Demonstrating the benefits of early establishment of tissue culture plants to the NSW banana industry

Peter Newley
NSW Department of Industry and Investment

Project Number: BA08010

BA08010

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the banana industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Banana New South Wales.

ISBN 0 7341 2422 8

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399

NSW Department of Industry & Investment
HAL Project Final report.

Project BA 08010 (August 2010)

'Demonstrating the benefits of early establishment of tissue culture plants to the NSW banana industry'

Peter Newley
Industry and Investment NSW
Division of Primary Industries

BA 08010 (August 2010)

Demonstrating the benefits of early establishment of tissue culture plants to the NSW banana industry.

Peter Newley, District Horticulturist,
Industry and Investment NSW
PO Box 530, Coffs Harbour, NSW, 2450.
peter.newley@industry.nsw.gov.au
02 6650 3111

This report gives details of the comparative establishment of banana plants grown from either vegetative material (suckers and bits) or from tissue cultured plants grown in a NSW nursery to three different sizes.
Due to production limitations of the NSW climate, the earliest planted tissue cultured plants were the smallest at planting and each successive planting was of larger plants in larger pots. At the end of the growing season the plants which were planted first had out grown the larger, later planted groups.
When plants were measured in April, at the end of the season, it was found that the banana plants were larger if the in-field growing time can be maximised, even if this means planting tissue culture plants early in the season when the plants are still quite small. The suckers planted first emerged over a six week period but grew the largest plants by the end of the season. There is no establishment advantage from using tissue culture plants in NSW.

The trial was conducted by NSW DPI with supporting funding from Bananas NSW and Horticulture Australia Limited.

Report date: August 19th, 2010.

Table of contents.

Media summary.

Banana growers in NSW have been reluctant to adopt the use of tissue cultured plants when re-planting despite the well known advantages of pest and disease freedom and more concentrated harvest.

For best results in the subtropical climate, growers in NSW prefer to plant in the spring. Tissue culture plants are often not considered large enough for planting until late December or sometimes later. Growers often cite this, as well as the higher cost, as a reason they do not use tissue cultured plants more often.

This trial aimed to find out how smaller plants, planted early in the spring, would grow compared to larger plants planted later in the season. The success of each planting was determined by comparing the size of each lot of plants by the end of the peak growing season in the following autumn. A planting of conventional planting material was included in the trial for comparison with the tissue cultured plants.

The trial has shown that the suckers planted in early November grew the largest plants. It has also shown that within the three tissue culture plantings the smallest, November planted plants were larger by the end of summer when compared to the plants which were kept for a longer time in the nursery and planted in December and January. In other words, the banana plants with a shorter time in the nursery but a correspondingly longer time in the field grew to be larger than the plants with a longer time in the nursery but less time in the field. The smaller plants are cheaper to grow and significantly cheaper to transport.

So, while there is no indication of any production advantage from using tissue culture plants in NSW, it is still recommended that growers in NSW who are using tissue cultured plants for new varieties and/or biosecurity reasons should aim to have plants in the ground before the middle of December, or earlier if possible to give the plants the best establishment opportunity.

Technical Summary.

The timing of deflasking and potting of tissue cultured banana plants in NSW is limited by the climate. The deflasking process cannot begin until temperatures in the production nurseries are warm enough to enable vigorous root growth from the tiny plants as they become established in the pots. This usually means plants are not deflasked in the nursery before mid August and that even though the banana planting season begins in NSW around October, planting of tissue cultured plants cannot usually happen until December, and often January, if growers or the nurseries wait for the plants to grow "big enough". The industry standard size is currently plants larger than the ten leaf stage, which was a requirement of the early QBAN scheme to allow for rouging of off types. This QBAN requirement no longer applies. This trial aimed to discover if smaller plants planted in the field in November would result in better establishment and growth than larger plants planted in December and January.

This field trial at Alstonville, NSW (latitude 28° 51' south), compared three groups of tissue cultured banana plants with a conventional planting to determine which group produced the largest plants by the autumn after planting. The plantings were made at four different times in the summer of 2008/2009, each three weeks apart. The first planting was of bits and suckers planted in early November 2008. The following three plantings were of tissue cultured plants produced by Yarrahappini Nursery at Stuarts Point on the NSW Mid North Coast (latitude 30° 49' S). Each of the plantings were from a group of tissue cultured plants deflasked and potted up as early in the spring as the season allowed, which was August 22nd that year. The plants planted in late November were therefore much smaller than is usual in NSW. The plants in the December planting three weeks later were of course a little larger, but still considered small compared to the size of plants usually planted in the field in NSW and the planting in January was of plants that were about normal size for NSW with the top of the funnel leaf about 35cm above the pot.

Plant size for all treatments was measured on the 27th of April 2009 and the data analysed. Statistically important impacts of treatment on leaf length were detected via the analysis of variance ($p=.001$) as seen in the table below.

Treatment	Leaf length averages
S	147.1
TC1	119.3
TC2	118.1
TC3	93.9

Standard error of the means = 4.8
"Least significant difference" = 15.8 (thus statistically S> TC1/TC2 > TC3)

S = Bits and suckers planted in early November
TC1 = small tissue culture plants planted in late November
TC2 = medium tissue culture plants planted in mid December
TC3 = large tissue culture plants planted in early January.

These results have shown that the suckers planted in the field in early November grew to be the largest plants. It has also shown that of the three tissue culture plantings the smallest, November planted plants were larger by the end of summer when compared to the plants kept longer in the nursery and planted in December and January. In other words, the banana plants with a shorter time in the nursery but a correspondingly longer time in the field grew to be larger than the plants with a longer time in the nursery but less time in the field. The smaller plants are cheaper to grow and significantly cheaper to transport.

So, while there is no indication of any production advantage from using tissue culture plants in NSW, it is still recommended that growers in NSW who are using tissue cultured plants for new varieties and/or biosecurity reasons should aim to have plants in the ground before the middle of December, or earlier if possible to give the plants the best establishment opportunity.

Introduction.

Over recent years the Australian banana industry has moved to the use of disease free tissue culture plants for new banana plantings to exclude potentially devastating diseases such as banana bunchy top virus (BBTV) and panama disease (*fusarium oxysporum f. sp. cubense)* and pests such as banana weevil borer and nematodes, from new plantings.

Apart from the exclusion of pest and diseases, tissue culture plants generally have a quicker growth rate from planting to bunch emergence, and provide a more concentrated harvest period which allows for increased efficiencies in the plantation (Hamill. 2008).

However, only a small proportion of NSW growers are using tissue culture plants when replanting. Growers say this is due to a number of factors including the following; a perception that tissue culture plants cannot be used if irrigation is not available, the lateness of delivery times for tissue cultured plants produced in NSW which often limits growers to planting after Christmas, and the additional costs of tissue culture plants when compared to the cost of using corm bits and suckers.

A trial by Johns and Akehurst (1997) planted tissue culture bananas on ten dates over ten weeks and showed that tissue culture plants will establish successfully without irrigation if watered in well at planting even if no follow up watering occurs and that follow up watering improves the growth rate if the establishment period stays dry. Their trial conclusively demonstrated that tissue cultured banana plants will establish without irrigation.

The delivery time limitations in NSW are due to the climate. Nurseries cannot deflask plantlets until the season warms in the spring. This normally occurs around mid August but each season is different. The peak growing season for bananas in NSW is from October through to April, with growth rates slowing markedly during the winter period. Growers with new tissue cultured plantings will benefit if plant growth from the time from deflasking through until the end of April can be maximised, either in the field or nursery.

This trial investigated the effect of planting different sized tissue cultured plants at different times through the season, and compared these with conventional planting material to determine which group produced the largest plants by the following April. The plantings were made at four different times in the summer of 2008/2009, each three weeks apart. The first planting was of bits and suckers planted in early November 2008. The following three plantings were of tissue cultured plants produced by Yarrahappini Nursery at Stuarts Point on the NSW Mid North Coast. Each of the tissue culture plantings were from a cohort of plants deflasked and potted up on August 22nd, 2008 so the first group planted were relatively small and the later plantings spent more time in the nursery and were larger plants in larger pots, but spent less time in the field before the April measurement date. The size of each group of plants at the end of the growing season was compared. The production costs for each of the plant sizes was also recorded for comparison.

The trial has shown that conventional planting material will produce a significantly larger plant by the end of the growing season when compared to any of the tissue cultured plantings. The larger size, as measured by leaf length in April, was expected to lead to an earlier bunch than for the smaller plants grown from tissue culture. Collection of bunching data after the trial was complete has confirmed this assumption. The data also show that of the three plantings of tissue culture plants, the first planting of the smallest plants grew to be larger plants than the later two plantings, which suggests that banana plants take better advantage of the peak of the growing season if they are in the field than do plants which remain in the nursery for much of the growing season.

The costs of banana plants in pots increases as the pots get larger due to the added potting mix and the extra space and time required in the nursery. However the major cost difference between the different plants used in this trial will be the transport cost, with the 90mm square tubes needing about eight times the space of the 2" tubes, with about seven times the weight.

Materials and Methods.

A site for the trial was selected at NSW DPI's Centre for Tropical Horticulture, at Alstonville, NSW (latitude 28°51' S). The site was prepared by ripping the planting lines with a single tyne to a depth of around 200mm and then spraying the grass growing on the site along the same strips.

The trial had four planting treatments, all of the Williams variety. Treatment 1 was of bits and suckers. Treatment 2 was of small tissue cultured plants grown in 2" tubes (50 x 50 x 75mm). Treatment 3 was medium sized tissue cultured plants grown in olive pots (65 x 65 x 140mm) and Treatment 4 was large tissue cultured plants grown in 90mm square pots (90 x 90 x 150). These treatments were planted at three week intervals and there were three replications of each treatment set out in a randomised complete block design. Each plot had 21 plants in three rows of seven. The middle five plants were used as data plants.

Treatment 1, the initial planting of bits and suckers, was carried out on November 5th, 2008. The bits and suckers were cut from an adjacent banana patch and planted on the following day. The bits and suckers were planted into the bottom of a hole about 300mm deep. A small amount – approx 15g - of super phosphate was mixed with loose soil at the bottom of each hole before the planting material was placed at the bottom of the hole, which is industry standard. The holes were then filled with soil to ground level.

Treatment 2 was planted on the 26th of November in the pouring rain. This first batch of tissue cultured plants were collected from Yarrahappini nursery and transported in a covered vehicle to Alstonville on the 25th of November. The plants were planted into similar sized holes as the bits and suckers had been. A similar amount of fertiliser was again applied under the plants. Due to the need for long term stability the developing banana corms are planted about 20 cm below the final ground level. These first plants were only 20 cm high and were therefore planted into the bottom of the hole with the hole only being partially filled so the developing pseudostem was about

half covered with soil. The plants were watered in the pots just before planting and each rep was watered with about 4 litres of water per plant soon after planting. No more water was applied to these plants.

Treatment 3, the second group of tissue cultured plants, were transported from the nursery on the 16th of December and planted on the 17th in hot humid conditions in a similar fashion to the previous planting. The plants were approximately 30cm high. Attention was again given to having the bottom of the developing corm well under ground level and the planting holes were again only partially filled so the plants were once again planted in the bottom of the partially filled holes. No more water was applied to these plants.

The final planting of Treatment 4, the largest and oldest plants, which were approximately 35cm high was made on the 7th of January, 2009 on a warm, dry day. The planting method was similar to the previous plantings but these plants were tall enough to allow for complete filling of the holes back to ground level. The plants were watered after planting in the same manner as Treatments 1 and 2. At this time all the tissue cultured plants were large enough for all the planting sites to be filled to ground level. This planting was watered again on the 19th of January.

Further small amounts of fertiliser were applied to each planting each three weeks until the end of February and weed competition was controlled by lightly cultivating around the plants on the 7th of January and spraying with Basta® after that.

The length of the latest fully expanded leaf was measured on each of the data plants on the 27th of April 2009.

Results.

Plant size for all treatments was measured on the 27th of April 2009 and the data analysed. Statistically important impacts of treatment on length were detected via the analysis of variance (*p=.001*) as seen in the table below.

Treatment	Length averages
S	147.1
TC1	119.3
TC2	118.1
TC3	93.9

Standard error of the means = 4.8
"Least significant difference" = 15.8 (thus statistically S> TC1/TC2 > TC3)

Block effects were not important although block 3 tended shorter than blocks one and two by about 6cm. The dot plot below shows plant heights for each treatment.

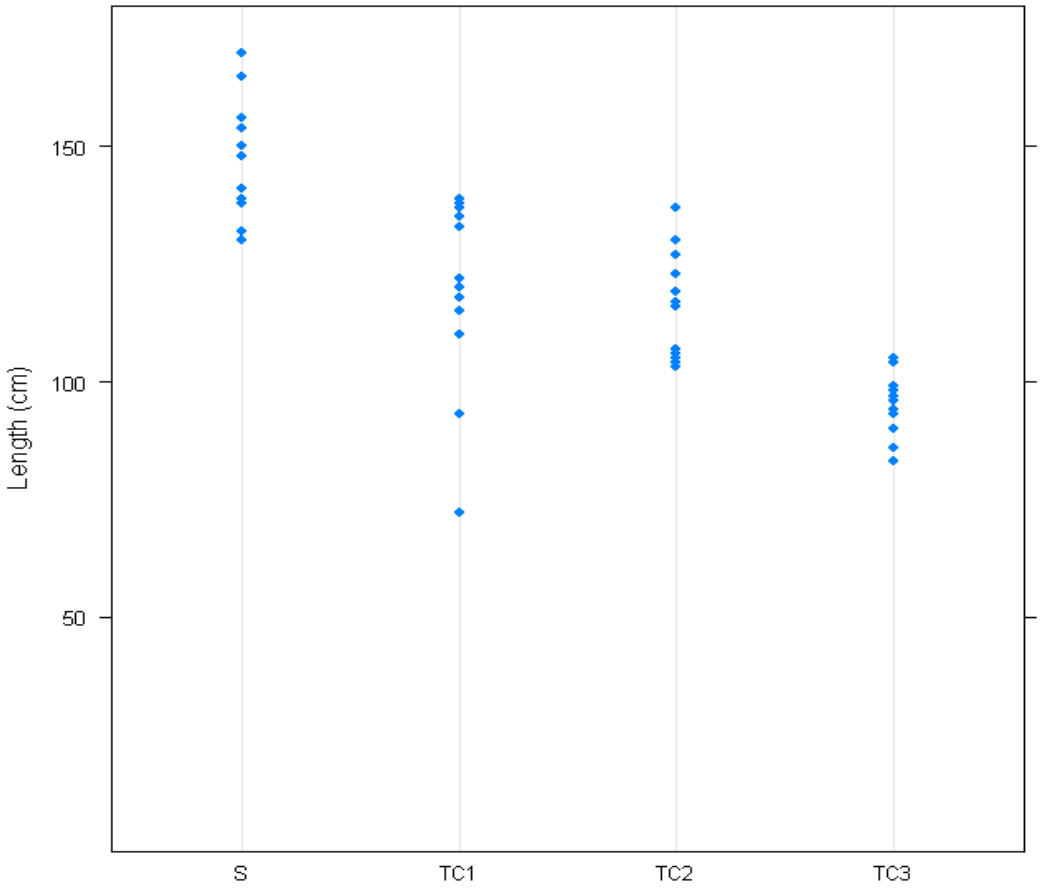

Figure 1. This dot plot of the data for all plants shows clearly that the bits and suckers (S) planted in October produced the largest plants, the first and second plantings of tissue cultured plants (TC1 and TC2) were of similar size and the third lot of tissue cultured plants (TC3) were smallest when measured in April, 2009.

Discussion.

The performance of the plants in this trial has demonstrated that when establishing a banana plantation in NSW, planting bits and suckers at the start of the planting season rather than using tissue cultured plants later in the season will result in a larger plant by the end of the summer. The data also show that when using tissue cultured plants in NSW, banana plants take better advantage of the peak growing season if the time in the field is maximised. Conversely the data show that keeping plants in the nursery so plants can be bigger at planting, which unavoidably means a shorter time in the field, has a detrimental effect on plant size at the end of the season. Somewhat suprisingly, the data collected at the end of the planting season does not seem to indicate that tissue culture plants will produce more concentrated harvests, as the variability between plants is no greater for the plots planted from suckers than those planted from tissue culture.

Each of these treatments were planted at a different time so experienced different weather in the few weeks after planting. The suckers were planted on November 5th into soil damp from rainfall in the second half of October. 30mm of rain fell on the 9th of November and falls for November totalled 236mm. The first planting of tissue culture plants were planted on the 26th of November in the rain. The plants were watered in and a further 40mm of rain fell the next day. Another 40mm fell on the 7th of December.

The second planting of tissue culture plants were planted on the 17th of December and watered in. 10mm of rain fell on the 19th of December, 17mm on the 25th , 12mm on the 29th and 21mm on the 2nd of January. The third planting of tissue culture plants were planted into moist soil and watered in on the 7th of January. There was no significant rainfall until the 26th to 28th of January when a total of 82mm fell. This group of plants (TC3) had an additional watering of 4 litres per plant on the 19th of January.

Conditions were ideal for the first three plantings but there was a 12 day period after the third group of tissue cultured plants were planted that was warm and dry. It is likely that the plants suffered a few days of moisture stress before they were watered on the 19th but rainfall came again on the 26th and was ample for the following month. It is unlikely that the differences in the seasonal experience of each group of plants explains the differences in size between the treatments.

The results clearly show that when planting bananas in NSW, suckers will produce the largest plants by the end of the summer. Growers aiming to have their banana crops well established before the onset of winter, who have access to a reliable source of disease free planting material in the numbers they require will achieve the best result by using conventional planting material. The planting of suckers for this trial was somewhat later than normal for NSW banana plantings, so under usual practice, the advantage of using suckers will increase.

The results also show that when using tissue cultured plants, there is nothing to be gained by keeping plants in the nursery so they are bigger when planted because the plants take better advantage of the growing season if the time in the field is maximised, which means planting smaller plants sooner to get the best results.

Several NSW growers experienced with tissue culture plants were interviewed. Their views can be distilled into three themes. When asked why they had used tissue culture plants it was always to establish a new variety and often to have the guarantee of disease freedom. Varieties introduced included ladyfinger, Goldfinger, dwarf ducasse, red dacca and the Rossi ladyfinger. These growers were generally happy with the final result of the planting but all would have liked the plants earlier than they got them.

Cost benefit study.

Production costs have been collected from the nursery, and the costs of producing each of the different sized plants has been compared. This has shown that the smallest plants in the 2" tube have a unit cost of $3.91, the medium sized plants in the olive pots which were planted in December had a unit cost of $5.99 and the larger plants in the 90mm square tubes have a cost of $6.60. This compares with the previously used standard 100mm round pot which cost $6.75 each, and were never available in full consignments before Christmas. There will also be significant increases in freight and handling costs as the pot size increases with freight costs for the 90mm square plants estimated to be about four times the cost of transporting smaller 2' tube plants. So, growers using smaller tissue culture plants will get a better result for a considerably lower cost. The following cost comparison is for one hectare of a new variety planted at normal Cavendish spacing, which requires 1540 plants per hectare.

Table 1. Cost comparisons of treatments.

	TC 1	**TC 2**	**TC 3**	**Suckers**
Unit cost ($)	$3.91	$5.99	$6.60	$2.00
Transport cost/Ha	Tc x D	(Tc x 2) x D	(Tc x 4) x D	0
Planting cost	P	P x 1.2	P x 1.4	P x 0.7
Watering cost	W	W	W	0
Cost per plant in the ground	$3.91 + Tc x D + P + W	$5.99 + Tc x 2 x D + P x 1.2 + W	$6.60 + Tc x 4 x D + P x 1.4 + W	
Cost per hectare planted	$6021 + (Tc x D + P + W) x 1540	$9224 + (Tc x 2 x D + P x 1.2 + W) x 1540	$10164 + (Tc x 4 x D + P x 1.4 + W) x 1540	$3080 + P x 0.7

NB:
Tc = transport cost. This will increase as the pots get bigger but would be zero if the material is dug on site.
D = distance from nursery to plantation. This cost will vary with location.
P = planting cost. This will vary with planting site, staff arrangements and plant size. Smaller plants are a little quicker to handle in the field so the planting cost will increase as the pot size increases. Distributing suckers to the planting site is quicker so the cost will be smaller.
W = cost of watering the plants. This will vary depending on the watering options available but will be constant regardless of plant size. Watering is not required when planting suckers.

Planting a hectare of plants from suckers has the lowest unit cost, lower planting costs and no transport or watering costs so will be significantly cheaper than any of the tissue culture options. Planting a hectare of tissue cultured plants will cost around double for the planting material, even when using the smallest plants and labour costs for planting will be higher. It also involves costs for transport and watering which do not accrue when using suckers. The extra costs of using tissue culture plants increases as the plants get bigger.

Apart from the obvious biosecurity benefits growers can access when planting into new land, there is no production benefit from using tissue culture plants in NSW. That is, there is no return on the extra investment in tissue culture plants. Sites to plant new plantings of bananas are limited in NSW and it is rare that a new site is planted, so for most established growers the only time there is benefit from the extra costs of using tissue culture plants is when they are introducing new varieties which are much more quickly multiplied in the laboratory.

These factors explain the preference of NSW growers to use suckers for planting material in most circumstances and why tissue culture plants are usually only used when introducing new varieties.

Technology transfer.

April 2009. Article in the new Subtropics Banana News First edition.
A brief description of the trial and an invitation to a field day at the trial site.

May 2009. Presentations to local Banana Growers Association.
Presentations were made at the local Banana Growers Association at their meetings at Macksville on May the 5th and Coffs Harbour on May 6th explaining the results of the trial and inviting growers to the field day.

May 2009. Departmental press release.
A NSW DPI press release was sent to all north coast media explaining the trial and inviting people to the field day.

May 2009. Coffs Harbour Advocate.
Article published about the trial and the field day.

May 20th, Trial site field day.
A field day was held at the NSW DPI Centre for Tropical Horticulture at Alstonville on May 20th to allow growers to inspect the trial and discuss the results. A handout was given to attendees which included the history of the trial and preliminary analysis of the data. Results were discussed with industry at length

May 20th. Radio interview, ABC northern rivers.
An interview was done with the ABC northern rivers for the rural news segment the following day. This radio article was replayed by ABC mid north coast a few weeks later.

August 2009. Article in Ag Today.
This publication is distributed across NSW by NSW DII, in cooperation with The Land newspaper. The story explained the trial and the results.

June 2010. Primefact 1019. Establishing tissue cultured bananas in NSW. Published on the Industry and Investment NSW website (see appendix 2).

Recommendations.

Growers who have used tissue culture plants in NSW generally do so to introduce new varieties. They also acknowledge the biosecurity benefits of using tissue culture and are generally happy with the results achieved but they would prefer cheaper plants earlier in the season. The results of this trial show that planting small, cheaper plants early in the season achieves the best outcome of the tissue culture plantings trialled.

To further encourage use of tissue culture plants across the NSW banana industry the nurseries producing these plants need to ensure plants are deflasked as early as possible in the spring to maximise the limited growing season. The industry will benefit if nurseries are able to deliver smaller, cheaper plants in smaller pots earlier in the season, ideally by early December, to give the plants the maximum opportunity to be well established before the following winter.

Acknowledgements.

The BIC (operating as Bananas NSW) committee assisted in the development of the project.

Carolyn Dobson from Yarrahappini nursery grew the plants for the trial.

Many personnel from Industry and Investment NSW contributed to this project including;

Arthur Akehurst, Matt Stewart, Geoff Quinn, Mick Bolt, Alister Janetzki and Mark Hickey helped prepare the paddock and plant the trial.

Steve Muldoon, Stephen Morris, Ian Purdue, Mark Hickey and Ruth Huwer contributed to the field day.

Bibliography.

Hamill, S. (2008). Growing uptake of tissue culture reflect benefits and spark change. Australian Bananas, Vol 26, pp40-41. Australian Banana Growers Council.

Johns, G. and Akehurst, A. (1997). Testing tissue culture plants under dry land conditions. BGF Bulletin, March 1997. BIC.

Appendix 1. Primefact 1019. Establishing tissue culture bananas in NSW.
See any updated version of this publication at -
http://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/bananas/tissue-culture

WWW.INDUSTRY.NSW.GOV.AU

primefacts

FOR PROFITABLE, ADAPTIVE AND SUSTAINABLE PRIMARY INDUSTRIES

JUNE 2010 PRIMEFACT 1019

Establishing tissue culture bananas in NSW

Peter Newley

District Horticulturist, Mid North Coast

Introduction

Over recent years much of the Australian banana industry has moved to the use of disease free tissue culture plants for new banana plantings to exclude potentially devastating diseases such as banana bunchy top virus (BBTV) and panama disease (*fusarium oxysporum f. sp. cubense*). The use of tissue culture plants also eliminates the risk of introducing pests such as banana weevil borer and nematodes with the planting material.

However, only a small proportion of NSW growers are using tissue culture plants when replanting. Growers say this is due to a number of factors, including a perception that tissue culture plants cannot be used if irrigation is not available, as well as the lateness of delivery times for tissue cultured plants produced in NSW, which often limits growers to planting after Christmas.

Irrigation is not critical

A trial by Johns and Akehurst in 1997 planted tissue culture bananas at Alstonville on ten dates over ten weeks and showed that tissue culture plants will establish successfully without irrigation provided they are watered in well at planting, even if no follow up watering occurs. They also found that follow up watering improves the growth rate if the establishment period stays dry. This trial conclusively demonstrated that tissue cultured banana plants will establish in NSW banana growing districts without irrigation.

Timing is important

A further trial conducted by this author in 2009 found that a better result is achieved by the end of the growing season if the plants are planted before Christmas, and preferably in early December.

This trial investigated the effect of planting time on subsets of plants grown from the same batch of tissue cultured plantlets, which were deflasked on 22 August 2009. The trial showed that of the three plantings of these tissue culture plants, the first planting of the smallest plants were, by the end of the growing season in late April, larger than the two later plantings. This outcome suggests that banana plants take better advantage of the peak of the growing season if they are in the field than do plants which remain in the nursery for more of the growing season.

Smaller plants are cheaper and easier to handle

The costs of banana plants in pots increases as the pots get larger due to the added potting mix and the extra space and time required in the nursery. However the major cost difference between the different sized plants used in this trial will be the

NSW GOVERNMENT Industry & Investment