Demonstrating soil fracturing for the improvement of drainage in avocados

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Introduction

The aim of this three-year demonstration was to improve the drainage surrounding avocado trees across five orchards located on the Mornington Peninsula. Poor drainage can adversely affect avocados, and trees can die within 36 hours of their root systems being immersed fully in water.

Figure 1 Avocado orchard

Waterlogging favours the fungal pathogen *Phytophthora Cinnamomi* that can be a major problem in avocados. *Phytophthora* affects the transportation of water within the tree as the pathogen blocks the water and nutrient transport system in the plant. The plant can show signs of water stress, and death can occur. Some areas across Steve's plantations on the Peninsula have been affected by drainage problems, which has resulted in sick or dying trees. There is no avocado rootstock that is resistant to *Phytophthora*, only varying degrees of tolerance.

Conventional soil ripping to improve drainage can damage surface avocado roots and is not an advisable drainage methodology. Conventional treatment of this root rot fungus is either chemical (Phosphonic acid) or a combination of Phosponic acid treatment and the establishment of a disease suppressive soil (Broadbent & Baker, 1974).

Background

Seal Rock Orchard is a four hectare property managed by Steve Marshall. There are 930 trees planted with four metre spacings. There is underground drainage in some blocks and irrigation infrastructure which can supply up to 600 litres per tree, per day.

Australian avocado production in 2016/17 was 66,000 tonnes with the gross value of production estimated at $398 million (Avocado Facts at a Glance, 2016/17). At the present time (March 2018), there is a supply shortage of avocados.

Steve has established a marketing company (Peninsula Avocados) that grades, packs and delivers the avocados to the wholesale market; the market take all the avocados he can produce.

Plantation management of avocado trees

The trees in Steve's plantations are planted into raised beds at four metre spacings. Avocados have very shallow root systems, so mulching to a depth of 10-to 15 cm out to the drip line with organic matter is essential. Steve applies composted green waste mulch at the rate of 75t/ha. This replicates its natural rainforest environment as well as supplying a slow release of plant nutrients, improving the soils physical characteristics and, particularly, moisture retention. As food for soil microorganisms, the mulch assists in building a disease suppressive soil.

Complete fertiliser application is based on regular soil and sap analyses. This accounts for nutrient removal by the crop, normal growth patterns and potential leaching losses. Avocados require substantial amounts of nitrogen, potassium and phosphorus along with calcium and magnesium. Trace elements such as boron and zinc are critical for successful pollination and fruit set. Steve uses fertigation to supply the trees with the required nutritional elements.

Although the Ferrosol soils are free-draining there are a number of wet spots where water accumulates and can cause problems at root depth in the orchards. It was this problem that prompted Steve's idea to try a hydraulic soil fracturing program. Particularly as deep ripping, or agi drains, are not often possible in an established plantation.

As part of the cultural management of the trees, judicious pruning is undertaken.

Figure 2 Avocados affected by *phytophthora*

Developing the solution

Figure 3 Steve Marshall amongst his avocado trees

Steve Marshall, an agricultural scientist and avocado grower, has a 25 year involvement with avocados and is in demand for his expertise in both the planning and development of a range of orchards. He currently manages six orchards with 4,000 trees on the Mornington Peninsula, and has recently established an avocado nursery. These orchards are well designed with underground drainage, however, due to soil variations there are still areas in the orchards that show signs of poor drainage and symptoms of *phytophthora*. Steve and his employees have worked on improving the drainage in specific areas of the established orchards where it was required. After much thought and planning, Steve decided that the key to improving drainage in established orchards was through fracturing the soil between

the trees and the existing underground drainage. This allows moisture to flow freely through the clay loam soil and improve drainage.

To help achieve this, Steve applied for a grant through the Demonstrating Sustainable Farming Practices project supported by the Western Port Catchment Landcare Network. The grant enabled the development of some monitoring regimes, and assistance with getting the demonstration off the ground.

Steve has developed an innovative machine that fits onto the front of one of his tractors. A metal probe is hydraulically inserted up to 900mm into the ground and then, on command, releases a blast of compressed air, temporarily lifting the soil and fracturing the structure for approximately one metre around the probe. The air is compressed by an air compressor driven by the tractor power take off (PTO). It compresses the air to over 100psi and the air is then stored in a large tank. The probe is actioned every two metres each side of the tree. After the charge is released the tank pressure reduces to approximately 50psi. About 60 blasts per hour can be delivered. The current machine is the 7th generation and incorporates more technology and greater safety redundancies than the earlier models.

The design of the probe also allows liquids such as fertilisers and soil bio-stimulants to be released with the blast and into the fractured area, allowing tree roots to access these compounds.

Figure 4 Soil fracturing machine in operation

Figure 5 Tractor mounted compressor to generate the compressed air

Early trials have indicated that this technique does not affect roots in the blast zone. The intention in the trial was to blast every two metres on both sides of the trees across the five orchards that Steve manages on the Peninsula.

The soils on the properties are generally Ferrosol soils derived from Tertiary volcanics. They are brown to red in colour with generally good structure. They contain good levels of organic matter and have an acid pH. These soils with the addition of fertilisers are highly productive.

Monitoring

The fracturing took place on five farms. Observational monitoring, and soil moisture and temperature monitoring, was carried out at the Seal Rock Farm orchard. Several parameters were monitored on the treatment site and compared against a control (no treatment). The following soil and visual characteristics were monitored over the demonstration period.

- Soil chemistry – initial benchmark and final soil tests
- Bulk density – initial benchmark at two depths (0-15cm & 20-40cm)
- Soil moisture sensors placed at 30cm and 60cm depth in the treatment and control areas with Carta-sense M-Sensor (A-Sensor soil)
- Soil temperature, monitored at 30cm depth with Carta-sense M-Sensor (A-Sensor soil)
- Insertion of dye to determine spread of liquids when fracturing
- Photo points to monitor changes in growth
- Visual inspection of previously unhealthy trees

Analysis of Results
Physical observations

The benchmark soil assessment indicated a red to brown topsoil with depth greater than 300m. It had good structure with excellent water absorption. Steve pointed out that although the soil generally has good structure there are areas in the plantation where prominent wet spots occur affecting tree health.

Figure 6 Soil after fracturing with the air blast

Physical observations of the soil after the hydraulic blasting indicated a fractured soil with increased water penetration. Dye that was passed through the probe on blasting indicated fracturing up to 0.5metre radius from the probe insertion point.

Steve indicated that areas that previously had poor drainage were not affected during episodes of increased water inundation after the fracturing occurred. He further commented that trees that were indicating drainage stress have recovered. These trees were still treated by chemical means but past experience indicated that these trees would not recover due to ongoing waterlogging problems, despite treatment.

At the conclusion of the demonstration four avocado properties and one vineyard have been treated with this method.

Moisture monitoring

Gypsum blocks were used to monitor soil water. The gypsum blocks were connected to a data logger that sent the measurements data via the Internet to a Server where it could be viewed on a standard web browser. The technology used was Carta-sense M-Sensor (A-Sensor soil).

The gypsum blocks and data loggers were moved mid-trial to a more suitable position. Results do not appear to indicate any significant change in moisture over the period of the monitoring.

Bulk density

Samples for bulk density were taken from soil cores taken to a depth of 800mm from within tree drip lines of the trees affected by *phytophthora*. It was thought that the bulk density may indicate a soil with less structure and therefore more prone to waterlogging than a soil taken from a similar depth of healthy trees, however the results of this testing were inconclusive.

Figure 7 Sampling 800mm soil cores for bulk density

Soil analysis

It was suggested that with the fracturing of the soil at depth, the increased oxygen may increase biological activity which might be reflected in an increase of some soil nutrients such as available nitrogen.

The data from the soil analysis of the treated area and the untreated area is inconclusive in terms of indicating any significant change due to the fracturing. Any differences seen are more likely to be as a result of fertilisation or the addition of soil amendments.

Costing

Machine construction cost:	$15,000-$20,000
930 trees treated (4ha) $1,000 per/ha:	$4,000

Summary

The use of an innovative soil fracturing technique has demonstrated its potential for negating water logging in a Peninsula avocado orchard. The success of the fracturing/aeration has been difficult to assess through traditional laboratory analytical and moisture monitoring methods, but visual observation of both the soil's drainage characteristics and tree health has confirmed the success of such a technique.

Prior to soil fracturing Steve had observed water flowing over the surface in major problem areas in the plantations during the wet season. Since fracturing, the water in these areas has dispersed quickly and the trees have begun to recover.

The design of the machine had various modifications as Steve developed a number of prototypes. Over time, the machine was adapted and refined until Steve felt that is was achieving his objectives. The difficulty throughout the process has been to try and identify a way to scientifically quantify the effects of the machine.

Once the probe has been withdrawn from the soil the 'insertion point' is clearly visible for over 6 months and it believed to act as a point of 'air' interaction directly into the deeper soil structure. As air/oxygen is critical for the growth of beneficial soil micro –organisms, this is believed to be a major benefit provided by the fracturing process

It has been reported earlier in this case study that *phytophthora cinnamomi* is a major cause of tree loss in the avocado industry. The novel technique demonstrated in this trial offers a cost effective method to manage potential *phytophthora* conducive soils. The use of this management tool in conjunction with heavy mulching and selective fertiliser inputs has improved the health of water-stressed trees that may not have survived their previous soil conditions.

Key learning's from demonstration

- Soil fracturing is a cost effective technique to negate water logged areas in an avocado orchard
- Cultural techniques including fertilisation, mulching and water supply are critical in maintaining tree health
- Heavy mulching with organic matter will assist in building a disease suppressive soil (Broadbent & Baker 1974)

Reference

Broadbent, P., Baker, K.F., 1974 Behaviour of Phytophera cinnamomi in soils suppressive and conducive to root rot, *Australian Journal of Agricultural Research* 25(1) 121 - 137

Facts at a Glance, 2016/17 for the Australian avocado industry https://horticulture.com.au/wp-content/uploads/2018/03/Acocado-Facts-At-A-Glance-2016-17.pdf
Downloaded from Internet 26/3/18

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