# CULTIVAR EVALUATION FOR DISEASE AND YIELD DELIVERY INDEX IN WINTER-SOWN WHEAT RECOMMENDED LIST TRIALS

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## ABSTRACT

The concepts of yield potential and yield delivery index are discussed in relation to assessment of cultivars. In the trial reviewed, yield potential (i.e. that yield produced with prophylactic disease control) ranged from 5.2 to 7.1 tonnes per hectare and indicated attainable yield in the absence of disease but with other growth constraints. Yield delivery indexes (i.e. the proportion of yield potential produced without disease control) ranged from 60 to 100% and indicated yield sensitivity to disease, mostly to stripe rust. The use of such data as a basis for recommended lists and cultivar choice by advisers and growers is illustrated. Some practical problems associated with recommended list trials are also reviewed.

*Additional Key Words: stripe rust*

## INTRODUCTION

The yield of cereal crops is affected by genetic, physical and biotic factors. The evaluation of cultivars for yield performance is therefore influenced by soil type, climate and the presence of disease and other harmful agents. Cultivar evaluation trials are carried out to provide a basis for recommended lists in many countries. The objective of a recommended list is to help growers choose cultivars which are most likely to give maximum returns for their situation. The choice of trial inputs for mineral fertility, water availability and disease control is difficult and is often controversial. An evaluation trial with prophylactic fungicide treatments estimates the potential yield of genotypes in the absence of disease. Trials conducted without disease control place more emphasis on the resistance characteristics of cultivars for prevalent diseases and estimate yield performance without the cost of fungicide treatments. Recommended lists based on either trial system do not fully describe the field situation and may not provide the grower with sufficient information to choose the most suitable cultivar.

Until recently, evaluation trials in the United Kingdom were carried out without the use of fungicides in a deliberate attempt to encourage the use of cultivars with at least some degree of relevant disease resistance. Disease susceptibility ratings were shown to be a reasonable estimate of yield response to fungicide treatment (Rowe and Doodson, 1976). Following increased fungicide useage, the National Institute of Agricultural Botany (N.I.A.B.) now carry out some trials both with and without fungicide treatment in an attempt to provide data on yield potential and yield delivery index (Priestley, 1983). In this context, yield potential was defined as "the yield achieved when the constraint of disease is removed by fungicide control" and yield delivery index as "the proportion of the potential which a variety will deliver without routine fungicidal control". In New Zealand a modified version of the N.I.A.B. Recommended List system has been adopted. This was described by Wynn-Williams (1984) who pointed out the desirability of special fungicide x cultivar interaction trials.

In this paper we report results from a winter-sown wheat cultivar evaluation trial in which both yield potential and yield delivery index were measured. Such data could be presented as a supplement to Recommended Lists in New Zealand, thereby aiding advisers and growers in their cultivar choice.

## MATERIALS AND METHODS

A cultivar evaluation trial was sown on 24 June 1983 on the Research Farm, Lincoln College on Wakanui soil. Twenty-two cultivars were sown in four replicates of a strip plot experimental design of two sub-blocks containing randomised plots (12 m x 1.5 m) of all cultivars. In one sub-block there was no disease control but in the other, seed was treated with Baytan F17 (15 g ai triadimenol and 2 g ai fuberidazole/100 kg seed). Five sprays of Bayleton (triademefon at 125 g a.i./ha) were applied during the growth season of the latter sub-block using a hand held 3m boom with hollow cone nozzles (D2-25) applying 300 litres/ha of fluid at 450 kPa. Sub-blocks and replicates were separated by 2 m buffer zones of bare soil, and the trial was surrounded by untreated Rongotea wheat to provide an inoculum source for prevalent diseases.

Stripe rust (*Puccinia striiformis* West), the prevalent disease, was first observed in plots on 7 September and disease was assessed thereafter at approximately 14 day intervals. Disease was assessed visually and expressed as the percentage non-green leaf area on each fully expanded leaf of 6 plants sampled randomly from each plot. A disease index was calculated as the mean percentage non-green leaf area on the top three expanded leaves at each growth stage. At each assessment date, incidence was noted to determine the dominant diseases in the trial.

The trial was harvested in three groups of cultivars with early, mid and late maturity to avoid both premature harvesting and grain shed. Plants in ten 0.1m$^2$ quadrats were removed from each plot for analysis of yield and yield components (ear number/m$^2$, grain number/ear and grain weight). The remainder of the plot was mechanically harvested after removing a 1 m strip from both ends of all plots to avoid end effects. The harvested grain was weighed and the header yield adjusted to 14% moisture content. Data were analysed by ANOVA and LSD for paired mean comparisons in all data using the Genstat statistical package.

## RESULTS

The yields of Oroua and Rongotea, assessed by quadrat and header harvest samples, were significantly reduced in those plots where no disease control was used compared to those with full disease control (Table 1). The

**TABLE 1: Quadrat (g DM/m$^2$) and header harvest (t/ha) grain yields of twelve wheat cultivars with and without disease control.**

| | Header Yield | | | Quadrat Yield | | |
|---|---|---|---|---|---|---|
| Cultivar | Diseased | Healthy | YDI % | Diseased | Healthy | YDI % |
| Oroua | 3.2 | 5.2* | 61 | 381 | 564* | 68 |
| Rongotea | 3.8 | 6.3* | 60 | 520 | 702* | 74 |
| Karamu | 4.8 | 5.8* | 83 | 545 | 625* | 87 |
| Kopara | 5.0 | 5.7* | 88 | 558 | 696* | 80 |
| Konini | 5.4 | 6.0 | 90 | 575 | 660* | 87 |
| Crossbow | 5.4 | 6.2* | 87 | 731 | 782 | 93 |
| Advantage | 5.6 | 5.9 | 94 | 593 | 791* | 85 |
| Abele | 6.2 | 7.0* | 89 | 754 | 831* | 91 |
| Cultivar B† | 6.5 | 6.4 | 102 | 724 | 750 | 97 |
| Bounty | 6.7 | 6.6 | 101 | 688 | 714 | 96 |
| Cultivar C† | 6.7 | 7.0 | 96 | 808 | 858 | 94 |
| Cultivar A† | 7.1 | 7.0 | 101 | 796 | 826 | 96 |
| L.S.D. (P = 0.05) | 0.73 | | | 78 | | |
| C.V. (%) | 6.5 | | | 6.9 | | |

YDI % is yield delivery index (Yield Diseased/Yield Healthy x 100%)

* Denotes significant differences between diseased and healthy plants (P = 0.05) by L.S.D. (0.70 and 71.5 for header and quadrat yields respectively).

† Cultivars presently under evaluation.

**TABLE 2: Effect of disease on yield components of twelve winter-sown wheat cultivars.**

| | Ears/m$^2$ | | Grains/ear | | Grain weight (mg) | |
|---|---|---|---|---|---|---|
| Cultivar | Diseased | Healthy | Diseased | Healthy | Diseased | Healthy |
| Oroua | 530 | 583 | 25.9 | 28.2 | 27.7 | 34.3* |
| Rongotea | 483 | 533 | 29.1 | 30.3 | 37.0 | 42.7* |
| Karamu | 562 | 624 | 28.7 | 25.6 | 37.4 | 39.4* |
| Kopara | 433 | 486 | 33.4 | 35.7 | 38.5 | 40.1* |
| Konini | 538 | 578 | 26.1 | 27.3 | 41.1 | 42.0 |
| Crossbow | 483 | 490 | 33.7 | 34.2 | 44.9 | 46.7* |
| Advantage | 405 | 457 | 29.7 | 31.6 | 49.3 | 48.7 |
| Abele | 415 | 446 | 45.3 | 46.2 | 40.2 | 40.4 |
| Cultivar B | 572 | 550 | 30.7 | 33.2 | 41.4 | 41.4 |
| Bounty | 380 | 390 | 39.3 | 38.7 | 46.2 | 47.5 |
| Cultivar C | 466 | 464 | 38.1 | 39.8 | 45.6 | 46.6 |
| Cultivar A | 460 | 463 | 45.0 | 45.8 | 38.7 | 39.0 |
| L.S.D. (P = 0.05) | 63 | | 4.6 | | 1.4 | |
| C.V. (%) | 8.6 | | 7.7 | | 2.2 | |

* Denotes significant differences between healthy and diseased plants (P = 0.05) by L.S.D. (67.0, 3.8 and 1.6 for ear number, grain number and grain weight respectively).

yield delivery indices (YDI) ranged from 60 to 74% for these cultivars compared with yield delivery indices greater than 94% for Bounty, Cultivar A, Cultivar B and Cultivar C. There were no significant responses in the latter cultivars to disease control. The cultivars, Kopara, Konini, Karamu, Advantage, Crossbow and Abele were intermediate in response, with YDI values of 80 to 94%.

In those cultivars which had significant yield responses to disease control, the major effect of disease was on grain weight (Table 2). The components ear number per unit area and grain number per ear were unaffected.

Disease, assessed at GS 24 and GS 59, (Zadoks *et al.*, 1974) increased mean percentage non-green leaf area most on those cultivars which had the greatest yield reductions. For example Rongotea, Oroua, Kopara and Konini had relatively large values at GS 59. On these cultivars there was a large proportion of the leaf area with senescence, flecking and (in Rongotea, Oroua and Kopara) sporulation. In contrast, there were small values for non-green leaf area in the cultivars with high values for YDI. Advantage, Crossbow and Bounty differed at the two growth stages assessed as a result of seedling susceptibility to stripe rust (Table 3).

**TABLE 3: Mean percentage non-green leaf area on top three expanded leaves of diseased and healthy winter-sown wheat, assessed at GS 24 (9 cultivars) and GS 59 (12 cultivars).**

| Cultivar | Growth Stage 24 (Tillering) | | Growth Stage 59 (Ear emergence) | |
|---|---|---|---|---|
| | Diseased | Healthy | Diseased | Healthy |
| Oroua | 77.1 | 48.7* | 55.5 | 29.8* |
| Rongotea | 70.6 | 37.3* | 40.1 | 12.5* |
| Karamu | 27.0 | 15.6 | 15.4 | 16.8 |
| Kopara | 72.4 | 34.8* | 34.1 | 16.5* |
| Konini | 71.8 | 44.9* | 36.1 | 13.8* |
| Crossbow | 39.5 | 23.4* | 2.0 | 1.5 |
| Advantage | 65.2 | 42.6* | 10.5 | 8.3 |
| Abele | 6.5 | 3.6 | 1.5 | 1.4 |
| Cultivar B | — | — | 4.6 | 4.7 |
| Bounty | 28.0 | 12.8* | 5.4 | 5.6 |
| Cultivar C | — | — | 2.2 | 1.6 |
| Cultivar A | — | — | 5.0 | 4.2 |
| L.S.D. (P = 0.05) | 12.2 | | 8.5 | |
| C.V. (%) | 21.6 | | 52.0 | |

* Denotes significant differences between healthy and diseased plants by L.S.D. (P = 0.05) at GS 24 and GS 59 is 12.2 and 8.4 respectively.

## DISCUSSION

The use by growers of information on yield potential and yield delivery index may be illustrated with the cultivars Rongotea, Kopara and Bounty. The yield potential (quadrat sample) was similar for the three cultivars but yield delivery index varied from 74 to 96%. Thus growers presented with such data may conclude that it would suit their purposes best to grow Kopara or Bounty in preference to Rongotea and thereby reduce the disease risk and costs of disease control in their production system. Priestley (1983) recommended that data for both yield potential and yield delivery index be presented to growers in recommended lists. This system was introduced by the N.I.A.B. for winter wheat and barley and for spring barley in 1984. Under the New Zealand system, fungicides are applied to a large proportion of cereal recommended list trials thus biasing the results in favour of susceptible cultivars. If a system based on trials both with and without fungicides were introduced, growers would be able to choose cultivars on the basis of yield potential and yield delivery index. Ideally, a cultivar would be chosen with a large yield potential and yield delivery index. Failing this, options exist to make a choice either for:

(i) high yield, accepting that disease was not prevalent or that disease control could be implemented,

(ii) low disease risk for those areas with conducive disease conditions so that inputs for disease control could be minimal.

No bias would be displayed for either resistant or susceptible cultivars. A further consideration that may dictate a growers choice of cultivar may be the relative price received and the various outlets for crop disposal.

Harvest by machine was difficult in these trials because of the range of cultivar maturities. This was overcome by harvesting on three occasions. In standard trials this is not practical and causes error in yield assessment for both very early and very late maturing cultivars. Also the presence of very susceptible cultivars caused problems with flecking on partially resistant cultivars because of high inoculum production.

The results of one trial on one site over a single season serves to illustrate the potential value of these cultivar evaluation comparisons. By reducing the number of trials and the number of replicates, a system as described here may be feasible without large additional resources. Tonkin and Silvey (1982) reported that three replicates in a small number of well conducted trials were satisfactory for cultivar evaluation, especially if the trials were conducted over two to three years.

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