

Appendix 38. 'Whole of block' experimental analysis of nitrogen strip trial

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Introduction

Precision agriculture (PA) as a tool becomes useful to end users (farmers) when appropriate decisions about where (and where not) differential management decisions can be applied. Yield monitoring and processing that data into yield maps often provides farmers with their first visualization of the variability on their farms. The process of PA uses these observations, adds supplementary information and then through a process of interpretation and evaluation produces a plan for implementation (Bramley, 2009).

The supplementary information used to help interpret observations can include spatial information such as high resolution soil survey, remote sensing and digital elevation models, or point data such as soil and tissue testing. Lawes and Bramley (2012) have proposed a method of spatially analyzing experimentation such as an 'N rich' strip via a moving t-test to identify areas where yield is significantly different, and therefore where variable management could be applied.

In this study we apply the moving t-test of Lawes and Bramley (2012) to a number of nitrogen rate treatments in a sugarcane block and interpret the results with a yield map to help identify if varying the nitrogen application rate is warranted.

Methods

The site was located in the Burdekin sugarcane farming district at Denis Pozzebon's farm, close to latitude 19°40' south. Rainfall at the nearby Bureau of Meteorology 'Ayr DPI' station (5 km to the north east) averages 933 mm per year, with more than 75% of rainfall occurring in the months from December to March (Bureau of Meteorology, 2014a). Maximum temperature averaged 32C in the hottest month (December) and 25.1C in the coolest (July). Minimum temperature averaged 22.8C in the warmest month (February) and 11.7C in the coolest (July; Bureau of Meteorology, 2014b).

Soil at the site was a very dark grey surface of light clay that has been degraded by cultivation and bed-forming operations. The subsoils were most commonly whole coloured brown light clay to a depth of 60 – 100 cm, below which the light clay - light medium clay deeper subsoils were coarsely mottled brown and grey with many fine ochreous mottles (Coventry, 2012). Percent sand averaged 39 to 45%, silt 24 to 26% and clay 31 to 35% in the top 600 mm.

The trial was established in block 12, where sugarcane (variety Q183) was planted in May 2012, following a break crop of Red Caloona cowpea (planted October 2011 and mulched April 2012). The cowpea returned an average of 113 kg N/ha in residue. The entire block received 37 kg N/ha via a custom fertiliser blend at planting. Four months after planting the centre of the block had six strips, each nine rows wide, of varying nitrogen fertiliser treatments installed (with treatments totalling 170, 153, 153, 37, 132 and 153 kg N/ha from south to north). The site was irrigated so that water was non-limiting.

The site was harvested on 16th August 2013 after burning. The sugarcane was harvested with machines fitted with yield monitors mounted on the elevator, monitoring hydraulic pressure applied which could then be used to calculate yield on a three second harvesting interval. The yield monitor

data was converted into a yield map. Yield values were extracted from the yield map every 3 metres along a centre line of each treatment strip. The yield from 30 metres of the eastern boundary and 10 metres of the western boundary from each treatment was discarded due to the yield there being unreliable as an artefact of the conversion of raw data to yield as the harvester only harvested the cane in one direction (east to west).

Each treatment was paired with the treatment to the immediate north and extracted yields paired to the yield of a point in that treatment the same distance from the eastern block boundary (approximately 14 metres between paired yields). Paired yields and the yield difference (northern treatment yield minus southern treatment yield) were plotted.

The first ten extracted point yields (representing yields from 30 metres to 60 metres from the eastern block boundary) for each treatment were compared via a paired two tail t-test with the first ten extracted point yields from the treatment to the immediate north and the p-value assigned to the fifth extracted yield value. The t-test was performed for the next ten extracted yield values by moving the starting value along one (performing a t-test on the 2nd to 11th extracted yields) and 'rolled' until a t-test was performed on every paired group of ten extracted yield values, using the method described by Lawes and Bramley (2012). The p-values less than 0.01 were marked on the yield difference plots as zones of significantly different yield.

Results

The yield map and centerlines of the six treatments in shown in Figure 38.1. The overall yield of the block was very high, averaging 186 fresh tonnes per hectare. Along the entire eastern boundary is a zone of low yielding area, which is possibly an artifact in converting the raw yield monitor data because the harvester only harvested in an east to west direction; it is also an area of lighter sandier soil. This area was excluded from further analysis.

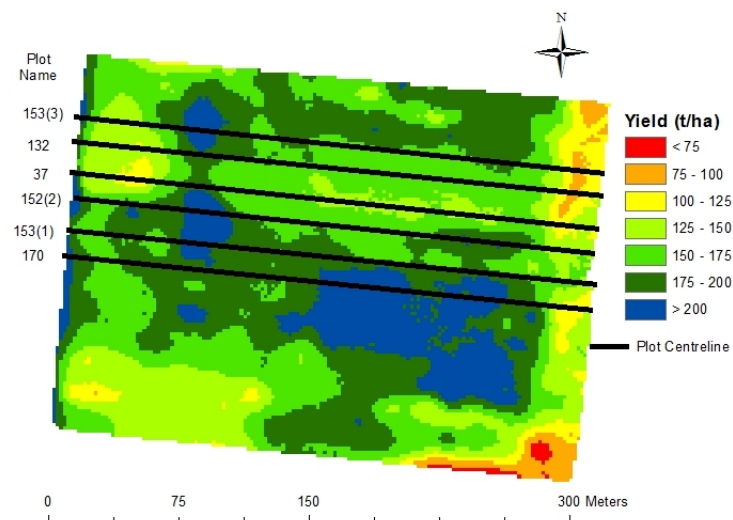


Figure 38.1 Yield map of block 12 harvested in August 2013 showing centerlines of six nitrogen rate treatments

The average yield for each treatment (average and standard deviation of all extracted yield values along the centre of each strip) is shown in Figure 38.2. The lowest N treatment (37 kg N/ha) yielded the lowest, with the three southern strips (170, 153(1) and 153(2)) yielding very similar values. The standard deviations are all in the range of 10 to 18 tonnes per hectare.

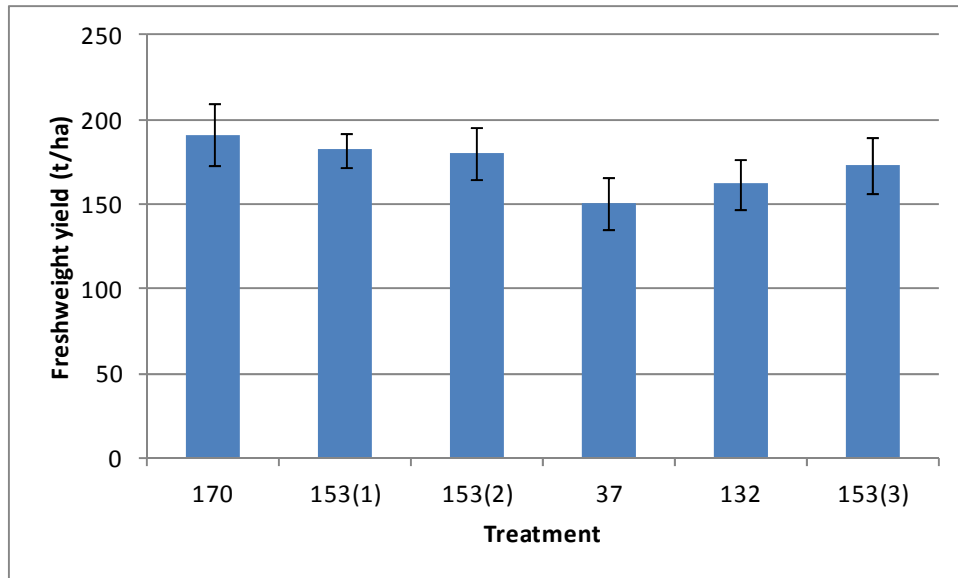


Figure 38.2 Average of extracted yield values (and standard deviation) from the centerline of treatment strips

The extracted yield values along the entire strip (starting 30 metres from the eastern boundary) for each treatment in comparison with the treatment to the immediate north are shown in Figure 38.3. The yield difference, and where it is significant ($p < 0.01$) is also shown. In all of the treatment strip comparisons there are large areas where the yield difference between the two strips are significantly different. A constant area of significantly different yield between 170 and 153(1) exists (between 147 and 267 metres from the eastern boundary) with the yield in the higher N treatment oscillating around 20 t/ha more). The yield differences between the two side by side 153 kg N/ha treatments is significant for much of the distance along the strip, but is rarely more than 20 t/ha. Almost the entire 37 kg N/ha strip is significantly lower than the 153(2) treatment, with the difference exceeding 40 t/ha in a number of places, and reaching a maximum of 73 t/ha. Similarly, the 132 kg N/ha treatment is almost significantly higher than the 37 kg N/ha treatment for the entire distance along the strip. However, the difference in yield is mostly below 20 t/ha. The 153(3) treatment is significantly greater than the 132 kg N/ha treatment for much of the distance along the centerline. However, the yield difference is mostly less than 15 t/ha.

Discussion

The rolling t-test, as described by Lawes and Bramley (2012), can be used with an 'N-rich' strip (that is, a much higher N application) to identify areas where yield is significantly higher, and thus areas where the crop will respond to additional nitrogen. In this instance the 37N treatment is an 'N limiting' strip, which can be used in the same way. The differences in fertilizer application between the 170 and 153 treatments (17 kg N/ha) and the 153 and 132 treatments (21 kg N/ha) are probably too small to make meaningful statements. To test this it is worth looking at the two side by side 153 kg N/ha treatments. We see in Figure 38.3 (b) more than 50% of the strip is identifying significantly different yield between the two treatments (even though the treatments are the same). The overall yield of these two strips is the same (Figure 38.2), and the yield difference between each pair of yields mostly oscillates between -20 and +20 t/ha. (Figure 38.3). This gives an indication that underlying variability can result in significant yield differences over short (14 m) distances.

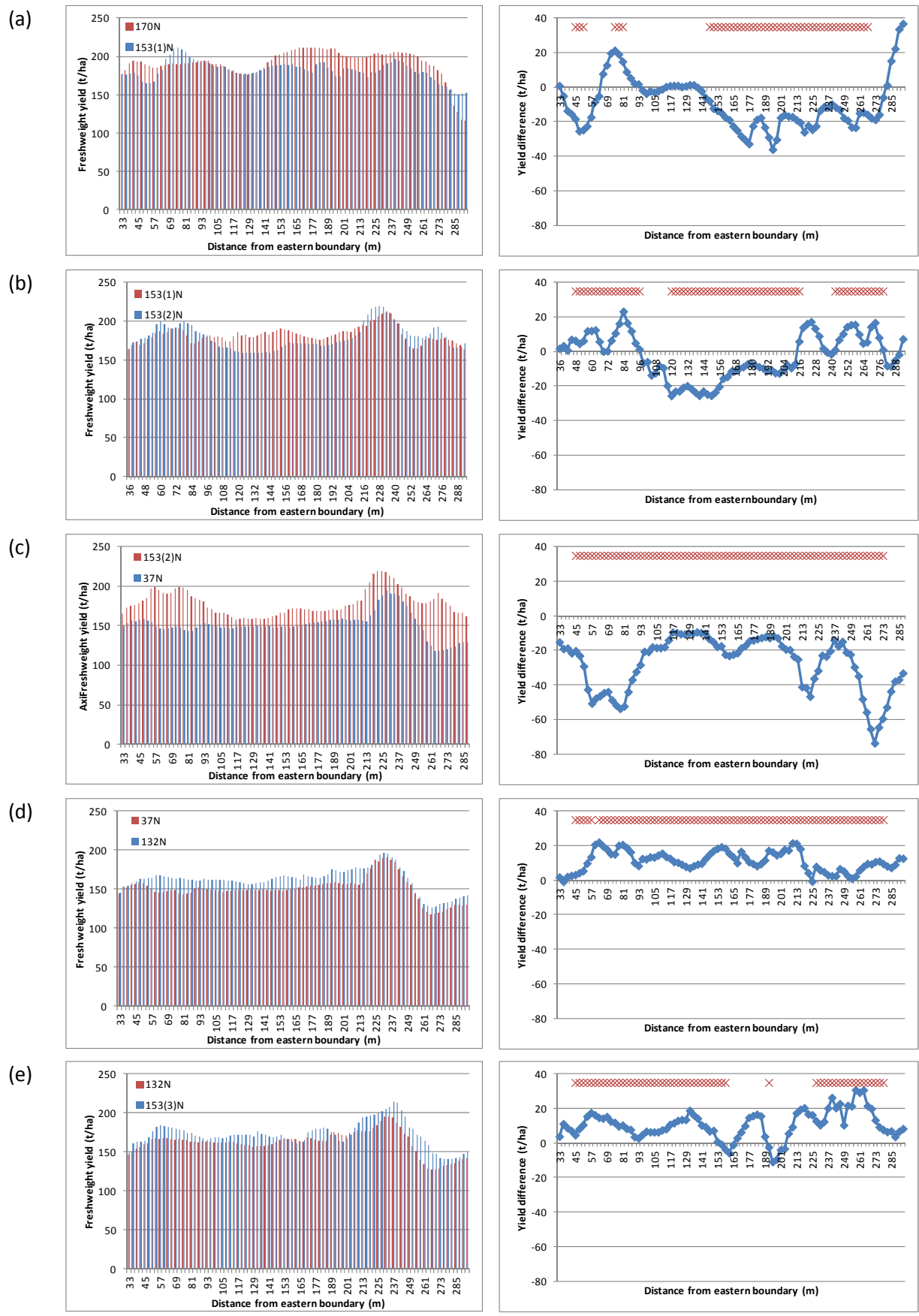


Figure 38.3 Extracted yield values for treatments compared with the treatment to the immediate north and yield difference between those treatments with areas of significance ($p < 0.01$) shown (x). (a) = 170, (b) = 152(1), (c) = 153(2), (d) = 37, (e) = 132.

To help interpret the moving t-test it is instructive to consider the yield map (Figure 38.4). Observation of the yield map reveals large areas where the yield is higher than average (Figure 38.4 (a)) and areas where the yield is lower than average (Figure 38.4 (b)). These areas should be considered when interpreting the significance of yield differences in the moving t-test (Figure 38.3). For example, Figure 38.3 (c) shows the 37 treatment being significantly lower than the 153(2) treatment by up to 73 t/ha in the vicinity of 265 metres from the eastern block boundary. This may well be due to an area of generally lower yield identified in Figure 38.4 (b) covering the 37 strip, but not the 153(2) strip. We can see in Figure 38.3 (c) that at the same point, 265 metres from the eastern boundary, the 132 treatment is only 10 t/ha higher than the 37 treatment.

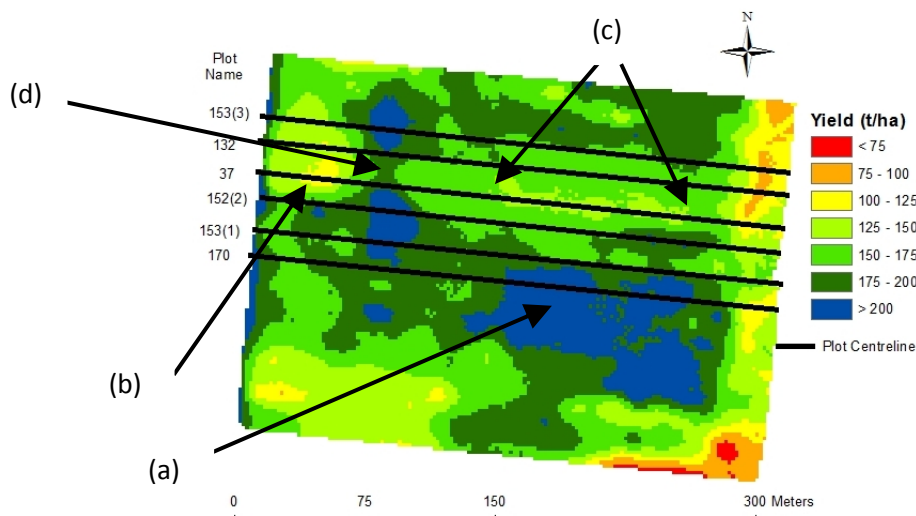


Figure 38.4 Yield map showing areas of higher than average yield (a), areas of lower than average yield (b), an area along the 37 treatment strip that appears to be lower than average yield (c) and an area of the 37 strip where yield increases, but not as much as the strips on each side (d)

What we can see from the yield map is an area associated with the 37 treatment where yield appears to be lower than surrounding areas (Figure 38.4 (c)). This area of reduced yield extends from approximately 54 to approximately 170 metres from the eastern boundary. This can be interpreted with the aid of the moving t-test where the 37 treatment is significantly lower yielding than both the 153(2) and 132 treatments over this distance (Figure 38.3 (c) and (d) respectively). Even though the yield difference is often less than 20 t/ha, it appears the entire 37 treatment is limiting yield, albeit to varying degrees along the strip.

Figure 38.3 does identify an area of the 37 treatment between 215 and 250 metres from the eastern boundary where the yield increases in concert with the treatments on both sides of the 37 treatment, identified in Figure 38.4 (d). This range is the highest yielding point along the 37 strip (reaching 190 t/ha) and it appears there is enough residual nitrogen along here to generate significant growth. The 37 treatment is still significantly lower than both the 153 (2) and 132 treatments, so increased nitrogen could increase yield here. To accurately determine how much extra nitrogen is needed at this point is worthy of future investigation.

Conclusion

Yield maps on their own can be used by practitioners of PA to identify zones of differential management (Bramley and Quabba, 2002). While yield maps are instructive, the simple tool of analyzing N rich (or N limiting) strips using a moving t-test can add value to the interpretation (Lawes and Bramley, 2012). Here we show that yield can be significantly different along strips 14 metres apart when the treatment is the same. We also highlight areas of the 37 kg N/ha treatments (specifically between 54 and 170 metres from the eastern boundary) where extra nitrogen is warranted. We also highlight area of the block approximately 215 to 250 metres from the eastern boundary where further testing could be done to examine how much extra nitrogen above 37 kg N/ha is needed. In conclusion, when areas of significantly different yield (from the moving t-test) are analysed in conjunction with yield maps, more meaningful identification of areas to target future investigation or differential management can be made.

References

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