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Effect of different rootstocks on some aspects of water physiology in the almond

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ABSTRACT

The use of different rootstocks (bitter almond, peach GF 305, peach × almond GF 677, Marianna GF 8-1) does not seem to induce significantly different responses, in drought conditions, in some aspects of water physiology of the almond (cv 'Fellamasa').

We have taken into consideration: 1) the leaf water potential with weekly measurements carried out at dawn and, just for two significant days, from dawn to sunset; 2) the leaf resistance at 12 a.m. with weekly measurements; 3) the transpirational flux.

The diffusion of rootstocks to be used in alternative to the traditional almond and the use of the irrigation as a fundamental cultural practice, are some of the main factors which contributed to the renewal of almond industry in different producing countries.

Some researches have been carried out in order to verify the different productivity and a few other aspects of the species, with regard to the rootstoscks used and to the water conditions of the soil (5, 13). But there is a lack of specific researches which could link the water status of the plant and some related physiological aspects to the rootstocks used. Actually, if the literature is wide enough for some species, like citrus (1, 7, 8, 20), grape (17, 27), pear (2), apple (3, 10) and peach (9), it practically does not exist for almond.

However, apart from the rootstocks used, the almond is considered as one of the most drought-resistant tree crops. On the subject, we would like to mention the works of Loughridge (cited in Grasselly-Crossa Raynaud, 1980), Poliakoff (1945), Spiegel Roy and Mazigh (1976), El Sharkawy and El Monayeri (1976), Holmberg and Werensfeld (1967).

According to Grasely and Crossa-Raynaud (1980), the reasons of this resistance can be found in a better functionality of the roots and in the power of reducing transpiration, when the water in the soil is next to the wilting point.

More recently, Castel and Fereres (1982) have pointed out, on almond trees cv Non Pareil on peach rootstock, that resistance to water stress is at first under control of an accumulation of solutes, thanks to osmotic adjustment which permit to keep the turgor pressure unchanged. Later, with an increase of the severity of water stress, a mechanism of stomatal control reducing transpiration enter into play.

If the stress is still more intense, we notice a leaf rolling with, consequently, a reduction in radiation interception and in the temperature which, otherwise, because of the stomatal closure, would tend to increase. But we could even have a shedding, proportionally to the intensity of water stress, which implies a reduction of the transpirating surface. As it is well-known, these are mechanisms of drought-resistance, typical of Mediterranean plants (Kozlowski, 1976).

As we have seen, the drought resistance, for different species, is influenced by the rootstock. The possible reasons are of different nature: a different water conductivity of the stem (Cristoferi 1963), intensity and velocity of ABA accumulation (Scienza 1980), width, depth and distribution of the roots (Castle 1977), vigour given to the scion (Milella and Deidda 1973).

Finally, as far as almond rootstocks are concerned, all the literature consulted (Graselly and Crossa-Raynaud, 1980; Gall and Grasselly, 1977; Ross and Catlin, 1978) assert that peach is more drought-sensitive than peach × almond, and that the latter is equally or even more resistant than almond. The aim of this work is to verify, with regard to the rootstock used, and on the basis of some physiological parametres, a different behaviour of the almond in various stages of water stress.

MATERIALS AND METHODS

The research was carried out in 1981 and in 1982, in an experimental orchard of Lascari, Palermo the almond variety used was 'Fellamasa' or 'Casteltermini', grafted on four different rootstocks: bitter almond, peach GF 305, peach × almond GF 677 and Marianna plum GF 8—1. The trees, of four years old, were set out in terraces with a distance of 5×6 m.

The soil turned out to have a clayey-textured tendence (sand 20 %, silt 32 %, clay 48 %) and the hydrological constants taken into consideration - field capacity and permanent wilting point (P.W.P.) - were, respectively, of the 22 % and 9 % of the d.w.

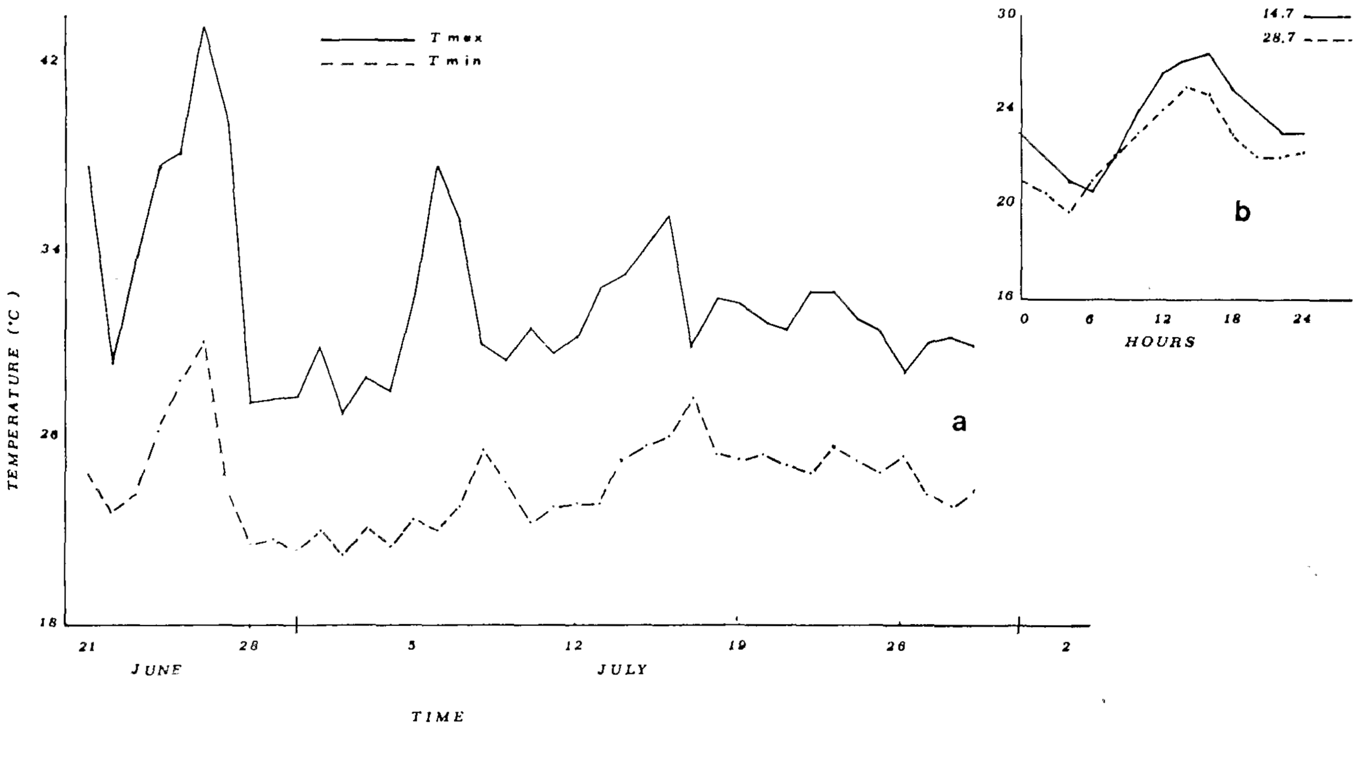
Fig. 1 shows the temperature behaviour in 1982 and, for the two dates in which the surveys we will talk about later were performed, in 1981 too.

It should be noted that we did not show the rainfalls values: this is due to the fact that, during the periods taken into consideration, no relevant rainy event was registered. One week before starting the measurement, an irrigation was performed.

The survey concerned the leaf water potential and the leaf resistance during a period of about one month after the irrigation. But they also concerned the moisture content of the soil and the vapour pressure deficit in the air (VPD).

More precisely, the water potential was estimated in the field with a pressure chamber. The measurements were carried out on four matured leaves per tree, at weekly intervals, before sunrise, that is to say when

Figure 1. a) Maximum and minimum air temperatures relative to 1982.
b) Mean temperature relative to two sampling dates, 1981.



the water potentials, in the tree and in the soil, are perfectly balanced.

During the first year, the surveys were performed at two different dates (14/7 and 28/7), every three hours, from 4 a.m. to 5 p.m. However, on the 28th/7, because of a damage of the pressure chamber, we were obliged to interrupt them at 12 h30 a.m.

On the contrary, leaf resistance was measured, in 1981, on the abaxial side of the leaves (four per tree) at 12 a.m. and always at weekly intervals.

For this purpose, we used a diffusion porometer (LI-COR LI-65 model), according to the suggestions of Morrow and Slatyer (1977). At the same time, with an aspirated psychrometer, we measured the VPD, which allowed the estimate of the transpirational flux, on the basis of the ratio VPD/rs (Elfving et al., 1972). Finally, soil moisture was obtained thanks to gravimetrical measurements in the layer 0-80 cm. (fig. 2).

RESULTS

Leaf water potential:

In 1981 and 1982, as we have already said, we measured the values of the leaf water potential. In particular, fig. 3, which refers to the first year, shows a reduction of these values, that reached the minimum 28 days after the irrigation, when a sudden rain led to the necessary interruption of the measurements, before we could reach, in the soil, values higher than the PWP. However, the values obtained do not

Figure 2. Soil moisture at the different sampling dates.

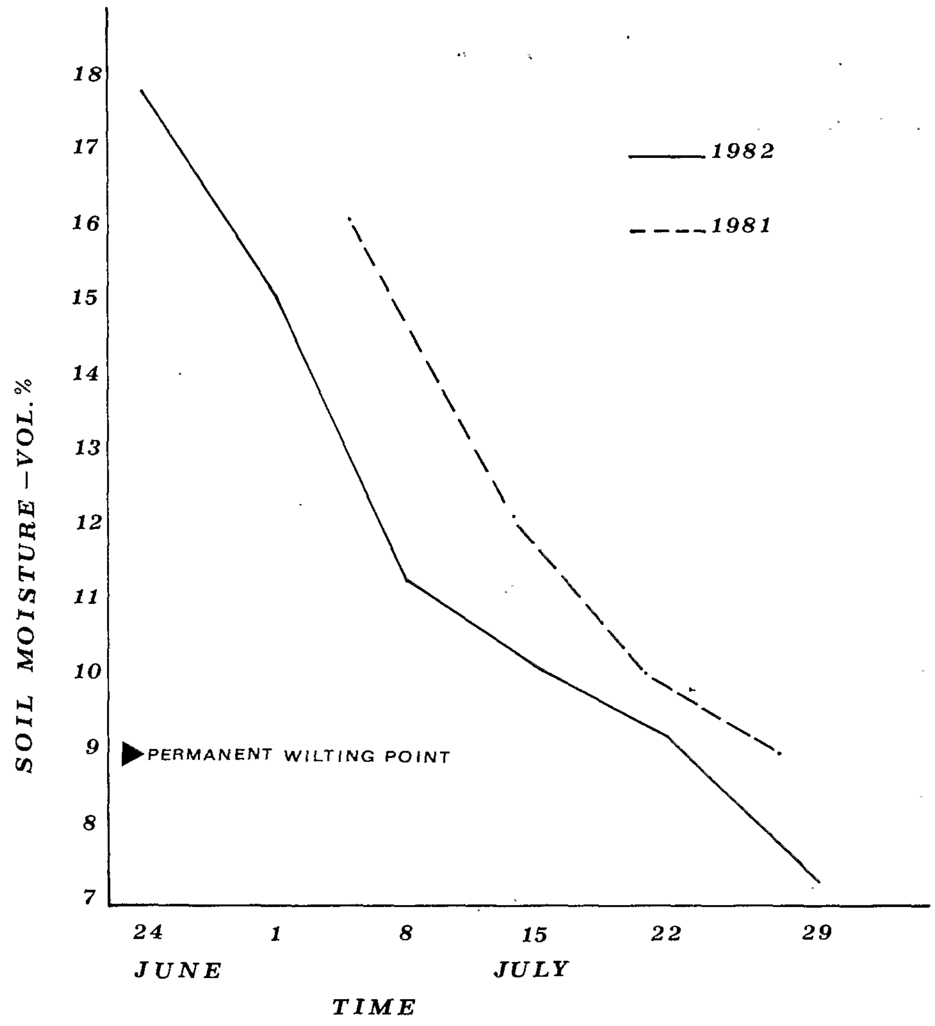


Figure 3. Leaf water potential taken from 7th to 28th July 1981 at 4 a.m.

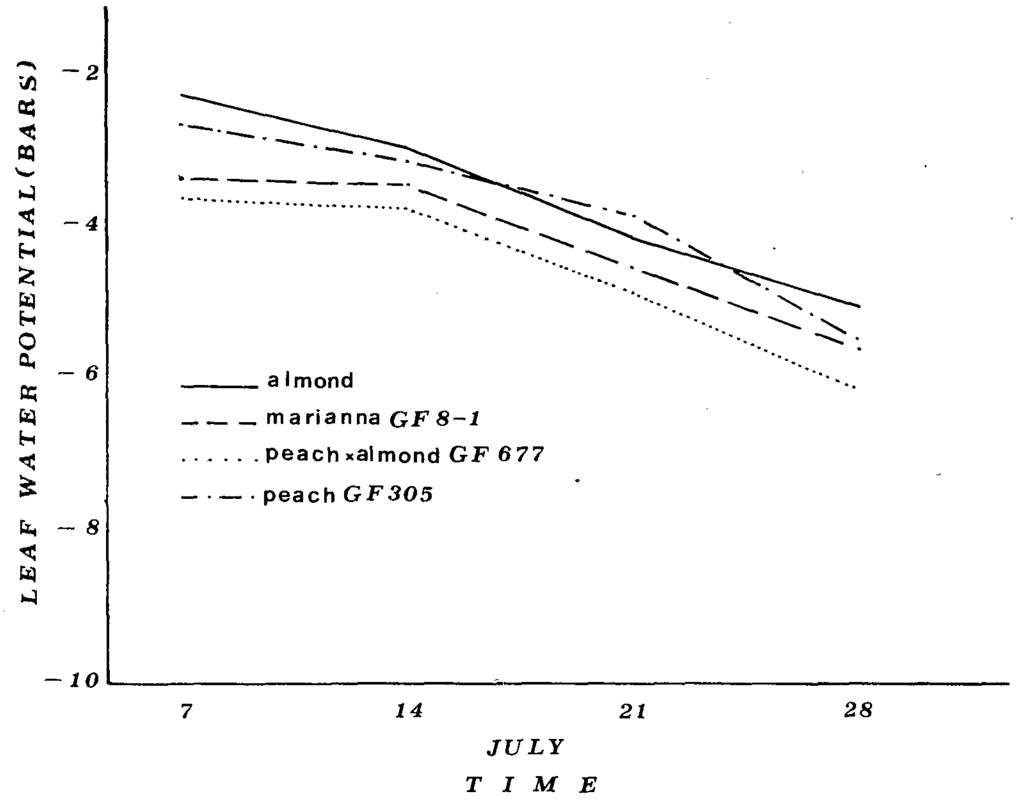
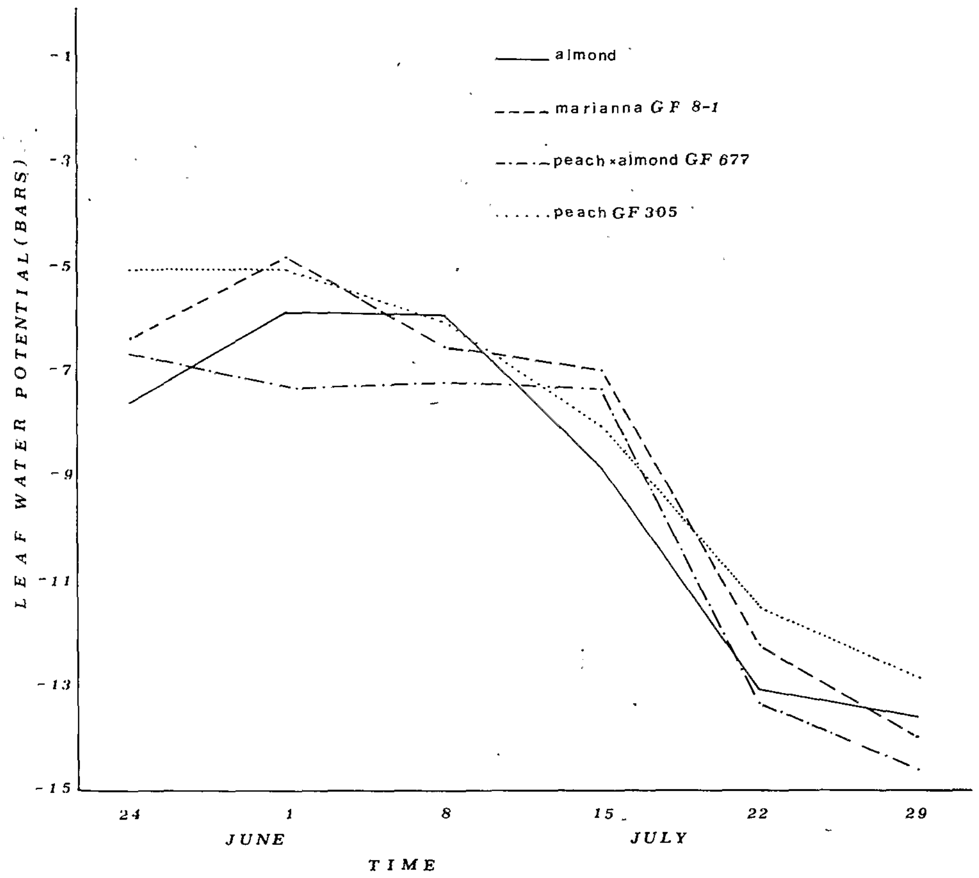


Figure 4. Leaf water potential taken from 24th June to 29th July 1982 at 4 a.m.



show any substantial difference among the rootstocks used.

The 1982 surveys (fig. 4) show a more irregular trend, also because of weather events (a hot and arid wind, called «sirocco») which led, in some days of the period considered, to remarkable increases of medium temperature values and to very low contents of relative humidity in the air. Namely, the measurements carried out on the 24th/6 coincided with a day of «sirocco», which can justify the presence of values lower than those obtained with the following survey.

However, the rootstocks used do not seem to suffer from the reduction of moisture values in the soil, as long as these values stay within the limits of the water available. Besides, the leaf water potential values clearly decrease only when they get nearer and nearer to the PWP.

If we compare the data obtained from the different rootstocks used, we notice that the lowest value (—14.6 bars) comes from peach GF 305, and that the highest ones (—12.8 bars) derive from peach × almond GF 677.

Figure 5. Leaf water potential taken on 14th July 1981.

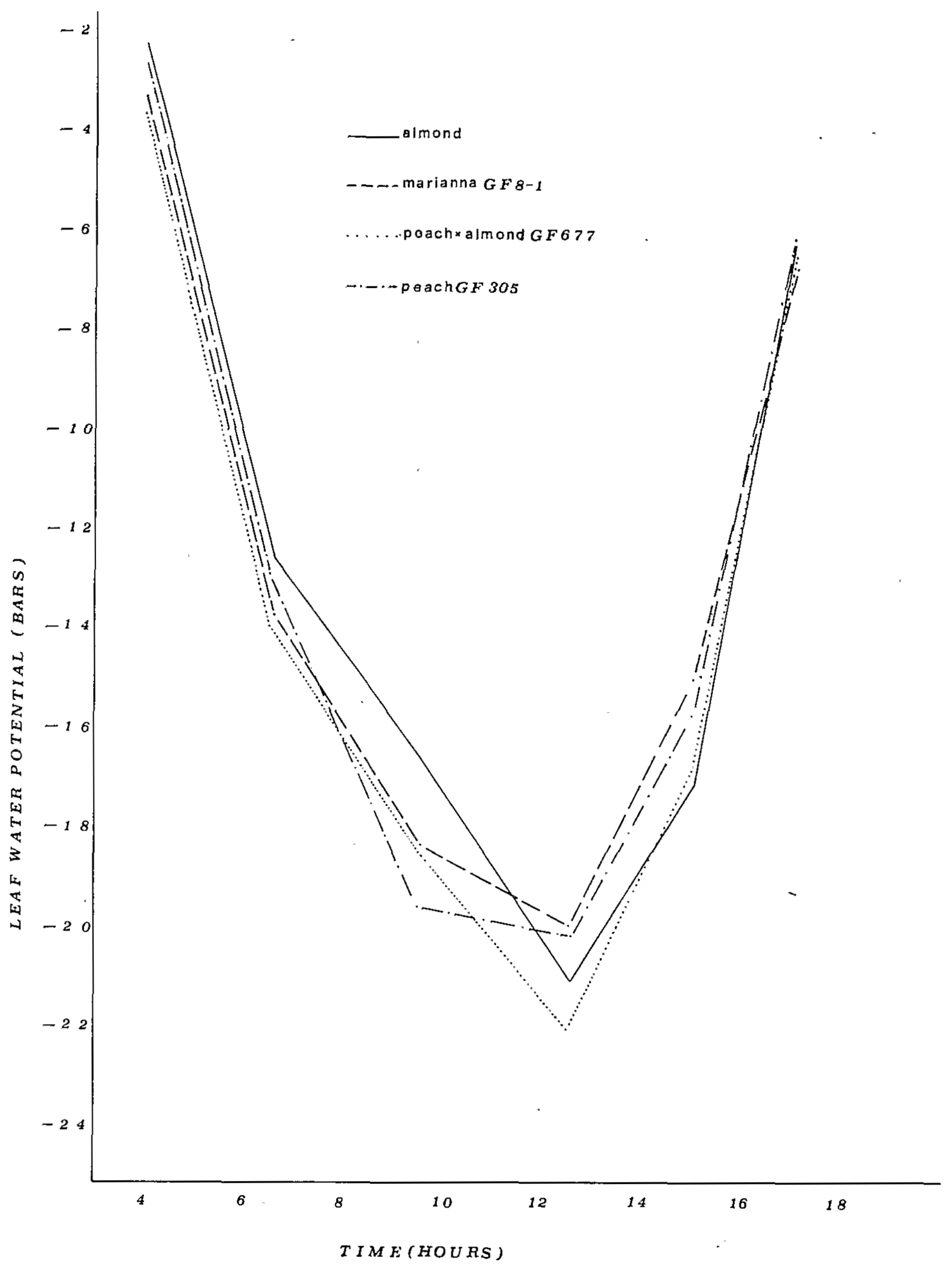


Figure 6. Leaf water potential taken on 28th July 1981.

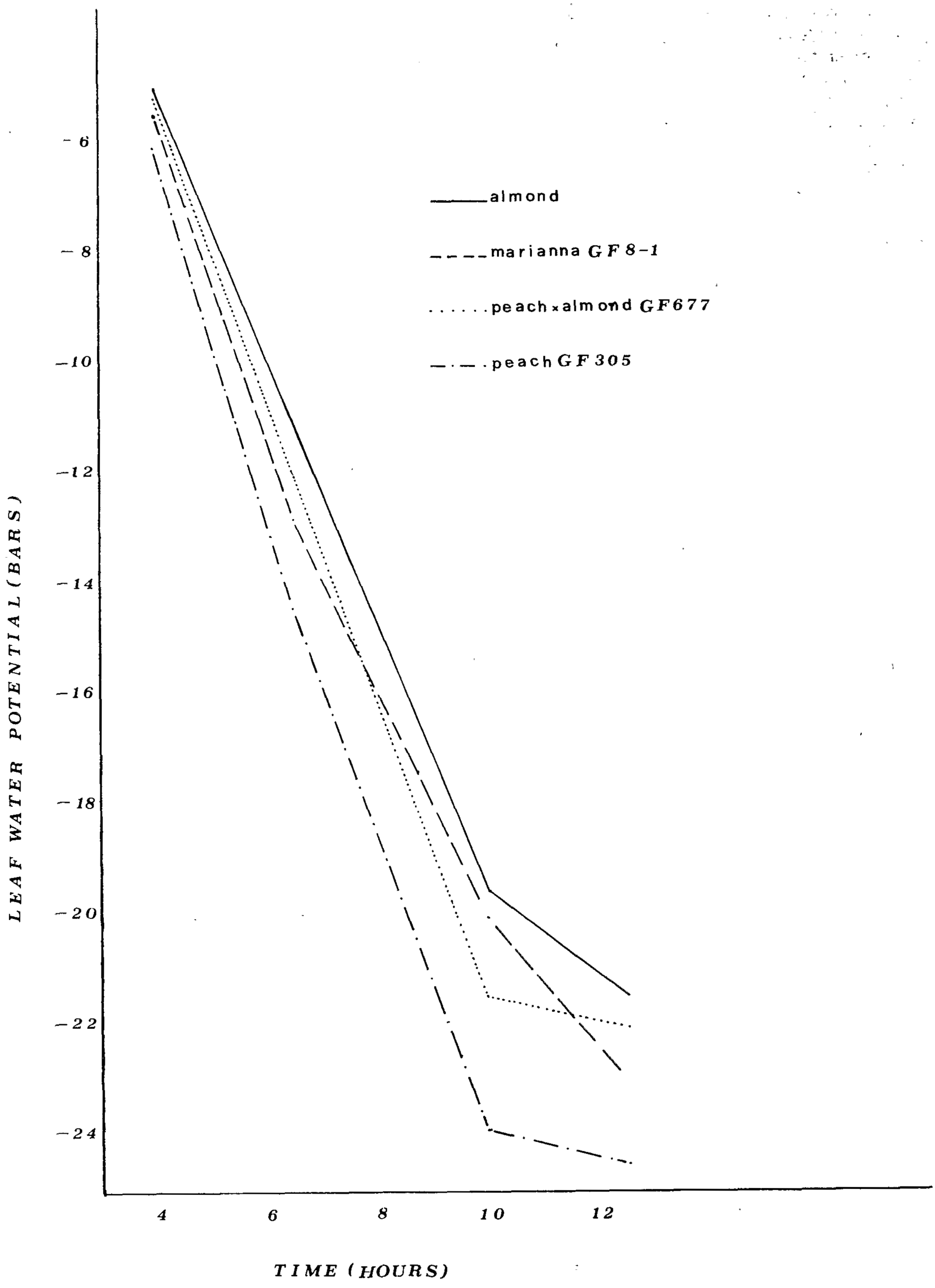


Fig. 5 and 6 show the leaf water potential trend, as we recorded it on the 14th and the 28th July 1981, from dawn to sunset.

During the first of the two days mentioned above, the soil moisture is still far from the PWP values, the trees are not yet stressed, and only in the hottest hours of the day, when the water potential decreases, we do find differences among the rootstocks. The lowest value is recorded at 12h30 a.m., in peach × almond (—22 bars).

Fig. 6 shows the potentials trend on the 28th/7, when the soil moisture values are next to the wilting point, that is to say when the trees already show a water shortage. The measurements were interrupted at 12h30 a.m. because, as we have said, a sudden damage of the pressure chamber forced us to stop.

However, from the data available, we can notice, as the day goes by and, consequently in its hottest hours (fig. 1 b), a different behaviour of the rootstocks.

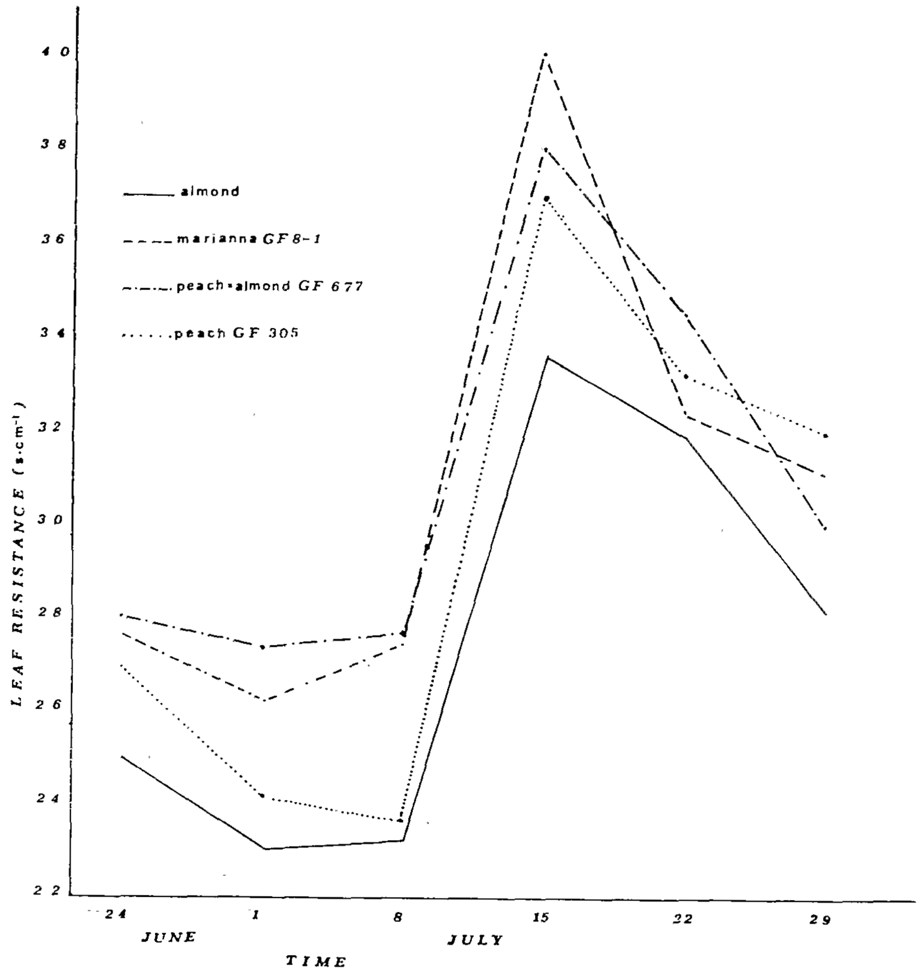
More precisely, the rootstock which, at 12h30 a.m. shows the lowest potential values (—25 bars) is peach, while almond only reaches —21.4 bars.

LEAF RESISTANCE

Fig. 7 shows how almond rootstock, during the whole period of measurement, leads to values of leaf resistance (time of measurement: 12 a.m.), that are clearly lower than the other rootstocks used. As far as the values during the period considered are concerned, in the first three measurements of the different rootstocks between 23 and 28 sxcm m., notwithstanding the high temperatures recorded in the air and the low relative humidity, the stomata are open because the water supply is still assured by the roots.

On the contrary, the last measurements show higher values, as the water content in the soil is next to the PWP. The very high values recorded on the 15th/7 and the 22nd/7 could be explained with the pres-

Figure 7. Leaf resistance taken from 24th June to 29th July 1982 at 12 a.m.



ence of high temperatures (36 °C) and with the lack of wind which, as it does not renew the air saturated with water vapour next to the leaves, led to the stomata closure.

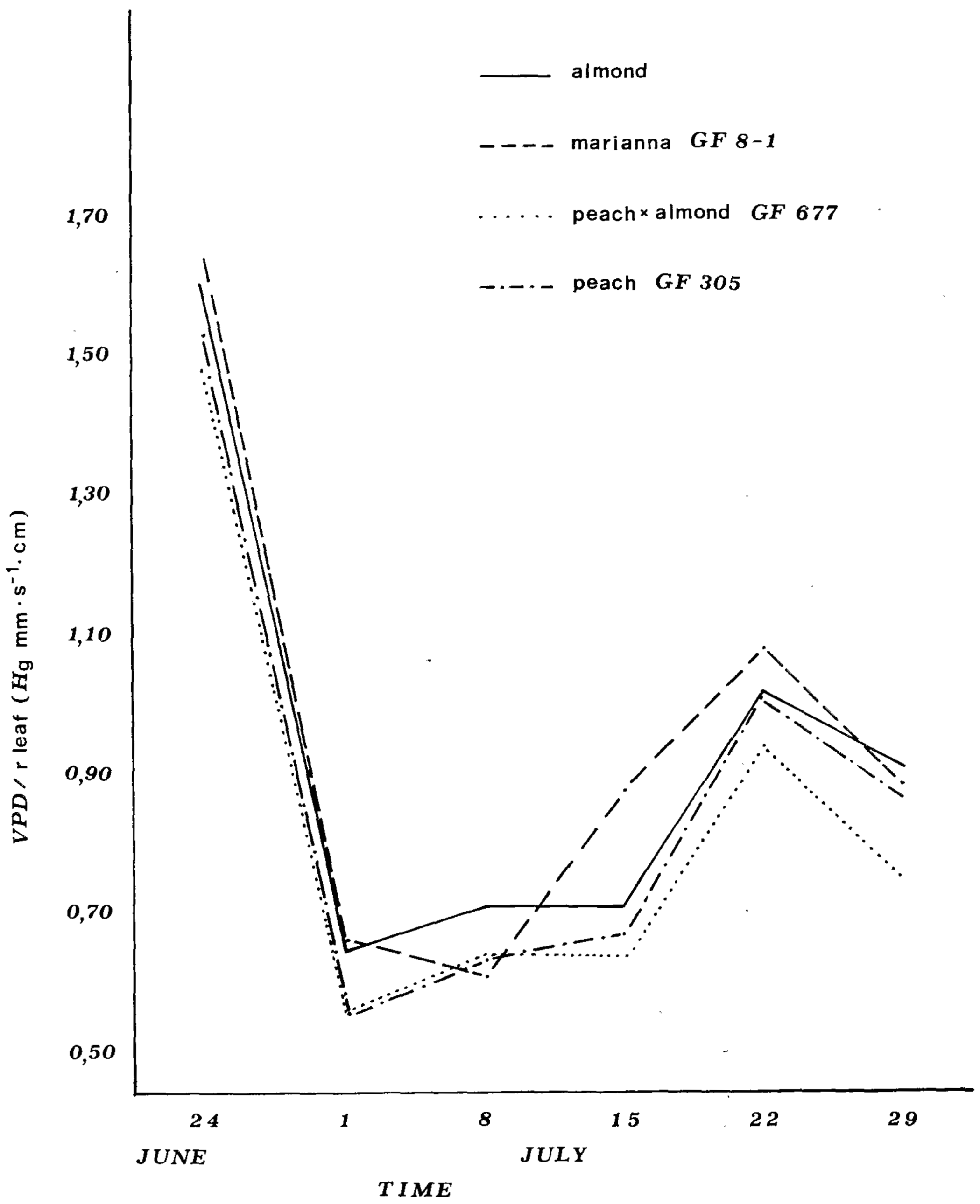
TRANSPIRATIONAL FLUX

Fig. 8 shows the trend of the transpirational flux at 8 a.m. during the period considered. At the date of the first measurement, the values are very high since the high temperature (34,9°) caused by «sirocco», corresponds to high soil moisture which does not determine a stomatal closure, and the consequent reduction of transpiration.

Later on, the data show a reduction of the flux, which increases again on the 22nd/7 because of «sirocco» (T=33.8; R.H.=27 %) even if with much lesser intensity, the soil moisture being next to the PWP, and consequently, the water supply by the roots being scarce.

Fig. 9 shows the measurements performed in the same days but at a hotter hour (12 a.m.). The trend of the transpirational flux is more or less equivalent to what we said earlier. It should however be noted that, when the soil reaches the PWP, there is a clear decrease of the transpirational levels. As far as the different rootstocks used are concerned, almond,

Figure 8. Tanspirational flux taken from 24th June to 29th July 1982 at 8 a.m.



especially during the hottest hours, maintains higher levels of the transpirational flux.

CONCLUSION

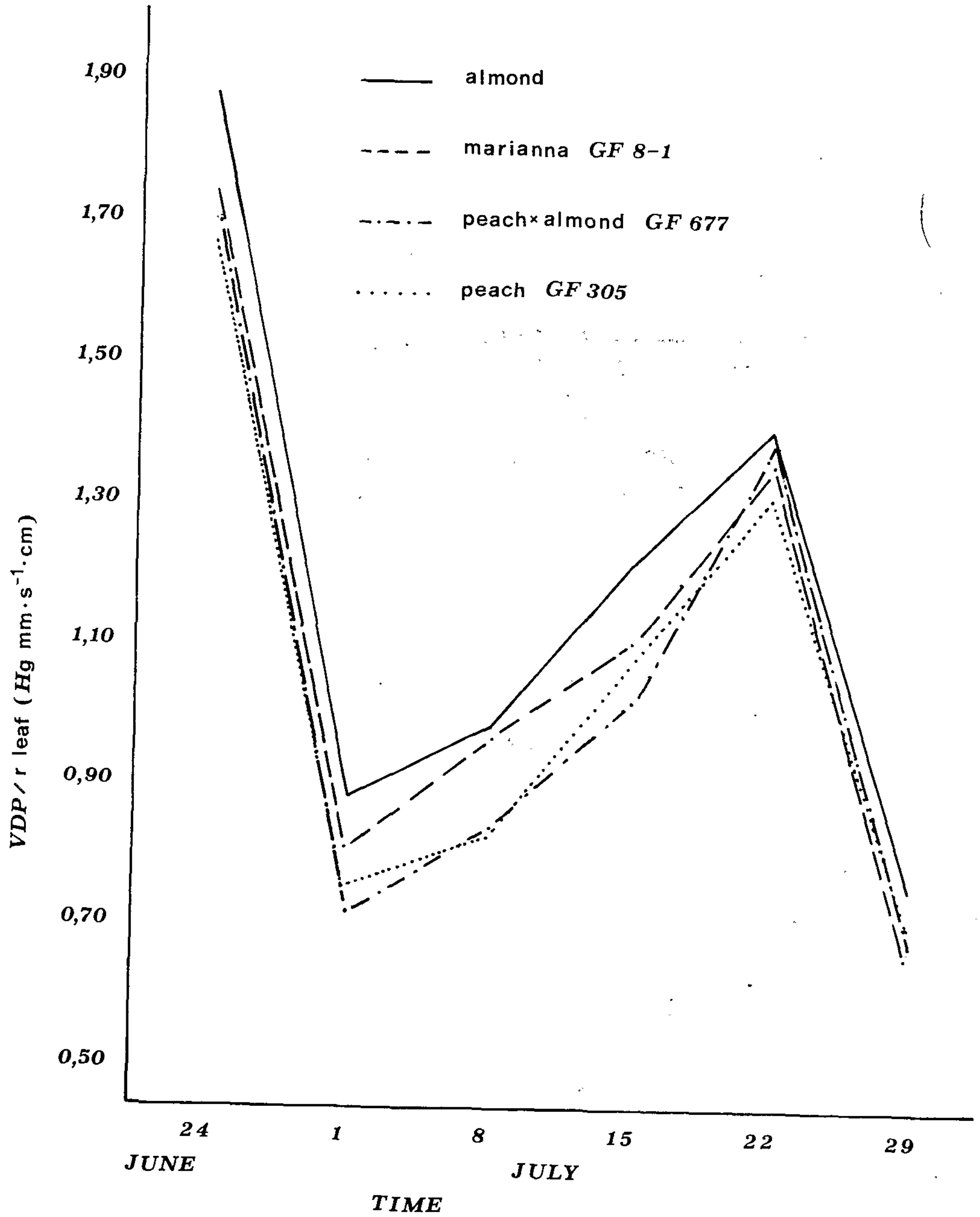
From the data obtained during the research, we can draw some considerations which substantially confirm what has been asserted by other authors[4, 15, 25] about the almond rootstock resistance to soil water-shortage.

Actually, this study showed, in relation to the other rootstocks used (marianna GF 8-1, peach × almond GF 677, peach GF 305), a lower leaf resistance to vapour diffusion (fig. 7), with a consequent maintenance at higher levels of the transpirational flux intensity (fig. 8, 9).

Another confirmation of the better adaptability of almond to low soil moisture, is also given by the maintenance (fig. 6), during the hottest hours of the day and with soil moisture values next to PWP, of lower values of the leaf water potential, which, as it is well-known, shows in an indirect way the water status of the plant.

What has been asserted by Grasselly, Crossa-Raynaud (1980) with regard to peach × almond, is partly confirmed by our data which actually show, in relation to water stress, an unequal behaviour to the

Figure 9. Tanspirational flux taken from 24th June to 29th July 1982 at 12 a.m.



one we noticed in almond, but however better than peach and plum rootstocks.

A further justification of the better response of almond rootstock to drought-conditions, we would like to remind, is a greater development of its roots. However, we did not carry out any survey on this aspect.

Finally, it should really be noted that data obtained, apart from the rootstock used, confirm what has been asserted by Castel and Fereres (1982), when they say, with regard to the almond stomatal resistance, that a gradual stomatal closure maintains appreciable levels of photosynthesis, even during prolonged periods of water stress. So, as a conclusion, we can confirm, on the basis of the physiological aspects considered in this study, that in relation to the water status of the trees, almond, especially when grafted on itself, is a tree crop with strong characters of drought-resistance.

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