

# AN INDIRECT TEST FOR ESTIMATING SUNFLOWER DROUGHT TOLERANCE

MARIA ȚERBEA

Research Institute for Cereals and  
Industrial Crops, 8264 Fundulea,  
Romania

## INTRODUCTION

Although sunflower often is considered as a drought tolerant plant (Boyer, 1971; Vrânceanu, 1974; Sionit and Kramer, 1976), the present cultivars have shown a different reaction to moisture stress and high temperatures.

Under the climatic conditions of Romania, the months of July and August, when flowering and seed development take place, are generally characterized by high temperatures and moderate rainfalls, phenomena which influence the behaviour of sunflower plants. During this period, some sunflower genotypes manifest a high wilting degree, while others stand well the high temperature and moisture stress. In dry years, some of these genotypes do not fill well the achenes.

Tolerance to high temperatures and moisture stress is therefore an important objective in sunflower breeding, especially in selection of inbred lines and hybrids, but its implementation depends on the availability of a discriminating and rapid method of testing. Our investigations have aimed at finding out such methods which would permit to examine on a large scale the tolerance of the current breeding material.

## MATERIALS AND METHODS

The study of seed germination at various osmotic pressures was performed with the aid of mannitol solutions of different concentrations (Helmerich and Pfeifer, 1954). Osmotic pressures of 6.5, 7.5, 8.5, 9.5, 10.5 and 11.5 atmospheres were obtained in this way. Seed germination in distilled water was used as a control.

Sunflower seeds previously disinfected by mercury chloride, were placed for germina-

tion in petri dishes with mannitol solutions, using polystyrene plates with orifices as seed support (Figure 1). Seed germination was noted after 7 days and seedling growth in the same solutions, after 10 days.

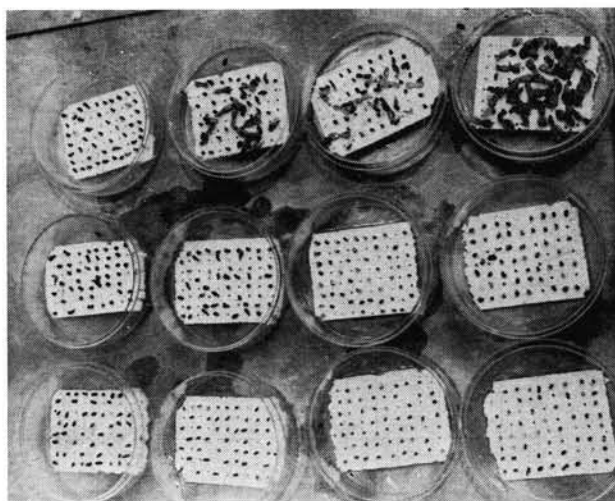


Fig. 1 — Seed germination test in mannitol solutions

A second indirect test under investigation is based on chlorophyll stability index (CSI), defined as the difference between light transmission through chlorophyll samples taken from leaves exposed or not to thermic stress (Kilen and Andrew, 1969). Sunflower plants were grown under field conditions until the stage of 12—14 leaves. Samples of 0.25 g leaves of the same age, without veins, in 4 replications, were used for determinations. Two replications were exposed to a thermic treatment of 65°C and the other two were left at the room temperature. After 60 minutes, the leaf samples were minced in acetone 80% and filtered, than each sample was brought to a final volume of 100 ml. Light transmission

was read with the help of the spectrophotometer at the wavelength of 663 m $\mu$ .

Tolerance under field conditions was evaluated taking into account the wilting or withering degree of sunflower leaves under conditions of high drought as well as the grain filling degree and the seed yield per plant. A scale with grades from 1 to 5 was used for drought evaluation, the grade 1 standing for very susceptible and 5 for very resistant.

## RESULTS AND DISCUSSION

1. Evaluation of sunflower drought tolerance in terms of seed germination percentage and seedling growth at various osmotic pressures.

Germination percentage of seeds from 5 inbred lines and 3 hybrid combinations is given in Table 1. A very good seed germination at

Table 1

Seed germination (%) at different osmotic pressures of some sunflower genotypes

Genotype	Osmotic pressure (at.)							
	F-101	F-102	F-103	F-109	F-117	F-101 × F-102	F-101 × F-103	F-102 × F-109
6.5	22	98	36	90	0	50	60	80
7.5	12	78	30	75	0	25	35	65
8.5	8	72	18	68	0	10	8	50
9.5	12	74	8	60	0	0	2	35
10.5	4	40	0	35	0	0	0	25
11.5	0	15	0	0	0	0	0	0
Distilled water (control)	86	98	86	95	80	90	86	95
Field drought tolerance (grades 1—5)	2	5	3	5	1	3	4	5

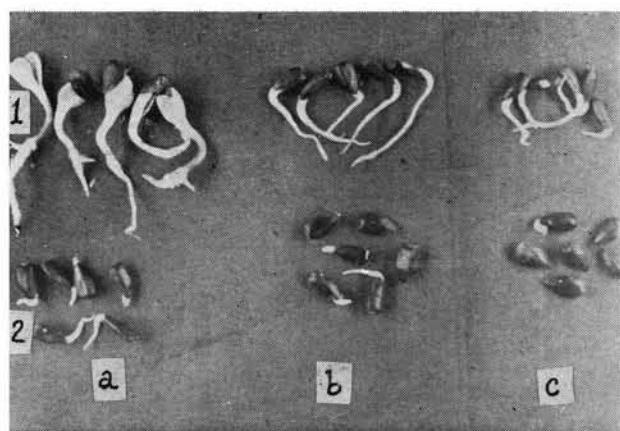


Fig. 2 — Seedling growth at different osmotic pressures:

1 = inbred line F-102, tolerant; 2 = inbred line F-101, susceptible; a = 6.5 at; b = 7.5 at; c = 8.5 at.

relatively high osmotic pressures such as 9.5 atmospheres, exhibit the inbred lines F-102 (Figure 2) and F-109. It is worth mentioning that the hybrid obtained by crossing these two inbred lines (F-102 × F-109) has also displayed a good seed germination at higher osmotic pressures. Two other inbred lines, F-101 and F-103, have a low seed germination and the same reaction is characteristic to their F<sub>1</sub> hybrid (F-101 × F-103). Finally, there is an inbred line, F-117, whose seeds have germinated neither at the lowest osmotic pressure used in this test.

The grades of field drought tolerance confirm the susceptibility of the inbred line F-117 and the good tolerance of inbreds F-102 and F-109 and of their hybrid combination (F-102 × F-109).

The osmotic pressure of the nutritive medium has exerted the same influence upon the subsequent growth of sunflower seedlings, as it can be seen from data presented in Table 2.

Table 2

Stem (S) and root (R) length (mm) of sunflower seedlings grown in mannitol solutions, after 10 days

Osmotic pressure (at.)	F-101		F-102		F-103		F-109		F-117		F-101 × F-102		F-101 × F-103		F-102 × F-109	
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
	6.5	5.7	17.0	5.4	21.0	4.2	12.2	7.4	9.5	—	—	9.6	14.7	4.1	8.2	5.9
7.5	4.9	12.8	4.5	13.9	4.1	7.0	6.2	8.0	—	—	5.1	10.3	3.9	10.3	6.6	8.4
8.5	—	—	2.8	11.5	3.0	5.8	6.3	6.0	—	—	—	6.2	2.6	6.8	4.5	5.2
9.5	—	—	2.3	7.6	3.4	4.6	4.6	5.7	—	—	—	—	—	5.6	5.6	7.3
10.5	—	—	2.0	4.1	—	—	—	4.5	—	—	—	—	—	—	—	—
11.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Distilled water (control)	11.9	39.3	12.0	20.2	11.1	15.3	14.4	26.4	8.5	13.5	6.5	24.6	9.6	28.1	10.3	20.2
Field drought tolerance (scale 1—5)	2		5		3		5		1		3		4		5	

A good growth of both seedling stem and roots manifest the inbreds F-102 and F-109.

2. The chlorophyll stability index test (CSI).

As is well-known, the lipoproteic complex of chloroplasts is the first affected under mois-

## CONCLUSIONS

Seed germination and seedling growth at high osmotic pressures obtained by using concentrated mannitol solutions indicate a good drought tolerance of certain sunflower genotypes. Thus, the inbred lines F-102 and F-109, which show a good drought tolerance under field conditions, have a satisfactory seed germination and seedling growth at high osmotic pressures, while the germination of the susceptible inbred line F-117 is inhibited even at low osmotic pressures.

The chlorophyll stability test at high temperatures has revealed a similar reaction of the investigated genotypes.

The results of this study indicate the possibility of obtaining sunflower  $F_1$  hybrids with drought and high temperature tolerance, by crossing inbred lines with a good seed germination at high osmotic pressure and an adequate chlorophyll stability index.

Table 3

Chlorophyll stability index test (CSI)

Genotype	Light transmission		CSI	Field drought resistance (grades 1-5)
	heated	unheated		
F-101	59.0	51.0	8.0	2
F-102	70.0	68.0	2.0	5
F-103	57.5	50.0	7.5	3
F-109	54.0	52.0	2.0	5
F-117	83.0	60.0	23.0	1
F-101 × F-102	50.0	39.5	10.5	3
F-101 × F-103	59.2	52.7	6.5	4
F-102 × F-109	53.5	51.5	2.0	5

ture stress conditions. On the basis of scientific information from literature (Kilen and Andrew, 1962) we have tried to evaluate the degree of chlorophyll destruction under the influence of adverse environmental conditions, to the above-mentioned genotypes. The data in Table 3 reflect the light transmission in terms of chlorophyll destruction degree, under the influence of high temperatures. Here again the good behaviour of inbreds F-102 and F-109 and of their  $F_1$  hybrid (F-102 × F-109) is evident, while the other genotypes show a prominent modification of this characteristic.

From the above-mentioned data, one can ascertain a relationship between the results of the indirect tests and the field tolerance to moisture stress of the investigated sunflower genotypes.

The preliminary results presented in this paper indicate the possibility of developing drought and high temperature tolerant  $F_1$  hybrids by crossing two inbred lines with high level of seed germination and seedling growth at high osmotic pressures and with a high chlorophyll stability index. Nevertheless, it should be underlined that the proposed test, although useful for sorting the breeding material, has an orientation value, because drought tolerance is a very complex phenomenon and for its evaluation, a greater number of physiologic indices must be taken into consideration.

## REFERENCES

- Boyer J. S., 1971, *Recovery of photosynthesis in sunflower after a period of low leaf water potential*. Plant physiol., 47, 816-820.
- Helmerich H., Pfeifer R., 1954, *Differential varietal responses of winter wheat germination and early growth to controlled limited moisture conditions*. Agr. J., 46, 12 (562).
- Kilen T. C., Andrew R. H., 1969 *Measurement of drought resistance in corn*, Agr. J., 61 (5), 669-671.
- Sionit N., Kramer P. J., 1976, *Water potential and stomatal resistance of sunflower and soybean subjected to water stress during various growth stages*, Plant physiol., 58, 537-540.
- Vrânceanu A. V., 1974, *Floarea-soarelui* (Sunflower), 137-138, Ed. Acad. R.S.R., București.
- Williams T. V., Snell R. S., Ellis J. F., 1967, *Methods of measuring drought tolerance in corn*, Crop Sci., 7 (3), 179-184.

## UN TEST INDIRECT POUR L'ÉVALUATION DE LA TOLÉRANCE DU TOURNESOL À LA SÉCHERESSE

### Résumé

La germination des semences et la croissance des plantules à de hautes pressions osmotiques, obtenues à l'aide de solutions concentrées de mannitol, indiquent une bonne tolérance à la sécheresse de certains genotypes de tournesol. Ainsi, les lignées autofécondées F-102 et F-109, ayant une bonne tolérance à la sécheresse en plein champ, présentent aussi une germination des grains et une croissance des plantules satisfaisantes à des pressions osmotiques élevées, tandis que chez la lignée sensible F-117 la germination est inhibée même à des pressions osmotiques basses.

La test de la stabilité de la chlorophylle aux températures élevées a mis en évidence une réaction semblable des genotypes examinés.

Les données obtenues indiquent qu'il est possible d'obtenir des hybrides F<sub>1</sub> tolérants à la sécheresse, par le croisement des lignées autofécondées qui germent à des pressions osmotiques élevées et qui ont une bonne stabilité de la chlorophylle à des températures élevées.

TEST INDIRECTO PARA DETERMINAR  
LA TOLERANCIA DEL GIRASOL  
A LA SEQUIA

*Resumen*

La germinación de las semillas y el crecimiento de las plantas en condiciones de presiones osmóticas elevadas, obtenidas con la ayuda de las soluciones con-

centradas de manitol, indican, en algunos genotipos de girasol, una gran tolerancia a la sequía. De este modo, las líneas consanguíneas F-102 y F-109, que muestran gran tolerancia a la sequía en campo, presentan una germinación de semillas y un crecimiento de las plantas satisfactorios, a presiones osmóticas elevadas, mientras la línea sensible F-117 está inhibida en la germinación incluso con presiones osmóticas bajas.

El test de la estabilidad de la clorofila en condiciones de temperaturas altas ha puesto de relieve una reacción semejante a la de los genotipos estudiados.

Los datos obtenidos indican la posibilidad de obtener híbridos F<sub>1</sub> resistentes a sequía y a temperaturas excesivas, por el cruce de las líneas consanguíneas que germinan a presiones osmóticas elevadas y que tienen a la vez una gran estabilidad de la clorofila a temperaturas altas.