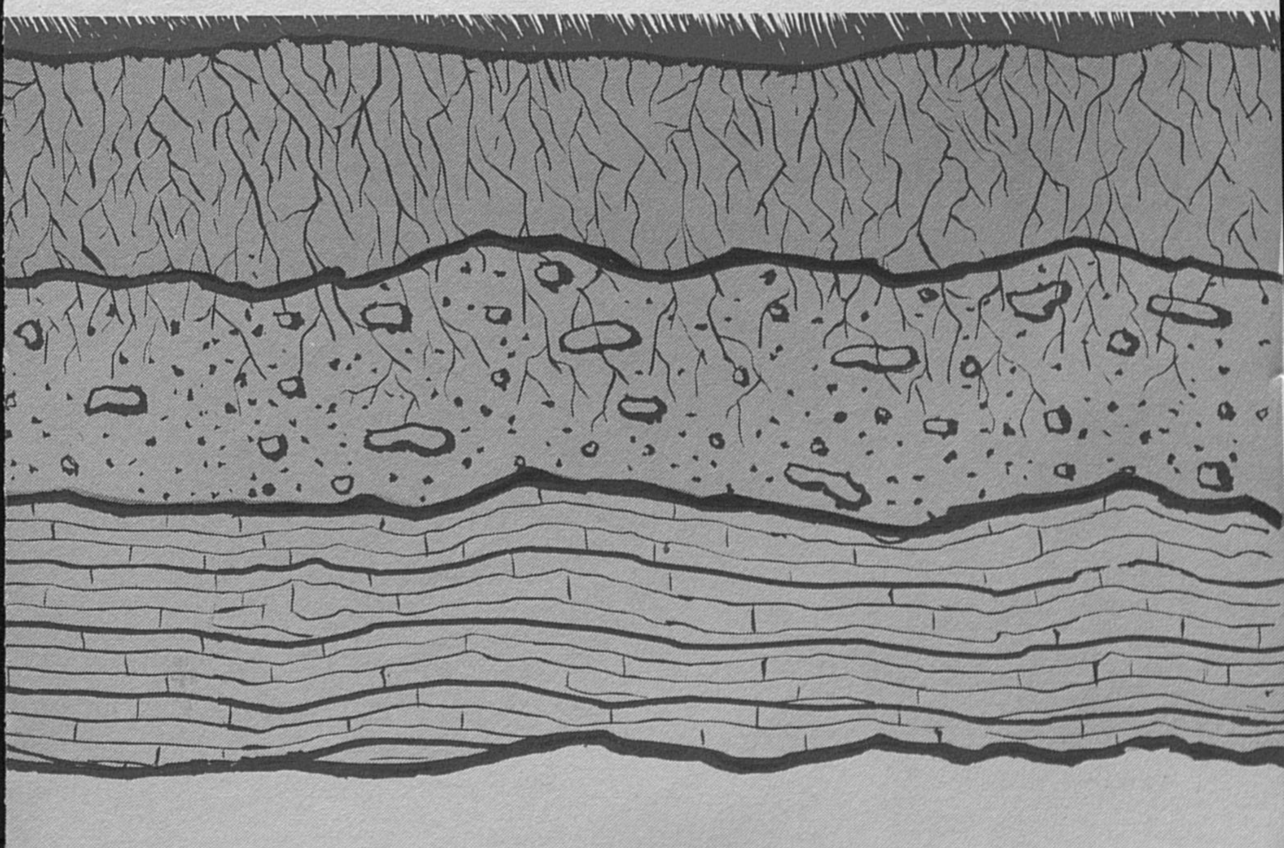
SECONDARY AND MICRONUTRIENT ELEMENT NEEDS FOR FIELD CROPS IN KENTUCKY

By Harold F. Miller and George D. Corder

UNIVERSITY OF KENTUCKY
COOPERATIVE EXTENSION SERVICE
AGRICULTURE AND HOME ECONOMICS

Circular 613



CONTENTS

Secondary And Micronutrient Element Needs For Field Crops In Kentucky Soils

By HAROLD F. MILLER And GEORGE D. CORDER

Sixteen elements are known to be essential for plant growth and maturity. Of these carbon (C), hydrogen (H), and oxygen (O) make up 90-95 percent of the dry weight of plants. Plants get carbon and oxygen from carbon dioxide gas in the air. Hydrogen is obtained from water which plants absorb from the soil. The remaining 13 essential elements are obsorbed from the soil by plant roots (Fig. 1).

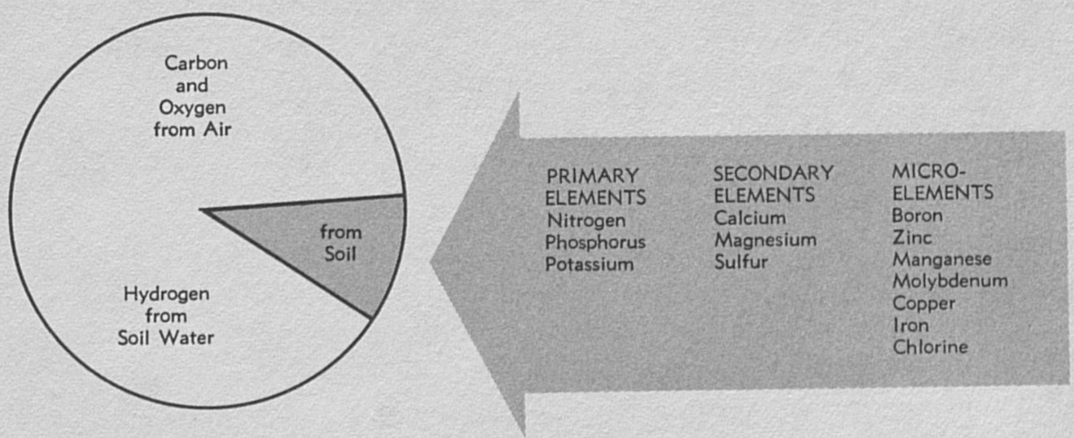


Fig. 1.—Source of essential plant nutrients.

A *deficiency* of *any one* of these essential plant nutrients will limit plant growth and yield. A lack of moisture or one or more of the nutrients obtained from the soil limits crop yields on much of the land in Kentucky.

PRIMARY ELEMENTS

Nitrogen (N), phosphorus (P), and potassium (K) are called primary elements because soils often do not release them in the relatively large quantities needed for vigorous plant growth. Most Kentucky soils are deficient in one or more of the primary elements. Commercial fertilizers are available that supply one, two, or all three of these elements. The kind and the amount of each depends on the fertilizer analysis.

SECONDARY ELEMENTS

Calcium (Ca), magnesium (Mg), and sulfur (S) are called secondary elements because plants require them in fairly substantial quantities for normal growth. Adequate amounts of these are presently available in most Kentucky soils for field crop production but may be lacking in some soils.

Calcium

While limestone supplies calcium, much of the yield response from liming acid soils in Kentucky is attributed to benefits derived from reducing soil acidity. Most of the land in Kentucky needs application of ground limestone to correct soil acidity. Acid soils must be limed if maximum crop yields are to be obtained. On the other hand, soil having a pH of 7.0 or above should not be limed (see Kentucky Cooperative Extension Service publications, Circular 584, "Controlling Soil Acidity" and Leaflet 249, "Liming Acid Soils"*).

Calcium deficiency has appeared in some varietes of burley tobacco in recent years, but it does not seem to affect appreciably the yield or quality. The deficiency will normally show in the small leaves near the bud and in the sucker growth. The edge of the small leaves become necrotic resulting in irregularly shaped leaves (Fig. 2).

The calcium content of affected plants is usually at or near the levels of unaffected plants. The conclusion is that it is a problem of calcium availability *within* the plant and not a deficiency of calcium in the soil.

Recent work at the Kentucky Agricultural Experiment Station indicates that some burley varieties contain larger quantities of oxalic acid (a naturally occurring organic acid) than others. This characteristic appears to be inherited. The oxalic acid and soluble calcium within the plant form an insoluble compound, calcium oxalate, which renders calcium unavailable for plant metabolism. Burley 21 appears to be the most susceptible of the present varieties to this disease.

Since there is evidence that calcium deficiency is not due to a lack of available calcium in the soil, it may be advisable to grow Ky

* These publications are available at your County Extension Office.

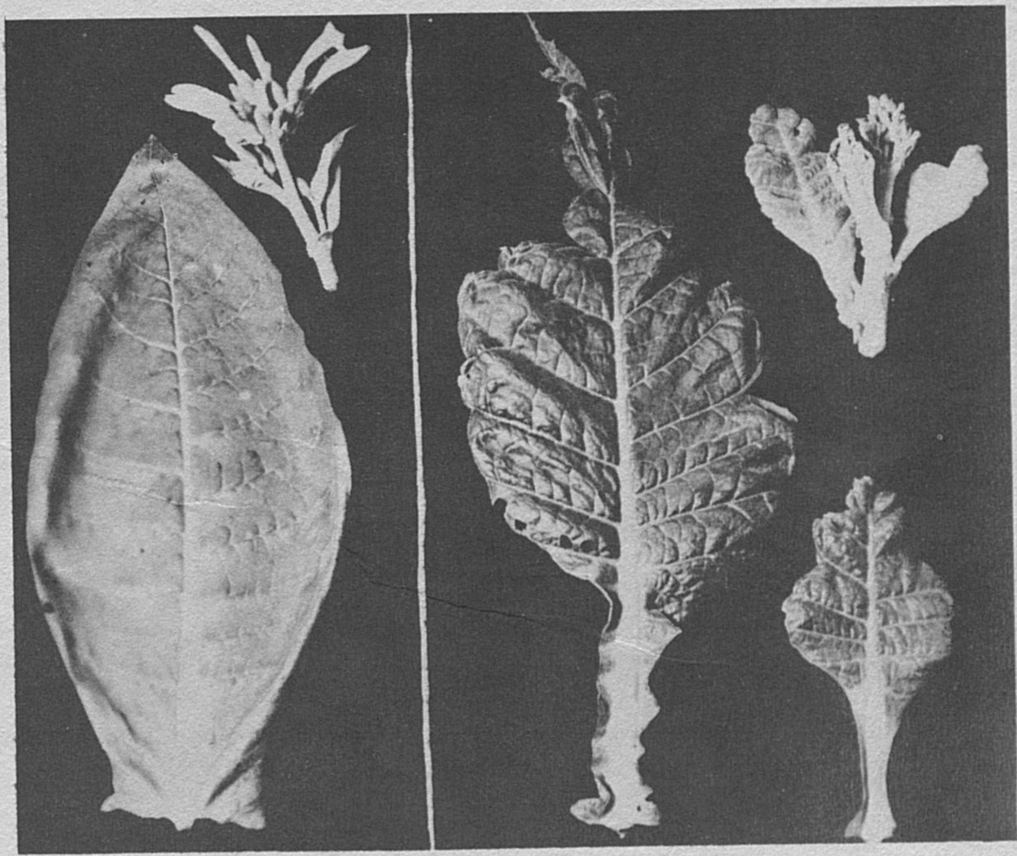


Fig. 2.—Tobacco showing calcium deficiency symptoms.

10 which is not so susceptible to the disease, should be a serious calcium problem exist when Burley 21 is grown.

When a sound liming program is followed for field crops in Kentucky, it is not necessary to buy fertilizers to which supplemental calcium has been added.

Magnesium

To date none of the research with field crops on Kentucky soils has shown a yield response to application of magnesium. Burley tobacco grown on the Campbellsville soil experiment field contained less magnesium than that produced on any of the other experimental plots throughout the state. Since 1952 magnesium has been added to tobacco plots on the Campbellsville field, but no response in yield or quality has been obtained.

During 1953-55, an experiment on the effect of secondary and micronutrient elements including magnesium on burley tobacco was conducted on Pembroke silt loam at the Princeton Substation in Caldwell county. No response in yield or quality was obtained from the application of the secondary or micronutrient elements in this experiment (see Kentucky Agricultural Experiment Station Bulletin 651, "Minor Elements for Burley Tobacco"*).

Since 1962, magnesium applications have been made on more than 150 burley tobacco fields in trials conducted throughout the state to check the effect of magnesium under a wider range of soil and cropping practices. No striking differences in yield or quality have been reported from any of these field trials. They are being continued.

Nearly all of the ground limestone in Kentucky contains some magnesium. The amount varies considerably from one quarry to the next and even within the different strata in the same quarry.

Heavy applications of farm manure supply considerable magnesium in a readily available form.

Sulfur

At present, there is no known sulfur deficiency in field crops grown on Kentucky soils. The sulfur content in rainfall from six locations in Kentucky averaged 8.5, 8.8, and 15.4 pounds per acre annually in 1953, 1954, and 1955, respectively.

In addition to the sulfur supplied in the annual rainfall most fertilizer materials contain some sulfur. However, the trend toward less burning of coal and the use of higher analysis fertilizers is reducing the sulfur supplied to soils. Perhaps continued crop removal and decreasing additions of sulfur will eventually result in deficiencies.

MICRONUTRIENT ELEMENTS

Plants need some elements in very small quantities; therefore, these are called micronutrient elements (trace elements). However, if the small amount needed by plants is not available, crop yield will be reduced, sometimes to the point of crop failure. Sandy soils and peat and muck soils are more often deficient in micronutrient elements than heavier soils. Other factors affecting the availability of micronutrient elements are parent material, soil pH, and drainage. Where known deficiencies exist, a fertilizer supplying the particular nutrient that is deficient should be applied at a rate to correct the deficiency.

The major plant nutrients (nitrogen, potassium, and especially phosphorus) are most readily available in the 6.0 to 7.0 pH range while the micronutrient elements with the exception of molybdenum are more readily available in more acid soils. In fact, in strongly acid and even the lower range of moderately acid soils, excessive amounts of certain of these elements are available, causing toxicity which can

* Available at your County Extension Office or local library.

reduce crop yields as drastically as deficiencies. Molybdenum is most available when the soil pH is around 7.0 and becomes less available at lower pH values.

Boron (B)

More than 25 years ago boron deficiency was found in alfalfa grown on Kentucky soils. In 1942, 327 soils from all over the state were analyzed for soluble (available) boron. Approximately one-half of these samples contained less than 0.5 part soluble boron per million parts of soil (PPM). This level generally is considered to be the dividing point between soils which need boron application and those which do not. About half of the many test demonstrations with boron applications on alfalfa have shown a response in yield. Boron deficiency in alfalfa has been found in all the major soil regions of Kentucky. Consequently, boron applications are recommended on all Kentucky soils for alfalfa hay and for clover crops for seed production.

Boron is usually applied as borax or fertilizer borate. However the percentage of boron in borax and fertilizer borates varies considerably; therefore, recommendations on an elemental basis are best. Broadcast applications of 1.5 to 2 pounds of elemental or actual boron per acre annually have been very effective. The amounts of the various compounds required to supply 2 pounds of elemental boron per acre are shown in Table 1.

Table 1.—Boron Compounds

Compound	Percent Boron	Amount required to supply 2 lb. boron per acre
Borax	11.4	17.6
Borate - 46	14.3	14.0
Borate - 65	20.2	9.9
Solubor	20.5	9.7

When boron is added to mixed fertilizers the guaranteed analysis shows the percentage of *elemental boron.*

Boron in large quantities is toxic to plants, and especially to seedlings. Thus, applications in excess of the recommended rates should be avoided.

Zinc (Zn)

Corn is the only field crop presently grown in Kentucky that has shown zinc-deficiency symptoms and has definitely given a response to zinc applications. Isolated instances of zinc deficiency have been reported from nearly every area of the state. However, the difficulty appears to be more prevalent in soils of the central Bluegrass and the Western Pennyrile regions.

Considerable variation in respect to zinc deficiency has occurred within these regions. Corn producers, in these areas particularly, should watch this crop closely for deficiency symptoms during the period of 4-6 weeks following planting.

Zinc-deficient corn shows a definite chlorosis (lack of green color) in the early stages of growth. The chlorotic areas generally appear as broad white stripes in the leaves at or near the growing point. In some varieties there is considerable purpling of the lower leaves, but this purpling may not show up in other varieties. This condition will usually be observed when the corn is 10-12 inches high and often disappears as the corn makes more growth. If the stalk is split lengthwise, a brown or black discoloration is usually apparent at the base of the stalk and at the first leaf nodes up the stalk. Unfortunately, other factors cause similar symptoms, and determining the exact cause is difficult.

Maize Dwarf Mosaic, a virus disease of corn, may be easily confused with zinc deficiency since similar leaf chlorosis occurs. Root feeding and pruning by insects may cause similar conditions to exist in growing plants.

An important factor influencing the availability of zinc is soil reaction. Zinc is most soluble, hence more available, in acid soils. Less zinc is available in soils with a high pH. Another factor influencing the fixation of zinc is the phosphate level. Zinc deficiency sometimes occurs as a result of heavy phosphorus fertilization and is more common in naturally high-phosphate soils.

In low-phosphate soils zinc deficiency may occur when pH values are 6.5 or higher. In high-phosphate soils, zinc deficiency has been found when soils have levels of 6.0 to 6.3. This does not mean that zinc deficiency will always occur when the soil pH is high. Corn grown in many fields having much higher pH values has shown no evidence of zinc deficiency.

Zinc deficiency is most likely to be found in eroded areas. Apparently the subsoil is usually lower in available zinc than is the topsoil of non-eroded areas.

Where zinc deficiency is known to exist, 3-6 pounds of elemental zinc per acre should be applied at the row in a starter fertilizer. Except under conditions of severe zinc deficiency, the lighter rate should be sufficient. The placement of fertilizer in the row results in less zinc fixation by the soil.

Heavier applications of zinc should be made when the fertilizer is applied broadcast. A minimum of 10 pounds of elemental zinc per acre is suggested for broadcast applications. Zinc sulfate or zinc oxide are satisfactory sources of zinc.

Premium grades of fertilizer may contain a little zinc. If so, the amount is shown in the guaranteed analysis. However, many of these premium grades of fertilizer will not normally contain a sufficient amount of zinc to correct zinc deficiency.

Sidedressing with zinc, once the deficiency has occurred, is not effective in correcting it. The zinc must be applied before the corn is planted or at planting time.

Foliar sprays on zinc-deficient corn have been tried with varying degrees of success. In some instances the deficiency has been corrected, while in others no response has been obtained.

The best method of determining whether observed symptoms are caused by zinc deficiency in fields of corn is to chop out 20 to 30 hills of corn and replant. Apply 1/8 to 1/4 teaspoon of zinc sulfate per hill and mix it with the soil on one-half of the replanted hills. By observing the corn 4-6 weeks following replanting, any response to zinc can be observed.

When corn is grown on fields where zinc-deficiency symptoms were observed the last year the field was in corn, zinc should be applied.

Since the occurrence of zinc deficiency in certain areas of the Bluegrass and Western Pennyrile regions is more frequent, farmers should consider establishing field trials with zinc on fields that have a pH value above 6.2 and are high in available phosphorus or on fields where the pH is above 6.5, and are low in available phosphorus. This can be done by using a starter fertilizer with sufficient zinc to correct the deficiency on a portion of each field and using the same analysis of a starter fertilizer without zinc on the remainder of the field.

Manganese (Mn)

Soil pH has a drastic influence on manganese availability. Manganese toxicity, caused by too much manganese in the soil solution, is a common disease in tobacco grown on soils where the pH is below 5.3 to 5.5 (see Kentucky Cooperative Extension Service Leaflet 286*). The disease causes plants to grow slowly following setting. The leaves turn a light to yellowish green color with narrow bands of dark green adjacent to the veins (Fig. 3).

Toxicity is also being found in an increasing number of corn

* Available at your County Extension Office.

Fig. 3.—Manganese toxicity in burley tobacco caused by too much manganese being available in the soil solution.

fields as well as a few grass and small grain fields where these crops are grown on strongly acid soils.

Manganese deficiency (too little manganese) in soybeans has been found in certain areas of the state. The deficiency symptoms in soybeans are very much like the manganese toxicity symptoms in tobacco. The leaves turn a light green to almost white with the areas close to the veins remaining a dark green. Where the deficiency is not severe, the lower leaves are the first to show symptoms. As the deficiency becomes more severe, the new growth as well as the older leaves will show symptoms of a lack of manganese.

Since the availability of manganese in the soil is reduced at higher pH values the deficiency is most likely to occur in soil in the slightly acid range or higher (6.1 or above). However, manganese deficiency has been found in soybeans grown on soils having a pH value as low as 5.9. This does not mean that soybeans grown in all soils having a pH above 6.1 will be deficient in manganese. Soybeans grown on many fields in the state where the soil pH is above 7.0 show no evidence of manganese deficiency.

Manganese deficiency can be corrected quickly by foliar spray. When the foliage of soybeans having manganese deficiency is sprayed with a manganese solution they will regain a normal healthy green color within a week.

Manganese sulfate (25.1 percent elemental manganese) is water soluble. Apply 2 to 3 pounds of *elemental manganese* dissolved in 10-25 gallons of water per acre as a foliar spray. Observations under Kentucky conditions indicate that more than one spray will be necessary to keep soybeans free of deficiency symptoms until maturity. Higher concentrations will cause burning of the foliage.

It does not appear that broadcast applications of manganese at reasonable rates will correct the deficiency because of manganese fixation in the soil.

Molybdenum (Mo)

A preliminary study of the molybdenum status of Kentucky soils was made by R. H. Lowe and H. F. Massey. Laboratory and greenhouse studies of soils from 43 locations indicate that the molybdenum content in three or four of these soils may be reaching the critical level.

In an alfalfa experiment on Grenda silt loam having a pH of 5.6, molybdenum added to the fertilizer increased yields, but on plots having a pH of 7.2 no response was obtained for the addition of molybdenum.

Molybdenum deficiency symptoms in alfalfa are similar to those of nitrogen starvation. The leaves become light green in color and growth is retarded. Eventually the older leaves develop a scorched appearance and are shed prematurely. Root nodules may be present but appear aged and inactive.

A number of field trials with a seed treatment of soybeans with molybdenum showed no yield response for the additional molybdenum. The soils where these trials were conducted had a pH above 6.0.

Since molybdenum becomes more available as the soil acidity approaches neutrality, yield response for molybdenum applications on alfalfa and soybeans are not likely on soils having pH values above 6.0. When alfalfa and soybeans are planted on soils having pH values below 6.0, there is a possibility that a seed treatment with molybdenum could be beneficial. Owing to extremely low amounts required, molybdenum can best be applied as a seed treatment when the seed is being inoculated or as a foliar spray on established stands. Four ounces of sodium molybdate, crystaline grade (25 percent molybdenum), per acre should be applied in field trials. This is at the rate of 1 ounce of *elemental molybdenum* per acre.

Caution must be followed in the use of molybdenum. While plants are fairly tolerant to high concentrations of molybdenum, ruminant animals grazing on forage having high concentrations of molybdenum may develop copper deficiency.

Copper (Cu), Iron (Fe), and Chlorine (Cl)

While small amounts of these elements are essential, Kentucky soils at present are releasing sufficient quantities of these materials for maximum production of field crops.

USE OF TEST STRIPS

The Kentucky Agricultural Experiment Station has conducted numerous experiments with secondary and micronutrient elements on field crops. In addition, a large number of field trials have been carried on. These experiments and field trials will be continued. Results of these experiments and field trials have shown that the only secondary and micronutrient elements known to be needed by field crops in Kentucky at present are boron for alfalfa hay and for clover seed production, zinc for corn in isolated cases, manganese for soybeans in specific areas, and molybdenum on alfalfa in some instances where soil pH is below 6.0.

Since soil and management practices vary considerably, it is impossible to conduct carefully controlled experiments or field trials under all conditions. For this reason, carefully planned and conducted test strips with secondary and micronutrient elements by farmers may be helpful in determining the need for these elements on a particular soil for a given crop.

The use of test strips is the best way to determine the true value of primary, secondary, and micronutrient elements applied to crops at present. It is misleading to compare one field with another or this year's crop with last year's due to differences in soil, cropping history, weather, and management. If you want to know whether or not you need secondary or micronutrient elements on a particular field, apply the desired elements on a small portion of the field. The nitrogen, phosphorus, and potassium fertilization and cropping history must be the same for the treated and untreated areas. At harvest time, check yields in the test strips and compare them with yields from a nearby area of the field of equal productivity to see if there is a yield difference.

Should you wish to know if fertilizers containing micronutrient elements are profitable to use, buy some fertilizer containing the micronutrient elements as well as the same analysis fertilizer without micronutrient elements. Apply the two fertilizer materials at the same rate in adjacent parts of the field and compare the crop response.

FUTURE NEEDS

As we continue to increase crop production with heavier fertilization and better management practices, there is always the possibility that the need for secondary and micronutrient elements will become more important in field crop production on Kentucky soils. Until the time that a profitable crop response can be obtained from applying these elements, there is no advantage in paying premium prices for fertilizers to which secondary or micronutrient elements have been added.

The Kentucky Fertilizer Law now requires that when plant nutrients other than nitrogen, available P_2O_5 and available K_2O are claimed, they must be guaranteed on the elemental basis. When claims are made that a fertilizer contains secondary or micronutrient elements they must be a part of the guaranteed analysis but should not appear as an additional number in the grade numerals. By checking the guaranteed analysis, you can determine the amounts of secondary and micronutrient elements added to the fertilizer.

This publication replaces University of Kentucky Cooperative Extension Service publication, Miscellaneous 302, "Secondary and Trace Element Needs for Field Crops on Kentucky Soils."

Agricultural and Home Economics Extension Service of the University of Kentucky, the United States Department of Agriculture cooperating. W. A. Seay, Director. Issued in furtherance of the Acts of May 8 and June 30, 1914.

10M—6-67