A BASIS FOR CROP CULTIVAR EVALUATION

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ABSTRACT

The number of trials required to test adequately any cultivar is dependent on what yield difference needs to be shown between a new cultivar and the standard. Evidence suggests that such trial programmes should be spread over three years although the testing programme should remain flexible. Acceptance or rejection of a cultivar is dependent on the size of difference from the standard and an assessment of the seasonal conditions experienced. Trial data to support these views are presented and discussed in relation to formulating rational crop evaluation programmes.

INTRODUCTION

The field evaluation of crops and crop cultivars has been carried on in New Zealand virtually continuously since the turn of the century. Early comparisons used single plots (Anon 1910) but these were replaced by replicated paired plots in the twenties (Hilgendorf 1925, Hudson 1926) which in turn were superseded in the thirties by randomised block designs of Fisher. Since then trial design and techniques as applied have remained virtually unchanged apart from refinements dealing with specific problems such as the effect of edge rows on plot yields (Miller and Mountier 1955, Mountier 1964) and the controlling of variation caused by edaphic factors, weeds and pests. Today a high level of precision for within-trial treatment comparisons is possible and typically this accounts for 5 to 20% of between-trial variance.

The question of how many yield trials should be conducted, and how the sites should be distributed, to allow sound judgement on whether to accept, reject or continue testing a new cultivar has received little critical attention and no guidelines are available. An examination of the number of trials conducted to test earlier released wheat cultivars illustrates a wide variation. Amongst the all-purpose wheat cultivars Cross 7 was released after 36 trials (Frankel 1934), Aotea——124 (Copp 1958) and Kopara——159 (Douglas *et al.*, 1971) but for wheat cultivars for specific purposes the numbers of trials were: Tainui——11 (Frankel 1939), Arawa——39 (Copp and Lobb 1956) and Takahe——34 (Sheath *et al.*, 1975)..

Efficient use of resources necessitates closer definition of the number of trials required to test adequately a new crop cultivar, hence this investigation. The following results and discussion relate to the testing of crop cultivars in regions where the crop is commonly grown rather than to testing the potential of a crop in a new area.

DISCUSSION AND ANALYSIS OF PREVIOUS CROP TRIAL PROGRAMMES

Background

The acceptance or rejection of a new cultivar in any area is dependent on how well it performs in relation to the standard. It is obviously easier to make such a decision where the pattern of results shows a regular effect rather than where it is quite variable from site to site. Consequently an examination of the between-trial variability of yields relative to the standard provides a basis to estimate the number of trials needed to show a significant difference between two cultivars. The number of trials required is also dependent on what threshold level of difference between two cultivars has been set. Whereas a few trials are sufficient to detect a large yield difference, many trials are needed to establish fine differences between cultivars. In showing that a new cultivar is higher yielding than a standard, the relative yield of that cultivar must be high enough for its lower 95% confidence limit to be greater than the 100 value of the standard. For example the 95% confidence limits around a realised mean with a between-trial coefficient of variation of 10% are for 10 trials± 7.0, 30 trials ± 3.7 and 100 trials ± 2.0. Thus in such a testing programme a relative yield of 106 would not be significantly different from the standard (at the 5% level of probability) in 10 trials but if such a relative yield were maintained it would be significantly above 102 in 30 trials. If a threshold difference had been set at 3% further testing would be required. Possibly a 10% level of probability is adequate and it would assist in the earlier release of good material but with the added risk of releasing poor material.

RESULTS

An examination of some previous cultivar comparisons for oats, barley, maize, wheat, potatoes and turnips is shown in Table 1. Since differences in yield were proportional rather than absolute, analysis of variance was applied to the logarithm of the relative yield. Regional effects were removed where practical but not year effects, thus retaining climatic effects as a part of the between-trial variation.

The major cereals, apart from Karamu wheat, showed reasonably uniform between-trial variation but the potatoes and turnips were very variable. When considering what threshold level of difference should be aimed at for cultivar comparisons some guidance can be obtained from earlier results (Table 2). For

TABLE 1: Composite analyses of cultivar comparisons for various crops

Test/Standard	Number of Trials	Between-trial CV% of Rel. Yield	Number of trials required to show as significant at 5% level a relative yield difference of:					Significance of Regional Interaction
			3%	5%	7%	10%	15%	
OATS								
Mapua/Milford	10	6.2	19	9	6	4		N.A.
Makuru/Mapua	20	5.4	15	8	5	4		NS
BARLEY								
Zephyr/Carlsberg/Research	24	12.2	66	26	15	9		1%
MAIZE								
Various/W575	45	12.1	66	25	15	9		N.A.
Various/PX610	24	11.5	59	23	13	8		N.A.
WHEAT								
Kopara/Aotea	140	9.4	41	17	10	6		0.1%
946/Aotea	26	11.9	63	25	14	8		NS
1169/Aotea	64	11.3	57	23	13	8		NS
1178/Aotea	59	9.6	42	17	10	7		0.1%
Karamu/Aotea	43	18.1	143	54	28	15		5%
Karamu/Gamenya	17	18.8	154	57	31	17		NS
Takahe/Kopara	34	9.8	44	18	11	7		NS
POTATOES								
Wha/Ilam Hardy	13	23.4	-	-	46	24	12	N.A.
Whitu/Ilam Hardy	13	31.4	-	-	80	41	20	N.A.
TURNIPS								
Green Kapai/Green Globe	11	17.6	-	50	27	15	8	N.A.
York Globe/Green Globe	15	31.2	-	153	79	40	20	N.A.
CCR York Globe/York Globe	11	9.5	-	17	10	6	5	N.A.

cereals a 2-5% threshold difference between cultivars appears a reasonable objective while that for turnips might be 7-10%. It can also be seen that in these earlier programmes some cereal cultivars were overtested nationally though the results have been very valuable in giving a strong foundation to comparisons between regions. Table 1 relates mainly to cultivars which were released and not to those which were rejected mostly after being tested less intensively.

Regional Effects

Where major crops are concerned, such as wheat, regional differences between cultivars may be as important as national ones. A statistical test showing as significant a national difference in relative yield of say 6% would be expected to show as significant regional differences of about 16% between 3 or 4 regions. Where many regions are examined a trend should be sought, or a partitioning into a few distinct zones. Thus either the national figure, the regional figure or a compromise could be considered in determining the number of trials needed. Table 3 shows the significant variation which occurred between districts in three wheat comparisons. It will be noted that Aotea was the denominator in each comparison and it may be that Aotea performs poorly in the north of the South Island rather than the other cultivars performing particularly well.

Distinct times of sowing of a crop within a region were considered initially as different 'regions' when examining relative yield x region interactions.

Number of Years of Testing

Traditionally, a minimum of three years' yield data has been looked upon as the basis for cultivar comparisons to cover a range of seasonal conditions. It was possible to examine this rationale by using six years' data comparing the wheats Kopara and Aotea (Table 3). Either of the pairs of years 1966/67 or 1968/69 would have given a misleading indication of relative yield and this reinforces the tradition that a three year programme is desirable for testing cultivars. However, there is no reason why the programme should not be flexible with decisions on exceptional material, either good or bad, being made after one or two years. This would also depend on how normal the seasonal conditions had been. If grossly atypical years were experienced, additional years of testing might be required.

RECOMMENDATIONS

A testing programme should be spread within the regions growing the crop under test rather than throughout all New Zealand with sufficient trials to

TABLE 2: Indications of suitable threshold yield differences for various crops, derived from previous results

Test/Standard	Number of Trials	Percentage Yield diff.	Number of trials required to show relative yield significantly higher (5% level) than a threshold value of:			
			100	102	105	110
OATS						
Mapua/Milford	10	15.1	5	5	5	9
Makuru/Mapua	11	6.1	6	10	95	-
BARLEY						
Zephyr/Research	24	27.0	5	5	5	5
Zephyr/Carlsberg	56	3.9	10	15	40	-
MAIZE						
PX610/W575	18	10.0				
WHEAT						
Kopara/Aotea	124	10.8	6	7	13	500
946/Aotea	26	0.9	700	-	-	-
1169/Aotea	64	9.6	8	11	26	-
1178/Aotea	51	5.6	14	30	1000	-
Karamu/Aotea	43	16.6	8	9	12	32
Takahe/Aotea	34	5.9	14	27	500	-
POTATOES						
Wha/Ilam Hardy	13	15.8	11	14	21	65
Whitu/Ilam Hardy	13	6.4	95	200	2000	-
TURNIPS						
Green Kapai/Green Globe	11	15.1	8	10	15	50
York Globe/Green Globe	15	29.7	7	8	9	13
CRR York/York Globe	11	1.6	140	-	-	-

TABLE 3: Regional and Yearly effects in wheat cultivar comparisons expressed as a % (Aotea = 100).

	Karamu/Aotea	1178/Aotea	Kopara/Aotea		
				National mean for year:	
North Island	129 (3) *	114 (2)			
Marlborough	145 (7)	121 (12)	122 (19)	1966	118
Canterbury	113 (7)	112 (15)	113 (36)	1967	112
South Canterbury	115 (15)	106 (15)	108 (40)	1968	108
North Otago		102 (5)	110 (7)	1969	104
South Otago	108 (3)	90 (4)	111 (13)	1970	112
Southland	102 (9)	103 (4)	102 (25)	1971	113

* Number of trials

examine marked regional differences. This would adequately cover the national requirement. The number of trials (Fig. 1) needed for such a programme can be estimated from earlier work, given a clear indication of the criteria for acceptance on a yield basis. In practice such a figure needs to be increased by about 20% to cover the problems of unreliable data caused by drought, floods, bird damage, etc. It is imperative that trial techniques should be standardised so that the full benefit can be gained from such programmes. Particular attention should be paid to storage of seed and potato tubers and to ensure comparable sowing conditions for all cultivars. The positive identification of causes of

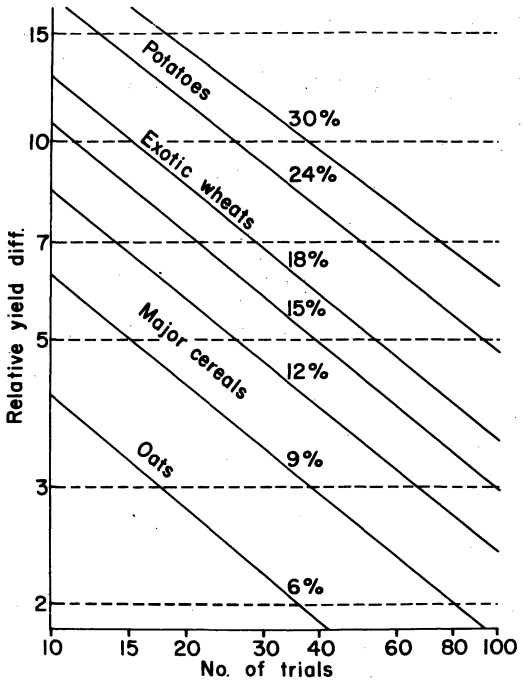

FIG. 1: Percentage relative yield differences significant at the 5% level according to the number of trials conducted on the crop at the levels of between-trial cv% indicated.

strongly atypical varietal performance or a high within-trial coefficient of variation is an important aspect in these programmes.

Further work is proceeding on genotype x environmental interactions, methods of analysis based on using the mean of several cultivars as denominator for relative yields and the introduction of qualitative assessments into the decision process.

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