Are You Using Your Soil Banking Service?

*by J. L. Abbott**

Few farm problems have been studied as extensively as has soil phosphorus availability. Researchers have come up with many partial answers to why phosphorus may be abundant in soil but not available to plants. Many studies have been conducted and much has been written and said about various phosphate fertilizers and the effects that soil moisture, salt content, pH and temperature have on their solubility and availability. These things are important, but there is another matter that warrants perhaps more attention. That is the role that crop residue plays in phosphorus availability.

To understand soil, one must remember that it is not merely a sterile mixture of sand, silt and clay. Rather, it is a complex living system in which chemicals, micro-organisms and plant life react to and with one another.

Our irrigated desert soils as a rule contain very little humus or organic matter. Even though large amounts of crop residue may be incorporated into the soil, not much remains for long because of our high temperatures and rapid breakdown or decay. But research has shown that the organic matter present is very important to a growing crop. It seems to act as a soil "banking service" for vital plant nutrients such as phosphorus.

An experiment to study the effects of crop residue on cotton was conducted in 1967 at the U of A Mesa Experiment Farm. Acala cotton was grown following forage sorghum which had been either plowed under or removed from the plots. Half of the plots were on soil of low phosphorus level (unfertilized) and half on high phosphorus level (annually phosphate fertilized). Nitrogen fertilizer was applied at rates from zero to 200 pounds of nitrogen per acre. Each plot received the same fertilizer treatments it had received in six years of cropping prior to this experiment. Soil was sampled to one foot depth in all treatments before planting in April, in July and again in September. Yield data came from boll counts in a section of row in each plot. Significant yield data resulted from boll counts. (Table below.)

A tool useful in studies such as this was developed in the Soils Laboratory at the Cotton Research Center. It is a measurement of soil phosphorus soluble in a simple salt solution. This solution dissolves soil phosphorus in two forms, inorganic and organic. Inorganic phosphorus is available to plants. Organic soil phosphorus is not absorbed by plant roots, but it is part of a reserve supply. Separated and measured in the laboratory, the two forms change and fluctuate during the summer. (See Figures 1 - 3.) This fluctuation, or cycling from one form to another affects the availability of phosphorus to crop plants.

The change from inorganic to organic phosphorus occurs when a plant or soil micro-organism (bacteria, fungi, etc.) absorbs the nutrient and makes the phosphorus a part of its living tissue. When the plant or micro-organism dies, the tissue decays, and the phosphorus again becomes part of the soil, as organic phosphorus. In the spring, after the crop residue is plowed under and the field is readied and irrigated for another crop, the micro-organisms again become active. Their food is the crop residue, and since they require the same nutrients, including nitrogen and phosphorus, that crop plants do, they compete for them. Most of their activity and growth takes place before the crop plants get big enough to demand more than the soil can supply. By that time, decay is nearly complete. Some of the micro-organisms die, while others continue the process of decay. T

Yields of cotton (as number of bolls per 10 feet of row) as affected by nitrogen and phosphorus fertilizers, and by plowing under or removing crop residue.

Residue Treatment	*Phosphorus Level*	*Nitrogen fertilizer applied, pounds N per Acre* None	*50*	*100*	*200*	*Average*
Plowed Under	**Low**	137	232	253	252	218
	High	151	245	245	273	231
	Average	144	239	261	286	225
Removed	**Low**	142	190	236	229	199
	High	116	233	268	299	229
	Average	129	212	252	264	214
Average,	**Low P**	140	211	244	241	209
Average,	**High P**	134	239	261	286	230

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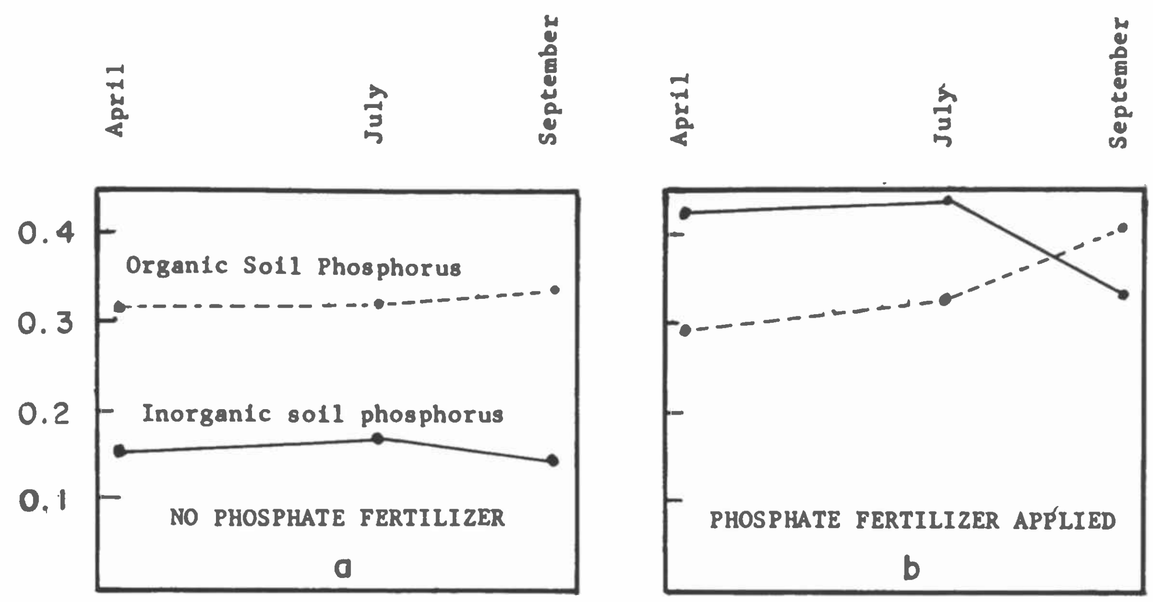

FIGURE 1

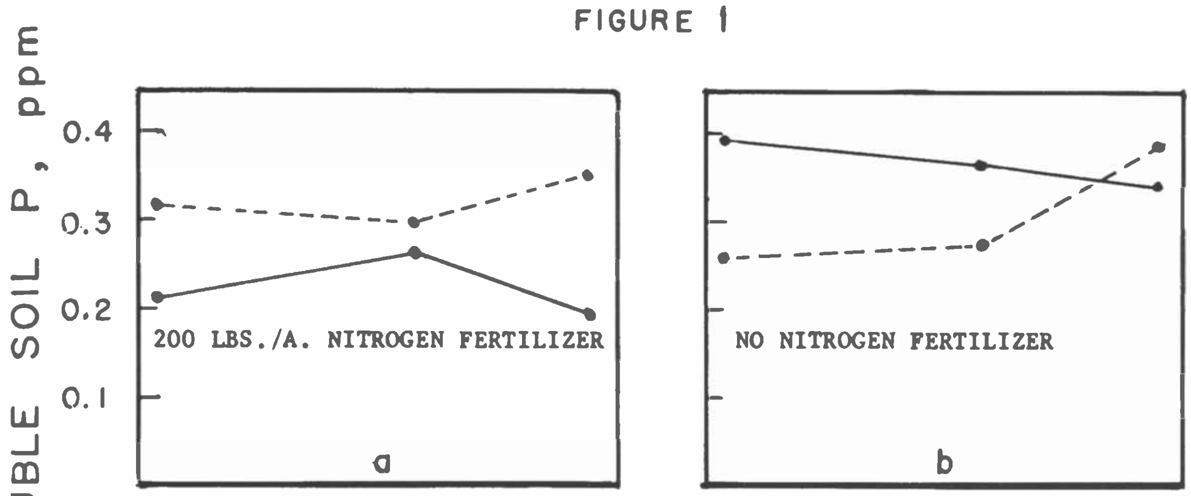

FIGURE 2

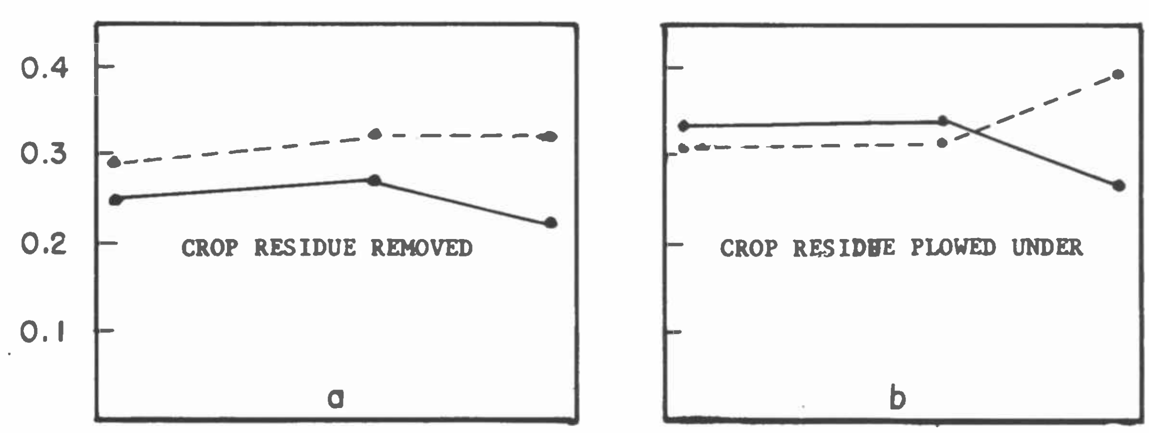

FIGURE 3

Effects of fertilizers and crop residue on soluble soil phosphorus

releases phosphorus in the inorganic form. Any condition that causes a drop in number of the micro-organisms — lack of water, essential nutrients, or cold soil — results in a slow-up in the phosphorus release cycle. The effect is often seen as poor crop growth.

Figures 1 through 3 show how the soil phosphorus "banking service" operates. The conditions studied in the experiment either reduced or increased phosphorus available to the crop. In Figure 1-a, soil inorganic phosphorus (solid lines) in plots that had not received phosphate fertilizer for over six years was low: 0.15 to 0.17 parts per million from April through September. The organic form (broken line) was more abundant, but changed little in that period. Figure 1-b shows that the phosphate fertilized soil had three times as much inorganic phosphorus as the no phosphate soil in April and through July. By September the inorganic phosphorus had dropped to about twice that of the unfertilized soil. Between July and September the "banking service" operated here. Part of the decline in the inorganic phosphorus was from absorption by the crop. An important amount, however, was converted to the organic form, which was up sharply in September, more than in the no phosphate soil.

After six years of cropping with heavy nitrogen fertilization (Figure 2-a), the inorganic phosphorus was lower than in soil where no nitrogen was applied (Figure 2-b). This was because much large crops were harvested after fertilization. The smaller plants in the no nitrogen plots removed less phosphorus from the soil in spite of the greater abundance of available phosphorus. In both cases, between July and September there was an increase of the organic form and a decrease of the inorganic form of phosphorus.

The graphs in Figure 3 show the place of crop residue in the availability picture. With crop residue removed (Figure 3-a), the inorganic phosphorus remained low throughout the season. The organic phosphorus did not increase, because there was no food left in the soil to allow the micro-organisms to put anything "in the bank." On the other hand, where the residue was plowed under (Figure 3-b), the natural processes allowed the increase in the amount of organic phosphorus that could be "withdrawn" as available phosphorus by the following crop.

It is not just coincidence that good farm management is built on practices that cooperate with nature. Heavy fertilization usually is necessary to achieve profitable production of crops. An abundant crop naturally requires an abundance in the soil of all of the nutrients that the plant needs. If more than enough nitrogen fertilizer is applied, but adequate phosphorus cannot be supplied by the soil, part of the nitrogen will be unused. The fertilizer program usually should include the application of phosphate, placed *where the plant roots can find it,* or occasional application of animal manure, as advised in U of A Bulletin A-55. The return of crop residue allows nature to make use of more of the soil's supply of phosphorus. Some results have shown that where residue had been removed, a greater response to phosphate resulted. But this emphasizes the importance of plowing under the residue to allow nature to maintain a nutrient balance in the soil.