THE INFLUENCE OF SIMULATED GAPS ON YIELD OF POTATOES
(Progress Report)

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In 1967, plant stand counts made by the senior author indicated a surprisingly high number of gaps in many Alberta potato fields. In 1968 and 1969, with the co-operation of T.A. Preston (Ag. Engineer), W.P. Skoropad and N. Colotelo (Plant Pathologists), studies were made to determine the causes of such gaps. Based upon the data obtained in 1968 and 1969, the major problem appears to be one of planting mechanics, i.e. the seed piece was not where it was supposed to be. To determine the influence of missing seed pieces or gaps on the yield of potatoes, studies were initiated in 1970 on the basis of what might be considered 'simulated gaps'. Specific numbers of gaps were created in rows of potato plants. The information reported here outlines the procedures and results of the 1970 investigations.

Combinations of plants and gaps were as follows:

____ 1 plant followed by 1 gap, 1 plant followed by 2 gaps, 1 plant followed by 3 gaps, 4 gaps;

____ 2 plants followed by 1 gap, 2 plants followed by 2 gaps, 2 plants followed by 3 gaps, 4 gaps, 5 gaps, 6 gaps.

The same procedure was followed in plots containing 3, 4, 5, and 6 plants. The combinations were replicated 6 times. The rows were 36" apart with 12" between each plant (or gap) within the rows. The experiment was divided into two major phases.
A. Where continuous guard rows were planted on each side of the rows in which the gaps were created. The gaps created within the center row were the only ones assumed to influence yield.
B. Where there were no guard rows so that the influence on yield of gaps in adjacent rows might be estimated (theoretically) as well as the influence of the gaps in the center row itself.

The diagram that follows illustrates a portion of the field design for testing the influence of 2 gaps on from 1 to 6 adjacent plants.

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    x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x
A   x x o o x x x x o o x o o x x x x x x o o x x x x x o o x x x o o
    x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x x

    o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o
B   x x o o x x x o o x o o x x x x x x o o x x x x x o o x x x x o o
    o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o

    x= 1 plant            o= 1 gap or missing plant
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The production from each plot was manually harvested, graded into Canada No. 1's, Canada No. 2's and culls. References to 'marketable' potatoes in the following discussion refer to the sum of the No. 1's and No. 2's.

Since there has been some conjecture as to the influence of gaps on the yield of plants adjacent to gaps, the data in Table 1 should be of interest. They may also assist in answering the question "Will the plants on each side of a missing plant(s) yield extra to compensate in part for the loss of yield from the gap or missing plant?"

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TABLE 1 INFLUENCE OF GAPS ON MARKETABLE YIELDS OF ADJACENT PLANTS 1970

No. of Gaps	With Guard Rows (A)	Without Guard Rows (B)
0	1.45 lb/plant	2.47 lb/plant
1	1.85	2.87
2	2.30	3.72
3	2.26	3.80
4	2.45	3.66
5	2.19	3.39
6	2.24	3.53

On the basis of the data in Table 1, it would appear that when there was 1 gap in the row and no gaps in adjacent rows (A), the yields of marketable tubers on plants adjacent to the gap increased from 1.45 lb/plant to 1.85 lb/plant. If there were 2 plants missing or 2 gaps, there was a further increase in marketable yield of adjacent plants to 2.30 lb/plant. When there were 3, 4, 5, or 6 gaps or plants missing, there appeared to be no compensating increase in yield of adjacent plants beyond the increase resulting from 2 gaps. Thus gaps of 3 positions or more reduced yield proportionately more than gaps with only 1 or 2 plants missing.

When there was no gap in the center row but there were gaps or plants missing in the 2 adjacent rows (B), the yields in the center row averaged 2.45 lb/plant; reflecting the lack of competition from adjacent rows. If 1 gap occurred in the treatment row, the yield of the plants next to the gap (with no competition from adjacent rows) increased to 2.87 lb/plant. If there were 2 gaps, the adjacent plant yield rose again, to 3.72 lb/plant. As in the (A) situation, an increase in the number of gaps beyond 2 apparently has no further influence on the yield of plants adjacent to the gaps. The influence of gaps on the yield of No. 1 tubers (Table 2) on plants adjacent to the gaps was very similar to the influence of gaps on the yield of marketable tubers.

TABLE 2 INFLUENCE OF GAPS ON NO. 1 YIELDS OF ADJACENT PLANTS 1970

No. of Gaps	With Guard Rows (A)	Without Guard Rows (B)
0	0.83 lb/plant	1.99 lb/plant
1	1.27	2.46
2	1.64	3.41
3	1.78	3.52
4	1.86	3.28
5	1.49	3.07
6	1.68	3.20

It would appear that when 1 or 2 plants were missing there was some increase in the yield of both marketable and No. 1 tubers from plants adjacent to the gap, compensating to some degree for the zero yield of the missing plants. Such is apparently not the case when the gaps increase to 3, 4, 5, or 6 missing plants.

From a practical view, the influence of gaps on the ultimate yields per acre is more important than the influence on yields of adjacent plants. The yield per acre must be determined on the basis of an average between the zero yield of the gaps and the yields of the plants adjacent to the gap.

In Tables 3 and 4 the data indicate what yields were obtained when gaps occurred in 1 row and no gaps occurred in the adjacent rows(A), or if gaps occurred in the center row and the 2 adjacent rows were blank (B). Although the decrease in yield with increase in number of gaps is somewhat more definite in reference to marketable yield (Table 3), the decrease in yield of No. 1 tubers with increasing number of gaps is also apparent (Table 4).

TABLE 3 INFLUENCE OF GAPS ON MARKETABLE YIELDS PER ACRE 1970

No. of gaps	With Guard Rows (A)	Without Guard Rows (B)
0	210 cwt/ac	120 cwt/ac
1	204	102
2	202	100
3	193	86
4	187	73
5	184	69
6	182	66

TABLE 4 INFLUENCE OF GAPS ON NO. 1 YIELDS PER ACRE 1970

No. of Gaps	With Guard Rows (A)	Without Guard Rows (B)
0	121 cwt/ac	96 cwt/ac
1	123	86
2	123	91
3	120	80
4	115	65
5	112	63
6	110	59

In a situation where only a single row yield is considered and translated to yield per acre the yield would be within the ranges evident in Table 5. The data in Table 5 were determined without considering either yield or influence of the adjacent rows. As might be expected, the yields lay somewhere between the A situation (perfect stands in adjacent rows) and the B situation (no plants in adjacent rows), presented in Tables 3 and 4. One might assume that the conditions leading to the yield differences shown in Table 5 might be encountered more frequently under practical farm conditions than the two situations associated with the data in Tables 3 and 4.

TABLE 5 INFLUENCE OF GAPS ON YIELD PER ACRE OF MARKETAHLE AND NO. 1 POTATOES (SINGLE ROW BASIS) 1970

No. of Gaps	Marketable	No. 1's
0	210 cwt/ac	120 cwt/ac
1	190	120
2	185	126
3	157	119
4	141	104
5	131	96
6	121	88

The influence of gaps on tuber size or weight (Table 6) is another factor of practical significance to the grower. In some cases an increase in tuber size is an advantage, but when increased size is found only on plants adjacent to gaps, lack of uniformity in size is a possible consequence. An increase in size might also be associated with somewhat rougher potatoes, thus increasing the effort required in grading the tubers.

TABLE 6 INFLUENCE OF GAPS ON WEIGHT OF MARKETABLE TUBERS 1970

No. of Gaps	With Guard Rows (A)	Without Guard Rows (B)
0	4.3 oz.	5.6 oz.
1	4.7	6.0
2	5.0	7.0
3	5.4	7.4
4	5.6	7.2
5	5.3	7.0
6	5.3	7.3

TABLE 7 INFLUENCE OF GAPS ON WEIGHT OF NO. 1 TUBERS 1970

No. of Gaps	With Guard Rows (A)	Without Guard Rows (B)
0	5.4 oz.	6.6 oz.
1	5.7	6.8
2	6.0	7.8
3	6.3	8.1
4	6.5	8.1
5	5.3	6.4
6	5.3	6.7

As a consequence of the interest in percentage plant stands reported in the 1967-68-69 studies, a number of growers have asked what relationship percentage plant stand bears to yield per acre. It appears evident that the influence of reduced stand was complicated by the pattern or frequency of occurrance of the gaps. For example, if the plant stand was 50% and 1 gap alternated with 1 plant (Table 8), the yield reduction (4%) was of considerably less magnitude than the reduction in yield (39%) when 6 plants alternated with 6 gaps. While the plant stand remained constant at 50%, the per acre yield reduction rose from 4% to 39% as the size of the gaps increased from 1 to 6 spaces.

TAB:E 8 RELATION SHIP OF PERCENTAGE PLANT STAND AND NUMBER OF GAPS TO PERCENTAGE YIELD PER ACRE 1970

Stand		Reduction in Yield
75%	(3 plants 1 gap)	17%
50%	(1 plant 1 gap)	4%
50%	(2 plants 2 gaps)	12%
50%	(3 plants 3 gaps)	14%
50%	(4 plants 4 gaps)	29%
50%	(5 plants 5 gaps)	39%
50%	(6 plants 6 gaps)	39%
25%	(1 plant 3 gaps)	55%

SUMMARY

We would emphasize that the following statements are based on one year's results only and although treatments were replicated six times, we expect to get more accurate results in the second year working with larger populations. On the bases of the 1970 work, however, it appeared that:

1. if 1 plant was missing, the yields of plants adjacent to the missing plant were increased.
2. if 2 plants were missing, the yield increases of adjacent plants were greater than when only 1 plant was missing.
3. the increased yield of the remaining plants was not sufficient to compensate for the loss in yield from the missing plant.
4. when 3 or more plants were missing there was no further increase in the yield of adjacent plants, beyond the increase associated with 2 missing plants.
5. larger gaps decreased yields to a proportionately greater extent than did smaller gaps.
6. plants missing or gaps in adjacent rows at a 36" row spacing were associated with an increase in yield from plants in the middle row. Again, however, the increased yields were not sufficients to compensate for the zero yields of the missing plants in the adjacent rows.
7. gaps or missing plants were associated with a reduction in uniformity of tuber size. Plants adjacent to gaps produced larger tubers than plants not adjacent to gaps.
8. increase in tuber size of adjacent plants was greater when 2 or more plants were missing than when only 1 plant was missing.
9. the degree of reduction in yield per acre as a consequence of decreased plant stand varied with the frequency of occurrance and size of gaps.

The practical significance of these findings relates particularly to the intrinsic design of planting machines. The regular occurrance of single gaps is more common in "picker" or "cup" planters than in "belt" planters.

A broken or mal-functioning picker will, for example, create one gap in every 16 plant spaces. Belt planters are less prone to causing single gaps.

In 1968 and 1969 over 50% of the gaps found in commercial fields which had plant stands of 65% - 85% originated with mechanical planting errors.

There appears to be a case for developing a gap index, in which the various sizes of gaps are weighted by factors which reflect the potential loss in yield of marketable tubers.

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