HISTORY OF SOIL TESTING AT WSU

A. R. Halvorson

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The Prelude to Soil Testing

Washington State University is the Land Grant University for the State of Washington. It opened its doors in 1892. As with all Land Grant Universities, part of the agricultural research that it carried out was studies of the soils of the state, their nature and properties, and especially those properties of the soil that limited crop production. From these studies it soon became evident that chemical analysis of soils and crops was an essential for determining and establishing improved and dependable soil management practices for sustainable levels of profitable crop production. Some of the early work on crops and soil analysis at Washington State University--then The Agricultural College, Experiment Station and School of Science of the State of Washington--was done by Fulmer and Fletcher (1894), who were the Station Agricultural Chemists.

Lime and fertilizer experiments were some of the early studies carried out on the acid soils of western Washington. Research of this type was carried out at the Western Washington Experiment Station at Puyallup. About 1911, the Central Washington Irrigated Research Center was established for studying the various aspects of production under irrigation on the desert soils of south-central Washington. Later, other research stations were established in the state to study crop and soil management practices for the specific soil and crop production problems that existed in those areas.

Teaching, as well as research, was being carried out at the Pullman

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campus. Some of the students in Agronomy and Soils, after graduating, returned to the farm. They, of course, brought back with them the interest, concern, and knowledge of soils and soil fertility management and what might be done to improve production on their farms. During their student days, when returning to the campus, they would bring soil samples with them and test them in the laboratory classes related to soil testing. Occasionally, faculty would be pressed into doing some soil testing when a grower would come to the campus and visit with a faculty member about a soil problem. The faculty member would do the testing and make some suggestions as to proper management practices. Some of the WSU graduates became county agents. Some did have soils training and had gone through the course in which they studied soil testing. A few county agents bought soil testing kits so they could do some testing for growers in their respective counties. They realized that a soil testing kit was an inadequate approach to soil fertility diagnosis, but they did feel that using a kit was better than a guess.

With the end of World War II, many returning GIs went back to college, and some of them got their degrees in agronomy and soils. At about this time, too, fertilizer use was on the increase, making it all the more important to know something about soils and the factors related to proper use of fertilizers. If money were to be spent on fertilizers, at least it should be known whether fertilizers were needed at all, and if needed, which kind of fertilizer. This increased the pressure for some kind of an organized soil testing system. Faculty members were being pressed harder and harder for soil test information by growers, by county agents, and, in some cases, by people from the fertilizer industry. During the '40s there was an increasing amount of field research by the agricultural experiment stations into the soil fertility needs of the soils of the State of Washington. Increasingly, it became clear that proper soil fertility management could bring about increased yields and profits for a grower. A big question was: "Which of the various plant nutrients were needed and how much? What other soil properties (both chemical and physical) also affected crop yields?" Earlier research showed that "soil testing" could give very useful insight into these matters. Research workers were using soil tests in connection with their research to help guide their programs. There are various soil testing methods, each with a somewhat different capability for reliable evaluation of the fertilizer needs of a specific area. However, there hadn't been sufficient field experimental research correlating soil tests with fertilizer responses up to this point to select the "best" one(s). Several different methods were being tried by researchers across the state. At any one experiment station there were probably no two researchers using the same soil testing method and guide for interpretation. With an increasing number of growers checking with researchers and county agents about soil testing, it soon became very evident that a potentially valuable soil management tool should be made available to growers (and researchers) through some kind of organized program. Up to this point confusion reigned relative to soil testing.

The collective wisdom of all concerned--administrators, researchers, and county agents--was that the only way unified and standardized soil test information could be provided on a statewide basis was to have a centralized laboratory with someone in charge of coordination of the soil testing program. Also, it was apparent that the only practical way of making available to all growers of the state the benefit of scientific knowledge about soil fertility management was through a soil testing program that could serve the entire state. The decision to institute such a major program did not come to fruition without debate, doubts and delays. It was the strong leadership and strong support given to the idea of a soil testing program by the newly aoppointed head of the Agronomy Department, Dr. B. R. Bertramson, that finally led to the establishment of the soil testing program at Washington State University. The laboratory was to be located at Pullman in the Agronomy and Soils Department. It was to be a joint venture between the Agricultural Experiment Station and Cooperative Extension.

The Formative Stages of the Soil Testing Program

The establishment of such a laboratory came about in 1950. Dr. Mike Reisenauer, who was in charge of soil fertility research at Washington State University, was the person who organized WSU's soil testing service. He set up the laboratory, designed the management system in the laboratory, and made some special equipment for mass production of soil test results. Also, he gathered the available research information that could be used for correlating crop responses to fertilizer applications with soil tests. These data, although limited, served as a basis for calibrating soil tests. Subsequent experience proved his judgement to be "right on track". Dr. C. B. Harston, Extension Soil Specialist, at this time began to devote a major part of his time to field experiments to provide a broader data base for correlating crop response to fertilizer applications with soil tests.

The first laboratory testing of soil samples involved an analysis for pH, percent organic matter, the phosphorus, potassium, calcium and magnesium levels in acid soils, both of eastern and western Washington. For the central Washington irrigated area, the tests were pH, organic matter, phosphorus, potassium, and salinity level. A special test was offered to determine the gypsum requirement of soils of central Washington that were affected with high levels of sodium ("alkali soils"). The charge for the testing was $1.50 per sample. Likewise, a special test was made available for the tree fruit area--a test for residual arsenic. Arsenate of lead sprays had been used for many years to control codling moth. Arsenic residues built up in the soil. At some point the level was toxic to many plants. A test to determine the level of residual arsenic was essential for developing proper management practices for such soils.

Testing of water for its suitability for irrigation was also carried out by the soil testing laboratory. Irrigated agriculture is a major component of Washington's agricultural economy. Close attention must be paid to the quality of this irrigation water--quality as it relates to its mineral components. The quantity of dissolved minerals (soluble salts) or the proportion of one mineral to others can make waters totally unsuitable for irrigation, suitable but only by following certain special management practices, or can be used with no likelihood of problems developing. Columbia River water, which is Washington's single largest source of irrigation water, is in the last category. There are, however, many other streams, lakes and wells used for irrigation. For some, their only source of water is irrigation water return flow or drainage water or industrial waste water. If one proceeds blindly to use water for irrigation without knowing its quality, saline (excess soluble salts) or sodic (alkali) soils may develop. Preventive measures applied from the beginning are almost always less costly than subsequent reclamation procedures. This is why irrigation water quality analyses are essential before the decision is made to apply the water to the land.

There is another important reason for testing the mineral components of irrigation water. Often natural waters contain sulfate. Sulfur is an essential plant nutrient, and most of Washington's soils provide less than an adequate amount for our high crop yields. Some waters contain sufficient sulfate to adequately supplement the soil's supply of this nutrient. This knowledge is vital to making knowledgeable fertilizer management decisions. When sulfur is present in adequate amounts, a reduction of fertilizer cost is the outcome.

During the initial stages of the soil testing program, the interpretation and appropriate recommendation that needed to be made for each of these tests from across the state was first done by Dr. Mike Reisenauer. With continued expansion, this task was assumed by the Extension Soils Specialist, C. B. Harston.

At this point Nick Holoboff, a graduate student in soils, was hired to supervise and manage the laboratory operation while he was working on a Master's degree in soils.

The WSU Soil Testing Program Challenged

Shortly after inauguration of WSU soil testing, the legitimacy of a state-operated and supported soil testing service was challenged by a group of privately operated analytical laboratories also offering soil testing services. Their attempt to stop what appeared to them to be unfair competition from a state-supported laboratory soon involved state, and even some national legislators. When Washington State University faculty and administrators were given an opportunity to make a presentation as to what constituted a soil testing program--that it was far more than just offering an analytical service, and that only the Land Grant University had the capability of providing statewide correlation-calibration of soil tests to support a soil testing program--the opposition subsided.

"Outlying Testing" (Research and Educational Program)

As the program grew and developed, in the mid 1950s it became necessary to train the county agents so they could make the recommendations for the soil test results for growers from their county. Not all had specific training in soils, but they wanted to become familiar with soils as they felt the contact with the grower by means of a soil test report provided a unique opportunity for communicating with growers in their county. Also at this time the task of carrying out the field research for correlation-calibration data became large enough that it was necessary to put a full-time person on this matter for western Washington and for central Washington. Dr. Lowell Nelson was hired for this position in 1956 for western Washington. Harold Cosper filled the position for central Washington from 1953-1955. He was followed by A. I. Dow who carried out this function for the irrigated central Washington area for the next 25 years.

This program of having university faculty carrying out a field research program to study soil fertility management problems on farmers' land with their participation and with the county agents involved with the planning and execution of the projects became known as "the Outlying Testing Program". The field experiments were designed for correlation of soil test with crop response to fertilizer to serve two functions: (a) to provide quality research data, and (b) to provide plots that could be used by county agents as "demonstration" plots for county field day educational programs. This program proved to be especially effective in the Columbia Basin project, where new lands (desert lands) were being put under irrigation. Management of these lands was a new experience for most settlers coming in. They were eager and enthusiastic participants (learners) in all educational and demonstration programs.

The concept for this program effort (joint effort between Extension and Experiment Station) originated at WSU. It was an extremely successful program, and was soon picked up by several other states.

Changes in Program Management and Operations

By 1956 the task of managing the soil testing operation became sufficiently involved that it was necessary to change the overall management and supervision of soil testing. Dr. Lowell G. Nelson was hired to be the person in charge (Director) of the entire soil testing program, which involved the laboratory aspect, the matter of supervising county agent training for making recommendations, etc. With Lowell Nelson's move to Pullman, the Outlying Testing position was open in western Washington. It was immediately filled by a county agent, Darrell Turner, who had earlier received a Master's degree in soils at WSU.

Special Soil Tests For Dryland Agriculture

At about the time that the Outlying Testing Program was getting underway in central Washington and western Washington, Glenn Leggett and Tom Jackson, graduate students at Washington State University, Pullman, were doing a great deal of field research on wheat to relate nitrogen fertilizer needs and available soil moisture supply to maximum wheat yields. A very effective soil testing system was built up around the correlation data developed from their studies. Preliminary studies on these relationships had been carried out by Harley Jacquot, who was then agronomist for the McGregor Land and Livestock Co., Hooper, Washington. His early work showed so much promise of helping guide a nitrogen fertilizer program for dryland wheat production (under the summer fallow system) that supervisors of several of the Soil Conservation Districts (SCD) wanted to set up nitrogen and moisture testing laboratories in their districts to serve the growers within that area. The first such Soil

Conservation District lab was set up at Lacrosse in Whitman County in about 1953.

Harley Jacquot, formerly superintendent of the experiment station at Lind, and a member of the agronomy faculty, provided early guidance to the group planning for that first laboratory. It was patterned after Harley's laboratory in the basement of the McGregor store in Hooper, Washington. These laboratories were set up to test for available soil moisture and the nitrate form of nitrogen that had accumulated in the soil before planting in the fall. With additional information from Jackson's and Leggett's work, other laboratories were set up in several of the other eastern Washington counties. The reason for the district laboratories was that soil samples taken for moisture and nitrate determinations had to be handled very carefully. The samples had to be kept sealed to prevent loss of moisture and they had to be kept cold to stop biological activity. With the Soil Conservation District laboratories, no farmer would have more than about a two-hour trip to deliver his samples. During that time, little or no change in the moisture or nitrate level in the soil sample would have occurred, even without special sample handling systems.

The general supervision of these laboratories was to be done by the Director of the soil testing program at Washington State University. This involved training the technicians to run the moisture and nitrate tests and also involved preparing the chemicals used in the analytical process. The county agent of the county in which there was an SCD laboratory became an integral part of this program since he was trained to be a general overseer of the program for his area, and to be alert to potential problems that might develop in the laboratory operation or field interpretation. When problems did develop, the Director of the WSU Soil Testing Program was available to help, as he was ultimately responsible for the proper technical operation of this program. Each year, training sessions were held for the technicians, and also, in almost all cases, every year the Director of the WSU soil testing program went to the Soil Conservation District Laboratories to check up on the operation of the Laboratory and the quality of the analysis. The interpretations of those test results was done by a Soil Conservation Service (SCS) unit conservationist or the county agent who had in turn been trained by the person in charge of the soil testing program at Pullman.

"Growing Pains"--Changes

In June of 1957 Dr. Lowell Nelson resigned as Director of the WSU soil testing program. The position was refilled in September 1957 by Dr. A. R. Halvorson. In the meantime, Nick Holoboff, who was immediately in charge of the laboratory analysis, together with other soils faculty, kept the soil testing operation going through the summer.

Part of the "growing pains" was the fact that a test for available soil boron needed to be incorporated into the soil testing program at this time. Field experience and field research had shown that most soils in the state of Washington did not provide adequate boron for high boron-requiring crops like alfalfa. Boron fertilizer came into quite general use. Equally a matter of concern was the fact that some crops are extremely sensitive to even a slight excess of this nutrient. To make sure a crop like alfalfa had sufficient boron, and also to make sure there wasn't an excess for the next year's crop (e.g. beans) required soil fertility management based on knowledge and facts, and certainly soil testing can provide some of the essential facts. The "growing pains" revolved around the nature of the boron test--its very empirical nature. Training a technician for this analytical procedure is tedious and time-consuming. This was a problem because, in the early years of soil testing, there was a very rapid turnover of laboratory technicians. In spite of this, the boron soil test proved quite reliable and, as a result, a valuable step forward in overall scientific soil fertility management.

By 1959 the volume of soil samples being sent to the WSU soil testing laboratory was sufficiently large that the limited laboratory space was taxed beyond its capacity. There was insufficient space for processing incoming samples and for setting up a "flow system" of analytical steps. Nick Holobof was the head technician and chemist. Beyond what he could do, the routine laboratory work was done by students who were hired on a part-time basis. Their schedules were irregular and often exams took priority over their job at the soil testing lab. With limited space and inadequate help, there were delays in turning out test results within a reasonable time. Fortunately, one of the laboratory's customers was one of the Board of Regents who operated a large wheat ranch. In his mind, when a university program unit wasn't functioning up to expectations, it was a matter that should be brought to the attention of the university president--President C. Clement French. After having the opportunity to fully explain the state of affairs that existed for the laboratory operation, it immediately became possible to hire fulltime laboratory assistants who could be adequately trained and who could be counted on to be at work on time and when scheduled. During the 24 months from September 1957 to September 1959, 19 different student technicians had been used in the laboratory!

The limitation of laboratory space was shortly overcome by a move into the new soil testing laboratory in Johnson Hall (in January 1961). Shortly after moving into the new location, and before getting fully set up, the University Space Committee came to investigate "all the space allocated to soil testing". Apparently they gained the impression that this was far too much space for such an operation. (Here was an example of committees, removed from the scene of actual operation and having no concept of what is involved, trying to run someone else's area of work!). Within one month, the laboratory, in its new location, was analyzing 100 samples per day on a sustained basis (averaging 5 analyses per sample, or 500 analyses per day, an average of over 1 analysis per minute). It was service of this nature that was a credit to Washington State University, and which prompted Dean Madsen (Dean of the College of Agriculture--then called the Institute of Agricultural Sciences) to comment: "It is service of this type that helps gain and maintain support for WSU."

The volume of testing referred to earlier occurred only during the "rush" season (mid-January until mid-May). During the rest of the year soil samples from research plots were analyzed, new procedures tried, and equipment repaired and renovated.

The increased volume of samples was having its effect at the county level. By this time soil analysis reports were being sent to the county agent, who then wrote a letter to the grower, giving him an interpretation of the analysis report, and suggesting a fertilizer program for the grower. (For example, Grant County one year had 1,000 soil test reports.) The county agent was unable to write letters sufficiently fast to avoid a backlog of soil test reports. During the spring planting season, growers wanted their test reports and recommendations <u>without delay</u>! Furthermore, writing letters of recommendation under great pressures of time resulted in both typographical errors and errors of statement made by the person dictating the letter. For example, on one occasion a lime recommendation of 1 ton per acre was called for, but due to errors creeping into the statement it came out <u>1 pound</u> per acre. Conversely, with boron, for example, 1 or 2 pounds of boron might have been recommended, but due to a misstatement it came out 1 to 2 tons of boron per acre. If that amount of boron fertilizer were actually applied it would sterilize the soil for several years! Such letter writing was time-consuming and too prone to errors. Hence it was necessary to work out a remedy to these problems.

Drawing From the Experience of Others--Oregon

Oregon State University was also experiencing comparable problems with their soil testing program. They had been experimenting with what they called "Fertilizer Recommendation Leaflets" (later called "Fertilizer Guides"), which were prepared statements giving the fertilizer recommendations for the different soil test levels for each specific crop. By carefully preparing these ahead of time the miscellaneous errors such as mentioned earlier could be eliminated. Also, the county agent could be relieved of the task of writing a full letter of repetitive statements for each grower's test report. By eliminating the letter writing bottleneck in the county agent's office, days and, in some cases, weeks could be cut from the time it took a grower to receive his soil test report and fertilizer recommendation. A "Fertilizer Recommendation Leaflet" was prepared for each crop and for each area of the state of Washington. These leaflets contained the necessary information for the county agent, or the grower, to arrive at the proper fertilizer recommendation for each soil test. In some cases there might be a need for some modification of the standardized recommendation due to special local conditions, but here the county agent could add a few brief notes without the need to write an entire letter. At this point, the soil test reports were still sent to the County Extension office with the idea that the county agent would in turn send a copy of the Fertilizer Guide with any notes or comments that he felt important to the growers. The agent would send a copy of his comments back to the soil testing office in Pullman so the director of the laboratory could monitor the agent's knowledge of soil fertility management principles and his ability to communicate the proper information to the grower. This system served as one of the bases for designing future training programs for county agents. It became an ideal teaching tool. The Soil Testing Laboratory at Pullman would also send extra copies of the soil test report to the county agent for him to distribute to other agencies (SCS, ASCS, etc.) as they also, in many cases, needed soil test information. The local ASCS office needed copies since, in many cases, they would make payments for certain cultural and management practices. The SCS needed the report for their "farm plan" for the grower. The increased "paperwork" required additional secretarial help (two full-time secretaries).

Efficiency, Uniformity and Speed Needed by Users

The next developmental stage in making the soil testing program more efficient in terms of providing quicker and more direct service to the grower came in the mid to late 1960s. This step involved sending directly to the grower his test report and the Fertilizer Guide (directly from the Soil Testing Laboratory). Sending the test report to the county agent resulted in several days' delay in getting the information to the grower because of time for transit in the mails. If the agent was gone for several days to a week, the information would likely reach the grower too late to be of any value. When weather permitted field work, the grower simply could not afford to wait for anything. At a certain point in the spring there is a major price to pay (in reduced yields) for each day of delay in planting the crop. The new procedure of sending the soil test report and the Fertilizer Guide directly to the grower worked well because, by this time, growers were better "educated" about soil fertility management and how to use soil tests as a management tool. Extension's effort at bringing new technology to growers had worked as planned. Likewise, fertilizer dealers and fieldmen were better trained too, as a result of WSU's conducted field tours, fertilizer conferences, and various other educational programs. Some events were conducted with help and participation from industry agronomists and soil scientists.

Concurrent with the expansion of soil testing, the fertilizer industry had been getting increasingly interested in, and involved with, the WSU Soil Testing Programs. Fertilizer dealers would encourage their customers to have soil samples tested so that they could use this as a basis for fertilizer recommendations. In fact, it soon became a practice of many fertilizer dealers to provide soil sampling services for their customers. This meant the dealer was also intimately and inextricably involved in the soil testing program. He would also receive a copy of the grower's soil test report. This meant that, in many cases, the soil testing office would need to prepare up to five copies of each soil test report. Five copies was about the limit that could be typed in one typing. Fortunately, in the early '60s copy machines came to the rescue. Other changes also occurred: Nick Holobof, who had been a dedicated and capable chief laboratory technician, moved to another position. Maurice Moneymaker was his replacement. Also, changes and improvements were being made in chemical analysis equipment and procedures. Moneymaker was able to make the best possible adaptation of all this (within budget limitations) to gain speed and accuracy. This resulted in one of the most reliable soil testing laboratories in the Northwest.

With increasing participation of fertilizer dealers in soil testing, the whole process of managing the soil test reports also became more complex. For example, a fertilizer dealer near a state border might serve customers in both states. While each of the states adjoining Washington had their own state soil testing laboratory, a dealer who served customers across the state line would not likely want to divide his collection of soil samples by state of origin and send samples from each state to the respective state's laboratory. In particular, this grew to be a matter of concern in the Washington-Idaho border area of Pullman and Moscow. Each state had a somewhat different soil testing and reporting system and a somewhat different set of correlation-calibration data. As a consequence, if the Idaho samples came to Washington, Washington would use its basis for reporting and interpreting the test reports. This would probably be foreign to the Idaho grower who had formerly used Idaho's soil testing system. Also complicating the whole matter was the fact that, in a number of cases, the specific recommendations made by Washington would be different from those made by Idaho. Whenever testing of this nature was done for customers across state lines it was a practice to inform the county agent of the county in the other state. Since the two states had different testing systems, the test results were expressed differently. For example, one state expressed available phosphorus as parts per million (ppm), while the other expressed it as lbs/A--a difference in value by a factor of two.This confused the county agent and, in general, left the whole concept of soil testing in a state of doubt as to its value. Certainly there should be no major difference in recommendation for one field in Idaho from that which would be made for a field just across the line in Washington which adjoined that same field. At one point, in an attempt to avoid the confusion, it was agreed by both Washington and Idaho that each state would not test soil samples from the other state. This might have helped to avoid some confusion, but of course it evaded the main issue, which was the matter of being consistent across state lines. This clearly pointed out the need for the states to have a coordinated soil testing-field calibration program and uniformity of testing procedures.

Such a standardized and coordinated soil testing-interpretation program is as important to the business of agriculture as is a standardized monetary system between states for unhindered trade between and across state lines.

Industry's Support and Encouragement

Industry, of course, encouraged such cross-state coordination. The results of such efforts would help their task of providing consistent information in border areas. Since industry was actively involved in soil testing-fertilizer recommendations, and since a very good working relationship had developed between the three northwest state universities and the industry, an attempt was made by the industry organization (the Northwest Plant Food Association) to develop some consistency of interstate testing services. Knowing that reliable recommendations depended on correlation of crop responses to fertilizer treatments with soil test values, people in the fertilizer industry very strongly encouraged field experimentation that contributed to these goals. If this could be accomplished, they could freely work across state lines and could then also count on reliable, accurate soil test interpretation information. The Northwest Plant Food Association had a special committee, the Soil Improvement Committee, which dealt with problems of this nature and with other matters that were of concern to the industry and the universities. An example of such a cooperative effort was a joint sponsorship of a research project with Dr. F. E. Koehler, WSU researcher, to study the fertilizer needs of the eroded hills and ridges in the Palouse area. It was quite obvious that these areas needed special fertility management, but the exact nature could be determined only by field research. The Northwest Plant Food Association gave a small grant of money to help encourage and hasten this type of research, which was a joint WSU and U of I project. This program was successful, in fact so successful that it soon became difficult to find an unfertilized (low phosphorus) area on which to conduct phosphorus fertilizer experiments.

As indicated earlier, in 1960 we adopted Oregon's idea of using "Fertilizer Recommendation Leaflets". The first such Fertilizer Recommendation Leaflet (later called Fertilizer Guide) was written by Dr. Walt Mortenson and Darrell Turner of the Western Washington Research and Extension Center. It was for white clover grass pasture for western Washington. In very short order other fertilizer recommendation leaflets followed for central and eastern Washington. The fertilizer industry was also very much in favor of this approach to providing basic reference material for recommendations for different crops for each of the soil test levels. In the early 1960s, and particularly toward the middle '60s, industry, through the Soil Improvement Committee of the Northwest Plant Food Association, very strongly pressed the matter of coordination, standardization, development of better recommendations, etc. This persuasion from industry resulted in the formation of a Tri-State Soil Test Standardization Committee, which involved the state soil testing laboratories of Washington, Oregon and Idaho. The first chairman of this committee was Dr. A. R. Halvorson from WSU. At each annual summer fertilizer conference the industry representatives of the Soil Improvement Committee wanted a report from the three states as to their progress related to standardization and development of fertilizer recommendations.

Maturing

It was more than fortuitous that the soil testing operation at Washington State University had earlier moved to the new Plant Sciences Building as it had become essential that more space (and equipment) be available. The soil testing facility, which had been located in Wilson Hall until 1961, was so limited in space that it simply could not handle the volume of samples which were coming in. The move into the new building occurred in January of 1961. The facilities in Wilson Hall were so overcrowded that incoming soil samples had to be stored in the hallway. On some days over 300 samples would arrive. Our capacity for testing and turning out test results was about 60 samples a day. This meant that in one week's time we would have a backlog of about 1,000 samples. Some of these had to be stored in a hallway and, of course, in some cases the janitor thought these samples were put out in the hallway to be discarded, which, as can be imagined, resulted in some disasters and embarrassing situations. The new facilities in Johnson Hall were excellent, and in a very short time a mass production system was set up so that large volumes of samples could be handled. In fact, it was possible to test 100 samples a day on a sustained basis.

As the WSU soil testing program moved into the late '60s and early '70s it had matured and was able to provide essentially any and all soil analyses that were needed. A relatively good base had developed from field research for proper interpretation of these test results. By this time the laboratory was a very efficiently operating soil analysis laboratory which produced very reliable data. The claim can justifiably be made that this was the "best" soil testing laboratory, and soil testing program, in the Northwest.

By 1969, the five Pacific Northwest states had made a considerable amount of progress in standardizing procedures for a number of the soil tests. Soil testing and accompanying fertilizer suggestions had become relatively well accepted, and in fact, in some cases, so well accepted that soil test results were rather blindly followed without giving proper thought and consideration to other factors involved in developing a good soil fertility management program. To help users of soil test results understand that other factors needed to be considered when making a recommendation, it was suggested by A. R. Halvorson at the 1969 Fertilizer Conference session which dealt with standardization, that we change the name "Fertilizer Recommendation Leaflet" to "Fertilizer Guide". This was accepted by all states involved. In 1970 a "Current Status of Soil Test Standardization in the Five Northwest States" was published in the Proceedings of the Northwest Plant Food Association summer meeting.

Soil Testing Service Shifts to Industry

While the WSU soil testing program had begun to mature, so had the fertilizer industry and all the service aspects of the fertilizer and ag. chemicals business. Each state Land Grant University had been steadily graduating students from the fields of crop science and soil science, many of whom went back into agriculture, some to the farm, some to the fertilizer industry, some as commercial consulting agronomists, and some into the business of commercial soil testing laboratories. Most of the new commercial soil testing laboratories that were set up in the state of Washington were set up by individuals who had soils testing and agronomic training, and thus understood the principles underlying sound soil testing-fertilizer recommendation programs. They knew, for example, that chemical analysis of soil by a noncalibrated soil testing system would have no meaning as far as agriculture was concerned. During this time a number of commercial laboratories entered the field of soil testing. Many started but few continued. Generally there would be from four to six that would be operating at any one time. Since one of the main factors determining economic viability of such an operation is volume of samples, these laboratories made a great effort to develop a large clientele.

An attractive feature of a soil testing service to a fertilizer dealer or a farmer is a short "turnaround" time. The standing question is: "How long does it take a laboratory to get test results into the hands of the sender?" This seemed to be the criteria by which a soil testing laboratory would be judged. A short turnaround time is, without question, an important feature of a soil testing service, particularly in the spring when there is a rush of samples and a need by the dealers to have information in a short time. However, from the laboratory standpoint, a short turnaround time can be one of the more costly aspects of running a soil testing operation. If a laboratory succumbs to the pressure for short turnaround time there is increasing likelihood that erroneous analytical results will be produced, unless special and costly precautions are taken. A typical turnaround time for the WSU laboratory during the "rush season" was 4-5 working days, with many test results actually being returned in 3-4 days. Maintaining a 4-5 day turnaround time was a time schedule that allowed for all the care and attention necessary to assure reliable results. It did not require hiring additional help, which would have required the head technician (Moneymaker) to divert his attention from management of the overall operation to training new personnel. Additionally, new technicians need extra guidance and supervision for some time after their initial training period. With a short-term "rush" period (about 3-4 months), the cost of the special training and added supervision time needed for such a short period of time makes that feature of "speeded-up turnaround time" impractical. Errors would also increase.

On the other hand, when the flow of samples drops well below the amount that the laboratory has capacity to handle in a day's time, the cost/sample of running the laboratory "full speed" for 15-30% of its capacity is obviously very high. Dropping the routine testing to a schedule of once or twice a week is the obvious answer, leaving a few full days a week to efficiently handle other necessary work.

For those growers who could not manage their soil sampling schedules to provide sufficient time from sampling time to the time they needed the results to determine fertilizer need, they were referred to commercial laboratories who apparently were "geared up" for this special service and had a price schedule to accommodate such added costs.

In any event, grower service testing became more and more a function of commercial soil testing laboratories. This was a role that, early in the development of soil testing, could be adequately done on a statewide basis only by a Land Grant University (WSU for Washington). Hopefully, if relieved of the need to provide grower testing, WSU could shift resources from that activity to other basic components of soil testing: soil fertility research and Extension. The need for additional activity by WSU in these areas was becoming evident because of the rapid change in properties of soil such as increasing soil acidity, increasing concern about micronutrients, change in crops grown such as disappearance of the sugarbeet industry, increase in vegetable seed production in central Washington, change in cultural and crop management practices such as the introduction of no-till farming, band application of fertilizer with the seed, etc. WSU's role in soil testing went far deeper than just providing a grower testing service. The grower testing service was only a part of a greater concept--that of developing a sound soil management program for the state.

WSU's stated role in soil testing at the time of its initiation was to:

1. provide a standardized and unified soil testing system for those doing field research and an analytical service for Extension to deal with situations in the field that required analytical services to

provide information for enlightened interpretation or understanding, and ultimately for developing recommendations for remedial measures;

2. to develop this highly effective soil fertility management tool, which could be done on a statewide basis only by an institution such as a Land Grant University;
3. to make available to the growers of the state of Washington a soil testing service which was based on sound field and laboratory studies (correlation-calibration).

The volume of soil testing in the state had been steadily increasing. With an ever-increasing number of well-trained soil scientists and agronomists graduating from agricultural colleges, it was only logical that some would set up private-commercial soil testing operations. Some provided a complete service (sampling, analysis and recommendations). With this development, WSU's role in the grower service aspect of soil testing declined. With one major goal of the soil testing program at least partially achieved (that of making a reliable grower testing service available), WSU could move with confidence to the fulfillment of the two remaining, and most important, roles.

As time went on, it became evident that, more and more we (WSU) were called on to serve as a reference point for accuracy and reliability for commercial soil testing operations rather than to provide service testing. The WSU laboratory held as its highest and first commitment, accuracy and reliability of soil testing. In a few years it became evident that there would be a basic core of three to five commercial laboratories that could make soil testing a viable, continuing business. Since these laboratories were, in general, using analytical procedures based on WSU's system of testing and the research which backed it up, there was a need to bring about a coordination and standardization of soil testing done by these commercial laboratories.

WSU, The Reference Point for Soil Testing

About 1970, Washington State University set up a program referred to as "the WSU Reference Sample Service". This program was designed to work with those commercial laboratories that used WSU's soil testing system and its research-backed correlation-calibration information. But beyond just simply using the same procedures, it was necessary that these laboratories standardize their procedures with those used by WSU, to be sure that the same test results would be obtained as would be obtained at Pullman. Soil testing involves using many very empirical procedures, thus making it necessary that every step of the procedure be standardized and followed in exactly the same manner by each laboratory. To verify that all of these procedures were being followed precisely in every aspect, reference soil samples were provided for these laboratories. Several "shakedown runs" were necessary to bring the test results from these laboratories in agreement with the WSU soil test results. Since the WSU laboratory and the four to six commercial laboratories provided most of the soil testing service for the growers of the state, it was now possible to provide to the bulk of the growers of the state standardized soil testing services ensuring consistent results, even though WSU was no longer providing this service directly for growers.

The Closing of the WSU Soil Testing Laboratory

Beginning in the early '70s, WSU, as well as all other state agencies, began to suffer budget limitations and severe budget cuts. This limited WSU's capability for replacing obsolete equipment and buying new, modern equipment that would allow for faster and wider ranges of soil test results. By the mid- to later '70s the laboratory underwent personnel cuts, which further limited their ability to provide rapid turnaround time on soil samples. From then on, the major effort was concentrated on providing service for research and Extension, and for maintaining the Reference Sample Service. The final outcome of the budget crunch was that in November of 1981 the WSU grower testing service was discontinued. Research and correlation-calibration will still be continued, as will the Reference Sample Service. What once was the Soil Testing Laboratory is continuing as a tool of the research programs, and will continue to serve a crucial role in WSU's effort at developing the best possible soil fertility management system for its greatest resource: its agricultural land.

SUMMARY

In summary, it can be said of the soil testing program at Washington State University that, at its inception, agriculture in the state of Washington was introduced to the concepts and techniques of modern scientific soil fertility management. Through soil testing all the results of soil fertility research done by Washington State University across the state could be directly applied to any farmer's field. This has meant that agricultural production in the state has been more efficient and, thus, more profitable. In the state of Washington approximately 100 million dollars worth of fertilizer and agricultural lime is used on the state's farmland each year. When used in accordance with scientific soil fertility management principles, 2-4 dollars/acre are returned for each dollar invested in such materials. This amounts to an increase in agricultural income in the state by 200-400 million dollars per year. Even if soil testing could be credited with only one percent of this added return, that amounts to 2 to 4 million dollars returned to the state's economy because of the soil testing program! Each bit of crop production knowledge and technology that has been applied to agriculture has boosted US agriculture from the level that exists in the underdeveloped countries to our present efficient food and fiber production enterprise. Soil testing certainly has been one of those technical inputs that has made American agriculture the efficient production system it is.

The WSU soil testing program has, since its inception, been a major factor in bringing about efficient utilization of the state's land resources and the fertilizers and soil amendments applied thereto. Its forerunner, the informal service provided by outlying experiment station personnel and Pullman faculty, helped some in a similar way since the early days of the agricultural experiment station. Use of fertilizer lime and other soil amendments began shortly after the turn of the century, but did not become a major factor in the state's agriculture until after World War II. The first year for which official records of use of these products was kept by the Washington State Department of Agriculture, Olympia, was 1956. In that year 135,064 tons of fertilizer and soil amendments are reported as being used on Washington agricultural land. For the crop year July 1, 1984 to June 30, 1985, nearly a million tons of material are reported as being used. With further development of higher yielding crop varieties and gains in knowledge of improved management practices, the use of these products in the future will, no doubt, continue to increase.

The WSU Soil Testing Program had its struggles and trials, but it changed to keep pace with developments in the science of soil testing. It made appropriate changes whenever it became evident that improved service to agriculture was possible. The end result was that growers in the State of Washington had access to the best soil testing service in the northwest, and probably as good as any in the nation.

When the WSU soil testing service had to close, because of budget restrictions, the commercial soil testing services were left with a legacy of a strong scientific basis on which they could build their programs.

REFERENCES

Fulmer, Elton and Fletcher, C.C. 1894. Washington Agricultural Experiment Station Bulletin No. 13.

Fertilizer Guides (complete set as of January 1986 attached).