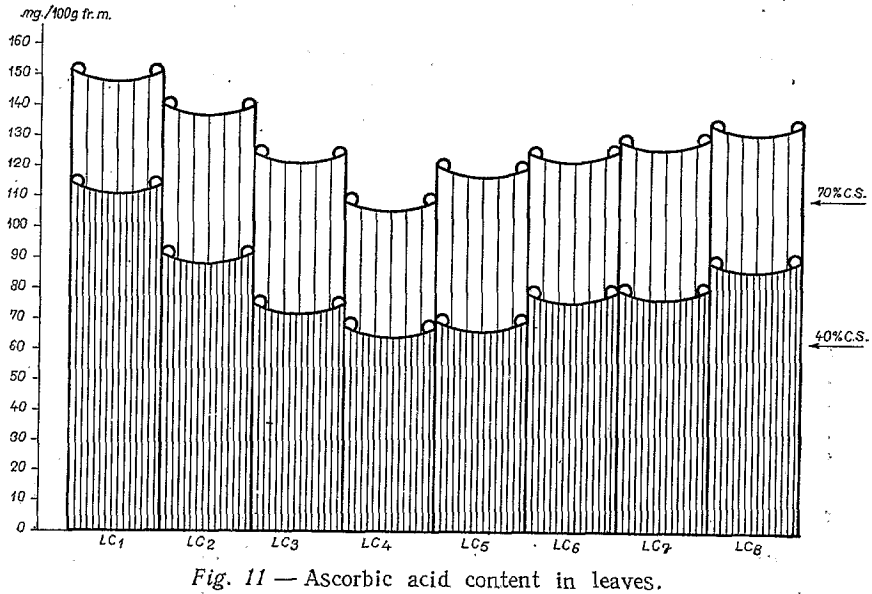

Fig. 11 — Ascorbic acid content in leaves.

one of the basic elements differentiating the characteristic responses of the various inbred lines, as depending on their resistance to drought potential, thus emphasizing the range of variability with respect to the factor water. Among the various inbred lines developed at Fundulea, those exhibiting the highest yielding capacity are : line 1, which appears to be best suited for arid areas or for zones with frequent dry periods,

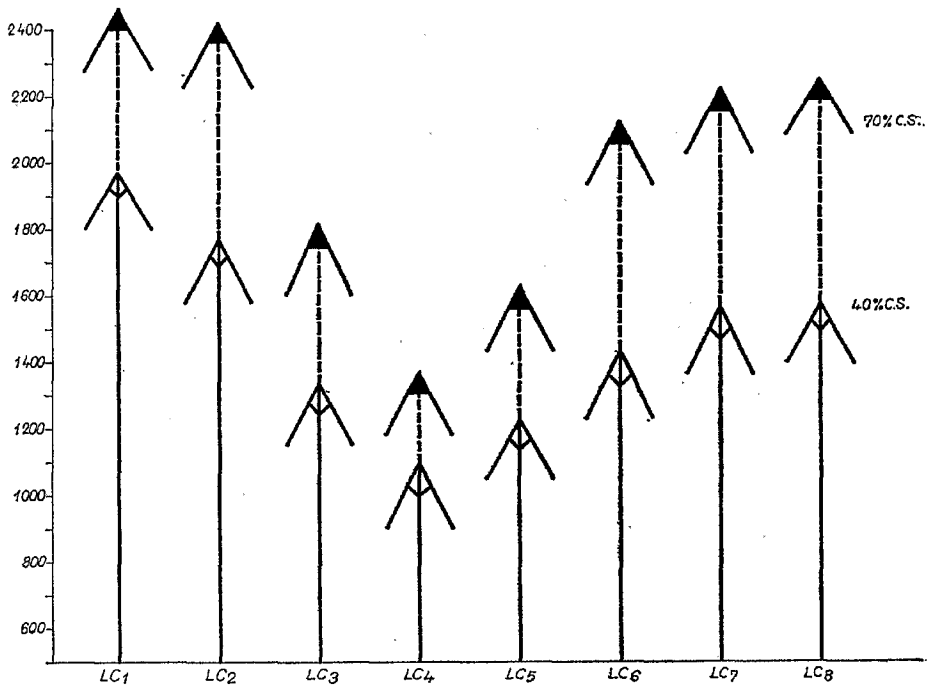

Fig. 12 — Chlorophyl content.

followed by inbred lines 2 and 8. The inbred lines 7 and 6 have a satisfactory production capacity and drought resistance potential, while lines 3 and particularly 4 should not be employed for hybrid seed production without irrigation in dry areas. Drought also affects grain quality by reducing the oil percentage in kernels.

It may thus be concluded that inbred lines exhibit important differences concerning their morphological features, water use and the physiological and biochemical processes contributing to yield formation, either in drought or normal moisture conditions. At the same time it is evident that the physiological and morphological analyses are effective for breeding based on resistance to drought and for determining the drought resistance potential of various sunflower varieties, hybrids and inbred lines.