EFFECT OF N, P, K, IRRIGATION AND SPACING ON ILAM HARDY AND WHA POTATOES

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ABSTRACT

Results are reported on four potato experiments carried out at Lincoln College on Wakanui silt loam over the seasons 1977/78 to 1979/80. In each trial the cultivars Ilam Hardy and Wha were compared with various fertiliser, irrigation and spacing treatments.

In 1977/78, there were no significant responses to N, P, K fertilisers or spacing. Wha had total tuber yields of 45 t/ha and Ilam Hardy of 40 t/ha. Although there was no overall response to N, Wha showed a depression of 8 t/ha to N, and Ilam Hardy a small response.

In the 1978/79 season, two experiments were carried out. In one of these there was no response to spacing, N, P or K. Ilam Hardy had a total tuber yield of 58 t/ha and Wha of 48 t/ha. In the second trial, trickle irrigation was applied as a basal treatment. In this trial Ilam Hardy had a mean yield of 80 t/ha and with 100 kg/ha of N gave 89 t/ha, while Wha's mean yield was 69 t/ha and gave a maximum yield of 74 t/ha at 50 kg/ha of N.

In 1979/80, irrigation was applied as a treatment and gave a mean response of 8 t/ha. In this experiment, Ilam Hardy had a mean yield of 68 t/ha and Wha of 54 t/ha. Significant interactions were recorded between cultivar and each of K, irrigation and P. In each case, Ilam Hardy gave a positive response to the treatment while Wha was unresponsive. There was a negative interaction between irrigation and K.

It is notable that, in all trials, Wha was substantially less responsive to fertiliser and irrigation than was Ilam Hardy.

Additional Key Words: Interaction, factorial, potato cultivars.

INTRODUCTION

Over thirty potato cultivars are available to New Zealand growers. Some of these were imported from U.S.A. or U.K. while others have been bred in New Zealand. The most popular cultivar is Ilam Hardy which had 50% of the total 1980 certified potato seed area. It was bred by Mr R.G. Robinson of Christchurch and was released in 1952. Ilam Hardy gained popularity in the 1960's and has been dominant for the last ten years in spite of work by Blackmore *et al.* (1972) who reported that the Crop Research Division DSIR varieties Toru, Wha and Whitu were up to 34% higher yielding. The increasing proportion of the potato crop being used for processing may have also been expected to favour the adoption of Wha and Whitu which were bred with high dry matter content and low sugars specially for processing (Driver, 1971, 1974).

One of the reasons for the continuing popularity of Ilam Hardy for both processing and domestic use may relate to difficulties encountered by growers when they try new cultivars. Cultural methods which have been proven with the commonly grown cultivar may be unsuitable for a new cultivar which could then be discredited after a poor performance. There is very little published information on interactions between cultivars and cultural treatments from local or from overseas research. The four experiments described in this paper are part of a continuing Lincoln College programme where recently released Crop Research Division potato cultivars are compared with Ilam Hardy under a range of fertiliser, irrigation and spacing treatments.

MATERIALS AND METHODS

All four experiments were conducted on a Wakanui silt loam at Lincoln College. Three multifactorial experiments measured responses by Wha and Ilam Hardy to nitrogen, phosphorus and potassium fertilisers in each of three seasons (1977/78 to 1979/80). A range of spacing treatments was included in the first two seasons and a December side dressing of nitrogen and irrigation were included as factors in the third season. In the second season four rates of nitrogen fertiliser were applied to each of the potato cultivars with basal irrigation in an additional experiment. Four row plots were used (Mountier, 1964). Plots were either 4.5 m (Trials 1, 2 and 3) or 5 m (Trial 4) long and rows were 0.75 m apart.

Trial sites were cultivated in September and a three furrow moulder was used to form rows for hand planting in early October. Seed, fertilizer and disulfoton (as 10% granules at 1.5 kg a.i./ha) for aphid control were placed in the furrows between ridges which were then levelled to cover the seed, fertilizer and insecticide. Ridges were reformed in mid November when all potato plants had emerged. Herbicide (metribuzin at 0.7 kg a.i./ha) was applied about two weeks later when annual weed seedlings had established. A diquat-paraquat mixture was used to

dessicate Wha haulms in early April. Normally, Ilam Hardy haulms were dead by this time and Wha had declined considerably in vigour. Trials were harvested in April or May using a single row apron type digger. Total yield, table grade yield and table tuber number were recorded for the two central harvest rows from each plot. Table grade were sound tubers over 50 mm diameter without tuber moth damage or greening but including any tubers which suffered digger damage.

Trial 1, 1977/78

The area was ploughed out of permanent pasture in February, 1976 and spring barley was sown after a winter fallow. The potato seed-bed was cultivated out of self sown barley greenfeed in September, 1977.

A single replicate of a five factor trial confounded into eight blocks was planted on 11 October, 1977. The factors were cultivar, nitrogen (applied as urea) at 0 and 140 kg N per hectare, phosphorus (applied as superphosphate) at 0 and 80 kg P per hectare, potassium at 0 and 150 kg K per hectare (applied as potassium chloride) and four within-row plant spacings of 215, 250, 300 and 375 mm. These spacings gave plant populations of 62,200, 53,300, 44,400 and 35,600 plants per hectare respectively. All fertiliser treatments were applied at planting. Disulfoton was not applied.

The crop was ridged on 14 November and metribuzin applied 25 November. Minimal basal irrigation (100 mm total) was applied on three occasions with an oscillating sprayline from late December to mid March.

Trial 2, 1978/79

Both Trial 2 and Trial 3 were grown on land which was in barley in 1976/77 and lupins in 1977/78 after being ploughed out of permanent dairy pasture in February, 1976. Trial 2 was planted on 17 October, 1978 as a single replicate of a factorial design with five factors each at two rates and with higher order interactions confounded to give four blocks. Ilam Hardy and Wha were compared with nitrogen (applied as urea) 0 and 100 kg N/ha, phosphorus 0 and 80 kg P/ha (applied as triple superphosphate), potassium 0 and 150 kg K/ha (applied as potassium chloride) and within-row spacings of 215 mm and 375 mm. Basal gypsum (100 kg S/ha) was spread in the furrows at planting with the seed and treatment fertilizers. Basal spray irrigation (75 mm total) was applied on two occasions in January and February.

Trial 3, 1978/79

This experiment was adjacent to Trial 2 and was planted on the same date. Ilam Hardy and Wha were compared at four rates of nitrogen (0, 50, 100 and 200 kg N/ha) applied as urea at planting time. There were four replicates of the eight treatments in a randomised block design. Basal fertilizer (80 kg P/ha as superphosphate plus 80 kg K/ha as KCl) was applied to all plots and plant density was 44,400/ha (300 mm within-row spacing).

Management of Trial 3 was the same as for Trial 2 except that Trial 3 had basal trickle irrigation and was not dessicated. Trickle irrigation was used to apply the basal water. Lateral pipes with micro-tubes at 15 mm intervals were placed along the furrows and water was applied when required from early January to the end of February. A total of 300 mm of water was applied to the crop.

Trial 4, 1979/80

Permanent dairy pasture was ploughed in August, 1979 and a seedbed was prepared for planting on 16 October, 1979. A factorial design with six factors each at two levels was used and high order interactions were confounded to form four blocks each with 16 plots. Ilam Hardy and Wha were compared with early nitrogen at planting and late nitrogen (11 December) each applied as urea at 0 or 100 kg N/ha, phosphorus as triple superphosphate (0 and 80 kg P/ha) and potassium as potassium chloride (0 and 150 kg K/ha). The sixth factor, irrigation, was applied from 2 December to 28 February as zero and "optimal" water by arranging the micro-tubes in the trickle irrigation laterals to match the plot randomisation. A total of 480 mm water was applied: 158 mm in December, 185 mm in January and 137 mm in February.

Plants were spaced at 300 mm and basal gypsum (100 kg S/ha) and disulfoton were applied at planting.

TABLE 1: Trial 1, 1977/78, total and table tuber yield (t/ha) and table tuber number per m².

	Yield t/ha		Number/m²
	Total	Table	Table
Ilam Hardy	40.3	30.1	15.4
Wha	45.3**	35.9**	18.3**
No N	43.8	34.2	17.4
140 N	41.8	31.2	16.3
No P	42.7	32.9	16.8
80 P	42.9	33.2	17.0
No K	41.6	32.0	16.3
150 K	44.0	34.1	17.4
Spacing 215	42.8	32.1	17.3
(mm) 250	42.7	33.1	17.6
300	42.6	33.1	16.4
375	43.1	33.9	16.3
Significant interactions	VN**	VN** V Sp*	VN** V Sp*
CV	15.7%	19.3%	19.3%

Interaction Tables

	Total Yield		Table Yield		Number	
	No N	140N	No N	140N	No N	140N
Ilam Hardy	38.3	42.3	37.9	32.4	14.1	16.8
Wha	49.4	41.3	40.5	31.5	20.7	15.9
Interaction table L.S.D.s	5.0		4.7		2.4	

	Table Yield			
Spacing (mm)	375	300	250	215
Ilam Hardy	29.0	31.1	32.8	27.6
Wha	38.3	35.1	33.3	36.5
Interaction table L.S.D.	6.6			

RESULTS

In Trial 1 (Table 1), yields were moderate (43 t/ha) and Wha outyielded Ilam Hardy by 5 t/ha. Infestations of aphid in early January and tuber moth in March/April affected Ilam Hardy more than Wha. Spacing caused no differences in yield and no fertilizer showed a significant main effect. Nitrogen, however, produced a highly significant interaction with cultivar: there was a small response to N by Ilam Hardy and a substantial depression to N by Wha. An interaction between cultivar and spacing reached the 5% level of significance in table potatoes. However, no coherent pattern emerged in the interaction table and it seems likely therefore that this is a chance effect. These remarks apply to both weights and tuber numbers.

Trial 2 (Table 2) gave heavier yields (53 t/ha) than Trial 1 and Ilam Hardy was higher yielding than Wha by 10 t/ha in total yield and by 5 t/ha in yield of table grade potatoes. There were no significant effects from spacing or from any fertilizer in this experiment.

Trial 3 (Table 3) which like Trial 2 was conducted in 1978/79, gave very high yields (75 t/ha). Ilam Hardy outyielded Wha by 11 t/ha in total and 7 t/ha in table

Trial 3 (Table 3) which like Trial 2 was conducted in 1978/79, gave very high yields (75 t/ha). Ilam Hardy outyielded Wha by 11 t/ha in total and 7 t/ha in table potatoes. The higher yield in this trial was associated with the trickle irrigation it received. This experiment had four rates of nitrogen and the curve fitting procedures used showed a significant quadratic response in both total and table tuber yields. An interaction component was significant in total weight showing Ilam Hardy to be much more responsive to N than Wha (Figure 1).

TABLE 2: Trial 2 1978/79, total and table tuber yield (t/ha) and table tuber number per m².

	Yield t/ha		Number/m²
	Total	Table	Table
Ilam Hardy	57.9	41.3	23.9
Wha	47.7**	34.6**	19.0**
No N	51.6	37.4	21.0
100 N	54.1	38.6	21.9
No P	52.6	37.7	21.1
80 P	53.1	38.3	21.8
No K	52.8	38.0	21.7
150 K	52.9	37.9	21.2
Spacing 215	53.2	36.8	21.4
(mm) 375	52.4	39.2	21.5
Significant interactions	—	—	—
CV	12.0%	16.3%	17.1%

TABLE 3: Trial 3 1978/79, total and table tuber yield (t/ha) and table tuber number per m².

		Yield t/ha		Number/m²
		Total	Table	Table
Ilam Hardy		80.4	55.2	21.9
Wha		68.8**	47.8**	17.0**
N	0	67.3	45.2	18.6
kg/ha	50	76.1	55.7	21.4
	100	78.7	53.8	19.2
	200	76.2	51.5	18.6
N significance:				
linear		*	NS	NS
quadratic		*	**	NS
Significant interactions		*	NS	NS
C V		9.7%	12.2%	15.0%

In trial 4 (Table 4), mean yield was high (61 t/ha) and Ilam Hardy again outyielded Wha by a substantial margin, 15 t/ha in total and 12 t/ha in table yields. There were also significant yield responses to each fertilizer factor and to irrigation. Moreover, a number of interactions were statistically significant. Those involving cultivar showed that Ilam Hardy responded to the factor and Wha either did not respond at all in the case of the fertilizer, or responded only slightly in the case of irrigation.

TABLE 4: Trial 4, 1979/80, total and table tuber yield (t/ha) and numbers per m².

	Yield t/ha		Number/m²	
	Total	Table	Total	Table
Ilam Hardy	68.4	56.5	35.3	23.6
Wha	53.7**	44.8**	30.3**	19.1**
No N	60.0	49.7	32.9	21.2
100 N	62.1*	51.6*	32.6	21.5
No N(applied Dec.)	59.9	49.2	33.1	21.2
100 N	62.2*	52.1**	32.5	21.5
No P	59.6	49.5	31.7	20.9
80 P	62.5**	51.8*	33.9**	21.9**
No K	58.8	48.3	32.2	20.8
150 K	63.3**	53.0**	33.3	22.0*
No irrigation	57.1	47.0	32.0	20.4
irrigation	65.0**	54.3**	33.6*	22.3**
Significant interactions	CK**,CI**,NP** KI** CP*	CN**, CP** CK*, CI** NP*		CN** CP*
CV	6.3%	6.1%	8.2%	9.5%

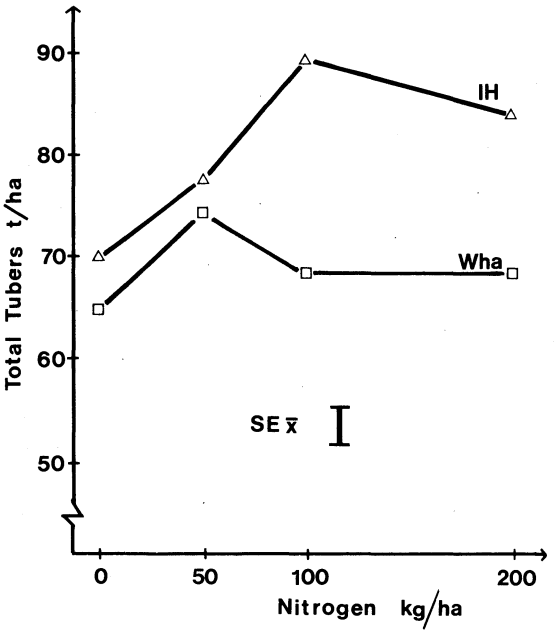

Figure 1: **Trial 3, 1978/79, total tuber yield (Cultivar x nitrogen interaction**).**

The significant interactions which did not involve cultivar were between late N and P, and between K and irrigation (Table 5). Both these showed negative interactions: there was a P response when no late N was applied but no such response in the presence of late N; there was a K response on the dry plots but virtually no K response under irrigation.

DISCUSSION

Only in Trial 1 did Wha outyield Ilam Hardy and this was the lowest yielding of the four experiments. 1977/78 was a dry season (Table 6) and Ilam Hardy suffered more from aphids and tuber moth. In the other three trials, Ilam Hardy was convincingly the higher yielder. The range of spacing treatments used did not affect total yield in either of the two trials in which spacing was a factor and this is consistent with the results of Martin (1979). McLeod (1973) did observe some yield differences to spacings, but only with much wider spacings (up to 525 mm) than those used in these experiments.

TABLE 5: **Trial 4, 1979/80, significant interactions CxP*, CxK**, C x irrigation**, late N x P** and K x irrigation**.**

Total Yield t/ha

	No P	80 P	No K	150 K	No I	I
Ilam Hardy	65.7	71.0	64.4	72.3	62.5	74.2
Wha	53.4	54.1	53.2	54.2	51.7	55.7
No Late N	57.0	62.9		No K	53.4	64.3
100 Late N	62.1	62.1		150 K	60.9	65.6
L.S.D. for all interaction tables			2.8			

TABLE 6: **Ministry of Agriculture and Fisheries "Quick Test" for soil from 0-150 mm depth at sites used for experiments.**

Trial Number	Season	pH	Ca	K	P (Olsen)	Mg
1	1977/78	5.5	10	16	44	27
2 & 3	1978/79	5.7	11	15	43	30
4	1979/80	5.8	11	6	10	32

No significant effects from phosphate or potassium occurred in Trials 1 or 2, but Trial 4 detected responses to each of these factors although the responses occurred only on Ilam Hardy. Soil tests showed that smaller quantities of P and K were present compared with the earlier trials (Table 7). There was also an interaction of K with irrigation in Trial 4 (Table 5) where a response of 7 t/ha to K on dry plots was reduced to 1 t/ha under irrigation. This observation is consistent with Van der Paauw (1956) who showed that potassium fertilizers had the greatest effect on potato yield in dry years.

TABLE 7: **Rainfall (mm) at Lincoln College.**

	1977/78	1978/79	1979/80	Station Mean
October	21	61	111	46
November	29	44	51	51
December	49	149	33	58
January	43	21	135	56
February	20	48	55	47
March	27	133	106	56

The effect of irrigation in 1978/79 was roughly indicated by the yield difference of over 20 t/ha between Trial 2 and Trial 3; in 1979/80 it was measured in Trial 4 with reasonable precision as a response of 8 t/ha on average. However, here again the interaction between cultivars was apparent: the irrigation response was 12 t/ha for Ilam Hardy and only 4 t/ha for Wha. The effect of nitrogen was variable from trial to trial. In Trial 1, Wha yields were depressed by N; in Trial 2, no effect from N was detected; in Trials 3 and 4, some N responses appeared.

Clearly the most striking result emerging from these trials is the difference in the response pattern of the two potato cultivars. In Trial 1, Ilam Hardy showed a suggestion of response to N while Wha had a significant

depression of 8 t/ha; in Trial 3, Ilam Hardy indicated a continuing response to N up to the 100 kg/ha rate whereas Wha had only a non-significant response at the 50 kg/ha rate and then a declining yield; in Trial 4 there were significant responses by Ilam Hardy to P, K, late N and irrigation while Wha showed virtually no response to P, K or late N and a much smaller response to irrigation than Ilam Hardy. Trial 4 was the only one in which the total numbers of tubers were counted (as distinct from numbers of table tubers). There was no suggestion of this irrigation by cultivar interaction in total tuber numbers which indicated that the effect must be in the bulking of the tubers. Trial 2 showed no significant responses at all to fertilizer, nor any significant interactions but an examination of the two-way tables showed the trends to be consistent with the other three experiments, where Ilam Hardy was more responsive.

There is little evidence in the literature to add support or cast doubt on the generality of potato cultivar differences in response to fertilizer. There are a few cases where irrigation has been studied on different cultivars. Harris (1978) discussed a range of overseas results which indicated that some cultivars respond more than others to irrigation. Bedi (1977) quoted the response to irrigation over four moist seasons as 39% for Ilam Hardy and 19% for Wha. Drewitt (1970) reported two experiments in which Ilam Hardy gave a significantly greater response to irrigation than Katahdin or Sebago. Martin (1979) found no significant interaction between irrigation and cultivars which included Ilam Hardy and Wha.

Speculation on the reasons for a marked difference in response to inputs between Ilam Hardy and Wha potatoes may not be very fruitful. It can be noted that Driver (1974) described Wha as having some drought resistance which suggests the possibility of a lesser response to irrigation.

A recent paper that analysed factors controlling the growth and yield of potatoes (Allen and Scott, 1980) concluded that the amount of solar radiation intercepted is a major cause of differences in production and that a cultivar which maintains substantial leaf cover for most of the growing season will give the highest yields. We took no measurements of light interception in these experiments and can simply note that Wha is considered to be of more erect habit and to have less bulky tops than Ilam Hardy (Blackmore *et al.*, 1972). In relative growth patterns, Ilam Hardy is about two weeks earlier in emergence and in foliage canopy closure but Wha is capable of growing on into autumn for at least four weeks longer.

The results reported here clearly demonstrate that Ilam Hardy was much more responsive than Wha to cultural inputs, and emphasise the need to study optimal conditions for growing any new potato cultivar.

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