

# Soil nutrient application: feeder root growth field trial

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## Introduction

Grape growers would like to have more detailed information on the optimal timing and rate of fertiliser applications in vineyards.

We have established a trial in the Murray Valley to address this need through field observations of root growth under different conditions and with different varieties of wine grapes.

## Periodicity of root growth

Grapevine roots do more than just anchor the vines. Roots absorb water and minerals, store carbohydrates and nitrogen, and produce hormones to control plant development (Comas et al. 2010).

The study of root growth is difficult, as roots are not easily measured or observed without damaging the environment in which they grow. Most studies have used root chambers to examine the pattern of root growth over the growing season. The perennial root system develops over a period of 5 to 7 years after planting, and the morphology and density of the roots that develop depend on the soil structure, depth and moisture and also on the rootstock if the variety is grafted.

New roots are produced on a yearly or seasonal basis from perennial structural roots: they are white when they are growing and become brown over the season. The new root system formed yearly, namely the fine roots, is very important for vine function. The number of fine roots affects vine water status (water adsorption) and vine mineral balance (mineral adsorption). The growth pattern of the fine roots has been determined by numerous studies (e.g. Freeman and Smart 1976; Van Zyl 1984, 1988) and is shown in Figure 17. Studies of root production on Chardonnay and Shiraz at Wagga Wagga

have indicated that the major flush of root growth occurs at about the time of flowering (Holzapfel et al. 2009).

Root growth appears to be regulated by soil temperature, moisture and mineral composition ('exogenous' factors) and carbohydrate and nitrogen reserves ('endogenous' factors).

Under different climatic conditions and with different soil structures, moisture (or irrigation management) levels, temperatures and mineral compositions, the periodicity of root growth could vary. The structure of the canopy could play a role as well.

Root growth is greatest when the nutrient demand of vines is at its highest (Holzapfel et al. 2012). This suggests that the most effective time to apply nutrients to improve grape production is when the roots are growing. Actively growing roots are white, and when they are this colour they are most active in nutrient uptake.

## Why study root growth?

Studying root growth in the Murray Valley region will help us to understand how the conditions at individual sites interact with the cultivar and the rootstock to influence the fine root growth profile. This can help us to make recommendations on soil management (including cover crop choice and the need for mulching), irrigation and fertilisation (e.g. whether to choose a soil or foliar fertiliser).

## Measuring root growth in root chambers

A number of options are available to measure root growth; they include using minirhizotrons, digging soil pits, sampling roots, planting into clear pots, digging up whole plants and using root chambers.

A root chamber is a non-destructive means of monitoring root growth (Anderson et al. 2003). The advantage of root chambers is that they require no specialised equipment. However, the limitations are that their large size makes them difficult to install, and at shallow depths the number of roots tends to be underestimated (Glinski et al. 1993). Because in this study we are interested in observing the timing of root growth, not the root density, we did not regard this latter characteristic as an issue.

## Root chambers and locations

A root chamber is a box with perspex and plastic sides; it has no bottom and a solid wooden or metal lid. The chambers are installed within the vine row midway between two vines.

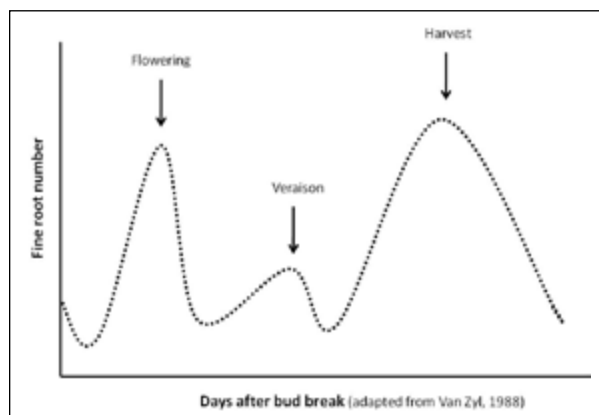


Figure 17. Possible rhythm of fine root growth on Colombard vines (Van Zyl 1988).



Root chamber installed in vine row. Photo: April Winckel

We selected six sites to cover the two main types of irrigation and three grape varieties. The sites are:

- Chardonnay grafted on Ramsey under drip irrigation and with no cover crop
- Chardonnay grafted on Ruggeri 140 under low-level sprinklers and with an active cover crop and mulch
- Shiraz (non-grafted) under drip irrigation and with a cover crop
- Shiraz (non-grafted) under low-level sprinklers and with a cover crop
- Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation and in a light soil
- Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation and in a heavy soil.

## First-season results

Roots were photographed from the start of the growing season in August, through to October, and then again after harvest until May, when root darkening indicated that growth had ceased.

In addition, soil temperatures were recorded with loggers placed in the base of each root chamber to evaluate whether there was a correlation between local soil temperature conditions and the timing of root growth.

### Temperature

Average air temperatures fluctuated greatly over the season, whereas the soil temperature was more stable. Figure 18 compares the soil temperature averaged over all root chambers with the air temperature.

One study of Thompson seedless grapes has shown that roots grow at soil temperatures of 15°C to 30°C (Callejas et al. 2009). We, too, observed that root growth stopped once the soil temperature dropped below 15°C.

Soil temperature varied only slightly among root chambers. This variation may have been due to differences in the position of the data logger, the location of the chamber, the vineyard soil type or vineyard management techniques. In the case of Cabernet Sauvignon drip-irrigated in a heavy soil, the soil temperature was consistently cooler during the season

(Figure 19). The soil was generally warmest in the case of Shiraz irrigated by drip and Cabernet Sauvignon drip-irrigated in sandy (i.e. light) soil.

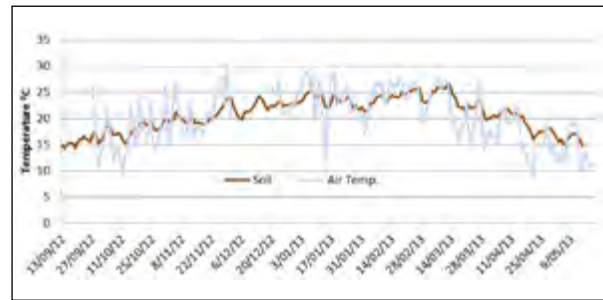


Figure 18. Soil and air temperature evolution across the growing season in 2012–2013.

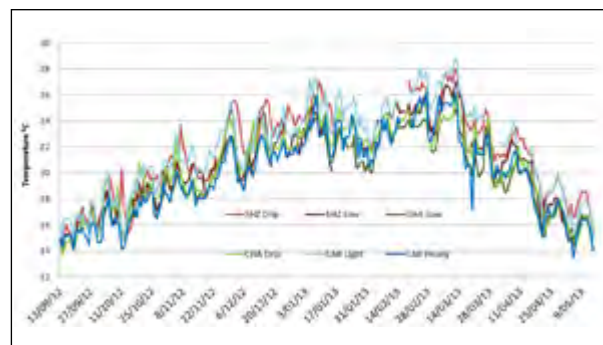
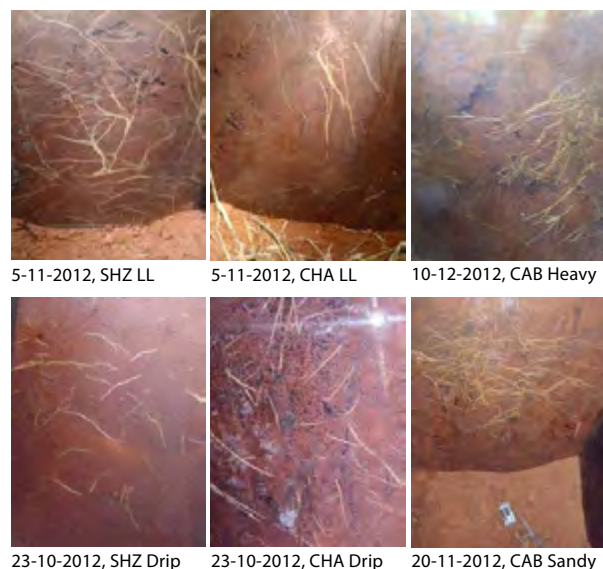


Figure 19. Changes in soil temperature according to soil type and irrigation method. Note that the temperature scale on the graph has been intentionally adjusted to visually enhance any differences.



Root chamber root growth according to soil type, irrigation and variety during flowering (E-L stage 19) to fruit set (E-L stage 27). SHZ LL, Shiraz (non-grafted) under low-level sprinklers and with a cover crop; CHA LL, Chardonnay (grafted on Ruggeri 140) under low-level sprinklers and with an active cover crop and mulch; CAB Heavy, Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation in a heavy soil; SHZ drip, Shiraz (non-grafted) under drip irrigation and with a cover crop; CHA drip, Chardonnay (grafted on Ramsey) under drip irrigation and with no cover crop; and CAB sandy, Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation and in a light soil. Photo: April Winckel

## Root growth timing

The flush of root growth, as shown by the growth of fine white roots, depend on various parameters, and the results of scientific studies vary (Van Zyl 1988; Callejas et al. 2009). Roots continue to grow throughout the year but at a slower rate during the winter.

The root chambers were installed late in August and therefore had been in the ground only for a short time before budburst. At the trial sites, budburst started on about 3 September for Chardonnay, on 12 September for Shiraz, and not until 21 September for Cabernet Sauvignon, and there was no root growth evident. In the Riverina, a few white roots have been seen before budburst on own-rooted Shiraz, but not on Chardonnay grafted on Ramsey; Cabernet Sauvignon was not included in that study (Holzapfel et al. 2012). In future studies it would be useful to see the canes bleeding (i.e. losing water through pruning wounds; this indicates that the root system is pumping water even if there is no root growth) so as to differentiate between root growth and root functioning.

In our study, flowering occurred on 23 October for Chardonnay, 30 October for Shiraz and 5 November for Cabernet Sauvignon, by which time there was root activity in all of the root chambers (see photos). Root activity ceased close to fruit set.

Post-harvest roots began to actively grow (see photos) in Shiraz and Cabernet Sauvignon but not in Chardonnay. Shiraz roots continued to grow for longer than did those of the other two varieties. These results are the reverse of

the 2007–08 Riverina study results, in which white roots were observed on Chardonnay but not Shiraz during the post-harvest period (Holzapfel et al. 2012).

## Soil type

Soil hardness strongly affects root growth. Plants growing in hard soil that is very loose have poorly developed and often stunted roots (Basso et al. 2003). In coarse-textured soils the root density is low in the top 20 cm, possibly because of soil moisture availability issues (Smart et al. 2006).

In the first season of our project the roots in the lighter soils displayed more growth than those in the heavier soils; moreover, the soil temperatures were higher in the former.

## First-year challenges

The initial installation required us to dig a hole for placement of the root chamber, thus causing root damage. Because of differences in root density, soil type and digging accuracy, the extent of root damage varied among sites. This problem will not be an issue in future observations because the chambers will already be in place.

## Perspectives

As new research continues to be done, it appears that our current understanding of root activity is incomplete and that root activity is far from simple. Climatic region and seasonal variation (Comas et al. 2010) have substantial influences on root growth and functioning, and new fine root growth vary according to soil type, structure, moisture, pH, temperature and mineral composition.

Continued examination of root growth is needed before recommendations can be made about the best time to apply nutrients. We intend to do further work using the root chambers this season (2013–14). Observations will start before budburst, at which time we will also observe the vines for cane bleeding.

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14-5-2013, SHZ LL

9-4-2013, CHA LL

27-2-2013, CAB Heavy



16-4-2013, SHZ Drip

27-3-2013, CHA Drip

27-2-2013, CAB Sandy

*Root chamber root growth post-harvest. SHZ LL, Shiraz (non-grafted) under low-level sprinklers and with a cover crop; CHA LL, Chardonnay (grafted on Ruggeri 140) under low-level sprinklers and with an active cover crop and mulch; CAB Heavy, Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation in a heavy soil; SHZ drip, Shiraz (non-grafted) under drip irrigation and with a cover crop; CHA drip, Chardonnay (grafted on Ramsey) under drip irrigation and with no cover crop; and CAB sandy, Cabernet Sauvignon (grafted on Schwarzmann) under drip irrigation and in a light soil.*

*Photo: April Winckel*

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