Which variety should I grow? – New statistical methods for NVT allow for better decision making

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National variety trials (NVT), varietal selection, variety by trial interaction
GRDC CODE
Statistics for the Australian Grains Industry

KEY MESSAGES

- Individual trial results from NVT provide only a snapshot in time and may lead to unsuitable varietal choice
- Combining data across trials (and years) enhances the chance of selecting the appropriate varieties, and the current long-term analysis is based on geographic region
- A new method of analysis forms environment groups from "similar" trials rather than geographic regions and will provide the most accurate prediction of relative yield performance of varieties for an environment.

BACKGROUND

How do you choose the variety that will make the greatest dollar return per hectare next season? All other things being equal, yield of a superior variety provides the profit margin that is there for the taking, with no cost differential other than seed supply. When it comes to yield assessment, there are two important aspects to varietal choice: which variety will give the highest yield, on average, and how will this variety stand up under different seasonal challenges?

To provide data for these decisions, the National Variety Trial (NVT) program was established by the GRDC in 2005. The program helps growers, agronomists and consultants select the best varieties for their environment and has been driven by the desire for independent evaluation of new varieties from all Australian breeding programs. Each year contractors around Australia, plant, manage and harvest around 650 trials at 300 sites covering wheat, barley, oats, canola and a range of pulse crops. Australian Crop Accreditation System Limited (ACAS) deliver the trialling system and make the information available through the website (www.nvtonline.com.au).

The wealth of information from NVT has historically been available online in two forms: as 'Individual Trial Reports' and as 'Long Term Yield Reports'. A pragmatic user of NVT online may look to the individual trial report closest to their property as the best predictor of variety performance for their conditions. However, these individual trial results are only a snapshot of what happened on a specific piece of land in a specific time-frame. If the trial had been sown a week earlier or later or had been moved 50m left or right in the paddock the results could be very different. So Individual Trial Reports do not provide the most accurate information for grower decisions and in reality typically have a one-in-five chance of providing misleading information when comparing varieties. The warnings given with individual trial results on the website are real, and could equate to a substantial and unnecessary loss of income. On the other hand, huge gains can be achieved by using data from a combination of trials in the NVT program.

IMPROVED DECISION MAKING THROUGH COMBINED INFORMATION ACROSS TRIALS

If the variety mean yields from the Individual Trial Reports are not recommended as the basis for grower selection decisions, then what is? The answer lies in the simple concept that the more data you have for a variety comparison, the more likely you are to make the right choice. The obvious way to achieve this is to combine data across trials, and this is the key concept underlying the NVT system. The system

is structured as a series of comparative field trials with a common set of core varieties for each crop for all trials across the growing region. Such a system is known as a multi-environment trial (MET) and it is the statistical analysis of these data that can provide the best information for grower decisions. A key reason is that an analysis across all trials increases the "weight of evidence" for selecting one variety over another. If results from a single trial are used, each variety mean is based only on a small number (typically three) of replicate plots in the trial. Substantial gains can be made by using data from other "similar" trials. For example, if we compare varieties using mean yields calculated from an analysis of five such trials instead of a single trial, we have up to 15 replicate plots measuring yield for each variety. In this instance, the error rate in making the correct varietal choice falls from a one-in-five chance to a one-in-twenty-five chance.

Decision making can be improved by averaging over similar trials; but what do we mean by "similar" trials? Similarity is measured in terms of the agreement in the variety ranking between the trials. For example, varieties that yield well above average (so rank near the top) in some trials may repeat this performance and result in a similar variety ranking in other trials. These trials form a group of "similar" trials. On the other hand, the top-ranking varieties in one trial may have average or below average yields in other trials. Sometimes the reasons for this behaviour are obvious, such as due to differences between trials in terms of soil type or rainfall. Other times it can be difficult to explain. Either way it only makes sense to average variety means taken across trials that rank the varieties in a similar way. The terminology given to the agreement in variety ranks is variety by trial (VxT) interaction. Close agreement in variety ranks is defined as little VxT interaction whereas poor agreement in variety ranks between two trials is defined as large VxT interaction. The characteristic of large VxT interaction is of a cross-over in variety ranks, from top-ranking in one trial to below average in another trial.

A common perception is that VxT interaction is a function of geographic distance between trials and, to date, the MET analyses that have been conducted for NVT are based on such a premise. The Long Term Yield Report for a crop provided on the website over the past years is based on a MET analysis of data combined across all valid trials grown in the current and preceding six or seven years, and varietal performance is reported on a regional basis. The use of pre-defined regions is based on the assumption that there is little change in variety rankings between trials within a region but potentially substantial interaction between trials in different regions. Unfortunately the truth is often the other way around so that means are being formed across trials that exhibit substantial changes in rank. Take, for example, four trials in Agzone 2 of Western Australia in 2011 and compare the similarity in variety ranks across trials (Figure 1). This graph demonstrates that some trial pairs (Buntine and Goomaling) have close agreement in variety ranks while others (Kulin and Goomaling) have poor agreement in variety ranks. Perfect agreement in variety rank between two trials would be graphed as a straight line going diagonally from top right for the highest yielding varieties at both sites, down to bottom left for the porrest yielding varieties at both sites. Any deviation from this line shows how the agreement in ranking between these two trials weakens. The extreme of no agreement looks like a scatterplot of points covering the whole square of the graph, as high yielding varieties at one site will be low yielding at the other site.
In addition, there is another layer of aggregation across years, and seasonal influences in each year can be very different. The end result is that important VxT interaction may again be masked by averaging over years. The poor agreement in variety ranking over years is shown for Wongan Hills (Figure 2).

A consequence in the current MET analysis is that sensitivity to changes in variety rankings for some trials is masked, as the method averages over trials within a region and across years even when these trials are dissimilar (see Figures 1 and 2). The result is that, while users of NVT are still likely to be able to identify varieties that are broadly adapted (yield reasonably well across most sites in the region and most years sampled) they may miss varieties with more specific adaptation (high yielding in a group of sites and years but not others).

COMBINING INFORMATION ACROSS "LIKE" TRIALS

So how do we choose which trials are similar? Underpinning this choice is the new statistical approach developed for the analysis of NVT MET data. From 2013, NVT will provide more information for growers in choosing the varieties most appropriate for their environmental conditions. The key is in replacing the pre-defined regional grouping of trials with data-driven groups or "clusters" within which there is minimal VxT interaction. So instead of grouping all trials in a

region, the new method uses the pattern of variety response in the trials themselves to identify trials that are similar. Groups of trials are formed as a combination of like trials which may come from many regions and years, but the response (or ranking) of the varieties in that environment type, or cluster, is consistent. For trials within a cluster, the varieties will be ranked from highest to lowest yield in a similar way. For trials from different clusters, varieties that have above average yields in one instance may have below average yields in the other.

The technique underpinning the modelling of VxT and hence the formation of clusters is called Factor Analysis which has been used for selection of varieties in plant breeding programs for more than 10 years.

INTERPRETING THE VARIETAL RESPONSE INFORMATION

The new analysis will provide measures of variety performance for each location and year, based on an analysis across all trials. Although at first sight this format might appear to be very similar to the Individual Trial Reports it is stressed that the information is far more reliable since it is based on the combination of information from similar trials as described in the previous section. And it provides far more information than the Long Term Yield Reports since VxT interaction can now be displayed rather than being masked through inappropriate averaging. The idea is simple. You can now select locations and seasons of interest and examine varietal responses across these environments to gain an insight into how well a variety may be specifically adapted to the conditions on your property and the seasonal challenges you may encounter. With this knowledge, informed decisions can be made on the best varieties for particular growing conditions.

Take, for example, one location from the NVT set where the ranking of four varieties will change, depending on the seasonal influence (Figure 3). Note firstly that the overall mean performance of three varieties; A, B and C, is similar across all years at this location. However, in seasons like 2008 and 2009, Variety C yields above the average and outperforms Varieties A and B. Conversely, environmental conditions typical to the years of 2010 and 2011 will favour Varieties A and B as the highest yielding varieties, over and above both Varieties C and D. Much more information for selecting the best variety for your conditions and spreading risk in varietal selection can be gleaned from the year by location predictions contained in the new analysis method.

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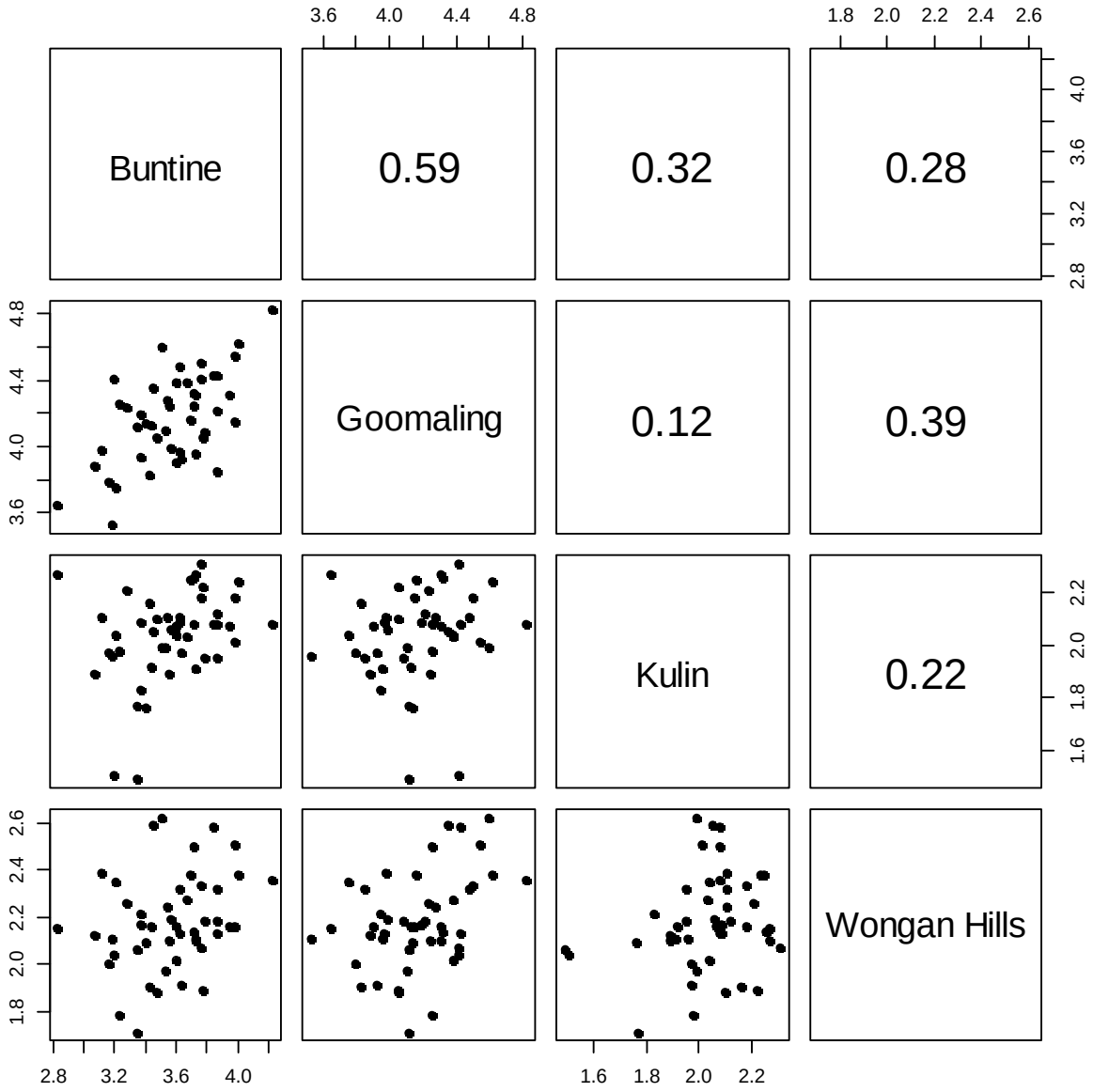

Figure 1: Variety yields from individual trial reports from 4 sites in Agzone 2 of Western Australia in 2011. Buntine and Goomaling have reasonable agreement in variety ranks (little VxT) while Kulin and Goomaling have poor agreement in variety ranks (strong VxT interaction). [Note: Perfect agreement in varietal ranks shows points lying alone a diagonal line from bottom left to top right. Poor agreement in varietal ranks is a random scatter of points.]

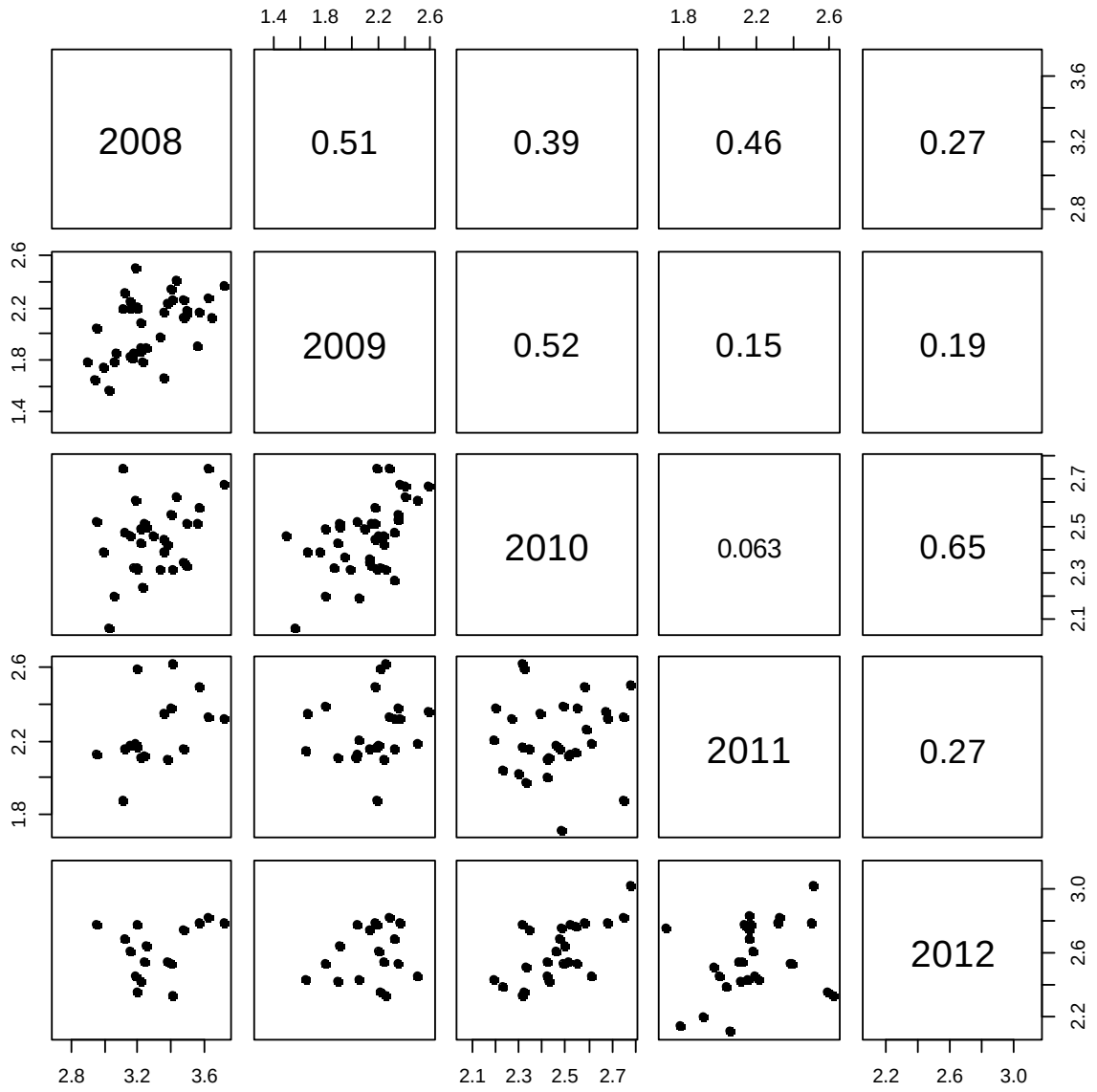

Figure 2: Variety yields from individual trial reports for five years at Wongan Hills in Agzone 2 of Western Australia. The strength of VxT interaction, that is, the agreement in variety ranks is much stronger between 2010 and 2012, than it is between 2010 and 2011.

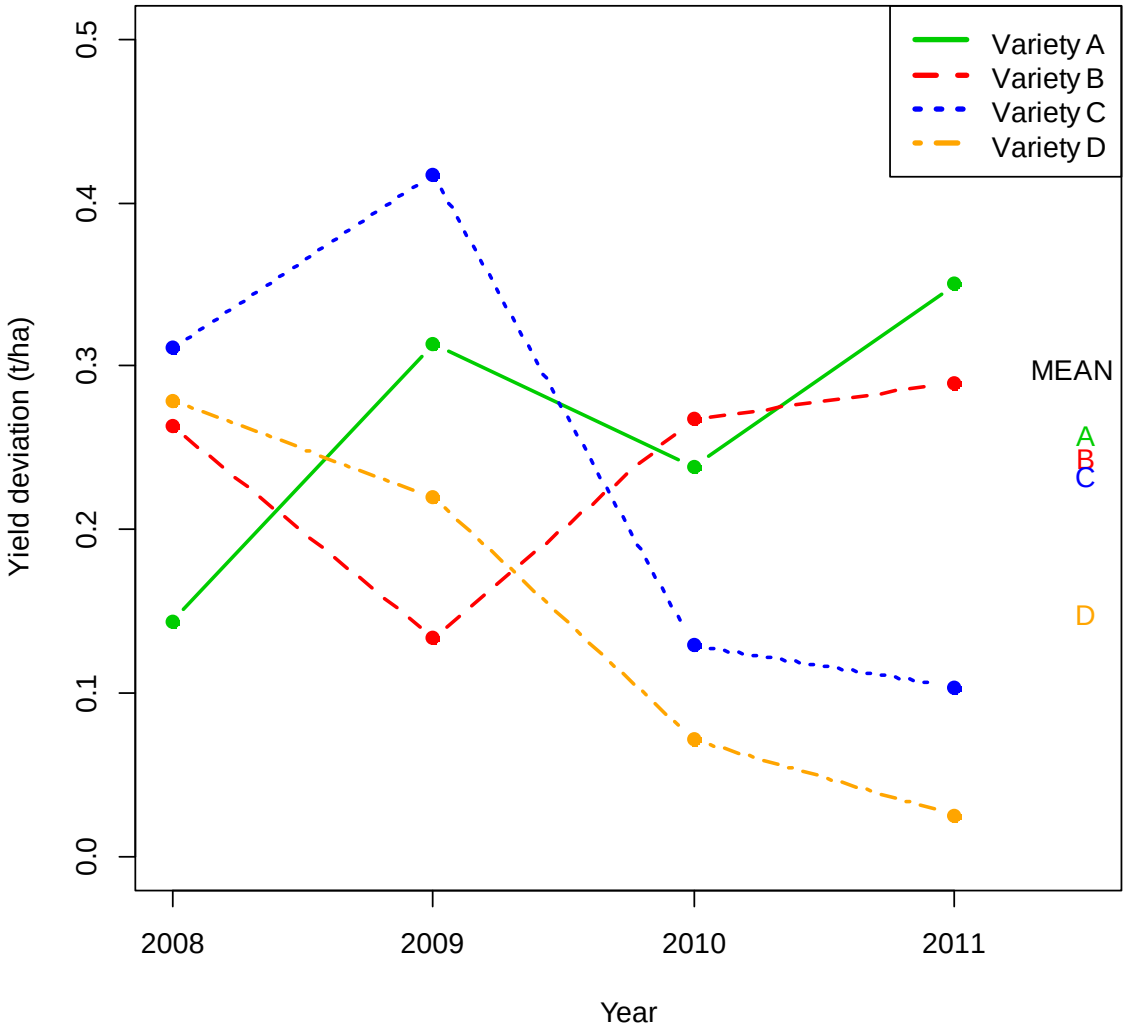

Figure 3: Location by season information from new NVT analysis: yield performance of four varieties across four years at Wongan Hills in Agzone 2 of Western Australia. A yield deviation of 0 is equivalent to the average yield for that environment, and positive yield deviations show above average performance. The mean yield deviation across four years is shown on the right of the graph.