An evaluation of small seed for ware-potato production

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SUMMARY

Sixteen experiments over six seasons (1981–87) compared the growth and yield of up to 16 seed-tuber weights, ranging from 1–5 to 110–120 g, in one second-early and four maincrop varieties. Four of the experiments (1986–87) examined effects in seed tubers from seed crops planted in July; the remaining experiments used seed from crops planted at the normal time, April–May. Effects were similar for seed from the different planting dates. Plants from seed < 5 g (and occasionally up to 15 g) emerged slightly later and produced a smaller crop canopy that those from larger seed. The later emergence from the smallest seed was a consequence of a slower rate of sprout elongation. There were no effects of seed weight above 15 g on stem emergence or growth of the canopy. In 1982, a severe frost completely defoliated all plants in four experiments but within 2 weeks complete plant emergence was re-achieved from all seed weights except the smallest (1–5 g). The results suggest few differences between seed weights > 5 or 10 g in emergence from similar depths of planting or in recovery from frost damage.

Tuber yields were little affected by seed weight > 5 or 10 g, even at constant within-row spacings. Consequently, seed rates from 0·59 to 5·4 t/ha produced similar yields and the results suggest considerable economic benefits and potential for using seed tubers of much smaller weight than may be sold under current legislation. The use of small seed tubers from late-planted crops may result in further economies in production costs and reduction in disease in seed tubers.

INTRODUCTION

In the UK, the sale of seed-potato tubers is restricted to the range 25–60 mm by statute (Anon. 1984) and, until relatively recently, tubers below 35 mm have been little used in commercial practice. As seed rates decrease with seed weight (Holmes 1967; Jarvis 1977; Allen 1978*a*), important savings on handling, storage and planting time can be achieved through the use of smaller seed. As the production of small seed only requires a short growing period (*c*. 8–10 weeks from planting), small seed could be produced following early-harvested crops such as winter barley, onions or carrots. Such production systems should result in further economies to ware growers and probably a lower incidence of tuber-borne diseases (Spencer & Fox 1979; Hide 1987). However, there is still a suspicion among growers that seed at the lower end of the statutory range may not produce full yields. There have been few comparisons using the whole range of seed sizes and the commercial value of seed < 25 mm has not been established. The potential may be considerable, because cut fragments of seed tubers can produce similar yields to whole tubers (Allen 1978*b*) and 5 g of tuber tissue has been shown to be sufficient for the growth of a mainstem (Hammes 1985). Seed < 25 mm is likely to have very low optimum seed rates, as the data of Wurr & Morris (1979) show that in Désirée the number of stems per tuber increases slowly with increasing seed tuber weight. Extrapolation of their fitted line suggests that a seven-fold increase in seed weight from 5–35 g would not double the number of stems per seed tuber. Thus, production of similar, optimum stem densities could be achieved with very low seed rates of tubers < 25 mm and weighing 20 g or less. This paper reports the results of 16 experiments which studied the growth and yield of seed tubers ranging in average weight from 2·5 to 115 g. Some of these tubers were produced from short-season seed crops planted in July (P. J. O'Brien & E. J. Allen, unpublished).

MATERIALS AND METHODS

Sixteen experiments were carried out from 1981 to 1987. Experiments 1–4 in 1981 were carried out at the University College of Wales Field Station, Trefloyne, Tenby on Devonian Sandstone soils of the Milford Association (Soil Survey of England and Wales 1984). The remaining experiments were carried out at Cambridge University Farm on gravelly loam soils of the Milton Association (Soil Survey of England and

Table 1. *Details of experiments and husbandry practised*

Experiment	Year	Variety	Date of Planting	Dates of harvesting	Fertilizer (kg/ha) N	P	K	Mg
1*	1981	Maris Piper	2 April	11 August	170	74	197	0
2*	1981	Record	4 April	29 August				
3*	1981	Désirée	2 April	2 September				
4*	1981	Pentland Crown	4 April	4 September				
5*	1982	Record	25 March	20–27 August	82	36	109	0
6*	1982	Pentland Crown	25 March	20–27 August				
7*	1982	Désirée	24 March	20–27 August				
8	1983	Maris Piper	15 April	28 September				
9	1983	Record	11 May	30 September				
10	1983	Désirée	30 April	27 September				
11	1983	Désirée	5 May	13 October				
12	1984	Désirée	16 April	14 September				
13†	1986	Record	29 April	4 September	100	75	188	27
14‡	1987	Record	14 April	11 August				
15‡	1987	Wilja	14 April	18 August				
16‡	1987	Maris Piper	14 April	24 July				

Treatment other than seed tuber weight.
* Two depths of planting: 5 and 15 cm.
† Two seed storage temperatures (ambient and 10 °C) and two dates of planting of the seed crop (10 and 31 July 1985).
‡ Two seed storage temperatures (ambient and 10 °C).

Table 2. *Seed rates* (*t/ha*) *resulting from seed weights and within-row spacings and recommended seed rates* (*t/ha*) *for four varieties of potato*

Seed tuber weight (g)	Number of tubers/ 50 kg	Within-row spacing (cm) 30	20	15	Recommended seed rate* Pentland Crown	Maris Piper	Record	Wilja
1–5	20000	0·12	–	0·23				
5–10	6667	0·35	–	0·70				
10–15	4000	0·59	–	1·17		Not given		
15–20	2857	0·82	1·23	1·64				
20–25	2222	1·06	1·58	2·11				
30–35	1538	1·53	2·28	–				
35–40	1333	1·76	2·64	–	2·4	1·7	2·0	1·8
40–45†	1176	1·99	2·99	–	2·5	1·8	2·1	1·9
40–50	1111	2·11	3·16	–	2·6	1·9	2·1	2·0
50–60	909	2·58	3·87	–	3·0	2·1	2·4	2·3
60–70	769	3·05	–	–	3·3	2·2	2·6	2·5
70–80	667	3·54	–	–	3·4	2·3	2·8	2·7
80–90	588	3·99	–	–	3·5	2·4	2·9	3·0
90–100	526	4·46	–	–	3·7	2·5	3·2	3·3
100–110	476	4·93	–	–	–	–	–	3·3
110–120	435	5·40	–	–	–	–	–	3·7

* Ministry of Agriculture, Fisheries and Food (1982).
† Used in Expts 13–16 only.

Wales 1984). In the experiments, up to 16 seed-tuber weights were compared as single rows with three replicates. The varieties, dates of planting and harvesting and other experimental treatments are shown in Table 1. Between-row spacing was 71 cm in all experiments.

Table 3. *Mean effect of seed weight on number of days from planting to (a) 50% plant emergence, (b) 75% foliar ground cover and (c) rate of sprout elongation (cm/day) from time of planting to 50% emergence in Record and Maris Piper*

		Seed weight (g)								
Variety	Experiment	1–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45
Record	13(a)	33	30	29	30	31	30	29	31	31
	(b)	69	66	66	66	65	65	65	65	65
	(c)	0·21	0·27	0·27	0·25	0·25	0·29	0·35	0·23	0·28
	14(a)	29	27	29	26	27	25	27	24	24
	(b)	73	66	65	65	65	64	65	64	64
Maris Piper	16(a)	28	23	21	17	17	16	15	15	15
	(b)	74	66	64	59	60	58	59	58	59
	(c)	0·22	0·29	0·28	0·39	0·37	0·40	0·43	0·42	0·33

In 1981 and 1982 (Expts 1–7), all 16 seed-tuber weights were planted at a within-row spacing of 30 cm. In 1983 and 1984 (Expts 8–12), 15 seed weights were used and the five lowest were spaced at 15 cm, the middle five weights at 20 cm and the largest five seed weights at 30 cm. In 1986 and 1987 (Expts 13–16), nine seed weights were used up to 45 g and were arranged in groups of three for different spacings; with increasing seed weight the groups were spaced at 15, 20 and 30 cm. The seed rates resulting from these spacings, assuming the mean weight in each grade was the middle of the seed weight range, are given in Table 2 together with the Ministry of Agriculture, Fisheries and Food (1982) recommended seed rates for a 2:1 seed:ware price ratio.

In Expts 1–7, the depths of planting (5 and 15 cm) were in main plots and the seed weights were planted systematically from the smallest to the largest within each main plot. In Expts 8–12, the three groups of seed spacings were randomized within each replicate and the five seed weights within each group were randomized. Seed weights were in sub-subplots in Expt 13 only and in subplots in Expts 14–16. In Expts 13–16, seed weights were planted systematically from the smallest to the largest or *vice versa* depending on randomization. Single-row plots were used in the experiments, as there were insufficient numbers of the smallest seed to plant guard rows. Randomization of individual seed weights was avoided because of shading effects caused by plant height increasing with increasing seed weight.

Experiments 1–12 were hand planted using pole dibbers. In Expts 13–16, tubers were pushed, with the longest sprout vertically upwards, into the soil so that the distance from the tip of the longest sprout to the soil surface was similar (*c*. 6–7 cm) for all seed weights. Experiments 5–10 were planted on a flat surface and the remaining experiments were planted on ridges.

Tubers were planted with a distance of 8 cm from the soil surface to the upper surface of the tuber in Expts 8 and 9 and *c*. 12 cm in Expts 10–12. In all experiments, emergence was recorded in all plots on the whole row of each seed weight. In Expts 13–16, percentage foliar ground cover was assessed visually in all plots by the same operator. After a severe frost in 1982, emergence was recorded as number of newly emerged (undamaged) plants and regrown plants with at least one expanded leaf.

Certified Scottish seed was used for Expts 1–4 and 8–12; once-grown seed from crops planted in April or May in mid-Wales was used for Expts 5–7. Seed for Expts 13–16 was obtained from crops planted in July in Suffolk (Expts 13 and 14) and Cambridge (Expts 15 and 16). Seed tubers for Expts 5–7 and 13–16 were dipped in a solution of thiobendazole (1% a.i.) soon after harvest to control infection by tuber-borne diseases.

Except in 1987, no visible symptoms of any fungal or virus diseases were observed in any experiment. In 1987, symptoms of leaf-roll virus were observed in Maris Piper (Expt 16) and a low incidence of mild mosaic was evident in all varieties in that year.

Rainfall was below average at Trefloyne in 1981 and the foliage of all four varieties was dead by late August. Frequent rainfall in 1982 ensured uninterrupted growth but there was a severe frost on 5 May which destroyed emerged foliage in all plots in Expts 5–7. No serious frosts occurred during establishment from 1983 to 1987. Irrigation water was applied to Expts 8 and 9 (25 mm), Expt 12 (40 mm), Expt 13 (60 mm) and Expts 14–16 (20 mm). Experiments 1–4 (1981) and 10 (1983) were not irrigated and during the dry weather in the summer months, plants began to senesce and all haulm was dead by the end of August.

Crops were harvested after complete foliage senescence in Expts 2–4 and 8–13 but before complete senescence in all other experiments.

RESULTS

As a systematic design was used in all experiments, analysis of the results could not be carried out using conventional analysis of variance techniques. Separate regressions of variates against increasing tuber weights were fitted for each replicate of all other factors in each experiment. An analysis of variance of the slopes of the regression lines for all experiments was carried out with experiments and varieties as treatments and all other field factors and replicates used as replicates and comprising the pooled experimental error. Effects of seed weight were assessed by inspection of the slope of the regression line for the general mean in the analysis and there was assumed to be no effect of seed weight included in the analysis if the slope approached zero. The field data are presented in some Tables for clarity and statistical analyses are available from the authors where not presented.

All experiments produced similar results and the effects are illustrated for 1981–84 from experiments with Désirée and for 1986–87 from experiments with Record. Tuber yields from other experiments are given in Appendices 1–5. The data for seed weights are presented as means over other treatments.

Table 4. *Main effects of seed weight on number of stems, tubers and total tuber yield (averaged over depths of planting) in Désirée (Expt 7)*

Seed tuber weight (g)	Mainstems (thousands/ha)	Tuber (thousands/ha)	Tuber yield (t/ha)
1–5	50	298	32·8
5–10	57	390	44·3
10–15	82	474	47·7
15–20	79	465	49·7
20–25	93	482	47·0
25–30	95	510	46·4
30–35	105	506	48·6
35–40	108	490	44·2
40–50	108	522	47·7
50–60	123	579	49·9
60–70	129	604	46·8
70–80	140	678	52·9
80–90	162	592	48·2
90–100	150	650	54·9
100–110	151	675	49·6
110–120	158	660	50·7

Emergence and foliar ground cover

On the first date of recording, emerged plants were always found from the whole range of seed weights. Overall, plants from seed < 5 g (and occasionally from seed < 15 g) emerged more slowly than plants from larger seed, but the initial effects of seed weight on plant emergence rarely persisted until stem emergence. The number of days from planting to 50% stem emergence was not affected by seed weights > 15 g in any variety (Table 3).

At planting depths up to 8 cm, all seed weights produced complete or near complete plant stands but the smallest seed in all varieties produced incomplete plant stands at planting depths of 12 cm. The smallest seed, especially in Maris Piper, invariably produced foliar ground cover more slowly and had lower peak values than larger seed; there was little difference between other seed weights in the rate of production of ground cover or peaks achieved (Table 3).

Table 5. *Effects of seed weight on number of stems, tubers and tuber yields in Désirée (Expts 10 and 11)*

Seed weight (g)	Above-ground stems (thousands/ha)		Tubers (thousands/ha)		Total yield (t/ha)	
	Expt 10	Expt 11	Expt 10	Expt 11	Expt 10	Expt 11
1–5	102	103	602	821	38·9	47·2
5–10	109	121	564	924	41·4	58·0
10–15	121	137	689	936	60·8	59·3
15–20	107	148	741	923	56·4	59·4
20–25	159	154	631	965	50·5	64·4
25–30	137	158	611	839	55·0	62·3
30–35	145	160	725	885	55·3	58·2
35–40	200	161	761	859	54·1	66·9
40–50	187	178	879	1208	58·5	62·1
50–60	207	189	915	1082	55·8	58·1
60–70	159	155	764	923	56·1	55·3
70–80	178	154	745	905	54·1	59·0
80–90	189	183	846	953	58·6	61·2
90–100	221	186	1028	926	63·1	71·6
100–110	211	184	1041	1185	58·5	65·4

Table 6. *Mean effect of seed weight on number (thousands/ha) of mainstems, above-ground stems, total number of tubers and total tuber yield (t/ha) in Record in 1986 (Expt 13) and 1987 (Expt 14)*

	Seed weight (g)								
	1–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45
					1986				
Number (thousands/ha)									
Mainstems	95·3	99·6	106·7	91·0	92·6	109·8	90·6	84·8	97·7
Above-ground stems	153	170	200	174	165	211	164	157	162
Tubers	701	798	858	772	753	794	717	696	701
Tuber yield (t/ha)	44·1	49·2	52·4	49·3	48·9	52·3	50·3	51·8	50·6
					1987				
Number (thousands/ha)									
Mainstems	90·6	93·0	101·6	82·0	90·6	100·8	75·0	77·3	84·4
Above-ground stems	97	106	113	95	108	118	88	93	91
Tubers	630	717	763	752	801	778	655	651	659
Tuber yield (t/ha)	35·8	50·6	43·1	50·4	49·9	55·8	49·9	53·8	46·3

Table 7. *Linear regression coefficients for relationship between tuber yield > 40 mm (t/ha) and increasing seed weight (g) above a minimum for ten experiments*

Variety	Experiment	All seed	Seed > 5 g	Seed > 10 g
Record	2	0·074	−0·009	−0·00001
	5	0·069	0·062	0·00006
	9	0·169	0·106	0·00010
	13	0·249	0·161	0·00024
Maris Piper	1	0·180	0·151	0·00012
	8	0·130	0·089	0·00016
Désirée	3	0·250	0·113	0·00012
	7	0·054	0·018	0·00002
	10	0·064	0·034	0
	11	0·031	0·020	0·00002
S.E. Record and				
Désirée		0·0375	0·0342	$4{\cdot}13\times10^{-5}$
Maris Piper		0·0751	0·0684	$8{\cdot}25\times10^{-5}$
Error D.F. = 47				

Number of stems

At a constant spacing in Désirée, the number of mainstems increased with increasing seed weight (seed rate) but the rate of increase was small. A 50-fold increase in seed weight only trebled the mainstem density (Table 4). In experiments with different spacings, the number of mainstems and above-ground stems usually increased with increasing seed weight at narrow spacings but there was frequently little effect at the widest spacing (Tables 5 and 6). There were large differences between years in number of above-ground stems from seed of similar weight planted at similar depths in some experiments. For example, in Record (Expts 13 and 14) almost twice as many above-ground stems were produced from all seed weights in 1986 as in 1987, as a consequence of the production of more secondary stems (Table 6). The crops in the two years experienced similar pre-emergence temperatures and emerged at similar periods after planting, but the period from emergence to 75% ground cover was much cooler in 1987 (mean air temperature 11·7 °C) than in 1986 (17·0 °C).

Number of tubers

In Expts 3 and 7 in Désirée, the number of tubers increased with seed weight up to 70 g but further increases in seed weight produced no consistent effects on number of tubers (Table 4). In other experiments with constant spacings, effects of increasing seed weight were small. In Expt 7, the deeper planting produced on average 132×10^3/ha fewer tubers than shallow planting, but there were no effects of depth of planting in any other experiment. In Désirée with varying spacings, the number of tubers increased with increasing seed weight at all spacings in Expt 10 but only at the narrowest spacings in Expts 11 and 12 (Table 5). In Expts 13–16, effects of seed weight on number of tubers were similar to effects on number of mainstems (Table 6).

Tuber yield

In all experiments, tuber yield was consistently affected only where very small seed (< 5 or 10 g) was used. Such small seed produced lower yield than larger seed but for all seed weights > 10 g in all varieties there was no consistent effect of seed weight despite very large increases in seed rate (Tables 4–6). Regression analysis of all results showed that the effect of increasing seed weight was negligible for seed > 10 g and of any significance only if seed of < 5 g was included (Table 7). The effect of increasing seed weight was greatest in Maris Piper, least in Désirée, with Record intermediate between them.

DISCUSSION

Seed weights > 40 g in Expts 10–12 and > 70 g in Expts 1–9 were planted at seed rates in excess of that currently recommended by the Ministry of Agriculture, Fisheries and Food (Table 2). The yields are, therefore, likely to represent the flat part of the yield–density relationship and the similarity of yields from these seed weights and smaller seed (down to 10–15 g) suggests that much smaller seed than that currently used is capable of producing full yields. As the seed rates involved with the smallest seed are so low, considerable economy in storage, handling and planting time would be achieved if these seed weights were adopted in commercial practice.

The results suggest that many of the features of growth of small seed which have concerned growers are either exaggerated or invalid. At similar planting distances from the soil surface to sprout tips, there were only small differences in emergence between seed weights. The widespread opinion of growers that emergence from small seed is much later than from large seed is likely to be almost entirely due to differences in effective planting depth due to planting all weights of seed into the same ridge. The effect of planting depth and two positions of seed tuber in the ridge on time to emergence is shown in Table 8. The length of three seed weights 7·5, 37·5 and 100 g of Maris Piper were measured as 29, 50 and 78 mm respectively. Using these tuber dimensions and the measured rates of sprout elongation in Maris Piper in Expt 16 (Table 3), the time taken from planting to

Table 8. *Calculated number of days from planting to 50% emergence for three seed weights of Maris Piper planted at different depths and two orientations, A (sprouted surface facing vertically upwards in smallest seed and downwards in the two larger seed sizes) and B (sprouted surface facing vertically downwards in smallest seed and upwards in the two larger seed sizes).*

	Orientation A			Orientation B		
Seed weight (g)...	7·5	37·5	100	7·5	37·5	100
Depth of planting (cm)						
4	3·5	–	–	13·7	–	–
5	7·0	11·8	–	17·2	–	–
6	10·4	14·2	–	20·6	2·3	–
7	13·9	16·6	–	24·1	4·7	–
8	17·3	19·0	19·0	27·5	7·1	0·5
10	24·2	23·7	23·7	34·4	11·8	5·2
12	31·0	28·4	28·4	41·2	16·6	9·9
14	37·9	33·2	33·2	48·1	21·3	14·7
16	44·8	37·9	37·9	55·0	26·0	19·4
18	51·6	42·7	42·7	61·9	30·8	24·1
20	58·5	47·4	47·4	68·7	35·5	28·9

50% emergence was estimated for the seed weights at two opposing orientations of the sprouted surface in the ridge. The rate of sprout elongation for 100 g seed was assumed to be similar to that for the larger seed used in Expt 16 (Table 3), and the seed tubers were assumed to have had limited sprout growth at planting. As the rate of sprout elongation was slower for seed < 15 g than for any larger seed in Expt 16, differences between the smallest and larger seed in time to emergence increased with increasing depth of planting. Taking a planting depth of 140 mm as typical of practice, the largest seed may emerge a minimum of 5 days and a maximum of 33 days earlier than small seed as a consequence of extreme orientation of the sprouts in the ridge (Table 8). Seed tubers may, in practice, be planted at any orientation between the extremes used, but these calculations suggest that delays in emergence of 2–3 weeks observed in practice from planting small rather than large seed are largely a consequence of deeper planting of the smaller seed, creating greater distances to be covered prior to emergence. A similar conclusion was reached by Thomas (1988). Seed ranging in weight from 15 to 150 g are frequently found in commercial stocks graded to wide tolerances, e.g. 35–55 mm, and such seed will result in much variation in emergence within individual crops. Such effects will affect yield and size grading.

Small seed usually has shorter sprouts than larger seed (Bean 1981) and where heavily sprouted seed is used, as for early crops, some disparity may be have to be accepted in the distance of sprout tips to the ridge surface if the depth of soil in which progeny tubers form is to be kept similar. Such an arrangement will inevitably mean a slight delay in the emergence of small seed. Bean (1981) reported for early varieties planted in ridges that initial emergence was less affected by seed weight than expected and the method of expressing emergence markedly influenced the result obtained. Using equal seed rates, the number of days to 50% plant emergence was only marginally altered by seed weight. If expressed as number of emerged stems per unit area, small seed rarely had fewer stems than large seed and frequently had more stems from the beginning of emergence. Thus, there is growing evidence that differences in the emergence of different seed weights are smaller than imagined and that synchronous emergence could be achieved by the appropriate control of planting depth. In the practical development of these ideas, all aspects of handling, storage and planting of small seed require study. The prospect of using very small seed requires a complete review of the planting operation and probably the soil types on which the seed and ware will continue to be grown. This review may be hastened by the need to devise mechanized systems for planting mini-tubers (< 25 mm) as the starting point of the seed multiplication cycle.

The view of many growers and Thomas & Eyre (1950) that small seed has less vigour than larger seed received no support from the results of these experiments, as there was no difference between seed weights > 15 g in rate of production of foliar cover. Vigour is frequently associated with the height of the haulm, which is principally determined by stem density. Low stem densities produce stems which are shorter than stems from high stem densities, irrespective of seed weight, and in many comparisons small seed is grown at lower stem densities than large seed. For these experiments, the recovery from frost damage of seed weights > 10 g was similar and only the smallest seed suffered any lasting damage from the severe frosts in 1982. As this frost completely destroyed all foliage, it was a severe test of the potential for recovery of different seed weights. The evidence suggests that frost damage is little affected by seed weight in maincrop varieties. As severe late frost occurs relatively rarely, it is misguided to concentrate on this aspect of seed weight and neglect the obvious potential of small seed in all seasons.

The results of Expt 9 with Record are important in dispelling the fear that small seed may be vulnerable to poor growing conditions. This experiment was not irrigated and was situated on a particularly light soil. During the dry weather in July and August, senescence began in all seed weights and no haulm survived into September. Observations detected no effect of seed weight on the onset of senescence or on the persistence of the foliage.

The results suggest substantial potential for the development of commercial systems of production and utilization of smaller seed. A range of seed weights will occur in all crops but earlier defoliation and harvesting of relatively small yields of smaller tubers would be capable of planting many more ware hectares than achieved by current systems (Allen & O'Brien 1987), if seed were closely graded and planted at seed rates determined by seed weight. The use of seed from late-planted crops following early-harvested crops in the same season offers further substantial reductions in seed costs to the ware grower compared with present systems of seed production (P. J. O'Brien & E. J. Allen, unpublished). For ware production, there is an immediate need to establish the optimum seed rates for seed < 35 mm (1400/50 kg).

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Appendix 1. *Effects of seed weight on number of stems, number of tubers and total tuber yield (averaged over depths of planting) in Pentland Crown (Expt 6)*

Seed weight (g)	Above-ground stems (thousands/ha)	Tubers (thousands/ha)	Total tuber yield (t/ha)
1–5	93	274	52·4
5–10	116	332	63·5
10–15	140	375	70·1
15–20	171	366	65·4
20–25	181	373	64·7
25–30	200	386	64·5
30–35	235	460	78·1
35–40	229	404	64·3
40–50	238	429	65·9
50–60	301	428	65·6
60–70	326	513	76·6
70–80	314	462	68·5
80–90	307	504	74·8
90–100	367	506	71·5
100–110	392	527	81·2
110–120	378	532	70·4

Appendix 2. *Effects of seed weight on number of stems, number of tubers and total tuber yield (averaged over depths of planting) in Record (Expt 5)*

Seed weight (g)	Above-ground stems (thousands/ha)	Tubers (thousands/ha)	Total tuber yield (t/ha)
1–5	66	372	35·3
5–10	77	423	44·3
10–15	92	518	47·9
15–20	98	521	46·8
20–25	122	529	42·5
25–30	134	523	44·5
30–35	144	543	45·8
35–40	152	550	48·2
40–50	173	547	42·8
50–60	177	542	44·4
60–70	197	597	46·0
70–80	188	584	43·7
80–90	205	633	45·0
90–100	230	639	45·1
100–110	236	693	49·4
110–120	245	735	49·0

Appendix 3. *Effects of seed weight on number of stems, number of tubers and total tuber yield (averaged over depths of planting) in Record (Expt 9)*

Seed weight (g)	Above-ground stems (thousands/ha)	Tubers (thousands/ha)	Total tuber yield (t/ha)
1–5	134	564	21·6
5–10	170	648	27·1
10–15	165	604	26·6
15–20	238	653	26·8
20–25	245	784	30·5
25–30	228	685	30·6
30–35	176	700	28·7
35–40	245	793	33·2
40–50	280	873	36·3
50–60	220	708	31·6
60–70	253	770	35·4
70–80	252	783	37·2
80–90	207	644	24·5
90–100	231	779	33·2
100–110	252	842	38·4

Appendix 4. *Effects of seed weight on number of stems, number of tubers and total tuber yield (averaged over depths of planting) in Maris Piper (Expt 8)*

Seed weight (g)	Above-ground stems (thousands/ha)	Tubers (thousands/ha)	Total tuber yield (t/ha)
1–5	118	775	40·4
5–10	124	840	49·5
10–15	188	930	52·4
15–20	159	1195	58·4
20–25	226	1338	64·5
25–30	190	896	54·4
30–35	218	1215	48·5
35–40	183	1204	54·8
40–50	216	1265	53·2
50–60	293	1516	56·4
60–70	235	1185	56·2
70–80	248	1247	61·8
80–90	211	1396	64·5
90–100	258	1552	69·4
100–110	261	1550	65·8

Appendix 5. *Mean effect of seed weight on number (thousands/ha) of above-ground stems, tubers and total tuber yield (t/ha) in Wilja (Expt 15) and Maris Piper (Expt 16) in 1987*

	Seed weight (g)								
	1–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45
					Wilja				
Number (thousands/ha) of									
Above-ground stems	92	102	110	108	116	131	93	91	103
Tubers	478	597	617	587	656	728	603	619	658
Tuber yield (t/ha)	37·6	57·4	51·7	55·4	57·4	60·0	57·3	63·7	51·6
					Maris Piper				
Number (thousands/ha) of									
Above-ground stems	105	119	124	118	123	140	93	100	114
Tubers	533	693	724	729	863	902	682	805	784
Tuber yield (t/ha)	24·2	40·0	35·3	42·2	39·4	48·3	38·2	43·7	40·8