Sowing Date Affects Dry Matter Yield of Fodder Beet (*Beta vulgaris* L.) Crops and Farm Profitability

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Abstract

Fodder beet (*Beta vulgaris* L.) is a high yielding and high energy supplementary ruminant feed. Including the crop in a pasture system means loss in production and additional costs during crop establishment, but economic benefits may be recovered with increased seasonal productivity and feed quality. In this study, the **A**gricultural **P**roduction **S**ystems s**IM**ulator was used to estimate herbage production of a typical dairy farm in the Canterbury region of New Zealand based on using a ryegrass (*Lolium perenne* L.)-clover (*Trifolium repens* L.) pasture ("Pasture only") or pasture in combination with fodder beet as winter feed ("Pasture+Fodder beet (FB)"). Mean yields of pasture were used to estimate the potential pasture yield lost from spraying out paddocks 1 month before establishing fodder beet. Fodder beet ('Rivage') yields from a 2014 sowing date trial: 19 September (Sep-FB), 17 October (Oct-FB), 17 November (Nov-FB), and 15 December (Dec-FB) were used. Dry matter (DM) yield was determined on 15 June 2015. Yield was 27 t DM/ha for both Sep-FB and Oct-FB and was reduced by 23 and 32% in Nov-FB and Dec-FB, respectively. The total annual yield for "Pasture only" was 16.7 t DM/ha compared with adjusted yield of 29.5, 30.2, 25.7 and 24.9 t DM/ha for "Pasture+Sep-FB", "Pasture+Oct-FB", "Pasture+Nov-FB" and "Pasture+Dec-FB", respectively. Production cost was NZ$0.08/kg DM each for "Pasture+Sep-FB" and "Pasture+Oct-FB", which was lower than NZ$0.09/kg DM for "Pasture only". Production costs increased to NZ$0.11/kg DM for "Pasture+Nov-FB" and NZ$0.12/kg DM for "Pasture+Dec-FB", but revenue from sale of surplus feed partially offset these costs. Our results show that sowing in October was the most profitable option. Yield gains from sowing fodder beet in September are unlikely because of low temperatures limiting crop growth. Delaying sowing can increase production costs and yield penalty, but potential returns are greater, compared with "Pasture only".

Introduction

In New Zealand, fodder beet (*Beta vulgaris* L.) production for supplementing ruminant stock increased rapidly in the 2000s. This was driven by the crop's high dry matter (DM) production (≥20 t DM/ha) and energy value (metabolisable energy ≥12 MJ/kg DM) (Matthew et al. 2011; Gibbs 2014). Fodder beet also requires less nitrogen (N) for production than alternative winter feed crops such as forage brassicas (Chakwizira et al. 2014, 2015). Therefore, incorporating fodder beet in a pasture renewal system provides the option to produce low-cost and high-quality feed with high N use efficiency. This appeals to farmers who are challenged to increase production, while reducing N lost from the paddock and whole-farm levels. Options for maximising DM production and minimising input costs while providing best environmental outcomes need to be understood.

Sowing date is one of the most important management factors affecting yield of fodder beet (Martin 1983; Khaembah et al. 2019). In New Zealand, the crop is commonly sown in October and grazed in June, although commercial seed companies recommend sowing any time between September and November (Specialty Seeds NZ 2019). Yield is strongly dependent on solar radiation intercepted over the growth of the crop. Therefore, early sowing to closely match leaf canopy development with seasonal radiation can help maximise fodder beet yield. However, yield benefits from early sowing can be hindered by low spring temperatures (Khaembah et al. 2019). In a dairy system, early sowing of fodder beet requires paddocks to be sprayed out of pasture at least a month before the crop is sown, reducing pasture production. On the other hand, sowing fodder beet late extends the growth season of pasture, but shortens the growth period and reduces DM yield of fodder beet (Martin 1983; Khaembah et al. 2019). The trade-offs in biomass production associated with different spring sowing dates of fodder beet indicate that the timing of pasture and fodder beet growth can have economic implications for a dairy farm system.

The objective of this study was to estimate feed production and the economic outcomes associated with different sowing dates for fodder beet as part of a pasture renewal system for a typical dairy farm in the Canterbury region of New Zealand.

Materials and methods

Whole-farm DM production and gross margins were based on continuous pasture comprising perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) mix or in rotation with fodder beet for a farm in Canterbury, New Zealand. Dry matter production was estimated by the **A**gricultural **P**roduction **S**ystems s**IM**ulator (APSIM) model (Holzworth et al. 2018). Pasture estimates were verified using historical yields for the region (DairyNZ 2018). Measured fodder beet yields, also well-predicted by APSIM, were used (Khaembah et al. 2017, 2019). Pasture was sown on 19 August 2004 and was managed as a grazed crop. The crop was carried through to 15 June 2015 ("Pasture only") or ended a month before the sowing of fodder beet ("Pasture+fodder beet"). Monthly yields averaged over 2004–2014 were used to estimate the pasture DM forfeited for the month preceding fodder beet sowing. Fodder beet ('Rivage') was sown on four different dates in 2014: 19 September (Sep-FB), 17 October (Oct-FB), 17 November (Nov-FB) and 15 December (Dec-FB) and DM production was determined on 15 June 2015 (Khaembah et al. 2019). Treatments were allocated to separate paddocks, and therefore production and economic comparisons made among those separate paddocks. Whole-season feed surplus and deficit for each feed combination were calculated based on the DairyNZ Facts and Figures guidelines (DairyNZ 2012). The total annual feed deficit or surplus was estimated based on an annual feed requirement (including winter feed) of 19.6 t DM/ha (11.0 MJ ME/kg DM) for a typical Canterbury dairy system (Jersey x Friesian crossbreed cows, stocking rate = 3.5 cows/ha, milk production = 450 milksolids/cow/yr) (DairyNZ 2012). The "Pasture+fodder beet" DM were energy-corrected to 11.0 MJ ME/kg DM for all feed combinations using the procedure outlined in DairyNZ Facts and Figures (DairyNZ 2012). An energy value of 12.5 MJ ME/kg DM for fodder beet reported by Chakwizira et al (2014) was used in the conversion.

Gross margins were calculated as revenue minus expenses. A price of NZ$0.25/kg DM was used to estimate revenue associated with sale of surplus feed or expenses incurred from purchase of supplementary feed. Production costs used in calculations were NZ$0.09/kg DM (DairyNZ 2016) for pasture and NZ$2,400/ha for fodder beet.

Results

Fodder beet sown in September and October did not differ in yield, but sowing in November and December reduced yield by 23 and 32%, respectively (Table 1). Irrespective of the sowing date of fodder beet, DM yield was greater for combined "Pasture+fodder beet" compared with "Pasture only" and exceeded the 19.6 t DM/ha requirement for a typical Canterbury dairy farm (Table 1). "Pasture only" production was insufficient to meet the annual feed requirement, and 2.9 t DM/ha of imported feed was required (Table 1). The "Pasture+Oct-FB" combination, which is the current industry standard, produced 3–21% more annual DM than the rest of the "Pasture+fodder beet" combinations. The cost of production for "Pasture+Sep-FB" and "Pasture+Oct-FB" was NZ$0.08/kg DM and increased to NZ$0.11 and NZ$0.12/kg DM for "Pasture +Nov-FB" and "Pasture+Dec-FB, respectively. Overall, the margins were greater from "Pasture +fodder beet" combinations than "Pasture only", with "Pasture+Oct-FB" giving the highest returns (Table 1).

Table 1: Annual dry matter (DM) production of a pasture only or pasture in combination with fodder beet (FB) crops drilled on four different sowing dates, associated costs production and gross margins for a typical dairy farm in Canterbury, New Zealand. Sep-FB, Oct-FB, Nov-FB and Dec-FB represent fodder beet crops sown in September, October, November and December, respectively.

Parameter	**Feed combination**				
	Pasture only	Pasture+Sep-FB	Pasture+Oct-FB	Pasture+Nov-FB	Pasture+Dec-FB
Pasture yield (t DM/ha)	16.7	0.8	1.7	3.6	5.4
Fodder beet yield (t DM/ha)	-	27.1	26.9	20.8	18.4
Energy-corrected total yield (t DM/ha)	16.7	29.5	30.2	25.7	24.9
Surplus (t DM/ha)	-	9.9	10.6	6.1	5.3
Deficit (t DM/ha)	2.9	-	-	-	-
Production cost (NZ$)	1,503	2,470	2,554	2,726	2,888
Imported feed cost (NZ$)	725	-	-	-	-
Revenue (NZ$/ha)	-				
Margin (NZ$/ha)	–2,228	6	103	–1,208	–1,556

Discussion

The aim of study was to evaluate the effect of fodder beet sowing date on DM production and the subsequent impact on the feed supply of a typical Canterbury dairy system using fodder beet as part of a pasture renewal process. Results indicate that growing fodder beet improved the feed supply of the farm with potential surplus feed from all "Pasture+fodder beet" combinations.

Sowing fodder beet in September did not result in DM gains compared with the traditional sowing date of October because low temperatures slowed germination and growth as detailed by Khaembah et al. (2019). Thus, Sep-FB production did not add to the annual system yield potential compared with the Oct-FB treatment. Therefore, under the conditions of this study, it would be more beneficial for a farmer to extend the pasture growth season and sow fodder beet in October.

Late sowing in November and December reduced fodder beet yield, and additional pasture production prior to the sowing of fodder beet did not compensate for the yield loss. Therefore, there was an overall net reduction in yield for these treatments. Despite these disadvantages, per ha DM production of these late-sown fodder beet crops in combination with pasture yields were in excess of 27–31% of the base feed requirement (i.e. 19.6 t DM/ha). Based on these findings, sowing fodder beet even as late as mid-December would be more cost-effective than importing supplementary feed under the "Pasture only" system. It is important to note that yields reported here were from fully irrigated crops. Thus, the decision to sow late will be influenced by the availability of adequate soil moisture to support crop growth. Without sufficient rainfall, sowing late under dryland conditions could represent a significant risk of low yields or even crop failure. For those farmers who routinely use irrigation as part of their crop management, water restrictions could affect yield especially in late sown fodder beet crops.

Sowing fodder beet and delaying the time of sowing of the crop increased the cost of production, raising the question of whether or not these costs are more than compensated for by increased DM production. Gross margin analysis indicated that the cost of operating a "Pasture only" system and importing supplementary feed to cover the deficit was greater than any of the "Pasture+fodder beet" systems. When calculating margins, however, "Pasture only" and "Pasture+fodder beet" combinations were assumed to be separate entities (treatments allocated to individual paddocks). It is therefore expected that results will be different if margins were based on fodder beet crops being sown in only a proportion of the farm.

Conclusions

This study shows that growing fodder beet can increase the amount of home-grown feed supply for Canterbury dairy farm systems. Dry matter production of fodder beet was affected by sowing date. Farmers would benefit from extra pasture grazing event(s) instead of sowing fodder beet in September because of the restriction of crop growth by low early-spring temperatures. This outcome needs to be considered with caution, as the study was conducted in one location within the Canterbury region and for only one season. Yield penalties and increased production costs are expected with delayed sowing of fodder beet. However, results indicate that DM production from delayed sowing even as late as December can partially offset these costs. Sowing fodder beet in October was the best option because it resulted in the greatest production gains and highest returns.

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References

Chakwizira, E., de Ruiter, J.M. and Maley, S. 2014. Growth, nitrogen partitioning and nutritive value of fodder beet crops grown under different application rates of nitrogen fertiliser. *N Z. J Agric. Res*., 57(2): 75-89.

Chakwizira, E., de Ruiter, J.M. and Maley, S. 2015. Effects of nitrogen fertiliser application rate on nitrogen partitioning, nitrogen use efficiency and nutritive value of forage kale. *N Z. J Agric. Res*., 58 (3): 259-270.

DairyNZ. 2012. Facts and figures for New Zealand dairy farmers. https://www.dairynz.co.nz/publications/dairy-industry/facts-and-figures/ [Accessed 11/05/2020]

DairyNZ. 2016. Cost of Pasture Calculator. https://www.dairynz.co.nz/Search/Results?Term=pasture+calculator. [Accessed 11/05/2020].

DairyNZ. 2018. Average pasture growth data by region. https://www.dairynz.co.nz/feed/pasture-management/pasture-growth-data/ [Accessed 11/05/2020].

Gibbs, J. 2014. Fodder beet in the New Zealand dairy industry. In: *The South Island Dairy Event*. SIDE, pp 1-8.

Holzworth, D., Huth, N.I., Fainges, J., Brown, H., Zurcher, E., Cichota, R., Verrall, S., Herrmann, N.I., Zheng, B. and Snow, V. 2018. APSIM Next Generation: Overcoming challenges in modernising a farming systems model. *Environ. Model. Softw*.,103: 43-51.

Khaembah, E.N., Brown, H.E., Zyskowski, R., Chakwizira, E., de Ruiter, J.M. and Teixeira, E.I. 2017. Development of a fodder beet potential yield model in the next generation APSIM. *Agric. Syst*., 158: 23-38.

Khaembah, E.N., Maley, S., George, M., Chakwizira, E., de Ruiter, J., Zyskowski, R. and Teixeira, E. 2019. Crop growth and development dynamics of two fodder beet (Beta vulgaris L.) cultivars sown on different dates in New Zealand. *N Z. J Agric. Res*., DOI: 10.1080/00288233.2019.1692042.

Martin, R.J. 1983. Effect of cultivar, sowing date, and harvest date on yields and sugar contents of beet on a dry land site in Canterbury. *N Z. J Exp. Res*., 11(3): 191-197.

Matthew, C., Nelson, N.J., Ferguson, D. and Xie, Y. 2011. Fodder beet revisited. *Agron. N. Z*., 41: 39-48.

Specialty Seeds NZ. 2019. Fodder beet. http://www.specseed.co.nz/portfolio-item/fodder-beet/ [Accessed 04/03/2020].