Know-how for Horticulture™

A partnership to build crisping potato capacity of West Java and Australian seed potato sales

Peter Dawson
Department of Agriculture
Western Australia

Project Number: PT02018

PT02018

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

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Department of Agriculture Western Australia on behalf of contributors.

ISBN 0 7341 1065 0

Published and distributed by:
Horticultural Australia Ltd
Level 1
50 Carrington Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au

Know-how for Horticulture™

FINAL REPORT

HORTICULTURE AUSTRALIA LIMITED

PROJECT PT02018

A PARTNERSHIP TO BUILD INDONESIAN CRISPING POTATO CAPACITY AND AUSTRALIAN SEED POTATO SALES

*Peter Dawson, Ian McPharlin and Bernardus Budi Dharmadi**

Department of Agriculture, Western Australia

&

**PT Indofood Sukses Makmur Tbk*

HAL Project: PT02018

Project Leader:
Peter Dawson
Department of Agriculture, Western Australia
444 Albany Highway
ALBANY WA 6330
Fax 08 9841 2707
Emai l pdawson@agric.wa.gov.au

Other personnel
Dr Ian McPharlin
Department of Agriculture, Western Australia
Phone 08 9368 3671
Email imcpharlin@agric.wa.gov.au

Mr Budi Dharmadi
PT Indofood Sukses Makmur Tbk
Phone 0011 62 21 5228822 extension 787
Email budi.dharmadi@indofood.co.id

Mr Brian Dickson
Western Potatoes
Phone 08 9335 8999
Email briand@potato.wa.gov.au

Purpose of this Report: To document first steps in capacity building of crisp processing in West Java and seed exports in Western Australia.

Funding Sources: Department of Agriculture, Western Australia, The Potato Marketing Corporation of Western Australia (Western Potatoes), PT Indofood Sukses Makmur Tbk and Horticulture Australia Ltd.

Date 29 October 2004

Frontispiece. A demonstration Atlantic crop grown for crisp processing from Western Australian seed at Citiis. Note the overstory of trees. The crop was grown in the dry season from intact and cut seed. Yields were 29 t/ha for intact seed and 25 t/ha for seed cut to two eyes.

Contents PT02018

Media Summary

Key components of project

Access to affordable high quality seed potatoes is considered to be the major constraint to potato production in South East Asia.

Seed potatoes from Western Australia were grown in a series of experiments and demonstrations in West Java in the dry seasons of 2003 and 2004. The variety was Atlantic which is grown specifically for crisp processing. The characteristics that make Atlantic suitable for crisp processing are its round shape, its high starch content and the light colour of its crisps after frying.

Industry significance

If the productivity of crisp processing crops grown in West Java improves with the use of seed potatoes from Australia then markets for both Australian seed potato producers and West Javanese potato growers will expand.

Key outcomes

The experimental and demonstration plantings showed that high yields of crisp potatoes can be grown in West Java using "young" seed potatoes from Western Australia.

We demonstrated that Australian seed potatoes can be grown once in West Java and the small potatoes from this crop can be re-used successfully as seed a second time. This will increase the availability of improved seed potatoes to farmers in West Java. It will also increase productivity of potato growers in West Java and stimulate the demand for more high quality seed.

We demonstrated that larger seed potatoes can be cut and grown successfully in West Java. When this techniques is developed it will help the West Javanese reduce their seed costs by increasing the number of seed pieces they can obtain from a kilogram of seed. It will also enable Australian farmers to export larger seed potatoes.

Increased seed orders were received by WA seed exporters following the harvest of this project's experiments and demonstrations.

Conclusions

Seed potatoes from Western Australia can help to improve the productivity of the processing potato industry in West Java. However Australian seed will only perform consistently if it is grown under suitable management. These management practices still need to be developed.

Recommendations for future R&D

- Improved agronomic management of the potato crop in West Java should be investigated so that crops grown from Australian seed will reach their full potential. Improved management of late blight disease should be a priority.
- The performance of Australian seed potatoes in the wet season in Java should be investigated.

Recommendations for practical application to industry

- Australian seed potato exporters should supply West Java with young, rather than old seed.
- Australian seed potato exports will benefit if best practice management guidelines for crop production in new markets can be developed.

Technical Summary

Nature of problem

Western Australian potato growers supply the fresh market and processors of crisps, French-fries and salads. Fresh table and crisp potatoes are also exported. Prospects for profitable growth in all these markets are limited. Western Australia also produces seed potatoes under conditions that have been described as ideal by the International Potato Centre (Schmiediche 1995). The potato industry in Western Australia believes that there is considerable potential for growth in exports of Western Australia seed potatoes. In order to develop new markets one important task is to demonstrate the performance of Western Australian seed in the target market.

Research undertaken

To demonstrate the performance of seed in a target market involves many stages. The work undertaken in this project was to demonstrate the performance of Atlantic seed potatoes from Western Australia. We wanted to determine the appropriate physiological age and whether cut WA seed would grow successfully.

Major findings & industry outcomes

- The experimental and demonstration plantings showed that high yields of crisp potatoes can be grown in West Java using "young" seed potatoes from Western Australia.
- Australian seed potatoes can be grown once in West Java and the small potatoes from this crop can be re-used successfully as seed a second time. This will increase the availability of improved seed potatoes to farmers in West Java. It will also increase productivity of potato growers in West Java and stimulate the demand for more high quality seed.
- In West Java large seed potatoes freshly imported from Australia can be cut and grown successfully. When this technique is developed it will help the West Javanese reduce their seed costs by increasing the number of seed pieces they can obtain from a kilogram of seed. It will also enable Australian farmers to export larger seed potatoes.
- Increased seed orders were received by WA seed exporters following the harvest of this project's experiments and demonstrations.
- Relationships formed during this projects has helped industry solve other challenges such as resolving quarantine issues.

Recommendations & future work

- Offshore investment that increases markets available to the Australian potato industry offers good returns and so should be continued.
- Seed from Australia should be supported with agronomy assistance. This will need to include a survey of production methods to identify constraints to seed performance. This could involve follow up commercial shipments.
- Travel to target markets is essential. Until the Australian Department of Foreign Affairs and Trade (DFAT) allows travel to Indonesia these projects will have to replace travel with training of target market staff in Australia in order to achieve the desired outcomes.
- Follow up commercial shipments should be monitored to initiate the development.
- Crisp varieties more suited to tropical conditions than Atlantic need to be evaluated in West Java.
- An economic analysis of the benefits and costs of the new seed source must be carried out after the demonstrations have been completed.

3. Introduction

3.1 Historical Background

Western Australian growers have exported seed potatoes to Mauritius for over 25 years. This market is limited and has averaged 500 to 600 tonnes per year over the last 10 years. The main variety exported is Delaware which is also grown for domestic consumption in WA.

There is potential for exports of seed potatoes to increase if other markets are developed. Batt (1998) investigated markets in Asia and showed a demand for 32,000 tonnes of seed potatoes. The actual amount of "seed" tubers used by farmers in Asia is an order of magnitude greater, but much of this is "saved" seed. The "saved" seed is small sized tubers which have been set aside from the farmer's commercial crop. The seed is saved because it is too expensive to buy in new seed every year. In West Java Adiyoga *et al*. (1999) showed seed costs were one third of the variable costs of potato production.

The saving of small seed is an acceptable practice in areas where seed degeneration rates are low and where healthy seed is frequently introduced. However, in areas where seed degeneration rates are high, the practice of saving of small seed tubers selects for diseased tubers and increases the rate of seed degeneration. Under these conditions it is difficult to produce large quantities of high quality seed potatoes. In these situations improved yields could be expected if healthy seed was more frequent introduced.

The main constraint to the introduction of healthy seed is the cost. However this constraint can be overcome when processing industries are established. The processing companies help farmers obtain disease free seed through subsidising the cost of the seed or by providing access to credit. The increased yield more than offsets the cost of the seed, leading to increased profit.

Therefore, where high quality seed potatoes are difficult to produce and where a processing industry exists, there is good potential to Australian seed producers to market their product. This is the situation in West Java.

Potato production in West Java.

Indonesia produced 977,349 tonnes of potatoes in 2000 {Badan Pusat Statistik (BPS-Statistics Indonesia)} of which 47% were grown in East Java. In 1999 Australian production was 1,326,760 tonnes (FAOSTAT) so West Java production is equivalent to one third of Australia's. Indonesia's potato production is growing rapidly, between 1986 and 1996 Adiyoga *et al*. (1999) reported that production grew more rapidly than in any other country.

The main variety grown is Granola which was bred in Germany for the fresh market. In Indonesia potatoes are used as a vegetable, rather than a staple as in Australia. Granola benefits farmers in Indonesia by producing high yields and being tolerant to seed decline (degeneration). The consumption of potatoes as a snackfood in Indonesia is increasing. Indonesians have traditionally consumed crisps, or kripik, made by small household-scale processors. However the popularity of potato crisps has increased following the establishment of large-scale potato crisp processing by PT Indofood.

This processor has had problems in obtaining adequate local supply of suitable potatoes. The supply problem is due to Atlantic, the processors' preferred variety, not yielding as well as the fresh market variety Granola. This makes processing crops less profitable for farmers compared with the fresh market. The processors prefer Atlantic to Granola because Atlantic has higher specific gravity and lighter fry colour than Granola. To increase processing production Indofood needs to be able to increase the yield of Atlantic crops grown in West Java.

Potatoes are mostly grown by highland farmers with small land holdings. Production is not mechanised and so is labour intensive. Yields are low in Indonesia with West Java averaging 16.7 t/ha (Baden Pusat Statisik) compared with Western Australia's average yield of 44 t/ha (Anon 2003). The yield of Atlantic would be lower still, probably 12 t/ha.

Reasons for the low yield are many. Seed quality and cost have already been mentioned. The lack of irrigation is a major constraint. In West Java the wet season is from October to March and rainfall of 200 to 500 mm per month is common (Adiyoga *et al*. 1999). In the wet season, late blight (*Phytophthora infestans*) can cause severe crop damage. In the dry season, from April to September, soil moisture could be expected to limit production. Other factors contributing to the low yields are declining soil fertility and pests such leaf miner (*Liriomyza huidobrensis*) (Adiyoga *et al*. 1999).

Indonesia produces seed potatoes in West Java through a government run scheme. Here source material from tissue culture is produced and bulked to generation 3 (G3) before it is passed onto certified seed growers (Adiyoga *et al*. 1999). About 2,400 tonnes of G4, or 20% of the seed requirement for West Java, are available to commercial farmers (Adiyoga *et al*. 1999). Bulking conditions that favour rapid infection with diseases reduces the quality of this seed. The seed crops are grown with little isolation and pathogen infection rates are high.

Therefore the provision of greater quantities of seed with low disease levels could be expected to help farmers in West Java raise their yields. The seed must not only be low in disease but it must be vigorous and ready to sprout and emerge without delay. However yields will only improve if the farmers' management inputs can overcome other constraints. Appropriate levels of soil moisture must be maintained, sufficient nutrients must be applied and the crop must be protected from pests and diseases. The same seed can produce vastly different yields under different management. For example yields of the variety TK51.6 (formerly VC51.6) varied from 16.3 to 31.4 t/ha in Vietnam (Batt *et al*. 2000). At some other sites yield was as low as 5 t/ha (Dawson, pers. comm.).

Management to ensure suitable size distribution for processing crops

Crisp potatoes must have high yields of tubers of the size required by the processor. Indofood pays a premium for tubers 50-70 mm in diameter (Dharmadi pers. comm.). Only 5% of potato received are allowed to be greater than 70 mm.

Importance of plant density

An important factor in determining the yield of processing size tubers is planting density (Travis 1987). The higher the planting density, and associated stem density, the greater the proportion of total yield is of small tubers (Struik and Wiersema 1999). For example the yield of small tubers (28-55 mm) increased from 38 to 55t/ha and large tubers (>55mm) decreased from 30 to 15t/ha as stem density increased from 8 to 40 stems /m^2 (van der Zaag 1987). Similarly yield of large (<250g) Sebago tubers decreased and small (35-100g) and medium (101-150g) increased as in-row spacing was reduced (density increased) in a spring-summer planting in Victoria (Strange and Blackmore 1990).

Importance of seed treatment

Seed performance can also have a large influence on the crisp yield of processing crops.

Whole, or intact, seed is usually preferred by farmers in tropical countries because cut seed, especially if uncured, maybe susceptible to bacterial and fungal disease attack. We will use the term "intact" instead of whole or round seed, as this is the term used in Indonesia. Another reason these farmers prefer intact seed is that as the tuber count per kilogram increases their seed cost per unit area is reduced.

Cut seed is commonly used in temperate areas without yield reduction compared to intact seed. For example yield of Norgold Russet and Russet Burbank grown from cut seed was as high as from intact seed in Washington State (Easton *et al.*1970). Cured cut seed may yield as well as intact seed in tropical environments. For example in the Red River Delta of Vietnam the yield of PO3 and TK51.6 from cured cut seed was as high or higher than when intact seed was used on 2 sites (McPharlin *et al.* 2003). By contrast yield of Sebago was lower on the cut versus intact seed treatments in Victoria (Strange and Blackmore 1990). The stem density of plantings from cut seed may differ from intact seed plantings depending on the precision of cutting, eyes per piece and the proportion of 'blind' (no eyes) seed pieces. In general intact seed of the same weight as cut seed pieces will yield more stems per unit area as there are more eyes per unit weight and less 'blind' setts (Sekhon and Singh 1985). For example the lower yield of Sebago on the cut seed treatment was attributed to less tubers/plant possibly because of more 'blind' pieces than in the intact seed treatment. The interaction between stem density, environment, variety and inputs will also be important in determining yield.

Therefore the interaction between seed treatment (cut and intact seed) and planting density on tuber yield and quality of Atlantic needs to be examined in West Java.

Importance of physiological age

The physiological age of a potato seed can influence the growth and yield of the crop it grows (Struik and Wiersema 1999). Physiological age of tubers is a function of their chronological age, environmental conditions during growth and storage conditions (Kawakami 1962, 1980). It will also vary with cultivar. Potato seed tubers age quicker at higher than lower temperatures. For example seed stored at 25°C for 3 months is physiologically older than the same seed stored at 4°C. Similarly seed will be physiologically older from crops grown in warmer compared with cooler conditions.

Seed needs to be the correct age for the intended crop. Seed that is too young has low sprout number (van der Zaag and van Loon 1987). Seed that is too old undergoes senile degeneration resulting in poor productivity of the crop (Kawakami 1962) and yield reduction (Kustiati *et al*. 2004). Physiological age may influence the size of tubers through stem and stolon number. For example physiologically old seed often produces more stems, stolons (sites of tuber initiation) and tubers than younger seed (Beukema and Van der Zaag 1990, Henderson *et al* 1999, Kustiati *et al* 2004). This may result in a crop with a higher yield of small (25-55mm) tubers than in a crop grown from younger seed. Consequently physiologically old (but not senile) seed is often used to produce crops of small tubers for seed. 'Young' (but not juvenile) seed is used to produce medium and larger tubers needed for crisp and French-fry production as the crops produce larger tubers than if grown with old seed. Using old or young seed within a reasonable period after harvest may influence the size range of tubers at harvest but may not unduly influence total yield. Allowing tubers to age too much may reduce total yield and therefore profits.

Thus it is important, for at least two main commercial reasons, to provide seed of the appropriate physiological age to potato growers. Therefore we will investigate the growth, yield and quality of Atlantic grown from seed of different ages (time since harvest) and sources in West Java.

3.2 Significance to Industry

The significance to the Australian potato industry is that Indonesia offers a new market for seed potatoes. Seed potatoes are a high value crop and Australia has a competitive advantage because of its low disease status, its location close to the markets and its ability to produce seed potatoes at various times of the year.

Investment in markets which have real potential for growth should give a high return on investment. Once Australia becomes established as a seed potato exporter of repute, then the opportunities available to the industry will increase. In Asia there are markets for seed potatoes in the Philippines, Thailand and Vietnam. Further afield there are larger markets in the Middle East.

This project is also significant to the industry as it recognises the importance of supporting Australian seed by monitoring its performance and attempting to determine management strategies to enable our customers to grow the seed to its full potential.

Aims

To increase crisp potato capacity in West Java through:

- Demonstrating an improved seed supply system,

- Determining the best seed age for Indonesian farmers,

- Demonstrating WA potato production to Indonesian potato industry stakeholders, and

- Investigating whether the use of cut seed can reduce seed costs for Indonesian farmers.

4. Materials & Methods

4.1 First time-of-planting in Indonesia

4.1.1 Intact and cut seed comparison experiments

Locations and planting times

Two locations were chosen for the experiments. The first was at Citiis at Pangalengan while the second was at Cicerang in Garut. Experiments were planted in April 2003.

Experimental design

The experiments were planted as a single factor experiment with a completely randomised design. Four replicates were used.

Seed source

Seed used was Atlantic grown in Western Australia. Two lots of seed were sent for evaluation. The physiologically older seed was harvested in February 2002 at Manjimup. The physiologically younger seed was harvested in November 2002 from a July planting at Busselton. This physiologically older seed was cool-stored until shipment to Jakarta in March 2003.

Treatments

Treatments were seed types comprising

- Intact seed de-sprouted once,
- Cut seed with one eye per sett, and
- Cut seed de-sprouted once.

Intact seed was 25 – 50 mm diameter (equates to 51 – 100 g). The seed was de-sprouted before planting. This was done by removing the apical sprout, dipping the seed in Bactocyn® solution (concentration 2.5 ml/L with 0.5 ml/L of Afsa® glue), drying at room temperature then allowing the tuber to resprout in the light until a new sprout of 5 to 10 mm grew. This took about 10 days.

Cut seed was not de-sprouted. Seed size was greater than 50 mm. The tubers were cut to give both one and two-eyed setts. Knives were sterilised with 90% alcohol. After cutting the seed was dipped (as for the intact seed). The cut surface was then dusted with either a 70:30 or a 40:60 mixture of Delsene ® and white cement. Delsene has the active ingredients of 6.2% carbendazim and 73.8% mancozeb. The seed was dried at room temperature then allowed sprout in the light until a sprout of 5 to 10 mm grew. This also took about 10 days.

Cultivation and ridging

Soil was tilled to 40 – 50 cm 15 days before planting. The soil was formed into ridges about 30 wide, 40 cm high separated with a 50 cm wide furrow. This allowed a plant spacing of 80 cm between rows.

Fertilisation

Pre-plant

One week before planting, chicken manure and inorganic fertilisers were applied. The chicken manure was spread on the ridge at a rate of 10 tonnes per ha. On top of this 310 kg/ha phosphate fertiliser (SP –36) was applied with 80 kg/ha urea and 113 kg/ha of KCl. The fertiliser was covered with 5 cm of soil. Cultivation just before planting mixed the soil and fertiliser.

Side-dressings

25 days after planting 160 kg/ha of urea and 227 kg/ha of KCl was applied along the ridge 15 cm from the stems. The application was covered with 5 – 15 cm of soil.

Plot size

Plot size was 10 rows each with 24 setts. Spacing in the row was 30 cm while rows were 80 cm apart. This resulted in a plot size of 8 metres by 7 metres containing 240 setts. For harvest 30 plants were sampled.

Planting

Seed was hand planted to a depth of 10 – 20 cm during dry weather.

Weed control

A desiccant herbicide was applied 5 days after planting before emergence. The crop was also hand weeded before flower initiation, no later than 45 days after planting.

Irrigation

Sprinklers were used to water the crop when soil moisture was less than 70% humidity as assessed with a thermo-hygrometer.

Crop protection

Pesticides were applied according to a schedule as well as in reaction to observed symptoms. For disease (*Phytophthora* blight) systemic and protectant fungicides were used in the following rotation; systemic-systemic-contact-contact-contact-systemic-systemic- etc.

Maturity

The crop was harvested 90 – 100 days after planting or when the tops had died-off and the tuber's skin had hardened.

Measurements

1. Site description: soil type and pH, altitude.
2. Management inputs.
3. Emergence percentage 20, 40, 60 and 70 days after planting.
4. Plant height measured at intervals of 10 days after planting until maximum height was reached.
5. Pest and disease incidence.

6. Yield was measured from 30 random plants from each plot. No end-plants were used. Yield was measured by seed grade (20-50 mm diameter), processing grade (50-80 mm), oversize (>80 mm) and rejects (rots, defects).
7. Processing quality. See Measurements 7, 8 & 9 in Section 4.2.1.

Kept-seed storage

Seed was dipped in a to protect against bacteria and fungus. The seed was then dried by spreading out on a dry floor. A fan was directed at the seed to speed drying. The dry seed was then stored in wooden trays and dusted with an insecticide. The seed was stored in the dark at 18 – 20°C. Under these conditions sprouting usually occurs after 2 – 3 months. The first sprouts are removed to stimulate multiple sprouts. After de-sprouting it was kept in the dark for 5 – 7 days them placed in diffuse light to produce compact, strong sprouts ready for planting.

4.1.2 First time-of-planting seed socialisation

Seed was distributed to farmers to allow them to evaluate the new source of seed. Performance of these plantings was to be monitored by Indofood field staff.

4.2 Second time-of-planting in Indonesia

Changes to the methods used in the first time-of-planting are recorded here. Methods not reported here can be found in Section 4.1.1.

4.2.1 Intact versus cut seed times density comparison experiments

Locations and planting times

Four locations were chosen for the experiments. The first was at Cikajang at Garut (Garut), the second was at Himalaya 1 in Pangalengan (Himalaya 1), and the third at Anjar Osaka in Lembang (Lembang) and the fourth was at Himalaya 2 in Pangalengan (Himalaya 2). Experiments were planted on the 28 March 2004 (Garut), 3 April 2004 (Himalaya 1), 10 April 2004 (Lembang) and 16 April 2004 (Himalaya 2).

Experimental design

The experiments were a factorial experiment with two seed treatments times three densities in a randomised block with four replicates.

Seed source

Seed used was certified Atlantic (G3) grown in Western Australia. The seed was harvested in April 2003 and cool stored at 4°C until shipment to Jakarta in January 2004. The seed was then cool stored in refrigerated containers at the port from January until mid February and then in diffuse light conditions in a shed at Pangalengan until planting.

Treatments

The density treatments were (between-row, in-row);

- 70 cm x 20 cm (target plant density of 7.1 plants/m^2)
- 80 cm x 25 cm (target plant density of 5.0 plants/m^2), and
- 70 cm x 30 cm (target plant density of 4.8 plants/m^2).

The seed treatments were;

- Intact seed 25-50mm in diameter.
- Cut seed pieces of similar size to intact seed (i.e. cut from larger seed, 50-90mm).

Intact and cut seed preparation and treatment were as described for the first time-of-planting experiment (Section 4.1.1).

Cultivation and ridging

Soil was tilled to 40 - 50 cm 15 days before planting. The soil was formed into ridges about 30 wide and 40 cm high, separated with a 40 or 50 cm wide furrow. This allowed a plant spacing of 70 or 80 cm between rows.

Plot size

The plots were 10 rows wide (7m) x 3.75m long in the 70cm between-row treatments and 8 rows wide (6.4m) x 3.75m long in the 80cm between-row treatment. The total number of setts (seeds or seed pieces planted) were 187 (70 x 20cm), 125 (70 x 30cm) and 120 (80 x 25cm).

Planting

Seed was hand planted to a depth of 10 - 20 cm with an in- row spacing of 30cm between setts during dry weather. Row spacing was 70 cm or 80 cm. The total number of setts per plot was 125.

Maturity and harvest

The crop was harvested after the plants had senesced.

Measurements

1. Site description: soil type and pH, altitude.
2. Management inputs.
3. Plant number, % emergence and days to full emergence.
4. Stem number, stem and plants/m^2, stems/plant and tubers/plant.
5. Pest and disease incidence.
6. Yield was measured by harvesting the middle 8 rows of the 70cm between-row spaced plots and the middle 6 rows of the 80cm between-row spaced plots. One plant from the end of each row was excluded from the harvest. The total length of row harvested (& potential plant number) was 26.8m (134), 19.5m (78) and 25.2m (84) for the 70 x 20, 80 x 25 and 70 x 30cm treatments respectively. Yield was measured by the weight and number of tubers in a seed grade (20-50 mm diameter), processing grade (50-70 mm), oversize (>70 mm) and rejects (rots, defects).
7. Specific gravity (SG) was measured on a 5kg sample of tubers (50-70mm) using the weight-in-air weight-in-water method (Edgar 1951). To be accepted by the factory non-chipping varieties had to have a minimum SG of 1.067.
8. Cooking colour was assessed by preparing crisps and measuring reflectivity in an Agtron meter. To be accepted by the factory samples could have to have no more than 16% of samples below the measured limit of 55.
9. Disorders were assessed from the processing sample. External faults included wet breakdown, greening, mechanical damage, growth cracks and secondary growth. Internal disorders included internal discolouration, vascular ring, hollow heart, insect damage and

black heart. The allowed tolerance for these external and internal disorders was 13% except for black heart where there was a zero tolerance.

4.2.2 Seed age and source comparison experiments

Locations and planting times

As for Section 4.2.1.

Experimental design

The experiments were a 2 or 4 treatments (seed ages and sources) in a randomised block with 4 replicates at the above four locations.

Seed source

See "Treatments" below.

Treatments

The treatments were:

- WA-Java: WA seed grown once in Java and harvested in August 2003.
- WA-April: seed harvested in April 2003.
- WA-August: seed harvested in WA in August 2003 and treated as per the description of "Kept-seed storage" in Section 4.1.1.
- Scottish: seed freshly imported from Scotland

Intact seed preparation and treatment was as described for the first time-of-planting experiment (Section 4.1.1).

Plot size

The plots were 10 rows wide (7m) x 3.75m long with 70cm between-row spacing.

Maturity and Harvest

The crop was harvested after the plants had senesced.

Measurements

As for Section 4.2.1.

4.2.3 Second time-of-planting seed socialisation

See Section 4.1.2.

4.3 Study tours

4.3.1 Background

It was intended that potato specialists from the Department of Agriculture, WA were to visit the experimental and demonstration plantings in West Java. These visits were to investigate agronomic management and pest and disease control in the project plantings. The explosions in Bali on 12 October 2002 and subsequent bombings throughout 2003 meant that Australians were advised by DFAT to defer non-essential travel to Indonesian. Instead of these visits another visit to WA by the Indonesian partners was arranged.

4.3.2 March 2003 to WA

A study tour to WA by Indofood staff and farmers was arranged early in the project to allow them to see potato production management practices used for high yielding crops in WA. Travelling to WA were Mr Nazihun Nafzs (Indofood Department Head Agri Business), Mr Bernardus Budi Dharmadi (Indofood Purchasing Manager), Mr Bunyanun Marsus (Production Director, PT Tani Unggul Nusantara) and Insinyur Bunyan Ismail (Junior Agronomist, Hikmah).

4.3.3 November 2003 to WA

In November 2003 Mr Bernardus Budi Dharmadi (Indofood Purchasing Manager) returned with Mr Agus Suranto (Indofood Agronomist, Garut) to attend a de-briefing on the results from the first time-of-planting experiments and demonstrations.

4.3.4 August 2004 to Indonesia

In August 2004 Mr Terry Hill (Manager Horticulture, Department of Agriculture, WA) and Mr Brian Dickson (Operations Manager, Western Potatoes) attended the harvest of experiments of the second time-of-planting.

4.5 Statistical analysis

All statistical analyses were carried out on the data using Genstat statistical software, version 7.

5. Results

5.1 Background

Project delays

The original schedule of this project was affected by terrorist activities. The explosions in Bali on 12 October 2002 and subsequent bombings throughout 2003 meant that Australians were advised by DFAT to defer non-essential travel to Indonesian. Consequently it was not possible for the Australian partners to inspect the experimental and demonstration plantings as planned.

The bombings also meant that the Indonesian partners were concerned about travel to Australia. The result was that the visit to WA by Indofood staff and farmers was delayed for five months and occurred in March 2003 instead of in October 2002.

The first shipment of seed was also delayed, being sent in April 2003 instead of October 2002. This meant that the seed was planted in the dry season 2003 instead of the wet season 2002. The seed was also older than planned by planting time.

It was decided that the second shipment of seed should also be delayed. This was to allow the results of the first shipment to be assessed before planning new work. This was to ensure that lessons learnt form the first time-of-planting could be applied to the second lot of experiments and demonstrations. To evaluate the first time-of-planting experiments and demonstrations two Indofood staff travelled to Australia in November 2003. The delay in the second shipment also ensured that it would be accepted by Indonesian quarantine following their review of quarantine after potato cyst nematode was found in Java in 2003.

Extensions were applied for during the life of the project, the first to 31 May 2004 and the second to 31 October 2004 to accommodate these changes.

Variety experiment.

In the initial proposal we planned to conduct a variety experiment. Seed for this experiment was not available as planned due to the finding of potato virus y in some breeding lines of the WA potato variety evaluation project. It was decided not to release seed from this source until it could all be screened to ensure virus had been eliminated from WA.

5.2 First time-of-planting in Indonesia

5.2.1 Intact and cut seed comparison experiments

5.2.1.1 Seed out-turn

The seed arrived in Jakarta on 5 April 2003. The February 2002 harvested seed had 12 tubers per kilogram. The November 2002 harvested seed averaged 16 tubers per kilogram and had started to sprout on arrival. The seed arrived in good condition. It was distributed to nine farming groups. About 3% of the seed suffered mechanical damage from handling before planting (Table 5.2.1.1).

Table 5.2.1.1. Seed out-turn from first shipment of Alantic.

Farmer/Farmers' Group	Seed received	Damage	
		(kg)	% loss
PD. Hikmah	1,940	60	3
Himalaya, KT	3,753	247	7
Tani Guyub	4,000		
Olan Mandiri, KT	865	9	1
Sobra, KT	1,000		
Bubun Bunyamin	850	150	18
Asep Saepudin	1,000		
Masngudi	800		
Bambang & Tani Sobra	200		
Total	14,408		3

* 135 tubers reported damaged, weight assumed to be 70 grams

5.2.1.2 Seed dust observation

An aim of the project was to compare intact and cut seed. In Australia, proprietary products are available for assisting the curing of cut seed. In Indonesia these products aren't available and so an assessment of two mixtures was made. The effect of seed dusts with differing proportions of Delsene® and cement was observed. The proportions used were either 70% Delsene® (6% carbendazim and 74% mancozeb) with 30% cement or 40% Delsene® with 60% cement. Seed treated with the dust containing the higher percentage of cement dried four days earlier than the seed treated with the other dust (Table 5.2.2.2).

Table 5.2.1.2. Condition of cut-seed treated with different seed dust mixtures 7, 10 and 14 days after cutting.

Treatment	Days after cutting		
	7	10	14
70% Delsene®, 30% cement	wet	wet	dry
40% Delsene®, 60% cement	wet	dry	dry

5.2.1.3 Citiis

Site description

This site was 1,670 metres elevation, soil was a grumosol with pH of 6.9. The site had 30% canopy coverage of trees (see Frontispiece). Rainfall fell seven times early in the life of the crop.

Emergence

Emergence rates were high and are shown in Table 5.2.1.3.1. For the intact seed the percentage emergence reached 100% 30 days after planting. For the cut seed the maximum emergence rate was less and was reached later at 40 days. For the cut seed, the one-eye setts had the higher emergence rate of 93% while the two-eye seed had 89% emergence.

Table 5.2.1.3.1. Emergence percentage of intact and cut seed planted at Citiis. All 960 plants for each treatment were assessed.

Days after planting	Intact seed	Cut seed	
		One-eye	Two-eyes
	Emergence (%)		
10	88	63	61
20	95	81	76
30	100	87	84
40	100	93	89
50	99	93	89

Crop health

Pests observed at Citiis were: thrips, green peach aphid (*Myzus persicae*), potato tuber moth (*Phthorimaea operculella*) and leaf miner (*Liriomyza huidobrensis*). Diseases seen were late blight (*Phytophthora infestans*), common scab (*Streptomyces scabies*) and bacterial wilt (*Ralstonia solanacearum*, formerly *Pseudomonas solanacearum*).

Yield

Yield of the Citiis site was high with a mean yield of 28 t/ha (Table 5.2.1.3.2). Intact seed produced the highest total yield of 31.2 t/ha. Cut seed with two eyes produced significantly lower yield ($P<0.05$) but the yield was still high for Atlantic in Indonesia at 27.1 t/ha. Significantly lower still ($P<0.05$) was yield of one-eyed cut seed with 24.6 t/ha. The yield decline from intact seed to two-eyed seed to one-eyed seed may reflect a density effect. The intact seed would be expected to have the most number of stems while the two-eyed seed could be expected to have more stems than the one-eyed seed. The yield of cut seed may increase if the density is increased.

Table 5.2.1.3.2. Yield of intact and cut seed at Citiis. Yield shown both as grams per plant (preferred Indonesian units) and tonnes per hectare.

Treatment	Yield (g/plant)				Tubers per plant
	Seed 25-50 mm	Crisp >50 mm	Reject	Total	
Intact seed	47	956	38	1,041	10.6
Cut seed 2 eyes	75	824	4	903	10.4
Cut seed 1 eye	70	739	11	821	9.2
Significance	ns	***	*	***	ns
l.s.d. (*P*=0.05)	44	50	24	60	2.0
	Yield* (t/ha)				
Intact seed	1.4	28.7	1.1	31.2	
Cut seed 2 eyes	2.3	24.7	0.1	27.1	
Cut seed 1 eye	2.1	22.2	0.3	24.6	

* assuming 30,000 plants per hectare.
* Mean total yield for site was 27.7 t/ha

5.2.1.4 Cicarenang

Site description

This site was 1,520 metres elevation, soil was a brown podsol with pH of 6.7. The site had no over storey of trees. Rainfall fell six times with 7 to 10 days between falls early in the crop.

Emergence

Emergence rates were high and are shown in Table 5.2.1.4.1. For the intact seed the percentage emergence reached 98% 20 days after planting. For the cut seed the maximum emergence rates were similar and were reached also at 20 days. For the cut seed the one-eye setts had the lower emergence rate at 20 days of 94% while the two-eye seed had 98% emergence.

Table 5.2.1.4.1. Emergence percentage of intact and cut seed planted at Cicarenang. All 960 plants for each treatment were assessed.

Days after planting	Intact seed	Cut seed	
		One-eye	Two-eyes
	Emergence (%)		
10	76	76	76
20	98	94	98
30	98	95	98
40	99	96	98
50	99	97	97

Crop health

Pests and diseases were the same as for the Citiis site.

Yield

The yield of the Cicarenang site was nearly as high as the Citiis site high with a mean yield of 27 t/ha (Table 5.2.1.4.2). Intact seed again produced the highest total yield (31.9 t/ha) followed by cut seed with two eyes (26.4 t/ha) then one-eyed cut seed (22.2 t/ha). Again the yield decline from intact seed to two-eye seed to one-eyed seed may reflect a density effect.

Table 5.2.1.4.2. Yield of intact and cut seed at Cicarenang. Yield shown as grams per plant (preferred Indonesian units) and tonnes per hectare.

Treatment	Yield (g/plant)				Tubers per plant
	Seed 25-50 mm	Crisp >50 mm	Reject	Total	
Intact seed	45	959	58	1,062	9.2
Cut seed 2 eyes	56	808	15	879	9.2
Cut seed 1 eye	41	686	12	739	6.8
Significance	ns	**	ns	**	*
l.s.d. (*P*=0.05)	26	114	44	126	2.0
	Yield* (t/ha)				
Intact seed	1.3	28.8	1.7	31.9	
Cut seed 2 eyes	1.7	24.2	0.5	26.4	
Cut seed 1 eye	1.2	20.6	0.3	22.2	

* assuming 30,000 plants per hectare.

* Mean total yield for site was 26.8 t/ha

5.2.2 Seed socialisation

The seed was distributed to 11 sites. Two of these were the experimental sites: PD Hikmah and Tani Guyab at Citiis. The amount of seed distributed and the locations are shown in Table 5.2.2.

Tato Sugianto, Field Supervisor for Indofood Frito-Lay, reported:

Seed size

Farmers at Pangalengan thought the quality of the seed was good when delivered but were disappointed because the seed size was larger than their preferred 20 tubers per kilogram. The seed from WA averages 12-16 tubers per kilogram depending on the source (Section 5.2.2.1). Farmers at Masngudi (Dieng-Central Java) also thought the size of seed must be reduced (minimum 17-20 tubers/kilogram).

Seed condition

Farmers at Pangalengan thought that the percentage of seed damage could be reduced. Most damage was mechanical from the loading and unloading process. Farmers suggested packaging using wooden crates would be better although but jute was still satisfactory.

Seed performance

Farmers at Himalaya, Hikmah, and Tani Guyub (Pangalengan) thought the condition of the seed at planting was good. Susceptibility with late blight was low because plantings were in the dry season. The farmers hope to test the susceptibility to late blight in the next wet season. Productivity per hectare was satisfactory and the round tuber shape was very good for processing. Farmers at Dieng also thought the quality of seed and productivity per hectare was good. They found that intact seed gave twice the yield of cut seed under the same conditions and treatment. Farmers at Garut generally had the same opinion about potato seed from WA as the farmers from Pangalengan and Dieng.

Bunyan Ismail (Junior Agronomist Hikmah), from a family with large potato plantations at Pangalengen, reported:
We received 1940 kg seed from Western Potatoes in April 2003. The seed came from Smith (G3, 480 kg), Terrigno (G3, 1260 kg) and Pessotto (G5, 200 kg). Half was planted on 10 May 2003 on furrow irrigated land with the following treatments: normal, de-sprouting, and cut seed. The other half will be planted in our isolated seed growing area under sprinkler irrigation.

Results from this planting were:

- Smith seed (younger seed) seems to grows more vigorous than the other two (at 2 weeks it was already homogenous (closed).
- Normal seeds grow more homogeneously than de-sprouted seed with a non-significant number of stems (2-5 stems/tuber).
- Rate of rotting (*Erwinia carotovora*) from cut seed were: Smith 8%, Terrigno 16%, and Pessotto 18% (N=300 tubers or 600 plants). All Smith seed was cut in half in 2 days before planting, but for Pessotto and Terrigno a quarter of the seed was cut in the field.
- Harvest occurred in August 2003 with an average yield of 25 t/ha but with a high percentage of bad potatoes compared to Granola in the same paddock and at the same

time planting which yielded 32 t/ha. The "bad potato" was due to the site being "rich" in bacterial wilt inoculant. The site had high levels of inoculant because it had been used to grow potato every year for a couple dozen years and the irrigation water that was being used came from other people's field. So the "bad potato" problems is not really due to the WA seed.
- The de-sprouted seed gave more yield in general.
- Seed from Pessotto (G5) which had the higher levels of rotting (bacterial wilt) was caused by its location in the wettest part of the field.
- Overall they were satisfied with the result.

Yield variability in demonstrations

Table 5.2.2 shows the variability in yield from the demonstrations. At Hikmah one planting produced the very high total yield of 43.8 t/ha of which 37.1 t/ha were of processing grade. Other yields in this Table vary from 12 t/ha to 22 t/ha.

Field day

Indofood organised a successful field day at Garut. The day coincided with the harvest of the demonstration plots, with the trial due for harvest in about 2 weeks time. The trial site has a good water supply and estimates of the yield from the demo plots ranged from 22-30 t/ha.

About 40 farmers attended as well as about 8 staff from the local Department of Agriculture and Indofood's field staff (including Pak Suranto from Garut and Pak Tato from Pangalengan).

Some participants had a wide ranging discussion afterwards which involved the Indofood representatives, the local Dupont representative, the Department of Agriculture and one of the farmers who visited WA, (Mr Bunjan). The main concerns were:
- Quality of seed, not as good as ex Scotland.
- It is important to have seed available for September planting; this planting window allows the crop to be grown in the early part of the wet season when it isn't too wet.
- An interest in testing any new processing varieties that will be easier to grow in the wet season than Atlantic
- They think that a next step in the research program could be some work looking at nutrition to ensure the correct balance of fertilisers is being applied.

Table 5.2.2. Seed distribution to experimental and demonstration sites in Java, April 2003. Some yield and quality data are shown.

	Farmer & location	Activity	Seed received (kg)	Yield* (kg/30 plants = t/ha)				Quality		Notes
				Seed (25-50 mm)	Crisp (>50 mm)	Reject	Total	Specific gravity	Defects (%)	
Pangalengen										
1	PD. Hikmah	Experimental & demo	1,940	3.7	37.1	3	43.8	1.080	7†	Furrow irrigated
2	Himalaya, KT	Demonstration	3,753							Sprinkler irrigation but crop is water stressed
Garut										
3	Tani Guyub, Citiis	Experimental & demo	4,000							32 farmers in group. Irrigated with good growth.
4	Olan Mandiri, KT (Pak Iwan)	Demonstration	865							Shallow soil, water stressed
5	Sobra, KT	Demonstration	1,000							
6	Bubun Bunyamin Garut	Demonstration	850							
7	Asep Saepudin	Demonstration	1,000							
Other										
8	Masngudi Dieng Central Java	Demonstration of cut & intact seed.	800	1.2	8.8	1.9	12.0	1.090		cut seed
				1.2	18.1	2.7	22.0	1.089		intact seed
9	Bambang & Tani Sobra Gumpelem	Demonstration	200	2.3	11.1	2.5	16.0	1.082	50‡	
	Total		14,408							

* data was collected as kg per 30 plants, this equals tonnes per ha assuming a density of 30,000 plants per hectare.
† stem end rot
‡ hollow heart

5.3 Second time-of-planting in Indonesia

The seed from WA for this planting had been held on the wharf by Indonesian customs for 5 weeks, before release to the growers, and as such was old and in relatively poor condition.

5.3.1. Intact and cut seed and density experiments.

5.3.1.1. Crop establishment and growth

Emergence

There was no difference in percentage emergence between cut and intact seed at either Garut or Himalaya 1 (Tables 5.3.1.1a & b). However the percentage emergence of intact seed was significantly higher than cut seed treatments at Lembang and Himalaya 2 (Tables 5.3.1.1c & d) but the magnitude of these differences was not great. At Lembang intact seed had 100% emergence while cut seed had 96% emergence.

The relationship between the percentage emergence and spacing was variable. For example at Himalaya 1 (Table 5.3.1.1b) and Lembang (Table 5.3.1.1c) emergence was highest at the closest spacing (70 x 20 cm) whilst at Himalaya 2 (Table 5.3.1.1d) emergence was lowest at the closest spacing. At Garut there was no significant difference in percentage emergence between spacings (Table 5.3.1.1a).

Density

The density of the crop (plant and stem number/m^2) generally increased with planting density and emergence %. For example at all sites plants/m^2 or stems/m^2 was highest (P<0.01 to 0.001) at the closest spacing (Tables 5.3.1.1 a to d) in both cut and intact seed treatments. Plants/m^2 and stems/m^2 was only significantly higher in the 80 x 25cm compared with the 70 x 30cm treatment at Lembang (Table 5.3.1.1c) whilst at the other three sites there was no significant difference.

The effect of seed treatment on the density of the crop was variable. Plants/m^2 and stems/m^2 were higher (P<0.05) in the intact compared with cut seed treatments at Himalaya 2 (Table 5.3.1.1d). At Lembang plants/m^2 was also higher (P<0.001) in the intact seed treatment (Table 5.3.1.1c) but there was no difference in stems/m^2 between seed treatments at this site. There was no effect of seed treatment on plant or stem density at Garut (Table 5.3.1.1a) or Himalaya 1 (Table 5.3.1.1b).

Neither seed treatment nor plant spacing had any effect on the number of stems per plant at Garut or Himalaya 1 (Tables 5.3.1.2 a&b). At Lembang stems/plant decreased as density decreased (P<0.01, 0.001) and we can offer no explanation for this effect. At Himalaya 2 stems/plant was higher (P<0.05) in the intact compared with the cut seed treatment.

Tuber number/plant increased as planting density (spacing increased) decreased at Himalaya 1 and Lembang but the increase was not significant at Garut or Himalaya 2.

Table 5.3.1.1a. Growth of Atlantic using WA intact or cut seed at different spacings (cm between-row x cm in-row). Planted 28 March 2004, senesced 7 June 2004. 71 days to senescence. Harvested 6 July 2004.
Location: Garut.

Seed treatment	Spacing (cm x cm)	Emergence (%)	Plants per m^2	Stems per m^2	Stems per plant	Tubers per plant
Intact	70 x 20	82	5.6	16.7	2.9	6.6
	80 x 25	73	3.4	10.8	3.2	7.1
	70 x 30	88	4.0	11.7	2.9	6.5
Cut	70 x 20	84	5.8	16.7	2.9	5.7
	80 x 25	80	3.7	12.0	3.2	5.9
	70 x 30	86	3.9	12.6	3.2	6.4
Significance	Seed trt.	(ns)	(ns)	(ns)	(ns)	(ns)
	Space	(ns)	***	***	(ns)	(ns)
	Sd. x Sp.	(ns)	(ns)	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	-	0.4	1.2	-	-
(*P*=0.05)	Space	-	0.5	1.5	-	-
	Sd. x Sp.	-	0.7	2.0	-	-

Table 5.3.1.1b. Growth of Atlantic using WA intact or cut seed at different spacings (cm between-row x cm in-row). Planted 3 April 2004, senesced 27 June 2004. 85 days to senescence. Harvested 10 July 2004
Location: Himalaya 1.

Seed treatment	Spacing (cm x cm)	Emergence (%)	Plants per m^2	Stems per m^2	Stems per plant	Tubers per plant
Intact	70 x 20	91	6.3	16.2	2.6	5.4
	80 x 25	75	3.5	8.9	2.5	8.2
	70 x 30	83	3.8	7.9	2.1	5.9
Cut	70 x 20	86	5.9	15.0	2.5	4.2
	80 x 25	67	3.1	7.8	2.6	10.1
	70 x 30	77	3.5	9.1	2.7	7.9
Significance	Seed trt.	(ns)	(ns)	(ns)	(ns)	(ns)
	Space	*	***	***	(ns)	***
	Sd. x Sp.	(ns)	(ns)	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	1.1	0.5	2.3	-	1.3
(*P*=0.05)	Space	1.3	0.6	2.8	-	1.6
	Sd. x Sp.	1.8	0.8	4.0	-	2.3

Table 5.3.1.1c. Growth of Atlantic using WA intact or cut seed at different spacings (cm between-row x cm in-row). Planted 10 April 2004, senesced 4 June 2004. 55 days to senescence. Harvested 26 July 2004.
Location: Lembang.

Seed treatment	Spacing (cm x cm)	Emergence (%)	Plants per m^2	Stems per m^2	Stems per plant	Tubers per plant
Intact	70 x 20	100	6.9	24.6	3.6	5.4
	80 x 25	100	4.7	16.6	3.5	6.5
	70 x 30	100	4.6	12.8	2.8	7.5
Cut	70 x 20	98	6.7	25.6	3.8	6.7
	80 x 25	97	4.5	17.8	3.9	9.3
	70 x 30	92	4.2	14.4	3.4	8.9
Significance	Seed trt.	***	***	(ns)	**	*
	Space	**	***	***	***	*
	Sd. x Sp.	**	*	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	1.5	0.04	1.4	0.24	1.5
(*P*=0.05)	Space	1.8	0.03	1.8	0.29	1.8
	Sd. x Sp.	2.5	0.06	2.5	0.42	2.6

Table 5.3.1.1d. Growth of Atlantic using WA intact or cut seed at different spacings (cm between-row x cm in-row). Planted 16 April 2004, senesced 15 June 2004. 60 days to senescence. Harvested 15 July 2004.
Location: Himalaya 2.

Seed treatment	Spacing (cm x cm)	Emergence (%)	Plants per m^2	Stems per m^2	Stems per plant	Tubers per plant
Intact	70 x 20	74	5.1	18.1	3.6	5.2
	80 x 25	85	4.0	8.9	2.3	5.6
	70 x 30	86	3.9	10.7	2.8	5.7
Cut	70 x 20	74	5.0	11.2	2.2	5.1
	80 x 25	80	3.8	9.4	2.5	5.2
	70 x 30	79	3.6	8.1	2.2	6.5
Significance	Seed trt.	*	*	*	*	(ns)
	Space	***	***	**	(ns)	(ns)
	Sd. x Sp.	(ns)	(ns)	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	3.6	0.18	2.5	0.5	-
(*P*=0.05)	Space	4.4	0.22	3.0	0.7	-
	Sd. x Sp.	6.3	0.32	4.3	1.0	-

Growing period

The length of the growing period varied markedly with site. The crop senesced only 55 days after planting (DAP) at Lembang, 60 DAP at Himalaya 2 and 71 DAP at Garut. At the other site, Himalaya 1, the crop lived longest, senescing 85 DAP. The crop was curtailed at the first three mentioned sites due to heavy infestations of late blight (*Phtytophthora infestans*). Harvest occurred on 6 July 2004 (Garut), 10 July 2004 (Himalaya 1), 15 July 2004 (Himalaya 2) and 26 July 2004 (Lembang).

5.3.1.2 Yield and quality

Yield

Total yield at Garut ranged from 12.0 to 19.1 t/ha (depending on treatment) and was higher (P<0.05-0.01) in the intact seed compared with cut seed treatment at 70 x 20 cm and 70 x 30 cm but not in the 80 x 25 cm spacing (Table 5.3.1.2a). Yield of small (<50mm) tubers increased (P<0.001) as spacing decreased (density increased) in both seed treatments whilst there was no effect of either spacing or seed treatment on crisp (50-70mm) yield and there were no oversize (>70mm) tubers. The overall mean total yield for the site was 13.9 t/ha and the crop senesced 71 days after planting (DAP).

Table 5.3.1.2a. Yield of Atlantic using intact and cut WA seed at three spacing s (cm between-row x cm in-row). Planted 28 March 2004, senesced 7 June 2004. 71 days to senescence. Harvested 6 July 2004.
Location: Garut.

Seed treatment	Spacing (cm x cm)	Yield (t/ha)					Quality	
		Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
Intact	70 x 20	6.8	11.7	0	1.0	19.1	1.084	63.7
	80 x 25	2.5	9.5	0	0.6	12.4	1.084	64.7
	70 x 30	3.0	11.0	0	0.5	14.3	1.086	64.0
Cut	70 x 20	2.7	9.9	0	0.7	13.0	1.083	63.3
	80 x 25	1.8	10.7	0	0.5	12.9	1.085	64.5
	70 x 30	1.7	9.8	0	0.9	12.0	1.086	64.1
Significance	Seed trt.	***	(ns)	-	(ns)	**	(ns)	(ns)
	Space	***	(ns)	-	*	*	(ns)	*
	Sd. x Sp.	*	(ns)	-	**	*	(ns)	(ns)
l.s.d.s	Seed trt.	1.0	-	-	0.2	1.7	-	0.4
(P=0.05)	Space	1.2	-	-	0.2	2.1	-	0.5
	Sd. x Sp.	1.7	-	-	0.3	2.9	-	0.7

* Mean total yield for site was 13.9 t/ha

Total yield at Himalaya 1 ranged from 18.8 to 32.1 t/ha and was higher (P<0.05-0.01) in the intact seed compared with cut seed treatment at 70 x 20 cm but lower at the 70 x 30 cm and 80 x 25 cm spacing (Table 5.3.1.2b). Yield of crisp (50-70mm) tubers increased (P<0.05) as spacing decreased (density increased) in the intact seed treatment but not the cut seed treatment where crisp yield was highest at the 80 x 25cm spacing. Yield of oversize tubers (>70mm) increased ($P<0.05$) with increased spacing (decreased density) in the cut but not the intact seed (increase not significant) treatment. There was no effect of either spacing or seed treatment on yield of small (50-70mm) tubers. The overall mean total yield for the site was 26.0 t/ha and the crop senesced 85 DAP.

Table 5.3.1.2b. Yield of Atlantic using intact and cut WA seed at three spacing s (cm between-row x cm in-row). Planted 3 April 2004, senesced 27 June 2004. 85 days to senescence. Harvested 10 July 2004
Location: Himalaya 1.

Seed treatment	Spacing (cm x cm)	Yield (t/ha)					Quality	
		Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
Intact	70 x 20	4.5	13.1	10.7	3.9	32.1	1.086	61.9
"	80 x 25	4.2	7.5	11.1	2.9	25.6	1.085	62.0
"	70 x 30	2.2	6.8	11.5	4.4	24.8	1.084	62.1
Cut	70 x 20	2.9	6.1	5.9	3.9	18.8	1.087	63.0
"	80 x 25	2.8	9.6	9.9	5.9	28.3	1.087	61.5
"	70 x 30	3.1	6.8	13.9	2.3	26.0	1.087	62.2
Significance	Seed trt.	(ns)	(ns)	(ns)	(ns)	(ns)	*	(ns)
	Space	(ns)	*	*	(ns)	*	(ns)	(ns)
	Sd. x Sp.	(ns)	**	(ns)	**	**	(ns)	(ns)
l.s.d.s	Seed trt.	-	1.9	2.9	1.2	3.3	0.0015	-
(P=0.05)	Space	-	2.4	3.5	1.5	4.0	0.0018	-
	Sd. x Sp.	-	3.3	4.9	2.1	5.7	0.0027	-

*Mean total yield for site 26.0 t/ha

Total yield at Lembang ranged from 10.3 to 13.7 t/ha but was not significantly affected by seed treatment or spacing (Table 5.2.1.2c). Yield of small (<50mm) tubers was higher ($P<0.001$) in the cut versus intact seed treatment, at all spacings, whilst yield of crisp tubers (50-70mm) was higher ($P<0.05$) in the intact seed treatment also at all spacings. There was no effect of either spacing or seed treatment on yield of oversize (>70mm) tubers and no effect of spacing on yield in any size grade. The overall mean total yield for the site was 12.6 t/ha and the crop senesced 55 DAP.

Table 5.3.1.2c. Yield of Atlantic using intact and cut WA seed at three spacing s (cm between-row x cm in-row). Planted 10 April 2004, senesced 4 June 2004. 55 days to senescence. Harvested 26 July 2004.
Location: Lembang.

Seed treatment	Spacing (cm x cm)	Yield (t/ha)					Quality	
		Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
Intact	70 x 20	7.6	5.6	0.2	0.1	13.5	1.080	62.9
	80 x 25	6.7	5.4	0.2	0.0	12.3	1.082	62.6
	70 x 30	7.7	4.6	0.3	0.1	12.7	1.080	62.4
Cut	70 x 20	10.4	2.5	0.0	0.0	12.9	1.081	63.0
	80 x 25	9.1	4.3	0.2	0.2	13.7	1.081	61.4
	70 x 30	8.2	1.9	0.0	0.2	10.3	1.082	64.0
Significance	Seed trt.	***	*	(ns)	(ns)	(ns)	(ns)	(ns)
	Space	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)
	Sd. x Sp.	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	1.1	2.4	-	-	-	-	-
(*P*=0.05)	Space	1.3	2.9	-	-	-	-	-
	Sd. x Sp.	1.9	4.2	-	-	-	-	-

*Mean total yield for site was 12.6 t/ha

Total yield at Himalaya 2 ranged from 10.5 to 12.9 t/ha but was not significantly affected by seed treatment or spacing (Table 5.3.1.2d). Yield of small (<50mm) tubers was higher ($P<0.05$) in the cut versus intact seed treatment at 70 x 20cm and 70 x 30 cm but lower in the cut seed treatment at 80 x 25cm spacing. There was no effect of seed treatment or spacing on the yield of crisp (50-70mm) or reject tubers and there were no oversize (>70mm) tubers. The overall mean total yield for the site was 11.6 t/ha and the crop senesced 60 days DAP.

Table 5.3.1.2d. Yield of Atlantic using intact and cut WA seed at three spacing s (cm between-row x cm in-row). Planted 16 April 2004, senesced 15 June 2004. 60 days to senescence. Harvested 15 July 2004
Location: Himalaya 2.

Seed treatment	Spacing (cm x cm)	Yield (t/ha)					Quality	
		Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
Intact	70 x 20	5.7	6.5	0	0.6	12.9	1.086	63.4
	80 x 25	5.0	5.1	0	0.4	10.5	1.087	61.9
	70 x 30	4.6	5.9	0	0.3	10.8	1.087	62.2
Cut	70 x 20	7.1	5.2	0	0.5	12.8	1.087	61.4
	80 x 25	4.6	6.2	0	0.3	11.1	1.088	61.1
	70 x 30	5.2	6.5	0	0.1	11.8	1.088	62.6
Significance	Seed trt.	(ns)	(ns)	-	(ns)	(ns)	(ns)	(ns)
	Space	*	(ns)	-	(ns)	(ns)	(ns)	(ns)
	Sd. x Sp.	(ns)	(ns)	-	(ns)	(ns)	(ns)	(ns)
l.s.d.s	Seed trt.	1.1	0.8	-	-	-	-	-
(P=0.05)	Space	1.3	1.0	-	-	-	-	-
	Sd. x Sp.	1.9	1.4	-	-	-	-	-

*Mean total yield for site was 11.6 t/ha

Quality

Specific gravity

There was no effect of seed treatment or spacing on specific gravity at Garut, Lembang or Himalaya 2 (Table 5.3.1.2a, c and d) but specific gravity was higher (P<0.05) in the cut seed versus intact seed treatment at Himalaya 1 (Table 5.3.1.2b).

Crisp colour

There was no effect of seed treatment or spacing on cooking colour (Agtron) at Himalaya 1 or 2 or at Lembang (Tables 5.3.1.2b, d & c). At Garut spacing had a significant effect on crisp colour. Colour was darkest (Agtron reading lowest) (P<0.05) at 70 x 20 cm and lightest at 80 x 25 cm spacing in both seed treatments (Table 5.3.1.2a). The difference in colour between spacing treatments was very low and not of practical importance.

5.3.2. Seed age and source experiments

5.3.2.1 Crop establishment

The crops senesced 71 DAP at Garut, 85 DAP at Himalaya 1, 55 DAP at Lembang and 68 DAP at Himalaya 2 (Tables 5.3.2.1a-d). Harvest occurred on the 6 July 2004 (Garut), 10 July 2004 (Himalaya 1), 26 July 2004 (Lembang) and 15 July 2004 (Himalaya 2).

Emergence as lower (P<0.05 – 0.001) in the WA-April seed (older seed) was compared with WA-August seed (younger seed) at Garut and Himalaya 2 (Tables 5.3.2.1a & d). At Garut WA-April seed had just 48% emergence compared with WA-August emergence of 76%. At

Himilaya 2 emergence of WA-April seed was 77% while WA-August seed was 93%. Emergence of the WA-April seed (74%) was lower than all seed sources {WA-August (93%), WA-Java (95%) and Scottish seed (100%)} at Lembang (Table 5.2.2.1a, c & d). There was no difference in emergence between WA-April and WA-August seed at Himalaya 1 (Table 5.3.2.1b).

Plants/m^2 was lower (P< 0.05, 0.001) in WA-April compared with other seed sources at Lembang and Himalaya 2 but there was no difference at Garut and Himalaya 1. Stems/m^2 was higher (P<0.05) in WA-April compared with WA-August seed at Garut but not significantly different at Himalaya 1 and 2. Stems/m^2 was higher (P<0.05) in WA-August compared with the other three seed sources at Lembang. Stems/plant and tubers/plant were higher (P<0.05-0.01) in WA-April compared with WA-August seed at Garut and Himalaya 2 and higher than the three other seed sources at Lembang (P<0.01-0.001) but not significantly different to WA-August seed at Himalaya 1.

Table 5.3.2.1.a. Growth of Atlantic from different seed sources. Seed sources: directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 28 March 2004, senesced 6 June 2004. 71 days to senescence. Harvested 6 July 2004.
Location: Garut.

Seed source	Emergence (%)	Density (plants/m^2)	Density (stems/m^2)	Stems per plant	Tubers per plant
WA-April	48	3.7	11.6	3.5	6.4
WA-August	76	3.7	7.4	2.1	4.3
Significance	***	ns	*	**	*
l.s.d. (P=0.05)	5.9	-	2.7	0.7	1.7

Table 5.3.2.1.b. Growth of Atlantic from different seed sources. Seed sources: directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 3 April 2004, senesced 26 June 2004. 85 days to senescence. Harvested 10 July 2004.
Location: Himalaya 1.

Seed source	Emergence (%)	Density (plants/m^2)	Density (stems/m^2)	Stems per plant	Tubers per plant
WA-April	90	4.1	11.3	2.8	6.6
WA-August	99	4.5	10.9	2.4	6.7
Significance	ns	ns	ns	ns	ns
l.s.d. (P=0.05)	-	-	-	-	-

Table 5.3.2.1.c. Growth of Atlantic from different seed sources. Seed sources: directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August), grown once in Java after importation from WA (WA-Java) and Scotland (imported directly from Scotland). Planted 10 April 2004, senesced 3 June 2004. 55 days to senescence. Harvested 26 July 2004.
Location: Lembang.

Seed source	Emergence (%)	Density		Stems per plant	Tubers per plant
		(plants/m^2)	(stems/m^2)		
WA-April	74	3.4	13.8	4.1	7.8
WA-August	100	4.6	17.0	3.7	7.1
WA-Java	95	4.4	14.2	3.3	6.4
Scotland	100	4.6	14.4	3.2	6.2
Significance	***	***	*	***	**
l.s.d. (*P*=0.05)	7.4	0.34	2.4	0.45	0.7

Table 5.3.2.1.d. Growth of Atlantic from different seed sources. Seed sources: directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 16 April 2004, senesced 22 June 2004. 68 days to senescence. Harvested 15 July 2004.
Location: Himalaya 2.

Seed source	Emergence (%)	Density		Stems per plant	Tubers per plant
		(plants/m^2)	(stems/m^2)		
WA-April	77	3.5	10.7	3.1	7.0
WA-August	93	4.3	7.2	1.7	3.6
Significance	*	*	ns	*	**
l.s.d. (*P*=0.05)	10	0.45	-	1.4	1.4

5.3.2.2 Yield and quality

There was no significant difference in total yield between WA-April and WA-August seed sources at any site although there was a trend to higher total yield in WA-August seed at Garut ($P<0.08$), Himalaya 1 and Lembang (Tables 5.3.2.2a, b & c) but not at Himalaya 2 (Table 5.3.2.2d). Yields of small tubers (<50mm) were higher ($P<0.05$) in the WA-April seed compared with WA-August seed at Garut but not other sites. At Lembang highest total yield ($P<0.05$) was from the Scottish seed and the WA-Java seed. Total yield was lowest from the WA-April seed and the WA-August seed. The higher total yields were mainly due to higher yields of larger tubers (>70mm) not processing tubers (50-70mm). There was no effect of seed source on specific gravity or cooking colour of tubers at any site.

Table 5.3.2.2.a. Yield of Atlantic from different seed sources. Seed used was directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 28 March 2004, senesced 6 June 2004. 71 days to senescence. Harvested 6 July 2004.
Location: Garut.

Seed source	Yield (t/ha)					Quality	
	Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
WA-April	1.48	10.97	0	0.45	13.25	1.087	63.19
WA-August	0.68	12.88	0	1.49	16.18	1.084	63.82
Significance	**	0.08		(ns)	0.08	(ns)	0.09
l.s.d. (0.05)	0.4	2.34		-	3.3	-	0.82

*The mean total yield for the site was 14.7 t/ha

Table 5.3.2.2.b. Yield of Atlantic from different seed sources. Seed used was directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 3 April 2004, senesced 26 June 2004. 85 days to senescence. Harvested 10 July 2004.
Location: Himalaya 1.

Seed source	Yield (t/ha)					Quality	
	Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
WA-April	3.2	6.9	10.3	5.4	25.8	1.084	62.9
WA-August	4.2	7.2	13.3	5.1	29.8	1.084	61.9
Significance	Ns	ns	ns	ns	ns	ns	ns
l.s.d. (0.05)	3.1	7.8	9.1	2.8	6.1		

*The mean total yield for the site was 27.8 t/ha

Table 5.3.2.2.c. Yield of Atlantic from different seed sources. Seed used was: directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August), grown once in Java after importation from WA (WA-Java) and Scotland (imported directly from Scotland). Planted 10 April 2004, senesced 3 June 2004. %5 days to senescence. Harvested 26 July 2004.
Location: Lembang.

Seed source	Yield (t/ha)					Quality	
	Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
WA-April	6.4	7.1	1.0	0.0	14.4	1.085	
WA-August	5.0	10.6	2.8	0.4	18.7	1.084	
WA-Java	3.1	10.1	8.4	0.1	21.7	1.084	
Scottish	3.8	14.4	12.8	0.0	31.0	1.084	
Significance	(ns)	0.08	***	(ns)	*	(ns)	
l.s.d.(0.05)	-	5.5	4.4	0.49	11.5	-	

*The mean total yield for the site was 21.5 t/ha

Table 5.3.2.2.d. Yield of Atlantic from different seed sources. Seed used was directly imported from Western Australia being harvested in April (WA-April) or August 2003 (WA-August). Planted 16 April 2004, senesced 22 June 2004. 68 days to senescence. Harvested 15 July 2004.
Location: Himalaya 2.

Seed source	Yield (t/ha)					Quality	
	Seed grade (<50mm)	Crisp grade (50-70 mm)	Over -size (>70mm)	Reject	Total*	Specific gravity	Colour (Agtron)
WA-April	4.1	6.5	-	0.7	11.3	1.087	61.2
WA-August	3.0	6.9	-	0.7	10.7	1.087	63.5
Significance	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)	(ns)
l.s.d. (0.05)	-	-	-	-	-	-	-

*The mean total yield for the site was 11.0 t/ha

5.3.3. Seed socialisation, second time-of-plantings

The seed from WA for the second time-of-planting had been held on the wharf by Indonesian customs for 5 weeks, before release to the growers, and as such was old and in relatively poor condition. However, the trail plots at Pangalengan looked promising and an Indonesian agronomist (Pak Budi Prihanto from TUNAS) commented that the local farmers had developed confidence in WA seed, as even with the problems at the wharf the seed performed reasonably well. He reported that the farmers now know that they will still get a crop from old seed and this lowers the risk of using imported seed.

Further reports from farmers' demonstration of the second time-of-planting were not available by the due date for this report.

5.4 Study tours

The first study tour allowed the Indonesian partners to see how high yielding crops in WA were managed. The visitors were most interested in the fertiliser programs used by farmers in WA. We were able to stress to them that the fertiliser programs used are just one part of the farmers integrated management and their benefit depends upon irrigation inputs.

The second study tour allowed the review of the first time-of-planting results and the planning of the second time-of-planting experiments. The results of these planning sessions were reported in the previous section (Section 5.3). This visit also enabled Indofood staff to discuss future seed potato requirements with Western Potatoes and other industry stakeholders.

The visit to Indonesia allowed the results of the second time-of-planting to be seen and for the data from these plantings to be compiled. This last visit was also aimed at demonstrating that Department of Agriculture, WA staff can travel safely in West Java. However the subsequent bombing at the Australian Embassy in Jakarta will now delay further approval for travel.

Discussion

6.1. Introduction

6.1.1 Seed size

The cost of seed is a major concern to farmers in West Java as it comprises 33% of their variable costs (Adiyoga *et al*. 1999). West Javanese farmers usually plant 30,000 seed tubers per hectare. As they pay for seed by weight they prefer small seed tuber size. At least 20 seed pieces per kilogram are sought. It is important the cost of seed per hectare is less than 17 million rupiahs ($2,500 AUD)(Sugianto pers. comm.). At 30,000 plants per hectare with 20 seed pieces per kilogram 1,500 kg of seed is required to plant one hectare. So seed needs to be supplied to the farmer at $2,500 AUD per hectare.

Australian exporters may find it difficult to supply all export seed tubers of Atlantic in the desired size of 50 grams. One solution is to supply larger seed for cutting. However it is not common practice to cut seed in the tropics, as there is a large risk of increased rotting. Farmers participating in the demonstration plantings said they weren't encouraged to cut seed because they worried about rotting from soil-borne wilt diseases (*Fusarium* and bacterial wilt) (Sugianto pers. comm.). However we have found in other regions that the rotting of cut seed has more to do with the condition of the seed rather than the environment into which it is planted. In Vietnam we found that freshly imported seed consistently produced the same high yields as intact seed (McPharlin *et al*. 2003).

It is therefore important to determine whether the use cut seed could be developed for use in West Java.

6.2. The performance of cut seed in West Java

6.2.1 Seed dust

Seed treated with a dust containing 40% Delsene® with 60% cement dried four days earlier than the seed treated with the other dust (Table 5.2.2.2). The dust with the higher cement concentration was more like the seed dust used in Australia where the active ingredient (mancozeb) is around 20% active and the rest is carrier or drying agent. These agents are mostly talcum powder and clay but sometimes fir bark is added to aid curing in wetter region like Victoria and Tasmania.

6.2.2 Yield and quality response of Atlantic to planting density and seed treatment (cut versus intact seed)

First time-of-planting

The two first time-of-planting experiments showed that cut seed had high emergence rates and high yields. However both emergence rate and the yield was less than that of intact seed. At Citiis the intact seed had 100% emergence (Table 5.2.2.3.2.1) and produced 29 t/ha (Table 5.2.2.3.2). Cut seed had 89-93% emergence and produced 22 to 25 t/ha. Average yields in West Java are 16.7 t/ha (Baden Pusat Statisik). The potential of the seed from WA is greater than shown in these experiments because at the Hikmah demonstration a yield of 43.8 t/ha was measured (Table 5.2.2).

At Cicarenang emergence of both intact and cut seed was similar (Table 5.2.2.4.1) but yield of the cut seed was lower than that of intact seed. Also at both sites crisp and total yield of one-eye cut seed was significantly lower that that of two-eyed seed. The intact seed would be expected to have the most number of stems while the two-eyed seed could be expected to have more stems than the one-eyed seed.

The yield reduction of cut seed shown in the first time-of-planting may be related to the density of the sprouts. Intact seed that is past the dormant stage would be expected to produce more stems per plant than the cut seed due to its greater number of eyes. Similarly two-eyed seed would be expected to produce more stems per plant that the one-eyed seed. Therefore the reduced yield of cut seed may be a factor of sub-optimal stem density. Cut seed may be able to produce higher yields if its density is increased so that stem numbers become equivalent to those of intact seed.

Second time-of-planting

This hypothesis was tested in the second time-of-planting. Here the yield response of cut seed to density was variable. Before the effect of seed cutting is discussed the over-riding factor of crop growth must be addressed.

The effect of growing period on yield for the second time-of-planting

The yields of the density and seed treatment experiments sites for the second time-of-planting were low ranging from 12 to 26 t/ha compared with the experimental yields from the first plantings in 2003 of 21 and 29 t/ha (Tables 5.2.2.2.2 & 5.2.3.2). The most likely reason for the low yields in the second time-of-planting is the short cropping time. The length of time the crop grew had a marked impact on total yield (Figure 6.2). For example the highest yielding site (Himalaya 1) the crop senesced at 85 DAP compared with only 55 to 60 DAP for the lowest yielding sites (Lembang and Himalaya 2). Length of duration of crop growth is important for dry matter assimilation and tuber bulking (Struik and Wiersema 1999). The early senescence appeared to be due to heavy infection of late blight (*Phytophthora infestans*) at Lembang and Himalaya 2. The early death of these experiments highlights the need for the effective management of all cropping constraints if seed is to perform to its potential. There is a need to improve late blight control of potato crops in West Java.

Density effects

At Himalaya 1, the highest yielding site, spacing caused a significant difference in total-yield from cut seed (Table 5.3.1.2b). The yields at the 80 x 25 cm and 70 x 30 cm spacings were significantly higher than the yield at the 70 x 20 cm spacing. These higher yields were due to increased tuber set at these densities. Only 4.2 tubers were set at the highest density of 70 x 20 cm while nearly double or more than double this number were set at the wider spacings with 10.1 tubers per plant at the 80 x 25 spacing and 7.9 tubers per plant at the 70 x 30 cm spacing (Table 5.3.1.1.b). This resulted in 26 tubers being produced per square metre by the cut seed at the highest density (70 x 20 cm) while the 80 x 25 cm density produced 34 tubers/m^2 and the 70 x 30 cm density produced 29 tubers /m^2. So the more widely spaced seed produced more tubers which were able to grow to a large size due to the longevity of the crop at this site. The intact seed followed the opposite pattern with the closer spacing producing the lowest number of tubers per plant but the close density meant that this treatment produced the highest number of tubers per square metre which resulted in the highest yield.

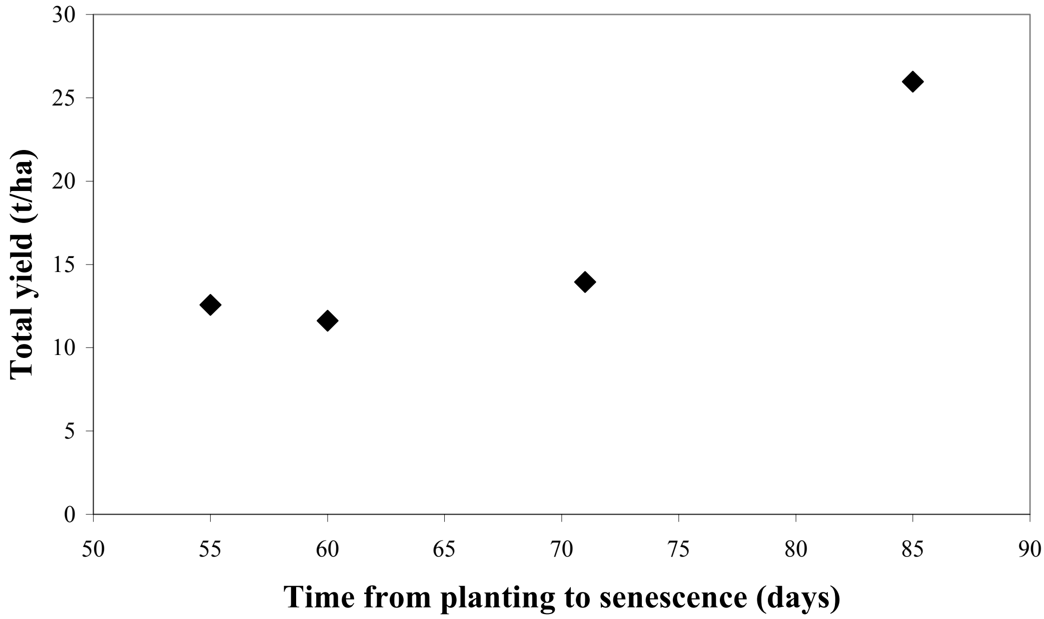

Figure 6.2. Crop life from planting to senescence of Atlantic grown at four sites in Java: Lembang (55days), Himalaya 2 (60 days), Garut (71 days) and Himalaya 1 (85 days) in 2004.

At the other three sites there was no significant difference in yield of cut seed at different densities (Tables 5.3.1.2a, c & d). One of these sites also showed a spacing effect on tuber set with the two lower densities having significantly more tubers per plant than the highest density (Table 5.3.1.1c).

The variable results with cut seed are difficult to explain. Possibly the seed was too old and so did not perform as expected due to senile degeneration. The seed used for the second time-of planting experiments was harvested in WA in April 2003 and was originally scheduled to be planted in October 2003 in Indonesia. Delays meant that the seed was not planted until April 2003 which was 12 months after harvest of the seed.

The performance of this old seed as seen by its yield and emergence rate, especially from cut seed, indicate that seed potatoes from WA grow in a robust fashion in Java even when very old. It would be expected that younger seed would perform better still. The farmers who tested the seed as part of the seed socialisation program recognised this too and Pak Budi Prihanto (pers. comm.) from TUNAS commented that “the local farmers now have confidence in seed potatoes from Western Australia”. The old seed turned out to be a benefit as the farmers know that they will still get a crop from old seed and this lowers the risk of using imported seed.

Alternatively the behaviour of the cut seed may indicate a complicated interaction between seed treatment, density and agronomic practices and tropical conditions (Struik and Wiersema 1999). At Himalaya 1 increased plant spacing (i.e. reduced plant density) increased the yield of larger tubers (Table 5.3.1.2b). Similar responses have been shown in different environments and with different varieties (Sekhon and Singh 1985, Strange and Blackmore 1990, Struik and Wiersema 1999, van der Zaag 1987). Even though tuber number/plant increases with spacing there are often less tubers/m^2 (plants/m^2 times tubers/plant) and therefore larger tubers at the wider compared with the closer spacing. The larger tubers at the wider spacings of cut seed at Himilaya 1 were produced even though these spacing treatments had more tubers per square metre than the closest density. Possibly the row width could explain this situation. The wider rows at Himilaya 1 produced significantly more tubers per plant than the closer spacing (Table 5.3.1.1b). The sites suffered some water stress during the life of the crop. Possibly the narrower hills become drier and hotter during periods of water stress due to their lower volume of soil compared with the wider rows. Consequently plants in narrower rows may re-sorb more tubers than plants in wider rows.

Total yield was significantly higher at the closest spacing (highest planting density) using intact seed at the Garut and Himalaya 1 sites but not significantly different at the other two. This shows that in some situations yields of Atlantic may be improved by increased planting density in West Java.

Conclusion

The large impact that length of crop life had on restricting yield on three out of the four sites because of early senescence makes a full understanding of the interaction between density and seed treatment difficult. Even at the highest yielding site (Himalaya 1) optimum density for total and processing yield was different for the intact (70 x 20cm) and cut (80 x 25cm) seed treatments which may indicate different spacing requirements for seed treatments.

Intact and cut seed

Crop establishment (emergence, plant and stem density) from cut seed was as high as that of the intact seed at Garut and Himalaya 1(Tables 5.3.1.1a & b). At Garut the same emergence rates as cut seed resulted in similar processing yields for cut and intact seed. For example at Garut there was no significant difference in processing yield (11.7 to 10.1 t/ha) between cut and intact seed treatments (Table 5.3.1.2a). However there was no significant difference in yield due to spacing either. It was hypothesised after the first time-of-planting that yield of cut seed would increase as density increased. That this did not occur may be due to the low yield at this site which meant the potential growth of the various treatments was not reached.

Himalaya 1 was the other site where emergence and plant and stem density from cut seed was as high as that of the intact seed. This site also had the highest yield of all four sites with an average of 26.0 t/ha. Here spacing did have a significant effect on yield. For the intact seed the closer in-row spacing produced the highest total yield of 32.1 t/ha. For the cut seed the intermediate spacing produced the highest total yield of 28.3 t/ha. The high yield at the intermediate spacing was due to this treatment setting the most tubers with 10.1 per plant compared with 4.2 tubers per plant at 20 cm and 7.9 per plant at 30 cm (Table 5.3.1.1.b). The cut seed also showed this response with most tubers being set at the intermediate spacing. The confounding factor of the different row spacing used at this intermediate in-row spacing may have contributed to this effect.

At the sites where the intact seed treatment showed better establishment than the cut seed, processing yield was higher for intact seed at Lembang but there was no difference in processing yield between seed treatments at Himalaya 2.

These results, although variable, give encouragement that cut seed could be used in Indonesia during the dry season. The results show that crops grown from cut seed can establish and yield as well as crops grown from intact seed. In Vietnam crops grown from cut-seed yielded as high or higher than crops grown from intact seed (McPharlin *et al.* 2003). Provided seed is healthy and vigorous, the cutting procedure hygienic and the seed cured before planting, cut seed can be used successfully in tropical environments. This is illustrated by the performance of cut seed at the highest yielding site which had a low disease incidence. In such environments cut seed does not limit high yield. Whilst cut seed usually yields as well as intact seed in temperate environments (Easton *et al.*1970) it is not always the case (Strange and Blackmore 1990). Healthy seed and hygienic cutting practices are needed in all situations.

6.3 Seed age and source experiments

The highest mean total yield on Himalaya 1 was associated with longest period of crop growth. Crops yielded less and grew for less time on the other sites but there was not a strong relationship between length of time to senescence and yield (Figure 6.2). For example the next highest yielding site (Lembang) senesced after only 55 DAP but out-yielded the other two sites that senesced after 71 DAP (Garut) and 68 DAP (Himalaya 2). A sufficient period of growth is required for dry matter assimilation and tuber bulking (Struik and Wiersema 1999). The incidence of disease is an important factor in determining the length of time before senescence. The high mean total yield at Lembang was assisted by the high yield from the Scottish seed at that site.

The lower yields of crops grown from WA-April compared with WA-August seed could be attributed to more senile degeneration in the WA-April seed. The WA-April seed was about 12 months old between harvest and planting compared with 7 months for the WA-August seed. The higher stems/plant and tubers/plant in the WA-April compared with WA-August seed support this, as this is a feature of older compared with younger seed. Similar results have been reported from previous work. For example sprout and stem number was higher in the varieties Atlantic, Dawmor, KT3 and PO3 stored for 16 compared with 26 weeks (Kustiati *et al.* 2004). Also stem number was higher in Atlantic that had been 'aged' by being stored in ambient conditions for 4 weeks longer than 'younger 'seed (Henderson *e. al.* 1999) and in Bintje stored for 15 versus 30 weeks (Buekema and Van der Zaag 1990). However the higher stems/plant number was not always translated into higher stems/m^2 with WA-April seed because of poorer emergence and establishment (i.e. plants/m^2) which can also be a feature of seed that is too old.

The higher yields from the WA-Java and Scottish seed are probably because these seed lots were younger (less time between harvest and planting) and so they had not undergone senile degeneration like the WA-April seed. The higher yield from the Scottish compared to the WA-August seed at Lembang shows that younger imported seed may perform better in West Java. It is thought that the Scottish seed was freshly imported after an October harvest and it had better storage conditions during and/or after shipment to Indonesia (cf. 5 weeks delay at the wharf for the WA seed, Section 5.3). The lower number of stems/plant and tubers/plant from the Scottish and WA-Java seed suggest they maybe younger seed sources than the WA-April and WA-August seed. WA exporters need to provide younger seed than provided here and ensure appropriate storage conditions during and after shipping to guarantee crops from the seed grow vigorously and produce high yield and quality. For an April planting in Java it is suggested that Atlantic seed should be harvested in December in WA, not August, to ensure higher yield and quality. However the high yields (32.1 t/ha) of Atlantic from April WA seed at Himalaya 1 in the density experiments (Table 5.3.1.2b) suggest that this seed is vigorous and capable of high yield. Improved agronomy maybe more important that seed quality in some instances.

The Scottish seed did not yield significantly higher than the WA-Java seed. This indicates that imported seed bulked once in West Java may perform as well as imported seed.

The high yield of oversize rather than crisp-grade size tubers from all seed sources at Lembang suggest plant spacing could be decreased to improve processing yield in Java.

6.4 Potential to augment Indonesian seed potato system with imported seed from Australia

The performance of WA seed potatoes in West Java show that there is potential to augment the Indonesian seed potato system with imported seed. West Java grows 28,000 hectares of potatoes which requires 42,000 tonnes of seed if seed rate is 1.5 t/ha. West Java itself only produces 2,400 of seed (Adiyoga 1999). It is estimated that with farmers saving seed to reduce costs, the annual seed requirement is around 10,000 tonnes (Prihanto pers. comm.).

The Lembang seed source experiments showed that WA seed once-grown in Java produced a high total yield which was not significantly different to freshly imported Scottish seed (Table 5.3.2.2c). The yield of the once-grown WA seed was better than the freshly imported, but old seed from WA. This indicates that the degeneration rates of potato seed in West Java do not preclude yield improvement with once-grown imported seed.

The concept of such a local single bulk up seed scheme, is being considered for Vietnam (McPharlin *et al.* 2003) and a similar scheme may benefit potato farmers in West Java.

6.5 Conclusions

A priority for successful experimental work in West Java is improved management of crops. Three out of four experiments in the second time-of-planting senesced before they reached maturity. The cause of the early senescence was probably uncontrolled late blight (*Phytophthora infestans*) infection. Future work should include investigations into improved agronomic management of potato crops in West Java.

WA seed produced above average yields of processing potato crops in West Java in the first time of planting. The highest total yield recorded was 43.8 t/ha from a demonstration at Hikmah (Table 5.2.2). In the second time-of-planting the yields were low except at Himalaya 1 where aged WA seed (WA-April) produced 26 t/ha and younger seed (WA-August) produced 30 t/ha.

The use of cut seed was shown to produce high emergence rates although yields were less than that of intact seed. Experiments designed to investigate the yield of cut seed at different densities gave variable results, probably due to the age of the seed. Delays to the project meant that plantings occurred 6 months later than planned.

The use of once-grown seed from WA in West Java could augment the West Java seed potato scheme which has problems in supplying the seed requirements of the province.

6.6 Outcomes achieved compared with objectives

The objective of the project was to increase the crisp potato capacity of West Java and Australian seed potato sales.

The project showed that Western Australian Atlantic seed can be used to produce high yielding crops in West Java. The full potential of the seed will require further agronomic work and once this is done benefits to the West Java crisp processing industry can be expected to increase.

During the life of the project Atlantic seed sales to Indofood increased and orders for 2004 and beyond have been placed.

Therefore the expected outcome of taking the first step in the development of a seed potato market in West Java has been achieved.

7. Technology Transfer

The technology transfer activities comprised demonstration plots of seed potatoes from WA plus a field day held at harvest of a first time of planting demonstration. These activities are described in Sections 5.2.3 and 5.3.3.

Valuable feedback from the farmers included:

- Seed size was larger than their preferred 20 seeds per kilogram and should be reduced from the 12-16 tubers per kilogram that was supplied.
- The percentage of seed damage should be reduced. The most of damage was mechanical from the loading and unloading process. Farmers suggested packaging using wooden crates would be better although but jute was still satisfactory.
- Farmers thought the yield was satisfactory and the round tuber shape was very good for processing.
- A total yield of 43.8 t/ha was recorded for Atlantic at one demonstration site. This yield is two-and-a-half times greater than the average yield for the high yielding Granola in West Java.
- Farmers at Masngudi found that intact seed gave twice the yield of cut seed under the same conditions and treatment.
- Young seed seems to grows more vigorous than the older seed
- Normal seeds grows more homogeneously than de-sprouted seed and gives a better yield
- Quality of seed was sometimes described as better than seed from Scotland and sometimes not as good.
- It is important to have seed available for September planting; this planting window allows the crop to be grown in the early part of the wet season when it isn't too wet.
- An interest in testing any new processing varieties that will be easier to grow in the wet season than Atlantic
- Preferred additional research is work to determine the correct balance of fertilisers to apply.

8. Recommendations

- Australian seed potatoes have been shown to perform well in West Java and Australian exporters should carefully develop this new market.
- Seed from Australia should be supported with agronomy assistance so the seed will perform to its potential. This will need to include a survey of production methods to identify constraints to seed performance. This could involve follow up commercial shipments. Improved management of late blight disease should be a priority.
- Exporters should consider exporting younger seed until the performance of aged seed can be demonstrated to be as good.
- Until the management of cut seed can be refined, Indonesian farmers will benefit from smaller seed. An economic analysis of the cost of cut seed versus intact seed and their relative yield performance needs to be done when consistent data from several seasons is available.
- Development of a West Javanese seed supply scheme based on initial Australian imports and limited in-country bulking will benefit both Australian and West Javanese potato farmers.
- Improved handling of seed is required to reduce mechanical damage.
- Investment in offshore research has been shown to increase the market available to the Australian potato industry. This outcome offers good returns and so investment in this research should continue to be considered by industry.
- Crisp varieties more suited to tropical conditions than Atlantic should be evaluated in West Java so Australian seed producers can offer this market more profitable varieties.
- An economic analysis of the benefits and costs of the new seed source must be carried out when commercial demonstrations have been completed.
- The performance of Australian seed potatoes in the wet season in Java should be investigated.
- Travel to target markets is essential. Until DFAT allows travel to Indonesia these projects will have to replace this travel with training of target market staff in Australia in order to achieve the desired outcomes.

9. Acknowledgements

Funding was supplied by the Horticulture Program of the Department of Agriculture, Western Australia, by Western Potatoes, by PT Indofood Sukses Makmur and by Horticulture Australia Ltd. The experiments were conducted in growers' crops and their assistance is greatly appreciated. Trevor Boughton, Regional Director, WA Indonesia Trade Office, is thanked for his valuable liaison with Indofood and his inspection of experimental sites. We gratefully appreciate the diligent and accurate work done by Indofood field and factory staff.

10. Literature

Anon (2003). Potato Marketing Corporation of Western Australia Annual Report 2003.

Adiyoga, W., R. Suherman, A. Asgar & Irfansyah (1999). Potatoes in West Java: A rapid appraisal of production, marketing, processing, and consumer preferences. International Potato Centre (CIP) Lima Peru.

Badan Pusat Statistik (BPS-Statistics Indonesia). http://www.bps.go.id/sector/agri/horti/table2.shtml

Batt, P. J. (1998). Estimating the true demand for seed potatoes in South East Asia. *Potato Australia* **9**, 22.

Batt, P., P. Dawson, P. X. Tung and R. Galuba. (2000). Performance of CIP clones in Western Australia export to Vietnam and the Philippines. P 169-173 In Potatoes 2000 Conference Proceedings (South Australian Research and Development Institute: Adelaide).

Beukema, H.P. and Zaag D.E. van der (1990). Introduction to potato production. Pudoc, Wageningen, The Netherlands, 208pp.

Easton, G. D. Nagle, M.E. and Bailey, D.L. (1970). Potato seed piece treatment in Washington. *American Potato Journal*. 47, 469-474.

Edgar A.D. (1951). Determining the specific gravity of individual potatoes. *American Potato Journal* **28**, 729-731.

FAOSTAT http://www.bps.go.id/sector/agri/horti/table2.shtml FAOSTAT World Database Results.mht

Henderson A., Moorthy, K., Carr, P., Fry, B. and Franz, P. (1999). 'Round seed trials 1998/99'. ExpHORT 2000 Publication No.70, National Resources and Environment, Victoria, Knoxfield Victoria, 47pp.

Kawakami K (1962). The physiological degeneration of potato seed tubers and its control. *European Potato Journal* 5, 40-49.

Kawakami K (1980). Age of potato tubers. *Potato Research*.23, 256.

Kustiati, T., Plummer, J.A. and McPharlin, I.R. (2004). 'Effects of storage time and gibberellic acid on the sprout behaviour and plant growth of potatoes suitable for tropical conditions. *Acta Horticulturae* (in press).

McPharlin I.R., Dawson, P.D., Dang Thi Hue and Truong Cong Tuyen (2003). Cut seed experiments. *In* "Increasing the capacity of the Food Crops Research Institute to enhance the production and management of potatoes in the Red River Delta". Final Report of AusAID project, July 2003, (Western Australian Department of Agriculture: South Perth Western Australia), pp85-95.

Sekhon, H.S. and Singh, M. (1985). Optimising seed rate and stem density for seed potato production. *Journal of Agricultural Science, Cambridge* **105**,189-91.

Schmiediche, P. (1995). The Production of Seed Potatoes in South East Asia in Batt, Peter J (Ed). Proceedings of an Industry Workshop. An emerging opportunity; The Export of Tropical Seed Potatoes to Asia. (Curtin University)

Strange P.C. and Blackmore K.W. (1990). Effect of whole seed tubers, cut seed and within row spacing on potato (cv. Sebago) tuber yield. *Australian Journal of Experimental Agriculture*. **30,**427-31.

Struik P.C and Wiersema S.G. (1999). 'Seed potato technology' (Wageningen Press: Wageningen), p212.

Travis K.Z. (1987). Use of a simple model to study factors affecting the size distribution of tubers in potato crops. *Journal of Science Cambridge*.**109**, 563-71.

Zaag, D.E. van der (1987). Growing seed potatoes. *In* J.A. De Bokx, F.Quak and J.P.H. van der Want (Eds.) "Viruses of potatoes and seed potato production". Pudoc Wageningen, pp.176-203.

Zaag D.E. van der and Loon C.D. van (1987). The effect of physiological age on growth and vigour of seed potatoes of two cultivars. *Potato Research* 30, 451-72.

11. Abbreviations

°	degrees
C	Celsius
DAP	days after planting
DFAT	Australian Department of Foreign Affairs and Trade
G	generation
ha	hectare
HAL	Horticultural Australia Ltd
l.s.d.	least significant difference
m	metres
ns	not significant
P	probability
Sd	seed
SG	specific gravity
sp	spacing
t	tonnes
t/ha	tonnes per hectare
trt	treatment
TUNAS	Name of farmers group in West Java
WA	Western Australia