EFFECT OF SEED-TREATMENT AND TIME OF HARVESTING ON THE YIELD AND QUALITY OF POTATOES FOR PROCESSING

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SUMMARY

The effect of seed source, physiological age and desiccation date on sprout growth, crop development, yield and fry colour following storage was investigated over four seasons for the variety Maris Piper and in a parallel study for the variety Rooster. Seed tubers were obtained from two areas of production, Carlow and Donegal and received physiological ageing for either 0 or 200 day degrees >4^{o}C. Sprout growth, crop development, yield and fry colour following storage was also compared over two seasons in the varieties Maris Piper, Rooster, Fianna and Navan which had received physiological ageing for 200 day degrees >4^{o}C and grown at two sites.

Seed source produced an inconsistent effect on dormancy break, sprout growth, emergence, tuber yield and reducing sugar concentration, but had no effect on tuber sucrose concentration or chip fry colour following storage.

Physiological ageing advanced sprout growth, crop emergence, crop establishment, usually improved tuber yield and dry matter content but had no effect on chip fry colour following storage.

Delaying the desiccation date significantly increased yield in the grade >45 mm in most experiments. Tuber sucrose concentration declined with delay in desiccation date whereas fry colour tended to deteriorate with delay in desiccation date.

When the varieties Maris Piper, Rooster, Navan and Fianna were planted at Kildalton, Navan gave the highest yield of tubers >45 mm, while Rooster gave the lightest fry colour following storage.

INTRODUCTION

The greater proportion of potatoes processed as chips are par-cooked, frozen and then delivered to retail outlets or the catering industry and described as ‘frozen chips’. This product is extremely price sensitive, and the quality (shape and fry colour) largely determines whether the final destination is the catering industry

(long pieces and light fry colours) or domestic consumers (short pieces and dark fry colours). By contrast, 'fresh chips' fetch a premium price, are processed in small batches, sliced prior to cooking and consumed immediately. Fresh chips are distinguished by their unique flavour and texture characteristics. Unlike the frozen product described earlier, there is no opportunity to manipulate reducing sugar concentration by blanching or other means prior to frying. Therefore potatoes for processing as fresh chips must conform to higher quality specifications. Nonetheless fresh chips are a commercially important snack food and utilise a significant proportion of the potato crop. Irish potato growers can readily produce the quantity required to satisfy domestic market requirements but encounter considerable difficulties producing tubers which conform to the fry colour specifications, particularly following prolonged storage. Consequently considerable amounts of potatoes are imported each year from the UK for processing as fresh chips (25,000 tonnes in 1997 - Thornton and Arnold, 1998).

Choice of cultivar is largely dictated by processing performance and there is a general recognition that some cultivars are inherently unsuitable. Maris Piper, regarded as the industry standard cultivar for fresh chip processing, is regularly specified in purchasing contracts. Recently however, newer cultivars which claim improved processing performance have become available from breeding programmes. Since these could help overcome the fry colour problems associated with Maris Piper, a parallel study was conducted to investigate the effect of agronomic influences on yield and quality of Rooster, a cultivar from the Potato Breeding Programme at the Crops Research Centre, Oak Park, Carlow.

In the literature there is a general consensus that early harvesting - before soil conditions deteriorate and soil temperature drops below 8^{o}C is essential to ensure that tubers attain appropriate fry colour following storage. For the grower, early desiccation and harvest may necessitate a yield penalty. A primary objective of the study is therefore to investigate agronomic factors which might offset any such yield penalty while ensuring that the crop had attained a sufficient degree of "maturity" prior to desiccation. Since late planting is inimical with an early harvest, strategies to promote rapid crop establishment and early growth were investigated.

Work in the UK on 'first early' potatoes has demonstrated the advantage of locally grown seed tubers compared with tubers from the traditional seed growing areas. Therefore seed tubers of the cultivars Maris Piper and Rooster obtained

from two sources, Carlow (locally grown) and Donegal (traditional seed growing area) were used. Very little research work has been conducted on physiological ageing of seed tubers for ware crop production, where the age requirements are vastly different from the requirements for 'first-earlies'.

For a potato grower, the profitability of the enterprise is dependent upon an economic yield of tubers in the required size grade which is suitable for processing. The effects of seed source and physiological age on yield and size distribution at three desiccation dates were examined. Since fresh chips are consumed throughout the year, tubers must conform to the required processing specifications not only following harvest but also following extended storage. Therefore the combined effects of seed source, physiological age and desiccation date on dry-matter content, Maillard reaction substrate concentration and fry colour was considered.

Production site, through its association with soil type, soil fertility and soil moisture is regarded as a significant contributor to tuber yield and fry colour following storage. Consequently, crop growth, yield development and fry colour performance of four cultivars (Maris Piper, Rooster, Navan and Fianna) was investigated at two sites, Kildalton Co. Kilkenny and UCD Lyons Research Farm, Newcastle, Co Dublin.

METHODS

Seed assembly

Seed tubers of the cultivars Maris Piper and Rooster were obtained from two production areas, Donegal and Carlow (except in 1994 when Rooster was only available from Carlow). The Donegal-grown seed had either an 'elite' or 'super-elite' certificate. The Carlow-grown seed was 'elite' or 'super-elite' seed grown in Donegal during the previous season. Seed from both sources was graded 35-55 mm and stored from December through to March in a refrigerated potato store.

In 1996 and 1997, the varieties Navan and Fianna were compared with Rooster and Maris Piper.

Physiological ageing

Half the seed tubers from each source were removed from cold store in mid-March each year. When 90% of the tubers had sprouts =/>3.0 mm, dormancy was deemed to have ended and physiological age accumulation was recorded thereafter. Tubers were exposed to physiological ageing under fluorescent lights for 200 day-degrees >4^{o}C then returned to the cold store to await planting.

Seed tubers of Rooster, Maris Piper, Navan and Fianna for planting at Kildalton and Lyons Research Farm received physiological ageing for 200 day-degrees >4^{o}C.

Crop establishment

Standard husbandry practices were applied during the growing season. The trials investigating Maris Piper and Rooster were planted each year according to the following schedule:

Treatment 1: Seed tubers sourced in Carlow and planted having received 0 day-degrees physiological ageing.

Treatment 2: Seed tubers sourced in Carlow and planted having received 200 day-degrees physiological ageing.

Treatment 3: Seed tubers sourced in Donegal and planted having received 0 day-degrees physiological ageing.

Treatment 4: Seed tubers sourced in Donegal and planted having received 200 day-degrees physiological ageing.

The planting and desiccation dates are presented in Tables 1 and 2.

Table 1: Planting and desiccation dates, Maris Piper and Rooster 1994-1997

Year	Planting date	Desiccation dates		
		1	2	3
1994	May 06	August 24	September 06	September 22
1995	April 20	September 06	September 19	October 05
1996	May 08	August 27	September 06	September 18
1997	April 08	August 25	September 04	September 17

Table 2: Planting and desiccation dates - Kildalton and Lyons Research Farm, 1996-1997

Site	Year	Planting date	Desiccation dates		
			1	2	3
Kildalton	1996	May 13	August 26	Sept. 09	Sept. 20
	1997	April 20	August 25	Sept. 05	Sept. 17
Lyons Res. Farm	1996	May 15	October 01	-	-
	1997	April 18	Sept. 10	-	-

Observations

Dormancy break and sprout growth:
The length of the longest sprouts was recorded prior to accumulation of physiological age and following accumulation of 200 day-degrees >4^{o}C. The length of the longest sprout on tubers stored throughout in cold store was also recorded prior to planting.

Rate of emergence:
The number of emerged plants was counted at 2-3 day intervals and counting continued until values stabilised.

Tuber yield:
Plots were harvested approximately three weeks after each desiccation date. The produce of each plot was graded over square mesh riddles into 9 size fractions with 5 mm increments from <35 - >80 mm and the weight in each fraction recorded. Yield in the composite fraction ">45 mm" is presented.

Dry-matter content:
Percentage dry-matter was determined after tubers were washed, chipped and oven dried at 100°C for 48 hrs.

Sucrose and reducing sugars:
Concentrations of sucrose, glucose and fructose were determined either by HPLC or by enzymatic procedure.

Fry colour:
Chips were fried in vegetable oil for 2.5 min at 180°C. Fry colour was assessed subjectively by comparing the colour of each chip with a USDA Fry Colour Reference Card which categorised fry colours into seven categories: 000, 00, 0, 1, 2, 3, 4, where 000 represented the lightest colour and 4 the darkest.

RESULTS AND DISCUSSION

Sprout growth

The effect of seed source on the date of dormancy break can be inferred from the length of the longest sprout on seed tubers prior to accumulation of physiological age. Since the Carlow-grown Maris Piper seed in 1995 had longer sprouts prior to accumulation of physiological age, these tubers broke dormancy before the Donegal-grown seed, whereas in 1996 and in 1997 the response was reversed (Table 3). The date of dormancy break in Rooster was not affected by seed source (Table 3).

Table 3: Effect of seed source on length (mm) of longest sprout of cv's Maris Piper and Rooster prior to accumulation of physiological age 1995-1997

Cultivar	Seed source	1995	1996	1997
Maris Piper	Carlow	3.6	3.4	3.6
	Donegal	3.0	4.1	4.0
Rooster	Carlow	3.6	3.1	3.4
	Donegal	3.5	3.0	3.6

On Maris Piper tubers, the length of the longest sprout following the accumulation of 200 day-degrees physiological age was not significantly different between Carlow-grown and Donegal-grown seed (Table 4). On Rooster, the length of the longest sprout was significantly affected by seed source. In 1995 and 1997 the Donegal-grown seed had the longest sprouts while in 1996 the Carlow-grown seed had the longest (Table 4). The length of the longest sprout following the accumulation of physiological age is however an unreliable guide to the level of physiological age accumulated, since light intensity in the store is a major determinant of sprout length.

Table 4: Effect of seed source on length (mm) of longest sprout of cv's Maris Piper and Rooster following accumulation of 200 day-degrees >4^{o}C physiological age, 1995-1997

Cultivar	Seed source	1995	1996	1997
Maris Piper	Carlow	10.7	11.1	10.3
	Donegal	10.2	11.6	10.5
Rooster	Carlow	13.7	14.7	12.6
	Donegal	16.0	12.6	13.7

Seed source significantly affected the length of the longest sprout on Maris Piper tubers held in cold store until planting. In 1995 the Carlow-grown seed produced the longest sprouts whereas in 1996 sprouts were longest on the Donegal-grown seed (Table 5). Similarly for Rooster, in 1996 sprouts were longest on the Carlow-grown seed while in 1997 the Donegal-grown seed produced the longest sprouts (Table 5).

Table 5: Effect of seed source on length (mm) of longest sprout of cv's Maris Piper and Rooster held in cold storage until planting 1995-1997

Cultivar	Seed source	1995	1996	1997
Maris Piper	Carlow	9.1	6.2	5.5
	Donegal	6.5	8.0	5.0
Rooster	Carlow	3.7	5.7	3.9
	Donegal	3.8	5.1	5.0

The two cultivars exhibit contrasting responses to storage conditions. Whereas the length of the longest sprouts on Maris Piper tubers which received physiological ageing was shorter than on Rooster (Table 4), the response was reversed for tubers held throughout in cold store, where the Maris Piper tubers produced the longest sprouts (Table 5).

Rate of emergence

Seed source significantly affected the rate of emergence of Maris Piper, expressed as the number of days from planting to 50% emergence (DAP_{50}) during 1994 (Table 6) with the Carlow-grown seed emerging significantly faster than the Donegal-grown seed. Seed source had no significant effect on rate of emergence in 1995. Physiological ageing for 200 day-degrees >4^{o}C significantly increased the rate of emergence in 1994 and 1995 with DAP_{50} values being reduced by 8.3 days and 5.0 days respectively, compared with seed planted from the cold store (0 day-degrees >4^{o}C). In 1996 and 1997 there were significant interactions between seed source and physiological age when the rate of emergence of the Carlow-grown and Donegal-grown Maris Piper seed depended upon the level of physiological ageing.

Seed source significantly affected the rate of emergence of Rooster in 1995 with the Donegal-grown seed emerging 1.0 days faster but seed source had no effect on (DAP_{50}) values in 1996 and 1997. Physiological ageing significantly increased the rate of emergence during each of four years (Table 6).

Table 6: Effect of seed source and physiological age on the number of days after planting to 50% emergence of cv's Maris Piper and Rooster, 1994-1997

Cultivar	Seed source	Physiol. age (dd >4^{o}C)	1994	1995	1996	1997
Maris	Carlow	0	34.7	33.7	33.5	40.0
Piper		200	27.0	28.8	28.0	29.7
	Donegal	0	39.0	33.5	29.8	38.5
		200	30.0	28.3	27.3	24.7
Rooster	Carlow	0	38.0	38.3	33.8	40.0
		200	25.0	30.2	27.0	25.7
	Donegal	0	-	37.5	33.3	40.0
		200	-	29.0	27.5	25.7

When seed tubers of Maris Piper, Rooster, Fianna and Navan received physiological ageing for 200 day-degrees >4^{o}C, there was no significant difference in the rate of emergence at Kildalton in 1996 (Table 8). In 1997 there was a difference between cultivars, with Navan and Fianna emerging significantly slower than either Maris Piper or Rooster.

Crop establishment

In 1994 there was interaction between seed source and physiological age on crop establishment with the values for Carlow-grown and Donegal-grown Maris Piper seed dependent upon the level of physiological ageing (Table 7). There was no effect of seed source on plant establishment in 1995 while in 1996 and 1997 the number of plants emerged from the Carlow-grown seed was lower than from the Donegal-grown seed. Physiological ageing significantly increased the number of Maris Piper plants established in 1995, 1996 and 1997. Crop establishment in Rooster was unaffected by seed source in 1995 or 1996 while in 1997 there was interaction between seed source and physiological age (Table 7). Crop establishment was increased significantly by physiological ageing in 1994 and 1995 with no effect in 1996.

Table 7: Effect of seed source and physiological age on % crop establishment of cv's Maris Piper and Rooster, 1994 -1997

Cultivar	Seed source	Physiol.age (dd >4^{o}C)	1994	1995	1996	1997
Maris Piper	Carlow	0	98.5	99.1	95.4	95.2
		200	99.9	100.0	97.8	97.6
	Donegal	0	94.9	99.4	98.7	98.4
		200	99.2	100.0	99.9	99.5
Rooster	Carlow	0	97.2	98.6	99.1	97.5
		200	100.0	99.7	99.5	98.8
	Donegal	0	-	98.8	99.4	95.8
		200	-	99.7	99.7	99.0

Crop establishment was similar for the four cultivars Maris Piper, Rooster, Fianna and Navan at Kildalton in 1996 (Table 8), but in 1997, establishment was significantly lower in Fianna compared with the three remaining cultivars.

Table 8: Rate of emergence and % crop establishment of cv's Maris Piper, Rooster, Fianna and Navan (Kildalton) 1996 and 1997

Cultivar	Days to 50% emergence		% establishment	
	1996	1997	1996	1997
Maris Piper	27.0	27.7	96.7	99.4
Rooster	26.0	29.5	98.4	99.2
Fianna	27.5	37.0	97.8	95.1
Navan	28.0	31.0	98.6	99.3

Yield development

Tuber yield is largely determined by the number of 'growing days' available to the tubers. In this respect therefore, the date of tuber initiation assumes central importance. In 1995 the effect of seed source and physiological age on the date of tuber initiation was investigated. Seed source did not influence the date of tuber initiation (Table 9). Whereas the duration from planting to tuber initiation was reduced significantly by physiological ageing, particularly in Rooster, the duration from emergence to tuber initiation was largely unaffected (Table 9) thus demonstrating the role of this post emergence phase in controlling the onset of tuber initiation.

Table 9: Effect of seed source and physiological age on number of days after planting (DAP) to tuber initiation and days after emergence (DAE) to tuber initiation, cv. Maris Piper and Rooster 1995

Seed source	Physiol.age dd > 4°C	Maris Piper		Rooster	
		No. DAP to tuber initiation	No. DAE to tuber initiation	No. DAP to tuber initiation	No. DAE to tuber initiation
Carlow	0	53.7	21.8	62.0	23.7
	200	50.6	20.0	53.6	23.4
Donegal	0	52.4	18.9	61.1	23.6
	200	50.2	21.8	53.2	24.2

Tuber size distribution

Under current purchasing specifications, all tubers >45 mm are acceptable. However there is a preference for tubers in the grade 60 - 80 mm. Enhancing the yield of these desirable large tubers at early harvest is a central objective of this project. The effect of seed source and physiological age on tuber size distribution of Maris Piper at the first desiccation date in 1997 is illustrated in Figure 1. Physiological ageing clearly increases yield in the grade 60 - 80 mm at early harvest.

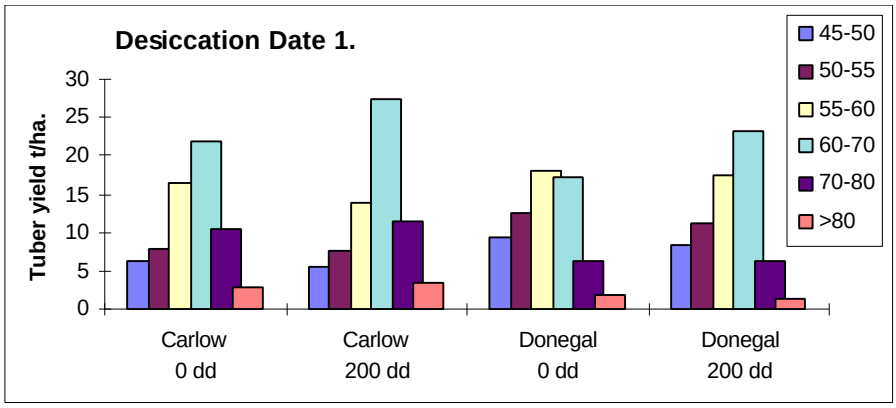

Figure 1. Effect of seed source and physiological age on tuber size distribution at the first desiccation date - cv. Maris Piper, 1997

Graded yield

The effect of seed source and physiological age on yield of Maris Piper and Rooster tubers >45 mm is shown as mean values in Tables 10 and 11 respectively. Within individual growing seasons there were significant interactions between desiccation date and either seed source or physiological age, nonetheless some general conclusions can be derived. During the years 1994-1997 the source of seed tubers used to establish populations of both cultivars significantly influenced tuber yield in only one experiment. Therefore seed source can be largely discounted as a factor modifying tuber yield. Yield of tubers >45 mm was increased significantly by physiologically ageing seed tubers.

Table 10: Effect of seed source, physiological age and desiccation date on yield of tubers < 45 mm (t.ha^{-1}); Maris Piper (Mean 1994-1997)

Seed source	Physiol. age (dd >4°C)	Desiccation date		
		1	2	3
Carlow	0	51.8	58.5	62.9
	200	56.5	63.6	65.2
Donegal	0	48.9	57.4	62.2
	200	56.3	60.4	67.1

Table 11: Effect of seed source, physiological age and desiccation date on yield of tubers < 45 mm (t.ha^{-1}); Rooster (Mean 1994-1997)

Seed source	Physiol. age (dd >4°C)	Desiccation date		
		1	2	3
Carlow	0	45.8	54.8	59.3
	200	55.0	61.5	66.3
Donegal	0	50.2	58.4	63.3
	200	55.2	60.5	65.0

This increase was most pronounced at early desiccation dates and while the response diminished with delay in desiccation date the effect persisted throughout. For Maris Piper, mean tuber yield was increased by 12% at the first desiccation date due to physiologically ageing seed tubers and by 7% and 6% respectively at subsequent desiccation dates. The corresponding yield increases from physiological ageing Rooster seed tubers was 15%, 8% and 7% respectively. Delaying the desiccation date similarly increased tuber yield. For Maris Piper, average yield increased by 12% during the first delay and 7% during the second delay while the corresponding values for Rooster were 14% and 8% respectively. However, yield increases were greater for plants from cold stored seed tubers compared with yield increases from physiologically aged.

There were significant differences in yield of tubers >45 mm for the four cultivars Rooster, Maris Piper, Fianna and Navan planted at Kildalton and UCD Lyons Research Farm in 1996 and 1997 (Tables 12 and 13). The highest yield at Kildalton in both years was provided by cv. Navan whereas at Lyons Research Farm, Maris Piper provided the highest yield in both years.

Table 12: Effect of delaying desiccation date on tuber yield >45 mm (t.ha^{-1}) of cv's Rooster, Maris Piper, Fianna and Navan - Kildalton 1996 and 1997

Desic. date	Rooster		Maris Piper		Fianna		Navan	
	1996	1997	1996	1997	1996	1997	1996	1997
1	49.6	61.8	43.2	62.1	51.5	45.4	52.4	61.2
2	56.9	74.1	53.1	73.6	58.3	56.0	59.9	80.6
3	58.0	78.0	56.3	74.3	58.5	60.6	61.2	85.6

Table 13: A comparison of yield of tubers >45 mm (t.ha^{-1}) in cv's Rooster, Maris Piper, Fianna, Navan - U.C.D. Lyons Research Farm 1996 and 1997

Cultivar	1996	1997
Rooster	54.1	62.2
Maris Piper	57.9	65.1
Fianna	51.5	51.0
Navan	55.5	59.9

Processing quality

Dry-matter content

The effect of seed source, physiological age and desiccation date on tuber dry-matter content of cvs. Maris Piper and Rooster is shown as mean values in Tables 14 and 15 respectively. Seed source significantly influenced tuber dry-matter content of Maris Piper in three of the four years. In 1994, tubers from Carlow-grown seed had the highest dry-matter content while in 1996 and 1997, tubers from Donegal-grown seed had a higher dry-matter content. Physiologically ageing the seed increased the dry-matter content of tubers in 1996, but in the remaining three years it induced no effect. Similarly delaying the desiccation date had no effect on dry-matter content of tubers after harvesting in 1994 and 1997 but in 1995 and 1996, it increased significantly as the desiccation date was delayed.

Table 14: Effect of seed source, physiological age and desiccation date on tuber dry matter content Maris Piper (mean 1994-997)

Seed source	Physiol. age (dd >4°C)	Desiccation date		
		1	2	3
Carlow	0	19.8	20.1	20.4
	200	20.4	20.1	20.6
Donegal	0	19.6	20.3	20.7
	200	20.1	20.9	20.9

Seed source had no effect on tuber dry-matter content of Rooster during the three years when seed was available from two sources. Similarly, physiologically ageing the seed did not influence the dry-matter of tubers in the progeny crop in 1995 and 1997 but in 1994 and 1996 tubers from physiologically aged seed had higher dry-matter compared with tubers from cold stored seed. Delaying the desiccation date did not influence tuber dry-matter content in 1994 or 1997, however in 1995 and 1996, it increased significantly as desiccation date was delayed.

Table 15: Effect of seed source, physiological age and desiccation date on tuber dry matter content Rooster (mean 1994-1997)

Seed source	Physiol. age (dd >4°C)	Desiccation date		
		1	2	3
Carlow	0	20.5	21.2	21.5
	200	20.8	21.3	21.9
Donegal	0	20.7	21.9	22.2
	200	21.4	21.8	21.7

The effect of delaying the desiccation date on tuber dry-matter content of the cvs. Rooster, Maris Piper, Navan and Fianna at Kildalton in 1996 and 1997 is shown in Table 16. In 1996 there was a significant interaction between cultivar and desiccation date indicating that the dry-matter content of cultivars responded differently to the three desiccation dates. In 1997 there were significant differences in dry-matter content between the cultivars and a significant increase with a delay in desiccation date. Fianna and Navan had significantly higher dry-matter content than Rooster or Maris Piper at the first and second desiccation

dates. At the third desiccation date Maris Piper had significantly lower dry-matter content than either Rooster, Navan or Fianna.

Table 16: Effect of delaying desiccation date on % dry matter of cv's Rooster, Maris Piper, Fianna and Navan - Kildalton 1996 and 1997

Desic. date	Rooster		Maris Piper		Fianna		Navan	
	1996	1997	1996	1997	1996	1997	1996	1997
1	20.3	19.2	19.7	19.4	20.6	20.8	20.7	20.3
2	20.4	19.2	20.4	19.3	22.4	21.6	20.9	20.5
3	21.8	20.0	21.3	19.9	22.7	21.9	22.1	21.2

The dry-matter content of Rooster, Maris Piper, Navan and Fianna grown at Lyons Research Farm in 1996 and 1997 is shown in Table 17. In both years there were significant differences between cultivars with Fianna having the highest value in 1996 and Navan in 1997.

Table 17: A comparison of % dry matter in cv's Rooster, Maris Piper, Fianna and Navan - U.C.D. Lyons Research Farm 1996 and 1997

Cultivar	1996	1997
Rooster	21.4	21.4
Maris Piper	20.7	22.5
Fianna	22.6	22.9
Navan	22.3	23.4

Tuber sucrose concentration

Tuber sucrose concentration provides an indirect measure of the degree of canopy senescence prevailing prior to desiccation and also a measure of the level of 'tuber maturity' attained. The effect of seed source, physiological age and desiccation date on sucrose concentration in Maris Piper prior to desiccation is shown in Table 18. During four years, seed source had no significant effect on sucrose concentration. Tubers on plants from physiologically aged seed had significantly lower sucrose concentrations in 1995 and 1997 while in 1994 and 1996 there was no effect of physiological age. Delaying the desiccation date reduced tuber sucrose concentration in 1994, 1995 and 1997 whereas the values increased in 1995. During the 1995 growing season, drought conditions, partly

alleviated by irrigation, prevailed. However, end-of-season rainfall and associated mineralisation of soil-N may have induced canopy 're-greening' with consequent increase in tuber sucrose concentration.

Table 18: Effect of seed source, physiological age and desiccation date on sucrose concentrations ($mg.ml^{-1}$) in Maris Piper tubers prior to desiccation (mean 1994-1997)

Seed source	Physiol. age (dd > 4^oC)	Desiccation date		
		1	2	3
Carlow	0	4.9	5.7	4.4
	200	4.2	4.7	3.7
Donegal	0	5.1	5.2	3.8
	200	4.4	4.5	3.4

The effect of seed source, physiological age and desiccation date on sucrose concentration in Rooster prior to desiccation is shown in Table 19. During 1995 to 1997, when seed from two sources was available, there was no effect due to seed source. Physiologically ageing the seed did not affect sucrose concentrations in 1994 and 1995. In 1996 and 1997, tubers on plants from physiologically aged seed had significantly lower concentrations of sucrose compared with tubers on plants from cold stored seed. Delaying the desiccation date had no effect on sucrose concentration in tubers in 1995 and 1996 but significantly affected concentrations in 1994 and 1997. The pattern of the response varied between years; in 1994 the values increased between the first and second desiccation dates and declined sharply at the third, whereas in 1997, values declined between the first and second dates and increased to the original level at the third date.

Table 19: Effect of seed source, physiological age and desiccation date on sucrose concentrations ($mg.ml^{-1}$) in Rooster tubers prior to desiccation (mean 1994-1997)

Seed source	Physiol. age (dd > 4^oC)	Desiccation date		
		1	2	3
Carlow	0	4.2	4.3	3.8
	200	3.1	3.6	3.7
Donegal	0	4.3	4.3	4.0
	200	3.7	3.4	3.6

At Kildalton in 1996 there were significant declines in sucrose concentrations with successive delays in the desiccation date (Table 20). Similarly there were significant differences between cultivars with Navan having the highest concentration; Rooster the lowest and intermediate values for Maris Piper and Fianna.

Table 20: Effect of desiccation date on sucrose concentrations ($mg.ml^{-1}$) in tubers prior to desiccation in four cultivars - Kildalton 1996 and 1997

Desiccation date	Cultivar	Sucrose concentration	
		1996	1997
1	Rooster	4.44	1.65
	Maris Piper	4.55	2.08
	Fianna	6.49	4.48
	Navan	7.62	4.29
2	Rooster	3.44	1.38
	Maris Piper	3.92	1.66
	Fianna	5.59	3.40
	Navan	5.22	1.73
3	Rooster	2.59	3.41
	Maris Piper	3.23	2.55
	Fianna	3.90	2.32
	Navan	3.35	2.39

In 1997 there was a significant interaction between cultivar and desiccation date. The pattern of response of cultivar to desiccation date depended upon the cultivar, with Rooster's sucrose concentration increasing significantly as desiccation date was delayed, Fianna and Navan decreasing and Maris Piper remaining unaffected. Fianna had the higher levels at the first and second dates while there was no difference at the third desiccation date

Reducing sugar concentration

Reducing sugar concentrations in tubers were assessed each year on five occasions encompassing both crop growth and tuber storage phases. But since a primary aim of the project was to investigate the influence of agronomic factors on fry colour following storage, the results presented here will be restricted to the concentration of reducing sugars in tubers at the final assessment following storage. The effect of seed source, physiological age and desiccation date on

reducing sugar concentration ($mg.ml^{-1}$) in Maris Piper tubers during 1994-1997 is presented as mean values in Table 21. Seed source significantly affected reducing sugar concentration only in 1994, with tubers from the Carlow-grown seed crop having lower concentrations of reducing sugars compared with tubers from the Donegal-grown seed crop. Tubers from plants grown from physiologically aged seed had lower concentrations of reducing sugar in 1994 compared with corresponding tubers from cold stored seed, but in 1996 and 1997 there was no effect due to the physiological age of the seed. Delaying the desiccation date had no effect on reducing sugars in Maris Piper in either 1994 or 1997. In 1996, delaying the desiccation date by 22 days increased the reducing sugar concentration in stored tubers, however delaying the desiccation date by 10 days had no effect.

Table 21: Effect of seed source, physiological age and desiccation date on concentrations of reducing sugars ($mg.ml^{-1}$) in Maris Piper tubers at final assessment following storage (mean 1994, 1996 and 1997)

Seed source	Physiol. age (dd > 4^oC)	Desiccation date		
		1	2	3
Carlow	0	3.7	3.8	4.8
	200	3.8	3.6	4.8
Donegal	0	3.8	3.9	4.7
	200	4.2	3.6	4.6

Reducing sugar concentration in Rooster was not affected by seed source in 1996 (Table 22). Physiologically ageing the seed did not influence reducing sugar concentrations in the progeny crops in 1994 and 1996, but in 1997 there was a highly significant response. Tubers on plants grown from physiologically aged seed had lower concentrations of reducing sugar compared with tubers from cold stored seed. Delaying the desiccation date did not influence reducing sugar concentrations in Rooster following storage in 1994 or 1996. In 1997 there was an interaction between seed source and desiccation date whereby reducing sugar concentration in tubers from the Carlow-grown seed was not significantly affected as desiccation date was delayed while that from the Donegal-grown seed was significantly decreased as desiccation was delayed.

Table 22: Effect of seed source physiological age and desiccation date on concentrations of reducing sugars ($mg.ml^{-1}$) in Rooster tubers at final assessment following storage (mean 1994,1996 and 1997)

Seed source	Physiol. age (dd >4^0C)	Desiccation date		
		1	2	3
Carlow	0	1.8	1.7	2.0
	200	1.4	1.4	1.7
Donegal	0	1.6	1.2	0.9
	200	1.1	1.1	0.8

Reducing sugar concentrations in the cultivars Rooster, Maris Piper, Navan and Fianna at Kildalton are shown in Table 23. In 1996 there was a significant interaction between cultivar and desiccation date on reducing sugar concentrations. Delaying the desiccation date had no effect on reducing sugars in tubers of Rooster and Fianna while delaying the desiccation date increased the levels in Maris Piper and Navan. In 1997 there was no effect due to delay in desiccation date but significant differences between cultivars, with Rooster having the lowest concentration and Maris Piper the highest and intermediate values for Navan and Fianna.

Table 23: Effect of desiccation date on reducing sugar concentrations ($mg.ml^{-1}$) at final assessment following storage in four cultivars - Kildalton 1996 and 1997

Desiccation date	Cultivar	Reducing sugar concentration	
		1996	1997
1	Rooster	0.42	0.54
	Maris Piper	2.23	2.77
	Fianna	0.70	1.65
	Navan	1.63	2.54
2	Rooster	0.65	0.79
	Maris Piper	2.00	2.09
	Fianna	1.06	2.30
	Navan	2.59	2.19
3	Rooster	0.41	0.75
	Maris Piper	3.03	2.01
	Fianna	1.08	1.45
	Navan	2.96	2.03

Fry colour

The effect of seed source, physiological age and desiccation date on the proportion of chips in each of the seven colour score categories was determined. However, to provide a more coherent understanding of the effect of agronomic factors on chip fry colour following storage, it was decided to combine the proportion of chips scoring 000 with the proportion scoring 00 and refer to this combined proportion as 'acceptable'.

Seed source did not influence fry colour of Maris Piper chips following storage in 1996 or 1997 (Table 24). In 1994 there was a significant interaction between seed source and desiccation date. At the first and second dates the Carlow-grown seed produced lighter fry colours while at the third date the Donegal-grown seed produced the lightest colours. Seed source had no effect on fry colours of Rooster following storage in 1996 and 1997 (Table 25).

Physiologically ageing Maris Piper seed tubers did not influence fry colour following storage during 1994, 1996 or 1997 (Table 24). Similarly there was no effect on Rooster in 1994, 1996 or 1997 (Table 25).

Delaying the desiccation date significantly influenced fry colour of Maris Piper chips following storage in 1997 when fry colour declined significantly with successive delays in desiccation date. Delaying the desiccation date only affected fry colour of Rooster chips in 1996 when fry colours at the first and third dates were similar but fry colours from the second date were darker.

Fry colour of the cultivars Rooster, Maris Piper, Navan and Fianna was not influenced by desiccation date in 1996 and furthermore, there was no difference between cultivars (Table 26). In 1997 there was a significant interaction between cultivar and desiccation date. At the first two desiccation dates there was no difference between cultivars while at the third desiccation date Navan had a lower score than Rooster, Maris Piper or Fianna.

Table 24: Effect of seed source, physiological age and desiccation date on the proportion of Maris Piper chips attaining acceptable* fry colour at final assessment following storage 1994 - 1997

Desic. date	Seed source	Physiol. age	1994	1995	1996	1997
1	Carlow	0	0.91	-	0.53	1.00
		200	0.80	-	0.58	1.00
	Donegal	0	0.56	-	0.75	1.00
		200	0.08	-	0.49	1.00
2	Carlow	0	0.90	-	0.70	0.49
		200	0.58	-	0.35	0.61
	Donegal	0	0.45	-	0.64	0.19
		200	0.39	-	0.39	0.68
3	Carlow	0	0.26	-	0.56	0.39
		200	0.33	-	0.71	0.06
	Donegal	0	0.49	-	0.44	0.28
		200	0.66	-	0.84	0.24

(*acceptable = proportion at score 000 + proportion at score 00 out of 1.00)

Table 25: Effect of seed source, physiological age and desiccation date on the proportion of Rooster chips attaining acceptable* fry colour at final assessment following storage 1994 - 1997

Desic. date	Seed source	Physiol. age	1994	1995	1996	1997
1	Carlow	0	0.88	-	1.00	1.00
		200	0.82	-	1.00	1.00
	Donegal	0	-	-	0.96	1.00
		200	-	-	0.98	1.00
2	Carlow	0	0.50	-	0.81	1.00
		200	0.94	-	1.00	1.00
	Donegal	0	-	-	0.94	1.00
		200	-	-	0.85	1.00
3	Carlow	0	0.67	-	1.00	0.90
		200	0.45	-	0.91	1.00
	Donegal	0	-	-	1.00	1.00
		200	-	-	1.00	1.00

(*acceptable = proportion at score 000 + proportion at score 00 out of 1.00)

Table 26: Effect of desiccation date on the proportion of chips of four cultivars attaining acceptable* fry colour at final assessment following storage - Kildalton 1996 and 1997

Desic. date	Cultivar	1996	1997
1	Rooster	1.00	1.00
	Maris Piper	0.85	1.00
	Fianna	0.94	1.00
	Navan	0.73	1.00
2	Rooster	1.00	1.00
	Maris Piper	1.00	1.00
	Fianna	1.00	1.00
	Navan	0.98	1.00
3	Rooster	1.00	1.00
	Maris Piper	1.00	0.86
	Fianna	1.00	1.00
	Navan	1.00	0.66

(*acceptable = proportion at score 000 + proportion at score 00 out of 1.00)

When tubers from the same seed lots planted at Kildalton were planted in Lyons Estate in 1997, there was no significant difference in fry colour between cultivars following storage (Table 27).

Table 27: Comparison of the proportion of chips of four cultivars attaining acceptable* fry colour at final assessment following storage - Lyons Estate 1997

Cultivar	1997
Rooster	1.00
Maris Piper	0.86
Fianna	0.91
Navan	1.00

(*acceptable = proportion at score 000 + proportion at score 00 out of 1.00)

CONCLUSIONS

- When seed tubers of cv's Maris Piper and Rooster grown in Carlow were compared with seed tubers grown in Donegal

    - seed source did not affect the date of dormancy break, length of longest sprouts following accumulation of physiological age, the rate of emergence, tuber yield, sucrose concentrations prior to desiccation, reducing sugar concentrations or fry colour following storage.

- Compared with cold stored seed tubers, physiologically aged seed tubers of cv's Maris Piper and Rooster

    - developed longer sprouts, emerged faster, achieved higher levels of crop establishment.

    - increased yield of Maris Piper in the grade >45 mm by 12%, 7% and 6% with successive delays in desiccation date and increased corresponding yield of Rooster by 15%, 8% and 7%.

    - increased yield of Maris Piper in the grade 60-80 mm by 28% and in the corresponding grade of Rooster by 41%.

    - increased dry matter content of Maris Piper tubers during one season from four and of Rooster tubers during two seasons from four.

    - reduced tuber sucrose concentration of both Maris Piper and Rooster prior to desiccation during two seasons from four, reduced reducing sugar concentration of Maris Piper and Rooster following storage during one season from three.

    - did not influence fry colours of Maris Piper or Rooster following storage.

- Delaying the desiccation date

    - increased yield of Maris Piper tubers > 45 mm by 12% during the first increment and 7% during the second with corresponding increases of 14% and 8% respectively for Rooster.

    - increased tuber dry matter content of Maris Piper and Rooster during two seasons from four.

    - generally decreased tuber sucrose concentration prior to desiccation

    - tended to increase reducing sugar concentrations and darken fry colours following storage.

- Comparing the cultivars Maris Piper, Rooster, Fianna and Navan

    - all provided satisfactory crop establishment except Fianna in 1997.

    - Navan achieved the highest yield of tubers >45 mm at Kildalton while Maris Piper achieved the highest corresponding yield at Lyons Research Farm.

    - dry matter content of all cultivars responded differently to delay in desiccation date at Kildalton.

    - while tuber sucrose concentration prior to desiccation declined with delay there was an inconsistent response between cultivars during both seasons.

    - Rooster had lowest concentration of reducing sugars and the lightest fry colours following storage in both seasons.

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CONTENTS