SUNFLOWER RESPONSE TO IRRIGATION UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

(Experimental Plan)

J. BERENGENA

National Center for Oilseed Crops, I.N.I.A.,
Apartado 240, Córdoba, Spain

1. PURPOSE OF THE WORK

The growth and development of a given plant results from its genotypic expression conditioned by complex and unceasing interaction with the environment. Among all the environmental factors, the one which most commonly limits the total production is water. The nature and degree of such limitation depends on its severity and duration.

Practically all the commercial sunflower open pollinated varieties and hybrids being at this time grown in the world have been obtained in areas where the amount and distribution of rainfall during the growing season is adequate, grain yield not being seriously limited. When they are grown in areas which do not meet such characteristics, production is considerably decreased.

So far, sunflower has been mostly cultivated under non-irrigated conditions. Under those conditions, it is clear that the crop is economically viable when the available water is enough not to seriously limit the manifestation of the potential yields. It has been widely recognized that sunflower has a certain drought resistance compared to other spring-summer crops. The key of such a behaviour lies, at least in part, on the morphology of its root sistem and on its ability to explore large soil volumes. This means that in dry summer areas, a sunflower crop under nonirrigated conditions will be able to give acceptable yields only when it is grown in relatively deep soils with moderate to high water holding capacity.

It can be deduced from the above that when the annual rainfall is enough to satisfy the crop water requirements but the seasonal distribution is unfavourable, the crop viability is conditioned by the severity of the climate along with the moisture holding capacity of the soil ; obviously, the latter is closely related to the soil depth. If such factors seriously affect the crop yield, the application of irrigation water will be necessary.

There are a great number of factors, quite different in nature, controlling the grain yield of sunflower plant community. The complexity of their actions, along with the difficulty added because of their mutual interactions, makes almost impossible a rational analysis leading the the definition of functional relationships able to describe the crop response under given conditions. There have been several attempts trying to find a relationship between seed production and water consumption in a given plant community under defined soil and climate conditions. The lack of generality of such relations in that way obtained precludes any kind of extrapolation due to their empirical nature. Owing to the fact that for a given amount of water applied the crop response — using seed production as an index — should be different depending on the moment or crop stage in which that water is applied, those relations are not expected to be unique even under the same soil and climate conditions.

It is, therefore, evident the necessity of making experimental studies under diverse soil and climate conditions in order to approach the problem of defining when, how much, and how often to irrigate in areas in which the hydrological balance during the growth season is clearly unfavourable. When water is scarce the main purpose should be to obtain the maximum water use efficiency, in other words, the maximum yield per unit water.

So, in a first stage, we have considered of interest to conduct simple field experiments using a common methodology, in order to study the behaviour of a community of sunflower plants under different environmental conditions and water regimes.

2. METHODOLOGY

As it has been said, we will try to unify the methodology as much as possible. However, for the countries or zones in which, because of the extremely dry climate, the basic experiment cannot be performed, an optional is proposed. Likewise, the control of those parameters whose measurement needs certain instruments or facilities not always available is presented here as optional.

2.1. Basic experiment.

It is the experimental plan to be followed whenever possible.

2.1.1. Experimental design.

2.1.1.1. Treatments.

The crop response to 5 different treatments will be studied. These will consist of :

Treatment 1 : Irrigation during the whole season.

Treatment 2 : Irrigation only until flowering.

Treatment 3 : Irrigation only from flowering.

Treatment 4 : Irrigation only during the critical period.

Treatment 52: No irrigation at all.

The number of replications will be 4. Therefore, there will be 4 blocks of treatments each. During the first year two different cultivars will be tested ; they will be sown in each one of the two halves in which the experimental units will be subdivided. A statistic design of split-plots will be used.

The experimental units will be rectangular with dimensions of 12.75 × 7.75 m. Assigned to each variety is an area of 49.41 m^2 per experimental unit.

In following years, the number of cultivars to be tested will be increased up to a maximum of ten with material considered of interest by the participant institutions.

2.1.1.2. Irrigation method.

The irrigation water will be applied by levelled furrows.

2.1.1.3. Frequency and doses of irrigation.

The frequency, as well as the doses, will be adapted to the zone where the treatised experiment is going to be carried out. In every case, the previously depleted soil moisture must be brought to levels in the vecinity of field capacity. Obviously, the frequency will be closely related to the evaporative demand of the surrounding air as well as to the soil water storage capacity.

2.1.1.4. Cultivars to be tested.

During the first year, one of the two cultivars to be tested will be the same for all subnetwork experiments ; this will be used as control. For that purpose the Russian variety "Peredovik" is proposed. The second could be optional for each participating country.

In the following years, the material from different Institutes will be progressively included. It will be tested in all the participating countries.

2.1.1.5. Plant density.

9 plant rows, 7.75 m in length, will be sown for each cultivar. The distances between plants and rows along with the plant density are given below :

Distance between plants : 0.25 m.

Distance between rows : 0.75 m

Number of plants per row : 32.

Density of plants : 53,333 plants/ha.

The number of rows will be decreased down to a minimum of five as the material to be tested increases.

2.1.1.6. Distance between experimental units.

The distance between two adjacent experimental units should be enough to prevent the extra supply of water due to horizontal fluxes between them, but not too large as to induce marked border effects. It is proposed to fix the distance between the units to 2 and 3 m.

2.1.2. Parameters to control.

2.1.2.1. Soil moisture.

The vertical soil moisture profile has to be determined at the moment of sowing, just before the application of each irrigation, and at the time of harvest. The profile will be characterized by means of samplig at points uniformally spaced ; the depth interval will be 30 cm, the first point being localized at 30 cm. The minimum of points per profile will be 3 and the maximum will obviously be conditioned by the depth of the soil and by the available facilities.

Always when possible, the soil moisture will be determined by means of a neutron scattering meter. When this instrument is not available the gravimetric technique is recommended.

Optional : Whenever it is possible to determine the soil-water potential profiles, it would be convenient to do so in order to complete information about the soil-water status. In such cases, profiles would be taken simultaneously to those of moisture.

2.1.2.2. Plant parameters.

2.1.2.2.1. Leaf area index (L.A.I.).

It is proposed to make an estimation of the L.A.I. twice throughout the crop cycle namely :

a) at the moment of flowering.

b) two weeks after flowering.

Sampling technique : In each of the specified moments 2 plants per sub-unit will be sampled, picked in such a way that its size would be representative of the rest of the plants. Due to the enormous amount of work that this would require, offered as an optional is the possibility of sampling only from one of the blocks, so that the total number of plants would be considerably reduced. In either case, the sampling will always be done in a plant row adjacent to those to be harvested in each subunit.

Measuring technique : The technique to determine the L.A.I. is left to good judgement and facilities of each of the investigators responsible for the experiments. When reporting the data it is adviced to indicate the way these were obtained. In the case where it results impossible to determine the L.A.I., it is recommended to measure the length and maximum width of the leaf blades which at each sampling moment seem to be photosynthetically active. It is understood by length of the blade, the distance between insertion at the petiole and the leaf apex.

2.1.2.2.2. Dry matter.

The dry matter will be determined at two moments of the cycle :

a) flowering.

b) harvesting.

Sampling technique : The same as for the L.A.I.

Determination technique : Oven dry at 70°C until constant weight. It is recommended to cut the plants and to use the ovens with forced ventilation to help quick drying.

2.1.2.2.3. Plant height.

It is understood by plant height, the distance between the first node and the insertion of the head on the stem.

It will be determined at the time of physiological maturity, sampling 5 plants per subunit ; the plants will be chosen in such a way that the rather small samples be representative of the different populations. This is important, keeping in mind the variability expected.

2.1.2.2.4. Head diameter.

Determined at the time of harvest. 20 heads per sub-unit chosen at random will be sampled.

The diameter of each head will be measured in two perpendicular directions ; only the mean of both determinations should be reported.

2.1.2.2.5. Production.

After discarding the sampling and edge rows there will be three to be harvested in each sub-unit. In each extreme of the harvested rows, 6 theoretical plants (1.50 m) will be discarded to eliminate the border effect. For each sub-unit it will be determined :

a) Weight of harvested grain as well as its moisture percentage at the moment of weighing ;

b) Number of harvested plants ;

c) Weight of 1.000 seeds, chosen at random between those harvested ;

d) Oil percentage.

In future years, when the number of cultivars to be tested will increase, only two rows will be harvested, leaving one for sampling and two to eliminate the border effect.

2.2. Optional experiment.

Everything the same as in section 2.1. (basic experiment) with the exception that treatment 5 is omitted.

3. ENVIRONMENTAL FACTORS.

3.1. Soil.

Among the soil properties, those considered of more interest for this work are those related to the ability of the soil to conduct and store water. In this respect it would be convenient to report a textural analysis, bulk density as well as the water desorption curve. Such determinations will be done in samples taken at 30 cm depth when the vertical soil profile is sufficiently homogeneous. When this is not the case, the samples will be taken at intervals of 30 cm to define the respective profiles.

Any additional information concerning chemical properties and soil taxonomy will be considered of secondary interest but will always be appreciated.

3.2. Water.

To characterize the quality of the irrigation water being used, the analysis of the same is considered of great importance. The minimum information to be reported is as follows :

— Electrical conductivity (mmhos/cm).

— SAR (Sodium absorption ratio).

3.3. Climate.

Daily mean temperature, rainfall and wind velocity recorded during the performance of the experiment is essential. Additional information considered of interest would be the daily mean relative humidity of the air, maximum and minimum temperature and hours of sunshine.

In the case of having a "class A" evaporation pan (U.S. Weather Bureau) installed in the vecinity of the experimental field, the including of the daily evaporation rates in the report would be also of interest.

4. PHENOLOGICAL OBSERVATIONS.

The phenological phases to be dated are the following :

— Emergence (when cotyledons are visible to 90% of the seedlings).

— Flowering (when the ray-flowers unfold to 50% of the plants).

— Physiological maturity (when 75% of heads are yellow and the rest yellow-brown coloured).

5. List of co-operators :

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

— Istituto di Agronomia Generale e Coltivazioni Erbacee, Pisa, Italy.

— Seed and Plant Improvement Institute, Karadj, Iran.

— Estaçao de Melhoramento de Plantas, Elvas, Portugal.

— Agricultural Research Institute, Edirne, Turkey.

— C.E.T.I.O.M., Paris, France.

— Experimental Agricultural Centre, Giza, Egypt.

— Field Food Crops Department, Baghdad, Iraq.

— Departamento Nacional de Plantas Oleaginosas, Córdoba, Spain (Liaison centre).