Fertilizer Treatments for Sweet Corn

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THIS CIRCULAR summarizes the results of six years of study of the effects of a large number of different fertilizer combinations on the yield and maturity of sweet corn, and makes certain recommendations for fertilizer treatments based thereon. The corn was grown on a dark silt loam prairie soil typical of the soils on which sweet corn is commonly grown in Illinois, and was included in a four-year rotation of wheat or oats, red clover, and two years of sweet corn.

A more complete report of the experimental work will be found in Bulletin 417 of this Station, consisting of 88 pages of tabular data and detailed discussion. The bulletin will be sent, on request, to those interested in the more technical aspects of the subject.
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SWEET CORN is the most important truck and canning crop grown in Illinois, and Illinois is the leading state in acreage and total production of this crop. Notwithstanding this prominence of sweet corn, there is little published information on the many problems encountered every season in growing it, particularly in regard to the effectiveness of commercial fertilizers.

Sweet corn is grown on a commercial scale in Illinois chiefly in certain parts of the central and northern sections of the state, where soil conditions are exceptionally favorable. Canners contract with only the most capable farmers who have good land and who rotate their crops with legumes. Even with this careful choice of growers, reasonably large yields of sweet corn are exceptional.

Growers have made numerous attempts to increase their yields, usually by applying commercial fertilizers, but the use of fertilizers, except in isolated instances, has been abandoned because of the very slight or even negative response to them.

This lack of favorable response of sweet corn to fertilizers is not due to a low plant-food requirement, for sweet corn has been shown to require comparatively large amounts of plant food. It is evident from the Illinois study that the sweet-corn plant is rather critical in its requirements, responding well to fertilizers only when the proper ratios of nitrogen, phosphorus, and potash are applied. Large increases in yield were secured when certain combinations of these nutrient elements were used, and there was failure to secure significant increases, or even any increases at all, when other combinations were used.

Suggestions for fertilizer treatments based on the Illinois study are given here, followed by a brief summary of the experimental results in these tests.

1The normal ear in late-maturing varieties weighs about 12 ounces unhusked, and the normal number of plants varies from 9,000 to 12,000 to the acre. Production might therefore be expected to range from about 6,700 to 9,000 pounds an acre. Even the smaller yield, however, is exceptional, the 7 tons to the acre is occasionally recorded from limited acreages.
RECOMMENDED TREATMENTS

In recommending fertilizers for sweet corn grown on soils of the dark silt loam prairie type used in the Illinois experiments, two general rules should first be stated:

(a) Treatments of single fertilizer salts should usually be avoided because their efficiency values are low and sometimes even negative.

(b) Mixtures of two salts containing nitrogen and phosphorus or phosphorus and potash give good results if the proper ratios are used.¹

Upon the basis of the results obtained in the Illinois study, the following specific recommendations are made:

1. Use a rotation including legumes in order to secure maximum responses from commercial fertilizers.

2. When nitrogen is omitted, apply 800 pounds of an 0-16-3 fertilizer per acre broadcast.

3. If it is desired to apply less than 800 pounds of fertilizer (without nitrogen) per acre, an 0-16-6 combination will probably prove superior to 0-16-3.

4. Mineral fertilizers applied without nitrogen should contain not more than 6 percent potash.

5. For consistent responses with three-element fertilizer combinations, apply 400 pounds of 0-16-12 supplemented by 50 pounds of side-dressed sodium nitrate per acre. (Of all 63 treatments investigated, this one apparently gave the best results.)

6. Under some conditions the 0-16-12 analysis mentioned above may possibly be reduced with advantage to 0-16-6, but the amount of nitrate used as a side-dressing should not be changed.

7. An application of 400 pounds of an 0-8-24 fertilizer, plus side-

¹Fertilizer recommendations which have been made as a result of these experiments, but previous to their publication (Bulletin 417) were limited to phosphorus-potash combinations. Such mixtures have given excellent results, in many instances, especially when applied around the hill with the cornplanter fertilizer attachment. A considerable portion of the sweet-corn acreage in the northern part of Illinois is being fertilized with 0-16-6 applied around the hill at the rate of about 100 pounds an acre. A good many efforts have been made by the senior author to introduce complete fertilizer analyses, but without success, owing to the fact that nitrogen, even in the form of sodium nitrate, applied around the hill at the time of planting frequently seems to exercise a depressing effect on yields. This statement is supported by considerable experimental evidence. The important point to remember is that nitrogen used as a side-dressing applied later may react quite differently from nitrogen forming part of a complete analysis and applied at the time of planting. (For further discussion of this subject see Ill. Agr. Exp. Sta. 45th Ann. Rpt., pp. 218-220.)
dressed sodium nitrate at the rate of 50 pounds per acre, may prove
profitable under some conditions.

8. Nitrate of soda should be applied 30 to 60 days after the corn is
planted.

The quantities of sodium nitrate recommended here are based
on applications made by hand around the hill. If machines are used
to apply this salt in continuous strips, the amounts per acre will prob­
ably have to be increased.

Treatments Hasten Maturing

Without exception, all the fertilizer treatments recommended above
hasten the maturing of sweet corn from three to five days. This is an
important consideration, not so much because an additional margin
is given against early fall frosts as because the planting season may be
extended to almost a week later in the spring.

SUMMARY OF EXPERIMENTS ON WHICH
RECOMMENDATIONS ARE BASED

Plan of the Experiments

The sweet corn grown in these experiments was included in a
four-year rotation of wheat or oats, red clover, and two years of
sweet corn, a rotation commonly practiced in Illinois in growing this
crop.

The plots were laid out in four 10-acre fields at Urbana on dark
silt loam prairie soil typical of the soils on which sweet corn is com­
monly grown in Illinois. Three of the fields had been planted for an
indefinite period to a rotation of field corn and oats, but the fourth
field was in bluegrass pasture for four years prior to the experiment.
Neither limestone nor commercial fertilizers of any kind had ever
been applied to any of the fields. Soil acidity tests of several areas
showed a limestone requirement of 3 tons an acre, and this was applied
at the beginning of the experiment.

The field methods used thruout the work were as accurate as
could be devised. The four fields were divided into 389 separate plots
laid out each year by means of a transit from bench marks estab­
lished at the beginning of the experiment. All the fertilizers were
broadcast by hand and harrowed in within 24 hours of planting (ex­
cept nitrate, which was side-dressed from 30 to 60 days after plant­
ing.) The corn was planted rather thickly by hand in check rows
42 by 42 inches and later thinned to three stalks per hill. Country Gentleman sweet corn, bred at the Illinois Agricultural Experiment Station, was used.

The fertilizers consisted of nitrate of soda, superphosphate, and muriate of potash, in varying dosages and varying combinations, supplying the three critical plant-food elements—nitrogen, phosphorus, and potassium. The nitrate of soda consisted of 15 percent nitrogen. It was applied separately as a top-dressing around the hills 30 to 60 days after planting, and then covered with a corn cultivator. The superphosphate contained 16 percent available phosphoric acid and was mixed, when so required, with muriate of potash but never with nitrate. The muriate of potash contained about 50 percent potassium oxide and was used singly or mixed with acid phosphate, as called for by the experiment.

Each of the three plant-food elements was applied in single, in double, and in quadruple dosages. The three dosages of the three elements were applied in all possible mathematical combinations, totaling 63 separate treatments plus one with no fertilizer. The dosages consisted of the following amounts per acre based on special chemical analyses:

**Nitrate of soda**
- Single: 50 pounds (7.5 pounds nitrogen)
- Double: 100 pounds (15 pounds nitrogen)
- Quadruple: 200 pounds (30 pounds nitrogen)

**Superphosphate**
- Single: 200 pounds (32 pounds phosphorus pentaoxid)
- Double: 400 pounds (64 pounds phosphorus pentaoxid)
- Quadruple: 800 pounds (128 pounds phosphorus pentaoxid)

**Muriate of potash**
- Single: 50 pounds (25 pounds potassium oxide)
- Double: 100 pounds (50 pounds potassium oxide)
- Quadruple: 200 pounds (100 pounds potassium oxide)

The double dosage of each ingredient was assumed to be an optimum treatment, the single dosage a minimum treatment, and the quadruple dosage to be in excess of actual requirements. The results obtained showed, however, that these assumptions were not always correct, and that in some cases the maximum yields would probably have been obtained with applications heavier than the quadruple dosages.

In harvesting the ears those from the border rows around the four sides of each plot were removed first. Then the plot proper was snapped, the standing order to the workmen being to "snap everything
showing a silk." A large number of useless culls were thus included, but no ears fit for canning were overlooked. The ears were then sorted, counted, and weighed by an experienced crew, and numbers and weights of marketable ears recorded.

The selection of the optimum fertilizer treatment or treatments for sweet corn on the basis of these records constituted the problem of this project. Because of the many different combinations of fertilizer involved, it was necessary to subject the data to exhaustive statistical analysis in arriving at the final recommendations.

**Effects of Nitrogen on Yield**

Nitrogen, used either alone or in combination with phosphorus or potash, or both, as a fertilizer for sweet corn, appears to have certain limitations, and the best combinations of potash and phosphorus to be used with side-dressed nitrogen are not readily found.

*Nitrogen Alone.*—When used as a side-dressing without an accompanying basal treatment of minerals, sodium nitrate produced variable effects on yield ranging from decided decreases to definite increases. With no clover in the rotation, a treatment of 50 pounds of nitrate of soda per acre resulted in a small increase in yield, but heavier applications gave lower yields than the adjacent checks. During both the first and the second years after clover, nitrate had no material effect on yields.

According to these results, therefore, growers would not be justified in side-dressing nitrate of soda when it is the only treatment.

*Used With Phosphorus.*—In fertilizers containing combinations of nitrogen and phosphorus (without potash), increases in yield due to nitrogen were much more consistent and were significantly\(^1\) greater than when nitrogen was used alone. The averages of the yields from all of the plots receiving treatments of nitrogen and phosphorus show that the most consistent increases occurred when nitrogen was used with 400 pounds of superphosphate per acre. Thus, al tho sweet corn does not draw as heavily as field corn upon the available supply of phosphorus in the soil, it is evident that an application of at least 400 pounds of superphosphate per acre is necessary before nitrate becomes effective.

\(^{1}\)The sweet-corn yields were analyzed by two different statistical methods to determine whether the increases or decreases due to fertilizer treatments were consistent and might be depended upon to recur regularly or were merely tendencies. Increases described as "significant" or as having "significant odds" were those which under the conditions of this experiment were practically certain to recur.
Used With Potassium.—Combinations of nitrogen and potassium, without phosphorus, did not give definite increases in yield over the adjacent check plots. With no clover in the rotation and during both the first and second years after clover, the effects of nitrogen-potash fertilizer combinations on yields were extremely variable, and showed no definite tendencies.

It is probable that phosphorus was the limiting factor in the soils used in these experiments. According to the Illinois soil survey, total phosphorus is low in many soils in Champaign county. While this does not necessarily indicate that available phosphorus also is low, and although sweet corn requires less phosphorus than field corn, according to Whiting, it is probable that available phosphorus was deficient in the soils of most of the plots to a sufficient extent to make phosphorus the limiting factor when nitrogen was used only with potash. It is therefore not surprising that nitrogen-potash combinations gave variable results. On the other hand, many of the soils in central Illinois contain large amounts of potassium (even though mostly in unavailable form), and a treatment of nitrogen and phosphorus, without potash, might be expected to give considerable increase in yield, an increase which might be explained on the assumption that the addition of nitrogen increases the absorption of potash by the plant. The sweet-corn plant uses potash in relatively large quantities, and this element is probably very necessary during the period of maturation.

Nitrogen in Complete Combinations.—In “complete” fertilizer combinations, that is, those containing all three major plant-food elements, nitrate gave large but inconsistent increases in yields. Its addition, in increasing amounts, to various constant amounts of phosphorus and potash, with no clover in the rotation, gave highly variable responses. On the other hand, applied the first year after clover in identical combinations, it gave very definite responses on many plots. The quantity of phosphorus used in the combination appeared to have considerable influence upon the size of the increases resulting from the nitrate. These increases were smallest where 200 pounds of superphosphate per acre was applied. In the second year after clover nitrate gave much larger increases where the applications of muriate of potash did not exceed 50 to 100 pounds per acre. Here again

nitrate responded least where the basal treatment of phosphorus was lowest. In general top dressings of 50 to 100 pounds of nitrate per acre gave increases larger than those resulting from the heaviest applications of 200 pounds.

Ordinarily one would expect nitrate to be more effective on soils in which this element is depleted than on fertile soils, and to be less effective during the first and second years after clover than when no clover at all has been used. For example, in these experiments best results with nitrate would be expected with no clover in the rotation in the field shown by the average yields of the check plots to have been low in fertility before clover was used; and least results would be expected on the fairly fertile soil of the other fields during the first year after clover. The actual results, however, were contrary to expectations: nitrates proved most effective following clover in the rotation.

From the results obtained by side-dressing sodium nitrate as part of a complete fertilizer, it is evident that the smallest nitrate treatment (50 pounds per acre) gave larger and more consistent increases in yields than the heavier dosages. It is apparent, also, that the increases depended to a considerable extent upon the amounts and proportions of minerals which were used as a basal treatment.

**Effects of Phosphorus on Yield**

As stated before, phosphorus was probably the limiting factor in the soils used in these experiments. Unfortunately, during the early years of these experiments qualitative field tests for available phosphorus, such as Bray's\(^1\) and Spurway's\(^2\) were not available, and there was consequently no reasonably inexpensive way of finding out how the available phosphorus in these plots checked against that of the soils upon which sweet corn is usually grown elsewhere.

*Phosphorus Alone.*—In view of the probable deficiency of available phosphorus in the soils of these plots, the heavier dosages of phosphorus, when this element was used alone, were expected to give the larger and more consistent increases in yield. The results here also were contrary to expectation. With no clover in the rotation, the largest increase was obtained by adding 400 pounds of superphosphate per acre, but according to the statistical analysis this was nothing more than a tendency. The smaller increases obtained with

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200 pounds of superphosphate per acre were very definitely significant. During the first, and also during the second, year after clover the largest increases occurred with 200 pounds per acre, but the odds were not significant. Similar effects of phosphorus have been noted by other investigators.

*Used With Nitrogen.*—Much larger and more uniform increases in yields were obtained from the use of combinations of nitrogen and phosphorus than from applications of phosphorus alone. The averages of the yields from all the plots receiving nitrogen-phosphorus combinations, show that the maximum increases were obtained for both numbers of ears and weights of ears when 400 pounds of superphosphate per acre was applied.

*Used With Potash.*—Combinations of phosphorus and potash also gave much better results than phosphorus applied alone. In general the yield increased as the amount of phosphorus used increased.

*Phosphorus in Complete Combinations.*—In complete fertilizers generous amounts of phosphorus were essential. The maximum efficiency of phosphorus was reached in combinations containing 50 pounds of sodium nitrate per acre supplementing 400 pounds of superphosphate per acre. Phosphorus and potash had a distinctly inverse relationship, on the basis of marketable ears, phosphorus maintaining an equivalent efficiency when the smallest dosage was combined with the heaviest potash dosage or the heaviest dosage with the smallest potash dosage. Apparently increasing the amount of potash applied to such soils as those under test tends to make phosphorus more available to plants, so that small quantities of phosphorus applied in combination with large quantities of potash are just as effective as large quantities of phosphorus combined with small quantities of potash. In view of the large increases in phosphorus efficiency which have been obtained by the use of potash in these experiments, the authors conclude that this indirect action of potash may be just as important as its direct action. There are, however, no chemical analyses available as proof of these assumptions.

**Effects of Potash on Yield**

*Potash Alone.*—The use of potash alone as a fertilizer cannot be recommended, for there is some evidence that even small dosages act unfavorably on yields. With no clover in the rotation, potash had virtually no effect on yields. During the first year after clover a dosage of 50 pounds muriate of potash per acre proved ineffective, and larger applications gave small but significant increases. During
the second year after clover the results were variable and the tendency was for potash to depress yields. As an average, 50 pounds of muriate of potash alone per acre caused a significant decrease in yields, and 100 and 200 pounds were ineffective.

*Used With Nitrogen.*—The effects of nitrogen-potash combinations have already been discussed from the standpoint of nitrogen. The high variation in yields and absence of a specific trend that occurred when potash was held constant and nitrogen was increased also occurred when nitrogen was held constant and potash was increased.

*Used With Phosphorus.*—In the tests with phosphorus-potash combinations, already discussed from the standpoint of phosphorus, substantial increases in yield occurred with increasing phosphorus applications. Certain inverse relations between phosphorus and potash were also pointed out. When phosphorus was held constant and the dosage of potash increased in the phosphorus-potash combinations, there was also a fairly consistent tendency for the yields to increase directly in relation to increases in the potash dosage.

*Potash in Complete Combinations.*—In the complete fertilizer combinations the action of potash was apparently affected by both nitrogen and phosphorus. In general, inverse relationships (wherein effectiveness was obtained with heavy potash dosages and light nitrogen dosages or *vice versa*, and heavy potash dosages and light phosphorus dosages or *vice versa*) were apparent between potash and nitrogen and between potash and phosphorus. The inverse relationship between nitrogen and potash is of great importance in determining a choice of fertilizer ratios. In selecting the ratios for complete fertilizers it is more difficult to choose between various potash-nitrogen combinations than between those of either potash-phosphorus or phosphorus-nitrogen.

**Influence of Fertilizers on Maturity**

Considered from the standpoint of the crop, commercial fertilizers are used for two purposes—to increase the total yield and to advance maturity.

A great deal of experimental work has been conducted on fertilizers and their effects on maturity. According to Russell,¹ nitrogen affects the growth of plants and, if present in excessive amounts, retards ripening. Phosphorus, on the other hand, promotes growth of the roots during the early life of the plant, but later on it hastens

the ripening process. Potash exerts an influence on the vigor and general health of the plant; it is intimately connected with photosynthesis and translocation of carbohydrates; and it influences the formation and especially the weight of grain. Potassium-starved plants are not only stunted in growth in the same way that plants are that lack nitrogen and phosphorus, but they may even fail to reach maturity.

In these experiments nitrate of soda was not at all consistent in its influence on the maturity of sweet corn. Used alone it had virtually no effect, but in combination with sufficient phosphorus, it hastened maturity. Added in increasing amounts to various potash constants, it hastened maturity slightly when a single dosage of potash was held constant, but gave variable results with heavier dosages of potash. In complete fertilizers the influence of nitrate was determined to a large extent by the nature of the combination. In general, nitrate was least effective in combinations with quadruple phosphorus and quadruple potash dosages.

Of the three fertilizer components, phosphorus had the most distinct effect on maturity. Used alone, in combination with potash, or in combination with nitrogen, phosphorus hastened maturity considerably. In complete fertilizers, phosphorus advanced maturity rather consistently, except where quadruple dosages were used in combination with the heavier dosages of nitrogen and potash.

Potash used alone or in combination with nitrogen retarded maturity; but when combined with double or quadruple dosages of phosphorus, the single dosage of potash appeared to advance maturity. In complete fertilizer combinations potash had, in general, an uneven effect on maturity. It hastened maturity only in certain combinations: as the constants of nitrogen increased, potash was effective only where the low phosphorus dosage entered into the combination. Combinations containing both quadruple nitrogen and quadruple phosphorus dosages retarded maturity progressively with increasing dosages of potash. On the other hand, in combinations containing quadruple nitrogen and single phosphorus dosages, potash effectively advanced maturity.

Thus on soils such as were used in these experiments it has proved to be possible not only to increase Illinois sweet-corn yields markedly by the application of the proper combination of fertilizing elements, but also to shorten materially the number of days required for the crop to mature.

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