PT432
Improved productivity of inland potato production, 1994-1997

Stephen Wade
NSW Agriculture

HAL

Know-how for Horticulture™

PT432

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Horticultural Research & Development Corporation
Level 6
7 Merriwa Street
Gordon NSW 2072
Telephone: (02) 9418 2200
Fax: (02) 9418 1352
E-Mail: hrdc@hrdc.gov.au

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Horticultural Research and Development Corporation

FINAL REPORT

"Improved productivity of inland potato production"

Project PT 432

July 1994 to June 1997

Stephen Wade
NSW Agriculture
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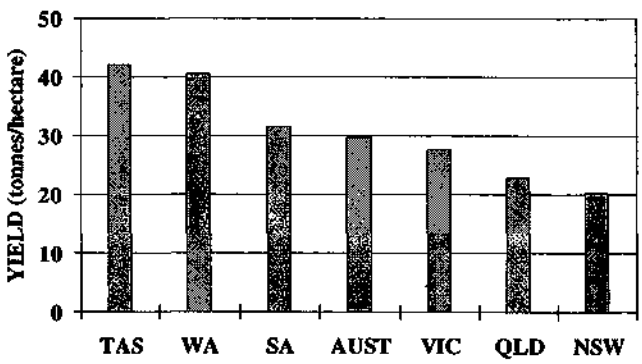
1.0 Project Summary

1.1 Low potato yields

Potatoes are the largest vegetable industry in New South Wales. During the 1994-95 season, 126,812 tonnes of potatoes were produced on 6,274 hectares, for an average yield of 20.2 tonnes a hectare. Two thirds of this production was located in the Riverina region of southern New South Wales. The industry had a farm gate value of $40.8 million.

Figure 1. Average Australian potato yields 1994-95 (Australian Bureau of Statistics, 1997).



Low potato yields are a major problem for New South Wales growers, with the average State yields the lowest in Australia (see Figure 1). In 1994 a three year project, PT 432 "Improved productivity of inland potato production," was funded by the Horticultural Research and Development Corporation to assist the Riverina potato growers to increase their early crop yields by six tonnes a hectare and to improve the average gross margins per crop by eight percent per annum.

1.2 Crop yield analysis

From July 1994 to June 1997 the performance of the early sown crops in the Riverina was measured. Records of crop yields and inputs such as seed type, paddock rotation, sowing date, row spacing, fertiliser application and irrigation water use were collected from the local potato growers. The growers' yields and inputs were then compared to determine the best crop management practices. Analysis of the crop records found seven best practices or "Spud Checks" that were linked to high yields. These recommendations were identified for the early Sebago, Coliban, Desiree and Atlantic crops, the main fresh and processing varieties grown in the Riverina region.

1.3 Best crop management practices

The seven best crop management practices were:

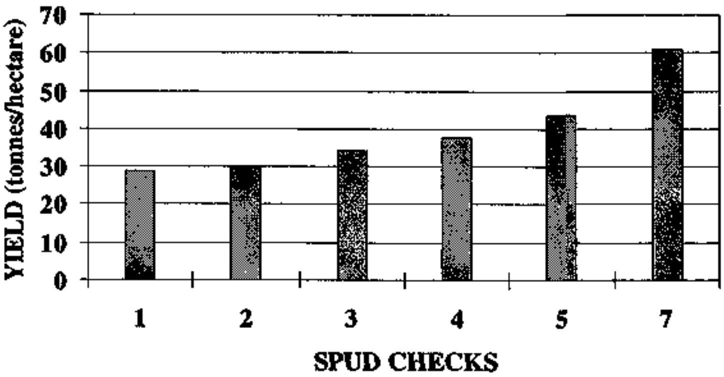
1. "buy Certified seed,"
2. "follow a grass rotation,"
3. "sow early to mid-August,"
4. "plant 81 centimetre rows,"

5. "spread 200 to 300 kilograms per hectare of nitrogen, 50 to 100 kilograms per hectare of phosphorus and 100 to 200 kilograms per hectare of potassium,"
6. "side dress 50 to 100 kilograms per hectare of potassium" and
7. "apply three to four Megalitres per hectare of irrigation water."

For the fifth Spud Check in the early Coliban and Atlantic crops, recommended phosphorus fertiliser rates of 100 to 150 kilograms a hectare were found to produce the highest yields.

The average crop yields increased with the total number of best crop management practices that were adopted by the Riverina growers. With the early Sebago crops, average crop yields increased from twenty nine tonnes a hectare with one Spud Check to sixty one tonnes a hectare when all seven of the Spud Checks were achieved (see Figure 2).

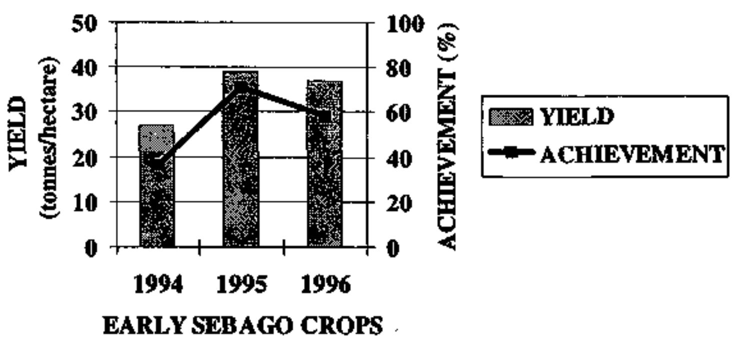
Figure 2. Early Sebago crop yield response to grower Spud Check adoption (1994-96).



1.4 Improved productivity

From 1994 to 1996 the average early Sebago crop yields in the project increased from twenty seven to thirty seven tonnes a hectare. This surpassed the project's yield target by four tonnes a hectare. The higher crop yields were achieved across the Riverina, with the number of producers exceeding the grower target yield of thirty one tonnes a hectare increasing from 36 to 58 percent (see Figure 3).

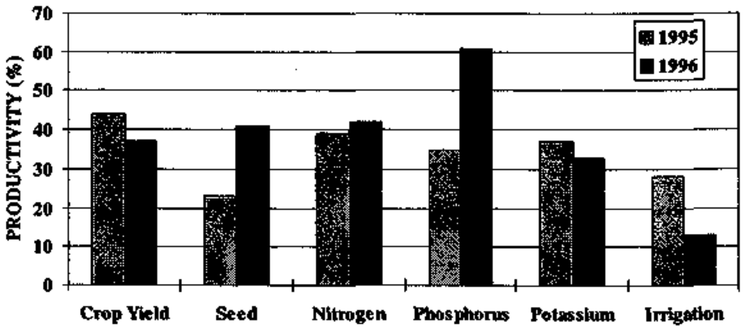
Figure 3. Average early Sebago crop yields and grower target yield achievement [1].



1. The percentage of growers exceeding the grower target yield of thirty one tonnes per hectare.

As a result of the higher crop yields, the productivity of the early Sebago crop yields improved by 37 percent, while the Certified seed, nitrogen, phosphorus, potassium and irrigation water productivity increased by 41, 42, 61, 33 and 13 percent respectively (see Figure 4).

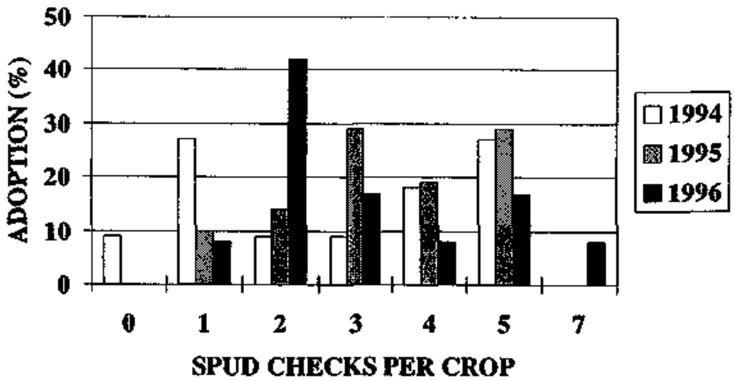
Figure 4. Productivity improvement in the early Sebago crops.



By 1996 the Riverina potato growers had achieved market returns of $5.35, $8.08, $26.62, $11.03 and $49.54 per dollar for each of these crop inputs. Along with the productivity gains, the estimated average gross margin per crop improved by 205 percent over the project. This exceeded the project's gross margin goal by 95 percent per annum.

The productivity improvements followed the increased adoption of the Spud Check recommendations by the Riverina growers, with the number of producers accomplishing two or three Spud Checks per crop rising from 18 to 59 percent over the project (see Figure 5).

Figure 5. Grower adoption of the Spud Checks in the early Sebago crops.



Project PT 432 demonstrated that by using the Spud Check approach, it was possible to identify the best crop management practices in a region. By adopting these best practice recommendations, the Riverina growers successfully increased their average crop yields by ten tonnes a hectare and raised the value of potato production in the Riverina by $193,000 per annum.

2.0 Introduction

2.1 Low potato yields

Potatoes are the largest vegetable industry in New South Wales. During the 1994-95 season, 126,812 tonnes of potatoes were produced on 6,274 hectares, for an average yield of 20.2 tonnes a hectare. Two thirds of this production was located in the Riverina region of southern New South Wales. The industry had a farm gate value of $40.8 million.

Table 1. Potato production in Australia 1994-95 (Australian Bureau of Statistics, 1997).

State	Tas	WA	SA	Vic	Qld	NSW	Australia
Production (tonnes)	255,738	103,572	247,414	279,876	109,004	126,812	1,122,416
Area (hectares)	6,068	2,553	7,831	10,135	4,782	6,274	37,643
Yield (t/ha) [1]	42.1	40.6	31.6	27.6	22.8	20.2	29.8

1. t/ha = tonnes per hectare.

Low potato yields are a major problem for New South Wales growers, with the average State yield of 20.2 tonnes per hectare the lowest in Australia (see Table 1). However within the potato growing districts there are often large differences in crop yields between growers. In the Riverina region, average early crop yields ranged from 20.1 to 31.7 tonnes a hectare during 1994-95 (see Table 2).

Table 2. Early crop potato yields in the Riverina 1994-95 (Australian Bureau of Statistics, 1994).

Shire	Average Yield (tonnes/hectare)
Corowa	31.7
Berrigan	28.3
Windouran	26.7
Urana	22.2
Conargo	21.6
Wakool	20.2
Average	26.3

This range in crop yields is often due to individual differences in the way crop production technology is managed. By comparing crop yields with crop inputs, the best crop management practices could be determined for the region. If these best practices were then adopted by the local growers, average potato yields would increase across the Riverina.

In 1994 a three year project, PT 432 "Improved productivity of inland potato production," was funded by the Horticultural Research and Development Corporation to assist the Riverina potato growers to increase their early crop yields by six tonnes a hectare and to improve the average gross margins per crop by eight percent per annum.

2.2 Riverina potato crops

A warm, dry climate gives the Riverina a long growing season, allowing two potato crops a year to be grown (see Table 3). The early crop is sown from July to September for harvest between November and February. Whole, round seed from this crop is used for planting the main crop, which is sown in February and March. Because the main crop yields are dependent on the seed produced in the early crop, the early crop was selected for the initial development of the best crop management practices. As Sebago, Coliban, Desiree and Atlantic are the main potato varieties grown in the Riverina, these cultivars were chosen for the identification of improved crop management practices with the Crop Check approach (see Table 4).

Table 3. Climate summary for Deniliquin (Bureau of Meteorology, 1996).

Temperature	J	F	M	A	M	J	J	A	S	O	N	D
Maximum (^{0}C)	33	32	29	24	19	15	14	17	20	24	28	31
Minimum (^{0}C)	16	16	13	10	7	5	3	4	6	9	12	14
Rain (mm)	29	28	32	31	40	41	35	37	38	40	29	29
Evaporation (mm)	285	244	195	114	59	36	40	59	93	158	222	276

Table 4. Varietal characteristics of the main Riverina potato cultivars (Seed Potatoes Australia Pty Ltd, 1996).

Cultivar	End Use	Growing Season (days)	Tuber Description
Sebago	Fresh	130	Oval tubers; creamy skin; white flesh.
Coliban	Fresh	130-140	Round tubers; smooth, white skin; white flesh.
Desiree	Fresh	90-110	Oblong tubers; smooth, pink skin; cream flesh.
Atlantic	Crisping	85-110	Round tubers; netted, white skin; white flesh.

2.3 The Crop Check approach

In the early 1980's it was recognised that the traditional extension methods were not an effective mechanism for technology transfer. The methods were slow to implement, often because many of the intended recipients did not accept the credibility of the extension process. As a result the Crop Check approach was developed in the mid 1980's to improve the adoption of crop technology (see Table 5).

Table 5. Traditional and Crop Check approaches to technology transfer (Lacy, 1998).

Traditional Extension Method	Crop Check Approach
Solves one factor.	Solves all factors.
Single factor information.	Information packages.
Motherhood recommendations.	Objective recommendations.
One way communication with growers.	Two way communication with growers.
No paddock checking.	Paddock checking.
No bench marks.	Bench marks to aim for.
Lack of target setting.	Target setting.

The Crop Check approach was based on checking the farmer's crops to identify the best management practices for increasing yields and productivity. The method worked because it determined what was actually happening in a grower's crops. Instead of measuring trial results on research station plots, the Crop Check approach directly monitored the grower's own paddocks.

As the Crop Check approach involved the farmers learning about their own crops and sharing their knowledge with each other, it provided a credible extension method which speeded up the delivery of new technology. It also promoted a two way communication between growers and extension officers, with the advisory staff facilitating the grower's research efforts through the use of crop reports, crop guides and discussion groups.

The important features of the Crop Check approach (Lacy, 1998) are:

- The Crop Check title, such as "Spud Check", which both markets the Crop Check concept and also implies action in terms of checking the grower's crops.

- The setting of specific grower targets for either crop yields, financial returns or productivity.

- The identification of the best crop management practices or Crop Checks, which must be adopted by producers in order to reach the grower yield, financial or productivity targets.

- The simple, concise definition of the Crop Checks to ensure their clear understanding by both the growers and extension officers.

- The assembly of an objective farmer management information package, which is based on all of the key Crop Checks. The objectivity of Checks, such as "plant 81 centimetre rows," is critical so the Crop Checks can be readily measured.

- The Crop Checks are identified from observing, measuring, recording and analysing the farmer's paddocks. This gives the Crop Checks credibility with producers as the Checks are derived from their own individual farms.

- The education of the growers in the implementation of the Crop Check approach. The aim is to progressively educate the producers to improve their performance at each of the following steps:

  Observing ➔ Measuring ➔ Recording ➔ Evaluating ➔ Action

- The establishment of grower discussion groups to encourage farmer education and collaboration. Grower feedback on the objective management package is an important aspect of the Crop Check approach, as it allows producers to influence changes and develop ownership of the information packages.

- The evaluation of the adoption of the objective information packages by adding up the number of Crop Checks achieved on each grower's crop records. Poorly adopted Crop Checks and barriers to adoption can be readily identified through this process.

3.0 Methods

Project PT 432 used the Crop Check approach to assist the Riverina potato growers to increase their early crop yields and gross margin returns. The project followed four steps over its implementation:

(i) collecting the grower crop records,
(ii) analysing the crop yields and inputs,
(iii) defining the best crop management practices, and
(iv) providing crop reports and crop guides to the Riverina potato growers.

3.1 Crop records

The first stage in the project was the collection of grower crop records, for to manage a crop you must first measure its performance. In 1994 the SpudCHECK potato record form was developed for this step. The crop forms were used to record crop yields and inputs such as seed type, paddock rotation, sowing date, row spacing, fertiliser application and water use (see Table 6). The performance of the 1994, 1995 and 1996 early crops was recorded by the growers or through grower interviews, with records collected for the early Sebago, Coliban, Desiree and Atlantic crops, the main fresh and processing potato varieties grown in the Riverina.

Table 6. Key crop records.

Crop Input	Crop Record
Location	Grower name, address and paddock name.
Variety	Variety.
Seed	Type and size.
Rotation	Paddock history over the last three years.
Sowing	Date, row and plant spacing.
Fertiliser	Type, total, pre and post sowing rates.
Irrigation	Irrigator and water use.
Harvest	Crop yield and harvest date.

3.2 Crop yield analysis

In the second stage of the project, the growers' yields and crop inputs were compared to determine the relationships between the highest crop yields and input levels. These relationships could then be used to recommend the best management practices for increasing the average crop yields.

The crop yield analysis followed three steps:

(i) listing each crop yield and crop input for all the crops in a variety,
(ii) ranking each crop yield and dividing them into quarters, and
(iii) calculating the average crop input for the quarter with the highest crop yields.

An example of the crop yield analysis for the crop input "seed type" is summarised in Table 7.

Table 7. Crop yield analysis for the crop input "seed type".

Crop Input	Average Yield (tonnes/hectare)	Comment
Certified Seed Certified Seed	47.5 37.5	4th Quarter with the highest crop yields.
Certified Seed Certified Seed	32.5 26.3	3rd Quarter.
Certified Seed Certified Seed	23.8 20	2nd Quarter.
Non-Certified Seed Non-Certified Seed	20 5	1st Quarter.

A crop yield analysis was not conducted on the effects of disease, pests or weeds in the early crops, as these factors were considered beyond the project's goal of lifting potential yields. Statistical analysis of the project's outcomes was performed using the Microsoft ® Excel Version 5.0 software package.

3.3 Best crop management practices

In the third step of the project, the best crop management practices were identified from the average crop inputs of the highest yielding crops. For the crop input "seed type", since the average crop input with the highest crop yields was Certified seed, the best crop management practice was identified as "buy Certified seed" (see Table 7).

Using this method of analysis, best crop practice recommendations were identified for seed type, crop rotation, sowing date, row spacing, fertiliser application, side dressing and irrigation water use in the early potato crops. As these recommendations provided a grower check list for achieving higher crop yields, each individual best crop management practice was called a "Spud Check."

3.4 Crop reports

The final stage of Project PT 432 was providing the Riverina potato growers with the crop reports and crop guides so they could evaluate the performance of their own crops (see Appendix A).

Each grower crop report listed the grower target yield, the seven best crop management practices, the grower's crop results and the number of the best practices the grower had achieved. It also included the average and top twenty five percent crop results and the percentage of growers who had achieved each best management practice.

The grower crop guide briefly explained the aims and methods of the project. It listed the seven best crop management practices, showed how the top growers were achieving their high yields, linked all the key crop factors needed for growing higher yielding crops and indicated what was reducing the yields in the poorer performing crops.

By giving the Riverina potato growers a yield target and identifying where and how their own crop performance could be improved, co-operators were able to increase their individual yields in the following season's crop and so progressively raise the average potato yields across the district.

4.0 Results

4.1 Sebago crops

The crop yield analysis of the highest yielding early Sebago crops in the project is summarised below.

Table 8. Crop yield analysis for the highest yielding early Sebago crops.

Crop Input		1994	1995	1996
Seed	Type	Certified	Certified	Certified
	Size (grams)	56-71	56-71	56-85
Rotation	Last Potatoes (years)	3	3	3
	Last Crop	grass	grass	grass
Sowing	Date	early August	early August	mid-August
	Row Spacing (centimetres)	81 or 91	81	81
	Plant Population (plants/hectare)	58,337	54,761	51,530
Fertiliser - Total	Nitrogen (kilograms/hectare)	258	217	213
	Phosphorus (kg/ha)	136	98	69
	Potassium (kg/ha)	251	163	201
	Sulphur (kg/ha)	95	172	152
Fertiliser - Pre Sowing	Nitrogen (kg/ha)	105	77	63
	Phosphorus (kg/ha)	136	98	69
	Potassium (kg/ha)	171	88	94
	Sulphur (kg/ha)	68	134	116
Fertiliser - Post Sowing	Nitrogen (kg/ha)	153	140	150
	Phosphorus (kg/ha)	0	0	0
	Potassium (kg/ha)	80	75	107
	Sulphur (kg/ha)	27	39	37
Irrigation	Irrigator	gun or boom	pivot	pivot
	Water Use (Megalitres/hectare)	6.2	3.9	4.9
Harvest	Crop Yield (tonnes/hectare)	38 to 48	47 to 60	50 to 61

The seven best crop management practices, called "Spud Checks" in the project, were identified as:

1. "buy Certified seed,"
2. "follow a grass rotation,"
3. "sow early to mid-August,"
4. "plant 81 centimetre rows,"
5. "spread 200 to 300 kilograms per hectare of nitrogen, 50 to 100 kilograms per hectare of phosphorus and 100 to 200 kilograms per hectare of potassium,"
6. "side dress 50 to 100 kilograms per hectare of potassium" and
7. "apply three to four Megalitres per hectare of irrigation water."

The crop performance and grower adoption of the Spud Checks are summarised in Tables 9 and 10.

Table 9. Crop performance of the early Sebago crops.

Crop Performance		1994	1995	1996
Crop Yield	Crops > 31 tonnes/hectare (%)	36	71	58
	Average Yield (tonnes/hectare)	27	39	37
	Yield Increase (t/ha)	-	12	10
	Productivity (%)	-	44	37
Certified Seed	Average Use (t/ha)	3.5	4.0	3.4
	Efficiency (tonnes/tonne)	9.3	11.4	13.1
	Productivity (%)	-	23	41
Nitrogen Fertiliser	Average Use (kilograms/hectare)	215	234	212
	Efficiency (tonnes/kilogram Nitrogen)	0.137	0.190	0.194
	Productivity (%)	-	39	42
Phosphorus Fertiliser	Average Use (kg/ha)	92	98	79
	Efficiency (t/kg Phosphorus)	0.346	0.467	0.556
	Productivity (%)	-	35	61
Potassium Fertiliser	Average Use (kg/ha)	179	192	200
	Efficiency (t/kg Potassium)	0.161	0.221	0.215
	Productivity (%)	-	37	33
Irrigation Water Use	Average Use (Megalitres/hectare)	4.2	4.5	6.0
	Efficiency (tonnes/Megalitre)	7.7	9.8	8.7
	Productivity (%)	-	28	13

Table 10. Grower adoption of the Spud Checks for the early Sebago crops.

Grower Adoption (%)		1994	1995	1996
Single Checks	Spud Check 1	73	62	50
	Spud Check 2	36	52	50
	Spud Check 3	45	71	75
	Spud Check 4	36	43	67
	Spud Check 5	9	14	8
	Spud Check 6	45	57	50
	Spud Check 7	36	43	17
Multiple Checks	0 Checks	9	0	0
	1 Check	27	10	8
	2 Checks	9	14	42
	3 Checks	9	29	17
	4 Checks	18	19	8
	5 Checks	27	29	17
	6 Checks	0	0	0
	7 Checks	0	0	8

The average crop yields of all the early Sebago crops in the project are summarised in Table 11.

Table 11. Average crop yields for all the early Sebago crops (1994-1996).

Crop Input			Average Yield (tonnes/hectare)
Seed	Type	Certified	39
		Non-Certified	31
	Size	43-56 grams	34
		56-71 gm	41
		71-85 gm	32
		> 85 gm	27
Rotation	Last Potatoes	0 years	27
		1 yr	37
		2 yrs	32
		3 yrs	41
	Last Crop	Grass	37
		Fallow	42
		Legume	36
		Potatoes	27
Sowing	Date	July	27
		early August	36
		mid-August	34
		September	48
	Row Spacing	81 centimetres	41
		84 cm	33
		86 cm	27
		91 cm	30
	Plant Population	40-50,000 plants/hectare	39
		50-60,000 plants/ha	32
		60-70,000 plants/ha	37
		70-80,000 plants/ha	41
Fertiliser - Total	Nitrogen	0-100 kilograms/hectare	8
		100-200 kg/ha	37
		200-300 kg/ha	36
		300-400 kg/ha	38
		400-500 kg/ha	31
	Phosphorus	0-50 kg/ha	26
		50-100 kg/ha	39
		100-150 kg/ha	36
		150-200 kg/ha	32
	Potassium	0-100 kg/ha	8
		100-200 kg/ha	37
		200-300 kg/ha	39
		300-400 kg/ha	23

Table 11. Average crop yields for all the early Sebago crops (1994-96) (continued).

Crop Input			Average Yield (tonnes/hectare)
Fertiliser - Total	Sulphur	0-100 kilograms/hectare	34
		100-200 kg/ha	36
		200-300 kg/ha	40
		300-400 kg/ha	18
Fertiliser - Pre Sowing	Nitrogen	0-100 kg/ha	37
		100-200 kg/ha	34
		200-300 kg/ha	31
	Phosphorus	0-50 kg/ha	26
		50-100 kg/ha	40
		100-150 kg/ha	35
		150-200 kg/ha	34
	Potassium	0-50 kg/ha	13
		50-100 kg/ha	41
		100-150 kg/ha	34
		200-250 kg/ha	34
	Sulphur	0-50 kg/ha	34
		50-100 kg/ha	35
		100-150 kg/ha	31
		150-200 kg/ha	51
		200-250 kg/ha	20
Fertiliser - Post Sowing	Nitrogen	0-100 kg/ha	35
		100-200 kg/ha	36
		200-300 kg/ha	35
	Phosphorus	0-50 kg/ha	25
		50-100 kg/ha	38
	Potassium	0-50 kg/ha	26
		50-100 kg/ha	40
		100-150 kg/ha	40
		150-200 kg/ha	35
		200-250 kg/ha	23
	Sulphur	0-50 kg/ha	36
		50-100 kg/ha	36
		100-150 kg/ha	33
		150-200 kg/ha	30
Irrigation	Irrigator	Pivot	41
		Fixed	30
		Gun	30
		Boom	24
	Water Use	0-3 Megalitres/hectare	28
		3-4 Ml/ha	41
		4-10 Ml/ha	33

Table 11. Average crop yields for all the early Sebago crops (1994-96) (continued).

Crop Input			Average Yield (tonnes/hectare)
Harvest	Crop Yield	Average yield	35
		Top 25% yield	47 to 61
	Season	110-120 days	45
		120-130 days	34
		130-140 days	33
		140-150 days	36
		150-160 days	32
		160-170 days	25
		170-180 days	35

The crop yield response to the number of Spud Checks achieved by the Riverina growers for the early Sebago crops is summarised in Table 12.

Table 12. Crop yield response to Spud Check adoption for the early Sebago crops (1994-96).

Spud Check Adoption	Average Yield (tonnes/hectare)
1 Check	29
2 Checks	30
3 Checks	34
4 Checks	38
5 Checks	43
6 Checks	-
7 Checks	61

4.2 Coliban, Desiree and Atlantic crops

As the crop yield analysis required a minimum of eight crops to determine an average crop input for the forth quarter yields, the smaller number of Coliban, Desiree and Atlantic crop records required the crop yield analysis to be conducted over the whole of the project for these cultivars (see Table 13).

Table 13. Number of crop records.

Variety	1994	1995	1996	1994-96
Sebago	11	21	12	44
Coliban	5	7	4	16
Desiree	2	5	1	8
Atlantic	5	9	5	19
Total	23	42	22	87

The crop yield analysis, crop performance, grower adoption and crop yield response to Spud Checks for the early Coliban, Desiree and Atlantic crops are summarised in Tables 14, 15, 16 and 17.

Table 14. Crop yield analysis for the highest yielding early Coliban, Desiree and Atlantic crops.

Crop Input		1994-96		
Variety	Variety	Coliban	Desiree	Atlantic
Seed	Type	Certified	Certified	Certified
	Size (grams)	71-85	71-85	56-71
Rotation	Last Potatoes (years)	2	2	3
	Last Crop	grass	grass	grass
Sowing	Date	early August	early August	mid August
	Row Spacing (centimetres)	81	81	81
	Plant Population (plants/hectare)	54,002	55,556	50,925
Fertiliser - Total	Nitrogen (kilograms/hectare)	263	248	231
	Phosphorus (kg/ha)	120	80	116
	Potassium (kg/ha)	223	182	199
	Sulphur (kg/ha)	105	116	149
Fertiliser - Pre Sowing	Nitrogen (kg/ha)	93	83	85
	Phosphorus (kg/ha)	120	75	91
	Potassium (kg/ha)	149	100	124
	Sulphur (kg/ha)	83	63	85
Fertiliser - Post Sowing	Nitrogen (kg/ha)	173	166	148
	Phosphorus (kg/ha)	0	5	25
	Potassium (kg/ha)	75	67	75
	Sulphur (kg/ha)	22	54	65
Irrigation	Irrigator	pivot or gun	pivot or fixed	pivot
	Water Use (Megalitres/hectare)	5.5	5.0	4.6
Harvest	Crop Yield (tonnes/hectare)	29	33	40

Table 15. Crop performance of the early Coliban, Desiree and Atlantic crops (1994-96).

Crop Performance		Coliban	Desiree	Atlantic
Crop Yield	Average Yield (tonnes/hectare)	29	33	40
	Crops > 31 tonnes/hectare (%)	44	50	84
Certified Seed	Average Use (t/ha)	3.9	4.4	3.5
	Efficiency (tonnes/tonne)	8.6	8.1	11.7
Nitrogen Fertiliser	Average Use (kilograms/hectare)	212	218	223
	Efficiency (tonnes/kilogram Nitrogen)	0.136	0.150	0.179
Phosphorus Fertiliser	Average Use (kg/ha)	88	62	105
	Efficiency (t/kg Potassium)	0.328	0.524	0.380
Potassium Fertiliser	Average Use (kg/ha)	176	164	178
	Efficiency (t/kg Potassium)	0.164	0.199	0.225
Irrigation Water Use	Average Use (Megalitres/hectare)	4.9	4.2	4.4
	Efficiency (tonnes/Megalitre)	5.9	7.8	9.1

Table 16. Grower adoption of the Spud Checks for the early Coliban, Desiree and Atlantic crops (1994-96).

Grower Adoption (%)		Coliban	Desiree	Atlantic
Single Checks	Spud Check 1	75	75	79
	Spud Check 2	31	38	53
	Spud Check 3	50	50	58
	Spud Check 4	50	50	100
	Spud Check 5	6	25	5
	Spud Check 6	56	50	63
	Spud Check 7	44	38	63
Multiple Checks	0 Checks	6	0	0
	1 Check	13	13	0
	2 Checks	31	25	16
	3 Checks	13	13	11
	4 Checks	25	25	21
	5 Checks	6	25	42
	6 Checks	6	0	11
	7 Checks	6	0	0

Table 17. Crop yield response to Spud Check adoption for the early Coliban, Desiree and Atlantic crops (1994-96).

Spud Check Adoption	Average Yield (tonnes/hectare)		
	Coliban	Desiree	Atlantic
1 Check	18	20	-
2 Checks	26	28	28
3 Checks	33	43	45
4 Checks	30	31	44
5 Checks	50	41	40
6 Checks	38	-	46
7 Checks	40	-	-

Along with the early Sebago crops, the seven best crop management practices were determined for the early Coliban, Desiree and Atlantic crops. With the exception of Spud Check 5, all the Spud Check practices were identical to the early Sebago crop recommendations. For Spud Check 5 in the early Coliban and Atlantic crops, phosphorus fertiliser rates of 100 to 150 kilograms per hectare were found to produce the highest crop yields.

5.0 Discussion

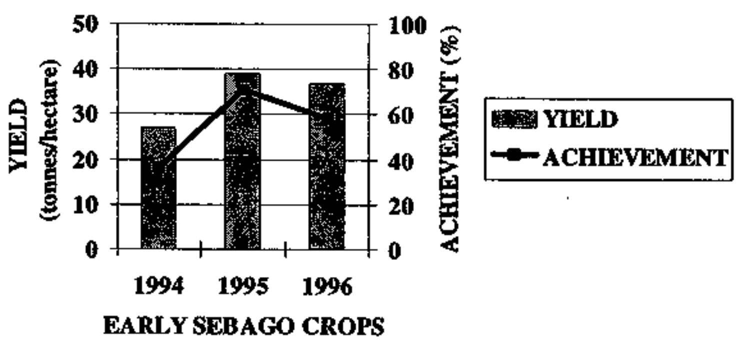
As most of Project PT 432's Crop Check activities were concerned with the early Sebago crops, the project's outcomes will be discussed in terms of the average early Sebago crop yields (see Table 11). However similar trends also occurred with the other potato cultivars that were analysed.

5.1 Increased crop yields

Project PT 432 aimed to increase the early crop yields in the Riverina by six tonnes a hectare. Under the Crop Check approach a grower target yield of thirty one tonnes a hectare was established for the early crops. This was the average crop yield of the Riverina potato cultivar improvement trials from 1990 to 1992 (Dowling and Wade, 1991-93).

From 1994 to 1996 the average early Sebago crop yields in the project increased from twenty seven to thirty seven tonnes a hectare. This surpassed the project's yield target by four tonnes a hectare. The higher crop yields were achieved across the Riverina, with the number of producers exceeding the grower target yield increasing from 36 to 58 percent over this period (see Figure 6).

Figure 6. Average early Sebago crop yields and grower target yield achievement [1].



1. The percentage of growers exceeding the grower target yield of thirty one tonnes per hectare.

Statistical analysis was used to detect any significant changes in the average early Sebago crop yields over the three years. While a single factor analysis of variance technique (ANOVA) using an F test is the preferred method of analysis for multiple population means, the unequal sample variances between the three years ($s^2_{1994, 95, 96}$ = 127, 113, 309) and the small population sizes of the crop records ($n_{1994, 95, 96}$ = 11, 21, 12) required multiple two sample Student's t tests to be used for the detection of any significant crop yield differences.

The Student's t tests found there was a significant difference between the 1994 and 1995 early Sebago crop yields (26.9 verses 38.9 tonnes a hectare, two-tailed test, $P = 0.05$). The mean yield difference for the two crops at the 95 percent confidence level was 12.0 ± 9.2 tonnes a hectare. No significant yield differences were identified for the 1995 and 1996 early Sebago crops (38.9 verses 37.2 tonnes a hectare, two-tailed test, $P = 0.05$). Because of the unequal sample variances and small population sizes, statistical analysis of the crop records was susceptible to Type II errors, where no significant yield differences are found as the null hypothesis is accepted when in fact it is actually false.

5.2 Best crop management practices

The higher early Sebago crop yields resulted from the increased adoption of the seven Spud Check recommendations by the Riverina growers. These best crop management practices were identified as:

1. "buy Certified seed,"
2. "follow a grass rotation,"
3. "sow early to mid-August,"
4. "plant 81 centimetre rows,"
5. "spread 200 to 300 kilograms per hectare of nitrogen, 50 to 100 kilograms per hectare of phosphorus and 100 to 200 kilograms per hectare of potassium,"
6. "side dress 50 to 100 kilograms per hectare of potassium" and
7. "apply three to four Megalitres per hectare of irrigation water."

An estimate of the contribution of each Spud Check to the early Sebago crop yields is summarised in Table 18. While these estimates do not allow for any interactions between the best crop management practices, they do indicate that the Riverina growers only required between one and four additional Spud Checks per crop to increase their average Sebago yields by ten tonnes a hectare.

Table 18. Yield contribution of each Spud Check to the early Sebago crop yields (1994-96).

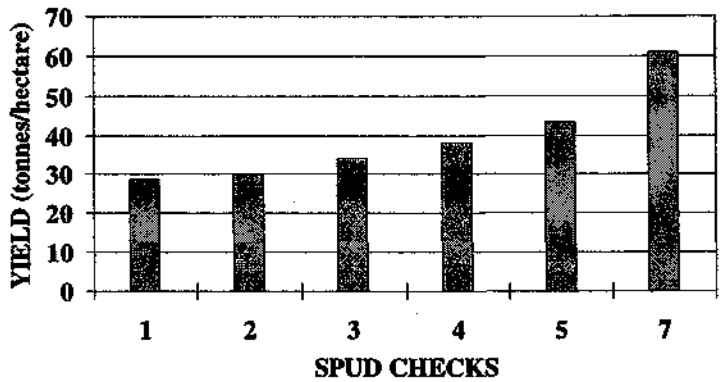
Spud Check	Average Yield (tonnes/hectare)	Yield Gain (tonnes/hectare)	Yield Contribution (%)
1. Certified seed	39	4	11
2. Crop rotation	37	2	6
3. Sowing date	36	1	3
4. Row spacing	41	6	17
5. Fertiliser	56	21	60
6. Side dressing	40	5	14
7. Irrigation water	41	6	17
Average	35	6	17

The estimates indicate that fertiliser management (74%), irrigation water use (17%) and row spacing (17%) are the most important practices for increasing early crop yields. The analysis also showed that sowing date (3%), crop rotation (6%) and Certified seed (11%) were the lowest contributors to higher potato yields.

The average crop yields also increased with the total number of Spud Checks that were adopted by the Riverina growers. The significant yield differences between the Spud Checks (One-tailed F test, P = 0.05) showed the Crop Check approach could identify the relevant best crop management practices from a large range of possible crop inputs, even if many of these individual best practices did not have statistically significant crop input to yield relationships.

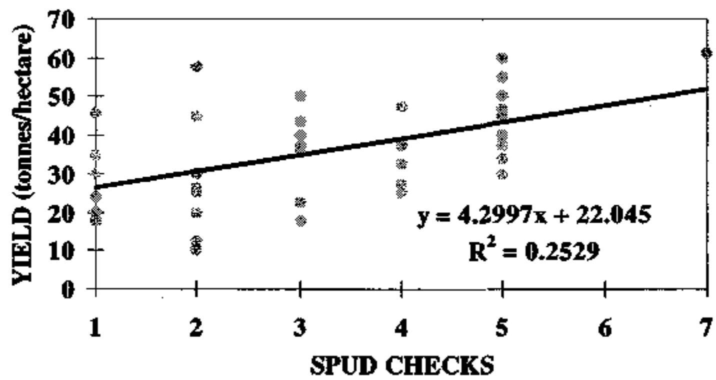
For the early Sebago crops, the average crop yields increased from twenty nine tonnes a hectare with one Spud Check to sixty one tonnes a hectare when all of the seven Spud Checks were achieved (see Figure 7).

Figure 7. Early Sebago crop yield response to grower Spud Check adoption (1994-96).



Regression analysis of the Spud Check adoption rate found a significant, moderate, positive linear correlation ($r = 0.50$, two-tailed t test, $P < 0.001$) between the number of Spud Checks adopted and the average early Sebago crop yields. The coefficient of determination ($R^2 = 0.2529$) indicated 25 percent of the variation in early Sebago crop yields was associated with the number of Spud Checks adopted by the Riverina potato growers (see Figure 8).

Figure 8. The effect of Spud Check adoption on early Sebago crop yields (1994-96).



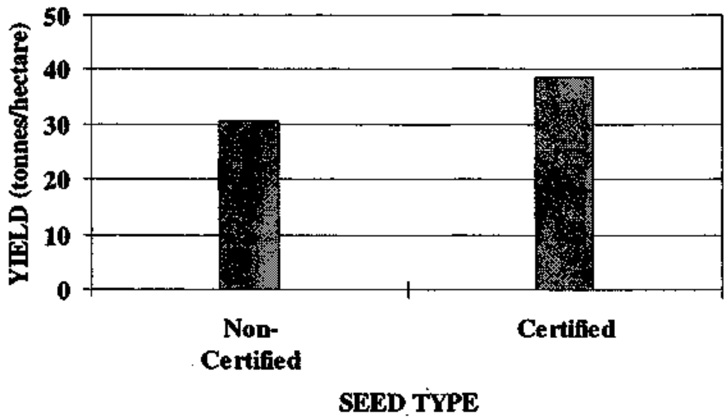
The gradient of the regression line estimated that each additional Spud Check increased early Sebago crop yields by an average of 4.3 ± 0.1 tonnes a hectare ($P = 0.05$). The regression equation also predicted that if every grower could achieve all seven Spud Checks, potential average early Sebago crop yields in the Riverina could increase to 52.2 ± 1.2 tonnes a hectare ($P = 0.05$). This potential crop yield is nearly twice the average Riverina early Sebago yields during the 1994 season and over two and a half times the average New South Wales State yield for 1994-95.

The project demonstrated that by using the Crop Check approach, it was possible to identify the best crop management practices in a region. By adopting these best management practices, the Riverina growers successfully increased their average early Sebago crop yields by ten tonnes a hectare. If a similar Spud Check project was adopted on a national basis, it could also potentially double average 1994-95 potato yields (from 29.8 to 59.9 tonnes a hectare) and significantly improve the international competitiveness of the Australian potato industry.

5.3 Certified seed

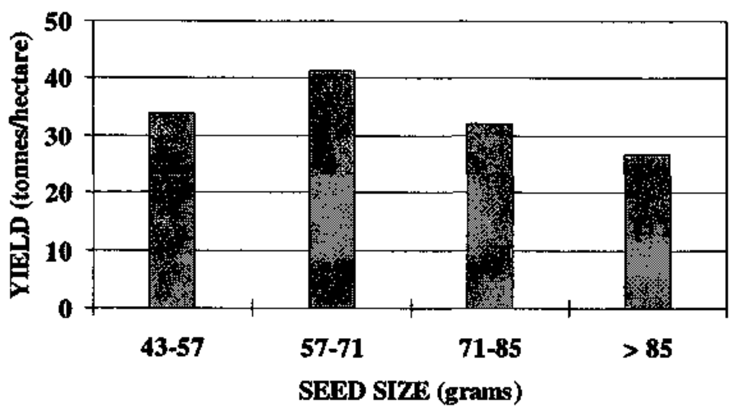
The first Spud Check recommendation was to "buy Certified seed." Analysis of the early Sebago crops found those sown with Certified seed averaged eight tonnes a hectare more yield than those using Non-Certified seed (39 verses 31 tonnes a hectare) (One-tailed t test, P = 0.05) (see Figure 9).

Figure 9. Yield response to seed type for the early Sebago crops (1994-96).



Sowing cut, Certified seed pieces with an average size of 57 to 71 grams weight produced the highest yields in the early Sebago crops (Not significant, two-tailed F test, P = 0.05) (see Figure 10).

Figure 10. Yield response to seed size for the early Sebago crops (1994-96).



While the project showed the potential yield gains from sowing Certified seed, it also raised questions with regard to the growers' ability to consistently capture the economic benefits. If the average cost of Certified seed in the Riverina is estimated at $450 per tonne (seed and transport costs), and the average price for Sebago potatoes is estimated at $200 a tonne on-farm, then the eight tonnes a hectare of yield gained by sowing Certified seed provided an additional income of $1,035 a hectare (Not significant, two-tailed t test, P = 0.05). However in the 1995 early Sebago crop, when the yield difference was only two tonnes a hectare between the two types of seed, those growers who planted Certified seed had an additional income of -$755 a hectare due to the higher cost of using Certified seed (Not significant, two-tailed t test, P = 0.05) (see Table 19).

Table 19. Cost benefit analysis of sowing Certified seed for the early Sebago crops.

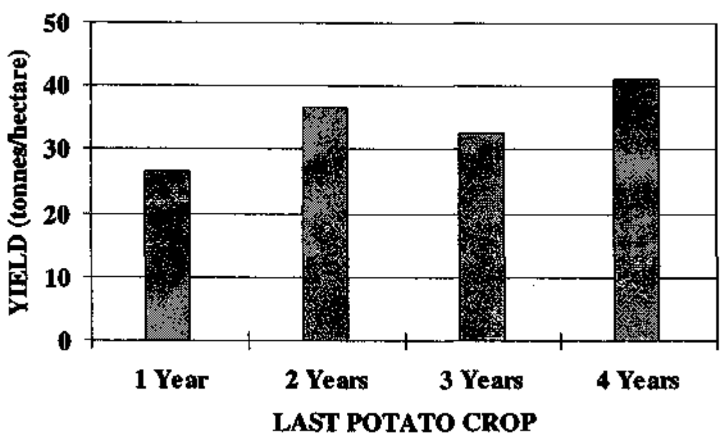
Cost Benefit Analysis	1994-96 Crops	1994 Crop	1995 Crop	1996 Crop
Certified Seed				
Yield (tonnes/hectare)	39	32	40	45
Seed (tonnes/hectare)	3.7	3.5	4.0	3.4
Gross Income ($/hectare)	$7,728	$6,348	$8,048	$9,033
Seed Cost ($/hectare)	$1,667	$1,574	$1,815	$1,544
Income ($/hectare) (A)	$6,061	$4,774	$6,233	$7,490
Non-Certified Seed				
Yield (t/ha)	29	14	39	21
Seed (t/ha)	4.0	3.6	3.9	4.5
Gross Income ($/ha)	$5,802	$2,833	$7,774	$4,167
Seed Cost ($/ha)	$794	$711	$786	$896
Income ($/ha) (B)	$5,008	$2,123	$6,988	$3,270
Benefit of Certified Seed				
Additional Income ($/hectare) (A-B)	$1,053	$2,651	-$755	$4,219

Despite these income fluctuations, the first Spud Check "buy Certified seed" was recommended to the Riverina potato growers as it increased their early Sebago crop yields while also producing a higher quality seed for the following main crop.

5.4 Crop rotation

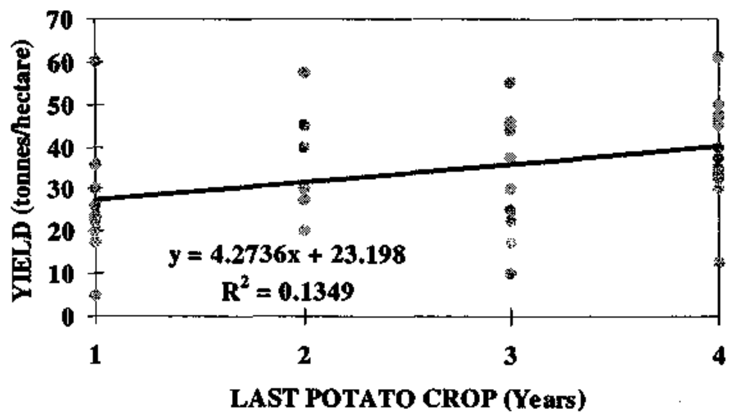
The second Spud Check for the early Sebago crops was to "follow a grass rotation." Project PT 432 showed that by practising crop rotations, the Riverina growers could increase their early crop yields. The longer the period between potato crops - the higher the following potato crop's yields - with the average early Sebago crop yields increasing from twenty seven tonnes a hectare on a nil rotation to forty one tonnes a hectare when there was a four year break between potato crops (Not significant, two-tailed F test, P = 0.05) (see Figure 11).

Figure 11. Yield response to the last potato crop for the early Sebago crops (1994-96).



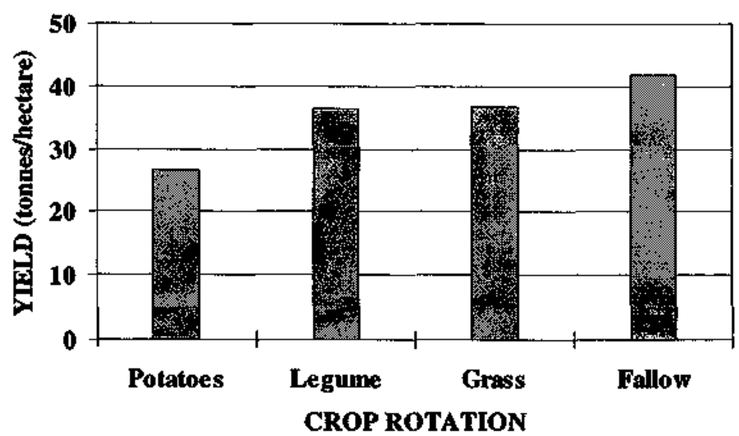
Regression analysis of the crop rotation interval found a significant, weak, positive linear correlation ($r = 0.37$, two-tailed t test, $P = 0.05$) for the number of years between potato crops and the average early Sebago crop yields. The gradient of the regression line estimated that for every additional year between potato crops, the early Sebago yields increased by 4.3 ± 0.2 tonnes a hectare ($P = 0.05$). The coefficient of determination ($R^2 = 0.1349$) indicated that 13 percent of the variation with the early Sebago crop yields was related to the number of years between potato crops (see Figure 12).

Figure 12. The effect of crop rotation interval on early Sebago crop yields (1994-96).



The particular crop rotations with the highest yields varied between years, with grass rotations giving the highest yields in 1994, no rotation producing the largest crops in 1995 and a fallow rotation providing the best results in 1996. When all the early Sebago crops over the project were analysed, the traditional fallow rotation provided the highest average crop yields (Not significant, two-tailed F test, $P = 0.05$) (see Figure 13).

Figure 13. Yield verses crop rotation for the early Sebago crops (1994-96).

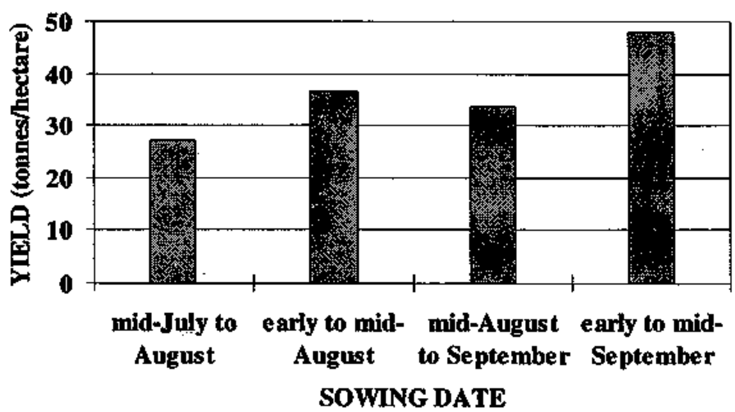


However as the highest yielding rotation for the top twenty five percent of early Sebago crops was a grass rotation, either a cereal crop or a pasture ley, this rotation was used for the second Spud Check recommendation.

5.5 Sowing date

The third Spud Check for the early Sebago crops was to "sow early to mid-August." Although the average yields of potato crops sown in this period were below the September planting's (36 verses 48 tonnes a hectare), the recommended sowing dates were used by the majority of the highest yielding early Sebago crops (Not significant, two-tailed F test, P = 0.05) (see Figure 14).

Figure 14. Yield response to sowing date for the early Sebago crops (1994-96).



The sowing date recommendation represented a practical compromise between higher crop yields and harvesting the early crop on time. While higher crop yields could be obtained with the September sowing's, the early Sebago, Coliban and Desiree crops provided the seed for sowing the main crop in February. For this seed to have sufficient time to break dormancy, it required an early enough sowing date to be ready for December harvesting. With the early Atlantic crops, most growers had contracts which specified December factory delivery dates that also required early planting dates.

When the Riverina growers didn't have to meet these conditions, the September sowing's may have the potential to increase the early crop yields. These yields could be achieved with a shorter growing season and faster seasonal growth rates (Not significant, two-tailed F test, P = 0.05) (see Table 20). By spreading the early crop sowing dates, the Riverina growers could better utilise their planting and harvesting equipment and also reduce the risks of total crop failures with a single sowing date.

Table 20. The effect of sowing date on the growth rates for the early Sebago crops (1994-96).

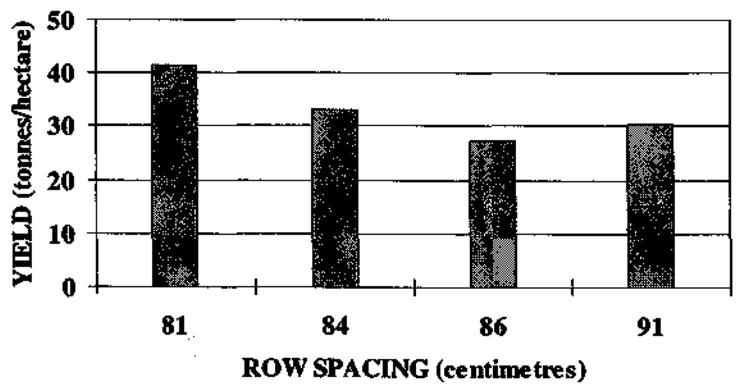
Sowing Date	Growing Season [1] (days)	Average Yield (tonnes/hectare)	Growth Rate (tonnes/hectare/day)
mid-July to August	142	27	0.193
early to mid-August	145	36	0.246
mid-August to September	140	34	0.242
early to mid-September	137	48	0.351
Average	143	35	0.244

1. Growing season is defined as the period between planting and harvest.

5.6 Row spacing

The forth Spud Check for the early Sebago crops was to "plant 81 centimetre rows." Crops planted on the 81 centimetre wide row spacings (the distance from crop furrow to furrow) produced fourteen tonnes a hectare more yield than those grown on the lowest yielding 86 centimetre rows (41 verses 27 tonnes a hectare) (One-tailed F test, $P = 0.05$) (see Figure 15).

Figure 15. Yield response to row spacing for the early Sebago crops (1994-96).



Analysis of the row spacing yields found the quadratic curve $y = 0.311x^2 - 54.634x + 2426.3$ provided the best line of fit between the data points ($r = 0.44$, two-tailed t test, $P < 0.01$). The coefficient of determination ($R^2 = 0.1942$) indicated that 19 percent of the variation in the early Sebago yields was associated with the variation in row spacings between potato crops.

The yield response to 81 centimetre rows was consistent for all the Sebago, Coliban and Desiree crops and was the only row spacing used by the Atlantic growers. While the 84 centimetre rows permitted the highest theoretical plant populations, the average yields for the early Sebago crops showed there was no significant relationship between crop yield and plant population (Two-tailed F test, $P = 0.05$).

Statistical analysis of the plant yields for each row spacing also indicated that the 81 centimetre rows provided the highest yield per plant (One-tailed F test, $P = 0.05$). The 81 centimetre wide rows were the only row spacings with above average plant yields of 0.79 kilograms per plant, which further validated the forth Spud Check recommendation to "plant 81 centimetre rows" (see Table 21).

Table 21. Average plant yields per row spacing for the early Sebago crops (1994-96).

Row Spacing	Population (plants/hectare)	Average Yield (tonnes/hectare)	Plant Yield (kilograms/plant)
81 centimetre	53,863	41	0.79
84 cm	66,138	33	0.50
86 cm	52,208	27	0.54
91 cm	52,797	30	0.57
Average	55,018	35	0.66

5.7 Fertiliser application

The fifth Spud Check for the early Sebago crops was to "spread 200 to 300 kilograms per hectare of nitrogen, 50 to 100 kilograms per hectare of phosphorus and 100 to 200 kilograms per hectare of potassium."

(i) Nitrogen

If the nitrogen fertiliser rates are considered first, the highest yielding early Sebago crops were grown with a pre-sowing nitrogen application of 0 to 100 kilograms per hectare, followed by a post-emergent side dressing of between 100 to 200 kilograms of nitrogen per hectare (Not significant, two-tailed F tests, $P = 0.05$) (see Figures 16 and 17).

Figure 16. Yield verses pre-emergent nitrogen fertiliser for the early Sebago crops (1994-96).

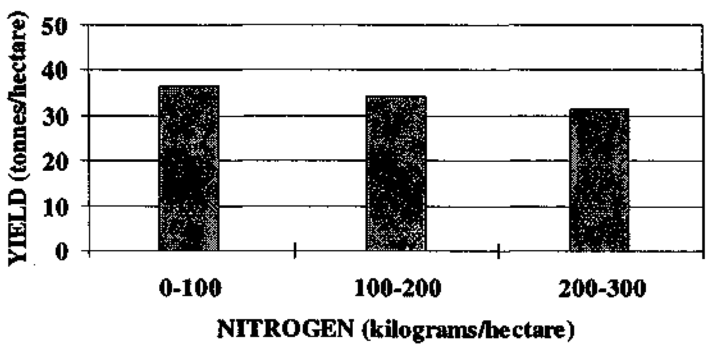
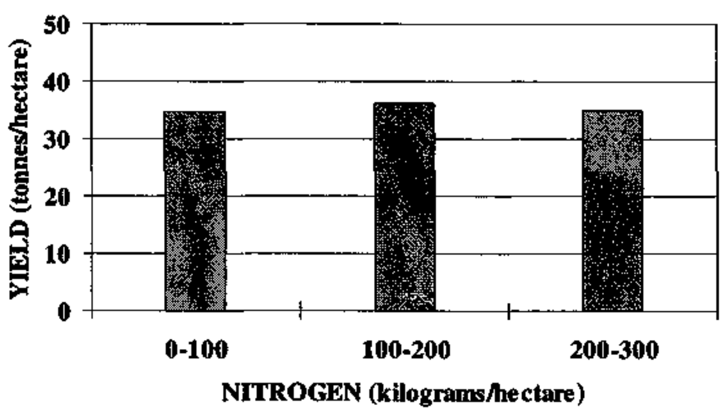


Figure 17. Yield verses post-emergent nitrogen fertiliser for the early Sebago crops (1994-96).



The highest nitrogen fertiliser efficiency (NFE), calculated as the crop yield divided by the nitrogen fertiliser rate, was achieved with a total nitrogen rate of 100 to 200 kilograms per hectare (Two-tailed F test, $P < 0.01$). Growers using this fertiliser rate had an NFE of 0.242 tonnes of yield per kilogram of nitrogen (t/kg N), which was one and a half times the NFE of 0.160 t/kg N for the recommended nitrogen fertiliser rate. Despite having a lower NFE, it was still viable to apply the recommended nitrogen rate as its NFE was above the average NFE of 0.178 ± 0.026 t/kg N ($P = 0.05$) for the early Sebago crops (see Table 22).

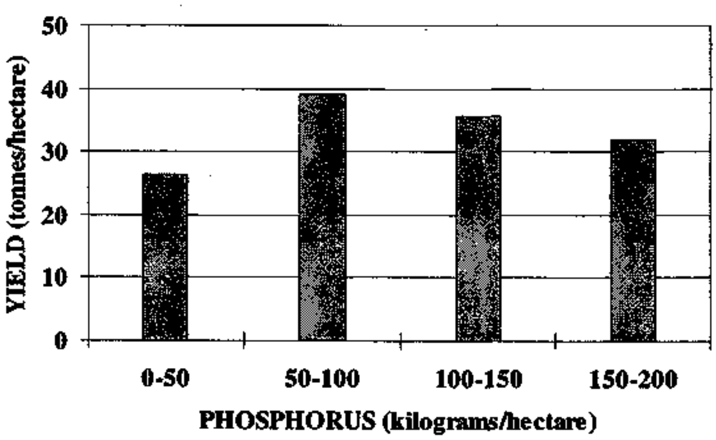
Table 22. Nitrogen fertiliser efficiency of the early Sebago crops (1994-96).

Nitrogen Fertiliser (kilograms/hectare)	Fertiliser Efficiency (tonnes/kilogram Nitrogen)
0-100	0.111
100-200	0.242
200-300	0.160
300-400	0.122
400-500	0.075
Average	0.178

(ii) Phosphorus

When the phosphorus fertiliser rates are examined, the highest early crop Sebago yields were grown with a pre-planting rate of 50 to 100 kilograms of phosphorus per hectare (Not significant, two-tailed F test, P = 0.05) (see Figure 18).

Figure 18. Yield response to phosphorus fertiliser rates for the early Sebago crops (1994-96).



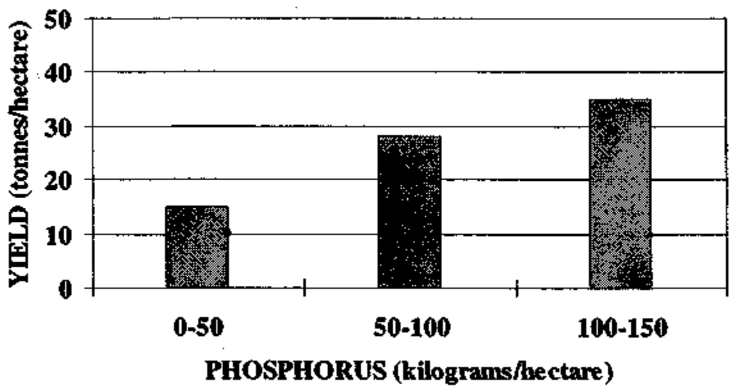
No significant crop yield improvements were found at any post-emergent applications of phosphorus fertiliser (Two-tailed F test, P = 0.05). As with the nitrogen rates, the efficiency of the phosphorus recommendation was below the maximum phosphorus fertiliser efficiency (PFE) (Two-tailed F test, P < 0.01). Again it was still viable to apply the recommended phosphorus rate as its PFE was above the average phosphorus fertiliser efficiency for the early Sebago crops (see Table 23).

Table 23. Phosphorus fertiliser efficiency of the early Sebago crops (1994-96).

Phosphorus Fertiliser (kilograms/hectare)	Fertiliser Efficiency (tonnes/kilogram Phosphorus)
0-50	0.796
50-100	0.498
100-150	0.278
150-200	0.201
Average	0.467

The phosphorus fertiliser rates provided the only differences in the Spud Check recommendations for the four potato varieties analysed in the project. With the early Coliban (Two-tailed F test, $P < 0.01$) and Atlantic (Not significant, two-tailed F test, $P = 0.05$) crops, phosphorus rates of between 100 to 150 kilograms per hectare were found to produce the highest crop yields (see Figure 19).

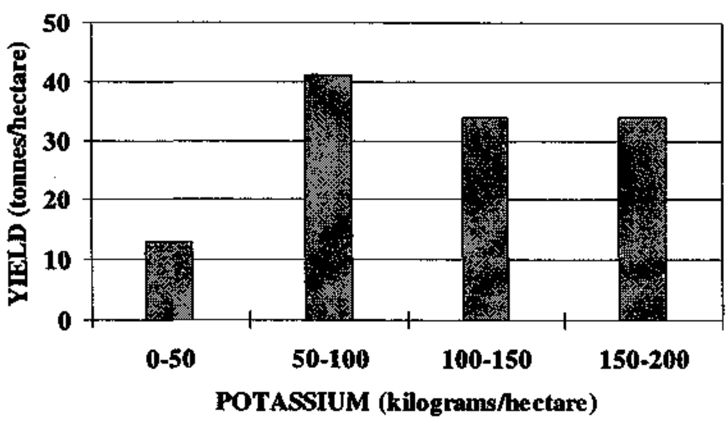
Figure 19. Yield response to phosphorus fertiliser rates for the early Coliban crops (1994-96).



(iii) Potassium

As potassium is an important factor in tuber bulking and increasing crop yields, it was adopted as the sixth Spud Check best practice recommendation to "side dress 50 to 100 kilograms per hectare of potassium." The highest early Sebago crop yields were achieved with pre-emergent (Two-tailed F test, $P = 0.05$) and post-emergent (One-tailed F test, $P = 0.05$) potassium rates of 50 to 100 kilograms per hectare (see Figures 20 and 21).

Figure 20. Yield verses pre-emergent potassium fertiliser for the early Sebago crops (1994-96).



Unlike nitrogen and phosphorus, the highest potassium fertiliser efficiency was at the recommended fertiliser rate for potassium (Two-tailed F test, $P < 0.001$). Potassium was the only nutrient where the Riverina potato growers were able to achieve both the maximum technical and economic fertiliser efficiency at the recommended application rates (see Table 24).

Figure 21. Yield verses post-emergent potassium fertiliser for the early Sebago crops (1994-96).

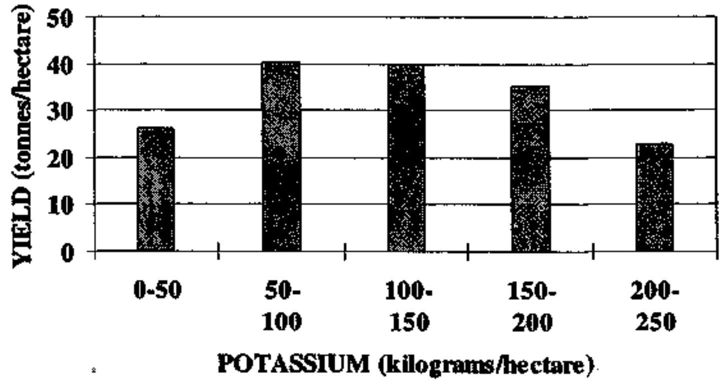


Table 24. Potassium fertiliser efficiency of the early Sebago crops (1994-96).

Potassium Fertiliser (kilograms/hectare)	Fertiliser Efficiency (tonnes/kilogram Potassium)
0-100	0.191
100-200	0.244
200-300	0.166
300-400	0.068
Average	0.205

(iv) Sulphur

As the sulphur fertiliser rates were related to the types of phosphorus and potassium fertiliser used by the Riverina potato growers, the practical relevance of determining separate sulphur recommendations was limited. Although a crop yield analysis was preformed on sulphur, for simplicity and ease of understanding, the sulphur recommendations were omitted from the fertiliser Spud Checks.

If a recommendation for sulphur was required, the highest yielding early Sebago crops used 100 to 200 kilograms of sulphur per hectare, split between pre-emergent (One-tailed F test, $P = 0.05$) and post-emergent (Not significant, two-tailed F test, $P = 0.05$) rates of 50 to 100 kilograms per hectare. While the sulphur fertiliser efficiency of the recommended rate was below the maximum fertiliser efficiency (Two-tailed F test, $P < 0.0001$), it remained near the average sulphur fertiliser efficiency of 0.379 ± 0.095 tonnes/kilogram of sulphur ($P = 0.05$) (see Table 25).

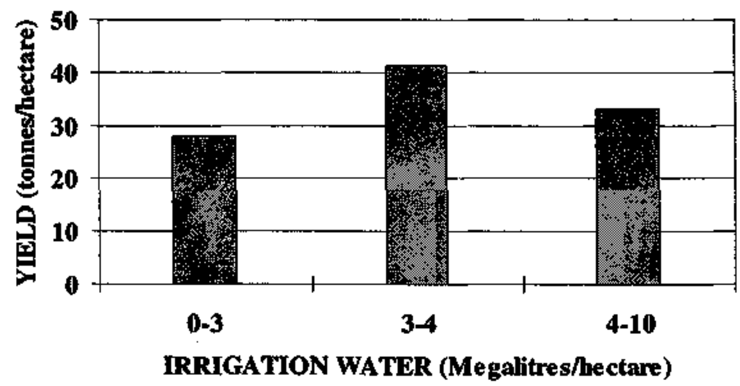
Table 25. Sulphur fertiliser efficiency of the early Sebago crops (1994-96).

Sulphur Fertiliser (kilograms/hectare)	Fertiliser Efficiency (tonnes/kilogram Sulphur)
0-100	0.747
100-200	0.280
200-300	0.185
300-400	0.052
Average	0.379

5.9 Irrigation water use

The seventh and last Spud Check for the early Sebago crops was to "apply three to four Megalitres per hectare of irrigation water." Crops using this recommendation produced thirteen tonnes a hectare higher yields than those grown with less than three Megalitres of irrigation water per hectare (41 verses 28 tonnes a hectare) (Not significant, two-tailed F test, P = 0.05) (see Figure 22).

Figure 22. Yield response to irrigation water for the early Sebago crops (1994-96).



As with the sowing Spud Check, the irrigation recommendation was a practical compromise between higher crop yields and maximising water use efficiency. While the average water use of the highest yielding growers often exceeded the three to four Megalitre per hectare recommendation, as half these crops were grown within this range, this irrigation rate was adopted as a way of improving the water use efficiency of the Riverina potato industry. This approach was subsequently vindicated when the local water authority, Murray Irrigation Limited, introduced a four Megalitres a hectare cap on whole farm irrigation water use in 1997.

Just like the fertiliser recommendations, the efficiency of the recommended irrigation rate was below the maximum water use efficiency (Two-tailed F test, P < 0.001). Again it was viable for the Riverina potato growers to apply the recommended irrigation rate of three to four Megalitres per hectare, as its water use efficiency (WUE) was above the average WUE of the early Sebago crops (see Table 26).

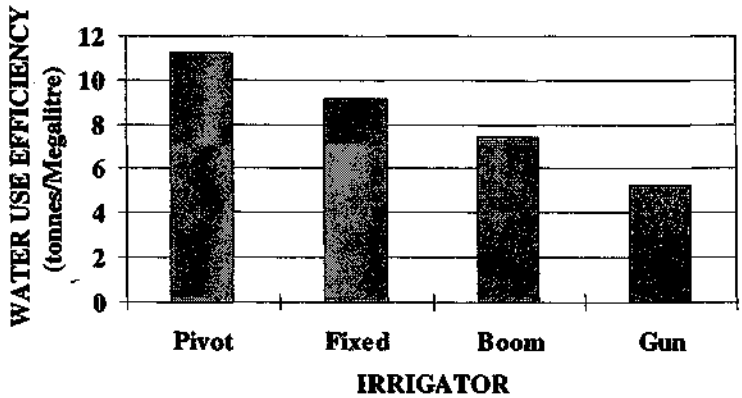
Table 26. Irrigation water use efficiency of the early Sebago crops (1994-96).

Irrigation Water Use (Megalitres/hectare)	Water Use Efficiency (tonnes/Megalitre)
0-3	14.2
3-4	11.9
4-10	4.8
Average	9.0

The WUE's also provided an indirect validation of the irrigation Spud Check recommendation. While no significant statistical differences were found between the crop yields and irrigation water use (P = 0.05), the highly significant differences between the WUE's and crop yields (P < 0.001) showed the irrigation recommendation was a relevant Spud Check for increasing the early Sebago crop yields.

When the water use efficiencies were compared between the different types of irrigators, the centre pivot irrigators had the highest water use efficiency, followed by the fixed sprinklers, booms and gun irrigators (Two-tailed F test, P = 0.05) (see Figure 23).

Figure 23. Irrigator water use efficiencies for the early Sebago crops (1994-96).



One of the difficulties in monitoring the irrigation performance of the early Sebago crops was that despite the lower seasonal evaporative demand in the later years of the project and the greater use of centre pivot irrigators by the Riverina potato growers, the average crop water use increased from 1994 to 1996 (see Tables 27 and 28).

Table 27. Seasonal evaporative demand for the Finley district (CSIRO, 1996).

Crop	Weather	Aug	Sept	Oct	Nov	Dec	Total	Evaporation-Rain
1994	Rain (mm)	3	14	26	20	29	92	827
	Evaporation (mm)	69	105	175	243	327	919	
1995	Rain (mm)	8	11	27	31	22	99	687
	Evaporation (mm)	71	92	159	192	272	786	
1996	Rain (mm)	47	53	27	27	8	162	631
	Evaporation (mm)	54	93	159	211	276	793	

Table 28. Water use and irrigator type on the early Sebago crops (1994-96).

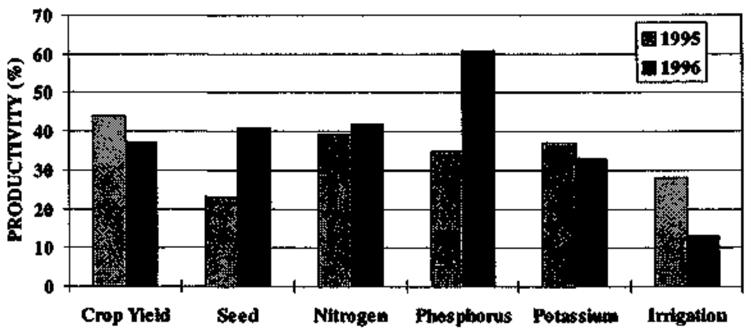
Crop	Irrigator Use (%)				Water Use
	Pivot	Fixed	Boom	Gun	(Megalitres/hectare)
1994	18	18	27	36	4.2
1995	62	19	0	19	4.5
1996	67	0	0	33	6.0
Average	51	14	7	28	4.8

The increased crop water use was a result of the higher water consumption of the gun irrigators in the 1996 crop, which used an average of 8.2 Megalitres per hectare compared with 4.9 Megalitres per hectare for the centre pivot irrigators. As one third of the 1996 crop was grown under gun irrigators, this factor reduced the overall improvement in irrigation water productivity from 28 to 13 percent.

5.10 Improved productivity

As a consequence of the early Sebago crop yields increasing by 37 percent, the productivity of the Certified seed, nitrogen, phosphorus, potassium and irrigation water inputs increased by 41, 42, 61, 33 and 13 percent respectively (Not significant, two-tailed F tests, P = 0.05) (see Figure 24).

Figure 24. Productivity improvement in the early Sebago crops.



In order to calculate the market returns for each crop input, costings of $490.00 a tonne for Certified Seed (cut), $4.79 a kilogram for nitrogen fertiliser, $4.18 a kilogram for phosphorus fertiliser, $3.90 a kilogram for potassium fertiliser and $35.00 a Megalitre for irrigation water were used. The fertiliser costs were based on a Pivot 5:2:1 fertiliser price of $230.00 a tonne.

When the market returns per dollar of crop input were compared for the early Sebago crops, irrigation water ($50 per dollar) had the highest market return followed by fertiliser ($26, $11 and $8 per dollar) and Certified seed ($5 per dollar). The high market returns for irrigation water also contributed to its increased consumption in the early Sebago crops from 1994 to 1996 (see Table 29).

Table 29. Crop performance of the early Sebago crops.

Crop Performance		1994	1995	1996
Certified Seed	Efficiency (tonnes/tonne)	9.3	11.4	13.1
	Return ($/tonne)	$1,859	$2,287	$2,623
	Market Return ($/$)	$3.79	$4.67	$5.35
Nitrogen Fertiliser	Efficiency (tonnes/kilogram Nitrogen)	0.137	0.190	0.194
	Return ($/kilogram Nitrogen)	$27	$38	$39
	Market Return ($/$)	$5.71	$7.92	$8.08
Phosphorus Fertiliser	Efficiency (t/kg Phosphorus)	0.346	0.467	0.556
	Return ($/kg Phosphorus)	$69	$93	$111
	Market Return ($/$)	$16.54	$22.34	$26.62
Potassium Fertiliser	Efficiency (t/kg Potassium)	0.161	0.221	0.215
	Return ($/kg Potassium)	$32	$44	$43
	Market Return ($/$)	$8.27	$11.36	$11.03
Irrigation Water Use	Efficiency (tonnes/Megalitre)	7.7	9.8	8.7
	Return ($/Megalitre)	$1,536	$1,960	$1,734
	Market Return ($/$)	$43.88	$56.00	$49.54

A similar market return ranking for the crop inputs was also found for the early Coliban, Desiree and Atlantic crops (see Table 30).

Table 30. Crop performance of the early Coliban, Desiree and Atlantic crops (1994-96).

Crop Performance		Coliban	Desiree	Atlantic
Crop	Average Yield (tonnes/hectare)	29	33	40
	Average Price ($/tonne)	$220	$200	$250
Certified Seed	Efficiency (tonnes/tonne)	8.6	8.1	11.7
	Return ($/tonne)	$1,892	$1,620	$2,925
	Market Return ($/$)	$3.86	$3.31	$5.97
Nitrogen Fertiliser	Efficiency (tonnes/kilogram Nitrogen)	0.136	0.150	0.179
	Return ($/kilogram Nitrogen)	$30	$30	$45
	Market Return ($/$)	$6.25	$6.26	$9.34
Phosphorus Fertiliser	Efficiency (t/kg Phosphorus)	0.328	0.524	0.380
	Return ($/kg Phosphorus)	$72	$105	$95
	Market Return ($/$)	$17.26	$25.07	$22.72
Potassium Fertiliser	Efficiency (t/kg Potassium)	0.164	0.199	0.225
	Return ($/kg Potassium)	$36	$40	$56
	Market Return ($/$)	$9.25	$10.21	$14.42
Irrigation Water Use	Efficiency (tonnes/Megalitre)	5.9	7.8	9.1
	Return ($/Megalitre)	$1,298	$1,560	$2,275
	Market Return ($/$)	$37.09	$44.57	$65.00

5.11 Higher gross margins

For the calculation of the gross margin returns, the variable costs published in the NSW Agriculture 1996 Farm Budget Handbook Potatoes (Spring/Summer) budget were used (see Table 31).

Table 31. Gross margin budget costs for the 1996 early Sebago crop (Curthoys *et al*, 1996).

Variable Cost	1996 Crop	Rate	Cost
Machinery			
Disc Ploughing (2)	1	hour/hectare	$13.75/hour
Lime Application	1	hour/hectare	$13.75/hour
Broadcast (3)	0.3	hour/hectare	$13.75/hour
Sowing	0.65	hour/hectare	$13.75/hour
Hilling (2)	1	hour/hectare	$13.75/hour
Ground Spraying	2	@	$8.75/hectare
Aerial Spraying	4	@	$12.00/hectare
Slashing	0.5	hour/hectare	$13.75/hour
Harvesting	6	tonnes/hour	$43.00/hour
Tractor/Trailer	6	tonnes/hour	$13.75/hour

Table 31. Gross margin budget costs for the 1996 early Sebago crop (continued).

Variable Cost	1996 Crop	Rate	Cost
Crop Inputs			
Lime (1 year in 2)	2.5 tonnes/hectare	@	$49.00/tonne
Pivot 5:2:1		@	$230.00/tonne
Certified Seed (cut)		@	$490.00/tonne
Uncertified Seed (cut)		@	$240.00/tonne
Sencor ™	0.5	litres/hectare	$69.60/litre
Nitofol ™	0.5	litres/hectare	$39.60/litre
Ambush ™	0.25	litres/hectare	$142.00/litre
Bravo ™ (2)	2	litres/hectare	$14.15/litre
Reglone ™	4	litres/hectare	$14.60/litre
Irrigation		@	$35.00/Megalitre
Marketing			
Casual Labour	0.66	hours/tonne	$10.00/hour
Bulk Bag Rental	1 bulk bag/tonne	@	$6.00/bag
Freight		@	$40.00/tonne
Commission		10 percent	of gross sales

As a result of the crop yield and productivity gains, the estimated average gross margins for the early Sebago crops increased by 205 percent from -$471.47 a hectare in 1994 to $494.21 a hectare in 1996 (Not significant, two-tailed F test, $P = 0.05$) (see Table 32).

Table 32. Estimated gross margins and value of production for the early Sebago crops.

Crop	Gross Margin ($/hectare)	Value of Production ($)
1994	-$471.47	-$94,294
1995	$427.44	$85,488
1996	$494.21	$98,842

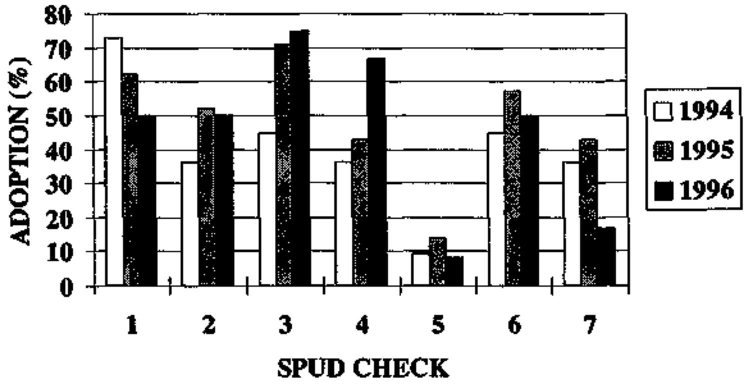
This exceeded the project's gross margin goal by 95 percent per annum. With over 200 hectares of early Sebago crops recorded each year, the value of production increased by $193,136 (200 hectares x ($494.21--$471.47) per hectare) through the adoption of the seven Spud Check best crop management practices. A benefit/cost ratio of 13:1 was achieved by the Riverina potato industry on the $14,349.05 of Horticultural Research and Development Corporation funds spent on Project PT 432.

5.12 Spud Check adoption

(i) Single Checks

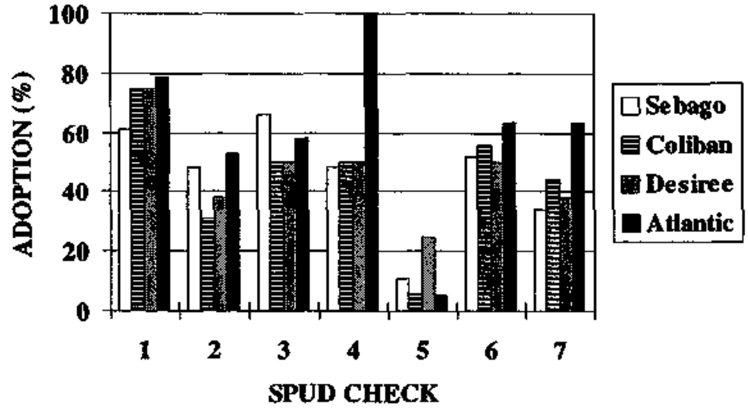
The adoption of single Checks in the early Sebago crops ranged from a maximum of 75 percent of the Riverina potato growers applying Spud Check 3 to minimum of eight percent achieving Spud Check 5 in 1996. With the exception of Spud Checks 5 and 7, the rest of the best practice recommendations had a grower adoption rate of 50 percent or more by the end of the project (see Figure 25).

Figure 25. Grower adoption of the individual Spud Checks in the early Sebago crops.



When the adoption of individual Spud Checks was compared between varieties, the early Atlantic and Coliban crops had the highest rates of grower adoption (Two-tailed F test, $P < 0.001$) (see Figure 26).

Figure 26. Single Spud Check adoption in the early Sebago, Coliban, Desiree and Atlantic crops (1994-96).



This result reflected the higher prices paid for these cultivars compared to Sebago ($250 and $220 verses $200 a tonne), which provided an additional financial incentive for the Riverina potato growers to improve their crop management practices.

Of concern was the low adoption rates for Spud Check 5, the fertiliser recommendation, for although this recommendation provided the largest potential increase in early crop yields (see Table 18), it had the lowest adoption rate for any Spud Check. Paradoxically the fertiliser industry is one of the best serviced sectors in the Riverina, with resellers, fertiliser company staff and Department of Agriculture officers all advising the local potato growers.

This outcome demonstrated the Crop Check approach can readily identify poorly adopted Checks and quickly recognise any potential barriers to better crop management practices. However if the Riverina

growers are to continue increasing their early crop yields then the low adoption rate for Spud Check 5 will need to be addressed.
One way of achieving this goal is with a more precise definition of the fertiliser recommendations. In future crop reports, Spud Checks 5 and 6 for the early Sebago crops will be revised to read:

FERTILISER - PRE SOWING
Spud Check 5 "spread up to 100 kilograms of nitrogen per hectare, 50 to 100 kilograms of phosphorus per hectare and 50 to 100 kilograms of potassium per hectare before sowing."

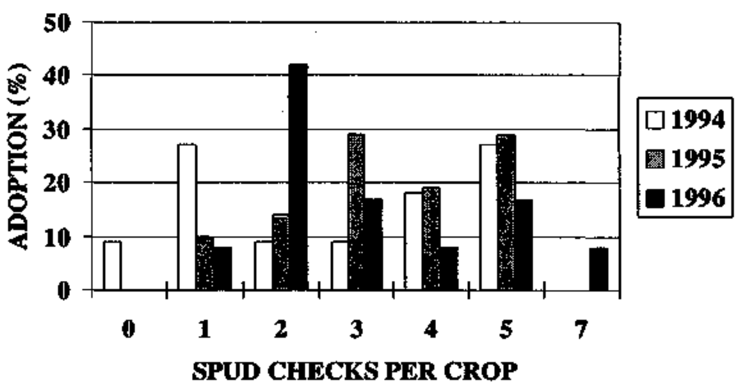
FERTILISER - POST SOWING
Spud Check 6 "side dress 100 to 200 kilograms of nitrogen per hectare and 50 to 100 kilograms of potassium per hectare after sowing."

A more concise definition of these two Spud Checks should permit a clearer understanding of the fertiliser recommendations by both the growers and extension officers servicing the potato industry.

(ii) Multiple Checks

The higher early Sebago yields followed the improved adoption of the seven Spud Check practices by the Riverina growers, with the number of producers achieving two or three Checks per crop increasing from 18 to 59 percent over the project (Not significant, two-tailed F test, $P = 0.05$) (see Figure 27).

Figure 27. The number of multiple Spud Checks adopted in the early Sebago crops.



As well as monitoring the adoption of the Spud Check recommendations by the Riverina growers, the multiple Spud Checks also provided an indicator on the effectiveness of extension performance within the project. With the number of growers achieving two or three Spud Checks per crop increasing from 18 to 59 percent over the project, 41 percent of the program's co-operators directly benefited from its extension activities.

The range of grower adoption rates also showed the Spud Check approach can increase average yields at all levels of management and was relevant to every potato grower in the Riverina industry. While only one to four Spud Checks were required to increase the early Sebago yields by ten tonnes a hectare, if further yield gains are to be achieved then most of the Riverina growers will have to improve their adoption rates by a further two to three Spud Checks per crop.

6.0 Conclusion

Low potato yields are a major problem for New South Wales growers, with the average State yields the lowest in Australia. In 1994 a three year project PT 432, "Improved productivity of inland potato production," was funded by the Horticultural Research and Development Corporation to assist the Riverina potato growers to increase their early crop yields by six tonnes a hectare and to improve the average gross margins per crop by eight percent per annum.

6.1 Best crop management practices

The project identified seven best crop management practices for the early Sebago, Coliban, Desiree and Atlantic potato crops grown in the Riverina. The seven best practices or "Spud Checks" were:

1. "buy Certified seed,"
2. "follow a grass rotation,"
3. "sow early to mid-August,"
4. "plant 81 centimetre rows,"
5. "spread 200 to 300 kilograms per hectare of nitrogen, 50 to 100 kilograms per hectare of phosphorus and 100 to 200 kilograms per hectare of potassium,"
6. "side dress 50 to 100 kilograms per hectare of potassium" and
7. "apply three to four Megalitres per hectare of irrigation water."

For the early Coliban and Atlantic crops, phosphorus fertiliser rates of 100 to 150 kilograms a hectare were found to produce the highest yields. Average crop yields also increased with the number of best crop management practices that were adopted by the Riverina growers. For the early Sebago crops, the average crop yields increased from twenty nine tonnes a hectare with one Spud Check to sixty one tonnes a hectare when all seven Spud Checks were achieved.

6.2 Improved productivity

From 1994 to 1996 the average early Sebago crop yields in the project increased from twenty seven to thirty seven tonnes a hectare. This surpassed the project's yield target by four tonnes a hectare. The higher crop yields were achieved across the Riverina, with the number of producers exceeding the grower target yield of thirty one tonnes a hectare increasing from 36 to 58 percent.

As a result of the higher crop yields, the productivity of the early Sebago crop yields improved by 37 percent, while the Certified seed, nitrogen, phosphorus, potassium and irrigation water productivity increased by 41, 42, 61, 33 and 13 percent respectively. By 1996 the Riverina potato growers had achieved market returns of $5.35, $8.08, $26.62, $11.03 and $49.54 per dollar for each of these crop inputs.

Along with these productivity gains, the estimated average gross margin per crop improved by 205 percent over the project. This exceeded the project's gross margin goal by 95 percent per annum. The productivity improvements followed the increased adoption of the Spud Check recommendations by the Riverina growers, with the number of producers accomplishing two or three Spud Checks per crop rising from 18 to 59 percent over the project.

6.3 Future applications

Project PT 432 demonstrated that with the Spud Check approach, it was possible to identify the best crop management practices in a region. By adopting these best management practices, the Riverina growers successfully increased their average crop yields by ten tonnes a hectare and raised the value of potato production in the Riverina by $193,000 per annum. If a similar Spud Check project was adopted on a national basis, it could potentially double average crop yields and significantly improve the international competitiveness of the Australian potato industry.

6.4 Acknowledgments

The author would like to thank Joe Beazley, Phillip Boustead, Micheal Cochrane, James Cornish, John Doyle, John Dunmore, the late John Harris, Jim MaCartney, Ray Menegazzo, Geoff Moar, Ken Moar, Robert Muratore, Ian Nagle, Anthony Pisasale, Gordon Saunders, John Troy, John Rennie, Len Savage, Mark Savage, Barry Sutton and Laurie Way for their co-operation with this project. Further thanks is extended to John Doyle, potato grower, and to Mark Hickey, Acting Special Horticulturist (Vegetables), NSW Agriculture, for refereeing this report.

6.5 References

Australian Bureau of Meteorology (1996). Climate and Consultancy Section. NSW Regional Office.

Australian Bureau of Statistics (1994). Agriculture Census Data. Australian Bureau of Statistics.

Australian Bureau of Statistics (1997). Agriculture Australia 1994-95. ABS Catalogue No. 7113.0.

Commonwealth Scientific & Industrial Research Organisation (1996). Water Watch 1994-96. Division of Land and Water. Griffith Laboratory.

Curthoys, C., Reilly, T., Salvestrin, J., Murison, J., Davies, L., Beckingham, C. and Hickey, M. (1996). Farm Budget Handbook 1996 NSW Vegetable Crops. NSW Agriculture ISSN 1038-8168.

Dowling, B., and Wade, S. (1991) Berrigan (Summer) 1991. Potato cultivar trials in Australia 1990-91. Department of Agriculture ISSN 0818-528X.

Dowling, B., and Wade, S. (1992) Berrigan (Summer) 1992. Potato cultivar trials in Australia 1991-92. Department of Agriculture ISSN 0818-528X.

Dowling, B., and Wade, S. (1993) Berrigan Summer Harvest. Potato cultivar trials in Australia 1992-93. Department of Agriculture ISSN 0818-528X.

Lacy, J. (1998) Learning from farmers - the check approach. Proceedings of the 9th Australian Agronomy Conference. The Australian Society of Agronomy ISBN 0815-3779.

Seed Potatoes Australia Pty. Ltd. (1996) Crookwell Potatoes Seed Buyer's Guide.

For further information on this project please contact:

Stephen Wade, District Horticulturist
NSW Agriculture, PO Box 108, Finley NSW 2713
Telephone: 03 5883 1644
Facsimile: 03 5883 1570
Email: stephen.wade@agric.nsw.gov.au

Spud Check Crop Report

1994 SPRING CROP

A Crop Report from HRDC Project PT432: *"Improved Productivity of Inland Potato Production."*

Grower:	Spud Potato		
Address:	"Check Farm", Finley 2713		
Variety:	Sebago	**Paddock:**	Top Paddock

Please note - the accuracy of these results is only as good as the information provided by co-operators.

Spud Checks	**Your Crop**		**All Crops**		
	Results	**Checks**	**Average**	**Top 25%**	**Adoption**
YIELD ***Target yield*** **"31 tonnes/hectare (t/ha)"**	47.5 t/ha	✔	27 t/ha	38 to 48 t/ha	36%
SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	73%
CROP ROTATION ***Spud Check 2*** **"Follow a grass rotation"**	93 - Grass	✔	Rotation	Grass	36%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	5/08/94	✔	8/08/94	14/08/94	45%
ROW SPACING ***Spud Check 4*** **"plant 81 cm (32") rows"**	81 cm	✔	81/91 cm	81 or 91 cm	36%
FERTILISER ***Spud Check 5*** **"spread 300-400 kg/ha nitrogen, 100-150 kg/ha phosphorus, and 200-300 kg/ha potassium"**	306 kg/ha 126 kg/ha 205 kg/ha	✔ ✔ ✔	215 kg/ha 92 kg/ha 179 kg/ha	258 kg/ha 136 kg/ha 251 kg/ha	18%
SIDE DRESSING ***Spud Check 6*** **"side dress 80 kg/ha potassium"**	80 kg/ha	✔	69 kg/ha	80 kg/ha	55%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Ml/ha of water"**	3.75 Ml/ha	✔	4.2 Ml/ha	6.2 Ml/ha	64%

You have achieved **SEVEN** of the **SEVEN** Spud Checks.

Funding - Project PT432 is funded by the Australian Potato Industry Council and the Horticultural Research and Development Corporation.

Research - Stephen Wade, District Horticulturist (Finley). ☎ (058) 831 644.

NSW Agriculture

Spud Check Crop Report

1995 EARLY CROP

A Crop Report from HRDC Project PT432: "*Improved Productivity of Inland Potato Production.*"

Grower: Spud Potato
Address: "Check Farm", Finley 2713
Variety: Sebago **Paddock:** Top Paddock

Please note - the accuracy of these results is only as good as the information provided by the co-operators.

Spud Checks	Your Crop		All Crops		
	Results	Checks	Average	Top 25%	Adoption
YIELD ***Target yield*** **"31 tonnes/hectare (t/ha)"**	60 t/ha	✔	39 t/ha	47 to 60 t/ha	71%
SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	62%
CROP ROTATION ***Spud Check 2*** **"follow a grass rotation"**	Potatoes	✖	Grass	Grass	52%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	18/08/95	✖	9/08/95	10/08/95	71%
ROW SPACING ***Spud Check 4*** **"plant 81 cm (32") rows"**	81 cm	✔	81 cm	81 cm	43%
FERTILISER ***Spud Check 5*** **"spread 200-300 kg/ha of nitrogen, 50-100 kg/ha of phosphorus, and 100-200 kg/ha of potassium"**	202 kg/ha 83 kg/ha 155 kg/ha	✔ ✔ ✔	234 kg/ha 93 kg/ha 192 kg/ha	217 kg/ha 98 kg/ha 163 kg/ha	14%
SIDE DRESSING ***Spud Check 6*** **"side dress 50-100 kg/ha of potassium"**	66 kg/ha	✔	93 kg/ha	75 kg/ha	57%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Ml/ha of water"**	3 Ml/ha	✔	4.5 Ml/ha	3.9 Ml/ha	43%

You have achieved **FIVE** of the **SEVEN** Spud Checks.

Funding - Project PT432 is funded by the Australian Potato Industry Council and the Horticultural Research and Development Corporation.

Research - Stephen Wade, District Horticulturist (Finley). ☎ (058) 831 644.

NSW Agriculture

1995 EARLY SEBAGO CROPS

The Spud Check project has been developed by NSW Agriculture to increase Riverina potato yields. The early Sebago crops averaged 39 tonnes/hectare, a 12 tonnes/hectare increase over last year's crop yields. Growers who achieved four or more Spud Checks per crop had six tonnes/hectare more yield than those with less than four Spud Checks per crop. The key points for the 1995 early Sebago crop are listed below:-

SPUD CHECK 1 - "buy Certified seed"

Sixty two percent of growers purchased Certified seed for the 1995 crop. Crops sown with Certified seed had two tonnes/hectare more yield than those with non-Certified seed (40 verses 38 tonnes/hectare).

SPUD CHECK 2 - "follow a grass rotation"

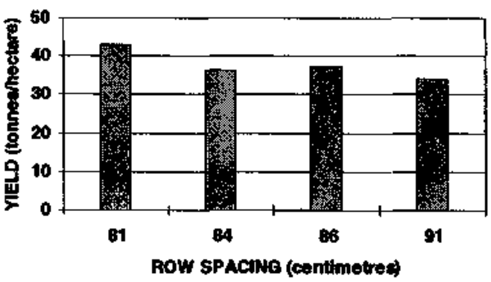
Grass rotations were used by 52 percent of growers, an increase of 16 percent over last year.

SPUD CHECK 3 - "sow early to mid August"

Seventy one percent of growers planted from early to mid-August, an increase of 23 percent on last season.

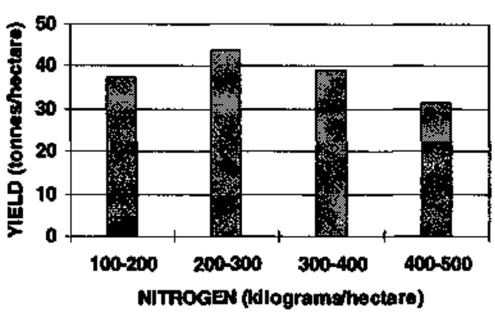
SPUD CHECK 4 - "plant 81 cm (32") rows"

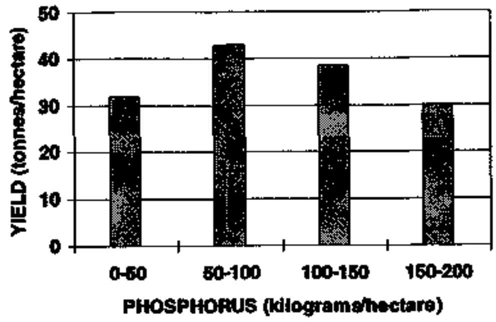
Forty three percent of growers planted their crops on 81 centimetre rows, the row spacing which produced the highest early Sebago crop yields (see below).

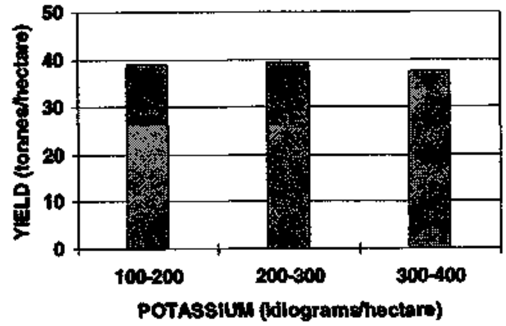


SPUD CHECK 5 - "spread 200-300 kg/ha of nitrogen, 50-100 kg/ha of phosphorus and 100-200 kg/ha of potassium"

Only 14 percent of growers achieved this Spud Check. However Sebago crops fertilised at the recommended fertiliser rate grew 10 tonnes/hectare more yield than those grown at any other rates (47 verses 37 tonnes/hectare). The benefits of using the recommended fertiliser rates are illustrated below:-

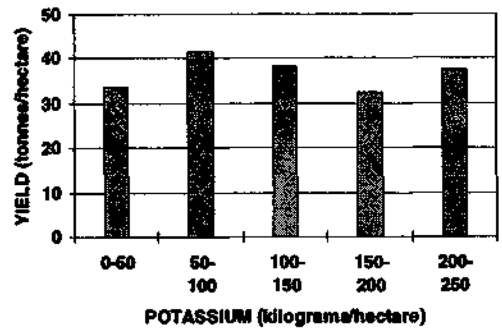






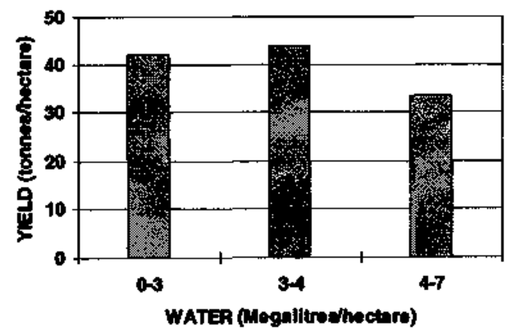
SPUD CHECK 6 - "side dress 50-100 kg/ha of potassium"

Over half the growers side dressed their crops with 50 to 100 kilograms/hectare of potassium fertiliser. The recommended potassium rate had a two tonnes/hectare yield advantage on all other rates (see below). The highest yields were achieved in conjunction with post-planting applications of between 100 to 200 kilograms/hectare of nitrogen fertiliser.



SPUD CHECK 7 - "apply 3-4 Ml/ha of water"

Forty three percent of growers applied three to four Megalitres per hectare (ML/ha) of irrigation water on their crops, which produced the highest early Sebago crop yields (see below).



Spud Check Crop Report

1996 EARLY CROP

Grower: Spud Potato
Address: "Check Farm", Finley 2713
Paddock: Top Paddock
Variety: Sebago

Spud Checks	Your Crop		All Crops		
	Results	Checks	Average	Top 25%	Adoption
CROP YIELD ***Grower target yield*** **"31 tonnes per hectare (t/ha)"**	61 t/ha	✔	37 t/ha	50 to 61 t/ha	58%
POTATO SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	50%
CROP ROTATION ***Spud Check 2*** **"follow a grass rotation"**	Grass	✔	Grass	Grass	50%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	12/08/96	✔	14/08/95	12/08/95	75%
ROW SPACING ***Spud Check 4*** **"plant 81 centimetre (cm) rows"**	81 cm	✔	81 cm	81 cm	67%
FERTILISER - TOTAL ***Spud Check 5*** **"spread 200-300 kg/ha of nitrogen, 50-100 kg/ha of phosphorus, and 100-200 kg/ha of potassium"**	202 kg/ha 83 kg/ha 155 kg/ha	✔ ✔ ✔	212 kg/ha 79 kg/ha 200 kg/ha	213 kg/ha 69 kg/ha 201 kg/ha	8%
FERTILISER - SIDE DRESSING ***Spud Check 6*** **"side dress 50-100 kilograms per hectare (kg/ha) of potassium"**	66 kg/ha	✔	97 kg/ha	107 kg/ha	50%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Megalitres per hectare (Ml/ha) of irrigation water"**	3.6 Ml/ha	✔	6.0 Ml/ha	4.9 Ml/ha	17%

You have achieved **SEVEN** of the **SEVEN** Spud Check best practice recommendations.

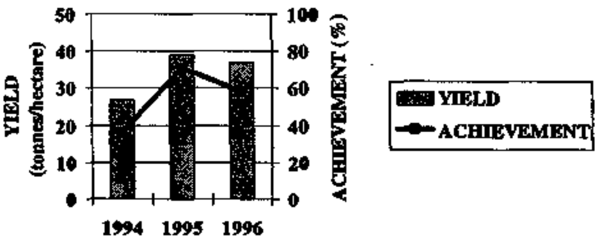
This project is funded by the Australian Potato Industry Council (APIC) and the Horticultural Research and Development Corporation (HRDC).

Research by Stephen Wade, District Horticulturist (Finley).
For further information, please ☎ (058) 831 644.

NSW Agriculture

1996 EARLY SEBAGO CROPS

The 1994-96 Spud Check project has been developed by NSW Agriculture to increase Riverina potato yields. This season's early Sebago crop yields averaged 37 tonnes/hectare, a 10 tonnes/hectare increase over the 1994 crop yields (see below). The number of growers who exceeded the grower target yield of 31 tonnes/hectare also increased from 36 to 58 percent.

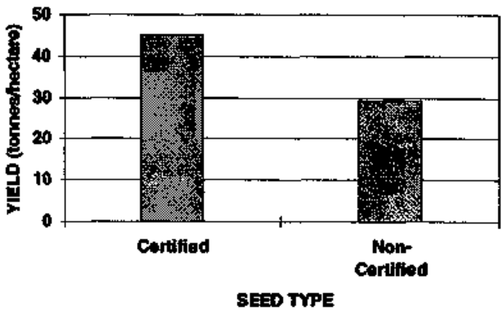


EARLY SEBAGO CROPS

This year growers with four or more Spud Checks per crop had 19 tonnes/hectare more yield than those with less than four Spud Checks per crop (50 verses 31 tonnes/hectare). The key points for the 1996 early Sebago crop are listed below:-

SPUD CHECK 1 - "buy Certified seed"

Fifty percent of growers purchased Certified seed for the 1996 crop. Crops sown with Certified seed had 16 tonnes/hectare more yield than those grown with non-Certified seed (45 verses 29 tonnes/hectare).



SPUD CHECK 2 - "follow a grass rotation"

Grass rotations were used by half the growers this season, a drop of two percent on the 1995 crop.

SPUD CHECK 3 - "sow early to mid August"

Seventy five percent of growers planted from early to mid-August, an increase of four percent on last year.

SPUD CHECK 4 - "plant 81 centimetre rows"

Sixty seven percent of growers planted crops on 81 centimetre rows, an increase of 24 percent over 1995.

SPUD CHECK 5 - "spread 200 to 300 kilograms/hectare of nitrogen, 50 to 100 kilograms/hectare of phosphorus and 100 to 200 kilograms/hectare of potassium"

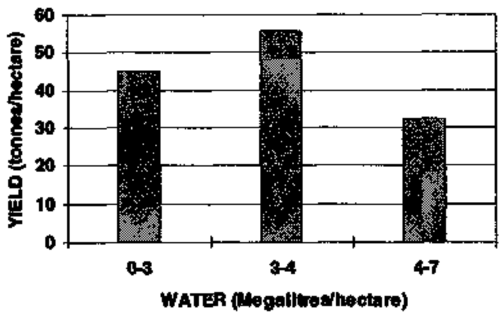
Only 8 percent of growers achieved this Spud Check. Sebago crops fertilised at the recommended fertiliser rates grew 19 tonnes/hectare more yield than those fertilised at other rates (53 verses 34 tonnes/hectare).

SPUD CHECK 6 - "side dress 50 to 100 kilograms/hectare of potassium"

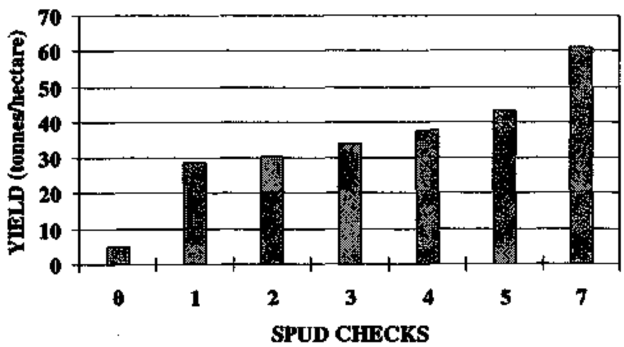
Half the growers side dressed their crops with 50 to 100 kilograms of potassium per hectare this season.

SPUD CHECK 7 - "apply three to four Megalitres per hectare of irrigation water"

Only 17 percent of growers applied between three to four Megalitres per hectare of irrigation water on their crops in 1996, although this irrigation rate produced the highest early Sebago crop yields (see below).



While there are many factors required to achieve high potato yields, the project demonstrated the more Spud Checks adopted by a grower - the higher the grower's crop yields. For the 1994-96 early Sebago crops, the average crop yields increased from 5 tonnes/hectare with no Spud Checks to 61 tonnes/hectare when all seven Spud Checks were achieved.



Spud Check Crop Report

1994 EARLY CROP

Grower:	Spud Potato
Address:	"Check Farm", Finley 2713
Paddock:	Top Paddock
Variety:	Coliban

Spud Checks	Your Crop		All Crops		
	Results	Checks	Average	Top 25%	Adoption
CROP YIELD ***Grower target yield*** **"31 tonnes per hectare (t/ha)"**	50 t/ha	✔	29 t/ha	40 to 50 t/ha	44%
POTATO SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	75%
CROP ROTATION ***Spud Check 2*** **"follow a grass rotation"**	Grass	✔	Potato	Grass	31%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	16/08/94	✖	13 August	11 August	50%
ROW SPACING ***Spud Check 4*** **"plant 81 centimetre (cm) rows"**	81 cm	✔	81 cm	81 cm	50%
FERTILISER - TOTAL ***Spud Check 5*** **"spread 200-300 kg/ha of nitrogen, 100-150 kg/ha of phosphorus, and 100-200 kg/ha of potassium"**	170 kg/ha 93 kg/ha 218 kg/ha	✖ ✖ ✖	212 kg/ha 88 kg/ha 176 kg/ha	263 kg/ha 120 kg/ha 223 kg/ha	6%
FERTILISER - SIDE DRESSING ***Spud Check 6*** **"side dress 50-100 kilograms per hectare (kg/ha) of potassium"**	79 kg/ha	✔	68 kg/ha	75 kg/ha	56%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Megalitres per hectare (Ml/ha) of irrigation water"**	3.5 Ml/ha	✔	4.9 Ml/ha	5.5 Ml/ha	44%

You have achieved **FIVE** of the **SEVEN** Spud Check best practice recommendations.

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Research by Stephen Wade, District Horticulturist (Finley)
For further information, please ☎ (058) 831 644.

NSW Agriculture

Spud Check Crop Report

1995 EARLY CROP

Grower:	Spud Potato
Address:	"Check Farm", Finley 2713
Paddock:	Top Paddock
Variety:	Desiree

Spud Checks	Your Crop		All Crops		
	Results	Checks	Average	Top 25%	Adoption
CROP YIELD ***Grower target yield*** **"31 tonnes per hectare (t/ha)"**	45 t/ha	✔	33 t/ha	43 to 45 t/ha	50%
POTATO SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	75%
CROP ROTATION ***Spud Check 2*** **"follow a grass rotation"**	Grass	✔	Grass	Grass	38%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	7/08/95	✔	12 August	6 August	50%
ROW SPACING ***Spud Check 4*** **"plant 81 centimetre (cm) rows"**	81 cm	✔	81 cm	81 cm	50%
FERTILISER - TOTAL ***Spud Check 5*** **"spread 200-300 kg/ha of nitrogen, 50-100 kg/ha of phosphorus, and 100-200 kg/ha of potassium"**	185 kg/ha 80 kg/ha 176 kg/ha	✖ ✔ ✔	218 kg/ha 62 kg/ha 164 kg/ha	248 kg/ha 80 kg/ha 182 kg/ha	25%
FERTILISER - SIDE DRESSING ***Spud Check 6*** **"side dress 50-100 kilograms per hectare (kg/ha) of potassium"**	86 kg/ha	✔	55 kg/ha	67 kg/ha	50%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Megalitres per hectare (Ml/ha) of irrigation water"**	4.9 Ml/ha	✖	4.2 Ml/ha	5 Ml/ha	38%

You have achieved **FIVE** of the **SEVEN** Spud Check best practice recommendations.

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NSW Agriculture

Spud Check Crop Report

1996 EARLY CROP

Grower: Spud Potato
Address: "Check Farm", Finley 2713
Paddock: Top Paddock
Variety: Atlantic

Spud Checks	Your Crop		All Crops		
	Results	Checks	Average	Top 25%	Adoption
CROP YIELD ***Grower target yield*** **"31 tonnes per hectare (t/ha)"**	48 t/ha	✔	40 t/ha	45 to 48 t/ha	84%
POTATO SEED ***Spud Check 1*** **"buy Certified seed"**	Certified	✔	Certified	Certified	79%
CROP ROTATION ***Spud Check 2*** **"follow a grass rotation"**	Grass	✔	Grass	Grass	53%
SOWING DATE ***Spud Check 3*** **"sow early to mid-August"**	14/08/96	✔	20 August	25 August	58%
ROW SPACING ***Spud Check 4*** **"plant 81 centimetre (cm) rows"**	81 cm	✔	81 cm	81 cm	100%
FERTILISER - TOTAL ***Spud Check 5*** **"spread 200-300 kg/ha of nitrogen, 100-150 kg/ha of phosphorus, and 100-200 kg/ha of potassium"**	351 kg/ha 80 kg/ha 204 kg/ha	✖ ✖ ✖	223 kg/ha 105 kg/ha 178 kg/ha	231 kg/ha 116 kg/ha 199 kg/ha	5%
FERTILISER - SIDE DRESSING ***Spud Check 6*** **"side dress 50-100 kilograms per hectare (kg/ha) of potassium"**	64 kg/ha	✔	74 kg/ha	75 kg/ha	63%
WATER MANAGEMENT ***Spud Check 7*** **"apply 3-4 Megalitres per hectare (Ml/ha) of irrigation water"**	3.1 Ml/ha	✔	4.4 Ml/ha	4.6 Ml/ha	63%

You have achieved **SIX** of the **SEVEN** Spud Check best practice recommendations.

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