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Background

Since the late 1970's, farmers in the Wheatley Community of Owen County have reported seeing potassium (K) deficiency on tobacco during the growing season. Most of them had been following University of Kentucky fertilizer recommendations for burley production. Analyses of cured leaf samples from one such crop in 1980 confirmed K deficiency. It was decided that the problem warranted conducting some field experiments in order to define the problem and hopefully develop a solution. Consequently, we located a field on the Harold Malcomb farm near Wheatly, that tested low in soil K and designed a field experiment with the objectives of (1) testing the effectiveness of UK soil test recommendations for potash, (2) testing K rates applied pre-plant, sidedressed, and in combination, and (3) since soil Zinc (Zn) levels were low, we also decided to test for a tobacco yield response to fertilizer Zn. Subsequently, K studies were conducted in different fields of the Malcomb farm during 1981, 1984, 1985, 1986, and 1987, and in a field on the Steve

Simpson farm near New Columbus in 1986. The following report summarizes what we learned.

Methods

The fields were soil sampled to a 6 inch depth each spring prior to plowing, with a composite sample taken from each replication . Samples were tested in the UK Soil Testing Laboratory at Lexington with K being extracted by neutral, normal ammonium acetate.[1] Phosphorus tested high in all the fields and consequently no phosphate fertilizer was used on the experiments. Nitrogen was applied to the experiment by the producer at the same rate and time as it was applied to the remainder of the field in which the experiment was conducted. Potash fertilizer treatments (sulfate of potash) were broadcast by hand onto appropriate plots just prior to final disking of the field and transplanting of the crop. Sidedress treatments were hand spread between rows of the plot prior to layby cultivation. Fields on the Malcomb farm were irrigated during droughty periods. In most experiments, a wheat cover crop was plowed under.

Plots were either 40 or 50 ft long (depending on the field and the year) and four rows wide. The two center rows of each plot were used as a stick row for harvest with six plants per stick. Five sticks from each plot were tagged, cured, hand-tied, and weighed for determination of plot yields. In most years, soil samples were also taken from individual plots immediately

[1]All soil test K levels mentioned in this report were determined from use of this extractant. At the current time, the UK soil test lab extracts with Mehlich-III solution which results in higher numbers. Mehlich-III numbers can be estimated from ammonium acetate extraction numbers by multiplying the ammonium acetate number by 1.2.

after harvest to determine the effect of K rates on changes in soil test K levels at the end of the growing season.

Results

<u>1981</u> - The site was located on Lowell silty clay loam soil, 2-6% slope. Initial soil test levels were: pH 7.0; P 122; K 184; Ca 3610; Mg 120; Zn 2.0. The data of Table 1, indicate that leaf yields peaked at 600 lbs K_2O/A which was twice the rate the UK soil test level would have indicated was necessary. The 600 lbs K_2O/A also resulted in boosting soil test K from an initial reading of 184 to a reading of 316 at the end of the growing season. There was a slight yield increase to zinc applied preplant with 600 K_2O, but the split application of 600 K_2O without Zn yielded even more.

<u>1984</u> - The site was located in a different field on a Lowell silty clay loam soil, 2-6% slope. Initial soil test levels were (av. of the 4 rep composite samples): pH 6.6; P 177; K 218; Ca 2275; Mg 112; Zn 1.5. Plots were not soil sampled at the end of the growing season. Yield data are summarized in table 2. Yields peaked at 600 lbs K_2O/A, again about twice the rate the UK soil test recommendation would have indicated necessary. There was a slight increase to zinc applied with 600 K_2O preplant, but the 600 K_2O applied without zinc in a split application yielded as well as that with zinc.

<u>1985</u> - The site was located in a different field on a Nicholson silt loam soil, 2-6% slope, which was plowed out of an old alfalfa-grass sod. Initial soil test levels were (av. of the 4 rep composite samples): pH 6.7; P 84; K 157; Ca 3875; Mg 196;

Zn 3.6. Yield and soil test data at the end of the season are summarized in Table 3. Potassium was severely limiting in this field even though irrigated because of droughty conditions. Foliar deficiency symptoms were present even on the 300 K_2O plots. The producer's tobacco, immediately adjacent to the test plot, received 400 K_2O/A. His crop showed only slight K deficiency, yielded better than the 300 K_2O plots, and raised soil test K level from 153 in March, before fertilization, to 310 after harvest. This indicated the 300 K_2O treatment, which would have been the UK soil test recommendation, was insufficient even though yields from the 300 K_2O treatments were excellent. There was no yield response to zinc, applied either preplant or sidedressed.

1986 - Two tests were conducted in 1986, with one site being located in the same field on the Malcomb farm as in 1985, but in a different location. Soil type was the same, a Nicholson silt loam, 2-6% slope. Initial soil test levels were (av. of the 4 rep composite samples): pH 6.8; P 191; K 198; Ca 2685; Mg 122; % of organic matter 2.1. Table 4 summarizes yields and soil test K levels at the end of the growing season for the site on the Malcomb farm. At that site in 1986, the growing season weather conditions were nearly ideal, resulting in very high yields, even on the control plots. Also, there was a small increase in yield to 800 lbs K_2O/A.

The same experiment was conducted on the Steve Simpson farm near New Columbus, Kentucky. Soil type at this site was an Eden silty clay, 6-12% slope. Initial soil test levels (av. of the 4 rep composite samples): pH 6.6; P 219; K 197; Ca 3715; Mg 249; % organic matter 2.8. Results obtained from this site are summarized in Table 5. The growing season was droughty, and the field was not irrigated. Yields were increased at all levels of K_2O tested, up to 800 lbs/A, despite the fact that the UK soil test recommendation would have been 300 lbs/A.

1987 - The site was located on a Nicholson silt loam soil, 2-6% slopes. The purpose of this test was to evaluate UK soil test K recommendations in a very detailed manner. This was accomplished by establishing a 5 X 5 Latin Square experimental design where the five treatments were 0, 0.5, 1.0, 1.5, or 2.0 times the soil test K recommendation. After laying out the experiment, each individual plot was sampled prior to fertilization in order to determine the specific amount of K_2O necessary to provide the soil test recommendation for each individual plot. Initial soil test levels were high enough in many individual plots that no K_2O was applied, even if the plot was in a 1.5 or 2.0 X soil test treatment. Each plot was subsequently soil sampled at the end of the growing season. Results from this experiment are summarized in Table 6.

The amount of K_2O applied to each individual plot was variable since it depended on the initial soil test level. Because of this the end-of- the-season soil test K averages are not related to any specific amount of K_2O applied. The amount actually applied varied from 0 to 210 lbs/A, depending on initial soil test level and the soil test level tested an individual plot. For that reason, the average soil test K levels for the five replications in each treatment shown in Table 6 are not directly comparable to the data in Tables 1, and 3-5. There was a small response to the soil test recommendations tested as compared to the control treatment. However, average yields were about the same regardless of the soil test recommendation level tested. This probably was due to a large proportion of the individual plots testing high before conducting the experiment.

Discussion

Based on soil test K levels measured before K_2O was applied and again at the end of the growing season, we observed a fairly good relationship between yield and soil test K levels at season's end (figure 1). This relationship was better than the effect of K rate applied on yields (figure 2). Our interpretation of these figures is that soil test K at the end of the growing season (September - October) should be in the 300-350 range to have provided maximum yields. Results from the K_2O rate tests (1981-86) indicate that at initial soil test levels below 200-250 lbs/A, the amount of K_2O which would have been recommended based on UK soil test interpretations, would have been only about half enough to produce maximum yields. However, as soil test K levels approached and exceeded 300, the UK soil test recommended K_2O rate was about right.

This raises the question as to why the UK calibration curve was not appropriate for these soils. To try and understand this, we analyzed samples of the Nicholson soil for type of clay minerals present. Results showed that vermiculite and interstratified mica-vermiculite were dominant clay minerals.

Both these clay minerals, particularly interstratified vermiculite, have the capacity to "fix" sizeable amounts of K into their crystalline structure. Such "fixed" K would not be very rapidly released into soil solution where it would be available for plant uptake. Until the "fixation capacity" for K by these clay minerals is saturated, sizeable quantities of fertilizer K can be "fixed" in relatively unavailable form to plants. We feel this is the mechanism which resulted in relatively inefficient plant utilization of fertilizer K on these soils when initial soil test K levels were below 200-250 lbs/A. It is likely that until soil test levels of K exceed these values, the clay minerals are "fixing" K, which could account for the need for about twice as much fertilizer K at such soil test levels than has been previously recommended. Once soil test K levels reach the 250-300 lbs/A range, the "fixation capacity" has apparently been largely saturated for the season and proportionately more of any fertilizer K added to the soil is available for plant uptake. Currently, detailed basic studies on the chemical and mineralogical properties of Nicholson, Lowell, and Eden soils sampled from a field on the Malcomb farm, are being conducted in the soil chemistry laboratory in UK's Agronomy Department.

Conclusions

1 - UK soil test recommendations for K_2O on tobacco resulted in only 75-90% of maximum yields when soil test levels were below the 200-250 lbs K/A for the soils on which we conducted these studies. Instead of the 300 lbs K_2O/A which

would be recommended by UK, it took 600 lbs/A to achieve maximum yields.

2 - The yield response to rates of K_2O higher than that recommended by UK was greater in drier seasons than in seasons with more ideal moisture conditions.

3 - There was no strong indication that sidedress application of K_2O was more effective than preplant applications.

4 - In two of three experiments conducted on high pH, high P, low zinc soils, there was a small yield response to 36 lbs Zn/A. Equivalent yield could be obtained without Zn by splitting the K_2O application.

5 - There is reason to believe that soils with significant content of vermiculite and interstratified mica-vermiculite clay minerals "fix" significant amounts of fertilizer K especially during dry years when soil test levels of K are below 200-250 lbs/A (neutral, normal ammonium acetate extractable K).

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Table 1. Effect of Fertilizer Treatments in 1981 on Yield and Soil Test K[1], Lowell Silty Clay Loam Soil.

Treatment	lbs Cured Leaf/A	Soil Test K[2] after Harvest
No K_2O	2,800	187
300 K_2O, preplant	3,210	245
600 K_2O, preplant	3,266	316
600 K_2O + 36 Zn, preplant	3,471	-
600 K_2O, 1/2 preplant + 1/2 sidedress	3,595	-
600 K_2O, sidedress	3,200	-
1200 K_2O, preplant	3,434	446

1/ Av. 4 reps/tmt
2/ Initial composite Soil Test K level for field was 184

Table 2. Effect of Fertilizer Treatments in 1984 on Yields,[1] Lowell Silty Clay Loam Soil

Treatment	lbs Cured Leaf/A[2]
No K_2O	2640
200 K_2O, preplant	2603
400 K_2O, preplant	2749
600 K_2O, preplant	2737
600 K_2O + 36 Zn, preplant	2893
600 K_2O, 1/2 preplant + 1/2 sidedress	2860

1/ Initial soil test K level, Av. of 4 reps, was 218
2/ Av. 4 reps/tmt

Table 3. Effect of Fertilizer Treatments in 1985 on Yield and Soil Test K,[1] Nicholson Silt Loam Soil.

Treatment	Lbs Cured Leaf/A	Soil Test K after Harvest
No K_2O	2380	152
100 K_2O, preplant	2982	171
200 K_2O, preplant	2856	227
300 K_2O, preplant	3120	234
300 K_2O + 36 Zn, preplant	3116	268
300 K_2O, 1/2 preplant + 1/2 sidedressed	3130	298
300 K_2O + 36 Zn; 1/2 K_2O preplant + 1/2 K_2O and all Zn sidedress	3017	295

[1]Av. 4 reps/tmt
[2]Initial Soil Test K Level, Av. of 4 reps was 157

Table 4. Effect of Fertilizer Treatments in 1986 on Yield and Soil Test K on the Malcomb Farm, Nicholson Silt Loam Soil.

Treatment	Lbs Cured Leaf/A[1]	Spoil Test[2] K After After Harvest
No K_2O	3471	218
200 K_2O, preplant	3518	283
400 K_2O, preplant	3487	304
600 K_2O, preplant	3521	335
800 K_2O, preplant	3629	314

[1]Av. 4 reps/tmt
[2]Initial Soil Test K Level, Av. of 4 reps, was 198

Table 5. Effect of Fertilizer Treatments in 1986 on Yield and Soil Test K on The Simpson Farm, Eden Silty Clay Soil.

Treatment	Lbs Cured Leaf/A[1/]	Soil Test K[2/] After Harvest
No K_2O	1959	156
200 K_2O, preplant	2166	199
400 K_2O, preplant	2264	252
600 K_2O, preplant	2405	244
800 K_2O, preplant	2783	263

1/Av. 4 reps/tmt
2/Av. of 4 reps, was 197

Table 6. Effect of UK Soil Test Recommended K_2O Rates on Yield of Tobacco, Nicholson Silt Loam Soil[1/].

Treatment	Soil Test K Before Fertilization	Lbs Cured Leaf/A	Soil Test K After Harvest
No K_2O	274	3052	250
0.5 Soil Test Recom.	303	3142	251
1.0 Soil Test Recom.	304	3110	243
1.5 Soil Test Recom.	285	3201	306
2.0 Soil Test Recom.	301	3195	308

1/Av. 5 reps/tmt

Fig. 1. RELATIONSHIP BETWEEN TOBACCO YIELD AND SOIL TEST K LEVELS AFTER HARVEST

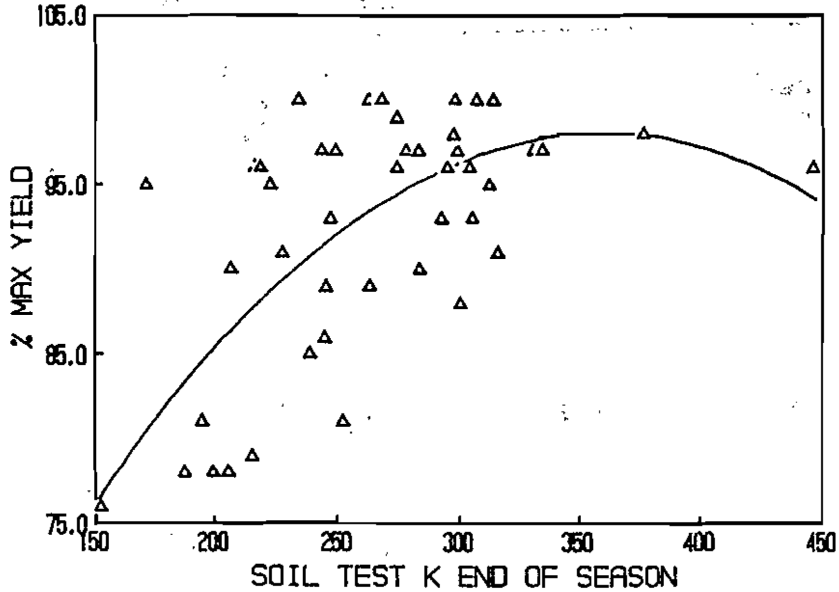

Fig. 2. Effect of Fertilizer K2O On Yield of Tobacco