SOIL FERTILITY TRENDS IN A LONG TERM CROP ROTATION-SOIL FERTILITY TRIAL[1]

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Penn State soil test recommendations are based on fertilizing for crop response at soil test levels below the critical level for response, maintenance fertilization based on expected crop removal in the optimum range just above the critical level, and finally no fertilizer recommended in the high range. Using a sufficiency level approach, a soil that was at the critical level would have a zero recommendation, however this zero recommendation would not be valid for 3 or 4 years until a new soil test is run. Thus for subsequent years a maintenance recommendation is necessary unless soil testing is done annually. Over time, the soil test levels should approach the critical level and then be maintained at that level. An optimum range is used instead of a single critical level to compensate for variability in soil testing, making recommendations and applying nutrients.

In 1969, Dr. Albert Hunter began a long-term crop rotation-soil fertility study at the Agronomy Research Farm at Rockspring, PA. The original study contained 5 crop rotations and 3 fertility treatments. All rotation x fertility treatments are present every year in this experiment. Each plot was sampled every year. Prior to 1991 the samples were analyzed by Bray P 1 and neutral, 1N ammonium acetate methods. Since 1991 the Mehlich 3 extractant has been used for both P and K. The design of the experiment has been modified over the years in response to changing research questions, however, several basic treatments have been maintained. We are able to use a selection of this large database to evaluate the results of our soil test recommendations over time in the different crop rotation systems.

One of the fertility treatments is fertilization based on the recommendations from annual soil testing. The soil test levels over time for P and K for three of the rotations are shown in Figure 1. The rotations shown are continuous corn; two years corn /three years alfalfa prior to 1990 and four years corn/four years alfalfa after 1990; and corn/soybeans. The results support the assumptions that the Penn State recommendations are based on. These plots started out with high soil test levels and initially there was a significant reduction in both P and K soil test levels for all of the rotations. As the levels dropped into the optimum range they seem to level off and were maintained in this range. While no one seems to know how the size of the optimum range was originally set, it looks like it is about right because it encompasses most of the observed variation. One large source of variation is that the maintenance recommendations are based on an expected crop yield. For corn in this study a yield goal of 200 bu/a was used. Actual yields rarely achieved that expectation and were very variable. As an example, Figure 2 is a graph of the actual yields in the continuous corn rotation treatment. Annual yields for this set of treatments ranged from 70 bu/A to 185 bu/A with an average of only 139 bu/A. This could explain why, while the soil test trends approach the critical level, they do tend to be consistently

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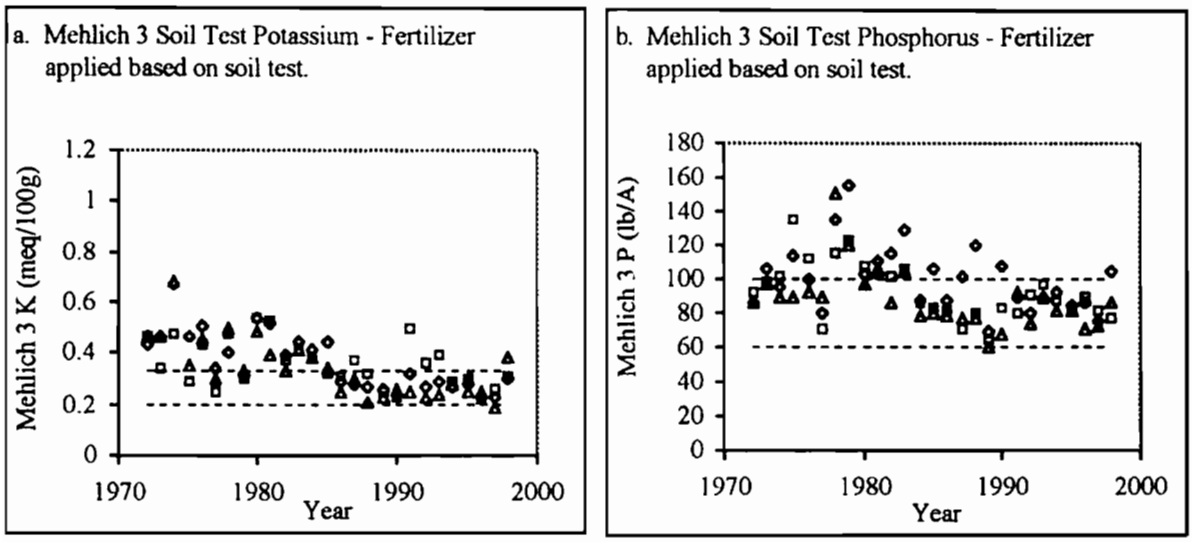

Figure 1. Annual soil test P and K levels from 1972 – 1998 for three different crop rotations: ◇ Continuous Corn, □ Corn/Alfalfa, △ Corn/Soybeans with fertilizer applied according to soil test recommendations. Horizontal lines indicate the optimum range. The bottom of this range is the critical level for crop response.

higher than the critical level. Finally, there was no apparent difference in the soil test trends due to the different rotations.

Another initial fertility treatment was to apply no P and the recommended K. From 1972 until 1990 this treatment resulted in soil test P levels well below the critical level while K levels remained in or slightly above the optimum range (Figure 3) similar to the other other treatment as shown in figure 1. In 1990, in response to concerns about the environmental impact of nutrients, this treatment was replaced with a treatment where no fertilizer was applied and manure was applied at a rate to meet the N requirement for each crop. The impact of this treatment change is obvious in the figures. There is a dramatic increase in soil test P and K when manure is applied based on N. This increase is greater in the continuous corn system because manure is applied at a full N rate every year. In the other rotations there are years when there is a legume in the field that no manure is applied. In other years when a non-legume follows a legume a much reduced rate of manure is applied because of the reduced N recommendation. The corn-alfalfa rotation in this manure system is particularly interesting because we have been assuming that in this rotation, which is very typical for PA dairy farms, the rotation should be close to balance for P and slightly deficient on K. However, as can be seen in figure 3, this is not the case, both the P and K are increasing significantly.

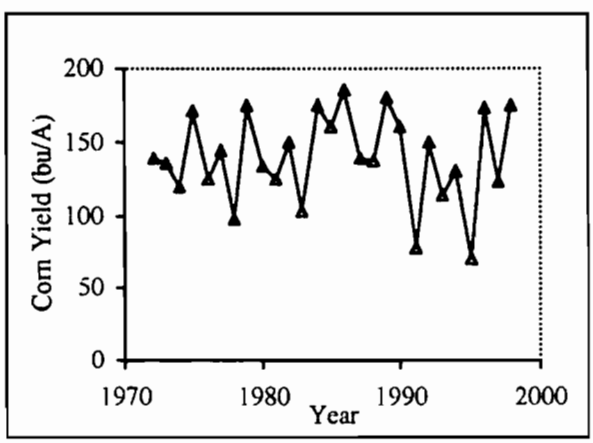

Figure 2. Corn grain yields from 1972-1998 in the continuous corn rotation and fertilizer applied according to the soil test recommendations.

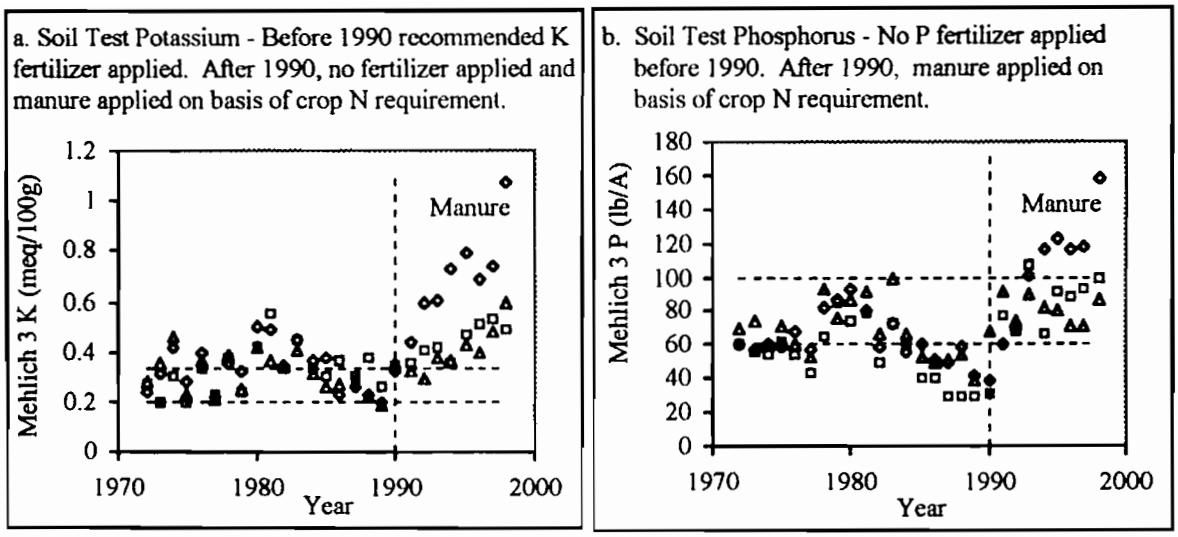

Figure 3. Annual soil test P and K levels from 1972 – 1998 for three different crop rotations: ◊ Continuous Corn, □ Corn/Alfalfa, Δ Corn/Soybeans with no P applied prior to 1990, recommended K applied prior to 1990 and manure based on crop N requirement applied after 1990. Horizontal lines indicate the optimum range. The bottom of this range is the critical level for crop response.

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