Effect of type and weight of nursery produced planting material on the development of banana cv. Williams in North Queensland

P. J. O'Farrell [A], *P. K. Shepherd* [B], *and J. W. Daniells* [C]

[A] Queensland Department of Primary Industries, Walkamin Research Station, Walkamin, Qld 4872, Australia.
[B] Queensland Department of Primary Industries, P.O. Box 1085, Townsville, Qld 4810, Australia
[C] Queensland Department of Primary Industries, P.O. Box 20, South Johnstone, Qld 4859, Australia.

Summary. Bananas cv. Williams grown from planting material produced in a nursery were studied to determine minimum planting weights for planting material from this source. There were 3 weights of both suckers (0.25–0.5, 0.5–1.0, and 1.0–1.5 kg) and bits (0.45–0.6, 0.6–1.0, and 1.0–1.5 kg).

Shoot emergence from suckers occurred on average 17 days earlier than from bits. Small and medium bits had shooting failures of 8 and 2% respectively.

Medium and large suckers produced 2 bearing plants in the plant crop, the 'first' from the apex, the 'second' (shoot emergence 8 weeks later) from a lateral bud. The 'second' reduced sucker growth and bunch size of the 'first'. High sucker number was more consistent on plants from small suckers, and medium and large bits in the plant crop, which facilitated selection of even-sized followers. Cropping was most uniform in these treatments in ratoons 1 and 2.

Yield of medium and large suckers in the plant crop was twice that of the other treatments and represented the combined yields of the 'first' and 'second' plant. However, the average annual yield of medium and large suckers over both the plant and ratoon 1 crops (57 t/ha) was the same as the other treatments, due to both a 12% reduction in yield and a longer period to harvest in ratoon 1. Yield of small suckers, and small, medium and large bits was the same in the plant crop (25 t/ha) and ratoon 1 crop (73 t/ha).

Further work is required with nursery material to elucidate its response to time of planting, and the interaction of bud state and weight of bits.

Introduction

Production of banana planting material has undergone a major change in recent years in North Queensland. The principal source of planting material was once old plantings, which were nematode infested. This material was pared and hot water treated to reduce transfer of nematodes to new plantings. However, this treatment can be harmful because buds not protected by corm or leaf tissue can be damaged by high temperatures and rough handling. As well, paring predisposes the material to fungal infection. The recommended weight to survive this treatment and develop vigorous plants is 0.68–0.91 kg (Mobbs 1965; Colbran 1967).

Approximately 30% of growers in North Queensland now establish nurseries in a similar manner to that described by Broadley (1978) to produce nematode-free planting material. Claims that this material has greater vigour, coupled with the opinion that hot water treatment is not required, have led growers to plant material less than 0.68 kg. We have observed, in local plantings established with nursery material, a large degree of variation in plant development over the range of types and weights used. Examples are shooting failure, uneven shoot emergence, and the development of double plants.

The effects of type and weight of planting material from either old plantings or nurseries on the development and yield of bananas have not been studied in North Queensland. Previous recommendations for planting material were based on the work of Berrill (1960) and Colbran (1967), whose studies did not use nurseries and were carried out under the different climatic and cultural conditions of southern Queensland.

The aim of this experiment was to study the growth and productivity of plants grown from a range of sucker and bit weights prepared from a nursery to establish recommendations for minimum weights for planting material from this source.

Materials and methods

Location and climate

The experiment was conducted from 1977 to 1980 on a plantation at Tully, North Queensland (lat.17°56'S.). The average annual rainfall of this area is 3500 mm, concentrated mainly in the months January to May.

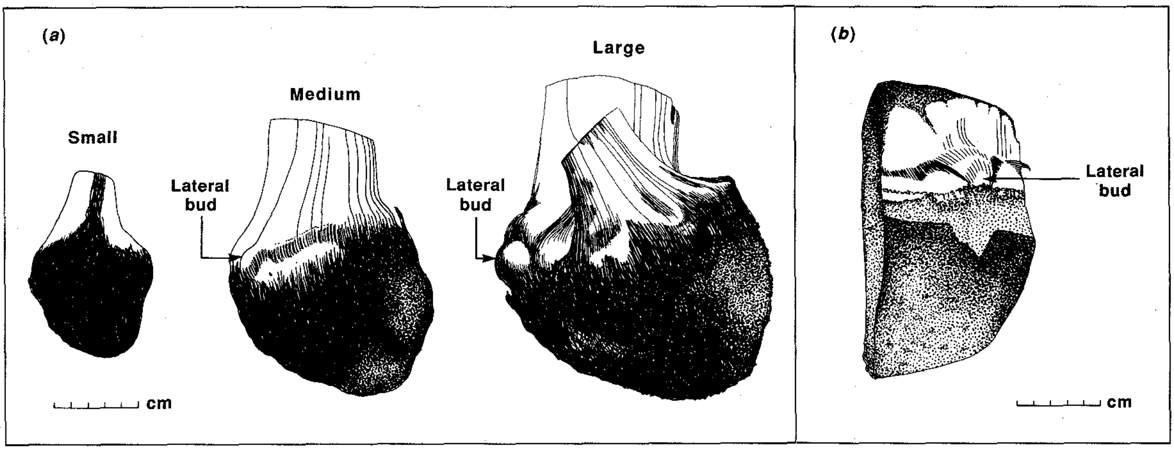

Fig. 1. (*a*) Small, medium and large sucker planting pieces. (*b*) Bit planting piece.

Mean maximum temperatures range from 24.4°C in July to 31.1°C in January, and minimum temperatures range from 15.7°C in July to 22.9°C in January (Bureau of Sugar Experiment Stations, Tully Station, 1975–81).

The soil of the experiment site was a brown structured alluvial clay known as Innisfail series (Murtha 1986).

Design and treatments

The experiment used 5 replicates of 6 treatments, and was laid out in a randomised complete block design. There were 10 plants in each plot made up of 8 sample plants and 2 guards, 1 at each end. A guard row separated each sample row.

Suckers and bits (Stover and Simmonds 1987) were taken from an 8-month-old nursery of bananas, *Musa* (AAA, Cavendish subgroup) cv. 'Williams'. Suckers (Fig. 1*a*) were prepared from sword suckers, and bits (Fig. 1*b*), from corms of plants which were close to bunching or had recently bunched. Each was graded into 3 weight ranges. The total range of suckers, 0.25–1.5 kg, and of bits, 0.45–1.5 kg were representative of the weights prepared by the farmer.

The treatments were: (i) small suckers (SS), 0.25–0.5 kg; (ii) medium suckers (MS), >0.5–1.0 kg; (iii) large suckers (LS), >1.0–1.5 kg; (iv) small bits (SB), 0.45–0.6 kg; (v) medium bits (MB), >0.6–1.0 kg; (vi) large bits (LB), >1.0–1.5 kg.

Lateral buds were well developed on the medium and large suckers (Fig. 1), and were more advanced on the latter. Bits (Fig. 2) had 1 bud, similar to the type described by Mobbs (1965) as 'pink eye'. Every effort was made to keep bud size uniform, have buds centrally positioned on the face of the bit, and keep bit shape uniform.

The material showed no signs of nematode infestation and therefore was not pared or hot water treated.

Establishment and management

The planting material was prepared on 19 August 1977 and planted the following day.

The planting system used was the single row-double follower system. Inter-row and intra-row spacings were 4.5 and 2 m respectively. This gave a planting density of 1110 plants/ha. Suckers were planted upright, and bits at 45° to the horizontal with buds facing downwards, in

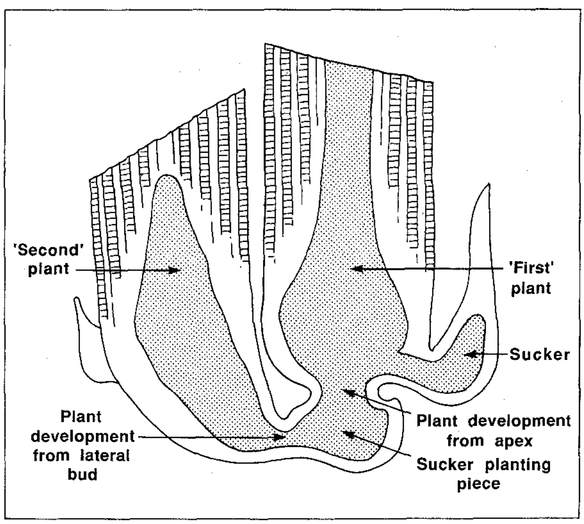

Fig. 2. Cross-sectional view of a sucker planting piece showing the relationship between 'first' and 'second' plants.

drills 30 cm deep. Rows were arranged in an east-west direction.

Bearing plants were produced from the apex of sucker planting material and the lateral bud of bit planting material. An additional bearing plant was produced by medium and large suckers. These developed from a lateral bud on the sucker planting pieces (Fig. 1). They are referred to as 'second' plants (Fig. 2) in this study. The plant arising from the apex is called the 'first' plant. The bunches of 'second' plants were harvested on average 89 days after the 'first' plant and were included with the latter in the calculation of yield (t/ha) of the plant crop. This was done because the 'second' plant, having developed from the original planting material, constituted part of the plant crop.

Followers were selected prior to bunch emergence in each crop by using the method described by Daniells (1984). In MS and LS there were often few and very uneven sized suckers on plants with a 'second' plant. Followers were therefore selected where possible, sometimes both on either the 'first' plant or the 'second' plant, or 1 on each. The density of the ratoon 1 and 2 crops was 2220 plants/ha.

Planting material which failed to shoot was replanted. No data were recorded from the replant plants that developed.

Fertiliser was applied 4 times a year at the rate per application of 61 kg N/ha, 9.5 kg P/ha, and 98 kg K/ha. This rate was doubled in ratoons 1 and 2 because of the increased number of plants/ha. Dolomitic limestone was applied annually at the rate of 2.5 t/ha. Both the fertiliser and dolomitic limestone were broadcast on the rows with a Vicon fertiliser spreader.

Weed growth was controlled during the first 4 months of the experiment by chipping and discing. Sodium arsenite was then used as required. Irrigation water was applied with a travelling irrigator. Pests and diseases were controlled according to Queensland Department of Primary Industries recommendations.

Bunches were harvested by the farmer, when, in his opinion, the fruit was of a marketable standard. The girth of the middle finger of the outer whorl of the third hand was measured in the plant crop to determine if variation in this standard occurred. It was consistent over all treatments, being on average 12.4 cm.

Measurements

Data were recorded from 3 crops that were, in order of timing, plant, ratoon 1 and ratoon 2. Shoot emergence was recorded 3 times a week and sucker emergence every 2 weeks. Shoots and suckers were considered to have emerged when they had broken through the surface of the soil.

Leaf area (L) was calculated as: $L = 0.83\ lb$, where l was the lamina length and b the leaf width (Summerville 1944).

A plant had bunched when the inflorescence could be seen in the throat of the plant. Recordings were made twice a week. Bunch weight was the total weight of green fruit plus bunch stem measured immediately after harvest. Finger girth was recorded at the same time. This measurement was taken at the widest point around the middle finger of the outer whorl of the third hand from the proximal end. To estimate the yield of green fruit (t/ha.year) the average bunch weight was multiplied by a correction factor (± s.e.) of 0.9 ± 0.01 to remove the bunch stem weight. This correction factor was determined by recording hand weight per bunch from a sample of bunches from both plant and ratoon crops. The yields of the 'second' plants in MS and LS treatments were further corrected by factors 0.78 and 0.94 respectively, as these were the proportions of 'second' plants in each of these treatments. Pseudostem height was measured from the ground to the underside of the curve in the bunch stem at the throat of the plant. Pseudostem girth was measured 15 cm above the ground.

Statistical analyses

For all variables, the significance of treatment effects was tested with an analysis of variance. The l.s.d. procedure was used to test for pairwise treatment differences when the F-test was significant.

To determine the influence of treatments on between plant variability, individual treatment variances were estimated using the variation between plants within each plot. Bartlett's test (Snedecor and Cochran 1980) was used to test homogeneity of variances. If Bartlett's test was significant, pairwise comparisons were made using the F-test.

Data from the 11 plants in MS which did not produce a 'second' plant were meaned. Data for the 3 plants in LS which did not produce a 'second' plant were considered unreliable and are not presented.

Results

Phenology (Table 1)

Plant crop. Time P–SE was shorter ($P<0.05$) in sucker treatments compared with bits and for both suckers and bits decreased with increasing weight. SB and MB, which took the longest time P–SE, had shooting failures of 8 and 2% respectively. Time SE–BE was on average 10 days shorter ($P<0.05$) in MB and LB compared with the other treatments.

Variation in time P–SE was least in sucker treatments and decreased in both suckers and bits with increasing weight.

Shoot emergence, bunch emergence, and harvest of 'second' plants occurred after the 'first' plants in MS and LS.

Table 1. Effect of type and weight of banana planting material on phenological characteristics, days from planting (P) to shoot emergence (SE), bunch emergence (BE), and harvest (H)

SS, small suckers; MS, medium suckers; LS, large suckers; SB, small bits; MB, medium bits; LB, large bits
Values are means (with standard deviations in parentheses). Means not followed by a common letter differ significantly ($P<0.05$). Standard deviations (in parentheses) not followed by a common letter differ significantly ($P<0.05$)

	Plant			Ratoon 1		Ratoon 2
	P–SE	P–BE	P–H	P–BE	P–H	P–BE
SS	45.2b (6.3bc)	225.5b (8.5a)	375.9a	521.3a (40.3bc)	626.7ab	849.6ab (64.2b)
MS	37.5a (3.8a)	218.6a (5.2a)	377.3a	587.7c (53.2cd)	721.5c	819.8c (64.5b)
LS	36.8a (4.9ab)	219.3a (6.1a)	372.5a	606.4c (55.9cd)	739.8c	927.6c (54.1ab)
SB	60.6e (10.3c)	240.1c (19.7b)	382.8b	543.0b (57.6d)	648.2b	878.8b (59.8b)
MB	56.2d (7.7bc)	227.0b (7.8a)	379.8a	520.6a (30.1ab)	629.4ab	869.3ab (49.6ab)
LB	52.1c (5.0ab)	222.3ab (7.0a)	371.7a	515.0a (26.6a)	617.5a	855.0a (39.2a)
s.e.m.	1.10	1.88	3.28	15.0	18.92	15.37
'Second' plant MS	94.5 (12.2)	332.4 (39.0)	462.5 (26.6)			
'Second' plant LS	89.2 (13.7)	332.9 (43.8)	466.3 (33.7)			
MS, no 'second' plant	39.4 (3.8)	218.0 (6.4)	380.2 (17.2)	545.1 (43.9)	666.5 (59.3)	888.4 (49.7)

Ratoon 1. Time P–H was longer ($P<0.05$) in MS and LS due to both longer ($P<0.05$) periods P–BE and BE–H.

Morphology (Table 2)

Plant crop. Lighter ($P<0.05$) bunches in MS and LS was a function of fewer ($P<0.05$) fingers.

Total leaf area per plant (mean ± s.d.) was the same ($P>0.05$) for all treatments (18.1 ± 1.3 m^2). As planting material weight increased, total leaf number per plant decreased while total leaf area of the first 4 leaves increased.

Pseudostem height was unaffected ($P>0.05$) by treatments (mean 215 ± 11.7 cm). High sucker number was most consistent in SS, and MB and LB. MS, LS, and SB had plants which produced 2 or less suckers, the percentage being 6, 24 and 16 respectively.

Higher ($P<0.05$) yields in MS and LS represented the combined yields of the 'first' and 'second' plants.

The percentage of 'second' plants in MS and LS was 78 and 94% respectively. Their point of emergence relative to the 'first' plant was not consistent. They produced broad leaves from the time they emerged.

'Second' plants were larger than 'first' plants (mean pseudostem height of 'second' plants 246 ± 14.5 cm,

Table 2. Effect of type and weight of banana planting material on morphological characteristics

SS, small suckers; MS, medium suckers; LS, large suckers; SB, small bits; MB, medium bits; LB, large bits
Values are means (with standard deviations in parentheses). Means not followed by a common letter differ significantly ($P<0.05$). Standard deviations not followed by a common letter differ significantly ($P<0.05$)

	Bunch wt (kg)	No. of fingers/ bunch	No. of leaves/ plant	Leaf area of first four leaves (m^2)	Pseudostem girth (cm)	No. of suckers/ plant	Yield (t/ha)	Bunch wt (kg)	No. of fingers/ bunch	Yield (t/ha)
				Plant					*Ratoon 1*	
SS	24.5bc	142ab	34.7e	0.93a	69.0b	6.2c (1.36a)	24.5a	37.2b	223c	74.4b
MS	23.1a	139a	34.1d	1.06ab	66.6a	5.2bc (1.55ab)	47.8b	32.3a	195a	64.6a
LS	23.4ab	137a	33.6cd	1.47cd	66.0a	3.6a (1.41ab)	54.4c	31.5a	196a	63.9a
SB	26.1d	150c	33.0b	0.96a	69.3b	4.5ab (2.32b)	26.0a	35.5b	211b	71.1b
MB	25.5cd	147bc	31.6a	1.28bc	69.4b	5.4bc (1.11a)	25.5a	36.0b	215b	71.8b
LB	25.6cd	150c	31.3a	1.73d	69.3b	5.3bc (1.06a)	25.5a	36.8b	217b	73.6b
s.e.m.	0.48	2.10	0.19	0.10	0.45	0.36	0.83	1.30	8.30	1.14
'Second' plant MS	30.8(5.23)	165(17.76)								
'Second' plant LS	32.9(4.43)	175(17.59)								
MS, no 'second' plant	25.6(3.24)	148(6.73)	32(1.20)		68.3(2.61)	6.5(1.41)		34.0(6.09)	206(37.52)	

girth 77.3 ± 3.8 cm). 'Second' plants produced heavier bunches a function of more fingers.

Ratoon 1. Lighter (P<0.05) bunches in MS and LS was a function of fewer (P<0.05) fingers.

Neither pseudostem height nor girth (mean ± s.d.) were affected (P>0.05) by treatments (318 ± 28.1 cm and 88 ± 4.2 cm, respectively). Average annual yield over both the plant and ratoon 1 crops was the same (P>0.05) for all treatments (mean 57 ± 10.0 t/ha).

Discussion

Shoot emergence

Earlier shoot emergence from sucker material was also found by Berril (1960) and Karikari and Amankewah (1977). There was no suggestion in either study for the reason for this behaviour. The physiological makeup of suckers and bits, or what difference may exist between them is largely unknown. The vegetative apical meristem becomes larger as the banana plant ages (Turner 1970), and therefore, since suckers are an advanced stage of lateral bud development, their apical meristem would be larger than the meristem of lateral buds of bits. We believe the larger meristem of suckers is a contributing factor to earlier shoot emergence, and also to less variation in shoot emergence.

Berrill (1960) recorded no apparent effect of bit size on time to shoot emergence. However, his smallest size sucker (25.4 cm in girth) took 7 days longer compared with the average time of the other 5 sizes (30.5–50.8 cm). Karikari and Amankwah (1977) found that size had minor effect. The results of this study show that size remains an important consideration in planting material preparation, particularly with bits. Pre-emergent growth of the shoot is largely dependent on corm reserves (Stover and Simmonds 1987) and, if limiting, must affect its development. The influence of decreasing weight in this study on time to, and variation in time to shoot emergence, suggests limited reserves. This was the reason proposed by Berrill (1960) for slow shoot emergence of his smallest size sucker.

'Second' plant development

'Second' plant development was not reported by Berrill (1960). He removed all suckers as they emerged to 'minimise any effect of offshoot "parasitism" on bunch development.' During normal development a mother plant exerts controls over the following sucker to prevent it receiving 'excess' photosynthate at the expense of developing fruit or the mother while still in the vegetative stage (Stover and Simmonds 1987). It appears, from the delay in shoot emergence of 'second' plants, that controls were initially imposed by the 'first' plant restricting 'second' plant development. If no controls had existed it would have been reasonable to expect 'second' plants that developed from lateral buds to have emerged at about the same time as shoots in bits treatments; but shoot emergence of 'second' plants occurred approximately 5 weeks after bits. Controls had ceased by shoot emergence of the 'second' plant, as is indicated by the production of broadleaves by the 'second' plant (Turner 1978). 'Second' plant growth was most likely supplemented by photosynthate from the 'first' plant to develop to the size it did. Reduced bunch weight, pseudostem girth, and sucker growth of 'first' plants with 'second' plants, a response not apparent with 'first' plants without 'second' plants in MS also supports this belief.

Later bunch emergence of 'second' plants extended the bunch emergence and harvest periods in MS and LS in the plant crop. This means that more passes through a planting block are required to complete maintenance operations and harvest. This increases costs and also the risk of remnant populations of bunch pests persisting until the next crop if continued control is considered too expensive.

Follower selection will be more difficult using suckers >0.5 kg because of reduced sucker development caused by 'second' plant development. Most difficulty will be experienced in double row (DR) and single row-double follower (SR-DF) planting systems, where uneven sized or misplaced followers are less tolerable than in the single row-single follower (SR-SF) system.

Solutions to unsynchronised growth of the 'first' and 'second' plant and reduced sucker development with suckers >0.5 kg are needed. Removal of the apex of suckers >0.5 kg before planting or removal of the 'second' plant are possible solutions. Removal of the apex of suckers >0.5 kg stimulates lateral bud development resulting in multiple shoots (unpublished data). Whether the development of two, if retained, would be more even than 'first' and 'second' plants is unknown. The consequences of removing the 'second' plant are also unknown, although the likely response is suggested by the performance of plants in MS that did not produce 'second' plants. Until solutions are found, the cost of managing 'second' plants scattered through a planting block could be reduced by planting suckers >0.5 kg together, thereby confining their management to a single area.

Sucker development

Of the 6 treatments, SS, MB and LB had more plants with sufficient suckers to allow the selection of 2 evenly sized followers in the plant crop. These treatments subsequently had low between plant variabilities in bunch emergence in ratoon 1 and 2, which emphasises the importance of good suckering to obtain uniform cropping. Further, the ability to maintain planting distances in the SR-DF system, the system used in this study, where 2 followers are selected per plant in the plant crop is enhanced when the number of suckers per plant at follower selection increases beyond 2. All plants in SS, MB and LB had 3 or more suckers per plant.

Leaf development

During early development, the leaf area of the plants was proportional to planting material weight. This was a function of larger leaves rather than more leaves, and has been previously recorded by Turner (1978).

Within sucker and bit treatments, plants that produced larger early leaves also produced fewer total leaves by bunch initiation. While the exact mechanism which causes transition of the apex from a vegetative to reproductive state is not known, the transition is thought to be related to a critical functional leaf area where there are surplus carbohydrates which trigger it (Summerville 1944). If this is so, the greater the size of the early leaves, the sooner will the critical leaf area be attained and transition result. This will be expressed as a shorter period from shoot emergence to bunch emergence and fewer total leaves produced as occurred in the bit treatments. The confounding effect of the early sucker in MS and LS is probably the reason why a similar response did not occur in sucker treatments, as is indicated by the shorter time SE–BE and fewer total leaves of plants in MS that did not produce a 'second' plant.

Yield

The yield of MS and LS in the plant crop was approximately twice that of the other treatments. Despite this, average annual yields of MS and LS over both plant and ratoon 1 crops were the same as the other treatments. This was the result of a 12% reduction in yield and a longer period to harvest in ratoon 1 due to poor sucker growth in the plant crop and cooler temperatures during bunch development in ratoon 1.

The profitability of the 'second' plants yield is questionable when the extra maintenance and harvest costs of the extended bunch emergence periods are considered. Further, in this experiment harvest of the 'second' plants occurred during a period (October–February), when market prices are traditionally low.

Conclusion

There was no difference between the types and weights of planting material studied in this experiment in terms of average annual yield. However, growers should be cautious about using bits <1.0 kg because of the risk of shooting failure.

Further study of planting material from nurseries is required before firm recommendations of minimum planting weights can be made. This study considered only 1 bud state of bits when, in practice, a range of states is used, and 1 time in the planting season which extends from May to October.

Acknowledgments

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