

Short Note

Effect of bunch-covering methods on maturity bronzing, yield, and fruit quality of bananas in North Queensland

J. W. Daniells^A, A. T. Lisle^B and P. J. O'Farrell^C

^A Queensland Department of Primary Industries, PO Box 20, South Johnstone, Qld 4859, Australia.

^B Queensland Department of Primary Industries, PO Box 1054, Mareeba, Qld 4880, Australia.

^C Queensland Department of Primary Industries, Walkamin Research Station, Walkamin, Qld 4872, Australia.

Summary. The timing of bunch covering during the development of bananas was examined to find the optimum for fruit quality and reduction of maturity bronzing. Bunch covers, either open or sealed, were applied at various stages of bunch development. The experiments were carried out at South Johnstone, North Queensland.

Sealed covers increased the severity of maturity bronzing whenever they were applied. Sealed covers applied for the period either before or after finger diameter of the third hand had reached 2.7 cm increased maturity bronzing, but not by as much as when covers remained sealed throughout bunch filling. These data indicate that sealed covers increase maturity bronzing throughout fruit growth. Maturity bronzing was slightly less when open covers were applied as the last female bract lifted on the bunch (early), compared with a week or so later when the fingers had curled up.

Bunch weight was not increased by the application of open covers, but the use of sealed covers increased bunch weight by up to 9%. This was due to increased

finger length along the entire bunch. The application of covers (both open and sealed) at earlier than conventional times increased finger length at the proximal end of the bunch, the effect being greater the earlier covers were applied.

Open covers reduced the time taken from bunch emergence to harvest by 5-11 days compared with no covering. Very early and early covering gave the largest reductions. Sealed bunch covers delayed harvest by up to 16 days compared with no covering. There was a non-significant reduction of 2-4 days in fruit greenlife, related to the delay in bunch filling caused by sealed covers.

Sealed covers led to some fruit abnormalities, including severe spotting by *Deightoniella* sp., slightly s-shaped fruit, and dull fruit appearance. Early application of open bunch covers is recommended to reduce maturity bronzing. This treatment also increases finger length, and bunch filling time is reduced by about 1.5 weeks. This effect suggests sensitivity to the environment during and soon after bunch emergence.

Introduction

Bunch covers are applied in commercial banana plantations in North Queensland to protect fruit from mechanical damage caused by leaf rub, harvesting, handling, and transport to the packing shed. In addition, they protect fruit from fungicide sprays applied to control leaf diseases. Small increases in bunch weight have been demonstrated by Campbell and Williams (1976) (4%) and Daniells *et al.* (1987) (9%) for bunch covering in the North Queensland environment. Daniells *et al.* (1987) found that increased bunch weight was due to increased finger size towards the top of the bunch. Covered fruit was ready for harvest 5 days earlier.

Maturity bronzing is a physiological disorder, the symptom of which is a superficial bronze-red blemish appearing on the fruit skin near harvest (Daniells 1985).

The disorder is currently thought to be due to an imbalance in the calcium nutrition of the fruit and to unsatisfactory plant water relations (Daniells 1990). Bunch covering was shown by Campbell and Williams (1976) not to increase the severity of maturity bronzing, but observations by some local banana growers have indicated that the time of application of bunch covers may be critical to the later development of bronzing, early application tending to cause less bronzing.

When bunch covers are applied they are left open at the base of the bunch; however, if covers are sealed either by tying or by being too large for the bunch and sticking together at the base, then the incidence of maturity bronzing is markedly increased (Daniells 1982). This is perhaps due to relative humidities being maintained at >90% inside the covers (Daniells 1983; Johns and

Scott 1989a), since Campbell and Williams (1976) have shown that severe bronzing was associated with periods of high relative humidity. It is possible that there is a critical period in bunch filling when sealed covers cause an increase in the severity of maturity bronzing.

This study investigated the effect of the time of application of covers, both sealed and open, on the incidence of maturity bronzing, on yield, and on other aspects of fruit quality.

Materials and methods

Experiment location, design and treatments

The experiment was carried out at South Johnstone, North Queensland (lat. 17°38'S.), on a deep alluvial clay loam during 1987–88. The planting selected was a ratoon crop of bananas, *Musa* (AAA group, Cavendish subgroup) cv. Williams, grown in a double-row arrangement at a density of 1923 plants/ha. The nurse-sucker technique (Daniells and O'Farrell 1988) was used to control the cropping cycle so that fruit would be harvested during March–June, when maturity bronzing is most prevalent, giving the highest probability of detecting treatment effects on this disorder. Using this technique, the ratoon crop, which had recently been harvested, had its following suckers (about 2 m high) cut down and their growing points gouged out in June 1987. This produced a mass of suckers, 1 of which was selected as a following sucker in July 1987. Bunch emergence occurred from 14 December 1987 to 5 February 1988.

The experiment was arranged so that each of the 13 bunch-covering treatments (polyethylene clear silver covers, 50 µm thick) was repeated on 18 plants. Blocks of 13 plants were

formed according to bunch emergence date, and the treatments randomly allocated to bunches within each block. The 13 treatments are described in Table 1.

A third-hand finger diameter of 2.7 cm was chosen as a potentially critical stage because it is the largest finger diameter at which we have observed fruit to be always free of maturity bronzing. Perhaps bunch-covering management after the third-hand finger diameter reached 2.7 cm could control the disorder.

All plants received a banana mix fertiliser (11.1 : 1.7 : 17.6 NPK) at the rate of 430 kg/ha.month during the experiment. Dolomitic limestone was applied at 2.4 t/ha every 6 months. Paraquat was sprayed as required to control weeds. Irrigation by under-tree microsprinklers ensured that water was freely available to plants throughout their growth. Leaf spot caused by *Mycosphaerella musicola* Leach was controlled by the application of mancozeb and miscible oil at fortnightly intervals. Propiconazole was substituted for mancozeb on 4 occasions from February to May. Banana scab moth larvae (*Lamprosema octasema*) were controlled with twice-weekly bunch sprays of chlorpyrifos. Burrowing nematodes were controlled by sprays of fenamiphos applied to the soil every 4 months. Banana weevil borer was controlled with sprays of prothiofos applied to the soil and plant butt in October and March.

Measurements

Every week bunches were harvested on which the diameter of the middle 3 fingers of the outer whorl of the third hand from the proximal end was ≥ 3.7 cm. Bunch fresh weight, average finger length on hands 2, 5 and 8, weight of extra large

Table 1. Description of treatments and effect of bunch-covering treatments on yield and fruit quality

BE, bunch emergence; BH, bunch harvest. Maturity bronzing rating: 0, no blemish; 7, highest intensity blemish. Extra large fruit, ≥ 21.6 cm in length

Treatment description	BE–BH (days)	Bunch wt (kg)	Maturity bronzing rating (0–7)	Greenlife (days)	Extra large fruit (wt %)
1. Control (no cover)	110	33.4	2.0	25.8	93.7
2. Open cover applied very early, before any bracts lifted on inflorescence (about 4 days after bunch emergence)	99	34.0	2.0	25.6	94.1
3. Open cover applied early, when bract on last female hand had lifted (about 11 days after bunch emergence)	99	33.4	1.7	25.1	94.5
4. Open cover applied at conventional time, when fingers had curled up (about 20 days after bunch emergence)	105	32.9	2.3	23.4	92.3
5. Open cover applied 2 weeks after conventional time	104	32.9	2.1	25.0	92.0
6. Sealed cover applied very early	121	34.7	4.1	23.0	96.4
7. Sealed cover applied early	124	35.8	4.4	23.8	98.3
8. Sealed cover applied at conventional time	126	36.3	4.5	23.0	97.9
9. Sealed cover not applied until finger diameter of hand 3 was 2.7 cm (about 2.5 months after bunch emergence)	108	34.1	3.3	26.3	91.0
10. Sealed cover applied very early and cover removed at 2.7-cm finger diameter	117	33.8	3.6	22.3	94.8
11. Sealed cover applied very early and cover opened at 2.7-cm finger diameter	114	33.4	3.6	21.6	93.9
12. Sealed cover applied at conventional time and removed at 2.7-cm finger diameter	122	35.8	2.9	23.3	96.5
13. Sealed cover applied at conventional time and opened at 2.7-cm finger diameter	117	36.0	3.5	23.6	95.9
l.s.d. ($P = 0.05$)	6	1.5	0.6	3.1	2.8

fruit (≥ 21.6 cm long), and maturity bronzing damage rating (0, no blemish; 7, highest intensity blemish) on the top 3 hands were recorded at harvest. One finger from each of the top 3 hands was sampled at harvest, and greenlife (Peacock and Blake 1970) determined by maintaining these fingers at 18°C and 85% relative humidity in the absence of ethylene, until they reached colour stage 4 (Anon. 1969).

Statistical analysis

All measurements were subjected to an analysis of variance. The percentage of extra large fruit, and average finger length on hands 2, 5 and 8, were adjusted for bunch emergence date, and bunch weight was adjusted for both bunch emergence date and number of fingers per bunch, using analysis of covariance (Daniells and Mulder 1986).

Results

Bunch covers that were open at the base (treatments 2–5) tended to reduce the time from bunch emergence to harvest by 5–11 days compared with no bunch covering (Table 1), and the reduction was significant if these covers were placed early and very early. Bunch covers sealed at the base delayed harvest by up to 16 days

compared with bunches not covered. The longest delay occurred for bunches covered at the conventional time. If sealed covers were either opened or removed when the finger diameter reached 2.7 cm, harvest occurred a few days earlier than if the covers had remained sealed. Bunch covers sealed very late did not affect the time to harvest compared with no bunch covering.

There was no increase in bunch weight with the application of open covers. Some sealed treatments significantly increased bunch weight compared with no bunch covering. The effect was largest (9%) when the cover was applied at the conventional time.

Open bunch covers did not effect the level of maturity bronzing damage compared with no bunch covering; however, bunches with covers applied early tended to have less bronzing than those covered at the conventional time. Sealed covers greatly increased the severity of maturity bronzing. Damage from bronzing was less severe if the cover was opened or removed during bunch filling than if it remained sealed throughout bunch filling. Very late application of sealed

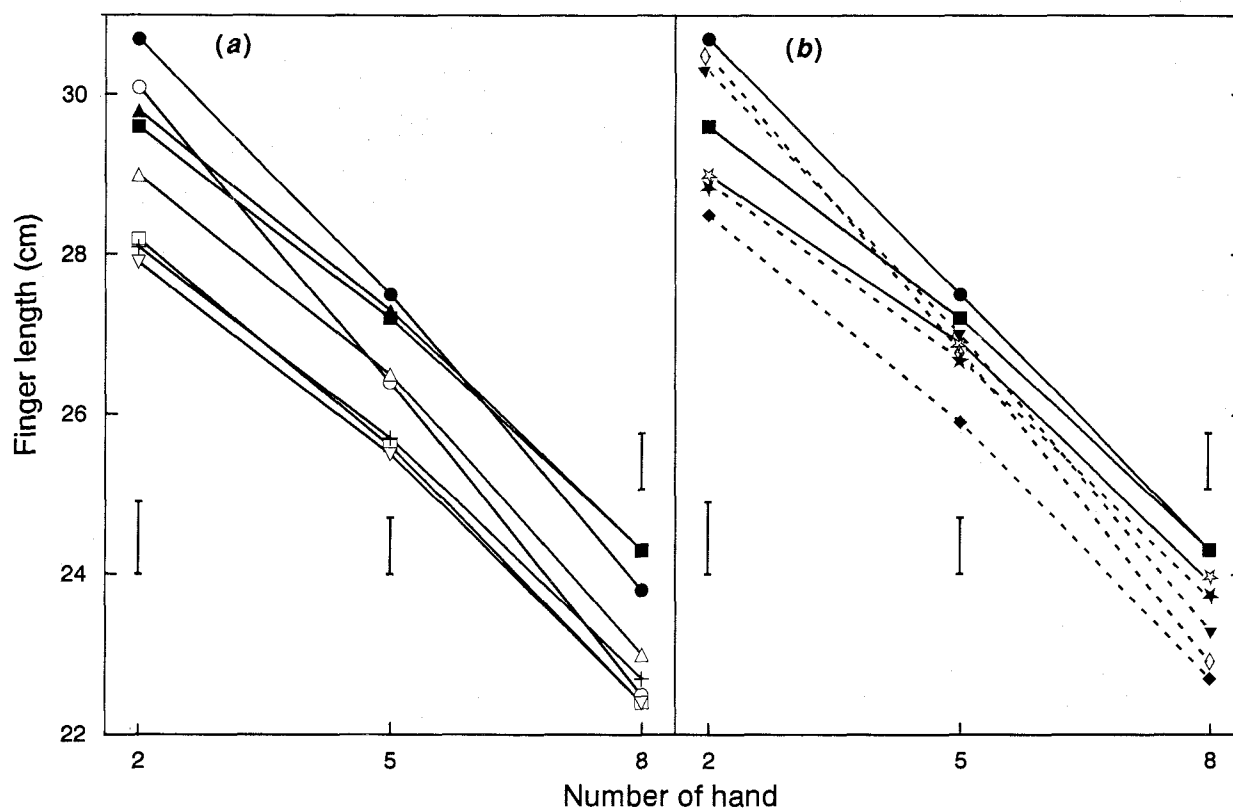


Fig. 1. The effect of different methods and times of bunch covering on finger length of hands 2, 5 and 8 on banana bunches. See Table 1 for treatment descriptions. No cover (+); open cover applied very early (○), early (△), at conventional time (□), or 2 weeks after conventional time (▽); sealed cover applied very early (●), early (▲), at conventional time (■), at 2.7-cm finger diameter (◆), very early then removed at 2.7-cm finger diameter (▼), very early then opened at 2.7-cm finger diameter (◇), at conventional time then removed at 2.7-cm finger diameter (☆), or at conventional time then opened at 2.7-cm finger diameter (★). Vertical bars indicate 1 s.d.s at $P = 0.05$.

covers also increased the level of bronzing compared with no bunch covering, but it was not as severe as on bunches with covers sealed throughout bunch filling.

There seemed to be a general decrease in fruit greenlife of 2–4 days with the application of sealed covers, but the effects of the various bunch-covering treatments on the greenlife of fruit were, generally, not significant. One bunch in each of treatments 6, 7 and 11, all of which had sealed covers, was ripe at the time of harvest. We have previously observed that this can occasionally occur where sealed covers are applied.

There was no increase in the percentage of extra large fruit with the application of open covers. Sealed covers significantly increased the percentage of extra large fruit, except when applied very late in bunch filling, or if the cover was removed or opened with very early treatment (Table 1). The effect of covering on finger length in various parts of the bunches is shown in Fig. 1. There were, on average, 9.4 hands per bunch. The earlier that open covers were applied the greater was the increase in finger length towards the proximal end of the bunch. A similar effect occurred for sealed covers but the differences were smaller. Compared with no bunch covering, sealed covers caused an increase in finger length along the full length of the bunch, unlike the open covers where the increase was towards the proximal end of the bunch.

A number of fruit abnormalities were produced by the bunch-covering treatments. Fruit from treatments with sealed covers generally had a dull appearance and were badly spotted by fungus (*Deightonella* sp.). Sealed covers also tended to produce 'reflex' (s-shaped) fingers, and often led to fruit splitting and associated, localised ripening, particularly if the sealed cover was opened or removed during bunch filling. There were no such abnormalities when application of the sealed cover was delayed until finger diameter reached 2.7 cm. When covers were applied very early, either open or sealed, about one-third of the bunches treated took on an open appearance with fingers not as strongly ageotropic and with greater nodal separation of hands at the distal end of the bunch.

Discussion

Our study has indicated a slight benefit of reduced maturity bronzing by early application of open bunch covers compared with application at the conventional time. The reduced bronzing obtained was associated with greater finger length towards the proximal end of the bunch where the maturity bronzing was rated. Williams *et al.* (1990) suggested that bronzing development was partly a function of high fruit-filling rates which caused a stretching of the peel epidermis beyond its elastic limit, leading to cracks and cell disruption and, eventually, maturity bronzing. Longer fruit should have a greater

capacity for fruit-filling and, hence, have less bronzing.

Sealed covers increased the severity of maturity bronzing if used during early or later bunch filling, the effect being similar for the 2 periods, and additive. The high humidities present inside sealed covers (Daniells 1983; Johns and Scott 1989a) may be critical to bronzing throughout bunch development, perhaps through high turgor pressures in fruit and reduced calcium transport into the fruit via the transpiration stream.

Despite the large increases in finger length caused by the application of open covers early and very early, there was no increase in bunch weight. Growth at the proximal end of the bunch, including the finger diameter of hand 3 (harvest criterion), has probably been enhanced, but growth at the distal end has not. The large increase in finger length at the proximal end of the bunch did not translate to a real increase in per cent extra large fruit for the whole bunch, because the cut off for extra large is generally close to the distal end of the bunch. Although there was no increase in bunch weight with the application of open covers in this trial (December–January bunch emergence), increases have been demonstrated at other times of the year. Daniells *et al.* (1987) obtained a small increase in bunch weight by covering bunches that emerged during April–May. In that study bunches filled over winter, and so the increased temperature under the covers (Daniells 1983; Robinson and Nel 1984; Johns and Scott 1989a) was probably more beneficial. Seasonal variation in the effect of bunch covering requires further investigation.

The increase in bunch weight achieved with the application of sealed covers was largely due to the increase in finger length throughout the bunch. This increase was not just at the proximal end of the bunch as found with open covers. Johns and Scott (1989a) have demonstrated that increases in temperature, relative humidity, and carbon dioxide levels occur under sealed covers. In the present study, bunches with sealed covers took about 2 weeks longer from emergence to harvest; this would have contributed to bunch weight but does not explain the finger length increase. The exact reason for the increased finger length remains unclear.

Finger growth rate is greatest during the 20 days following bunch emergence (Lassoudière 1978). The increases in finger length at the proximal end of bunches, caused by either open or sealed covers applied early and very early, demonstrates that the early stage of finger growth shortly after bunch emergence is critical. If the finger length increase obtained at the proximal end of the bunch could be induced at the distal end of the bunch, it would be extremely beneficial to banana growers. Perhaps if a cover were applied only towards the distal end of the bunch very early, or early, this effect could be achieved.

The increases in finger length due to early covering for cv. Williams in this study are probably of little

overall commercial benefit. If this effect also occurs for other cultivars, particularly those with shorter fingers, the increases may be more meaningful for the market.

The application of covers very early can be used to control bird damage in the Lady Finger cultivar (AAB-Pome). They are also used to control certain insect pests in Central America (F. A. Sierra pers. comm.), but extreme care must be taken in application because of the fragility of the bunch stalk at this stage. Also the flower bracts become caught up inside the cover and need to be removed to prevent fruit staining.

The delay in harvest of up to 16 days caused by sealed covers seemed to cause a small decrease in fruit greenlife. This is different to the findings of Scott *et al.* (1971) and Johns and Scott (1989*b*), where sealed covers delayed harvest but also increased greenlife. These authors, however, did not seal their covers until the latter part of bunch filling.

Conclusion

The time of application of covers and their type (open or sealed) have important effects on yield and fruit quality. Early application of open covers should be practised to minimise the severity of maturity bronzing. Despite increases in bunch weight and finger length caused by sealed covers, sealing is not recommended because of increased severity of maturity bronzing, severe fruit spotting by *Deighthoniella* sp., and general dull appearance of fruit.

Acknowledgments

Thanks are due to staff of the Queensland Department of Primary Industries, South Johnstone Research Station, for assistance in the conduct of the trial.

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Received 14 January 1991, accepted 1 August 1991