

Crop Management Research Report

Penn State University
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Evaluation of Fodder Beets as a Feedstock for PA Ethanol Production

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Locations: Rock Springs, Centre County; Landisville, Lancaster County; Shickshinny, Luzerne County; Middlebury Center, Tioga County; Somerset, Somerset County.

Collaborators: Pennsylvania Department of Agriculture; Mr. John Lucas, Luzerne County; Mr. Oliver Butler, Tioga County; and Ken Soldano, Somerset County.

Research Objective: To evaluate the performance of two varieties of fodder beets in Pennsylvania under various growing conditions and to evaluate the potential for ethanol production from the beets grown at each location.

Background: Fodder beets could have potential as an ethanol feedstock crop in Pennsylvania. Previous studies in the 1980's in the state indicated the crop could be grown here and suggested yields as high as 50 tons/acre could be achieved. The Fodder beet is a high yielding forage crop obtained by crossing two beet species: Sugar and Mangolds. The potential advantages of fodder beets compared to sugar beets are higher yield of fermentable sugars per acre, higher resistance to loss of fermentable sugars during storage, and the culture of fodder beets is less demanding than sugar beets. Fodder beets require a deep, well-drained soil with pH in the range of 6.5 to 8.0. The crop needs a good supply of water and fertilizer to produce maximum tonnage. A plant population of 28,000 plants/acre is considered ideal, but plant populations between 20,000 and 40,000 per/acre will yield about the same amount of sugar per acre. One of the potential advantages of fodder beets for making ethanol is that less energy is required compared to making ethanol from corn. The corn to ethanol process requires that corn be boiled for 20-30 minutes during the conversion of starch to sucrose before the fermentation can begin.

Study Description: The Fodder beet seed was provided by DLF Seeds (Danisco Seed) from Denmark. In addition to the Fodder beets a small trial consisting of two plots of both Sugar and Mangel beets was planted at each location. The Sugar beet seeds (designated as PAEB0801RZ) were provided by Syngenta seed and Mangel beet seeds were provided by P.L. Rohrer Seeds from Smoketown, Pennsylvania. All locations were planted between April 23-26 with a 2-row John Deere corn planter equipped with Almaco planting cones and seeded at a rate of 48,000 seeds/acre. All plots were planted as 4 rows, spaced 30 inches apart (10 feet wide) and 25 feet in length. The fodder beet trials were planted as a randomized complete block design with 4 replications, while the sugar and mangel beet trials had 2 replications in a randomized complete block design.

At each site a starter fertilizer of 10-20-20 was applied at 100 pounds per acre 2 inches beside the seed at planting and nitrogen fertilizer was applied pre-plant at 105 pounds of N per acre. Soil fertility levels were in the optimum range for pH, P and K. Weed control at all sites was provided by a pre-emergence application of Nortron, and a post-emergence application of Progress, Upbeat, and Outlook. Some location also required an application of Select for grass pressure. No mechanical harvesting equipment was available, so all harvesting was accomplished by digging with a homemade "beet fork", which could be described as a 2-pronged pitchfork.

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locations obtaining full canopy by July 15. During the 2007 crop year, the beets never reached full canopy. Crop emergence was faster this year with the later planting date. However, we only had plant populations in the 20,000-25,000 plants per acre range, less than our 28,000 target. The trial in Somerset had very low populations in all plots and was not harvested, but the plants that were present grew extremely well. The low populations were caused in part by an extremely heavy rainfall (>7 inches) which occurred soon after planting.

Mean fodder beet yields ranged from 19.4 tons/acre to 43.4 tons/acre at the Tioga location (Table 1). The high yields at the Tioga location were due to the lack of disease pressure and generally good growing conditions throughout the year. At Landisville, beet growth and vigor was good throughout the year, but disease pressure from *Cercospora* leaf spot caused some defoliation and likely limited yields. At the Luzerne location, dry conditions in the late summer limited beet development. At Rock Springs, dry conditions and poor soil structure likely limited the beet development. Averaged over all locations, the fodder beet yields averaged 30.1 tons/acre. This year the Kyros beets yielded higher than the Nestor beets at all four locations with three of these differences being statistically significant. The average yield advantage of the Kyros beets in 2008, averaged across all locations, was 9.1 tons/acre.

Sugar and mangel beet yields averaged 22.2 tons/acre with mangel beets yielding 25.7 tons/acre and sugar beets yielding 18.6 tons/acre (Table 2). Due to the low number of replications, these differences were only significant at the Tioga County location. In general, the sugar beet variety used had less vigor at most sites than either the mangel or the fodder beets. Mangel beets are much more uneven in size than the sugar or fodder beets and this would likely be an issue in mechanical processing of the beets.

The results for the 2008 season were similar to those observed in the 2007 season. For example in 2007, fodder beet yields averaged 25.6 tons/acre with Kyros tending to have higher yields than Nestor at all locations (Table 3). Averaged over both years, fodder beet yields averaged 27.9 tons/acre, with a 6.2 ton/acre advantage for the Kyros variety (Table 4). Trends for the sugar and mangel beet evaluations in 2007 were also similar to 2008, with trends for higher yields for the mangel beets at most locations (Table 5) and averaged over all locations during both years, mangel beets yielded 8.9 tons/acre more than sugar beets (Table 6). Ethanol analyses of the beets are pending. These will allow us to estimate the potential ethanol yields of the various treatments.

Conclusion: Based on this study, and results to date, fodder beet production is possible in Pennsylvania, with the potential for some very high yields at some locations. Yields could likely be improved with more consistent weed and disease control and perhaps the use of narrower rows like 20 or 22 inches which are common in sugarbeet production. Mangel beets can also produce high yields of material as well, but their uneven size and potentially lower sugar content could limit their usefulness. The sugar beet varieties we used had lower yields than the fodder or mangel beets, but could still be a potentially viable energy crop depending on the sugar content.

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Table 1. Fodder beet yield at four locations in Pennsylvania in 2008.

Variety	Beet yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Kyros	42.9	24.0	23.0	48.6	34.6
Nestor	32.8	15.2	15.9	38.1	25.5
LSD (0.05)	7.6	ns (p=.09)	2.8	8.7	
Mean	37.9	19.6	19.4	43.4	30.1

Table 2. Mangel and sugar beet yield at four locations in Pennsylvania in 2008.

Variety	Beet Yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Sugar beet	20.3	11.8	14.5	27.7	18.6
Mangel	33.5	11.3	21.3	36.6	25.7
LSD (0.05)	ns	ns	ns (p=.07)	7.6	
Mean	26.9	11.6	17.9	32.2	22.2

Table 3. Fodder beet yield at four locations in Pennsylvania in 2007.

Variety	Beet yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Kyros	32.9	18.0	24.9	33.5	27.3
Nestor	27.9	13.7	23.1	31.0	23.9
LSD (0.05)	ns	1.8	ns	ns	
Mean	30.4	15.9	24.0	32.2	25.6

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Table 4. Two year average, fodder beet yield at four locations in Pennsylvania in 2007 and 2008.

Variety	Beet yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Kyros	37.9	21.0	24	41.1	31.0
Nestor	30.4	14.5	19.5	34.6	24.8
Mean	34.2	17.8	21.8	37.9	27.9

Table 5. Mangel and sugar beet yield at four locations in Pennsylvania in 2007.

Variety	Beet Yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Sugar beet	22.3	11.4	18.2	14.8	14.8
Mangel	36.3	21.0	29.4	26.7	25.7
LSD (0.05)	ns	ns	ns	ns	
Mean	36.3	16.2	23.8	20.8	20.3

Table 6. Two year average, mangel and sugar beet yield at four locations in Pennsylvania in 2007 and 2008.

Variety	Beet Yield (Tons/Acre)				Mean
	Landisville	Luzerne	Rock Springs	Tioga	
Sugar beet*	21.3	14.0	16.4	21.3	18.3
Mangel	34.9	16.9	25.4	31.7	27.2
Mean	28.1	15.5	20.9	26.5	22.7

* different sugar beet varieties used each year.

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