Marginal cost analysis to determine optimal annual ryegrass sowing rates

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ABSTRACT

Replicated field trials demonstrate that annual ryegrass early season growth rates are sowing rate dependant and face a decreasing marginal return (kg yield/kg seed) as sowing rates increase. Yield within each year closely followed second order polynomial relationships with sowing rate (average r^2=0.95), and when multiple trials are combined, sowing rate explains the majority (r^2=0.7) of yield response. Due to the diminishing marginal return, marginal cost analysis is an economically rational tool to making sowing rate decisions. We demonstrate that depending on substitute feed cost, further profits can be captured by increasing sowing rates of cultivar Winterstar®II from the standard 20 to 30 kg/ha to 35 to 45 kg/ha.

Keywords: annual ryegrass; sowing rate; marginal cost analysis.

INTRODUCTION

Farmers are often advised that an optimal sowing rate for annual ryegrass in pure swards is between 20 and 30 kg/ha, or perhaps to increase sowing rates with expected rainfall/irrigation supply. However, work by (Wynn *et al*. 2011) and (Veneto *et al*. 2004) suggests farmers face a decreasing marginal response to sowing rate.

The objectives of this research were to determine the yield response function of annual ryegrass to sowing rate and develop a marginal cost analysis to make informed and profit maximising decisions regarding sowing rates.

MATERIALS AND METHODS

Trials were conducted in 2003, 2009 and 2010 in Ballarat, Victoria. A late maturing tetraploid annual ryegrass (cv 'Winterstar® II') was sown in autumn at 10, 20, 30, 40 and 50 kg/ha in a replicated randomized block design (four replicates) and yield determined by complete plot harvesting. Following each harvest, a replacement fertiliser application consisted of 48.0, 4.4, 5.0 and 5.5 kg/ha of N,P,K and S respectively. ANOVA was conducted using Statistix 9 (Analytical Software, 2008) and trend lines fitting by Microsoft Excel (Microsoft, 2007).

RESULTS AND DISCUSSION

Yield results of the sowing rate trials are presented in Table 1.

Table 1: Yield results of sowing rate trials

Sowing	Cut 1	Cut 2	Cut 3	Cut 4	Total
kg/ha	kg DM/ha				
Date	10/7/03	29/9/03	3/10/03	16/12/03	2003
10	1813^{a}	2427^{a}	1930^{a}	2363^{a}	8532^{a}
20	2269^{a}	2653^{a}	2035^{a}	2475^{a}	9432^{ab}
30	2467^{a}	2530^{a}	2030^{a}	2475^{a}	9502^{ab}
40	2823^{a}	2535^{a}	2097^{a}	2784^{a}	10240^{b}
50	2699^{a}	2441^{a}	1913^{a}	2391^{a}	9444^{ab}
CV	31.5	6.2	6.3	11.8	10.4
Date	7/7/09	8/8/09	28/8/09	16/9/09	2009
10	443^{a}	1245^{a}	1614^{a}	2068^{a}	5370^{a}
20	904^{b}	1801^{b}	1765^{ab}	2104^{a}	6575^{b}
30	1341^{c}	1983^{b}	1812^{ab}	1901^{a}	7037^{bc}
40	1491^{cd}	2197^{b}	1922^{ab}	1937^{a}	7547^{c}
50	1819^{d}	2010^{b}	1864^{b}	1869^{a}	7563^{c}
CV	17.6	14.8	10.0	9.1	8.4
Date	8/7/10	6/8/10	5/10/10	-	2010
10	115^{a}	862^{a}	3104^{a}	-	4081^{a}
20	241^{a}	1238^{b}	2740^{ab}	-	4218^{a}
30	523^{b}	1529^{c}	2762^{ab}	-	4814^{b}
40	689^{b}	1530^{c}	2947^{ab}	-	5166^{b}
50	936^{c}	1705^{d}	2609^{b}	-	5250^{b}
CV	26.2	7.7	8.9	-	7.69

P<0.05, CV = coefficient of variation

The 50kg/ha sowing rate results from 2003 are excluded from the following analysis, as experimental error appears responsible for erroneous results, i.e. first cut yield is not linear with sowing rate, contrary to findings of (Venuto *et al*. 2004), (Wynn *et al*. 2011) and subsequent work by PGG Wrighton Seeds.

YIELD RESPONSE

Consistent with previous studies, first cut yield increased linearly with sowing rate in all three years (r^2

averaging 0.98). As the seasons progressed, growth rates converged, presumably due to compensatory tillering at lower sowing rates. By the fourth cut in 2003 and 2009, growth rates were the same for all five sowing rates. These trials confirm sowing rate can manipulate early season annual ryegrass growth rates and increase total yield. The highest sowing rate trialled (50 kg/ha) appears to have marginally reduced late season yields.

To allow comparison of the three trials, data was normalised by subtraction of the applicable 10kg/ha sowing rate yield (Figures 1 and 2). Consistent with (Venuto *et al*. 2004), sowing rate variation explains almost all within year total yield via second order polynomials (Figure 1) with an average $r^2 = 0.95$.

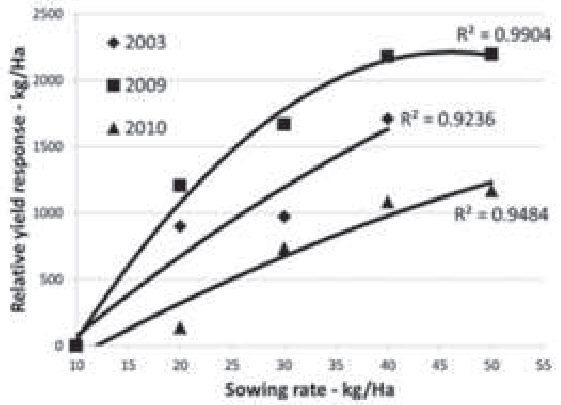

Figure 1: Within-year relative total yield response v sowing rate.

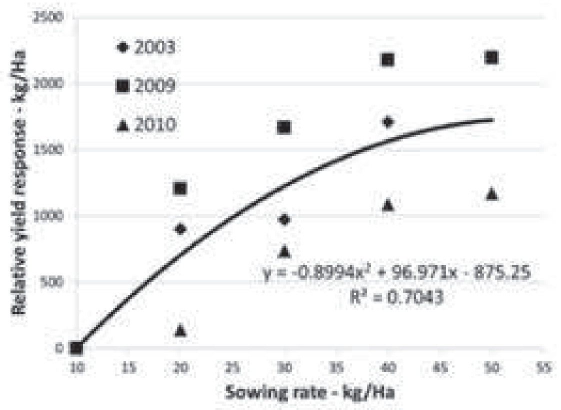

Figure 2: Relative total yield response v sowing rate. Polynomial fitted to all data points.

Yield response clearly suffers a diminishing marginal return, the rate of which varies slightly between years (Figure 1). When combined (Figure 2), all data points explain a majority of yield response (r^2=0.7) by a second order polynomial.

Marginal cost analysis

Between the 10 and 50 kg/ha sowing rate, yield differs by approximately 1.6 tonne/ha (Figure 2). Due to the diminishing marginal return, marginal cost analysis is the most suitable method to decide on how much of this 1.6 tonne/ha yield response is it rational to peruse. The derivative (Equation 1) of the equation in Figure 2 describes the marginal response (kg yield/kg seed) and can be transformed by including seed cost to describe marginal feed cost at any sowing rate between 10 and 50 kg/ha. Figure 3 presents marginal feed cost as a function of sowing rate assuming $3.80/kg seed cost. Fixed costs are excluded as they do not influence short run decisions.

Equation 1: Marginal response of yield to seed
Marginal Response=-1.7988*sowing rate+96.971

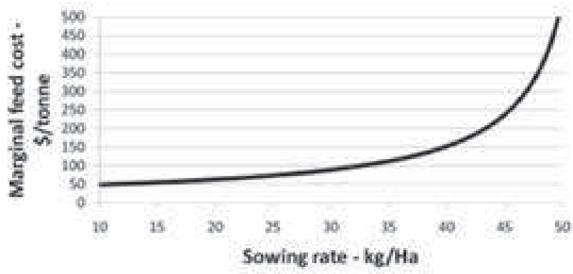

Figure 3: Marginal feed cost v sowing rate

In the case of a dairy, the most appropriate marginal revenue is likely to be the supplement cost of energy on a cents/MJ basis and equations should be transformed accordingly.

As an example of how this concept can be used to maximise resource use efficiency and profits, Figure 3 demonstrates that:

- where feed grown has a value of $150/tonne, approximately 40 kg Seed/ha would maximise profits; and
- importantly, unless marginal revenue is very low (i.e. extremely cheap supplement), the use of low sowing rates is sub optimal and will not maximise profits.

In addition, while beyond the scope of this paper, consideration should be given to utilisation and the minor value of nutrient removed in product.

Given the importance of short term ryegrasses (Annual and Italian) to dairy systems, further work is warranted to identify the cause of variability in response to sowing rate between years, and define the response curves of other cultivars. Work by the Authors suggests sowing time may explain a large portion of variance; however temperature and water availability will also likely contribute.

The authors also suggest the identified response curve is not be applied to common cultivars as seed sources vary in quality (germination and vigour) and genetic potential for early growth.

REFERENCES

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