RESEARCH PROGRESS AND NEEDS
CONSERVATION TILLAGE

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A North Central Region, Agricultural Research Service, U.S. Department of Agriculture soil tillage research workshop was held in Council Bluffs, Iowa, January 6-7, 1976. As a result of the discussions, the enclosed state of the art papers were prepared.

The purpose of this publication is to present an account of research needs in the field of soil tillage in the North Central Region.

Mention of companies or commercial products does not imply recommendation nor endorsement by the U.S. Department of Agriculture over others not mentioned.

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NUTRIENT LOSS RESEARCH

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NATURE OF THE PROBLEM

In the mid-1960's when environmental quality and water pollution became a worldwide concern, agricultural fertilizers were frequently cited as a major factor contributing to the pollution of surface and groundwater. However, at that time, little factual information was available for assessing the cause and severity of the problem. Therefore, research was started in the North Central Region to determine the effects of various fertilizer management and other cultural practices on the overland and deep percolation movement of nitrogen and phosphorus. Research attention was directed toward these nutrients because they are commonly supplied by commercial fertilizers to meet the needs of agronomic plants and have been cited as contributing to profuse growth of algae and aquatic plants in lakes and ponds. In addition, the nitrate form of nitrogen occurring in drinking water at concentrations in excess of 10 ppm can cause an abnormal blood condition in infants known as methemoglobin.

Nutrient movement research during the past decade has reemphasized the need to control erosion from agricultural land because sediment has been a major transport agent of N and P. Research has also shown that the movement of soluble N is closely related to hydraulic characteristics of soils. Amounts of soluble N lost in surface runoff and concentration levels have been low for moderately permeable soils but higher than desired for slowly permeable soils, such as the claypans. Soil profile studies have shown little movement of NO_3-N below the rooting depth for moderately permeable and slowly permeable soils when annual fertilization is at rates recommended for efficient crop production. When nitrogen fertilizer application exceeds the recommended rate, considerable movement of nitrate may occur below the rooting depth.

PAST AND PRESENT RESEARCH

Much of the nutrient movement research has been conducted on standard runoff-erosion plots used to evaluate the effects of cropping, fertilization, and tillage and residue management on runoff and erosion under natural rainfall conditions. Studies conducted at Morris, Minn., on a moderately permeable soil showed that cropping practices that provided good soil cover during the critical erosion period greatly reduced soil erosion and associated N and P losses (Timmons and others, 1968; Burwell and others, 1975). The study also showed that average annual losses of soluble N and P were low (less than 2.5 lbs/A/yr) and that concentration levels of NO_3-N were well below 10 ppm. Similar studies conducted on a slowly permeable claypan soil near Columbia, Mo., showed that soil erosion and associated N and P losses were greatly

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reduced by no-till planting of corn where surface residues were retained on the soil surface (Smith and others, 1974; Whitaker and others, 1976; Mikulcik and others, 1976). The study also showed that runoff, soluble P concentrations and losses were greater from no-till planting than from conventional tillage. Although runoff was greater from no-till than conventional tillage, soluble N losses were about the same for these two practices because nitrate-N concentrations were lower for no-till planting than for conventionally planted corn. Nitrate-N concentration frequently exceeded 10 ppm for both tillage practices when runoff occurred early in the crop season after fertilizer had been incorporated into the soil. The study showed that rate, time, and placement of N fertilizer application are important factors affecting runoff losses of soluble N from claypan soils and that fertilizer use efficiency can be increased by improved management of fertilizer application (Whitaker and others, 1976).

Small plot studies have been conducted in Indiana using simulated rainfall techniques. These studies evaluated the effects of fertilizer application practices and tillage methods on runoff losses of N and P. Moe and others (1967) reported nitrogen losses up to 15 percent of that applied when ammonium nitrate was applied on sod and fallow plots and runoff occurred shortly after application. Moe and others (1968) reported that under applied rainfall conditions, total nitrogen losses ranged from 2.4 to 12.7 percent of the applied nitrogen and that ammonium N loss in runoff was less for urea treated plots than for ammonium-nitrate treated plots. Nelson and Romkens (1968) reported that phosphate concentrations in runoff water appeared to be related to rate of phosphorus application and that amounts of soluble P removed in 10 inches of runoff water were 1.0 and 1.26 percent of that applied at rates of 100 and 50 pounds per acre, respectively. Romkens and others (1973) reported small losses of soluble N and P in runoff for conventional tillage, but losses of sediment-associated nutrients for this treatment were greater than for other tillage treatments. A simulated rainfall study at Morris, Minn., showed the need to incorporate fertilizer into the soil to minimize runoff losses of N and P (Timmons and others, 1973).

Watershed studies were started on deep loess soil near Treynor, Iowa, in 1969 to characterize the movement of N and P by crop use, surface runoff, deep percolation and subsurface discharge as affected by recommended and excessive fertilizer rates and by contouring and terracing conservation practices. These studies have shown:

(1) Terraces were highly effective in controlling erosion and associated N and P losses, but contouring alone was not sufficient (Burwell and others, 1974; Schuman and others, 1973a; Burwell and others, 1976);

(2) Soluble N and P losses in runoff and concentration levels were low even when fertilizer was applied at 2.5 times the recommended rate (Schuman and others, 1973b; Burwell and others, 1975; Burwell and others, 1976);

(3) Nitrogen originating in rainfall that ran off was equivalent to two-thirds of the soluble N measured in runoff from a watershed fertilized at a normal rate (Schuman and Burwell, 1974);

(4) Little NO_3-N moved below the rooting depth for the watershed fertilized at the recommended rate, but considerable movement occurred when fertilizer was applied at 2.5 times this rate (Schuman and others, 1975; Saxton and others, 1976);

(5) Soluble N in subsurface flow from a watershed fertilized at a normal rate represented a large portion of the annual soluble N discharged to streamflow during a five-year study period (Burwell and others, 1976)--however, concentrations of NO_3-N were below 10 ppm for 57 of the 60 months sampled; and

(6) Nitrogen used by corn fertilized at the recommended rate was about equivalent to that applied annually which reduced the chances of fertilizer N moving into water supplies by runoff and deep percolation (Burwell and others, 1976).

Nutrient losses in surface runoff from forested watersheds have been determined in Ohio (Taylor and others, 1971) and in Minnesota (Timmons and others, 1976). A field plot study was started in west-central Minnesota in 1969 by D. R. Timmons (results not published) to determine runoff losses of N and P from native prairie grass for natural precipitation conditions. This information from nonagricultural land resource areas will provide a basis for evaluating man's influence on surface water quality.

RESEARCH NEEDS AND APPROACHES

Experimental objectives, procedures, and results have varied widely among the many nutrient movement studies conducted within the North Central Region. The lack of common regional objectives, procedures, and management variables has not permitted a systematic approach to the nutrient loss and water pollution problems. Some of the independent research was justified because it provided answers to localized specific questions for a prescribed set of soil-climatic-management conditions. Increased coordination among research locations is needed to achieve basic objectives in regional nutrient movement research.

Scientists concerned with the movement of chemicals from agricultural land need to adopt a new philosophy in their research. Simply, improve use efficiency of agricultural chemicals. We know that--as soil and water move, so move N and P. We know that strip-cropping, terraces, and conservation tillage practices can help control soil movement from agricultural land. Retaining crop residues on the soil surface by conservation tillage practices can be highly effective in controlling erosion and associated N and P losses. We also know that some conservation practices alter the pathways by which water moves from watersheds, although these practices may not materially alter total water discharge. Tillage-infiltration research in Minnesota has shown that tillage, or lack of it, can have a tremendous effect on infiltration and runoff. Runoff-erosion studies on the slowly permeable claypan soil in Missouri have shown an infiltration advantage for tillage. Soluble N concentrations have been greater from conventional tillage than from no-till. Soluble P concentrations and losses were greater from no-till than conventional tillage because of greater runoff and reduced sediment loads and subsequent adsorption of P by sediment.

More research is needed to characterize the effects of tillage-induced physical parameters on soil chemistry and biology as they influence nitrogen mineralization and denitrification transformations. Tillage and surface residues have been shown to influence soil thermal and moisture properties, but information is limited on their effect on chemical and biological processes. Little is known as to the effects of tillage on soil insects and diseases that attack crop plants. Conservation tillage frequently accelerates the weed problem, which requires the use of larger amounts of herbicides. This may increase water pollution hazards and crop production costs. New information is needed as to what extent tillage can be utilized to overcome these crop production problems.

Greater effort needs to be expended toward an economic evaluation of conservation practices. To accomplish this, a total systems approach is needed which requires team effort among many disciplines. We need to know if a specified practice is a paying or costing proposition. Inquiries are frequently made as to the value of a ton of topsoil and to what extent conservation practices are economically practical. For example, a market is being established for corn stalk residues that are being used for synthetic rubber production. Removal of corn stalks from crop land will create additional erosion problems if this market becomes substantial. Management alternatives to corn residues must be found if that happens.

In addition, soybeans provide little residue soil cover for erosion control. Research is needed to determine nutrient movement from soybean cropping systems because soybean acreage is substantial in the North Central Region. Providing winter cover and multicropping practices appear to be very attractive alternatives. However, cultural management practices, including tillage, will need to be developed for a successful change from monocropping to multicropping systems.

Research is needed to establish relationships of N and P concentrations in field soils to the concentrations of these nutrients in eroded soil (sediment). This information used in conjunction with the Universal Soil Loss Equation would provide a basis for predicting sediment-associated nutrient losses from agricultural land.

EXPECTED BENEFITS

A potential benefit of nutrient loss research will be improved use efficiency of fertilizer. This will reduce production costs and increase crop production or both per unit of input. The research has reemphasized the need to prevent excessive erosion from cropland. When erosion control is accomplished, two benefits will be the retention of soil for future crop production and cleaner surface water supplies. The improvement of present conservation practices and the development of new practices will contribute toward achieving this goal.

POTENTIAL FOR INTERREGIONAL EXTRAPOLATION OF NEW TECHNOLOGY IN A PREDICTIVE SENSE

A basic requirement for developing a chemical transport model is intensive coordination of specialists in many scientific fields including soil chemistry, hydrology, erosion, crops, soil physics, tillage, weed control, disease control, insect control, and machinery design. These people would draw on local, area, regional, and national knowledge to develop a basic model and submodels required to predict nutrient losses for various crop-producing systems. Initial efforts would be directed toward developing interdisciplinary understanding and remedial action. Data assembly and study would provide a basis for establishing future research needed to improve the models.

RESOURCES REQUIRED TO ACHIEVE RESEARCH OBJECTIVES AND GOALS

Leadership among, as well as within, scientific disciplines needs to be established. Provisions are needed for data gathering and analyses beyond the local level. Some redirection of local, area, and regional research would be needed as established by interdisciplinary leadership. Local scientists would look toward this leadership in directing their research activities to generate data needed for regional and national predictive models. The local scientist would coordinate his research with state experiment stations and state action agencies.

Personnel and physical facilities required to obtain additional data needed would be determined after a thorough study of existing data.

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