Nutrient Balance and Interaction in Fertilizer Experiments

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Efficient fertilizer use can result only when each element is used to its fullest advantage by the crop. If a fertilizer element is applied in too small an amount to meet the needs of the crop, obviously it will prevent efficient utilization of other elements. Or, if the presence of one element interferes with the uptake or utilization of another, then poor efficiency will result. Therefore, it appears that nutrient balance may be of importance in determining sound fertilizer usage.

The importance of having a favorable nutrient balance within the plant has been shown by investigations of the chemical composition of the leaves and of the whole plant. In general, these investigations show that the nutrient balance within the plant can be influenced considerably through the application of fertilizers. They also indicate that certain interactions and antagonisms may affect the uptake of the different elements. Thus it appears that certain ionic antagonisms and interactions may have considerable agronomic significance. Comprehensive reviews of the literature have been presented recently by Tyner and Webb (3) and Shear, Crane, and Myers (2).

In order to gain sound information in the field on nutrient balance and interaction, the design of the experiment is highly important. In recent years, statistical science has developed rapidly and there has been much refinement in the design and analysis of experiments used in the field testing of fertilizers. In working with combinations of the nutrient elements the factorial design has many advantages. This design permits high efficiency in evaluating the effects of each element, and it is extremely comprehensive in that all possible interactions between the elements may be evaluated. Yates (4) discusses thoroughly the design and analysis of factorial experiments.

A large number of NPK factorial experiments have been conducted in Iowa during recent years. It is the purpose of this paper to summarize briefly these experiments from the standpoint of the kind of interactions observed, and to present certain experiments in detail as examples of the use of field experiments in showing interaction and nutrient balance. The assumption is made in this paper that the presence of significant interactions gives concrete evidence of the concept of nutrient balance. All discussion of these interactions relates directly to this concept.

EXPERIMENTAL PLANS AND PROCEDURE

One hundred and sixty-four NPK factorial experiments were conducted on the principal soil types of Iowa from 1944 through 1947. Of these, 85 were with corn. For the corn experiments, 2 by 2 by 2, 3 by 2 by 2, and 2 by 2 by 3 factorial designs were used. Rates of the fertilizer nutrients were, for the most part, 0, 10, 20, and 40 pounds of nitrogen per acre, 0 and 20 pounds of P2O5, and 0, 10, and 20 pounds of K2O. These were applied broadcast on the field before the oats were sown. Residual effects from the fertilizer applied on the oats were determined on the following year by extraction with 0.03 normal NH4F in 0.025 normal HCl.

The available phosphorus content of the soil was determined by extraction with 0.05 normal NH4F in 0.025 normal HCl. Exchangeable potassium was determined by extraction with neutral NaClO3. The pH was determined with glass electrodes on a 1:2½ soil water ratio.

Inasmuch as this paper is concerned largely with NPK factorial experiments, the reader may wish to skip discussion on their interpretation as presented in the Report for 1934 of the Rothamsted Experimental Station.

The data presented below are arranged to present the results of each treatment, the average responses for the individual elements, and the interactions. The two-factor interactions are given in the form of response to one element in the presence of, and in the absence of the other under the heading of differential response. The standard errors are shown. The rough rule to use with standard errors is that a quantity is significant greater than twice its standard error, and the difference between two quantities having the same standard error is significant even when the treatment produces no effects at all. Therefore about four of the 85 corn experiments encountered in 85 corn, 57 oat, and 22 hay experiments conducted on the major soils of Iowa through 1947.

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RESULTS

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