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DEMONSTRATING THE COMPATIBILITY OF A NEW SPREADMARK TEST WITH THE CURRENT METHOD

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Abstract
The New Zealand Spreadmark test which although proven to accurately measure the Coefficient of Variation (CV) of spreading equipment, entails a laborious procedure which is expensive to implement. This study aims to validate the accuracy of a newly developed test method based on the current one that hastens the process, making it increasingly cost effective. The proposed solution reduces the amount of trays used to collect and measure the fertiliser spread pattern. The proposed method reduces the number of trays by half, placing them one meter apart compared to the current industry standard of half a meter. An electronic tray weighing system developed by EuroAgri streamlines the process. This allows the scales to be, zeroed, after each pass by removing the need to empty trays. Collated data of previous Spreadmark tests sourced from certified Spreadmark testers. This had the support of the Fertiliser Quality Council that manages the scheme used in the study. Tray weights of each successive 0.5 and 1.0 metres were, averaged to imitate tray spaces of 1.0 metre. The 1.0 metre tray spacing showed a strong correlation to the 0.5 meter spaces, maintaining the normal distribution pattern of the spread fertilizer albeit in a slightly lower definition. Coupled with the electronic scales that reduces human error, this forms an accurate and efficient method of undertaking testing. This new system could have marked effects upon the future of spreader testing in New Zealand, including higher proportions of conforming spreaders (due to increased time and cost effectiveness) leading to lower field coefficient of variation (CV). As a result, fertiliser efficacy would increase, as would financial returns.

Keywords: Spreadmark test, tray spacing, weigh cells, coefficient of variation, CV, testing efficiency

Introduction
Accredited testing agents use the current New Zealand Spreadmark test across the country to certify fertilizer-spreading vehicles. Vehicles are, certified, to spread fertilizer at bout widths measured, at the correct CV for the product tested. To gain certification at any given bout width, a spreader must achieve a CV<0.15 for nitrogenous fertilisers and a CV<0.25 for non-nitrogenous fertilisers (Fertiliser Quality Council of New Zealand, 2018). Meeting these requirements with three different fertilisers (typically urea, superphosphate and a product used commonly by the spreader) is also a prerequisite of gaining Spreadmark approval.

Currently, the test requires setting out, adjacent collection trays with the following dimensions (500mm x 500mm x 150mm). Therefore, the distance between the centre of any two consecutive collection trays is 500mm (Fertiliser Quality Council of New Zealand, 2018) (Lawrence et al, 2006). There must be enough trays used to cover the complete spread pattern, of the tested vehicle. Anti-ricochet inserts are within the trays to ensure the amount of fertiliser bouncing out of the trays is minimal. Trays are displaced, for the wheels of the spreading vehicle to pass through, see Figure 1.

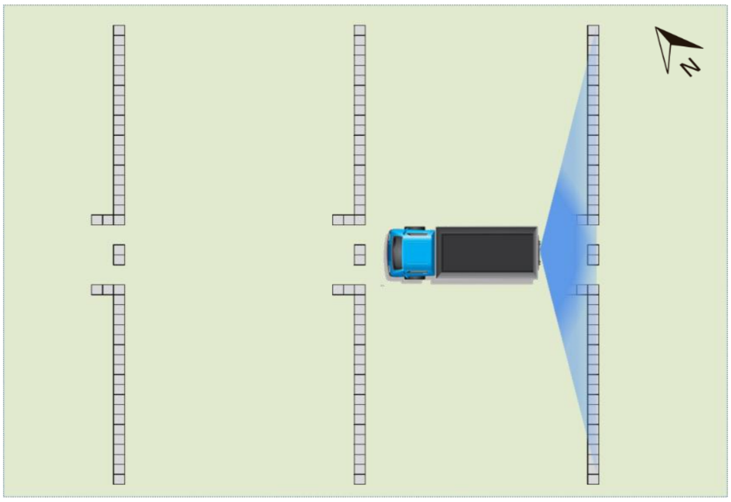

Figure 1: Spreadmark test layout (courtesy D. Acebes)

Fertiliser weights of the displaced trays are, adjusted by, interpolating weights of the adjacent trays. The fertiliser weight in the centre trays between the vehicle's wheels are, averaged with the displaced trays at an equidistant point. After a pass from a spreading vehicle, the trays are, emptied and fertilizer contents weighed. The data from each tray is, entered into software developed by Spreadmark (Spreadmark V17). This software calculates spread CV's at any given bout width (Fertiliser Quality Council of New Zealand, 2018). The CVs for "To and Fro" (TF) and "Round and Round" (RR) driving patterns are produced. As three passes with different fertilisers are required to certify a spreading vehicle, this process is, undertaken three times for each vehicle. Hence, Spreadmark testing has proven to be a laborious process. The aim of this study is to streamline the Spreadmark testing procedure by testing the feasibility of a new proposed system based off the current model.

The proposed system incorporates an electronic weighing system developed by EuroAgri. This will remove the necessity to empty collection trays after each pass, reducing the labour requirement of the process (Yule & Grafton, 2013). It is, proposed to use digital weigh cells under the trays to eliminate the need to empty and weigh the contents after each pass. To save cost and space moving equipment to operators it is, proposed that the number of trays be, halved, by eliminating every other tray. After each pass, the weigh cells will be, tared, before the next test. This exercise examines whether an increased distance between collection trays and the reduction of the number of trays significantly changes the test results. In the proposed system, trays will be, placed one metre apart, compared to the current half-metre spacing. The dimensions of the trays does not change. Using a data set of 122 Spreadmark tests sourced from accredited Spreadmark testers across New Zealand between January and February 2013, it will be determined whether the proposed changes maintain the accuracy of the current system.

Materials and Methods

All 122 of the Spreadmark test data sets was collected using a tray spacing of half a metre. The data set contains information from a range of fertilisers and trucks. The physical characteristics of the fertilisers, combined with spreader characteristics, such as disc speed, determines the trajectories, of the fertiliser particles (Grafton, et al., 2014). The data set also recorded a range of application rates, bout widths and disc speeds. Environmental conditions and driver influence are, not accounted for, as tests are, conducted on flat areas with little or no wind. The test data from each test was, duplicated. For the duplicated test, the weights of every tray were, combined and averaged to imitate a tray spacing of one metre, with the same sized tray. For example, the 2.5 metre and 3.0 metre tray weights were, averaged to find the weight of the tray contents 3.0 metres to the right of the spreading vehicle, to simulate interpolating the fertiliser weight if every other tray was missing. This spread pattern was generated and bout width calculated 'Spreadmark Test Report' Version 17, as if a one metre tray spacing was used.

A two-tailed F test was used to compare the 0.5 metre tray spacing CVs with the 1.0 metre simulated spacing CVs to determine whether the data sets were significantly different ($p<0.05$). The "Round and Round" (RR) and "To and Fro" (TF) simulated driving patterns were calculated. Figure 2, shows the data used to differentiate the two testing methods for a "RR" driving method, whilst Figure 3, shows the same for a "TF" application. These show that each data set was, compared for each test.

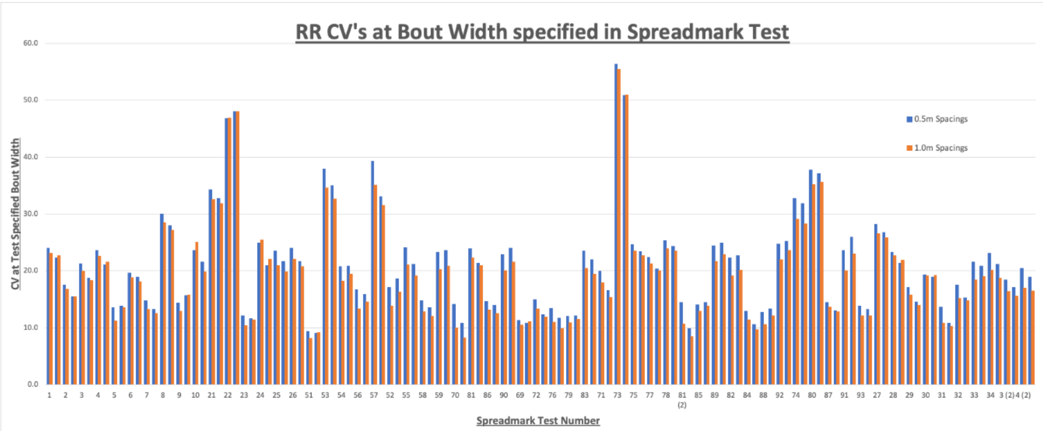

Figure 2: CV's calculated from both 0.5 metre and 1.0 metre tray spacing assuming a RR driving pattern.

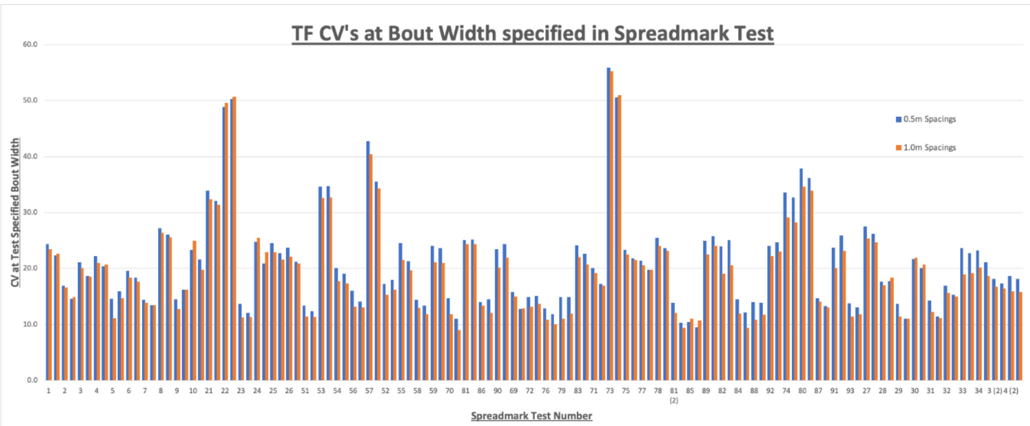

Figure 3: CV's calculated from both 0.5 metre and 1.0 metre tray spacing assuming a TF driving pattern.

Results

The F-test results show that the 0.5-metre, and the 1.0-metre tray spacing CVs were not significantly different for both “RR” and “TF” driving techniques. Figure 4 shows whisker and box plots of the standard deviations of the actual and simulated data for the test results. Figure 5, 98.1% of the time a 1.0 metre tray spacing will yield a similar CV as a 0.5 metre tray spacing for a RR driving pattern with a probability less than 0.05. For TF driving patterns, CV’s calculated with a tray spacing of 1.0 metre will be similar to that determined by a tray spacing of 0.5 metres 93.5% of the time. As this probability value is greater than 0.05 see Table 1, the “TF” patterns are significant to 0.1. Hence, we must accept the null hypothesis that the CV’s calculated from both the 0.5-metre and 1.0-metre tray spacing are not significantly different and are the same.

Observe that although not significant, the 1.0-metre tray spacing data is, skewed to the left compared to the 0.5-metre tray spacing data. This is, shown in Figures 3 and 4; all bout widths are smaller for the simulated 1.0-metre tray spacing.

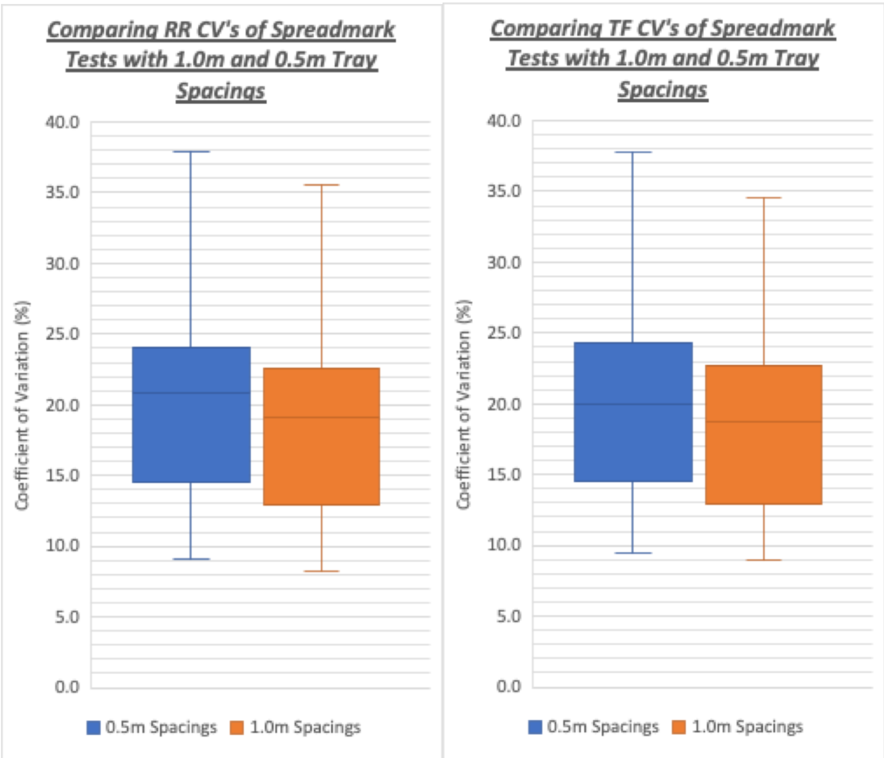

Figure 4: Side by side box and whisker graphs showing the limited variability of CV’s calculated by the two methods for a RR driving pattern. Figure 4: Side by side box and whisker graphs showing the limited variability of CV’s calculated by the two methods for a TF driving pattern.

Table 1: Summarises the two tailed F-Test used to show that there was no significant difference between the means of 0.5 metre and 1.0 metre tray spacing. Both RR (top) and TF (bottom) driving methods were tested. As $p>0.05$ for both cases, the null hypothesis that the means were equal for both application methods was supported.

F-Test

Question:	Are the results from the RR 1.0m tray spacings significantly different from the RR 0.5m tray spacings?
Null Hypothesis	RR1.0m = RR0.5m
Alternative Hypothesis	RR1.0m <> RR0.5m
p =	0.981423346
Result	Accept the null
	Approximately 98.1% of the time, the RR 1.0m tray spacings will yield similar results as the RR 0.5m tray spacings.
Question	Are the results from the TF 1.0m tray spacings significantly different from the TF 0.5m tray spacings?
Null Hypothesis	TF1.0m = TF0.5m
Alternative Hypothesis	TF1.0m <> TF0.5m
p =	0.935244774
Result	Accept the null
	Approximately 93.5% of the time, the TF 1.0m tray spacings will yield similar results as the TF 0.5m tray spacings.

Discussion

These results support the view that a tray spacing of 1.0-metre can be an accurate proxy for the current industry standard (0.5 metres). Implementation of this change, along with the electronic weigh cells developed by EuroAgri, would lead to a streamlined Spreadmark test with an increased cost effectiveness. This is due to the reduced labour requirement of the testing procedure. The necessity to empty collection trays is, removed by the newly developed weigh cells that are, tared after each pass. Halving the amount of trays also leads to a lessened data recording and setup/pack-up requirement and the amount of equipment that the tester has to bring.

An increased cost effectiveness should encourage a greater proportion of contractors/individuals to join the Spreadmark accreditation scheme and code of practise. Horrell, et al., 1999, stated that 50% of the national fleet of vehicles spreading N were not compliant with the Spreadmark code of practise, with a further 40% failing to meet the standard for P fertiliser. The current information (FQC, 2018) shows that around 12.5% of vehicles are tested. Increasing the number of compliant spreaders will lead to a general trend of decreased CVs, with positive outcomes for land profitability as well as the environment (Sogaard & Kierkegaard, 1994). By placing product where it is required, producers' gross margins will increase whilst excess nutrient lost by runoff and leaching are decreased.

The approach to this research was to calculate the 1.0-metre tray spacing data by finding the mean of each successive 0.5-metre and 1.0-metre tray. This compares to simply transposing the weights of every 1.0-metre tray from the Spreadmark dataset (0.5 metre spacing) to the new 1.0-metre spacing dataset. This is a conservative approach to the study, as the alternative would probably produce lower differences in CVs see Figures 3 - 4. The means of the CVs of 1.0-metre tray spacing are lower than, the 0.5-metre counterparts. This means the bout widths driven would be narrower under normal field conditions.

Lawrence and Yule, (2007) state *viz* ‘variation in spreading would probably double under field conditions when compared to a controlled transverse test’ in reference to work completed by Parish and Bergeron (1991). It is for this reason that a loss of some accuracy in the testing procedure would be over-shadowed by the benefit of having a larger proportion of the national spreading fleet being Spreadmark certified. Reducing the problematic gap between testing CVs and what actually occurs in the field, is of great importance, and one that must be solved if site-specific management of fertiliser is to ever be properly implemented on a large scale (Yule & Grafton, 2013).

Compared to overseas tests of similar nature (ISO 5690-2, 1984), (ASAE, 2009), European Standard and Accu-Spread (Australia), the Spreadmark test finds common ground between accuracy and efficiency (Lawrence, et al., 2006) (Jones, et al., 2008). This variation to the Spreadmark test could make it one of the most efficient in the world, without losing the accuracy that is required. However, Lawrence and Yule, (2006), also conclude that *viz* ‘there needs to be a far greater analysis of the entire fertiliser application system’, actual spreading variation will be different under field conditions. Environmental factors such as wind (Sogaard & Kierkegaard, 1994) and topography (Yildirim, 2008) as well as paddock shape and driving accuracy (Lawrence & Yule, 2007) will alter the spreading pattern of a spreading vehicle. For an insight to the steps taken during testing to mitigate these effects, see (ASAE, 2009; Sogaard & Kierkegaard, 1994; Yildirim, 2008).

A further variation of the proposed method is that a 1.0-metre tray spacing will be difficult to set out quickly and accurately, using the current 500mm x 500mm x 150mm trays. A potential solution is to increase the length of trays to 1.0 metre so that they can be laid-out consecutively. This could be beneficial as increasing the length of the trays will reduce the variance of the mean (Jones et al, 2008). Field tests would be required to assess the practicality of 500mm x 1000mm trays in a testing situation, as they would not alleviate the amount of equipment carried by testers.

Conclusion

This study suggests that an updated Spreadmark test can streamline the process, making it more cost effective whilst maintaining the accuracy of the current system. Proposed changes to the current system were (a) the introduction of an electronic weigh cell: (b) an increased tray spacing to 1.0 metre. Implementation of these changes may lead to higher amounts of accredited vehicles due to the testing method costing less time and money. This may lower CVs, increasing profitability and decreasing runoff/leaching of excess nutrient.

Future research could aim towards streamlining the Spreadmark testing procedure for aerial application. Due to steep gradients leading to increased runoff of excess nutrient, hill country farmers would benefit from lower CVs resulting from an increased number of compliant machines. Longer collection trays should be tested for practicality. High variations between testing and actual field application should prompt more work to investigate how mitigating, external influences could make testing more representative of what occurs in practise.

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