# ECOLOGICAL STUDIES ON SUNFLOWER ROOT SYSTEM

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## INTRODUCTION

Along their evolution, the different parts of plants, have adapted progressively to the most efficient utilization of the environmental conditions they are living in : the stem and the leaves to receive the solar energy necessary for elaborating the assimilates, and the root to fix the plant in the soil and mainly, to absorb the water and the mineral elements.

The morphological and physiological studies performed at the level of the aerial parts of plants resulted in accumulation of a rich bibliography, but for a better understanding of the plant as a unity, it is absolutely necessary to correlate these aspects with the phenomena occurring at the root level. Although during the past years the investigations in ecophysiology of the root system have elucidated many aspects of the complex interrelationship between aerial part and root, the data regarding these aspects in sunflower are as yet scanty enough.

An insufficient knowledge on the physiology of the root system of this crop plant, contributes to a large extent to the difficulties of explaining the different responses of sunflower genotypes to irrigation or fertilization.

The present paper outlines some aspects of the root system development and the relationship between the root system and the aerial part of different sunflower genotypes.

## MATERIALS AND METHODS

The investigations were carried out in several stages, consisting in laboratory, vegetation house and field determinations. The following methods were used to study the root system :

1. Monoliths method used in field experiments, by digging up a soil volume at 40 cm depth and 50/50 cm area, roots washing and measuring their total length, area and weight, using the method of intersections (N e w m a n, 1966 ; T e n n a n t, 1975).

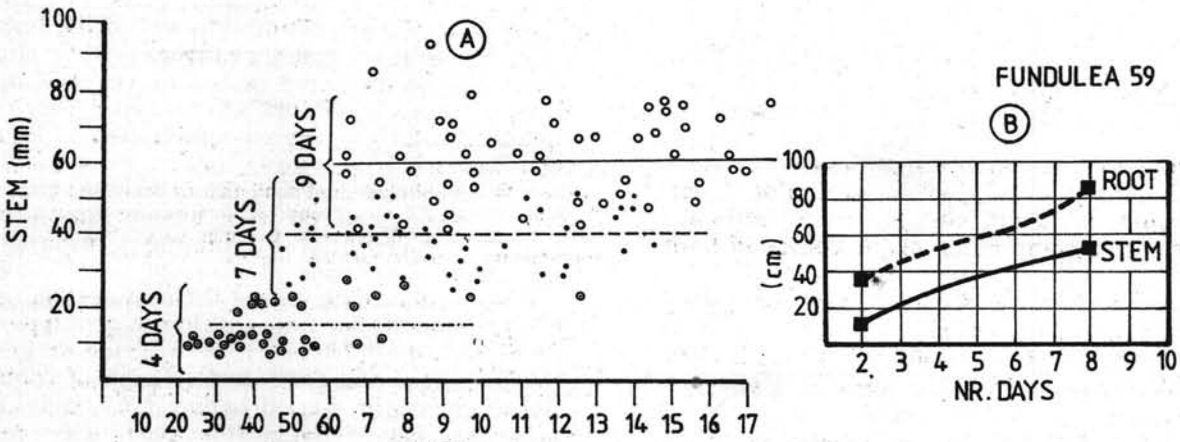


*Fig. 1.* — Amplitude of variation (A) and stem and root growth (B) of different sunflower genotypes

2. The endoscopic method, which allowed the appreciation of the speed of soil colonization by the root bulk and their density at different depths. In our determinations we used a medical endoscope (Maertens and Clauzel, 1982).

3. Besides these measurements, observations on roots in the period after flowering till maturity were made. To establish the role of different root parts in maintaining the plants in an upright position, the main roots were cut off in the flowering stage, in some cases, or the lateral roots, in other cases ; these plants were observed in the stage of seed filling with respect to plant stability and the degree of standing upright till harvesting.

## RESULTS AND DISCUSSION

The sunflower root system of tap-root type may explore a great quantity of soil reaching up to two metres depth.

Among the genotypes under study a large morphological variety, determined by endogen, hereditary, as well as environmental factors, was determined.

This variability of the root system was evident even in the seedling stage. Thus it was observed that the amplitude of root variation of different sunflower genotypes in the first stages of vegetation was higher than the amplitude of stem variation of the same seedlings (Fig. 1 a). It was also noted that the speed of root growing in the first stages of vegetation exceeded the speed of stem growing (Fig. 1 b).

Geisler (1982) and Werger (1983) showed that the ratio root/stem is constant for different crop plants and any modification of the environmental conditions changes this ratio.

In general, the vigour induced by heterosis to the investigated sunflower hybrids was also evident at the level of the root system which was

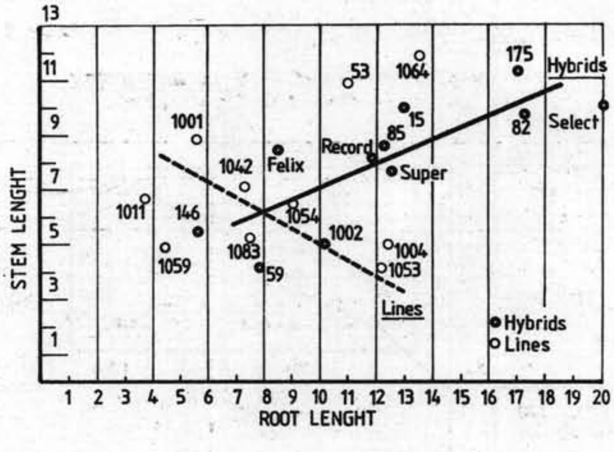


*Fig. 2.* — Relation between root and stem length (first stages of vegetation)

Table 1

**Morphological characteristics of roots of four sunflower genotypes in the 4—5 leaves stage (A) and at flowering (B), at the depth of 0—40 cm**

| Genotypes (Fi) | Total root length (m) | D.M. aerial part g/pl | D.M. root g/pl | Ratio R/AP | Speed of root growing until flowering (cm/day) |
|---|---|---|---|---|---|
| **A. Stage of 4—5 leaves** | | | | | |
| HS 826 | 2.64 | 5.7 | 0.36 | 0.13 | 8 |
| HS 940 | 4.08 | 5.5 | 0.54 | 0.13 | 20 |
| Fundulea 85 | 4.65 | 4.2 | 0.54 | 0.11 | 16 |
| Record * | 4.10 | 3.7 | 0.43 | 0.10 | 16 |
| **B. Flowering stage** | | | | | |
| **HS 826** | **40.3** | **250.9** | **38.0** | **0.10** | |
| **HS 940** | **93.0** | **345.1** | **49.5** | **0.14** | |
| **Fundulea 85** | **75.8** | **339.6** | **40.0** | **0.11** | |
| **Record *** | **76.3** | **332.3** | **47.0** | **0.13** | |

*** Open-pollinated variety**

very vigorous too (Fig. 2). On the contrary, the relationship was reversed in the inbred lines studied as shown in the same figure. The genotypes with a vigorous root system had a smaller size, except for the inbred line LC-1064.

Under conditions of plant cultivation in soil, this relationship was no longer preserved, the genotypes showing a great variability of the total length of root and of the dry matter content (*Table 1*).

This great variability is mainly due to the various conditions that plants meet in the soil. Among the most important factors that may affect root growing are temperature, water and minerals supply, aeration, pathogens, etc. However, because these conditions are not uniform along the zone of root spreading, or they change even during the same period of vegetation, the root growing is seldom affected and very often the genetic differences are annihilated under field conditions.

This is the reason why the researches referring to the ecology of the root system are difficult enough, but essential in obtaining information for agricultural practice.

So, noticing the size of the root system under field conditions for four sunflower genotypes under irrigation (*Table 2*), it was found that in the 4—5 leaf stage the total length of roots, at 0—40 cm depth, varied between 2.6 and 4.6 m, and the ratio root/aerial part was nearly constant. The dry matter weight of roots of the same genotypes, during the flowering stage, at the same depth, increased by about 100 times

*Table 2*

**Morphological characteristics of the root system of sunflower genotypes under study at flowering state ($F_1$ hybrids (A) and inbred lines (B))**

| Hybrids ($F_1$) and inbred lines | Total D.M. aerial part (g/pl) | Dry weight main root (g/pl) | Dry weight secondary roots (g/pl) | Root diameter (mm) | Length of main root (mm) | Length of secondary roots (m) | Root volume (cm$^3$) | Dry root weight (g/pl) | Ratio root/aerial part |
|---|---|---|---|---|---|---|---|---|---|
| **A. $F_1$ hybrids** | | | | | | | | | |
| Super | 48.5 | 4.5 | 6.1 | 20.6 | 133.3 | 160 | 133.3 | 10.6 | 0.21 |
| Fundulea 59 | 49.6 | 6.5 | 5.8 | 18.8 | 115.0 | 228 | 166.6 | 12.3 | 0.24 |
| Sorem 80 | 50.3 | 5.3 | 6.0 | 17.3 | 127.6 | 161 | 186.6 | 11.3 | 0.22 |
| Fundulea 85 | 88.9 | 6.1 | 5.3 | 21.6 | 159.3 | 273 | 196.6 | 11.4 | 0.13 |
| Felix | 74.2 | 4.6 | 6.6 | 19.0 | 105.3 | 168 | 176.6 | 11.2 | 0.15 |
| Select | 76.2 | 5.5 | 9.7 | 24.0 | 143.0 | 221 | 195.0 | 15.2 | 0.19 |
| **B. Inbred lines** | | | | | | | | | |
| LC—1059 | 41.8 | 5.1 | 5.3 | 20.0 | 92.6 | 129 | 123.3 | 10.4 | 0.25 |
| LC—1064 | 35.6 | 5.0 | 5.6 | 20.0 | 140.3 | 144 | 155.0 | 10.6 | 0.29 |
| LC—1011 | 43.3 | 5.6 | 5.. | 23.6 | 99.6 | 169 | 160.0 | 10.6 | 0.24 |
| LC—1054 | 44.4 | 6.0 | 4.0 | 21.6 | 148.3 | 138 | 116.6 | 10.0 | 0.22 |
| LC—1006 | 72.3 | 4.7 | 5.3 | 22.6 | 150.0 | 224 | 143.3 | 10.0 | 0.13 |
| LC—1002 | 69.0 | 4.1 | 7.8 | 21.3 | 155.0 | 300 | 193.3 | 11.9 | 0.17 |
| LC—1004 | 76.8 | 6.7 | 6.0 | 23.0 | 125.0 | 112 | 165.0 | 12.7 | 0.16 |

and the length by 20 times, the growing speed varied between 8—20 cm/day, and the ratio root/aerial part had almost constant values.

In case the plants were grown in pot house where the soil volume was limited and its minerals content poor, being a soil digged up from a deep layer of 1.5 m, the total length of roots was very great (*Table 3*). As a matter of fact, W e r g e r (1983) mentioned that in the case of poor or lacking in water soils, the roots become very numerous to meet the adverse conditions.

Under such conditions, the very great total length of roots, more than 100 metres, was noticed as well as the increase of the ratio root/aerial part.

Another important aspect is the length of the tap-root with a special role to anchor the plants in the soil which also varied to the different genotype studies. The hybrid Sorem 80 had the longest tap-root as well as a great quantity of secondary roots, the length of which summed up more than 200 m.

Among the inbred lines, mention should be made of the line LC—1002, with an abundant root mass of 300 m, this line being known as very resistant to drought.

It is obvious that the monoliths method as well as the method of plants cultivation in pot house and their sacrifice for measurements are destructive methods, which very often do not supply information on root density in different soil profiles or the degree of root colonization of the soil.

Using the endoscopic method, it was possible to appreciate the root disposition in different soil profiles up to 60 cm depth. It was observed (Fig. 3) that on June 10, when the plants had 12—13 leaves (HS 826) or 15—16 leaves (HS 940, Fundulea 85, Record), the root bulk varied from 35 cm depth (Record) to 55 cm (HS 826), and the average number of roots noticed

*Table 3*

**The role of different root parts in maintaining the upright position of sunflower plants**

| Hybrids ($F_1$) and OPV* | Root parts cut off: Main root | Root parts cut off: Secondary roots |
|---|---|---|
| HS 886 | Plants standing and well anchored | Plants are easily removed |
| Fundulea 85 | Idem | Idem |
| HS 940 | Plants are very easily removed | Idem |
| Record* | Plants lodging after flowering | Idem |

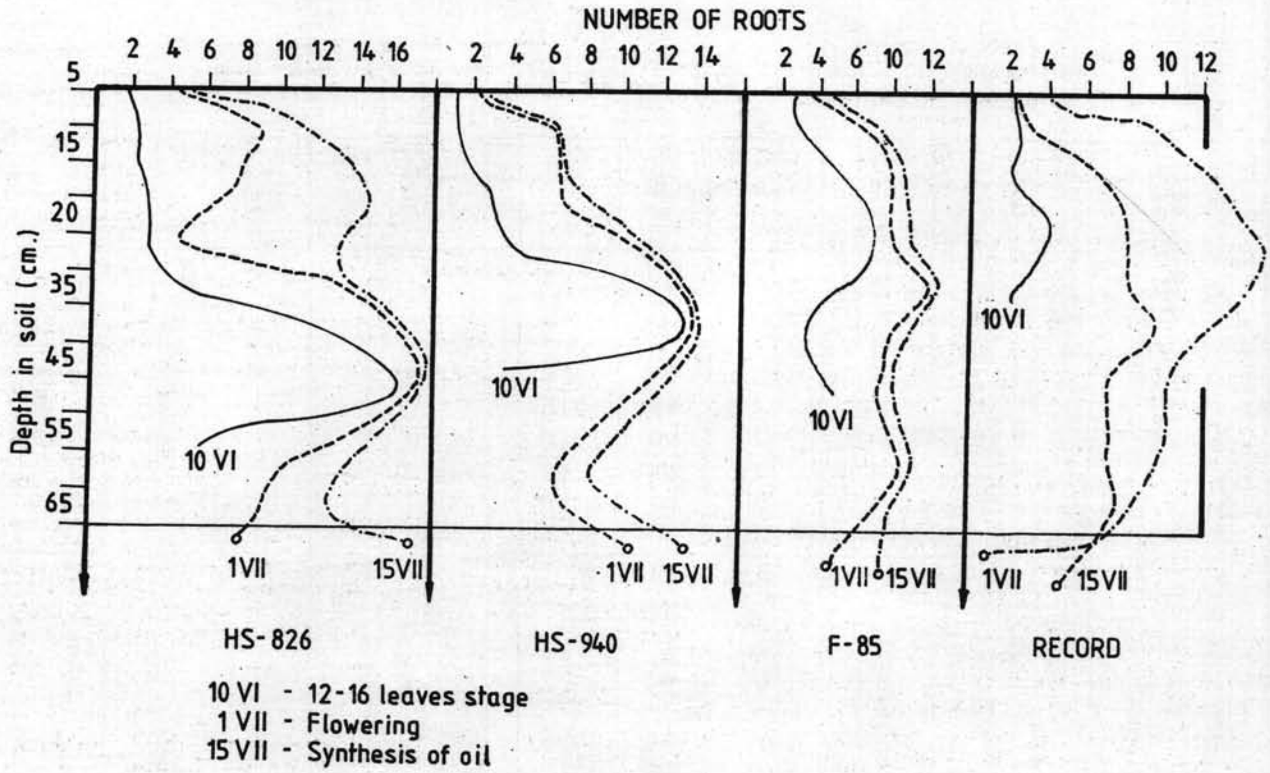


*Fig. 3.* — Root distribution in three stages of growth

in the visual area of the endoscope ranged from 4 (Record) to 26 (HS 826).

The root bulk in the flowering period exceeded the depth of 65 cm allowed by the endoscope to be observed and the highest density of roots in the visual field reached the number of 16 roots in the soil profile of 35—36 cm depth.

The hybrid Fundulea 85 distinguished by the uniform disposition of roots within the soil depth of 0—60 cm, while the hybrids HS 826 and HS 940 had a high density of roots in deeper layers, and the cultivar Record in shallow layers (0—30 cm).

Considering that the size of the tap-root is important in avoiding plant lodging, a study was carried out concerning its form and size, and the results are presented in Figure 4. It was observed that some hybrids (Fundulea 53, Select) had a vigorous tap-root as well as well developed lateral roots which help in plant fixing in the soil, comparatively with other genotypes (Sorem 82, Record), which have a short main root with a sudden interruption and very thin lateral roots.

By cutting off the tap-root or the lateral roots of the plants belonging to the genotypes HS 940, HS 826, Fundulea 85 and Record, the results summarized in Table 4 were obtained. The data presented in this table pointed out the fact that the hybrids Fundulea 85 and HS 826 had equally developed both main and secondary roots, being able separately to maintain the plant in upright position under difficult environmental conditions. In the case of the cultivar Record, by cutting off the tap-root, the plant could not maintain the erect position and lodged after flowering, the secondary roots not being able to fix the plant.

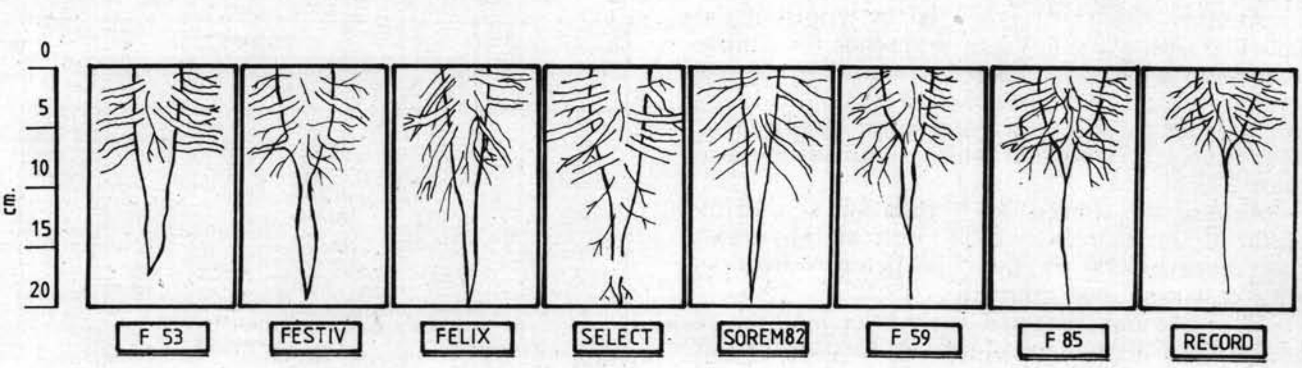


*Fig. 4.* — Morphological aspect of the main root of different sunflower hybrids

## CONCLUSIONS

The data presented in this paper allow the following conclusions :

1. The speed of stem growing during the first stages of vegetation was slower than that of root growing.
2. Sunflower showed a great variability of the root system.
3. Root system variability was influenced by the soil growing conditions. Under similar soil conditions, the ratio root/aerial part had almost constant values.
4. Under poor soil conditions, sunflower plants developed numerous roots with a total length exceeding 200 m, which determined the increase of the ratio between root weight and aerial part weight.
5. The genotypes known as resistant to drought developed a rich root system (the inbred line LC—1002, Fundulea 85 and Select).
6. The genotypes with a strong tap-root and thick secondary roots disposed in the deeper layers of the soil were resistant to lodging (Fundelea 85, HS 826) comparatively to the genotypes with numerous secondary roots but fixed in the shallow soil layers (Record), which proved to be very susceptible to lodging.

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ÉTUDES ÉCOLOGIQUE SUR LE SYSTÈME RADICULAIRE DU TOURNESOL


*Résumé*

Quelques aspects du développement du système radiculaire de différents génotypes de tournesol cultivés en champ et dans la maison de végétation sont mis en évidence. Les auteurs ont utilisé deux méthodes : la méthode endoscopique qui permet d'apprécier l'intensité de la colonisation du sol par les racines ; la méthode des monolithes qui permet de caractériser le système radiculaire au moment de la floraison.

Chez les génotypes étudiés, le système radiculaire a présenté une importante variabilité due à l'environnement.

Le rapport entre le poids radiculaire et celui des organes aériens reste, dans des conditions semblables d'environnement, presque constant et augmente chez tous les génotypes dans les sols pauvres. Les génotypes résistants à la sécheresse développent un système radiculaire abondant et très profond. Les génotypes à racine pivotante bien dévelopée et racines secondaires épaisses, situées dans les couches plus profondes du sol ont présenté la plus forte résistance à la verse.


ESTUDIOS ECOLOGICOS SOBRE EL SISTEMA RADICULAR DE GIRASOL


*Resúmen*

La presente publicacion muestra ciertos aspectos del desarrollo radicular de varios genotipos de girasol cultivados en macetas y en el campo.

Dos métodos fueron utilizados : El método de endoscopio, que permitió evaluar de la velocidad de colonización del nudo por las raices de girasol y el método monolítico que permitió una caracterización más completa del sistema radicular en el estado de floración.

Los resultados mostraron una gran variabilidad en el sistema radicular de los genotipos investigados influenciada por las condiciones ambientales.

La relación entre el peso de la parte aérea y de la raiz presentó unos valores casi constantes bajo las mismas condiciones ambientales y valores mayores en suelos pobres en todos los genotipos. Los genotipos resistentes a sequía desarrollaron un abundante y profundo sistema radicular. Los genotipos con la raiz pivotante bién desarrollada y raices secundarias densas dispuestas en capas de suelo más profundas se mostraron más resistente al encamado.