1986 Publication

PROCEEDINGS

COLORADO

CONSERVATION TILLAGE

SYMPOSIUM

November 12, 1985

Holiday Inn I-70 & Chambers Rd.

Sponsored by: Colorado Conservation Tillage Task Force

CONSERVATION TILLAGE IN COLORADO: SOIL FERTILITY [1/]

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A) Past Research and Current Recommendations

Until about 1982, very little soil fertility work had been conducted in Colorado using conservation tillage and reduced tillage systems. Therefore, until new research information becomes available, the best approach to soil fertility will be to use the recommendations used for conventional tillage systems. Changes to watch for with reduced tillage systems may be: a) an accumulation of plant nutrients near the soil surface (0 to 1 inch depth); b) a decrease in the soil pH of this surface layer as organic matter accumulates; and c) possibly an increase in N fertilizer needs if N is broadcast applied to the soil surface, especially during the initial years of conservation tillage because of a tie-up of N during organic matter decomposition by microbes.

As with conventional tillage practices, the place to start evaluating soil fertility is with a good soil test. Samples should be collected from the surface 0 to 6 inch soil depth for analyses such as pH, ogranic matter, N, P, K, S, Zn, Fe, and salinity. Deeper sampling for accurate N and S recommendations are needed. Additional samples should be collected from at least the 6 to 24 inch and 24 to 48 inch soil depths for N analysis.

Plant nutrient requirements to optimize crop yields will not change with a change in tillage system, but fertilizer needs may change depending on the tie-up of plant nutrients in the organic matter and microbes as a result of tillage system used. Reduced tillage systems may require the addition of more N fertilizer to achieve the same yield potential during the establishment years.

1/ Prepared for Annual Conference of the Colorado Conservation Tillage Task Force held November 12, 1985, Denver, CO.

2/ Soil Scientists, USDA-ARS, Akron and Ft. Collins, Colorado, respectively.

In general, wheat will require about 2.0 to 2.4 lb N/bu to optimize grain yield. This is a total N requirement and includes soil plus fertilizer N. Grain protein level is a good indicator of N sufficiency for winter wheat in Colorado. If the grain protein level is below 11 to 12%, N was probably inadequate for attaining optimum yields. Farmers generally have protein checked and therefore can use this approach to indicate whether or not their N fertility program is adequate.

Nitrogen requirements for optimum corn yields are generally estimated to be 1.1 to 1.5 lb N/bu. As with wheat, this N requirement includes residual soil N plus fertilizer N. For both wheat and corn, it is very important to establish an accurate estimate of yield potential for this approach to work. Inaccurate estimates of yield potential can result in over and under fertilization of the crop. Therefore, a combination of accurate yield potential estimates and soil test is a preferred method for determining fertilizer needs.

Phosphorus is one of the major limiting nutrients in Colorado soils. The sodium bicarbonate-extractable P soil test (Olsen test) was developed in Colorado and does an excellent job of indicating the level of plant available P. A soil test level of 16 ppm is generally considered adequate for producing optimum crop yields. Below this soil test level, the probability of a response to P fertilization increases as the soil test level decreases. There are several soil testing laboratories operating in and serving Colorado. The Olsen soil test should be requested when available for best result on the predominantly calcareous soils found in Colorado. Most of the soil test calibration data were obtained using this method, therefore, the probability of making a more accurate P fertilizer recommendation exists if the Olsen test is used.

Phosphorus fertilizer should be incorporated with the soil for best results, particularly if a broadcast application is to be used. In reduced and no-till systems, tillage for fertilizer incorporation is generally not desireable. Therefore, banding the P fertilizer with the seed or below the seed at seeding time is recommended. At low soil test P levels, banding is generally more efficient than broadcasting P. Dual placement of anhydrous ammonia and polyphosphates in a single band has been shown to enhance the availability of P fertilizer. This may be an effective method for applying N and P fertilizers in conservation tillage systems in Colorado.

Potassium is generally not a major limiting plant nutrient in most Colorado soils, but may be deficient for plant growth on some sandy soils used for both irrigated and dryland crop production. Corn and alfalfa are heavy users of K and may benefit from K fertilization on some soils.

Sulfur generally is not a limiting nutrient to most Colorado crops, but occasional sulfur responses have been observed in Colorado. A soil test for sulfur is currently being established and evaluated for use on Colorado soils.

Use of conservation tillage may improve the availability of micronutrients because of an accumulation of organic matter near the soil surface and the chelation of micronutrients by organic compounds. Soil test for zinc (Zn) and iron (Fe) is the easiest way to predict the need for these elements in Colorado soils. The DTPA soil test for micronutrients was developed at Colorado State University and functions very well for predicting deficiencies in Colorado soils. Zinc and Fe may be deficient in some Colorado soils for corn, sorghum, beans, and other sensitive crops. Foliar application is generally the easiest way to correct an Fe deficiency. Both soil and foliar applications of Zn can be used to correct Zn deficiencies in sensitive crops. Generally, Zn and Fe are adequate for wheat production in Colorado soils.

B) Current Soil Fertility Research In Colorado Using Conservation Tillage Systems.

Several soil fertility research projects are currently being conducted in Colorado by scientists from Colorado State University and USDA-ARS where conservation tillage systems are being used. Several other soil fertility projects are also being conducted that will benefit conservation tillage systems and will be listed in the appendix to this report. Most of the current soil fertility research projects in Colorado are concerned with dryland winter wheat. A few projects involve dryland corn, barley, sorghum, and millet as test crops.

At Colorado State University, Drs. D. G. Westfall and R. H. Follett are evaluating the effects of N and P source, rate, and time of application on nutrient cycling and winter wheat yields using a no-till system under dryland conditions. Drs. D. G. Westfall and C. V. Cole are studying the influence of various dryland winter wheat tillage systems on sulfur cycling. Dr. R. H. Follett has a study to evaluate sulfur needs for dryland winter wheat and evaluate a soil test for sulfur with some of the research sites involving conservation tillage practices. Drs. Westfall and Follett are also evaluating the N and P fertilizer requirements of dryland winter wheat and developing soil test correlations for numerous research sites in Eastern Colorado, some of which involve conservation tillage systems.

The USDA-ARS at Akron, Colorado has several on going soil fertility projects with dryland winter wheat and corn that use reduced and no-till systems. Dr. A. D. Halvorson has a project to

determine the effects of N and P fertilization on winter wheat, corn, and barley yields and crop quality and water-use efficiency by these crops. Another study involves the effects of time and rate of N application on soil nitrate-N distribution in the soil profile and on dryland winter wheat yields and crop quality. Dr. Halvorson also has a project to determine the effect of N rate and placement on crop yields in an annual cropping system using reduced tillage. Drs. Halvorson and R. H. Follett are studying the effect of N source (ammonium nitrate, urea, urea-ammonium n trate solution, and anhydrous ammonia), rate, and fertilizer placement method (broadcast without incorporation, band below seed, and dribble over seed row) on winter wheat yields and quality under no-till conditions. Drs. Halvorson and J. L. Havlin have initiated a study to determine the best method of managing P fertilization for dryland winter wheat in reduce and no-till systems. Phosphorus fertilizer placement method will be broadcast applied with and without soil incorporation, banded about 3 inches below the soil surface, and placed directly with the seed. The phosphorus will be applied with and without additional N. The residual value of the applied P will be evaluated for several years. Drs. Halvorson and J. F. Shanahan have initiated a study to evaluate the N requirements of winter wheat and corn (or sorghum) in a wheat-corn (sorghum)-fallow rotation using reduced and no-till systems. The effects of soil fertility on water-use efficiency by the crop will be evaluated. Dr. D. E. Smika, at Akron, is studying the effects of N and P fertilization and tillage system on dryland winter wheat production on soils where up to 1.5 ft of top soil has been removed.

C) Future Research Needs

Many important research needs can be identified in the area of understanding soil fertility in conservation tillage programs. The above discussion on current research indicates that most of the current effort in soil fertility as related to conservation tillage centers mainly around winter wheat and corn. The fertility requirements of other important Colorado crops will need to be addressed as conservation tillage systems are developed for them.

Recently (November, 1984), the USDA-ARS held an operational planning workshop on Conservation Production Systems for Great Plains Agriculture. At this workshop, future research needs in the area of soil fertility were outlined. These research needs are also very important to Colorado if we are to gain acceptance of conservation production systems in Colorado. The research problem followed by a brief discussion of type of research needed will be presented as follows:

a) Determine fertilizer management regimes optimum for plant

growth with conservation production systems. Use of reduced and no-till conservation-production systems are increasing in the Great Plains. However, acceptance of these systems has been slowed because of problems associated with fertilizer application techniques, lack of knowledge on nutrient needs and interactions with conservation-production systems, adequate equipment for simultaneous placement of fertilizer and seed, and poor performance of reduced and no-till systems on some soils and environments.

b) Define effects of surface residue on soil properties (physical, chemical, and biolobical). Surface residues are the key component separating conservation-production systems from other management techniques. Conservation tillage and proper residue management allow opportunity to decrease the amount of nutrients lost by soil erosion (wind and water) and to enhance nutrient uptake by crops. Insufficient information exists on the effects of conservation tillage and residue management on nutrient leaching and gaseous losses or retention of nutrients in the soil for subsequent crops to use. Soil physical, chemical, and biological properties need to be evaluated relative to surface residue because changes in these properties define the soil productivity.

c) Determine organic matter dynamics and nutrient transformations under conservation production systems. The surface plant residue maintained by conservation-production systems results in the surface few centimeters of soil being generally characterized as having higher organic carbon content, higher water content, and lower aeration status than bare tilled soils. There is a need to determine how these changes control microbially mediated nutrient transformations which affect both immediate and long-term soil fertility.

d) Identify and solve fertility problems associated with the transition to conservation production systems. The physical, chemical, and biological characteristics of soil under conservation-production systems differ greatly from those of conventional tillage systems. Problems in soil fertility may arise during the transition from conventional tillage systems to conservation-production systems. It is imperative that these problems be identified and solutions found to expedite general acceptance of the system.

e) Evaluate current soil test methods and calibrations for validity in identifying nutrient deficiency levels for conservation-production systems. Conservation-production systems result in soils having nutrient transformation rates and nutrient pool sizes different from conventional systems. There is a need to validate the efficiency of current soil test methods, procedures, and calibrations to maximize fertilizer use efficiency. Soil sampling procedures need to

be developed for fields where banded fertilizer application techniques have been used so that accurate assessments of soil nutrient status can be made.

f) Establish the relationship of conservation tillage to off-site damage. Research is needed to define how conservation tillage influences the movement of plant nutrients in the environment. Loss of nutrients with eroded sediments (wind and water) is expected to be decreased. However, concentration of nutrients in surface water runoff may be higher. In addition, more downward movement of water through and below the root zone is generally expected. This downward movement may influence the amount of nutrients leached below the root zone. Such leaching may result in reduced fertilizer use efficiency or ground water pollution. Another issue of nutrient loss to the environment may be gaseous losses, especially of nitrogen. Loss mechanisms can include denitrification or volatilization. Such losses, again, can result in reduced N-use efficiency or degradation of environmental quality.

g) Develop models to utilize existing knowledge and data bases and identify gaps in our current knowledge base. User oriented models need to be developed and/or adapted to Colorado conservation tillage systems that will assist crop consultants, Cooperative Extension Specialists, fertilizer dealers, soil testing laboratories, and others in making accurate and unified fertilizer recommendations to farmers. These models can serve to identify areas where additional research information is needed. Use of computer models can improve the accuracy of nutrient recommendations by having access to a large data base of knowledge and environmental factors. This improvement will result in improved fertilizer use efficiency and a reduction in potential environmental damage from improper nutrient use.

h) Adoption of conservation tillage systems improves the potential for more intensive cropping. Less tillage (including no-till) and improved water conservation enhance the opportunity for decreased use of fallow, including possible annual cropping in some years. Therefore, there is a need for additional research on predicting soil fertility needs and nutrient cycling with these more intensive cropping systems.

i) Other research needs could be mentioned, however, the above needs were identified as having the highest priority in the immediate future.

Soil Fertility Research Directory (Appendix A)

PROJECT TITLE: Effect of N and P fertilization on water-use efficiency by winter wheat, barley, and corn in the Central Great Plains.
Location: Central Great Plains Research Station, Akron, CO
Objective: Determine the effects of N and P fertilization on crop yield, quality, and water-use efficiency using reduced tillage under irrigated and dryland conditions.
Contact: Dr. Ardell D. Halvorson, USDA-ARS, Akron, CO ph:345-2259

PROJECT TITLE: Effect of N source, placement, and rate on dryland winter wheat yields in a no till system.
Location: Northeast of Platner, CO
Objective: Determine the effectiveness of several N sources for use in no till systems and the best method of managing these N sources for most economical wheat production.
Contact: Dr. Ardell D. Halvorson, USDA-ARS

PROJECT TITLE: Management of N fertilizer for dryland winter wheat in reduced tillage systems.
Location: Central Great Plains Research Station, Akron, CO.
Objective:Determine the N needs of crops grown in an annual cropping-reduced tillage system and the best placement method for N fertilizer in this system.
Contact: Dr. Ardell D. Halvorson, USDA-ARS

PROJECT TITLE: Effect of time and rate of N fertilizer application on soil profile nitrate-N distribution and crop yield and quality.
Location: Northwest of Otis, CO.
Objective: Determine the best time to apply fertilizer N for optimum winter wheat production and quality. Nitrogen fertilizer is being applied at 4 rates in early November, mid-May, mid-July, and mid-September during the fallow period and top dressed to the wheat in mid-March.
Contact: Dr. Ardell D. Halvorson, USDA-ARS

PROJECT TITLE: Management of P fertilizer for dryland winter wheat in reduced tillage systems.
Location: Peetz, CO and Scottsbluff, NE
Objective: Determine the most efficient method of P placement for optimum economic yields and the value of residual fertilizer P for future wheat production.
Contact: Dr. Ardell D. Halvorson, USDA-ARS

PROJECT TITLE: Crop rotation and nitrogen fertilization for efficient water use.
Location: Central Great Plains Research Station, Akron, CO

Objective: Determine the potential of producing economical dryland corn or sorghum yields following winter wheat in a wheat-corn-fallow rotation using reduced tillage techniques. The N fertilizer requirements for optimum crop production and efficient water use are being evaluated.
Contact: Dr. Ardell D. Halvorson, USDA-ARS

PROJECT TITLE: Reduced tillage/nutrient management for winter wheat production on eroded soils.
Location: Central Great Plains Research Station, Akron, CO
Objective: Nitrogen and P rate and application method for winter wheat production on soils where up to 46 cm of top soil has been removed in relation to the use of no-till, reduced till and conventional stubble mulch tillage systems is being studied.
Contact: Dr. Darryl E. Smika, USDA-ARS, Akron, CO ph:345-2259

PROJECT TITLE: Nitrogen use efficiency by corn supplied with various ratios of ammonium and nitrate forms.
Location: Rockyford, CO
Objective: Identify the optimum combination of ammonium and nitrate forms of N in relation to vegetative and grain yield response of corn and other crops, and determine their effect on N use efficiency by crop, leaching losses and denitrification.
Contact: Dr. Sterling R. Olsen, USDA-ARS, CSU, Ft. Collins, CO ph:482-3173

PROJECT TITLE: Phosphorus reaction products.
Location: CSU, Ft. Collins
Objective: Identify reaction products of dual N-P placement.
Contact: Dr. Dwayne G. Westfall, Dept. Agronomy, CSU, Ft. Collins. ph:491-6149

PROJECT TITLE: N and P fertilizer requirements and cycling under no-till.
Location: Several sites in eastern Colorado.
Objective: Determine N and P source, rate, and timing and cycling under no-till dryland winter wheat production.
Contact: Dr. Dwayne G. Westfall, CSU

PROJECT TITLE: Application of sewage sludge to dryland winer wheat.
Location: Front range area of Colorado.
Objective: Determine N equivalency of sludge and effect on production of dryland winter wheat.
Contact: Dr. Ken A. Barbarick, Dept. Agronomy, CSU, Ft. Collins ph:491-6394

PROJECT TITLE: Sulfur cycling in Great Plains Ago-Ecosystem.
Location: Ft. Collins and Sidney, NE.
Objective: Identify sulfur cycling as influenced by various

tillage systems under dryland winter wheat.
Contact: Dr. D. G. Westfall, CSU

PROJECT TITLE: Evaluation of industrial by-products as potential fertilizers for irrigated and dryland crops.
Location: Ft. Collins, CO
Objective: Determine the utility of various industrial by-products as potential fertilizers and identify toxic contaminant effects on plant growth.
Contact: Dr. D. G. Westfall, CSU

PROJECT TITLE: N and P requirement and soil test correlation for dryland winter wheat.
Location: Eastern Colorado
Objective: Determine the N and P requirement of dryland wheat and demonstrate to farmers the benefit of fertilization.
Contact: Dr. D. G. Westfall, CSU

PROJECT TITLE: Soil Testing Laboratory recommendation comparisons.
Location: Ft. Collins, CO
Objective: Evaluate the validity of various soil test laboratory fertilizer recommendations.
Contact: Dr. R. Hunter Follett, Dept. Agronomy, CSU, Ft. Collins ph:491-6201

PROJECT TITLE: Spring fertilization of dryland winter wheat.
Location: Eastern Colorado
Objective: Determine the feasibility of spring soil testing to determine spring N fertilizer requirements for wheat.
Contact: Dr. D. G. Westfall, CSU

PROJECT TITLE: Soil Test N and P variability in fields as influenced by topography.
Location:Ft. Collins, CO
Objective: Evaluate the variability in soil test level and its impact on fertilizer recommendations.
Contact: Dr. D. G. Westfall, CSU

PROJECT TITLE: Sulfur fertilization on dryland winter wheat.
Location: Eastern Colorado
Objective: Evaluate sulfur needs for dryland wheat and evaluate a soil test for sulfur.
Contact: Dr. R. Hunter Follett, CSU

PROJECT TITLE: Soil test calibration for Proso millet.
Location: Eastern Colorado
Objective: Calibration of the N and P soil test for determining fertilizer requirements of millet.
Contact: Dr. Gary A. Peterson, Dept. Agronomy, CSU, Ft. Collins ph:491-6804

PROJECT TITLE: Maximum dryland and irrigated winter wheat yields in the Central Great Plains.

Location: Northeastern Colorado, Western Nebraska, and Western Kansas.

Objective: Determine the levels of N and P fertilizer and other management factors needed to obtain maximum wheat yield potentials.

Contact: Dr. John L. Havlin, Dept. Agronomy, Kansas State Univ., Manhattan, KS. ph: (913) 532-6101