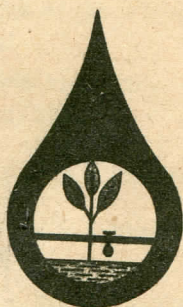


**PROCEEDINGS OF THE SYMPOSIUM ON DRIP IRRIGATION IN
HORTICULTURE WITH FOREIGN EXPERTS PARTICIPATING**

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APPLE - TREE ROOT DISTRIBUTION IN RELATION TO THE POSITION OF DRIP IRRIGATION NOZZLES

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ABSTRACT. The effects of the drip nozzle position on the root distribution have been studied in two experiments. In the first experiment with young Golden apple-trees, irrigated since the year they were planted, the best yield was found when two nozzles, at 50 cm on both sides of a tree were used. The rooting with this treatment in sandy-loamy soil was regular, dense and broad enough.

With the same water supply, the lowest yield was found when a single nozzle was laid 30 cm apart from the trunk and some water-logging and, maybe, nutrient leakage was also caused.

In the second experiment mature Golden trees have been irrigated for only the last four years. In this loamy-silty soil the best rooting was obtained when the trunk was near the border of the nozzle-effect area, which was one meter, in radius.

The „effect area” is the area where distribution is affected by water drip supply; the effect area radius depends upon the soils physical properties. It seems this radius is a good rating for the best distance between trunk and nozzles. A symmetrical position of nozzles also improves root distribution regularity.

INTRODUCTION

Drip irrigation has greatly extended these last years; this success mainly comes from its presumed easy use and the opportunities to save water and labour.

There are a lot of various outlets and irrigation materials, but at the same time a great need appears for knowledge in order to improve the efficiency of the practical use of drip irrigation in European conditions.

From a technical point of view, five main questions must be put before setting drip irrigation in an orchard:

- | | |
|----------------------------|-------------------------|
| 1. output level per outlet | |
| 2. frequency | } of irrigation |
| 3. duration | |
| 4. number | } of irrigation outlets |
| 5. position | |

1. For a given type of soil there is only one output value able to supply, on a point, a maximum amount of water without causing puddles. This typical maximum output depends only upon physical soil properties.

2. - 3. Frequency and duration of irrigation depend upon soil properties and water demand.

4. The number of outlets depends upon their output and also upon the maximum water supply needed for mature orchards.

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5. There still remains the question of outlet position, in relation to the trunk, in order to achieve optimum results. This means, that the root system must be able to fix trees firmly in the soil and improve the uptake of water and nutrients.

This is the reason why we studied the effects of outlet position on the distribution of the apple-tree root system in two experiments in the South-West of France.

Table 1. Apple-tree root distribution in relation to the position of drip irrigation nozzles

Young (4 years) Golden /MM 106	Mature (14 years) Golden / Seedling R.S.	
4 m x 2.5 m	6 m x 3 m	
spacing		
For 4 years (since plantation year) irrigation	for 5 last years	
4 treatments (3 replications)	2 treatments (6 replications)	
Dry cultivation	Near : Drip Irr. Nozzl.: 120 cm trunk	
Sprinkler irrigation	Far : Drip Irr. Nozzl.: 180 cm trunk	
1 drip irrigation nozzle: 30 cm trunk		
2 drip irrigation nozzle: 50 cm trunk		
Soil (0-50 cm)		
15 %	(<0.002 mm)	35 %
14	(0.002 to 0.05 mm)	43
66	(0.05 to 0.2 mm)	10
3	(0.2 to 2 mm)	9

The aim of the first trial was to study the effect of drip irrigation on roots when the irrigation started with the year of plantation. In the second trial, we studied the effects of drip irrigation set at tree maturity.

ROOT STUDY METHOD

Distribution of roots has been studied by the spiral trench method with computer data processing /Huguet, 1973, 1976, 1978/.

RESULTS

1. Young apple-trees /Fig. 1/.

In this trial with silty-sandy, deep soil, each irrigated treatment received the same amount of water based on climatic demand. But a ratio of restriction /0,70/ was casually introduced in the watering of two drip treatments.

Trees were four years old when root distribution was studied.

fig. 1

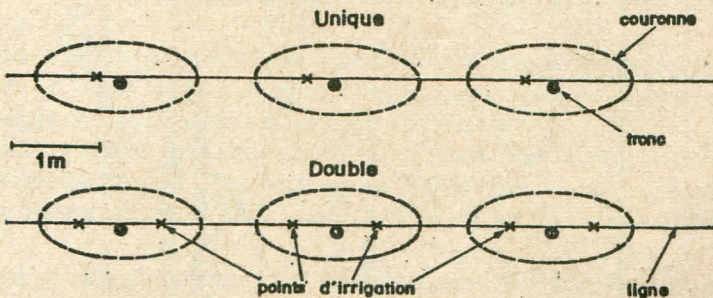
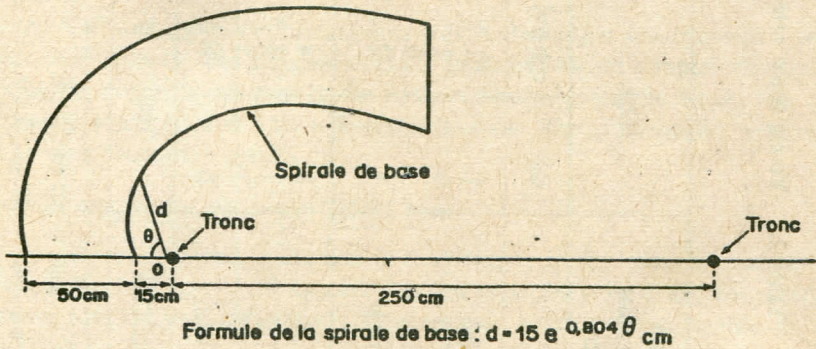


Table 2. Young apple - trees

	Trunk distances cm	Dry		Sprinkler		Drip irrigation			
						1 outlet/tree		2 outlets/tree	
		soil	sub-soil	soil	sub-soil	soil	sub-soil	soil	sub-soil
S Frame-work index mm ² /10 cm ²	30	1	1	8	1	3	0	3	1
	70	0	1	0	1	0	0	0	1
	120	0	0	1	0	0	0	0	1
	Total	1	2	9	2	3	0	3	3
N. Absorption system (nb. roots/100 cm ²)	30	3	4	5	3	4	2	2	3
	70	1	3	2	3	1	3	2	3
	120	1	2	2	1	1	2	2	3
	Total	5	9	9	7	6	7	6	9
YIELD INDEXES		100		100		80		120	

soil = 0 to 22 cm
sub-soil = 22 to 55 cm

Table 2 allows the rooting to be compared in the four treatments.

Data processing led us to study the correlations between two rooting indexes in a given area on the trench wall and the position parameters of this area. The rooting indexes are:

- N: number of fine roots /diameter \leq 1 mm/, corresponding to the absorption system;
S: the sum of section surfaces of „big” roots /diameter $>$ 1 mm/ corresponding to the root frame-work.

Table 2 shows a simplified relation of the correlations of these parameters and the trunk distance.

Root frame-work

The sprinkler treatment induces a strong but superficial framework; the „two outlets” treatment induces a less vigorous frame-work but with a good repartition between soil and subsoil. The dry treatment induces a poor but deep frame-work; and last, the „one outlet” treatment induces a very poor and superficial frame-work.

The absorption system

The „two outlets” and „sprinkler” treatments induce absorption systems with a very similar density of fine roots; but the „two outlets” treatment shows a superiority by better exploring the deeper layers even at the farthest distance from the trunk. The „dry” treatment comes in third position with a deep distribution. The „one outlet” treatment leads to the poorest absorption system.

Conclusion of the experiment on young Golden trees

Although we did not observe any increase in root density in the effect area of the outlets /60 cm radius in this soil/, it appears that the irrigation system and the position of outlets induce root systems with various distributions, which explains significant variations of yields.

The root behaviour induced by the „dry treatment” shows the positive effect of a certain watering limitation on the exploration of remote and deep layers when trees are young.

Sprinkler irrigation leads to an effective but superficial root system. Paradoxically, a very homogeneous supply of water causes a decrease of root zone volume. This root system will increase the susceptibility of trees to hazardous water-stress.

A single drip outlet too near the trunk causes, at the same time, a very poor root frame-work and absorption system. The main reason for this fact is certainly due to some water-logging around the trunk base, which leads to oxygen stress and mineral leaching.

Irrigation by two symmetrical outlets, far enough from the trunk and with an output suitable to soil properties, causes an effective root system, which combines sprinkler irrigation conveniences with those of dry culture.

2. Mature trees /Fig. 2 /

In this trial, carried out in a silty-loamy soil, we intended to study the effect of outlet positions /two different distances from the trunk/ on root distribution. When the roots were studied, trees were fourteen years old, and drip irrigation had been used for five years.

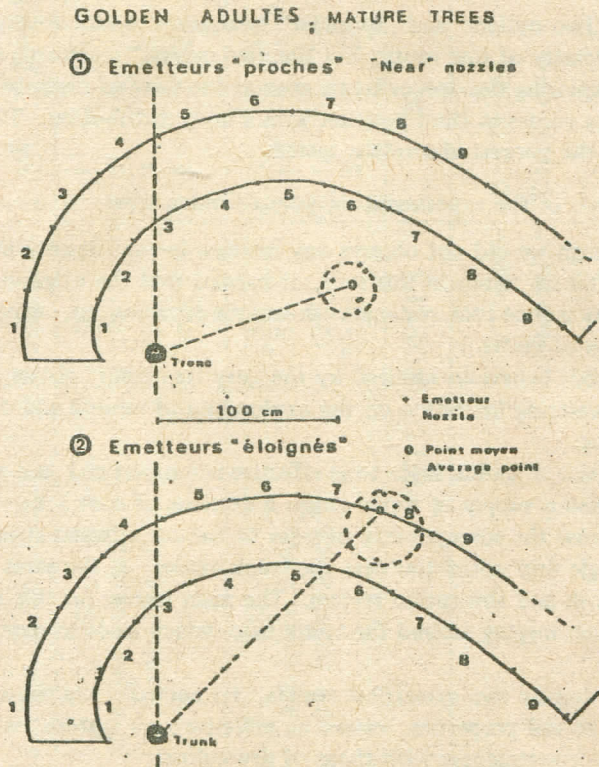
A general examination of rootings shows that a „near outlets” treatment induces a 10 per cent increase in the total root number /absorption system/ and a 33 per cent increase in the section surfaces of the big roots /root frame-work/, as compared to the „far outlets” treatment.

As a general rule, when watering is homogeneous /rain or sprinkler/, a maximum root density near the trunk can be observed. In this case root density shows a fast decrease with increasing distance from the trunk.

In this trial on mature Golden, we did not observe this general rule, as the maximum root density appeared rather far from the trunk, near the drip irrigation outlet.

The boundary of the outlet effect area is clearly shown in Fig. 3 by variations of the root density when outlet distances are decreasing. The radius of this effect area seems to be about 100 cm in this soil. Inside this effect area, there is no significant difference between the root densities in both treatments.

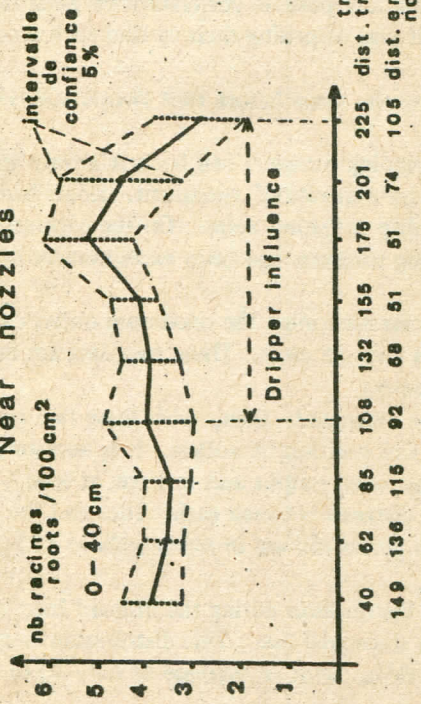
fig. 2



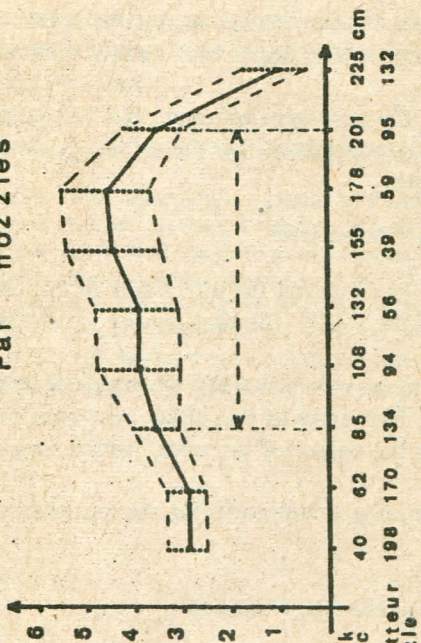
GOLDEN ADULTES MATURE TREES

fig. 3

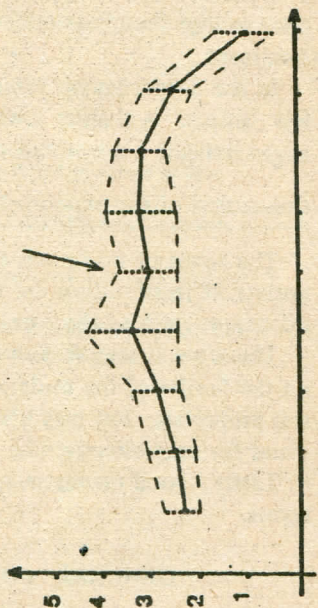
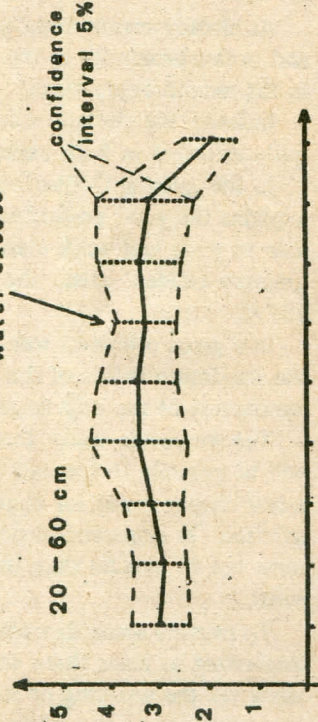
① Emetteurs "prochos"
"Near" nozzles



② Emetteurs "éloignés"
"Far" nozzles



excès d'eau
water excess



Outside this effect area and for the two distance classes nearest the trunk, we could observe that the „near outlet” treatment induces a higher root density than the other treatment.

In the deeper layers observations had the same general trend, but variations were less distinct. A slightly lower root density appeared below the dripper position, which might indicate a water excess at this depth.

Conclusion of the experiment on mature Golden trees

The zones of maximum root density appear inside the effect area of drip irrigation outlets. If these outlets are too far from the trunk, the root density cannot reach its maximum close to the trunk.

Therefore it seems the best rooting can be obtained when the trunk is standing just on the border of the outlet effect area. The radius of this effect area depends upon the soil properties, but may also depend on the nature of the trees, which need more or less water for root effectiveness.

Lastly, good management of drip watering would not bring any water excess in deep layers.

GENERAL CONCLUSION AND DISCUSSION

As already mentioned, we did not find any positive correlation between root density and outlet proximity in the first trial. It was surprising then to find such a correlation in the second experiment.

Indeed, the climatic conditions during the years before root examinations had been quite different in both experiments.

In the „young Golden” trial, the foregoing summers had been relatively wet, which explains the good performance of the „dry cultivation” treatment. Roots had been able to grow and work even out of the drip irrigation zones. On the contrary, in the „mature Golden” trial, the two foregoing summers had been exceptionally dry /1976-1977/.

In a given orchard, soil and tree species determine the maximum outlet output and the maximum radius of the outlet effect area on roots. These two data are invariant parameters of the drip irrigation management.

The maximum water demand must be estimated; then, with these two parameters, it will be possible to forecast the number and position of outlets. It is necessary to choose a real output lower /or equal/ to the maximum output and to have, at least, two outlets per tree, in symmetrical position. The distance between each outlet and the nearest trunk must not be smaller than the effect area radius /50 cm in sandy soils to 120 cm in very loamy soils/.

To provide some flexibility in outlet distribution during the orchard life, it might be interesting to place them according to a sinusoidal line. This distribution would also allow for the watering of trees on both sides, with an increase of only 30 to 40 per cent of the necessary pipes.

As the outlet number and output are determined when the irrigation system is set up, the adequation between water supply and water demand could be adjusted by choosing the watering frequency.

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