NITROGEN FOR SUGARBEETS IN MICHIGAN

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Nitrogen fertilizer recommendations as they are currently made are based upon at least three factors including crop sequence, the use of livestock manure, and anticipated sugarbeet yields. Minor deviations can be estimated by recognizing other factors such as a failure of a previous crop, the removal of the residues from a previous crop, and so on.

The fertilizer recommendations bulletin (3) includes the statement that "the total amount of nitrogen should not exceed 100 pounds per acre. Late nitrogen applications are apt to decrease the sugar content and increase the impurities." Such recommendations are based in part upon the results that have been obtained from the Ferden Farm sugarbeet rotation field experiments.

The purposes of this paper are to report recent data from the Ferden Farm experimental plots and to relate the results to the use of nitrogen fertilizers.

Treatments

Because the details of treatments and plot outlines have been described elsewhere, (Tables Nos. 1, 2, 4, 5 and 6), only a brief summary is included here. Briefly, the experiment involves seven systems of cropping, each being five years long. Some systems represent livestock, while others represent kinds of cash crop systems. The systems have been numbered to expedite discussion. Table No.1 describes the details of the crop sequence in each of the systems.

Each system of cropping is split into two basic fertility levels. The "high" level receives 160 + 640 + 320 ($N+P_2O_5+K_2O$) pounds per acre in the five year period. The "low" level receives 40 + 160 + 80 pounds per acre. One half of the entire amount of fertilizer is applied to the sugarbeet crop in each system of cropping.

Each level is further subdivided so that one half of each level receives supplemental nitrogen. For sugarbeets the nitrogen is side dressed at thinning time at the rate of 40 pounds per acre. While the nitrogen carrier has not been consistent from one year to the next, ammonium nitrate has been used in most instances.

To expedite discussion, the symbol "H" refers to the "high" fertility treatments, the letter "L" is the symbol for "low" fertility, "N" for nitrogen side dressings, and "Ck" for the no-nitrogen side dressing treatment.

Results and Discussion

No special insect or disease problems as related to systems of cropping have ever developed despite the fact that the experiment has been in effect since 1941. This illustrates the benefits of growing sugarbeets in long rotations.

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Sugarbeet Root Yields

It is difficult to separate the effects of the several systems of cropping from the effects of the fertilizer treatments.

In an attempt to do this, the high fertility plots where no supplemental nitrogen is used is considered to be the standard. The highest sugarbeet root yielding systems of cropping are reported in Table No. 2. Notice that the highest sugarbeet yields were from those rotations which returned the most organic matter to the soil. The lowest yielding rotations were those which produced the least amount of organic matter to be returned to the soil as crop residues, green manure, or cover crops. Notice that rotation six is not mentioned once.

Rotation number five was in the high yielding group in all of the years except 1965. In this system of cropping sweet clover is used as a seed crop. The straw is plowed down in late August or early September. Oats are then seeded as a cover crop. Such practices add measurable amounts of organic matter to the soil. It is believed that this explains the better physical condition which is observed in the soil treated with this sequence of crops.

The data in Table No.3 show the tons of roots per acre that were produced in 1968 on both the high and the low fertility plots, where no extra nitrogen was used. In interpreting these data remember that the two levels reflect differences not only in phosphate and potash but also in nitrogen.

The increase in root yields due to the extra fertility varied from 2.5 to 4.7 tons per acre. These data are very much in agreement with those obtained in previous years as is indicated by the numbers in the right hand column. The figures in this column show the per cent of the time in the past that the extra fertilizer produced yields higher than were produced on the low fertility plots. The increases observed in 1968 were somewhat higher than normally produced in previous years. In rotations one, five and seven, root yield increases have been obtained 100 per cent of the time since 1960.

The effect of the use of 40 pounds per acre of side dressing nitrogen upon sugarbeet root yields on the high fertility level plots is shown in Table No.4. The extra nitrogen seemingly decreased root yields in rotation three and produced only slight or insignificant increases in rotations one, two, and seven. However, in rotations four, five, and six, the increase ranged between 1.6 and 3.1 tons per acre.

The apparent decrease in yield in rotation three has not always been observed in previous years as is indicated by the 33 per cent occurrence shown in the column on the right of the Table. The great and significant increase of 3.1 tons in rotation six has occurred 100 per cent of the time in the past. This is the cash crop rotation which has no green manure or cover crops.

The effect of supplemental nitrogen used on the low fertility plots upon sugarbeet root yields is found in Table No.5. In 1968, in every rotation the use of extra nitrogen increased root yields. The response was slight in rotation seven but significant in all of the other systems of cropping. Thus,

it seems that the 20 pounds of nitrogen in the planting time fertilizer was not insufficient to produce maximum yields.

This increase in yield due to the side dressed nitrogen historically has not been as consistent on the low fertility plots as on the high. There is not one instance where the increase occurred 100 per cent of the years in the past. Thus, it would seem that some factor other than nitrogen is limiting the yields on the low fertility plots.

Taking into consideration the extra yields produced on the high fertility plots and the response to side dressed nitrogen on the high fertility plots it becomes apparent that in order to obtain maximum benefits from high levels of nitrogen, rather high levels of both phosphate and potash must be present.

From the discussion so far, the recommendations made in the fertilizer recommendations bulletin on the average are valid. The 80 pounds of nitrogen in the basic fertilizer treatment seems to be almost enough to take care of the requirement of the sugarbeet in rotations one, two, four, five and seven; but insufficient in rotations three and six. While no data are available to prove the point the beets in rotation six might benefit from even more nitrogen than is currently used.

Pounds of Recoverable Sugar Per Acre

The yield of roots by today's standards is only a part of sugarbeet production. Of equal importance is the yield of sugar per acre.

The rotations with the highest sugar yields are reported in Table No.6. Again, notice that rotation five was the highest yielding rotation as measured by the more recently developed technique involving "clear juice purity" which was first used in this project in 1964. As will be shown later, the response from nitrogen fertilizers in rotations five is not as great as in some of the other rotations.

The data in Table No.7 reflect the effect of two rates of basic fertilizer upon extractable sugar yields. In every instance the use of higher rate of fertilizer increased the extractable sugar per acre. This has been a very consistent reaction as is shown by the figures in the right hand column.

The effect of 40 extra pounds of nitrogen upon sugar yields on the high fertility plots is shown in Table No.8. In 1968, sugar yields were reduced in rotations one, two, three and seven. They were increased slightly in rotation five, but significantly in rotations four and six. These two rotations contained no cover or green manure crops. In each instance the beets are preceded by a crop which supplies relatively large amounts of low nitrogen crop residues.

On the low fertility plots where only 20 pounds of nitrogen are contained in the basic fertilizer treatment, the use of supplemental nitrogen significantly increased the sugar yields. (Table No.9). In 1968, the increase ranged between 92 and 817 pounds per acre. The effect has not been as consistent in previous years. In fact, in only two of the rotations, four and seven, the yields have been increased by extra nitrogen 100 per cent of the

time. These two rotations are those in which sugarbeets are preceded by crops which supply a rather large quantity of low nitrogen crop residues.

Summary

In evaluating sugarbeet yields, it is as important, if not more so, to measure the sugar production per acre as it is to measure the sugarbeet root yields per acre. The ideal would be a high production of roots that contain large quantities of extractable sugar.

From the data presented, it seems that the general recommendations for the use of nitrogen fertilizer on sugarbeets that are currently made are valid. The greatest problem is to correctly evaluate the effects of the crop residues from the crop preceding the sugarbeets.

The highest sugarbeet root yields were produced in those rotations which returns to the soil the greatest amount of organic matter, as crop residues, green manure crops, or cover crops. The use of more than 400 pounds of fertilizer consistently and significantly increased the sugarbeet root yields. In 1968, the increases ranged between 3.0 and 4.7 tons per acre.

The use of 40 pounds of side dressed nitrogen tended to increase the sugarbeet root yields. The greatest increases in yield were obtained in the intensive cash crop rotations where no leguminous cover or green manure crops were included in the rotation. The sugarbeet root yield increases on the low fertility plots tended to be higher than on the high fertility plots, due to the fact that the high fertility plots receive 80 pounds of nitrogen in the basic fertilizer treatment.

The extractable sugar per acre yields were consistently and significantly increased in each of the systems of cropping by the use of more than 400 pounds of planting time fertilizer. The use of 40 pounds of supplemental nitrogen tended to decrease the sugar per acre yields on the high fertility plots except in the intensive cash crop rotations. In one rotation yields were increased 505 pounds of sugar per acre from the use of 40 pounds of supplemental nitrogen.

In 1968, the yield of sugar was increased on the low fertility plots in each of the systems of cropping by the use of 40 pounds of supplemental nitrogen. The yield increase was greatest in the intensive cash crop rotations, amounting to 817 pounds per acre in one instance. The great increase in yield of sugar per acre from side dressing nitrogen to the low fertility plot in an intensive cash crop rotation has occurred 100 per cent of the years for which records are available.

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Table 1. The Sequence of Crops Grown in Seven Systems of Cropping

Rotation Number	Crop Sequence
1.	Alfalfa-brome, Alfalfa-brome, Beans, Sugarbeets, Barley.
2.	Sweet Clover (Oats)[1], Sugarbeets, Corn (GM)[2], Beans, Wheat.
3.	Beans, Sugarbeets, Corn (GM)[2], Soybeans, Wheat (GM)[2]
4.	Alfalfa-brome, Corn, Sugarbeets, Beans, Wheat.
5.	Sweet Clover (Oats)[1], Beans, Sugarbeets, Soybeans, Wheat.
6.	Beans, Wheat, Corn, Sugarbeets, Barley.
7.	Beans, Wheat (GM)[2], Soybeans, Sugarbeets, Corn (GM)[2]

1 - Winter cover crop
2 - Green manure - a mixture of sweet clover, alsike clover, mammoth clover, red clover and alfalfa

Table 2. The Highest Sugarbeet Root Yielding Systems of Cropping Since 1960

Year	Yield Level	Rotation Number
1960	More than 16.0 T/A	3, 5, 7
1961	More than 20.0 T/A	1, 3, 5, 7
1962	More than 16.0 T/A	1, 3, 5
1963	More than 17.0 T/A	1, 2, 4, 5, 7
1964	More than 23.0 T/A	1, 3, 4, 5, 7
1965	More than 21.0 T/A	2, 3, 4, 7
1966	More than 15.0 T/A	2, 5
1967	More than 20.0 T/A	1, 2, 4, 5
1968	More than 22.0 T/A	1, 2, 3, 5, 7

(High fertility plots - No extra nitrogen)

Table 3. Sugarbeet Root Yields Produced in Seven Systems of Cropping in 1968 as Affected by Two Rates of Commercial Fertilizer

Rotation	Tons Per Acre (No Extra Nitrogen) High	Low	Difference	Occurrence
1	22.1	18.9	3.1	100%
2	22.2	18.2	4.0	89%
3	22.8	18.1	4.7	89%
4	19.4	16.9	2.5	89%
5	22.8	19.7	3.1	100%
6	18.4	15.4	3.0	78%
7	22.2	18.9	3.3	100%

Table 4. Sugarbeet Root Yields Produced at High Fertility Levels in Seven Systems of Cropping in 1968 as Affected by the Use of 40 Pounds of Supplemental Nitrogen

Rotation	Tons Per Acre (High Level) N	Check	Difference	Occurrence
1	22.7	22.1	0.6	78%
2	22.9	22.2	0.7	67%
3	21.2	22.8	-1.6	33%
4	22.1	19.4	2.7	78%
5	24.4	22.8	1.6	89%
6	21.5	18.4	3.1	100%
7	22.6	22.2	0.4	33%

Table 5. Sugarbeet Root Yields Produced at Low Fertility Levels in Seven Systems of Cropping in 1968 as Affected by the Use of 40 Pounds of Supplemental Nitrogen

Rotation	Tons Per Acre (Low Level) Nitrogen	Check	Difference	Occurrence
1	19.8	18.9	0.9	67%
2	19.3	18.2	1.1	67%
3	20.8	18.1	2.7	89%
4	18.0	16.9	1.1	89%
5	20.7	19.7	1.0	67%
6	19.0	15.4	3.6	78%
7	19.4	18.9	0.5	33%

Table 6. The Highest Extractable Sugar Producing Systems of Cropping Since 1964

Year	Pounds of Sugar Per Acre	Rotation Number
1964	More than 7100 lbs./Acre	4, 5, 6, 7
1965	More than 6000 lbs./Acre	3, 7
1966	More than 4700 lbs./Acre	2, 5
1967	More than 6000 lbs./Acre	2, 5
1968	More than 5800 lbs./Acre	3, 5

Table 7. Extractable Sugar Produced in Seven Systems of Cropping in 1968 as Affected by Two Rates of Commercial Fertilizer

Rotation	Pounds Per Acre (No Extra Nitrogen) High	Low	Difference	Occurrence
1	5704	4937	767	100%
2	5796	4644	1152	100%
3	5844	4668	1176	80%
4	5162	4408	754	100%
5	5876	4862	1014	100%
6	5086	4212	874	100%
7	5763	4967	796	60%

Table 8. Extractable Sugar Produced at a High Fertility Level in Seven Systems of Cropping in 1968 as Affected by the Use of 40 Pounds of Supplemental Nitrogen

Rotation	Pounds Per Acre (High Fertility) Nitrogen	Check	Difference	Occurrence
1	5637	5704	-67	40%
2	5566	5796	-230	80%
3	4930	5844	-914	80%
4	5721	5162	559	80%
5	6070	5876	194	40%
6	5573	5068	505	80%
7	5699	5763	-64	60%

Table 9. Extractable Sugar Produced at a Low Fertility Level in Seven Systems of Cropping in 1968 as Affected by the Use of 40 Pounds of Supplemental Nitrogen

Rotation	Pounds Per Acre (Low Fertility) Nitrogen	Check	Difference	Occurrence
1	5074	4937	137	60%
2	4797	4644	153	80%
3	5183	4668	515	40%
4	4604	4408	196	100%
5	5061	4862	199	40%
6	5029	4212	817	100%
7	5059	4967	92	20%