# Italian ryegrass – optimising sowing rate to maximise profit

**Martin Harmer**

**Research Agronomist**
**PGG Wrightson Seeds Australia**
**Leigh Creek Research Station**
**mharmer@pgwseeds.com.au**

**28 January 2015**

## Background

Previous work by DEPI, PGG Wrightson Seeds and others in plot and farm scale trials demonstrate that profits (not yield) from annual ryegrass in drilled monocultures (without clovers) is maximised when rates of approximately 40 kgSeed/Ha are sown. Below this sowing rate, the yield response (kg yield per kg seed) is effectively cheaper than purchased supplement, and above this rate it is more economical to purchase feed than seed.

The benefits of changing annual ryegrass sowing rate practice from traditional rates (10 to 25 kg/Ha) to proven optimums are not trivial, and range from approximately $80 to $180/Ha/year.

Whenever this work is presented we are queried about what an optimal sowing rate might be in Italian ryegrass, hence in 2013 and 2014 PGG Wrightson Seeds research undertook trials to answer this question.

## Method

Both trials used fast starting, highly winter active diploid Italian ryegrass cultivars, Knight and Concord II, in 2013 and 2014 respectively. Trials were planted in the Autumn, 11 April 2013 and 17 April 2014 and a starter fertiliser was applied when plants reached the two leaf stage. Trials were fertilised to replace N post cut.

The 2013 trial had two replicates of the sowing rates 10, 20, 30, 40 50 and 60 kgSeed/Ha. The 2014 trial was a completely randomised design with a single entry of rates between 5 and 80 kgSeed/Ha in 5kgSeed/Ha increments, i.e. 16 plots. Yield was determined on both trials by collecting a dry matter sample and harvesting all forage with a plot harvester. The 2013 trial was harvested for six cuts between 31 July and 17 December 2013 and the 2014 trial until sowing rate differences disappeared, this required four cuts between 26 August and 4 October 2014.

## Results

Results of the 2013 trial are presented in Figure 1. Results of the 2014 trial are presented in Figure 2. Results for cut three of the 2014 trial are unavailable and we have assumed (based on evidence from all previous trials) that there is no response to sowing rate at this cut. Figure 3 presents the total yield results for the 2013 and 2014 trials respectively. Total yield for the two trials is different as there were different numbers of cuts. However, this is inconsequential as it is the differences between sowing rates within a year that is important for the purposes of this trial.

**Figure 1. Cut by cut results for the 2013 Italian sowing rate trial**

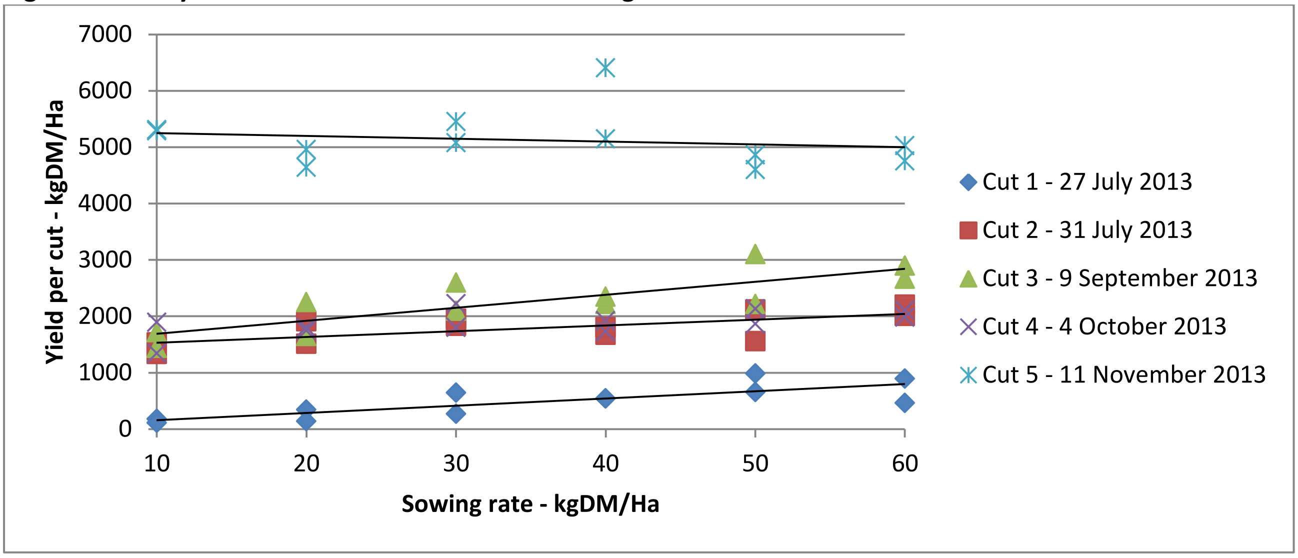



**Figure 2. Cut by cut results for the 2014 Italian sowing rate trial**

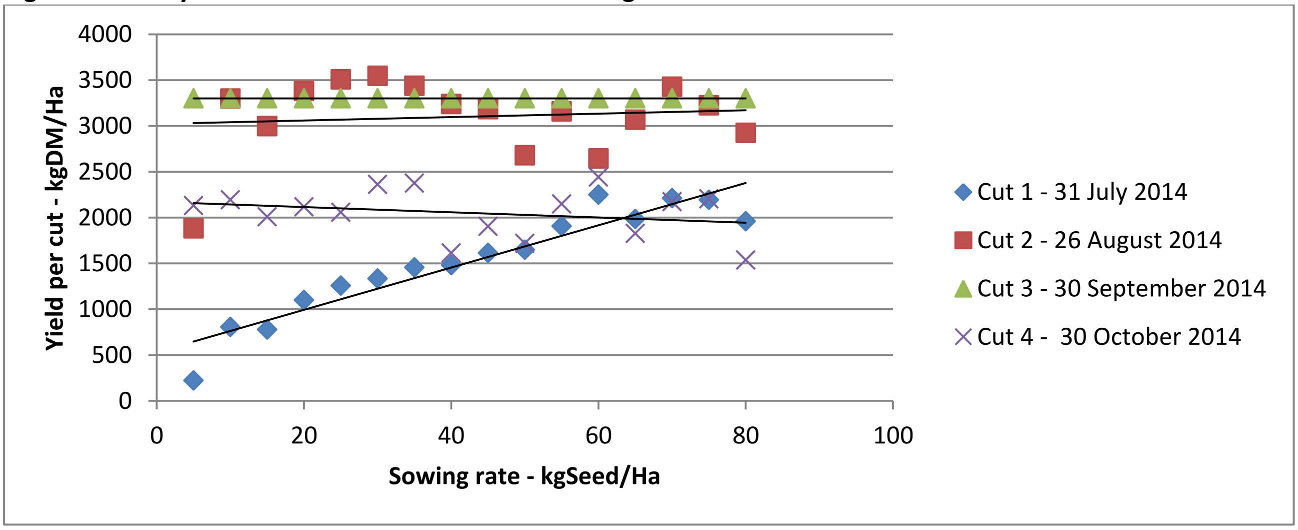
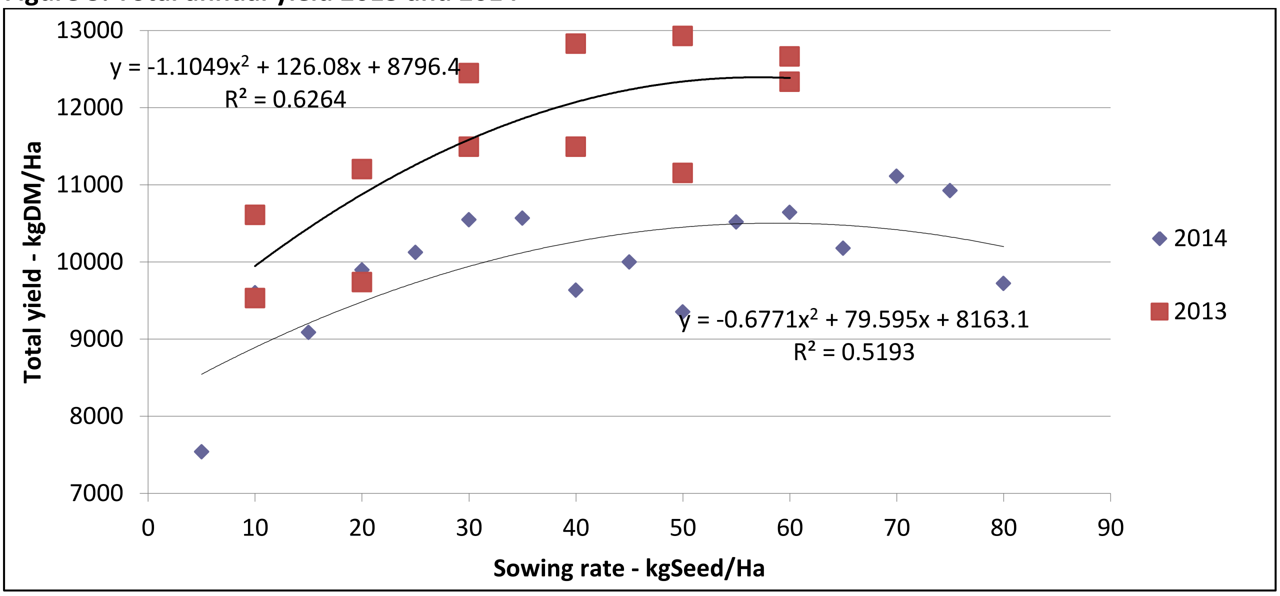



**Figure 3. Total annual yield 2013 and 2014**



# Discussion

**Early season yield**

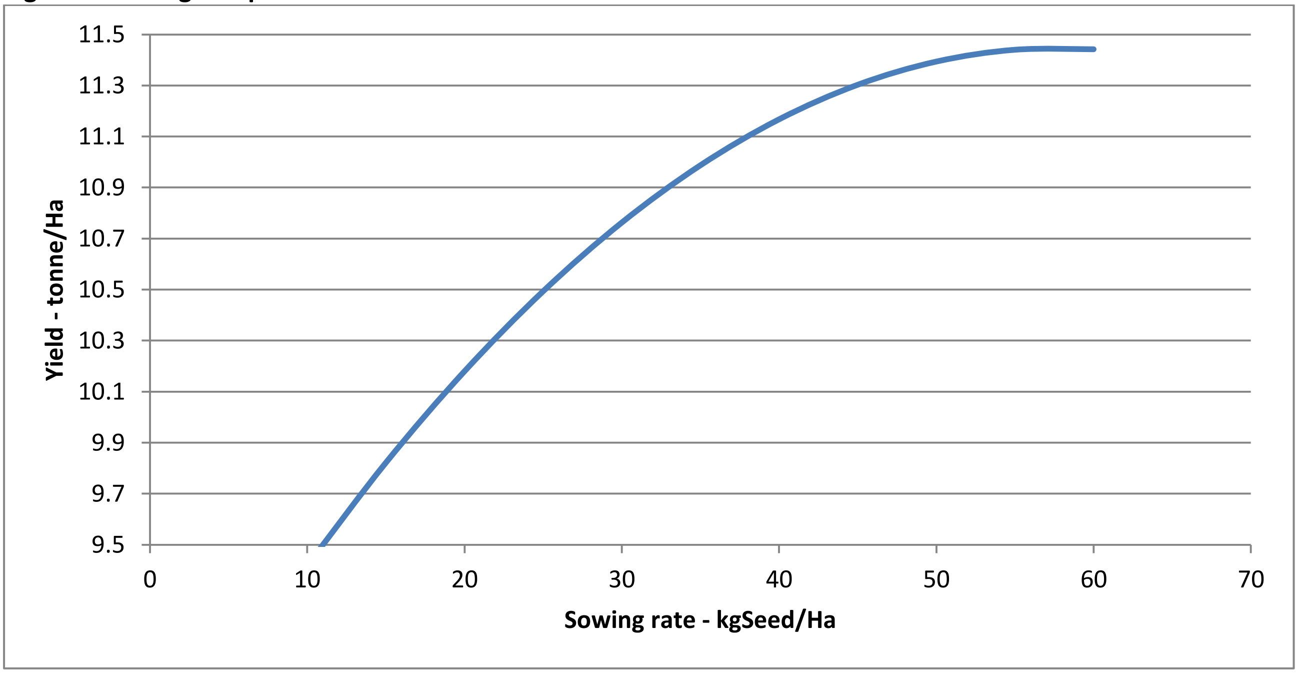
As expected, in both years large linear responses were seen in first cut yield to sowing rate. In subsequent cuts the benefit of the higher rates reduced as plants tillered out to a common density. After a number of cuts the benefit of the higher sowing rate no longer appeared. As such, just as in annual ryegrass', sowing rate can be used to adjust winter feed supply in Italian ryegrass.

**Total yield**

We know from previous work that short term ryegrass yield response is well described by a polynomial response curve as fitted in Figure 3. The following response function describes on average how total yield changed in response to sowing rate: $yield = -0.891 * sowing\ rate^2 + 102.83 * sowing\ rate + constant$ with the constant being dependent on how late into the season growth extends. This is demonstrated in Figure 4 as the average response for the two trials.

We can see in Figure 4 that the system has a diminishing marginal return (every additional kg of seed yields less forage than the previous kg) and maximum yield occurs at approximately 57 kgSeed/Ha rate.

**Figure 4. Average response of the 2013 and 2014 data sets.**




**Profit maximising sowing rate**

Information about how yield responds to sowing rate can be used to determine a profit maximising sowing rate. To determine how much forage can be gained by an additional kg of seed at any sowing rate we use the derivative of the equation above ($change\ in\ yield = -1.782 * sowing\ rate + 102.83$). This equation explains how much the yield moves in kg for an additional kg of seed at any given sowing rate. For instance if we are at 15kgSeed/Ha and sow an additional kg of seed we will yield an additional 76.1 kg of winter grown forage. At $5/kg for the seed the additional 76.1 kg of feed has effectively cost (marginal cost) of $65.7/tonne. At higher sowing rate the marginal response is reduced. For instance, if we are at 30 kgSeed/Ha and sow an additional kg of seed we yield an additional 49.3 kg of winter grown forage, an effective price (marginal cost) of $101.20/Tonne.

This increasing marginal cost is demonstrated in Figure 5. Those familiar with marginal cost analysis can use this to determine an optimal sowing rate for any given supplementary feed price. For those not familiar with the concept, please read on, as the approach is simplified and demonstrated in Table 1 using the average response of the 2013 and 2014 trials. All calculations assume that Italian ryegrass seed costs $5/kg.

**Figure 5. Marginal cost curve based on the average (2013 and 2014) response.**

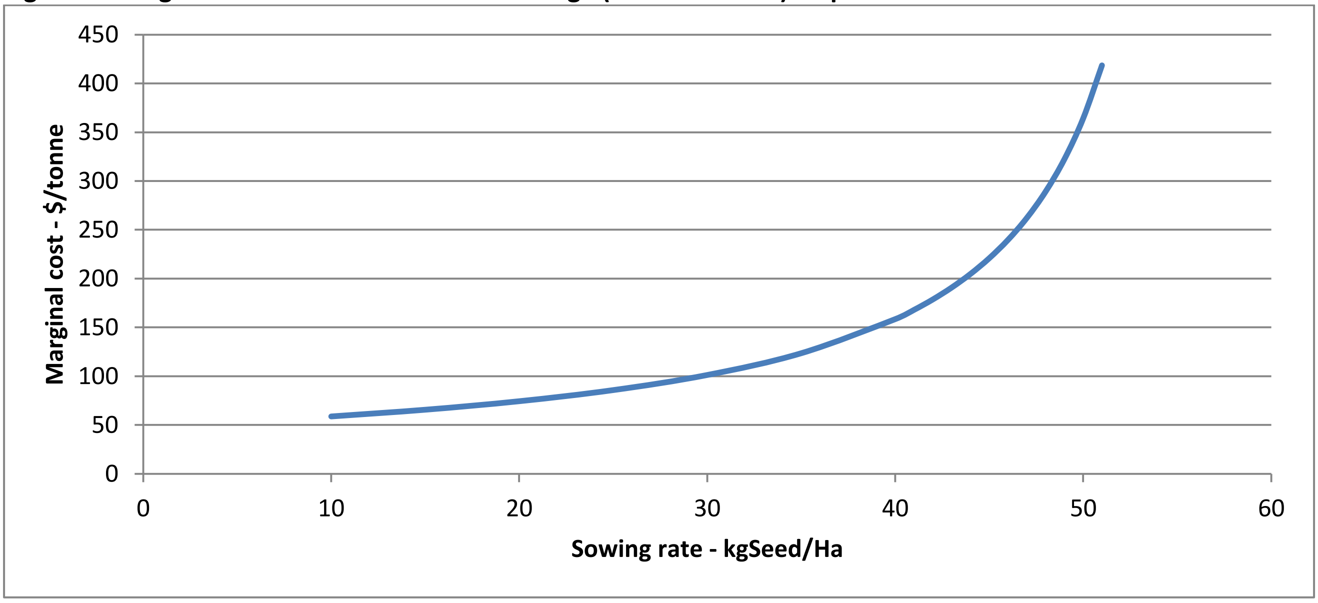



**Table 1. Change in profit from optimising sowing rates**

| Sowing rate | Total yield | Change in yield from lower rate | Change in costs | Supplementary feed saved (assuming $200/tonne) | Change in profit from lower rate | Cumulative change in profit |
|---|---|---|---|---|---|---|
| kgSeed/Ha | tonne/Ha | tonne/Ha | $/Ha | $/Ha | $/Ha | $/Ha |
| 15 | 9.82 | - | - | - | - | - |
| 20 | 10.18 | 0.36 | 25 | $72 | $47 | $47 |
| 25 | 10.49 | 0.31 | 25 | $63 | $38 | $84 |
| 30 | 10.76 | 0.27 | 25 | $54 | $29 | $113 |
| 35 | 10.99 | 0.22 | 25 | $45 | $20 | $133 |
| 40 | 11.17 | 0.18 | 25 | $36 | $11 | $144 |
| 45 | 11.30 | 0.14 | 25 | $27 | $2 | $146 |
| 50 | 11.39 | 0.09 | 25 | $18 | -$7 | $139 |

The assumptions used in Table 1 are that a producer is using Italian ryegrass to fill a winter feed gap, and that in winter they are supplementary feeding at a cost of $200/tonne. It is assumed that any additional feed grown in winter reduces their winter feed bill. The last two columns also assume they are currently sowing 15 kgSeed/Ha.

The table calculates benefit in a step-wise manner. For instance, if the producer moves from sowing 15 kgSeed/Ha to 20 kgSeed/Ha they grow an additional 0.36 tonne of feed. To achieve this they buy $25 of seed (5kg at $5/kg) which reduces their winter feed bill by $72 (0.36 tonne at $200/tonne). The net effect of this decision is a $47/Ha increase in profit.

Next the producer must decide if increasing sowing rate further will further increase profit. Again the producer increases sowing rate by 5kg/Ha, thus spending another $25/Ha. This decision results in an additional 0.31 tonne of winter feed being grown. Due to the diminishing marginal return the benefit of this decision (moving from 20 to 25 kgSeed/Ha) is smaller than the benefit of the previous change to the system, however the 0.31 tonne of feed is worth $63 and the seed only cost $25, this decision makes an additional $38/Ha profit.

These two decisions (moving from 15kg/Ha to 25kg/Ha) have made the producer an additional $84/Ha profit.

We continue to make similar stepwise decisions, each making a little less additional profit than the last, but each being rational as they further increase profit. Eventually we reach a point where, due to the diminishing marginal return the increase in profit from reducing the winter feed bill only just pays for the increase in seed cost. It is at this point that the producer has maximised profit from the system. We can see in Table 1, this appears to occur at around 40 to 45 kgSeed/Ha. While we could increase yield further with more seed, such a decision would be irrational as the seed would cost more than the feed gained from this point onwards.

How close you push the system towards the optimum is up to the producer's appetite for risk. You can see that the move from 30 to 35 kgSeed/Ha increases profits by an additional $20/Ha ($25 cost and $45 savings) but from this point onwards there is not much slack left in the system. Risk is discussed in more detail below.

**Managing the risks**

<u>How robust is the response?</u>

To understand how robust (does it change much from year to year) the response to sowing rate is, we can look at the quite different individual years data and decisions we would have made, do these differ much from the average response we have used in the decision making tool? Individual years data, responses and cost analysis are presented in Table 2.

**Table 2. Cumulative change in profit in individual years**

| Sowing rate | Total yield | | Marginal response | | Change in yield from lower rate | | Change in costs | Supplementary feed saved (assuming $200/tonne) | | Change in profit from lower rate | | Cumulative change in profit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kgSeed/Ha | tonne/Ha | | tonne/Ha/kgSeed | | tonne/Ha | | $/Ha | $/Ha | | $/Ha | | $/Ha | |
| Both years | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 | Both years | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| 15 | 10.44 | 9.20 | 93 | 59 | - | - | - | - | - | - | - | - | - |
| 20 | 10.88 | 9.48 | 82 | 53 | 0.44 | 0.28 | 25 | 87 | 56 | 62 | 31 | 62 | 31 |
| 25 | 11.26 | 9.73 | 71 | 46 | 0.38 | 0.25 | 25 | 76 | 49 | 51 | 24 | 114 | 55 |
| 30 | 11.58 | 9.94 | 60 | 39 | 0.33 | 0.21 | 25 | 65 | 42 | 40 | 17 | 154 | 72 |
| 35 | 11.86 | 10.12 | 49 | 32 | 0.27 | 0.18 | 25 | 54 | 36 | 29 | 11 | 183 | 83 |
| 40 | 12.07 | 10.26 | 38 | 25 | 0.22 | 0.14 | 25 | 43 | 29 | 18 | 4 | 202 | 87 |
| 45 | 12.23 | 10.37 | 27 | 19 | 0.16 | 0.11 | 25 | 32 | 22 | 7 | -3 | 209 | 84 |
| 50 | 12.34 | 10.45 | 16 | 12 | 0.11 | 0.08 | 25 | 21 | 15 | -4 | -10 | 205 | 74 |
| 51 | 12.35 | 10.46 | 13 | 11 | 0.01 | 0.01 | 5 | 3 | 2 | -2 | -3 | 203 | 71 |

We can see in either year that the 35 kg/Ha sowing rate is a good decision. In both years it would have captured most additional profit from adjusting rowing rate without pushing the system past its optimum.

What about years with different prices?

The recommendation to sow 35 kg/Ha in a monoculture is based on the assumption that feed grown displaces bought in feed at $200/tonne. What if the price of feed changes? A producer might incorrectly believe feed grown is worth $100 a tonne because that's what they believe their hay is worth. This would be incorrect as hay this cheap would have a very low feed value of (perhaps 9ME) whilst the Italian ryegrass will have a much higher energy value (approximately 12ME) and there are costs associated with feeding out. Likewise, a dairy producer purchasing supplement at $400/tonne may think the feed is worth $300/tonne, assuming a 75% utilisation of the grass. Table 3 goes through these different scenarios using the average response (2013 and 2014) and various feed prices.

**Table 3. Cumulative change in profit under different supplementary feed prices**

| **Sowing rate** | **Total Yield** | **Change in yield from lower rate** | **Change in costs** | **Supplementary feed saved** Price per ton below | | | | **Cumulative change in profit** Price per ton below | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **kgSeed/Ha** | - | - | - | **Feed values ($/tonne)** | | | | | | | |
| | | | | **$100** | **$200** | **$300** | **$400** | **$100** | **$200** | **$300** | **$400** |
| | **tonne/Ha** | **tonne/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** | **$/Ha** |
| 15 | 9.82 | - | - | - | - | - | - | - | - | - | - |
| 20 | 10.18 | 0.36 | 25 | 36 | 72 | 107 | 143 | $11 | $47 | $82 | $118 |
| 25 | 10.49 | 0.31 | 25 | 31 | 63 | 94 | 125 | $17 | $84 | $152 | $219 |
| 30 | 10.76 | 0.27 | 25 | 27 | 54 | 81 | 108 | **$19** | $113 | $207 | $301 |
| 35 | 10.99 | 0.22 | 25 | 22 | 45 | 67 | 90 | $17 | $133 | $250 | $366 |
| 40 | 11.17 | 0.18 | 25 | 18 | 36 | 54 | 72 | $10 | $144 | $279 | $413 |
| 45 | 11.30 | 0.14 | 25 | 14 | 27 | 41 | 54 | -$2 | **$146** | $294 | $442 |
| 50 | 11.393 | 0.09 | 25 | 9 | 18 | 27 | 36 | -$18 | $139 | **$297** | **$454** |
| 55 | 11.439375 | 0.05 | 25 | 5 | 9 | 14 | 19 | -$38 | $124 | $286 | $447 |

We can see from Table 3 that optimum sowing rates remain high even if the cost of supplement is low, if you use the unrealistically low value of $100/tonne, the optimum is still 30 kgSeed/Ha. If the value of feed is higher than $200/tonne, as might be the case in a dairy, the optimum sowing rate increases further, but the recommended and conservative rate of 35 kg/Ha still captures the majority of potential profits.

What if the season finishes early?

To think about how an early finish to the season (no late spring or summer growth) might affect the optimum sowing rate, look back to Figures 1 and 2 that graphs all cuts from the 2013 and 2014 trials respectively. We see a sowing rate response in the first couple of cuts in each year, but by spring and late spring all sowing rates yield the same amount of forage. As such, if we miss out on the last couple of grazings for the season, it won't affect how much better the 35 kgSeed/Ha rate is than the 15 kgSeed/Ha rate - it is these differences that drive our decision about sowing rate.

The differences that drive our decision are observed in winter (or Autumn if you sow early enough) when growth rates are most unlikely to be effected by moisture stress in a Mediterranean climate, as such whether the season finishes early or late has no bearing on what our sowing rate ought to be. If an early finish to the season is experienced we will already have benefited from the 35kgSeed/Ha sowing rate in the winter.

What if the seed is over-sown or dropped instead of drilled

When over sowing run down pastures, it is expected the benefits of higher sowing rates will depend on the ground cover of existing pasture.  As response to sowing rate when over sowing has not been investigated, at this stage we wouldn't recommend this work be directly applied, growers should continue with existing practice until further research suggests otherwise.  It would seem logical that seed dropped and rolled would benefit from higher sowing rates in a similar way to drill sown seed.  The work to confirm that has not yet been completed and it's something that should be looked at.

## Conclusion

This work demonstrates that like annual ryegrass, Italian rye grass yield increases with sowing rate and that there is a diminishing marginal return.  We also demonstrate that as the increased yield occurs in the first couple of grazing's, sowing rate can be used to alter winter feed supply.  Using marginal cost analysis we demonstrate producer profit is likely maximised with a sowing rate of approximately 35 kgSeed/Ha and that this recommendation is relatively robust to different seasons and supplementary feed prices.  It is also shown that the recommendation maximises profit in seasons with early or late finishes.  It is recommended that producers adopt a 35kgSeed/Ha sowing rate for Italian ryegrass sown in monocultures as it can result in an increase in profit in the order of $100 to $200 per hectare sown.