Research Note

POTATO SPACING IN RELATION TO THE USE OF HERBICIDES

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Summary

"Normal" and high plant densities of Glen Ilem potatoes are compared by using the 9 combinations of 3 spacing intervals for between-row spacing and within-row seed planting in linuron-treated, hand-weeded and unweeded crops.

High plant densities gave increases in total yield, but the average tuber size and yield per plant were lower. Yields were largely unaffected by row $\times$ seed spacing interactions and the different weed control treatments did not significantly affect production.

INTRODUCTION

TRADITIONALLY, both in New Zealand and in other temperate countries where it is an important arable crop, the potato has always been regarded as requiring, and benefiting by, intensive soil cultivation both before and after planting. However, this view is now falling more and more into disrepute. A large body of evidence is being established which shows that cultivation in any situation can be harmful if used to excess and this seems to apply to potato crops particularly. Cox and Elliott (1965) gave evidence for and against weed control by cultivation in potatoes and conclude that mechanical damage to the shoot and root, loss of moisture at critical growth periods, increased soil compaction and associated mechanical harvesting difficulties may all cause loss of yield. Arndt and Rose (1966) show that severe soil compaction can occur at a very shallow depth if cultivation is used for weed control, and Njos and Nordby (1966) conclude that even the passage of a tractor spraying for blight decreased potato crop yields because of soil compaction effects. Matthews (1966) notes that virus is spread rapidly by cultivation.

Because of proven crop damage resulting from mechanical weed control methods, a case for fewer cultivations after planting has been established. No cultivation after planting is desirable, but this is neither possible nor practicable in all climates and soils. Sumich (1966) puts forward the view that heavy clay soils need cultured practices and in this he is largely supported by Matthews (1966). Nevertheless, the use of mechanical implements on damp or wet clay soils causes particularly severe soil compaction which cannot be broken in succeeding cultivations without damaging the tubers. There is worldwide interest in chemical methods for weed control in potatoes. Matthews (1966) and Sumich (1966) describe work done in New Zealand. Both authors conclude that linuron is an effective herbicide, having both foliar and residual activity, although Matthews also lists other promising herbicides in the methoxy-urea and 2-methyl-mercapto groups.

If herbicides become established as alternatives to conventional row-cropping cultivations, the plant itself may be used to assist with weed control. Row and seed spacings currently used for potato growing are geared to mechanical methods of weeding, but if chemical methods replace these then re-evaluation of crop density and seed spacing for optimum yield of a chosen potato size, together with rapid ground cover to assist with weed control, must be evaluated for the different varieties under varying climatic and soil conditions.

The experiment described here was designed to explore the effects of seed density and spacing in relation to the total yield and its makeup in terms of tuber size using chemical weed control and hand-weeding compared with the unweeded crop. Only square and rectangular seed spacings were used, but Cox and Elliott (1965) have achieved increased yields for the same plant density by using triangular planting methods.

EXPERIMENTAL

The trial was laid down to compare row widths and within-row planting distances of 12, 18 and 27 in. using linuron for chemical weed control, hand-hoeing and unweeded crops.

The split-plot technique was used. Main plots were a factorial design of all between-row distances and within-row planting intervals *i.e.*:

<i>Width between Rows (in.)</i>	<i>Seed Spacing in the row (in.)</i>	<i>Row Width</i>	<i>Seed Spacing</i>	<i>Row Width</i>	<i>Seed Spacing</i>
12	12	12	27	12	18
18	12	18	27	18	18
27	12	27	27	27	18

Each of the 9 main plots were split into 3 sub-plots which were the weed control treatments:

- (1) Linuron 2 lb pre-emergence.
- (2) Hand-weeding.
- (3) No weed control.

Thus, there were 27 sub-plots per replicate. A total of 4 replicates brought the total number of sub-plots (from now on called plots) in the trial to 108.

The trial site was within 1 mile of the Hamilton airport. It was flat, sheltered, and the seedbed was a good, deeply worked Horotiu sandy loam tilth out of pasture.

Glen Ilam seed of 2 to 4 oz was planted by hand at the row and seed spacings shown above on November 3, 1966, about 4 in. deep and the rows were moulded immediately.

About 10 days before planting the area had received an overall dressing of 3 cwt serpentine-superphosphate. At sowing, an additional dressing equivalent to about 1 oz/sq. yd was broadcast over each row before moulding. Each plot was 9 × 20 ft which allowed for 4 × 27 in. rows, 6 × 18 in. rows and 9 × 12 in. rows 20 ft long.

On November 8, 1966, following 1.65 in. of rain the previous day, 2 lb a.i. per acre of linuron was applied pre-emergence to both crop and

weeds except for some regrowth *Paspalum dilatatum* up to 6 in. high. Spraying was with an Oxford Precision Sprayer using 30 gal of water per acre.

Following spraying, growth conditions were ideal, the crop was up within 2 days and the plants grew vigorously. Unfortunately, the weed population was only minor and it was only necessary to give the crop hand-weeding treatments one light hand-hoeing about a month after spraying.

Spraying with maneb was carried out regularly once a fortnight using a 9 ft hand-carried boom, but, despite this, blight swept through the crop in late January. Because of this, there might have been some loss in yield but at harvest time from March 6 to 15 the vast majority of tubers were firm and unaffected by blight.

TABLE 1: SEED SPACING, ROW SPACING AND WEED CONTROL TREATMENTS ON CROP YIELD (TONS/ACRE)

MAIN EFFECTS

	Table	Seed	Canning	Total
<i>Weedicide</i>				
Linuron	8.93a	3.17a	2.40a	14.51a
Cultivation	8.58a	3.42a	2.52a	14.54a
Control	8.54a	3.25a	2.35a	14.14a
<i>Row Spacing</i>				
12 in.	9.08a	4.08aA	3.48aA	16.64aA
18 in.	8.20a	3.41bB	2.30bB	13.91bB
27 in.	8.77a	2.35cC	1.50cC	12.63bB
<i>Seed Spacing</i>				
12 in.	7.88a	3.94aA	3.34aA	15.17aA
18 in.	9.34a	3.33bA	2.27bB	14.94abA
27 in.	8.83a	2.57cB	1.67cB	13.07bA
CV	23.3%	21.6%	25.0%	14.1%
Significant interactions	None	None	** Row × Seed spacing	None

ROW × SEED INTERACTION TABLE

Row Spacing (in.)	Seed Spacing (in.)	Seed per Acre	Table	Seed	Canning	Total
12	12	A	7.93	4.79	5.11aA	17.84
18	12	B	7.36	4.14	3.02bB	14.51
27	12	C	8.37	2.89	1.88cBCD	13.17
12	18	B	10.13	4.00	2.93bB	17.06
18	18	C	8.76	3.48	2.22bcBC	14.46
27	18	D	9.13	2.52	1.66cdCD	13.31
12	27	C	9.20	3.46	2.38bcBC	15.04
18	27	D	8.49	2.67	1.66cdCD	12.75
27	27	E	8.80	1.65	0.96dD	11.41

At harvest, potatoes were classed as either (a) Table potatoes (over 4 oz), (b) Seed potatoes (2 to 4 oz) and (c) Canning potatoes (under 2 oz).

RESULTS

WEED CONTROL

Weeds were not a major problem and this is illustrated by the lack of significant differences between the unweeded, cultivated and chemically-treated crop yields (Table 1).

The weed population was relatively sparse but *Plantago* spp., *Taraxacum officinale*, *Geranium* spp., *Solanum nigrum*, *Amaranthus hybridus*, *Polygonum persicaria*, *Stellaria media*, *Lolium perenne* and *Paspalum dilatatum* were all present in varying amounts.

Linuron applied pre-emergence to the crop and most weeds gave excellent broadleaf weed control without crop damage but grass control, particularly of regrowth *Paspalum dilatatum*, was only fair. It has been noted in the introduction that cultivation may reduce yield, but with the light hand hoeing used in this experiment there was no danger of tuber damage or soil compaction.

The different spacing treatments had an important effect on yield, but because of the low weed population any weed control effects were minor.

EFFECT OF PLANT DENSITY ON YIELD

The different row and seed spacings used represent different plant densities and seed rates (Table 2).

TABLE 2: EQUIVALENT PLANT DENSITIES AND SOWING RATES
(2-4 oz SEED) AT EACH SEED SPACING

12	12	81	50 (A)
12	18	54	34 (B)
18	12		
12	27	36	22 (C)
18	18		
27	12		
18	27	24	15 (D)
27	18		
27	27	16	10 (E)

Figure 1 shows that, within the limits of plant density used for a constant logarithmic rise in density, there was a constant arithmetic rise in total yield.

The "normal" seed spacing of 27 in. between rows and 18 in. between sets (density D) widely used in conventional row-cropping gives relatively low yields.

Figure 2 illustrates how the increased yields shown in Fig. 1 are brought about.

There is no evidence for change in yield of table grade potatoes with increasing plant density. Any increase in total yield with increased seed rate eventuates through increased yields of small potatoes. Clearly, although total yield is increased with increasing plant density, the tuber yields and average size per plant are decreased.

Fig. 1: Plant density and total yield

Fig. 2: Plant density and yield of table, seed and canning potatoes.

SEED SPACING, YIELD AND LEAF DENSITY

Table 1 shows that similar plant densities give very similar yields and it does not seem to matter if the spacing is, say, 12×27 , 18×18 or 27×12 in. However, it has already been shown that any overall increase in plant density brings about a decrease in tuber yield and average size per plant. This is to be expected because of an increase in interplant competition, and results are in agreement with similar work on other crops.

A significant interaction between row and seed spacing for the canning grade potatoes shown in Table 1 is because there was a greater increase in yield at closer row and seed spacings than would be expected from either used alone.

An examination of the leaf canopy in terms of density proved interesting. Measurements were taken in January 1967 when a complete foliage cover was established by lowering vertical needles along transects at right-angles to the rows.

Although overall leaf densities were similar for all between-plant spacings, the distribution was quite different as is shown in Fig. 3 for the smallest and largest plant spacing.

The leaf density was much more uniform the closer the rows were planted and this was true for within-row seed spacing also. Complete ground cover became established more rapidly where plants were grown closer together.

Fig. 3: Leaf density distribution at 12 and 27 in. spacings.

DISCUSSION

The results have shown that with a high plant population there is an increase in total yield. However, within the seed rates used, there was no evidence to show that yields of table grade potatoes changed; any total yield increase was entirely due to a higher production of small potatoes. Clearly, the high plant population gave the greatest total yield, but a lower yield per plant and a smaller average tuber size. These results agree with those of Cox and Elliott (1965).

The size of the individuals making up the total yield of a potato crop may be almost as equally important as the yield itself. If table potatoes are desired, then relatively low seed rates per acre should be sown. Conversely, potatoes grown for seed or for canning require to be restricted in size by increasing interplant competition.

Rather surprisingly, the actual seed spacing in and between the rows was apparently not very important in terms of crop yield unless it affected overall crop density. This result is not in line with experience in other crops—e.g., peas (Bleasdale, 1963), where the optimum plant density was an on-the-square arrangement. Further, the measurement of leaf density indicated that, the closer the spacing, the more even was the leaf distribution above the crop. Therefore, for the same overall leaf density, it would be expected that an even distribution of leaf over the whole area would use the solar energy more effectively than where mutual shading differed markedly from place to place (Black and Watson, 1960; Bleasdale, 1963).

Visual observations indicated that, for each seed rate, complete ground cover was achieved more rapidly the more square the planting, and the leaf density analysis confirms that this trend shows. If weeds had been a problem, planting distances might have been of greater importance.

Where a complete canopy is established most rapidly the less is the weed competition and so the greater the potential yield.

The principle of the full utilization of a weed-free environment applies to all crops where weed control chemicals are available. The methods of management used for many crops in the 18th and 19th centuries may well give much higher crop yields than the row-cropping techniques which usurped them, of necessity, at the time of the industrial revolution.

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