The Relation of Phosphorus and Nitrogen Ratio to the Amount of Seedling Diseases of Sugar Beets[1]

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Seedling diseases of sugar beets, or so-called "black root," were controlled efficiently in the heavy irrigated soils in Montana, by improving the physical condition of the soil and by providing sufficient and balanced fertilization. This resulted in good stands, rapid and vigorous development of young beets, and high yields. The amount of easily available phosphorus and nitrogen present in the soil, and their relative proportions to one another, have a great influence on the amount of seedling diseases of sugar beets. A soil deficient in available phosphorus or nitrogen, or both, or an unbalanced ratio of these nutrients predisposes beets to seedling diseases.

In studying the effect of nutrition on the development of plants, not only the amount of available nutrients and their balance should be considered, but also the form in which these fertilizers are applied. This is especially important in the case of nitrogenous fertilizers. To interpret some previous results, an investigation was started to study the effect of different P :N ratios on the general development of the sugar beets and on the occurrence of diseases in the young beets. In this study, nitrogen in the form of nitrates and ammonium salts, and phosphorus in the form of treble superphosphate were used. In one of the experiments nitrogen, phosphorus, and manure were used to study the effect of the manure when used with different P :N ratios.

As a basic application, 20.8 pounds of treble superphosphate, containing 9.6 pounds of P_2O_5, and 62.3 pounds of calcium nitrate, containing 9.6 pounds of nitrogen, or equivalent amounts of ammonium sulfate were used per acre of soil as a side-dressing. This is a 1:1 ratio of phosphorus (P_2O_5) and nitrogen (N). The actual amounts of fertilizers applied per each flat of soil and their ratios are given in table 1. For each P :N ratio 2 duplicate soil flats, 20 x 12 x 3 inches, containing approximately 25 pounds of soil each were used.

Three different series of ratios were used. In the first series, treble superphosphate was used in combination with calcium nitrate in 7 ratios, and in the second series treble superphosphate in combina-

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Table 1.—Amounts of fertilizers applied.

	Ratio P_2O_5		N	Treble superphosphate and calcium nitrate				Treble superphosphate and ammonium sulfate				Treble superphosphate,* ammonium sulfate and manure			
				Amount used				Amount used				Amount used			
				Per acre in lb.		Per flat in grams		Per acre in lb.		Per flat in grams		Per acre in lb.		Per flat in grams	
				Tr. super.	Cal. nitr.	Tr. super.	Cal. nitr.	Tr. super.	Am. sulf.	Tr. super.	Am. sulf.	Tr. super.	Am. sulf.	Tr. super.	Am. sulf.
1	0		3	0.0	186.9	0.0	16.2	0.0	141.3	0.0	12.2	0.0	141.3	0.0	12.2
2	1		3	20.8	186.9	1.8	16.2	20.8	141.3	1.8	12.2	20.8	141.3	1.8	12.2
3	1		2	20.8	124.6	1.8	10.8	20.8	94.2	1.8	8.2	20.8	94.2	1.8	8.2
4	1		1	20.8	62.3	1.8	5.4	20.8	47.1	1.8	4.1	20.8	47.1	1.8	4.1
5	2		1	41.6	62.3	3.6	5.4	41.6	47.1	3.6	4.1	41.6	47.1	3.6	4.1
6	3		1	62.4	62.3	5.4	5.4	62.4	47.1	5.4	4.1	62.4	47.1	5.4	4.1
7	3		0	62.4	0.0	5.4	0.0	62.4	0.0	5.4	0.0	62.4	0.0	5.4	0.0
8	0		0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*On a basis of 16 tons manure per acre.

tion with ammonium sulfate, and in the third series treble superphosphate, ammonium sulfate, and manure, thus 7 different ratios and a check were used in each series.

Soil from a plot growing a third year of alfalfa in a rotation at the Huntley Field Station, Huntley, Montana, was used. This soil in early studies always developed a high percentage of seedling diseases. It contained 0.07 percent of total phosphorus (P) and 0.14 percent of total nitrogen (N).

The sugar-beet seed was planted in flats in a greenhouse with 3 rows in each flat and 20 seedballs in each row. The total length of these seeded rows was 5 feet. The fertilizers were applied as a side-dressing at time of planting and at the proportionate rate that 5 feet of row would be to the total length of rows in an acre field (26,136 feet).

Readings of healthy and diseased beets were made at regular intervals, and the sugar beets remained in the greenhouse until they were in the stage of the third pair of leaves. At the time of harvesting, the tops and the roots from each P :N ratio were weighed separately, and a chemical determination was made of phosphorus and nitrogen.

Results of Experiment

The amount of seedling diseases of sugar beets (graph 1) was lowest where treble superphosphate, ammonium sulfate, and manure were used and highest with treble superphosphate and ammonium sulfate. The amount of seedling diseases in the series where treble superphosphate and calcium nitrate were used, occupied an intermediate position between the above extremes. The results also showed a high correlation of the amount of seedling diseases in individual ratios in all series. The lowest amount of seedling diseases was in the P :N ratios of 1:3 and 1:2, and the highest with 3 :0 and the check. The amount of seedling diseases with the other ratios was between these two extremes.

The fresh weight of sugar-beet seedlings was calculated on a percentage basis (graph 1) using 100 percent as the highest weight of the beets in each series. These weights showed high correlation with the amount of seedling diseases. The heaviest plants of all series were in ratios 1:3 and 1:2 of P and N, and the smallest plants were in ratios 0 :3 without manure, 3 :0, and the check. The weight of the plants in the other ratios of all series was between the two extremes.

Phosphorus (P) and nitrogen (N) were determined in the tops and the roots of all harvested beets and the amounts calculated on a dry-weight basis. In graph 1 only the ratios of N :P present in the roots of the sugar beets are given. The ratios of tops followed very

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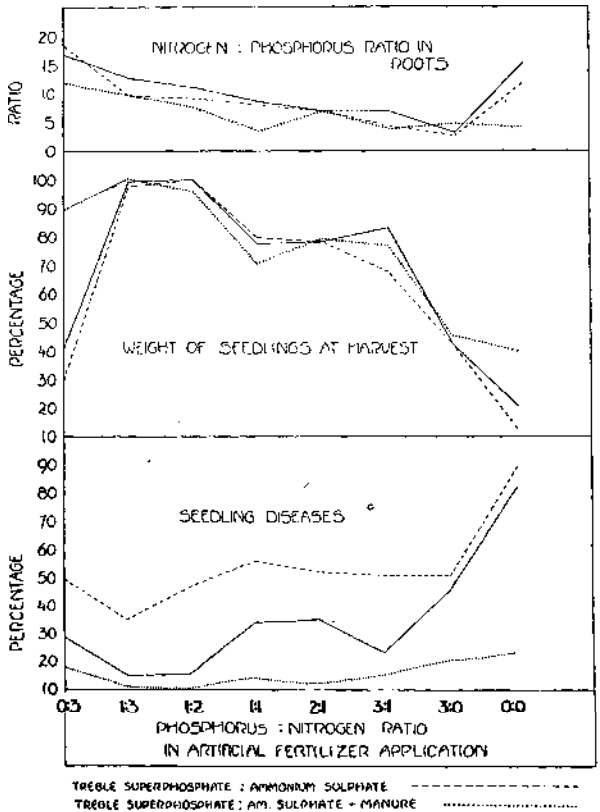

closely the root ratios. The roots of the sugar beets growing in the soil to which phosphorus (P_2O_5) and nitrogen (N) were added, in 1:3 and 1:2 ratios, had F:N ratios between 1:9 and 1:12.5, with the exception of the series with manure where these ratios were slightly lower. With an increase of nitrogen in the soil the ratio of P:N of plants became wider, and with an increased amount of phosphorus in the soil the ratio of plants became narrower. This undoubtedly indicated that the soil was more deficient in P than in N.

It is not intended that the P:N ratios of fertilizers, which in this study showed the smallest amounts of disease and highest growth, should be recommended for all soils, as the optimum ratio of P:N in fertilizers applied to different soils undoubtedly will vary.

The results of this study emphasize the importance of balanced fertilization, not only as an aid in controlling seedling diseases of sugar beets, but also in obtaining the maximum possible yield under given environmental conditions.

This study considered not only the amount of fertilizers required for proper development of sugar-beet seedlings, but also the form in which the fertilizers should be applied, particularly for nitrogenous fertilizers. When calcium nitrate was applied, the amount of seedling diseases was less than when ammonium sulfate was used. As sugar beets are so dependent on nitrates, it is not difficult to explain the differences in the amounts of seedling diseases with calcium nitrate as compared to ammonium sulfate. Nutrition of young sugar beets is very localized and is dependent on easily available nutrients, Time and certain favorable environmental conditions are necessary before nitrogen, applied in the form of ammonium salts, becomes available to sugar beets. This period may be quite critical in making plants more or less resistant or susceptible to seedling diseases. This study was conducted in the greenhouse where conditions for nitrification were ideal. Under field conditions in the cold spring weather, this difference in the amount of seedling diseases between soils fertilized with nitrates and ammonium sulfate probably will be even greater.

When manure was added to artificial fertilizers, the picture was considerably changed. The amount of diseases was very low in all ratios, and the ration of recovered N:P in the roots of the plants was also lower than when artificial fertilizers were used alone, with the exception of ratio 3:0, Manure undoubtedly has significance, not only as a source of easily available nutrients, but also as a source of certain biological factors which considerably change all nutritional conditions in a soil.