# PREVIOUS CROP EFFECTS ON SUGARBEET PRODUCTION IN 2001

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Crop rotation has been used for centuries as a means to enhance crop productivity by increasing available nitrogen by using a legume crop and/or decreasing insect and disease problems. Crop rotation is important in sugarbeet to help control diseases like rhizoctonia root rot and cercospora leafspot or insects like the sugarbeet root maggot and sugarbeet nematode. Some crop sequence research in sugarbeet is available (Soine, 1975; Smith et al., 1988; Nordgarrd et al., 1981; Roebke et al., 1994), but no experiment had compared a wide range of crops under controlled conditions.

The sugarbeet crop presently is being grown in 3- to 4-year rotations with about 89% grown after small grains in the American Crystal Sugar district and 75 to 80% in Minn-Dak district, but about 72% is grown after corn and 12% after soybean in Southern Minn. (Personal comm. A. Cattanach, 1999).

American Crystal Sugar Company summarized their producer results from 1989 to 1998 on the effect of preceding crop on sugarbeet yield and quality (Personal comm. A. Cattanach, 1999). The best to poorest ranking of previous crops based on recoverable sugar/acre was field pea, edible beans, corn, potato, alfalfa, wheat, barley, flax, sunflower, sugarbeet, fallow, oat, and soybean; however, field pea, flax, sunflower, sugarbeet, and alfalfa results were based on 262 to 1500 acres and corn, oat, and soybean on about 5000 acres. The small acreage could bias the ranking due to individual producer differences in production. In addition, some crops like mustard and canola were not included and some like navy bean and pinto bean, and durum and wheat were lumped together.

Our objective was to determine the effects of 18 previous crops on establishment, yield, and quality of sugarbeet.

## Materials and Methods:

Eighteen previous crop treatments; six grasses (hard red spring wheat, barley, durum, oat, corn, and sudangrass); five legumes (alfalfa grown as an annual, pinto bean, navy bean, soybean, and field pea); four oilseeds (sunflower, canola, mustard, and flax); and sugarbeet, potato, and fallow; were grown in 2000 at two locations (Fargo and Prosper, ND). The field design was a randomized complete block with four replicates. The grain/seed/tuber/root yields in 2000 and the soil nitrate-nitrogen level during the fall were presented by Meyer et al. (2001).

Nitrogen fertilizer needed to have 120 lb/a in the top four feet of soil was calculated from the soil test of each plot and applied during the spring to the nearest 10 lb/A increment. All previous crop residues were incorporated by rototilling during the spring since the late fall conditions were too wet to allow tillage. Sugarbeet (Hilleshog Empire RR, a Roundup Ready cultivar) was seeded in six 22-inch rows across all previous crop treatments utilizing a John Deere Max Emerge II planter immediately following rototilling. Fargo was planted on May 3 while Prosper was planted on May 18 due to spring flooding delaying seedbed preparation. Two seed densities (3.5 and 4.6 inches between seeds) were used. The 3.5-inch spacing was thinned to 175 plants/100 feet of row about 5 weeks after emergence and the 4.6-inch spacing was considered "seeded-to-stand". The plant density treatment was laid out in the field as a stripped split plot.

Weed control at Fargo was obtained with three applications of Roundup at 0.5 lb a.i./acre and two applications at Prosper, which gave excellent weed control. Cercospora leafspot was controlled with two applications of Quadris fungicide applied at 14 oz/acre. Cercospora control was excellent with little indication of the disease during the first week of August so no further fungicide application was made. Harvest population was determined by counting the roots in the middle two rows following flailing of the tops. Sugarbeet yield was obtained by harvesting the middle two rows of each plot 20 feet in length. Representative roots from all plots were taken for quality analysis and submitted to American Crystal Sugar Company, Moorhead, MN, for determination on these transgenic samples. Quality analyses included percent sugar, percent dirt, and impurities.

## Results and Discussion

Analysis of variance of all measured variables across locations indicated a highly significant interaction between location and treatment for root yield, recoverable sugar/acre, gross sugar/acre, amino-N, cercospora leafspot at harvest, and yellowing of canopy and a significant interaction for percent sugar, sugar/ton, and sugar loss to molasses (SLM). As a result, data were analyzed and presented within each location (Tables 1 and 2).

At Prosper, no character measured was significantly different between seeding-to-stand and thinned treatments; however, percent sugar, sugar/ton, and SLM approached significance. Likewise, there was no significant interaction between previous crop and seed density treatments. Seeded-to-stand treatments averaged 160 plants/100 feet of row while thinned treatments average 165 plants/100 feet of row at harvest with no differences among the previous crop treatments. Therefore, data in Table 1 are presented as the average across the seed density treatments.

Root yields of sugarbeet, corn, and soybean previous crop treatments were significantly less than barley, sudangrass, pinto bean, and oat (the highest yielding previous crops) with no trend among the various groupings of crops (Table 1). Recoverable sugar/acre was substantially lower from the sugarbeet treatment than other previous crop treatments. Recoverable sugar/acre from the corn treatment was less than sudangrass, the only other significant treatment. All other characters measured were not affected by the previous crop treatment if the sugarbeet treatment was deleted. Cercospora leafspot infected sugarbeet plots earlier and more severely than all other treatments following discontinuance of fungicide application, which probably cause the lower root yield and recoverable sugar yields.

At Fargo, harvest population was 36 plants/100 feet of row higher in the seeded-to-stand than the thinned plots, but all other measured characteristics, other than SLM, were not significantly different between the treatments. The SLM was 0.044% less for the seeded-to-stand than the thinned treatment. Since the seed density treatment did not interact with previous crop treatment for any measured characteristic, all subsequent data are presented as the average across the seed density treatments. Therefore, adequate stands (number of plants) of sugarbeet were established on all previous crop treatments at both Fargo and Prosper in 2001.

Table 1. Previous crop effects on sugarbeet production at Prosper, ND in 2001.

| Previous crop | Root yield | Sugar | Recoverable sugar | Sugar/ton | SLM[†] | Na | K | Amino N |
|---|---|---|---|---|---|---|---|---|
| | --T/A-- | --%-- | --lb/A-- | --lb/T-- | --%-- | ------------ppm----------- | | |
| Grasses | | | | | | | | |
| Wheat | 26.7 | 14.8 | 6933 | 295 | 1.75 | 477 | 1969 | 659 |
| Barley | 27.8 | 14.2 | 6820 | 283 | 1.92 | 708 | 1878 | 728 |
| Durum | 26.3 | 14.2 | 6466 | 285 | 1.95 | 722 | 1924 | 737 |
| Oat | 27.2 | 13.8 | 6486 | 275 | 1.95 | 744 | 1945 | 717 |
| Corn | 23.7 | 14.6 | 6122 | 293 | 1.69 | 487 | 1964 | 606 |
| Sudangrass | 27.6 | 14.6 | 7068 | 292 | 1.76 | 599 | 1859 | 648 |
| Mean | 26.5 | 14.4 | 6646 | 287 | 1.84 | 622 | 1923 | 682 |
| Legumes | | | | | | | | |
| Alfalfa | 26.5 | 14.6 | 6772 | 291 | 1.80 | 484 | 1964 | 696 |
| Pinto bean | 27.5 | 14.6 | 7033 | 292 | 1.82 | 599 | 1955 | 671 |
| Navy bean | 26.8 | 14.5 | 6794 | 290 | 1.79 | 537 | 1970 | 665 |
| Soybean | 25.2 | 14.4 | 6356 | 288 | 1.80 | 587 | 1926 | 668 |
| Field pea | 25.9 | 14.4 | 6544 | 289 | 1.82 | 593 | 2005 | 658 |
| Mean | 26.4 | 14.5 | 6700 | 290 | 1.81 | 560 | 1964 | 672 |
| Oilseed | | | | | | | | |
| Sunflower | 26.3 | 14.0 | 6360 | 281 | 1.89 | 740 | 1964 | 673 |
| Canola | 26.2 | 15.0 | 7006 | 300 | 1.70 | 535 | 1931 | 604 |
| Mustard | 26.8 | 14.8 | 7018 | 296 | 1.75 | 553 | 1938 | 637 |
| Flax | 26.1 | 14.6 | 6679 | 292 | 1.81 | 598 | 2040 | 640 |
| Mean | 26.3 | 14.6 | 6766 | 292 | 1.79 | 606 | 1968 | 638 |
| Other crops | | | | | | | | |
| Sugarbeet | 19.0 | 13.8 | 4613 | 277 | 1.68 | 569 | 2028 | 555 |
| Potato | 26.7 | 14.6 | 6823 | 292 | 1.82 | 496 | 2046 | 686 |
| Fallow | 27.0 | 13.9 | 6483 | 278 | 1.92 | 766 | 1887 | 701 |
| Overall mean | 26.1 | 14.4 | 6576 | 288 | 1.81 | 598 | 1952 | 667 |
| LSD (0.05)[‡] | 2.0 | 1.4[§] | 953 | 27[§] | 0.33[§] | 369[§] | 235[§] | 131[§] |

[†]Sugar loss to molasses, [‡]LSD for comparison among previous crops, not the means.

§Nonsignificant $F$-test.

Significant previous crop effects were detected by anaylsis of variance tests for all measured characteristics except root yield and potassium content at Fargo (Table 2). Root yields of sugarbeet, soybean, navy bean, mustard, and potato were less than sunflower, the highest yielding previous crop treatment (based on an unprotected LSD). Recoverable sugar/acre was greatest from the flax treatment followed by sunflower, oat, canola, and corn treatments and least from sugarbeet, potato, pinto bean, navy bean, soybean, and mustard treatments. Percent sugar and sugar/ton were highest following sudangrass, barley, and canola and lowest following fallow, pinto bean, and potato. Sugar loss to molasses and Na and amino-N content were greatest following fallow, pinto bean, and potato and least following sudangrass and

Table 2. Previous crop effects on sugarbeet production at Fargo, ND in 2001.

| Previous crop | Root yield | Sugar | Recoverable sugar | Sugar/ton | SLM† | Na | K | Amino N |
|---|---|---|---|---|---|---|---|---|
| | --T/A-- | --%-- | --lb/A-- | --lb/T-- | --%-- | ------------ppm----------- | | |
| Grasses | | | | | | | | |
| Wheat | 23.1 | 15.9 | 6581 | 318 | 1.63 | 199 | 2201 | 604 |
| Barley | 22.6 | 16.4 | 6688 | 328 | 1.58 | 155 | 2178 | 587 |
| Durum | 23.5 | 15.8 | 6567 | 315 | 1.75 | 223 | 2285 | 664 |
| Oat | 24.1 | 16.2 | 7049 | 324 | 1.64 | 185 | 2273 | 598 |
| Corn | 24.2 | 16.0 | 6962 | 321 | 1.67 | 209 | 2214 | 630 |
| Sudangrass | 22.6 | 16.6 | 6807 | 332 | 1.53 | 166 | 2091 | 568 |
| Mean | 23.4 | 16.1 | 6776 | 323 | 1.63 | 189 | 2207 | 608 |
| Legumes | | | | | | | | |
| Alfalfa | 24.0 | 15.5 | 6644 | 311 | 1.75 | 240 | 2239 | 676 |
| Pinto bean | 22.7 | 15.1 | 5970 | 302 | 1.95 | 319 | 2234 | 800 |
| Navy bean | 21.6 | 15.7 | 6035 | 315 | 1.78 | 239 | 2209 | 708 |
| Soybean | 21.4 | 15.7 | 6035 | 315 | 1.66 | 209 | 2167 | 636 |
| Field pea | 23.3 | 15.7 | 6504 | 313 | 1.71 | 228 | 2216 | 655 |
| Mean | 22.6 | 15.5 | 6238 | 311 | 1.77 | 247 | 2213 | 695 |
| Oilseed | | | | | | | | |
| Sunflower | 25.4 | 15.9 | 7238 | 319 | 1.71 | 206 | 2227 | 657 |
| Canola | 23.9 | 16.3 | 6969 | 326 | 1.73 | 168 | 2296 | 673 |
| Mustard | 21.8 | 15.8 | 6168 | 316 | 1.69 | 197 | 2203 | 650 |
| Flax | 25.2 | 16.1 | 7295 | 323 | 1.69 | 187 | 2239 | 646 |
| Mean | 24.1 | 16.0 | 6917 | 321 | 1.70 | 189 | 2241 | 656 |
| Other crops | | | | | | | | |
| Sugarbeet | 21.2 | 15.5 | 5733 | 310 | 1.80 | 205 | 2282 | 717 |
| Potato | 21.9 | 15.2 | 5863 | 305 | 1.90 | 260 | 2314 | 763 |
| Fallow | 23.9 | 14.9 | 6158 | 297 | 2.00 | 382 | 2173 | 831 |
| Overall mean | 23.2 | 15.8 | 6544 | 317 | 1.72 | 218 | 2223 | 665 |
| LSD (0.05)‡ | 2.9§ | 0.7 | 802 | 15 | 0.17 | 66 | 158§ | 95 |

†Sugar loss to molasses, ‡LSD for comparing one crop to another, not the means.
§Nonsignificant $F$-test.

barley. Cercospora leafspot rating at harvest was significantly higher following sugarbeet, mustard, and canola than the other previous crop treatments (data not presented), which may have reduced root yield, recoverable sugar/acre, and percent sugar for these previous crop treatments.

Recoverable sugar/acre for several previous crops was impacted greatly by early season yellowing and stunting of plants at Fargo (Fig. 1). Soybean, potato, navy bean, and to a lesser extent, pinto bean and mustard had severe yellowing and delayed canopy development during most of May and June (relatively wet period); however, these symptoms disappeared by mid to late July with the warm temperatures in late June and early July. The yellowing and delayed canopy development was more severe on the two tiers spring incorporated than on the one tier fall incorporated. Stunting in the potato treatment may have been due to a carryover of Matrix herbicide used in 2000, but the other crops had Basagran used for Canada thistle suppression and Poast for grass control, which should have caused no carryover problems. Therefore, we hypothesize that the yellowing and stunting was caused by an allelopathic response caused by a chemical(s) released from the residue, which appeared more severe on the spring incorporated tiers. Spring incorporation might make allelopathic chemicals more available during early sugarbeet growth because of less time for chemical decomposition by soil microbes.

**Fallow** **Potato**

Navy bean Soybean

**Figure 1.** Slow sugarbeet canopy development in potato, navy bean, and soybean treatments 54 days after seeding at Fargo, ND, in 2001.

**2000 and 2001 Summary**

Analyses within a year between locations and across the four environments indicated a strong environment by previous crop interaction; therefore, results at each location and year should be evaluated for the effect of previous crops. Realizing this, we combined the data for recoverable sugar/acre across environments to compare with the American Crystal Sugar Company (ACSC) data (Table 3).

Recoverable sugar/acre was the highest following the alfalfa treatment, which was followed closely by flax, sudangrass, pinto bean, and potato (Table 3). Recoverable sugar/acre was the lowest following the sugarbeet treatment, 1190 lb/acre less than the next lowest crop, navy bean. Field pea, barley, mustard, and corn treatments were somewhat similar to navy bean. This ranking across environments is strongly influenced by the 2000 Fargo data where rhizoctonia root rot was a serious problem. Alfalfa, potato, fallow, and soybean treatments had the greatest recoverable sugar/acre in this environment, which increased their relative ranking across environments.

The previous crops that had the greatest relative ranking change were field pea, corn, and soybean (Table 3). Field pea was the highest ranked previous crop in ACSC data but next to the last in our data. The relative ranking of soybean, flax, alfalfa, sunflower, fallow, and oat increased compared to ACSC data, while field pea, corn, barley, sugarbeet, and wheat decreased. Sudangrass, canola, and mustard were not included in ACSC data. Navy bean was ranked much lower than pinto bean in our data, but durum was ranked slightly higher than wheat.

Table 3. Relative ranking based on recoverable sugar/acre of previous crop treatments average over four environments compared with American Crystal Sugar Company (ACSC) producer results from 1989 to 1998.

| | Four environments | | American Crystal Sugar Company | |
|---|---|---|---|---|
| Previous crop | Recoverable sugar/acre | Ranking | Recoverable sugar/acre | Ranking |
| | ------lb/A------ | | ------lb/A------ | |
| Alfalfa | 6953 | 1 | 5647 | 5 |
| Flax | 6778 | 2 | 5568 | 8 |
| Sudangrass | 6664 | -- | -- | |
| Pinto bean | 6657 | 3 | 6102[†] | 2 |
| Potato | 6624 | 4 | 5819 | 4 |
| Sunflower | 6396 | 5 | 5491 | 9 |
| Durum | 6365 | -- | -- | |
| Soybean | 6356 | 6 | 5252 | 13 |
| Fallow | 6345 | 7 | 5331 | 11 |
| Oat | 6320 | 8 | 5294 | 12 |
| Wheat | 6169 | 9 | 5593[‡] | 6 |
| Canola | 6168 | -- | -- | |
| Corn | 6081 | 10 | 5989 | 3 |
| Mustard | 6019 | -- | -- | |
| Barley | 6002 | 11 | 5593 | 7 |
| Field pea | 5978 | 12 | 6607 | 1 |
| Navy bean | 5930 | -- | -- | |
| Sugarbeat | 4740 | 13 | 5332 | 10 |

[†] Reported as edible beans, includes navy bean; [‡] Includes durum.

We conclude that the crop grown prior to sugarbeet impacts root and recoverable sugar yields, percent sugar, sugar loss to molasses, and Na and amino-N content, but these vary with the environment. Previous crop treatment did not influence plant density at harvest. Across environments, the rank of previous crops from best to worst was alfalfa, flax, sudangrass, pinto bean, potato, sunflower, durum, soybean, fallow, oat, wheat, canola, corn, mustard, barley, field pea, navy bean, and sugarbeet. Additional research should evaluate our observation that yellowing and early canopy development might be associated with an allelopathic response, which was enhanced by spring tillage.

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