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Recommendations for controlling the postharvest problems of the Pinkerton cultivar

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ABSTRACT

A study was conducted to characterize the grey pulp and black cold problems presently experienced with Pinkerton as well as to investigate the epidemiology of the disorders and to suggest potential control strategies. The results clearly showed grey pulp to be associated with over-mature fruit. In certain warm ex-banana areas with good soils and high organic soil nitrogen levels, the fruit are harvested too late in the season. A considerable improvement will be noticed if producers should harvest earlier during the season in these high risk areas. The fruit drop that occurs before harvest is due to over-maturity and we experimentally manipulated the drop rate by increasing or decreasing the ambient temperature around individual trees. In cooler, lower risk areas, grey pulp may also become a late season problem, especially during seasons with warm winters. In 'off-seasons' the problem may manifest itself earlier in these areas, presumably due to fewer fruit and faster oil acquisition. The same applies to young trees bearing their first crop. Also, at various farms the incidence of grey pulp was found to be lower in fruit from heavy bearing trees than in fruit from light bearing trees, presumably also because of slower maturation. It is recommended that the current maximum allowable moisture content of 75% be increased to 79%. A minimum moisture content of 75% is suggested for these hotter areas and 72% for the cooler production regions. The situation is, however, complicated by the long flowering period of the tree. There are indications that in a late harvested batch of fruit, the fruit with the biggest chance of turning grey are from the earliest set. Flower synchronisation and fruit thinning strategies should therefore receive attention in future. It is further suggested that packinghouses in high risk areas conduct orchard specific maturity evaluations using large sample sizes while testing the fruit individually. The confounding effect of intense rain in the 3 month period before harvest should be taken into account when interpreting commercial grey pulp incidence figures. During preliminary investigations, a higher calcium content was noticed in better storing fruit only while the fruit was still relatively small (+ < 100g) with no difference noticeable in bigger fruit. However, the incidence of grey pulp in fruit from experiments where calcium was applied to the soil did not differ significantly from the untreated controls. The results attained in a range of preharvest calcium and hormonal spraying trials as well as postharvest dip trials were either fairly positive or inconclusive and are reported on elsewhere. Controlled atmosphere trials indicated that the technique retarded the development of grey pulp indirectly due to delayed ripening. When used with a problematic consignment of fruit, electronic firmness sorting was found to be successful in identifying fruit that will break during the sea export period and

cut grey upon arrival. This method can, however, not be used to identify fruit that will arrive hard and only cut grey upon ripening. The epidemiology of black cold injury in Pinkerton was less clear than that of grey pulp. The available results, nevertheless suggested that black cold injury becomes more prevalent when the holding temperature is lower than 6°C. The presently used storage temperature of 7°C should therefore be retained. Although a reasonable measure of success was attained with step down temperature regimes and heat treatments, these procedures are not recommended for the industry. A trial specifically designed to address black cold injury in all export cultivars will be conducted during the coming season.

INTRODUCTION

Pinkerton is an extremely productive cultivar bearing highly palatable and attractive fruit. However, the problems presently encountered when exporting Pinkerton are considerable.

The most important physiological ailments of Pinkerton are grey pulp and black cold injury. Of these, grey pulp is more important as it renders the fruit completely unusable and may not be detected prior to consumer purchase. In contrast, black cold injury is unsightly but does not affect the eating quality of the fruit.

In the present paper we report on a set of trials conducted to characterize the grey pulp problem and to develop control strategies. There is also reference to specific observations made on the manifestation of black cold injury in Pinkerton.

TRIALS CONDUCTED

During the last two seasons, a number of trials were conducted aimed at solving the grey pulp problem. These included:

1. A longitudinal study to establish the relationship between fruit maturity and the development of grey pulp. This included three aspects, namely.

    1.1 Artificial manipulation of the temperature around individual trees to establish what effect this has on the rate at which fruit drop.

    This experiment was conducted to establish whether the current practice of producers to allow the annual mature fruit drop to take place before starting to harvest has any scientific base.

    1.2 Spraying of the fruit on trees with a range of plant hormones to establish to what extent the various classes of hormones alleviate or aggravate the incidence and intensity of grey pulp.

    During the first year of the study we developed the hypothesis that grey pulp is hormonally induced and that the hormones responsible for abscission are also responsible for grey pulp in the fruit that remain hanging on the tree. This hypothesis was investigated in this part of the study.

    1.3 Weekly harvesting and cold storage of fruit from a specific orchard of a

specific producer located in a high risk area.

This trial was done to establish at what stage of the season grey pulp develops and to determine which factors are responsible for fluctuations in the prevalence of the disorder. The trial commenced during the middle of April 1999 and was terminated by the end of July 1999.

2. A study was conducted to establish to what extent the chemical profile of Pinkerton avocados influence the storage potential of the fruit. This aspect was also addressed by conducting a number of trials:

    2.1 The chemical content of fruit from a range of producers producing fruit with various degrees of susceptibility to grey pulp was determined. The trial started during November 1998 and continued until April 1999.

    2.2 A range of calcium sprays were applied to trees at a Burgershall trial site during either the early, middle or late season and the fruit stored under simulated export conditions to determine the incidence of grey pulp.

    2.3 Fruit were dipped in calcium solutions after harvest in order to ascertain whether these dips can contribute towards the reduction of grey pulp. This trial was conducted with fruit from a high risk area and was later repeated with fruit from a low risk area.

    2.4 The effect of tree load on the calcium accumulation of Pinkerton avocado was determined by measuring the calcium content of fruit from heavy and light bearing trees. This trial was conducted at 4 locations over a 5 month period during 1999.

    2.5 The effect of the calcium concentration in the skin of the fruit on the incidence of black cold injury was determined. This trial involved chemical analysis and scanning electron microscopy of intact and damaged avocado skin.

3. The importance of holding temperature on the incidence of grey pulp and black cold injury was determined. This experiment was conducted during the 1998 season and entailed the storage of Pinkerton samples drawn on 6 occasions from 4 producers. The treatments included a range of constant temperatures as well as a number of steps down temperature regimes.

4. The influence of controlled atmosphere storage on the incidence of grey pulp and black cold injury was established. Two trials were conducted during 1999. In the first, fruit from a high risk area were used while less susceptible fruit from a low risk area were used in the second trial.

5. Electronic firmness testing was conducted to establish whether this apparatus has the ability to identify problematic fruit with a high potential for turning grey during storage. The Hall's Avoscan was used for this purpose.

6. The uses of postharvest heat treatments were investigated to establish whether this technique has the potential to reduce the prevalence of black cold injury.

CORE RESULTS

Grey pulp

Epidemiology

Grey pulp demonstrated a discernable pattern with regard to production region, producer and harvest window and was usually associated with cold stored export fruit. Fruit from certain geographical areas were found to be more prone to develop grey pulp and these areas may be described as 'high risk areas'. High risk areas were usually associated with old banana lands and characterized by stable subtropical temperature conditions, a high organic soil nitrogen content and good rainfall. A good example of such a region is the lower lying orchards in the Burgershall area near Hazyview where the producers have changed from banana to avocado production.

The study clearly showed grey pulps to be associated with over-mature fruit. The longitudinal survey further indicated that producers in high risk areas harvest their fruit too late in the season (Figure 1).

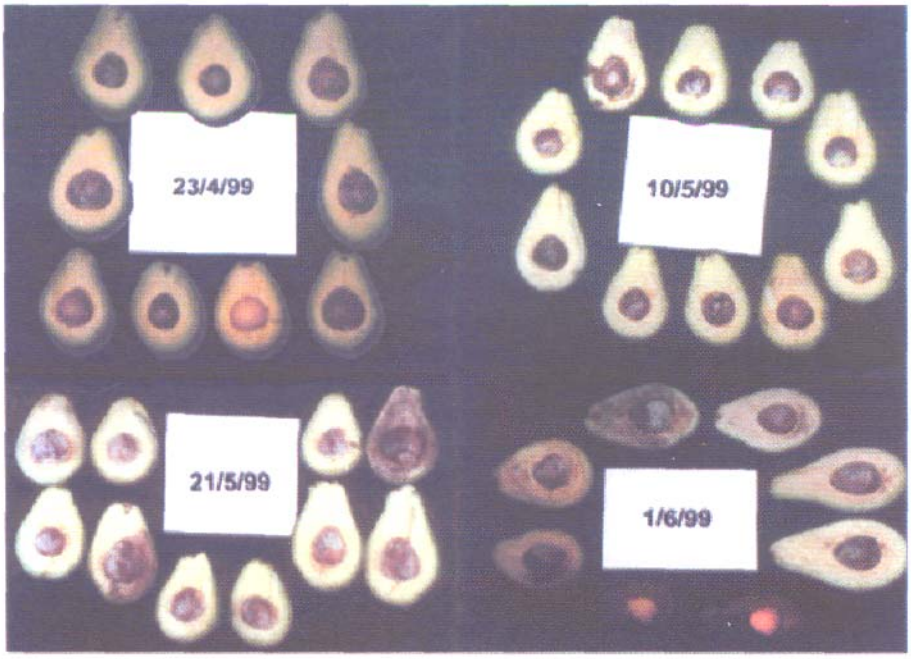

Figure 1 Increasing incidence of grey pulp in cold stored Pinkerton fruit harvested from the end of April to the beginning of June 1999 in an orchard in the Kiepersol area.

It was also demonstrated that the fruit drop that occurs before harvest was not due to stress or hormonal action but to over-maturity.

In contrast with the high risk areas, fruit from cooler production areas were found to be less susceptible to grey pulp and may be described as 'low risk areas'. Although other climatic and edaphic factors also play a role, the temperature logging stations put up in

both high and low risk areas clearly showed temperature to be the most important incidence governing factor. However, even though the incidence of grey pulp was found to be considerably lower in these areas, it became a problem from time to time; for instance, in the late season and during hot winters when oil acquisition is faster. Also, the incidence of grey pulp was found to be lower in fruit from heavy bearing trees than in fruit from light bearing trees, presumably also because of slower maturation. In addition, during 'off-seasons' and in young trees, the problem may also manifest itself earlier in the season.

Although the effect of orchard temperatures plays a deciding role with regard to the time of emergence of grey pulp in avocado, the amount and distribution of rain over a season is also important. It has been shown that high rainfall during fruit maturation results in an increased rate of oil acquisition and a subsequent increase in internal disorders (Kruger & Claassens, 1997). Critical examination of the rate at which grey pulp increased at different times during the season seemed to indicate that grey pulp in Pinkerton is also influenced by the rainfall pattern in the quarter before harvest. This aspect is certainly to be kept in mind when interpreting quality statistics retrospectively and when making predictions for the coming season.

As with climate, the extended fruit set period of Pinkerton can also confound the interpretation of grey pulp epidemiology. Although we did not attempt to divide the experimental avocados into fruit sets, certain casual observations made during the study would seem to indicate that more mature fruit from the first set were more inclined to develop grey pulp than less mature fruit from later sets.

Calcium content

When the calcium content of fruit flesh from fruit with varying storage potential was compared, a higher calcium content was only noticeable in better storing fruit while the fruit was still relatively small. As the fruit became larger and the calcium content became diluted, the difference became less obvious. The recommendations cited below are based on these observations but require the additional research referred to in the further research section.

The incidence of grey pulp in fruit from the Burgershall based experiments where calcium was applied to the soil did not differ significantly from that of the untreated control fruit. It must, however, be mentioned that the fruit were harvested at the inappropriately late harvest window described above. The same applies to a set of calcium spraying trials conducted at the same site. However, a similar trial conducted at Nelspruit, a lower risk area, showed more encouraging results and is reported on by Penter & Stassen (2000).

Postharvest calcium dip trials showed potential as a tool to reduce grey pulp in export fruit. Provisional recommendations with regard to the product to be used, the concentration at which to use the preparation and the exposure time are furnished by Penter & Stassen (2000) and are referred to in the recommendations hereunder.

Chemical analysis and electron microscopy of skin samples revealed the calcium content of the fruit skin to also be important with regard to the manifestation of black

cold injury. This aspect and the above are to receive attention during the coming season.

Controlled atmosphere storage (CA)

The CA trials indicated the technique to influence the development of grey pulp in an indirect way. When a trial batch of fruit was evaluated after export simulation, fruit stored under CA exhibited less grey pulp than fruit stored at regular atmosphere (RA). However, the reason for this is that fruit stored under RA ripens earlier than fruit stored under CA. Although grey pulp is sometimes observable in green fruit, it usually only becomes accentuated in ripe fruit. In a batch of fruit with a risk of developing grey pulp, the ailment will therefore be less obvious in the harder CA stored fruit than in the softer RA stored fruit after a number of days on the shelf. Notwithstanding the above limitations, the general improvement brought about by CA storage warrants its continued use.

Electronic firmness sorting

A phenomenon somewhat similar to CA storage applies to electronic firmness sorting (Kruger & Rowell, 1998). When an over mature batch of fruit, predestined to develop grey pulp, is sorted, the electronic sorter will identify a percentage of fruit that are significantly softer than the rest. These fruit have started to soften on the tree and would have dropped if they had not been picked. They further ripen under storage and cut grey upon arrival. However, a large proportion of the fruit which were hard and without grey pulp upon arrival, also develop grey pulp during subsequent ripening.

Black cold injury

Epidemiology

The epidemiology of black cold injury in Pinkerton was less clear than that of grey pulp. It has previously been shown that the incidence of black cold injury is highest at the beginning of the season and decreases as the season progresses (Swarts, 1982; Kritzinger & Kruger, 1997). During the last season, we noticed a pattern of black cold development that was quite dissimilar to the above while conducting the weekly storage trials from April to July. However, close scrutiny of electronically recorded cold room temperature revealed some interesting trends. Fruit stored at 6°C rarely develop black cold injury while transient exposure to lower temperatures caused black cold injury to occur. This was applicable from April until the second week of June, after which the sensitivity of the fruit to temperatures lower than 6°C decreased.

Step down temperature regimes

During the previous season, we conducted a set of step down temperature experiments to establish whether a step wise reduction in temperature can inhibit the development of black cold injury. The results from these laboratory based trials indicated the procedure

to have potential. During the 1999 season, step down temperature trials were performed at certain packhouses but the results were not spectacular and proved to be logistically difficult to perform.

Heat shock treatments

Heat shock treatments have been mooted by overseas avocado postharvest researchers as an effective method to inhibit the development of black cold injury (Woolf *et al.,* 1996). However, we have found the technique to be much less effective under South African conditions (Kritzinger & Kruger, 1997; Kritzinger *et al.,* 1998), an observation confirmed by other South African researchers (Kremer Köhne, 1999). Although we found 'Pinkerton' to be one of the cultivars that react positively to the treatment, the application is too delicate and the results too inconsistent to justify packhouse application.

RECOMMENDATIONS

The following recommendations emanate from the results attained thus far:

1. In warm, high risk areas with good soils and high rainfall, producers should start harvesting earlier. In practice this means that in an ex banana producing area such as Burgershall harvesting should commence during April and producers should not allow the fruit to hang until June, as is presently the case.
2. In cooler, lower risk areas, producers should be aware of the tree load, prevailing climatic conditions and the maturity of their fruit in order to prevent grey pulp occurrence towards the end of the season.
3. It is recommended that the current maximum allowable moisture content of 75% be increased to 79%. A minimum moisture content of 75% is suggested for the hotter areas and 72% for the cooler production regions.
4. It is suggested that packinghouses in high risk areas conduct orchard specific maturity evaluations using large sample sizes while testing the fruit individually.
5. If the first fruit set of the season is small and is followed by a good second set, the first set must definitely be removed.
6. The physiological disorder conducive effect of intense rain in the 3 month period before harvest should be taken into account when deciding when the harvest window should be. This aspect must also be taken into consideration when interpreting commercial grey pulp incidence figures.
7. Provisionally, a calcium content of above 1000 ppm is prescribed for fruit within the 50 - 100g mass range. See the publication of Penter and Stassen (2000) as to the most promising products and application rates for spray treatments.
8. It is recommended that the industry start installing calcium dip tanks in packinghouses. These tanks should allow the fruit to be exposed for at least 10 minutes to the calcium containing solution. The products and application rates are

listed by Penter and Stassen (2000).

9. It is recommended that the current storage temperature specification of 7°C be retained for the coming season and that the fruit be exported under controlled atmosphere.

FURTHER RESEARCH

During the coming year we will aim to further refine the above formulated Pinkerton maturity standards. We will firstly establish the effect of the envisaged advancement of the 'Pinkerton' harvest window and secondly attempt to quantify the effect of protracted flowering on fruit quality. Flower synchronisation and fruit thinning strategies will also receive attention.

The > 1000 ppm calcium in 50-100 g sized fruit norm will also be upgraded by means of a broad based chemical analysis survey followed by storage simulation trials. The preharvest calcium spray and postharvest dip treatments will also be repeated. The calcium preparations will further be mixed into the externally applied wax before being applied to the fruit.

As black cold injury is not restricted to Pinkerton only, this ailment will be addressed in all export cultivars during the coming season. The research will aim to develop clear guidelines for producers and packinghouse managers as to appropriate temperature, air flow and relative humidity rates per cultivar, maturity range and cultivation region.

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