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GENERATING A SELECTION INDEX FOR DROUGHT TOLERANCE IN SUNFLOWER I. WATER USE AND CONSUMPTION.

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ABSTRACT

Under rainfed conditions in Northern Mexico, the main cause of low yield in sunflower is drought. The objective of this work was to determine the water use and consumption patterns of 3 sunflower genotypes, evaluated in two sowing dates under irrigation–drought conditions. The mid and long season genotypes had more water consumption under drought, produced more dry matter, had a greater water use efficiency, better response to drought and more grain production than the short season control, which escaped drought.

Key words: Sunflower, drought, water consumption patterns

INTRODUCTION

In the rainfed agricultural areas of Northern Mexico, the main cause of low yields or total losses of sunflower is drought (Ortegon 1982). In Durango, under these conditions, yields are between 450 and 2000 kg/ha, depending on the location and year (Gómex and Martinez, 1987). Drought reduces transpiration and this is important as is directly related to dry matter and grain production and to oil percentages. Water use efficiency or transpiration coefficient is the amount of water consumed per dry matter unit produced (Vannozzi et al., 1983); moreover, water use efficiency and drought resistance are positively correlated (Hall and Patel, 1985). Drought resistance and water use efficiency are genetic characters of great difficulty to measure and select, as they are considerably influenced by environmental factors (Vranceanu et al., 1988). A methodology for obtaining drought tolerant genotypes consists in establishing selection plots, under irrigation–drought conditions. Some traits have been proposed for selection, for example: water consumption, yield differentials, morphophysiological and phenological characteristics (Fereres et al., 1986; Gimenez y Fereres, 1986). Therefore it is necessary to identify genotypes and characteristics correlated with water use efficiency and drought resistance (Quizenberry, 1982). The progenies derived from crosses between species of *Helianthus*, have morphophysiological characteristics that can increase water use efficiency (Škorić and Vannozzi, 1984). To initiate a sunflower breeding project for drought tolerance in Northern México, which will include progenies derived from interespecific crosses, it is necessary to identify a morphophysiologycal selection index and determine the pattern of water consumption. The objective of this section of the study was to determine consumption and water use patterns in soil and plant, of cultivars and outstanding experimental lines, under irrigated–dought conditions. A parallel paper will present the identification of a selection morphophysiologycal index.

MATERIALS AND METHODS

The experiment was stablished at the Durango Research Station of the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), under irrigated–drought conditions during the spring of 1990. The soil is a fine texture castagnozem luvie, with a gravel physic phase, the climate classification according to Koeppen is: BS1 K(W) (e); dry, temperate, with summer rain season; the annual mean precipitation for 20 years is 471 mm. To evaluate the long and the short season genotypes under similar conditions of drought at the beginning of blooming, two sowing dates (April 6 and 30) were used. The genotypes evaluated were: the short season variety Victoria (control); a mid season line from the University of Pisa (cms UP–02) derived from an interespecific cross between *H.annuus* L. cms dwarf and *H.argophyllus*; cms dwarf is an androsterile line with good drought tolerance (Gómez et al., 1990), cms UP–02 comes from a backcross 2 with the recurrent parent *H.argophyllus*; and the long season variety Sereno. Gimenez and Fereres (1986) have noticed that long season cultivars are well adapted to drought conditions, and Gómez et al. (1990) have observed that middle and long season cultivars are better adapted to drought under rainfed conditions in Durango. A population density of 50,000 plants/ha was used on rows 0.81 m wide, with a fertilization of 80–60–00. The experimental design was a split–split plot in randomized blocks with three replications. The main plots were sowing dates, middle plots were moisture conditions and the small plots were genotypes. Under irrigated conditions the plants were watered during the vegetative phase: three times for the first sowing date and two for the second date, and for both dates two times during the reproductive phase plus rain; under the drought condition water was applied two times during the vegetative phase. In order to prevent rain and assure the drought condition in the drought treatment, soil was covered with plastic mulch before the beginning of blooming for the long season genotype in the first sowing date and before the beginning of bloom for the short season genotype in the second sowing date. The amount of water available in the soil was measured with a neutron probe tester (Troxler AM BE). The exploration depth was between 0.3 and 0.6 m, this last one is the mean of the range of more root absorption: 0.45–0.75 m (Berengena et al., 1985). The available water was calculated by: $AD=Li+Lr+P+ETP$, where AD is the amount of water available, Li is the previous irrigation depth, Lr is the actual irrigation depth, P is the precipitation and ETP is the evapotranspiration. Observations were made of: number of days to physiological maturity, total dry matter, and grain yield. Harvest index (HI) was calculated as the ratio of grain yield to above ground dry matter. Actual evapotranspiration was estimated as follows: $ETP=E(0.75)KC$, where E is the evaporation in a class "A" pan, 0.75 is a constant and KC is the lysimeter transpiration coefficient for sunflower (FAO 1978). Water use efficiency was calculated by: $WUE=DM/ETP$ where DM is the above dry matter and ETP is the evapotranspiration (Temple and Benoit, 1988). Drought tolerance is defined as the Yd/Yp ratio where Yd is the grain yield under drought and Yp is the grain yield under irrigation (Fereres et al., 1986).

RESULTS AND DISCUSSION

The average number of days to physiological maturity (pm) were: Victoria (97), cms UP–02 (114) and Sereno (124); the number of days to pm were reduced in the drought versus the irrigated condition by 11, 5, and 1 days, respectively.

Water Availability

In the two sowing dates under irrigation, the amount of available water accumulated in the soil throughout the reproductive stage, was sufficient for good plant development: 684 mm for the first date and 804 mm for the second. Under drought, for both sowing dates, soil conditions for the middle season genotype cms UP–02 (112 days to pm) and the long season genotype (120 days to pm) was below the permanent wilting point (pwp=111 mm of water) throughout their reproductive stages. For the short season genotype Victoria (94 days to pm) soil was under pwp from 50% bloom for the first date and 100% bloom for the second, where it practically escaped drought (Fig. 1). The experiment was designed to have coincidence of soil at pwp at the beginning of blooming, for the long season genotype of the first sowing date and the short season genotype of the second sowing date. But only the soil of the long season genotype was below the pwp (82 mm of available water), since soil for the short season genotype was above the pwp (170 mm of available water). However, soil for the middle and long season genotypes of the second date, was near (125 mm) for the middle season and at pwp (111 mm) for the long season genotypes. Not withstandig that the same amount of water was applied in drought conditions for the three genotypes in the second sowing date differences in the amount of water available in the soil mean that water sonsumption patterns between genotypes were different, explaining why the drought levels for the long season genotypes of the first sowing date and the short season genotype of the second sowing date did not coincide at the beginning of bloom.

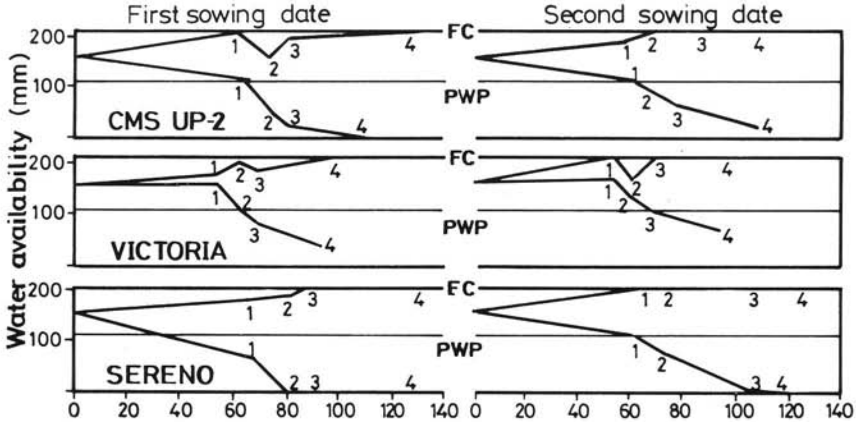

Fig. 1 Water availabilty during blooming stages: 1) initiation, 2) 50%, 3) 100%, and 4) physiological maturity.

Water Consumption and Dry Matter Production

There were significant differences ($p<0.05$) among the three genotypes, on both sowing dates, for water consumption, dry matter production and water use efficiency. The long season genotype was superior to the middle while these were superior to the short season genotype (Table 1). Under both moisture conditions there were positive and significant correlations ($p<0.05$) between the number of days to pm and evapotranspiration and dry matter production. There were no significant correlations between number of days to pm and WUE and yield. No significant differences were observed ($p<0.05$) among genotypes for total water applied, on each moisture condition; and there were significant differences among genotypes for water consumption pattern, dry matter production and water use efficiency. It could mean that these phenotypical differences are due to genetic causes. These are expressed on length of biological cycle, where the mid and long season genotypes under irrigation and drought, consumed more water and produced more dry matter in a more efficient way than the short season genotype.

Yield and drought effects.

Under irrigated condition grain yield of tested genotypes were similar ($p<0.05$), in contrast, under drought Sereno and cms UP–02 were similar and different from Victoria ($p<0.05$) (Table 1). Under irrigation no significant differences were found for harvest index among genotypes at $p<0.05$: 39, 34 and 36 % for Victoria, cms UP–02 and Sereno, respectively. But under drought there were significant differences among them at $p<0.05$: 36, 34, and 21 % for Victoria, cms Up–02 and Sereno, respectively. Only cms UP–02 kept the same value in both conditions while Victoria and Sereno reduced their values under drought (Fig.2). The genotypes cms Up–02 and Sereno reduced their yield less than Victoria, under drought respect irrigation conditions, showing thus more drought tolerance. Sereno had the best tolerance to drought but its yield potential was similar to cms UP–02. Victoria was less tolerant to drought and had less yield potential (Fig.3). There was a positive and significant correlation ($p<0.05$) between WUE and drought tolerance ($r=0.87$ and $r=0.70$), in both irrigated and droughted conditions, respectively (Fig.4). Under drought, Sereno had greater biomass production but lower rate of photosynthate translocation to the grain, cms UP–02 had good biomass production and good photosynthate translocation, and Victoria had lower biomass production and good photosyntate translocation. Probably water consumption, dry matter production, WUE, drought tolerance and yield potential of cms UP–02 (endogamic line) could be increased in hybrid combinations.

Table 1. Consumed and used water, in dry matter and grain yield production under two irrigation conditions at Durango, México 1990.

Genotype	Irrigation				Drought			
	ETP mm	DM g/m^2	WUE g.DM/mm	Yield Kg/ha	ETP mm	DM g/m2	WUE g.DM/mm	Yield Kg/ha
Sereno	578	1964	3.5	2935	553	1222	2.2	2243
cms UP–02	542	1033	1.9	3016	525	801	1.5	1895
Victoria	473	783	1.7	2820	453	627	1.4	1657
C.V %	1.2	10.2	10.3	32.3	1.2	10.2	10.3	32.3
LSDp<0.05	10.2	172	0.3	426	10.2	172	0.3	426

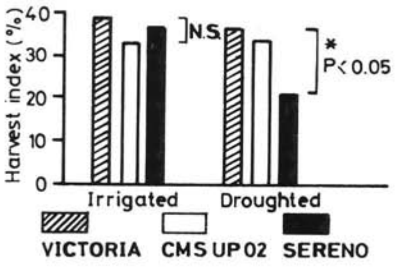

Fig.2 Harvest index for three genotypes

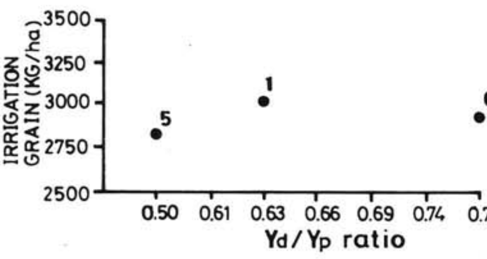

Fig.3 Relation between irrigation yield–Yd/Yp ratio.

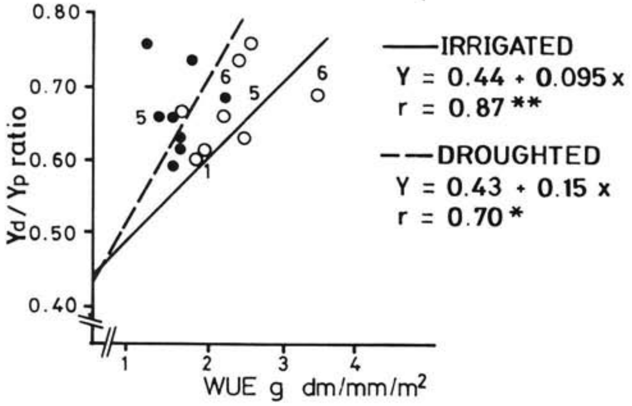

Fig.4 Relationships between Yd/Yp ratio and water use efficiency in irrigated and drought conditions.

CONCLUSIONS

For the rainfed conditions prevailing in Northern México, it is convenient, for breeding purposes, to select mid and long season genotypes based on WUE, harvest index, drought tolerance and yield potential.

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GENERACION DE UN INDICE DE SELECCION PARA RESISTENCIA A SEQUIA EN GIRASOL 1. USO Y CONSUMO DE AGUA

RESUMEN

Bajo condiciones de secano en el Norte de Méjico la principal causa del bajo randimiento en girasol es la sequía. El objetivo de este trabajo fué determinar las pautas de uso de agua y consumo de tres genotipos de girasol, evaluados en dos fechas de siembra bajo condiciones de riego y secano. Los genotipos de ciclo medio y largo tuvieron un mayor consumo de agua en condiciones de seguía, produciendo mas materia seca y tuvieron una mayor eficiencia del uso de agua, mejor respuesta a la sequía y mas producción de grano que el control precoz que escapó de la sequía.

CRÉATION D'UN INDEX DE SÉLECTION POUR LA TOLÉRANCE DU TOURNESOL À LA SÉCHERESSE: 1. UTILISATION DE L'EAU ET CONSOMMATION.

RÉSUMÉ:

Sous les conditions pluviométriques du nord-est du Mexique, la principale cause des faibles rendements du tournesol est la sécheresse. L'objectif de ce travail est de déterminer l'utilisation de l'eau et le type de consommation de trois génotypes de tournesol. L'évaluation de ces paramétres s'est fait grâce à deux dates de semis subissant des conditions d'irrigation et de sécheresse différentes. Les génotypes tardifs et semi-tardifs ont une consommation en eau supérieure en condition de sécheresse, produisent plus de matière séche, utilisent plus efficacement l'eau, ont une meilleure réponse à la sécheresse et une production de graines supérieure aux génotypes précoces qui évitent la période de sécheresse.