PT115
Utilising potato microtubers for the field production of seed potatoes

B G Dowling
NSW Agriculture

Know-how for Horticulture™

PT115

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FINAL REPORT

Project Title: **Utilising potato microtubers for the field production of seed potatoes.**

HRDC Project No.: PT 115

Research Organisation and Address

NSW Agriculture
Locked Bag 21
ORANGE NSW 2800

Ph: (063) 913219
Fax: (063) 923244

Principal Investigator:

B G Dowling, BSc.(App.Biol.)
NSW Agriculture
Phone (069) 530326
Percent of time involved: 35%

Work carried out at:

Yanco Agricultural Institute, PMB, YANCO NSW 2703
Field trial site at "Cottle Wolly", CROOKWELL, NSW 2583

Commencement date: 01/07/1991
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The total funds spent in this project amounted to:

Voluntary Contribution:	Crookwell Potato Association	$7,000
	Grass Roots Pty Ltd	$9,000
	Kimberley Clark Aust. Pty Ltd	$2,000
H.R.D.C.		$18,000
NSW Agriculture		$45,700

The complete findings from this study are not currently in the public domain. The project received industry funds from Voluntary Contributors rather than an industry levy, and there is currently an obligation to retain the findings as "Commercial in Confidence". This report represents a summary of the findings which may be released into the public domain.

Industry Summary

This project had 2 main objectives:

i) to investigate the physiological ageing of potato microtubers
ii) to identify the cultural practices required to plant microtubers in the open field, for seed increase.

Highlights of the laboratory-based physiological age study, which relate to microtubers produced according to the method developed by Grass Roots P/L & Crookwell Potato Association, are as follows:

i) microtubers have a uniform, clearly defined dormancy period;
ii) a method for inducing Bintje microtubers to develop multiple sprouts immediately after dormancy break has been discovered. (This method is currently considered "commercial in confidence").

Other trials demonstrated the effects on length of dormancy period of:

- storage at a range of temperatures (5-30°C), and Rel. Humidities (50, 75 & 95%).
- storage at alternating temperatures, and in darkness versus 8hrs/day light.
- cut versus whole microtubers

A number of field trials were conducted in Year 2 & 3 of the project, on a Foundation seed grower's property in the Crookwell district. Highlights from these trials are:

i) microtubers when planted out in the open field, are slow in their early vegetative growth, but go on to produce a vigorous, high yielding plant stand.
ii) yield data extrapolated from a physiological age trial indicate that microtubers planted at spacings of 20cm within row & 75cm between rows, and grown for 102 days between planting and haulm destruction, are capable of producing total yields of:

Cultivar	Tuber Number (000's/ha)	Tuber weight (t/ha)
Bintje	934	45.20
Pontiac	720	47.00
Desiree	799	45.80
Russet Burbank	716	45.00

iii) we demonstrated that a vaccum seeder is capable of planting sprouted microtubers with accurate placement (depth and in-row spacing), in singulated form, and without any observed damage to sprouts.

Other trials have provided information on planting depth and hilling up treatments, as well as the benefits of using floating crop covers.

In summary, this project has provided information -

- for the management of physiological age of potato microtubers,
- for utilising potato microtubers for the field production of seed potatoes,
- on the yield (number & weight) produced by microtubers planted in the field.

This information provides a good basis for the efficient commercial utilisation of potato microtubers for the field production of early generation seed potatoes.

Technical Summary

This project has led to a good understanding of the post-harvest management and field culture practices required for utilising potato microtubers for the field production of seed potatoes.

1. Physiological ageing of microtubers:

i) Microtubers have a uniform, clearly defined dormancy period;
   - the dormancy period for Bintje = 53 days.
   - the dormancy period for Russet Burbank = 75 days.

ii) The dormancy period of Bintje microtubers is independent of temperature over the range 10-25°C, and the dormancy period of Russet Burbank microtubers is independent of temperature over the range 15-30°C.

iii) By storing Bintje microtubers at 5°C for 2 weeks prior to sprouting, the dormancy break may be more concentrated throughout the batch of microtubers.

iv) The dormancy period of Russet Burbank microtubers was not shortened by cutting the microtubers.

A method for inducing Bintje microtubers to develop multiple sprouts immediately after dormancy break has been discovered. (This method is considered "commercial in confidence").

2. Field performance of microtubers:

i) microtubers may be planted out in the open field to produce a vigorous, high yielding plant stand.

ii) *a method for improving the establishment of plants grown from physiologically "juvenile" microtubers has been discovered. (This method is considered "commercial in confidence").*

iii) we demonstrated that a vaccum seeder is capable of planting sprouted microtubers at accurate placement (depth and in-row spacing), in singulated form, and without any observed damage to the elongated sprouts that were present on some of the microtubers.

3. Use of Crop Covers:

i). The floating crop cover material ("Evolution Crop Cover"), is able to provide a slight increase (1-4°C) in the overnight minimum terrestrial temperature, the soil temperature under the covers.

ii). The daily maximum air temperature increased significantly under the "Evolution Crop Cover" material.

iii) There were no significant differences between covered and uncovered plots, in terms of emergence times and yields.

These findings, which have been communicated in full to the Voluntary Contributors to project PT115, should allow for the commercial utilisation of potato microtubers as an end product from tissue culture-based programs.

TECHNICAL REPORT

Introduction

This project aims to identify the most efficient method by which potato microtubers (produced in-vitro) may be planted out for seed production. The primary aim was to develop a method of replacing micro-propagated plantlets with microtubers as the initial planting material for seed potato production.

The project began by studying the physiological ageing process of microtubers. This laboratory based work provided information on the dormancy period and subsequent sprout development of microtubers. Once the physiological ageing process had been investigated, field trials were conducted with the aim of identifying appropriate cultural practices for planting microtubers in hills in the open field.

Currently we have no comparative data on the performance of microtubers as against other potato propagules derived from tissue culture based programs. Having identified appropriate management strategies for the field culture of microtubers, a field trial was established to provide data on the comparative performance of microtubers versus "transplants" and "minitubers".

Objectives of the research project:

The primary objective was to identify pre-planting treatments and planting procedures that would facilitate planting large numbers of microtubers in the field to achieve a vigorous, high yielding plant stand. This information is necessary for the use of microtubers in Australian seed potato certification schemes, and will provide opportunities for Australian industry to develop an integrated microtuber technology package.

The Problem :

Research and development on potato propagation in tissue culture laboratories is aimed at mass production of microtubers as a means of releasing lower unit cost potato propagules to the seed potato industry.

However published reports of microtuber dormancy problems indicate that the physiological ageing process of these propagules was not well understood. This needs to be investigated so that the dormancy period of microtubers as produced, is well understood - and microtubers can then be utilised in field trials without encountering dormancy-related problems.

Also no data was available on the productivity of microtubers when planted in the open field. Without this information the industry is unable to compare the productivity of microtubers against other potato propagules derived from tissue culture based programs. At present, the industry is unable to determine their true cost effectiveness as an alternative to "minitubers" and "transplants".

Materials and Methods

The proposal was to use initial batches of microtubers produced in Year 1 of the project, in a series of unreplicated "demonstration trials", whereby microtubers were exposed to a range of temperature, relative humidity and light treatments.

Observations were made on the effect of these variables on:-
a) length of dormancy period,
b) dormancy break, and
c) subsequent sprout development.

The microtubers were produced according to the developed method, and the standard size was 5-7mm diameter.

This information was then used to plan field trials in Year 2, which aimed at evaluating the effect of physiological age on the field performance of potato microtubers.

Other field trials, both unreplicated observation trials and replicated trials, were conducted in Years 2&3 of the project. The objective of these trials was to investigate the cultural requirements (planting depth, hilling up etc.) for the planting and management of microtuber field crops.

The microtubers were hand-planted 5cm deep in rows 75cm apart, at a within-row spacing of 20cm. Special care was taken to ensure that sprouts were not damaged during planting. Each treatment was replicated 3 times, in a Randomised Complete Block trial design.

Nutrition and irrigation were managed as per G1 (first field generation) crop, and all plots were hand-weeded. Due to variable emergence over the trial site, hilling-up was done by hand (using a hoe), in order to hill up around each plant as was appropriate.

Results

1. Physiological ageing of Microtubers:

During 1992 a series of unreplicated "demonstration" trials were conducted using microtubers held in "Repli" dishes. There were 25 microtubers per treatment - with each microtuber in an individual compartment. (See Figures 2.1 - 2.4 on page 13). Highlights of the laboratory-based physiological age study, are as follows:

i) Microtubers have a uniform, clearly defined dormancy period;
  - the dormancy period for Bintje = 53 days.
  - the dormancy period for Russet Burbank = 75 days.

ii) The dormancy period of Bintje microtubers is independent of temperature over the range 10-25°C, and the dormancy period of Russet Burbank microtubers is independent of temperature over the range 15-30°C. See Figures 1.1 & 1.2 on pages 8 & 9.

iii) The dormancy period of Bintje and Russet Burbank microtubers is extended at 5°C.

iv) By storing Bintje microtubers at 5°C for 2 weeks prior to dormancy break, the dormancy break may be more concentrated through the batch of microtubers.

v) The dormancy period of Bintje and Russet Burbank microtubers may be slightly reduced by lowering the Relative Humidity from 95% to 50% or 75%.

vi) The dormancy period of Russet Burbank microtubers was not shortened by cutting the microtubers.

vii) The dormancy period of Russet Burbank microtubers was not shortened by exposing the microtubers to a sudden, short temperature shock (immersion of the microtubers in 30°C water for 15 minutes, followed by 5°C water for 15 minutes).

A method for inducing Bintje microtubers to develop multiple sprouts immediately after dormancy break has been discovered. (This method is considered "commercial in confidence").

Figure 1.1. Dormancy of Bintje microtubers over 5-25°C.

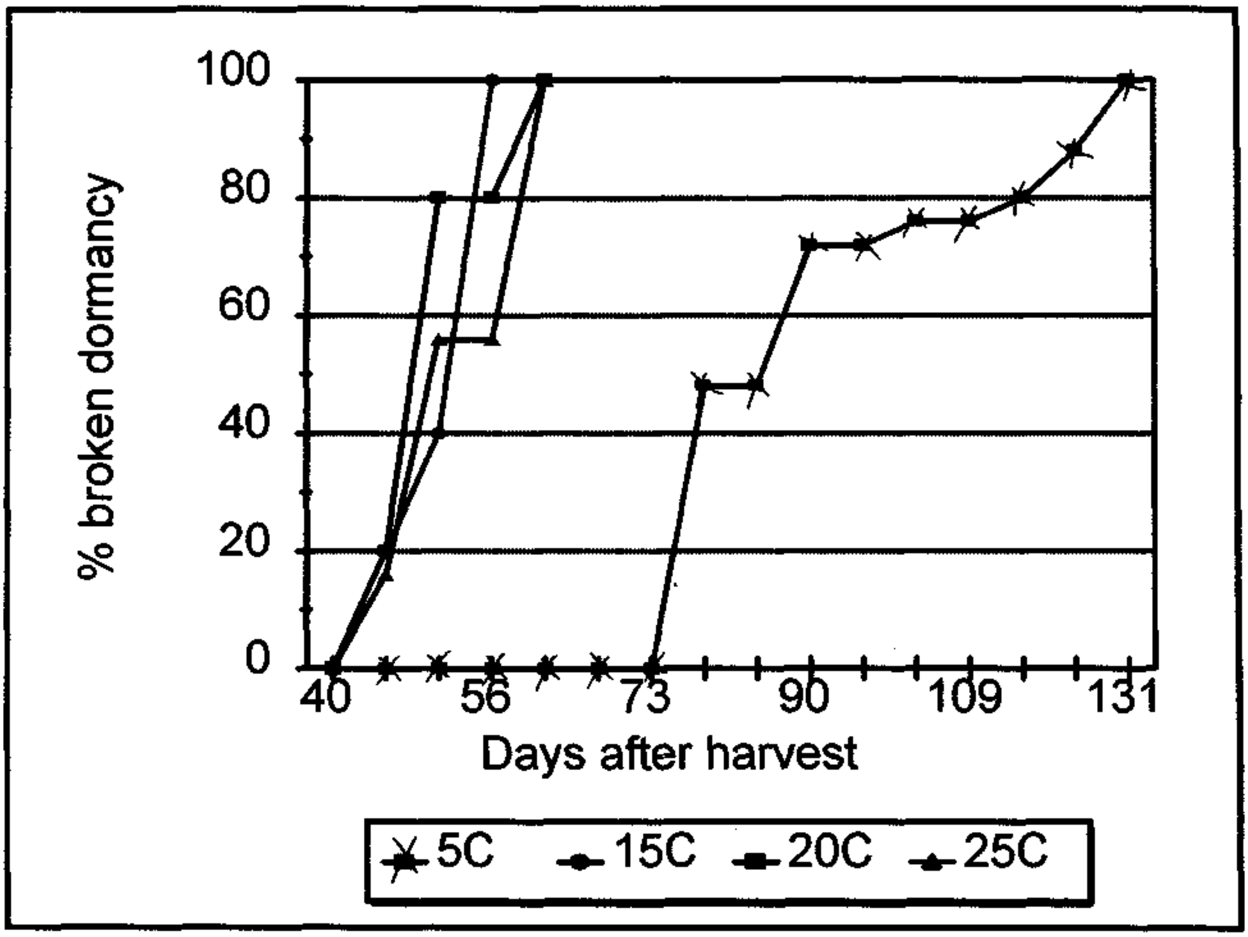
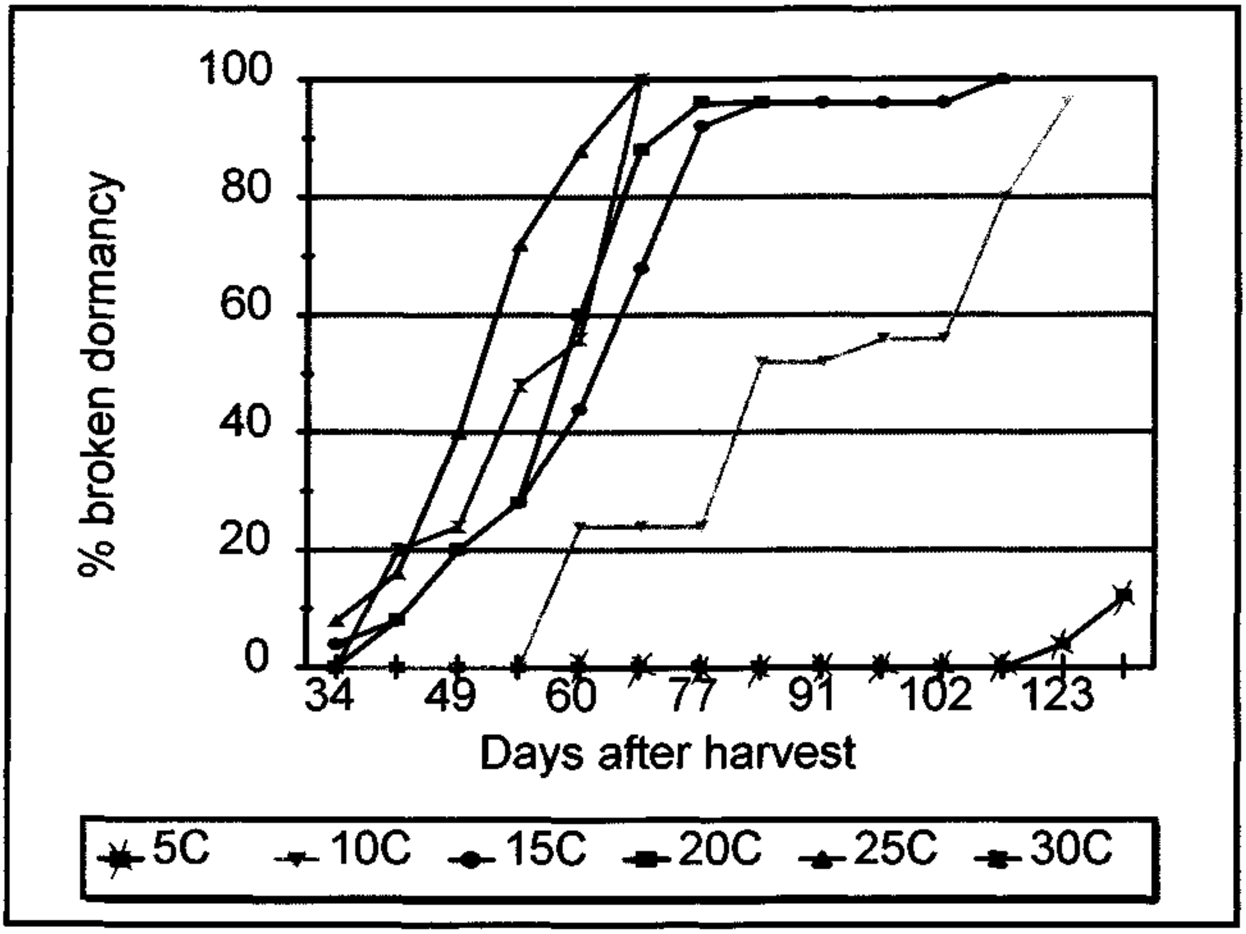


Figure 1.2. Dormancy of Russet Burbank microtubers over 5-30°C.



2. Field Performance of Microtubers:

A number of field trials were conducted in Year 2 & 3 of the project on a Foundation seed grower's property in the Crookwell district. Highlights from these trials are:

i) microtubers can be planted out in the open field to produce a vigorous, high yielding plant stand. Plants grown from microtubers were observed to have single stems and above-ground branching. "Chain tuberisation" was noted in some plants that were hand-dug prior to maturity. See Figures 2.7 & 2.8.

ii) *a method for improving the establishment, and subsequent yield of plants grown from physiologically "juvenile" microtubers has been discovered. (This method is held as "commercial in confidence").*

iii) yield data extracted from a physiological age trial, indicate that microtubers planted at spacings of 20cm within row & 75cm between rows and grown for 102 days between planting and haulm destruction, are capable of producing the following yields:

Table 1. Number of tubers produced per plot (20 plants at 0.20m within-row spacing and 0.75m between row spacing)

Number of tubers produced in each size grade.						
Cultivar	0-20mm	20-30mm	30-55mm	>55mm	20-55mm	Total
Bintje	14.3	52.7	202.7	10.7	255.3	280.3
Pontiac	24.0	47.0	107.7	20.3	154.7	216.3
Desiree	9.3	44.7	169.3	15.7	214.0	239.7
Russet Burbank	6.0	34.3	169.3	7.7	203.7	217.3
LSD(0.05)	14.6	25.3	30.8	8.6	46.0	55.6

Table 2. Weight of tubers produced per plot (20 plants at 0.20m within-row spacing and 0.75m between row spacing)

Weight of tubers (kg) produced in each size grade.						
Cultivar	0-20mm	20-30mm	30-55mm	>55mm	20-55mm	Total
Bintje	0.07	0.8	10.88	1.81	11.68	13.56
Pontiac	0.1	0.6	6.43	4.73	7.02	14.11
Desiree	0.05	0.68	10.02	2.78	10.70	13.74
Russet Burbank	0.04	0.55	9.56	1.23	10.11	11.38
LSD(0.05)	0.06	0.32	1.92	1.53	2.01	2.73

3. Mechanical Planting

We were able to demonstrate that a vaccum seeder is capable of planting sprouted microtubers at accurate placement (depth and in-row spacing), in singulated form, and without any observed damage to the elongated sprouts that were present on some of the microtubers. See Figures 2.5 & 2.6.

4. Use of Crop Covers:

1. The floating crop cover material ("Evolution Crop Cover"), can provide a slight increase (1-4°C) in the overnight minimum terrestrial temperature under the covers.

2. A slight increase in the soil temperature at a depth of 30mm was recorded under the "Evolution Crop Cover" material, compared to uncovered plots.

3. The daily maximum air temperature increased significantly under the "Evolution Crop Cover" material.

4. No frosts occurred during the conduct of this trial. However, the crop cover material may provide protection from mild frosts, by maintaining the minimum night air temperature at 1-2°C above that of uncovered potato hills.

5. There were no significant differences between covered and uncovered plots, in terms of emergence times and yields.

Discussion

This project has shown that potato microtubers produced according to the method developed by Potato Seed Services, are capable of producing a vigorous, high yielding plant stand, when planted in hills in the open field. We demonstrated that a vaccum seeder offers a suitable method for mechanically planting large numbers of microtubers, with precision placement, and without damage to sprouts.

The physiological ageing characteristics of microtubers of the cultivars Bintje and Russet Burbank have been studied, and it was found that the length of dormancy period at 20°C is clearly defined. New methods for manipulation of the physiological ageing process (especially the induction of multiple sprouting at dormancy break) have been discovered.

This project has shown that floating crop covers, such as "Evolution Crop Cover" (R), may have some role to play where microtubers are planted under very cold conditions, and with a significant risk of frost damage to the emerging shoots.

Acknowledgement:

I wish to acknowledge the excellent support provided by David Carter ("Cottle Wolly", Crookwell) to the field trials conducted in this project. His practical advice, together with the care and dedication provided in the management of the field trials was essential to their success.

I also wish to acknowledge the guidance provided by Peter Waterhouse and David Montgomery to the direction of this project.

RECOMMENDATIONS

Extension/adoption by industry

The complete findings from this study are not currently in the public domain. The project received industry funds from Voluntary Contributors rather than an industry levy, and there is an obligation to retain the findings as "Commercial in Confidence". This report represents a summary of the findings which may be released into the public domain.

In order to provide industry with some information on the direction, progress and potential outcomes from the utilisation of potato microtubers, presentations were made at potato field days and research workshops. The following publications outlined the background to and objectives of the project, and detailed progress at that point in time:-

Workshop Proceedings:

Dowling, B.G. (1992). Utilising potato microtubers. Finley Potato Workshop.

Dowling, B.G. (1994). Utilising potato microtubers. Crookwell Potato Field Day.

Conference Paper:

Dowling, B.G. (1993). Utilising potato microtubers. Proceedings from the 7th National Potato Research Workshop, Tasmania.

Adoption by industry, of the project's findings, is dependent on the Voluntary Contributor's commercialisation plans.

Directions for future research

The Voluntary Contributors to this project, having initially developed a commercial method for the mass production of potato microtubers, have recently indicated their desire to pursue a variation on this technology, i.e. factory-produced "Technitubers".

The physiological age study conducted in this project has demonstrated techniques which may be suitable for managing the physiological ageing process of factory-produced "Technitubers". Also, the cultural practices identified as suitable to the field culture of potato microtubers, (5-7mm in diameter), provide a good lead as to the cultural practices which may be required in the management of potato "Technitubers" (10-15mm in diameter). *However both the physiological age work and the field trial work needs to be repeated with potato "Technitubers" - since they are a completely different propagule to microtubers. The results cannot be extrapolated from microtubers to "Technitubers".*

Financial/commercial benefits

The commercial utilisation of large numbers of potato microtubers should lead to a reduction in the unit cost of early generation planting material. Minitubers produced commercially in Australia have a unit cost of approximately $1.00, whereas microtubers might be mass-produced for approximately 10 cents each.

The successful utilisation of microtubers in field plantings offers the possibility of providing immense benefits to the potato industry throughout Australia. Improvements should include: lower incidence and spread of diseases, higher yields, higher quality potatoes for processing and fresh market consumption, more rapid introduction of new varieties, as well as greatly expanded opportunities for the export of high quality seed potatoes.

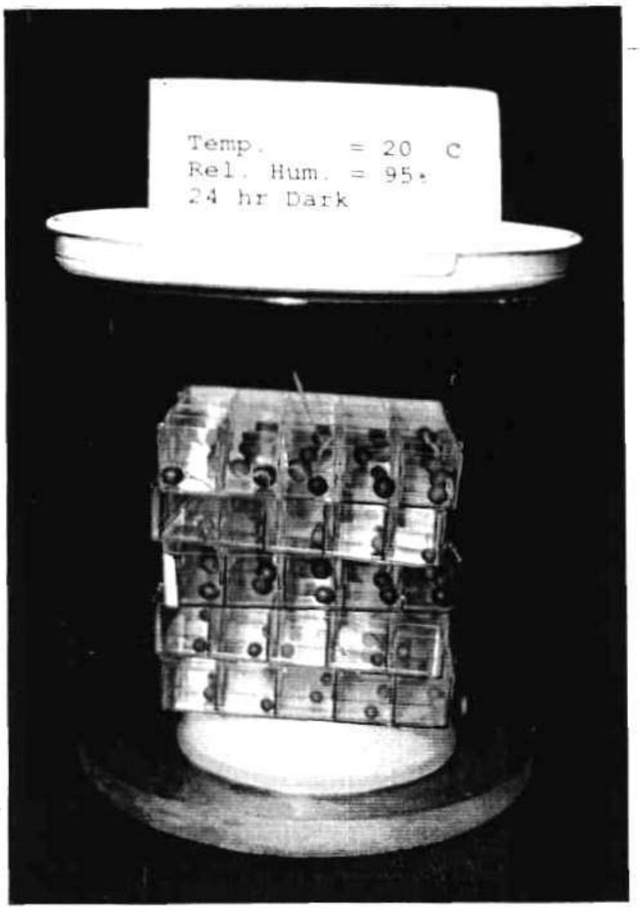


Figure 2.1 Physioloigcal age trials were conducted under controlled conditions in the laboratory

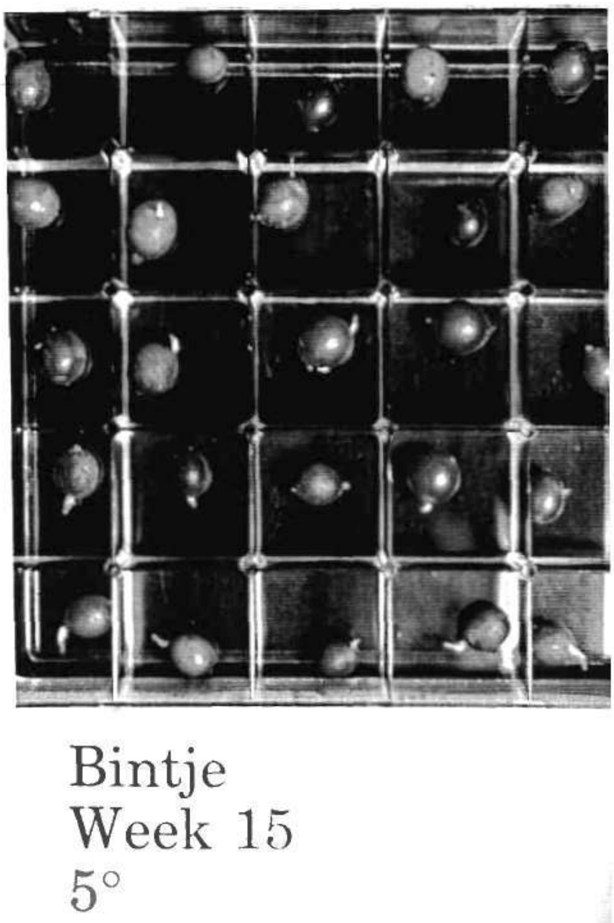


Figure 2.2 Bintje microtubers showing apical sprout formation after 15 weeks at 5°C

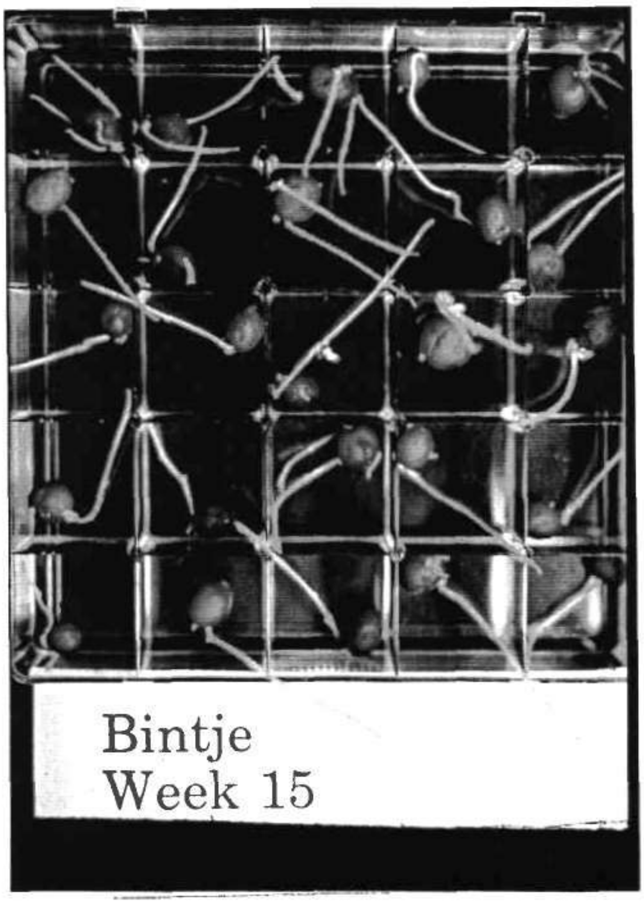


Figure 2.3 Bintje microtubers showing multiple sprout growth at 15 weeks after harvest

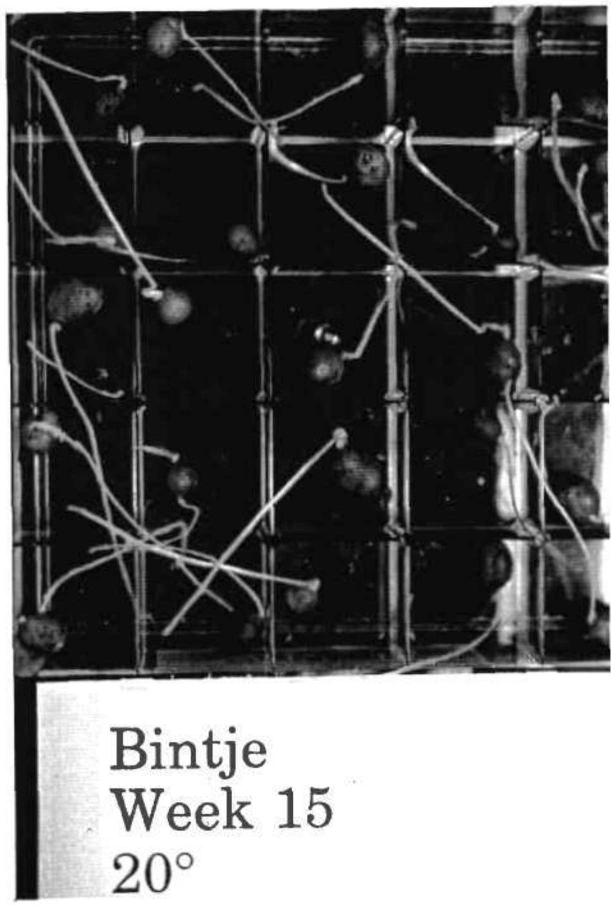


Figure 2.4 Bintje microtubers showing apical sprout elongation after 15 weeks at 20 °C

Figure 2.5 Vaccum seeder being used to sow microtubers

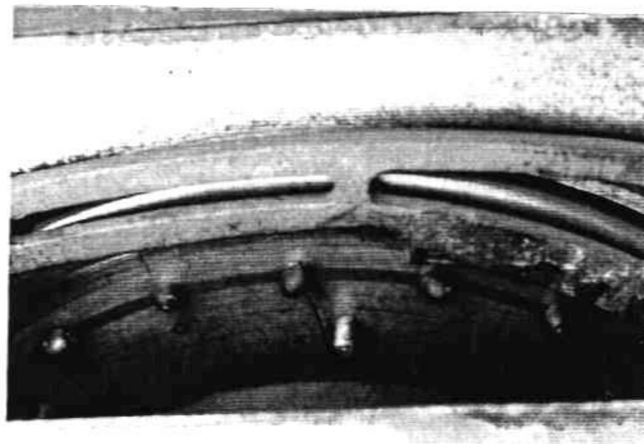


Figure 2.6 Microtubers held onto vaccum seeder plate

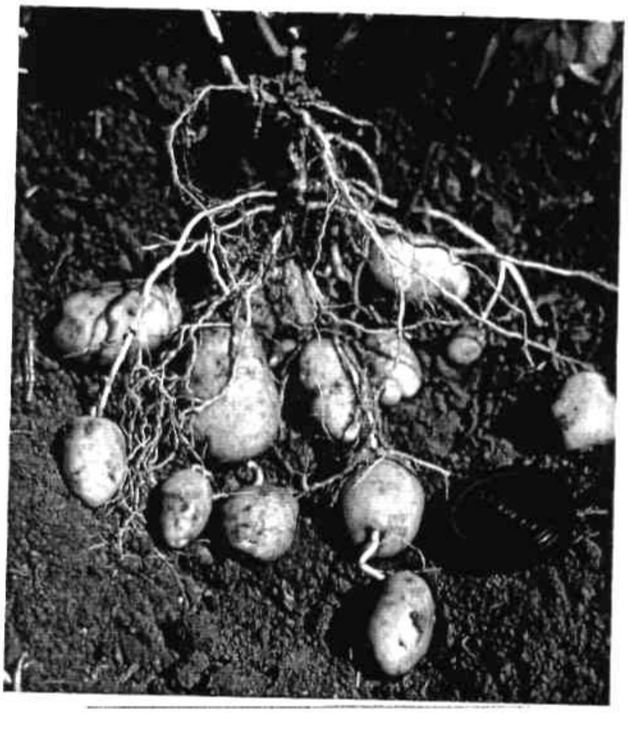


Figure 2.7 Tubers forming on plant grown from Bintje microtubers, at 73 d.a.s.

Figure 2.8 Plants grown from Bintje microtubers, at 73 d.a.s.