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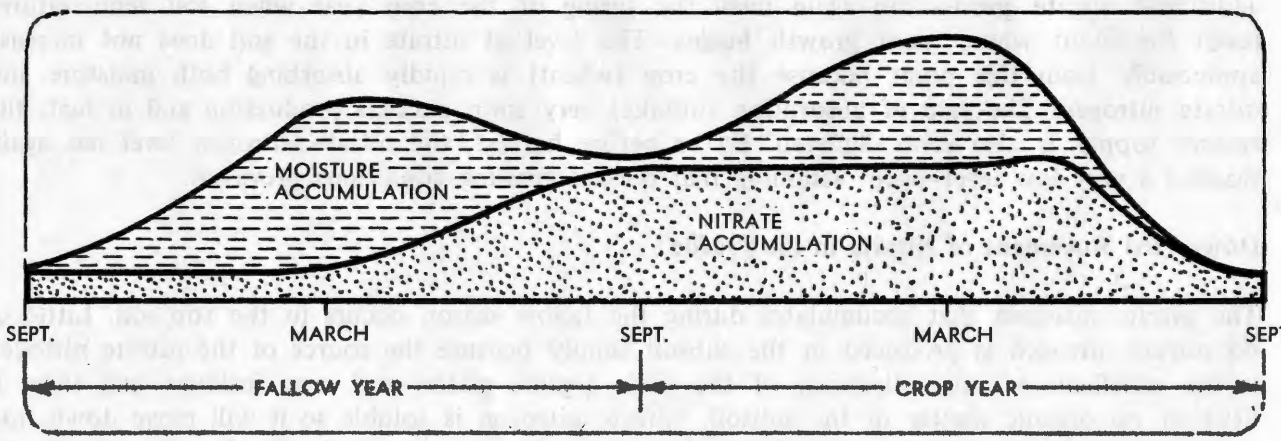
SOIL MOISTURE AND NITRATE TESTS– WHEN ARE THEY USEFUL?

Crop production in the eastern Washington dry land area depends largely on stored soil moisture. Approximately 80 per cent of the available supply will be stored in the soil by the time spring growth starts. For winter wheat under the summer fallow system it is generally true that the greater the moisture supply, the higher the yield (assuming that an adequate supply of nutrients is present and that other production factors are at the optimum level).

Research* has provided specific information regarding the amount of yield of winter wheat which can be expected from each inch of available soil moisture. The moisture supply in a soil profile may vary considerably from year to year and from field to field. Therefore, it is important to determine the moisture supply by tests so that a reliable estimate of potential yield can be made. The relationship of soil moisture and nitrate nitrogen to yield has been worked out for normal well-drained soils with no soil layers restricting root penetration, moisture movement, etc. When determining available moisture and nitrate supply, soils are sampled to a depth of 6 feet.

Available nitrate nitrogen accumulates in significant amounts during the fallow season. In fact, from one-fourth to one-half of the total crop needs may come from this source. It is essential to know the amount of nitrogen present in the soil from this source because it directly affects the amount of fertilizer nitrogen that will need to be applied.

The details of how to use results from a *moisture* and *nitrate* test are provided in Fertilizer Guide (FG) 34. Proper use of the "Moisture and Nitrate" test is undoubtedly the best single guide for determining specific nitrogen fertilizer needs under the wheat fallow system. However, there are certain limitations to the test. The specific situations under which it can or cannot provide reliable information are spelled out in the text that follows. The graph shows the moisture and nitrate accumulation-depletion pattern during the two-year crop-fallow cycle. A study of this will help to understand the importance of specific timing of sampling.



*Leggett, G.E., *Relationships Between Wheat Yield, Available Moisture and Available Nitrogen in Eastern Washington Dry Land Areas.* Washington Agricultural Experiment Stations Bulletin 609. Washington State University. Pullman, 1959.

Moisture Cycle Under the Fallow System

Note from the graph that after harvest, available soil moisture in the 6-foot profile will generally be very low—in fact, near zero. With the beginning of fall rains, the soil's available moisture supply begins to buildup and continues to increase through the fall and winter months. It decreases slightly during the summer of the fallow season. With the approach of the second fall and winter, the soil moisture supply increases further until early- to mid-spring of the crop year, when the actively growing crop removes moisture faster than it is being replenished. Uptake increases rapidly while precipitation decreases rapidly. Again by harvest time, the growing crop will have reduced the available moisture supply to near zero—provided all crop production conditions have been near normal.

Nitrate Build-up—Depletion Pattern Under the Summer Fallow System

The amount of nitrate nitrogen left in the 6-foot profile after harvest will be very little, commonly in the range of 5 to 20 pounds per acre, as indicated by the starting point of the nitrate line on the graph (lower left corner). Over-fertilization or some factor that limits crop growth and development (and thus limits uptake of added N fertilizer) may result in a greater amount of residual N than normal.

The nitrate nitrogen content of the soil profile following harvest will remain low throughout the following winter. Normally after harvest, the soil is too dry for nitrate production to take place. When the moisture supply becomes adequate for nitrate production, the temperature is too low. Very little nitrate production occurs at soil temperatures below 40^{o} F. The same moisture levels and temperatures that are favorable for the growth of wheat are also favorable for nitrate production.

In the spring of the fallow season, nitrate production begins when soil temperatures reach 40^{o} F. and above. The rate of nitrate production increases as soil temperatures become more favorable. In the fall it begins to taper off as the top soil becomes dry and as soil temperatures begin to drop. By early- to mid-September, nitrate production from the soil may be nearly completed. This nitrate nitrogen stays in the soil during the winter months. There is no additional nitrate production again until the spring of the crop year when soil temperatures reach the point where plant growth begins. The level of nitrate in the soil does not increase appreciably from this point because the crop (wheat) is rapidly absorbing both moisture and nitrate nitrogen. The rate of absorption (uptake) very soon exceeds production and in fact, the reserve supply is also soon depleted. By or before harvest, the nitrate nitrogen level has again reached a very low level—again assuming that normal growing conditions prevailed.

Downward Movement of Nitrate in the Profile

The nitrate nitrogen that accumulates during the fallow season occurs in the top soil. Little or no nitrate nitrogen is produced in the subsoil simply because the source of the nitrate nitrogen is the nitrification (mineralization) of the soil's organic matter and crop residues—and there is little or no organic matter in the subsoil. Nitrate nitrogen is soluble so it will move down into the profile as moisture from rainfall and snow melt moves into the profile. In the 18- to 20-inch rainfall area the soil moisture is generally replenished to a depth of approximately 6 feet. (In the rainfall areas above 20 inches per year, there will likely be movement of moisture and some nitrate below the 6-foot depth.)

Plant Rooting Depth and Moisture and Nitrate Recovery

Fall planted wheat will send its roots to a depth of at least 6 feet and can effectively use moisture and nitrate to this depth. Because of this, soil sampling must be done to a depth of 6 feet.

When To Take Soil Samples

For moisture. Delay sampling for moisture until the wheat begins its spring growth—at or near the point of maximum stored moisture and before a significant drop in the stored moisture supply occurs. Generally, the time interval between these two points is about one month. In that part of the wheat area where wheat growth begins early, the favorable sampling period will generally be from mid-February to mid-March of the growing season. In that part of the wheat area where spring growth starts later, the most favorable sampling period will generally be from early-March to early-April. The favorable sampling time will vary from year to year. The further away from the favorable period that sampling is done, the less complete the moisture information will be.

For nitrate. Sampling to determine the amount of nitrate nitrogen released during the fallow season can be done in late fall of the fallow season after nitrate release has stopped. From the practical standpoint, any time after September 15, would be satisfactory. Since nitrate nitrogen generally will not leach below 6 feet by the time spring growth begins (and spring uptake of nitrate begins) testing for nitrates can be done on the same spring samples that are taken for moisture determination. In other words, the same period that is favorable for spring moisture sampling is also favorable for sampling for nitrate.

Factors That Interfere With the Ideal Moisture and Nitrate Testing Program Under the Fallow System

1. **Injected applications of ammonia-type nitrogen fertilizer during the spring and early summer of the fallow season.** While all the ammonia applied that early in the season would be nitrified by early fall, the banded position of a high nitrogen concentration makes it impractical to obtain a dependable sample on that field in the fall. By spring of the crop year, the fertilizer band will have been diffused throughout the profile moderately well by moisture movement so that when sampled during the favorable period, a moderately reliable sample can be obtained. Sampling these fields before the ammonia is applied (i.e., in April, May, or June of the fallow year) will give little information about the soil moisture and nitrate supply for the crop a year away. In fact a test cannot be recommended for this time. The test would, of course, show whether there was any carry-over nitrogen.

2. **Injected applications of ammonia-type nitrogen fertilizer late in the fallow season (generally after September 1).** It is not possible to get a reliable sample even in the spring of the crop year under this fertilization practice. Nitrogen fertilizer will remain as ammonia because of the cool fall and winter temperatures. Also since the ammonia will not be fully nitrified by the time a sample is taken, an indefinite amount of ammonia nitrogen will remain, leaving an incomplete picture of the available nitrogen supply. The standard nitrogen test determines only nitrate nitrogen, not ammonia nitrogen. Continued nitrification would not proceed in the spring until after the favorable sampling period would have passed. Under this system of soil fertility management, sampling and testing to determine available nitrogen is not worth while.

3. **Leguminous green manure crops plowed under during the fallow year.** The production of nitrate nitrogen from leguminous crop residues proceeds over an extended period. In fact, only a portion of it (probably only one-half to two-thirds), will be released during the first season. Since a nitrate test will not determine how much nitrate *will be released,* a test before nitrate release is complete will give only incomplete information. Generally, the information is so incomplete and indefinite that the test for nitrate under these conditions is of little value.

4. **Leaching and de-nitrification.** In some areas sufficient rainfall occurs that some of the nitrate will move below the usual sampling and rooting depth of 6 feet. Under these situations, the reliability of test results is proportional to the extent of leaching–which is undeterminable.

   In some fields, conditions prevail which permit excess water to remain in the soil for extended periods. This can lead to denitrification. Under these conditions, testing for nitrate will likely be of little value–especially if denitrification might continue after sampling was done.

Moisture and Nitrate Testing Under Annual Cropping

The graph showing moisture and nitrate accumulation and depletion covers a two-year period–the fallow season and the crop season. When considering the possible use of the moisture and nitrate testing for annual cropped situations, study that portion of the graph that goes from September at the left side to the following March.

The stored moisture for the upcoming crop will have reached a peak–or nearly so by mid-March. A test at this time to determine this quantity of water would be useful information. Under normal situations, a nitrate test either in the fall or in the spring, would be of no value since there will have been no nitrate produced between harvest and spring planting. It would show whether there was any carry-over nitrogen. This normally does not occur, however. Only an occasional sample is necessary to verify if nitrogen is carried over from the previous crop.

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