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# *Mulching of Avocado Orchards: Quo Vadis?*

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## ABSTRACT

Composted pine bark mulch was applied to a depth of 15 cm under the drip of 6 year old Hass on Duke 7 trees at Everdon Estate, Howick in February 1993, and responses compared with unmulched trees for three seasons. The hypothesis was that improved root growth and health would reduce "stress", leading to delayed seed coat senescence and therefore larger fruit size. In spite of the comparatively cool, mesic, non-stressful environment, fruit size was increased by an average of 7%, fruit number by 15% and total yield by 23%. Mulched trees had lower leaf temperature, delayed seed coat browning, and less pedicel ringneck (all manifestations of lowered stress), and improved growth of "feeder" roots throughout the season.

The half-life of the particular compost was estimated at 5 years, so that the high initial costs could be amortized over a long period. Mulching with suitable organic materials (ideally with a carbon: nitrogen ratio between 30 and 100) is highly recommended in most situations in avocado orchards, and even better results could be expected in more stressful environments and where water is a limiting factor. The trial has also led to detailed studies on the physiology of avocado fruit growth, which increases our understanding of control mechanisms and their potential for manipulation. The role of orchard mulching in the changing environment of the new millennium is discussed.

## INTRODUCTION

The benefits of applying organic mulches to crops are well documented, and a good summary for citrus and avocado is provided by Turney & Menge (1993). These include improvement of soil structure, amelioration of soil temperature, improved root growth and root health, and more efficient use of water and nutrients. The pros and cons of mulching avocado orchards were summarised by Wolstenholme *et al.* (1996) for South African conditions.

The possibility of making soils more suppressive to root rot fungi such as *Phytophthora cinnamomi* was first reported by Broadbent & Baker (1974) in Australia, based on reinforcement of the natural leaf mulch under trees, combined with gypsum applications. Trochoulias *et al.* (1986) showed in a very high rainfall area in northern New South Wales that such treatments were unable to prevent eventual tree decline where soils were physically marginal or poorly drained. Nevertheless, in spite of the availability of the highly effective phosphorous acid (phosphonate) as a chemical treatment in South Africa and most other countries, there are increasing restrictions on the orchard use of chemical fungicides. This fungicide, for example, has not been registered in California. Biocontrol of *Phytophthora* by addition of organic matter to orchard soil, and through using specific microbial antagonists of pathogens, is therefore receiving priority research. Casale *et al.* (1995) discussed the probable reasons for the reduction of *Phytophthora* root rots of citrus and avocado by organic supplements.

Much of the interest in organic mulches in the United States of America is due to strict laws severely inhibiting the disposal of urban and agricultural plant waste into landfills. Composting to produce mulches and substrates for microbial biocontrol agents helps to resolve this problem.

Our own interest in mulching related initially to the Hass small fruit syndrome. Israeli workers had shown the importance of maintaining the functional integrity of the seed coat for as long as possible (Blumenfeld & Gazit, 1974). Small fruits are associated with premature death of seed coats. The hypothesis developed by J.G.M. Cutting, now resident in New Zealand, was that mulching would alleviate tree stress through enhanced root growth and root health, thereby leading to improved mean Hass fruit size. Four year trials at Everdon Estate, Howick tested his hypothesis (Moore-Gordon et al. 1997), and showed that mulching improved not only fruit size, but also (and more spectacularly) yield. With the physiological input of A.K. Cowan, this work is now leading to exciting new insights into avocado fruit growth physiology (Cowan *et al.* 1997).

The object of this paper is not merely to highlight the research results obtained to date (a new trial testing filter press cake in addition to composted pine bark was established at Cooling Estate, Bruyns Hill in 1996). We also wish to pose the question: in the light of the demonstrated benefits, the growing anti-chemical hysteria, the anticipated sharp rises in costs of irrigation water, and concerns about pollution of ground water with nitrates leached from nitrogenous fertilizer applications, can the modern avocado farmer afford to ignore mulching as a standard orchard practice? We attempt to provide such answers, in a language that is grower-friendly.

## MATERIALS AND METHODS

The four year trial ran from February 1993 through summer 1996, on Everdon Estate in the KwaZulu-Natal midlands mistbelt. Hass trees on clonal Duke 7 rootstock were 6 years old at the start of the trial. Further details are provided in Moore-Gordon *et al.* (1995), Moore-Gordon & Wolstenholme (1996) and Moore-Gordon *et al.* (1997). The mulch chosen was coarse composted pine bark from Gromed Organics, with an estimated half-life of 5 years, a particle size (graded) of 16-24mm, high levels of K, Ca, and B, and a carbon: nitrogen ratio of ca. 37:1 (N content of 1.1%). It was applied to a depth of ca. 15cm under the drip of the trees. Initial costs were high, but could be amortized over a period of years due to slow decomposition, and re-use where orchards were thinned.

Data were collected for three full seasons on major phenological events, fruit growth, and fruit number and size at harvest. In two seasons, pedicel "ringneck" was related to seed coat health and fruit size. Infrared thermometry was used to monitor canopy temperature for three months, as a measure of moisture stress. Other physiological studies on fruit growth are not discussed here. The orchard received excellent management and furthermore is situated in a relatively cold, mesic environment with lower stress levels than are the norm in South Africa.

## RESULTS

Results of the trial were summarized by Moore-Gordon *et al* (1997). We summarize only the main findings here. Table 1 gives data relating to Hass fruit size and yield.

Mean fruit mass, surprisingly, was lowest in the “off” season (1994/ 1995) and higher in the two "on" seasons. Mulching increased mean fruit mass by nearly 12% in both of the first two seasons, but not in the third season when both fruit size and yield were highest. Consequently the 3-season mean increase in fruit mass was reduced to 6.6% ($P<0.01$), but this was achieved despite a highly significant 14.7% increase in fruit number and a 22.6% increase in fruit yield. Yields, furthermore, were well above industry averages, the 3 year means being 20.0t $ha^{-1}$ in unmulched and 24.4t $ha^{-1}$ in mulched trees.

Table 1: Summary of the effects of pinebark mulching on Hass avocado productivity.

| | Control | Mulch | Percentage increase |
|---|---|---|---|
| 1993/94 | | | |
| Mean fruit mass (g) | 198.0 | 221.3 | 11.8** |
| Fruit number $tree^{-1}$ | 509 | 540 | 6.1 |
| Yield (kg $tree^{-1}$) | 101 | 119 | 18.5** |
| Yield (t $ha^{-1}$) | 21.2 | 23.8 | 18.5** |
| 1994/1995 | | | |
| Mean fruit mass (g) | 178.2 | 199.2 | 11.8** |
| Fruit number $tree^{-1}$ | 262 | 333 | 27.2** |
| Yield (kg $tree^{-1}$) | 47 | 67 | 42.4** |
| Yield (t $ha^{-1}$) | 9.4 | 13.4 | 42.2** |
| 1995/1996 | | | |
| Mean fruit mass(g) | 216.1 | 220.4 | 2.0 |
| Fruit number $tree^{-1}$ | 698 | 814 | 16.6** |
| Yield (kg $tree^{-1}$) | 151 | 179 | 18.9** |
| Yield (t $ha^{-1}$) | 31.7 | 35.8 | 18.9** |
| Overall | | | |
| Mean fruit mass(g) | 203.1 | 216.5 | 6.6** |
| Fruit number $tree^{-1}$ | 509 | 540 | 14.7** |
| Yield (kg $tree^{-1}$) | 100 | 122 | 22.6** |
| Yield (t $ha^{-1}$) | 20.0 | 24.4 | 22.6** |

Figures are means of six trees.
**denotes a significant ($P<0.01$) increase in response to mulching

Fruit count size distributions at harvest showed that mulching shifted fruits into shorter counts per carton, i.e. larger fruit sizes, in all three seasons. The numbers of fruits in the "small" counts of 22-26, plus factory grade fruit, were greatly reduced in mulched trees.

Overall, mulching increased mean fruit mass by 14.3 ± 1.2g, representing a gain of one count size. Mulched trees produced 45% more "highly suitable for export" fruits, and 20% more "acceptable" fruits, while "unsuitable" fruit sizes were reduced by 29% (3 season averages). A potential economic analysis, based only on the cost of the particular mulch used, showed that initial mulch costs were offset during the second season (Moore-Gordon *et al.* 1997).

Although the initial focus of this trial was on improving Hass fruit size through mulching, the most important result was the 22.6% increase in fruit yield (from 20.0 to 24.4 t $ha^{-1}$) over three seasons. This was achieved through both increased fruit size, and especially increased fruit number. That fruit size was increased in spite of such an increase in fruit number and yield, is undoubtedly the most important horticultural finding of this research. Considerable evidence was accumulated that this was associated with improved feeder root growth in the mulched zone, throughout the year and especially in mid summer. Also noteworthy was the greater root growth during the winter months in mulched trees.

It is tempting to attribute the benefits of mulching to an amelioration of overall "stress" in the tree, though an improved and perhaps also healthier root environment. Soil conditions were certainly not poor or marginal. Hutton type soils prevail at Everdon, with subsoil clay percentage of ca. 50%, and fair organic matter content of A horizon, although insufficient to be classed as humic. Improved root growth will lead to greater water and mineral nutrient uptake, as well as certain other physiological benefits. Table 2 shows that mulching reduced the incidence of pedicel (fruit stalk) ringneck by 47%, and of premature seed coat degeneration by 39% (means of 3 seasons).

Further evidence for a reduction in stress by mulching was obtained from canopy temperature measurements over 20 months. Canopy temperatures were cooler by 0.5 to 6°C in mulched trees. Effects were greatest from February through April or May, when leaf temperatures were consistently ca. 3°C higher in unmulched trees. There were also indications of less photo inhibited leaves in mulched trees.

Table 2: Effect of mulching on the incidence of pedicel ringneck and seed coat abortion

| | | 1993/94 | 1994/95 | 1995/96 | Overall |
|---|---|---|---|---|---|
| Pedicel ringneck | Control | 17.5±2.2 | 13.3±2.7 | 9.4±1.6 | 13.4±2.4 |
| | Mulch | 7.5±2.4 | 7.2±2.4 | 6.7±1.9 | 7.1±1.8 |
| | % decrease | 57.1** | 45.9** | $28.7^{NS}$ | 47.0** |
| Degenerate seed coat | Control | ND | 31.4±4.2 | 19.4±3.2 | 25.4±3.7 |
| | Mulch | ND | 13.9±2.4 | 17.3±3.0 | 15.6±2.8 |
| | % decrease | ND | 55.7** | $10.8^{NS}$ | 38.6* |

NS denotes not significantly different:
(ND=not determined)
* denotes a significant decrease (P≤0,05)
** denotes a significant decrease (P≤0,01).

## DISCUSSION AND CONCLUSIONS

Yield and fruit size in avocado are controlled by many interacting factors. These include genetic make-up, climatic extremes, poor flowering and/or poor pollination, self- vs cross-pollination, and vegetative reproductive competition at critical stages. Furthermore, many as yet poorly understood physiological events impact on the critical early and main periods of cell division when fruit size potential is determined. The time at which seed coat deterioration sets in will also affect ultimate fruit size.

These studies have clearly demonstrated the horticultural benefits of the correct use of suitable mulch, reinforcing the natural dead litter mulch which is always present under healthy avocado trees. The average increases over three seasons of 7% in Hass fruit size, 15% in fruit number and 23% in yield of mulched trees are dramatic for such a simple change in orchard floor management. That they were obtained in a relatively low-stress environment in well-managed, irrigated trees is even more remarkable. Horticulturally, we obtained evidence of improved root growth, and amelioration of stress as manifested in cooler canopies, less photo inhibited (photosynthetically more efficient) leaves in summer and autumn, and reduction in what we believe to be stress-induced pedicel ringneck and premature seed coat degeneration. Physiological studies reported by Cowan *et al.* (1997) shed considerably more light on avocado fruit development, and may lead to innovative new methods of orchard tree manipulation.

The composted pine bark (Gromed coarse potting mix) used in this trial was a relatively expensive but slowly degradable product with excellent physical properties. The choice of mulching material for avocado orchards will be affected by many factors. Availability is a key factor hardwood and softwood barks (not wood or sawdust) are often available in forestry areas and can be easily aged or composted on site. In KwaZulu-Natal, filter-press cake from sugarcane mills has useful properties, and is being evaluated for avocado orchards in a project at Cooling Farm, Bruyns Hill. For average orchard conditions, a carbon:nitrogen ratio between 25:1 and 100:1 is preferable, to avoid serious nitrogen "draw-down" associated with, for example, sawdusts (±400-500:1). For more rapidly decomposed mulches, time of application (autumn/winter) is important, so that the potential soil wetness problems are not aggravated with the onset of heavy summer rains. Very low carbon:nitrogen ratios imply a high nitrogen content (eg. poultry litter), which may be undesirable, and changes the emphasis from a *mulch* (soil cover) to an organic fertilizer. In any event, any mulch will affect leaf composition, and this must be monitored by regular leaf and soil analysis, and fertilization adjusted accordingly. Pine bark mulches, for example, contribute significant K and B, but in a slow release form. There are both pros and cons to mulching, and mulches must be used correctly. Each orchard situation must be evaluated. Mulching may be counter-productive in low-lying areas where the wetness hazard is greater. Handreck & Black's (1994) book is a mine of information on growing media and mulches.

In conclusion, the evolutionary history of the avocado tree suggests that it will, in most orchard situations, be responsive to mulching as a standard management practice. Roots are encouraged to proliferate in a better aerated, artificially enhanced "litter-layer". Our evidence of substantial increases in fruit size, and especially fruit number and yield, even in a relatively non-stressful environment, cannot be ignored. Careful and enlightened choice of the type of mulch is necessary, and ultimately mulching is an economic decision. The use of *inter alia* orchard prunings as a mulch is common sense - even large branches stacked under trees will ultimately be decomposed and slowlyrecycle their accumulated nutrients to feeder roots. Awareness of the benefits but also the potential dangers of mulching, relative to the particular situation, and monitoring of nutrition and water relations, is fundamental to success.

Finally, we draw attention to the future environment in which fruit growers (especially exporters) will have to operate. Irrigation water prices in South Africa are set to skyrocket- mulching conserves water. Drought cycles are more common than flooding rains- mulching will help to keep trees alive in worst-case scenarios. Fertilizer costs will increase- mulching helps to close the nutrient loop and promote *recycling* of nutrients. If legislation is introduced to reduce groundwater nitrate pollution, mulching will help to keep us honest in this regard. If we have to increasingly go the "organic" route to sell our avocados overseas, mulching is tailor-made to contribute. We also predict greater emphasis on the role of organic matter in soils in the new millennium, and in a warmer world. A study on organic matter dynamics in avocado orchards is overdue. Mulching is not the be-all and end-all of avocado orchard management, but the avocado tree is one of the most responsive to this style of management technique, and it makes a lot of common sense. But remember; get the other basics correct first, eg. root rot control. The whole question of "suppressive soils" must also be further researched.

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