EXPERIMENTAL DESIGN FOR SCREENING COMPETITIVENESS OF CROP CULTIVARS

R.D. Cousens and D.J. Fletcher
School of Crop Sciences, University of Sydney, N.S.W. 2006

Summary. The methodological problems of developing a screening programme for crop competitiveness are discussed. It is proposed that crop and weed density will have little effect on the ranks of varieties according to yield loss. Results of a single pot experiment tend to support this, but extensive further work is clearly required. It is argued that varietal ranks will be estimated most accurately where the spread of yield loss across varieties is greatest. This was calculated to be for 10 weeds/m^2 in the present example, but no optimum wheat density could be distinguished.

INTRODUCTION

Weed control advice for crops has largely become a question of how to kill weeds. Which herbicide and when? However, there are a range of additional options which a farmer can employ to help minimise current and future weed problems. One of these options is the selection of crop cultivar. We know that cultivars can vary considerably in their competitiveness towards weeds (2). A farmer with bad weed problems should be able to select his crop variety so as to ensure as much weed suppression as possible. Good cultivar selection will result in improved yields and reduced weed seed returns to the soil.

Advice on variety selection on this basis is currently available for some crops in some parts of the U.S.A. (G. Wicks, pers. comm.). No such advice is available in Australia to our knowledge. Yield potentials of cultivars are usually examined in the absence of weeds. There is some anecdotal information on perceived ability to suppress weeds, but this needs to be formalised. Screening of cultivar competitiveness towards weeds should be done routinely, as are yield, disease and herbicide tolerance trials.

What form should these screens take? Should they include a range of weed and crop densities? Should a range of weeds be used, a mixture, or just one 'typical' weed? Does sowing depth matter? We certainly cannot entertain multifactorials if we are to screen many cultivars. We need a simple protocol based on knowledge of competition principles. A series of pot and field trials are currently being conducted to see which factors have major effects on the ranking of cultivar competitiveness. This paper illustrates our approach, using choice of densities as an example.

THEORY

Considerable research has been devoted to the effects of weed and crop density on crop yield. Studies have shown that loss curves at a given crop density fall off steeply at first, then level off, as weed density increases (1). Increasing crop density tends to reduce yield loss, such that curves for different crop densities do not intersect. It is, perhaps, reasonable to hypothesise that crop varieties with different competitiveness will also produce non-intersecting yield curves (Fig. 1). In which case, ranking of varieties will be consistent across all combinations of weed and crop density. We would then need to choose only one density combination for a screen. However, experiments are subject to error; can we choose densities such that our likelihood of detecting the true ranking of cultivars is maximised? Given homogeneous variances, the best chance of observing the true ranking will be at the point where the curves are furthest apart.

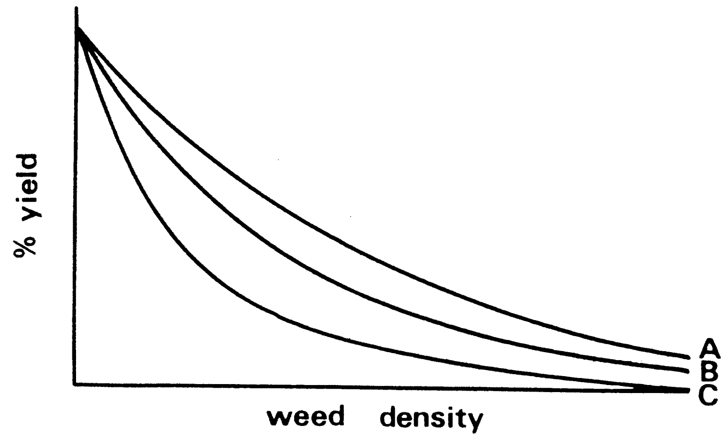

Figure 1. Hypothetical yield curves for three crop varieties.

The objectives of this experiment were to see whether rankings were consistent across weed and crop densities, and, if so, to estimate the combination giving greatest separation of % yield loss.

MATERIALS AND METHODS

Five wheat varieties were sown at a depth of 2.5 cm in a river loam, without fertiliser, in 15 cm pots with buckwheat as an artificial weed. Densities (per pot) were 5 wheat with 0 or 25 buckwheat; 10 wheat with 0, 5, 25 or 100 buckwheat; 15 wheat with 0 or 25 buckwheat. Wheat varieties were Sunstar, Shortim, Kite, Hartog and Rosella; these include a range of vernalisation and photoperiod responses so as to ensure a range of growth forms. The results were clearly not intended to reflect the true competitiveness of these particular cultivars at their ideal sowing dates. There were 4 replicates in a randomised complete block design. The pots were placed outside and watered on 28 September 1989. Thereafter, pots were irrigated daily by a sprinkler. Plants were harvested on 28 November 1989; dry weight yields per pot of wheat and numbers of surviving plants were assessed. At this time, development of varieties ranged from tillering to post-anthesis. Mean yields and % yield losses were ranked within each density combination. Consistency of yield and yield loss was examined by an ANOVA with variety as treatment, ranks as observations and each density combination as a block.

Equations of the form

$$y = ax_1/(1+b(x_1+cx_2))$$

were fitted for each variety, where y is yield, x_1 is crop density, x_2 is weed density, a, b, and c are parameters. The point at which there was maximum difference in % yield loss between the two extreme varieties was calculated by differentiation.

RESULTS

Ranks of varietal biomass remained relatively constant across all density combinations. The F-test in the ANOVA of ranks gave $p<0.001$, indicating this consistency. Although the presence of weeds decreased biomass considerably, those having the greatest biomass in monoculture were also the largest when weeds were present. The results for % biomass reduction were similar, but with some differences in the order of varieties. For example, on the basis of biomass, Sunstar ranked highest with Kite second, whereas for % biomass loss their order was reversed.

The yield equation gave a reasonable description of the data, but parameters had large confidence intervals due to the restricted range of densities. Over the range studied, differences in % yield loss between varieties were affected little by wheat density. It was therefore assumed for ease of differentiation that wheat density had no effect and only the buckwheat density was calculated to give the point of greatest separation between yield loss curves. This was calculated to be at 10.2 buckwheat plants per pot. The % yield loss for the two extreme varieties at this density would have been 41.1% and 58.8%.

DISCUSSION

Although only the results of a single pot experiment, the data give some support to the hypothesis that varietal competitiveness will remain consistent across density combinations. However, this needs to be confirmed by further experimentation. If this is the case, only one weed and one crop density need to be included in varietal screens. The densities should, from the results of this experiment, be sufficient to give a mean yield reduction of around 50%. In a field experiment on wheat and wild oats, this might indicate that a density of 50-100 wild oat plants/m^2 should be used. This will be tested in the field. Too many or too few weeds will give insufficient separation to be able to detect the ranks.

There is some evidence here that the variety yielding the highest biomass in monoculture will be the highest yielding in mixture. Again, this needs to be confirmed; however, biomass data in monoculture may be sufficient to predict varietal ranks in ability to suppress weeds.

ACKNOWLEDGEMENTS

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