A COMPARISON OF PRECISION AND NON-PRECISION DRILLING OF MAIZE FOR GRAIN

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ABSTRACT

Three trials conducted in the last 3 seasons have compared maize grown for grain over a range of plant populations. Intra-row spacing was either regular through a precision drill or somewhat irregular through a standard agricultural drill. The drills were compared at the between row spacing of 76cm. An extra agricultural drill treatment of 30cm spaced rows was included with, in the final trial, a treatment of paired rows 30cm apart and 76cm between centres. The results confirmed earlier findings on the flat-topped plant population - grain yield relationship and showed that in the context of 10-15% plant lossess there was an average yield advantage of 2% where the crops were sown precisely over imprecise sowing. The results are discussed in relation to maize growing practices.

INTRODUCTION

Maize grown for grain in New Zealand is precision planted predominantly in 76cm rows although earlier work showed that where similar populations were compared in 38cm or 76cm spaced rows the narrower rows gave 8-13% more grain (Douglas *et al.*, 1971).

Previous papers in this series (Douglas and Dyson 1972, Dyson and Douglas 1975) have shown that the grain yield response to increases in plant population forms a relatively flat-topped curve over a range of about 30 000 plants ha^{-1} with the maximum yielding population in the range 70 000 to 90 000 plants ha^{-1}. These results were obtained from precision hand planted "on the square" populations. Since the maize plant shows great adaptability in yielding well over a wide range of population pressures the question is raised as to whether this adaptability can overcome uneven placement within rows.

American work in which hill drop planting of 2 or 3 seeds was compared with singly spaced seed showed that changes in plant population had more effect on yield than the distribution within the row (Rossman and Cook, 1966). The response to pattern of planting ranged from 0-13% generally in favour of the single spaced seed, at plant populations well below those in use today.

More recent work in which precision hand planted seed was compared with machine planted areas showed that as the variability of spacing increased the grain yield decreased (Krall *et al.*, 1977). This effect occurred at only 2 of the 3 trial locations.

As part of our studies on plant population it was of interest to know whether precisely spaced seed gave any worthwhile advantage over imprecisely spaced seed over a range of plant populations. To do this we compared row sowings through a precision drill which gave very even placement of seed with a standard agricultural drill which gave uneven distribution.

METHOD

Three trials were conducted one each year from 1975 using a 'Nodet' 4 row pneumatic planter and a 16 coulter 'Duncan Seedliner' agricultural drill with seed fed down only the appropriate coulters. The suction-plate system of the Nodet, by placing individual seeds, gave precise spacing while the external force feed fluted rollers of the Duncan drill gave less controlled sowing, the rate depending on the size of the opening. The trials were planted at Rukuhia in late October on Horotiu silt loam in 75-76cm spaced rows (Nodet spacing 75cm, Duncan spacing 76cm) unless stated, with appropriate weed control. No insecticide was applied.

The prescribed plant populations were calibrated for the agricultural drill from 100m test runs but for the Nodet they were set from the operating manual. The same grade of seed was sown through both drills except in the first trial when large seed used in the Duncan drill proved unsuitable for the Nodet and it was replaced by smaller rounder seed. In the first 2 trials PX610 seed was used and in the last one XL45A.

No starter fertiliser was used as the trial areas had preplant dressings of 5-700 kg ha^{-1} 30% potassic superphosphate. However, in trial 1, 2 replicates had an additional 200 kg ha^{-1} NPK (10-21-0) fertiliser side-dressed by hand in late December because of an obvious colour difference from the other replicates.

Trial 1, 1975-76. Second year maize. The two types of drill were compared in subplots 8 rows wide within four main plot populations. An extra treatment of 30cm spacing through the Duncan drill at a medium population was included to simulate "coarse on the square" planting in plots 10 rows wide. Plots were 10m long and the 4 replicates were harvested by hand. At harvest severely bird damaged areas were excluded from yield assessment. Thus the mean area harvested per row was 6m^2 giving 24m^2 per replicate for an estimate of yield.

Trial 2, 1976-77. Out of Pasture. This trial was similar to the previous one except that it had three populations in a linear systematic spacing design (i.e. low-medium-high or vice versa) and 6 replicates. Plots were 11m long with a mean area of 7m^2 harvested per row, 29m^2 per plot.

Trial 3, 1977-78. In this trial the drills were compared at a single moderate population. A new treatment of paired rows 30cm apart at 76cm centres was sown in a linear systematic design of 3 populations through the Duncan drill as well as the previously used 30cm spaced treatment. The concept behind the paired rows is that the separation of 30cm within the pair is not large enough to present a problem to the combine, but permits a yield increase through a more uniform plant placement. Spacing with the Duncan drill was possible in multiples of 15cm. Plots were 22m long to give 20m harvested length and between 4.6m and 9m wide with 4 replicates as second year maize and 2 immediately after pasture. It was intended to harvest the 6 replicates by machine but extensive lodging precluded this. Yields were obtained from the drill comparison treatments in wide rows by hand harvesting 4 row lengths to give a harvest area of $60m^2$ per replicate. A single row-pair ($15m^2$) was harvested per replicate from the paired row treatment.

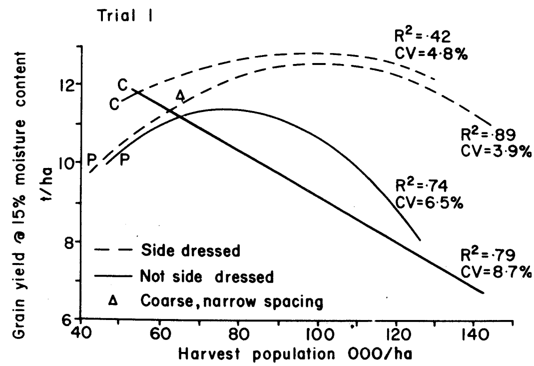
In each trial guard rows were used to distances of 4m from the ends of the plots and 6m from the ends of the blocks. Plant counts were generally made immediately before cobs were picked. All cobs were threshed and grain samples for moisture % put through a meter. The yield on population regression were fitted adequately by quadratic regressions in the region of moderate (optimal) populations.

RESULTS

Trial 1. The 4 mean harvest populations for the Nodet drill were 45 thousand plants ha^{-1} (sown 54), 67 (88), 102 (126) and 127 (162), for the Duncan drill 53, 59, 88 and 132 attempting the same populations in 76cm rows and 65 (95) in the 30cm rows.

Figure 1 shows the fitted quadratic regressions and Table 1 the fitted yields at 73 thousand plants ha^{-1}. When yields were assessed a fertiliser interaction was evident with yield declining sharply at higher populations where no fertiliser had been added. For this reason the fitted quadratic regressions in Figure 1 are shown separately for the drill x fertiliser combinations. The mean yield of the plants sown in narrow rows is also shown in Figure 1. At the same population the mean yield over fertiliser levels in 30cm rows was 1% lower than that in 76cm rows. It is not known whether the two different sizes of seed used in this high yielding trial could have affected the results. There was little difference between drills in the yields obtained in this trial.

Figure 1. Yield on population regression curves for coarse (C) and precision (P) drilling at two levels of fertility.



Trial 2. The mean harvest populations were 46 thousand plants ha^{-1} (51 sown), 84 (103) and 108 (152) for the Nodet drill, 44, 68 and 86 for the Duncan drill in 76cm rows and 95 in 30cm rows. Figure 2 shows the fitted quadratic regressions and Table 1 the fitted yields at 73 thousand plants ha^{-1}. The mean yield in 30cm rows was measured at 24%

TABLE 1: Grain yields at 15% moisture content, t ha^{-1}, in 75/76.2cm rows.

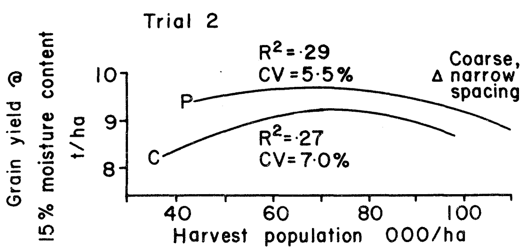
Trial	Plot Area (m^2)	Coeff of variation Coarse	Coeff of variation Precision	Fitted yields at 73 000 ha^{-1} Coarse	Fitted yields at 73 000 ha^{-1} Precision
1	24	6.8	5.2	11.61±.29	11.64±.22
2	29	7.0	5.5	9.17±.19	9.60±.15
3	60	7.6	6.4	4.60±.14	4.59±.12
	15	11.1	–	(4.24±.19 coarse in 38cm rows)	
		Mean		8.46±.13	8.61±.10

Trial	Population ha^{-1} for max. yield Coarse	Population ha^{-1} for max. yield Precision	Fitted max. yield Coarse	Fitted max. yield Precision	
1	97 000	101 000	12.80	12.53	Side-dressed
	(55 000)a	78 000	(11.80)a	11.40	Not side-dressed
2	71 000	68 000	9.18	9.63	
3	Perhaps 60 000		–	–	

a Curve did not show a maximum within range of data.

above the fitted yield in 76cm rows at the same population. However, the yields measured in these narrow plots with their high populations were almost certainly biased upwards, despite 3 guard rows, by as much as 10% according to estimates derived from technique studies associated with this work. The precision planting consistently outyielded the coarse planting in the trial by between 5 and 10%, an effect significant at the 5% level.

Figure 2. Yield on population regression curves for coarse (C) and precision (P) drilling.



Trial 3. Because of severe drought the drill comparison was limited to the moderate population of 73 thousand plants ha^{-1} (99 sown) planted in 75cm rows by the Nodet, 74 in 76cm rows and 70 (low population) in paired rows planted by the Duncan drill. The yields (at 73 thousand plants ha^{-1}) are shown in Table 1. The non precision planting in the 30cm rows of 118 thousand plants ha^{-1} gave a very low mean grain yield of 2.1t ha^{-1} but the yield on the blocks out of pasture was nearly twice that on the blocks following maize. It is surmised on account of cob size that maximum yields per ha occurred in the range 50 to 70 thousand plants ha^{-1}. There was no difference in yield between the two drills in wide rows at 73 000 plants ha^{-1}.

Inter-row variation.

The variation in the number of plants in a given row was examined by treating the harvest row counts within a plot as independent. It is certain that row counts are dependent as far as gross influences are concerned (e.g. bird damage, field variation) but the difference in variation between drills in the numbers of seeds planted would, it is thought, be reflected crudely in the harvest plant count. No allowance was made according to which coulter on the agricultural drill was used since this is a normal component of between row variation. Between-row within plot coefficients of variation are given in Table 2. No information was gathered on within-row variation in spacing. Within plot variation was pooled within blocks in some instances to provide at least 4 degrees of freedom in each coefficient of variation estimate to provide some stability. In the 21 direct comparisons of within-plot variability, the coarse spacing showed greater variation 16 times. This is significant at the 1% level in a non-parametric test. The statistical distribution followed by these CV's is not readily determined but the chi squared test used is presumed to be conservative.

DISCUSSION

These trials were conducted in an economical way in terms of inputs but using large plots to minimise bias. The number of replicates was progressively increased to six to confirm patterns which were seen to be emerging.

Coarse versus precision planting showed a small mean yield difference of 2% in favour of precision planting, over three years' trials involving two locations, two hybrids and contrasting seasons. The comparison was made at 73 thousand plants ha^{-1}, the only population in Trial 3 and a population fairly typical of commercial crops. The regression curves of yield on population in Trial 1 did not show a difference at low populations where coarse planting would be expected to be inferior because of wasted space between clumps. Indeed the reverse occurred, a phenomenon in agreement with that observed by Krall *et al.* (1977) in 1 trial. Nor did the curves show any superiority to coarse planting at high populations in Trial 2 where the spaces may have been advantageous to yield. It was correctly anticipated that in the optimal plant population range precision planting would have some advantage.

Examination of the variation in the number of plants per row at harvest (Table 2) showed the expected effect of greater variation with the coarse sowing and greater variation at shorter row lengths. Mean CV's were 13.9% for coarse and 8.9% for precision in a row area of 10m^2. Most of this variation in the precision plantings would have been caused by insect and bird damage with contributions from seed drop and germination failures. 22% of plant "positions" were not filled at harvest. These CV's may be set alongside weighted mean CV's for

TABLE 2: Comparison of variation in plant counts per row according to drill type.

Trial	Row area (m^2)	No of rows examined Coarse	Precision	No of groups[a]	Geometric mean of CV's Coarse	Precision
1	6	50	93	9	12.9	10.6
2	10	42	44	7	16.3	9.5
3	15	29	30	5	12.5	5.1

[a] A group consisted of comparable localised plots or plot pairs within blocks.

yield on a full plot basis of 7.0% for coarse and 5.5% for precision for a weighted mean plot area of $32m^2$. It is noteworthy that these advantages in uniformity in favour of the precision drill barely carried through to a grain yield advantage on a large plot basis. We have failed to demonstrate that there is any worthwhile advantage in precise placement of seed when 10-15% of seedlings are lost to birds or insects. On a paddock scale we should presume that losses to birds would be much reduced compared with the relatively isolated stands in these trials.

From this work it can be interpreted that sporadic early losses of plants from insect damage and other causes will be compensated for by the neighbouring survivors and little yield loss will occur as long as the plant population remains broadly within the optimum range. Possibly higher seed rates could be planted to allow for some loss of plants by birds and insects but the cost of additional seed needs to be compared with the cost of insecticide.

The planting of maize in wide rows seems to continue because of tradition and the constraint of the machinery used. Chemical weed control has reduced the need to plant maize in wide rows and sowings which give individual plants equal opportunity in all directions are probably most efficient. Maize planted in 30cm spaced rows with low intra-row populations closely approaches this ideal but it is not known if harvest machinery can handle such crops. Previous work (Douglas *et al*, 1971) has shown that maize in 38cm spaced rows generally gave higher yields than crops in 76cm spaced rows at equivalent plant populations. In the present work the 30cm spaced rows only showed to advantage in the second year trial. There was no difference at the sub-optimal population in the first year trial. We had thought that the paired rows (30-46cm row spacing) might give some of the advantages of narrow rows but still allow harvesting as for 76cm spaced rows. Unfortunately the very droughty season ruined this comparison.

The modern precision drills have the advantages of easy calibration but many are inflexible in regard to changing row width. On the other hand the agricultural drill is more difficult to calibrate but it does have the advantage of being flexible in row width with multiple combinations of 15cm. If maize grain production extends into cropping regions where agricultural drills are more common than row crop machines, there seems little reason why the former could not be used to good effect.

It should be noted that even though the curve is flat-topped the optimum plant population changes from season to season but is generally within the range of 70-90 000 plants $hectare^{-1}$. Allowing for 15% seedling mortality the sowing rates in the Waikato should be about 90-100 000 plant ha^{-1} to produce a harvest population of 70-80 000 plants ha^{-1}. This would be expected to produce within 3% of the maximum yield in any season other than a very unusual one. Where fertility levels are high and soil moisture levels good then higher harvest populations would be advantageous. If frequent droughts remain a feature of the climate of this maize growing area it may be worth considering spreading the risk by having contrasting populations in commercial plantings. If half the area had a harvest population of 65 000 plants ha^{-1} and the other half had 85 000 plants ha^{-1} then year to year climatic effects on yield would be less extreme.

CONCLUSIONS

This present series of trials has confirmed earlier results regarding plant population-grain yield relationships. They had indicated that individual plants compensate in yield to a large degree for missing neighbours or gaps in seed placement. From this we conclude that precise placement of seed is not as important as having harvest populations within the optimum range.

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