CONSERVATION TILLAGE-CROP PRODUCTION SYSTEMS FOR THE NORTHERN GREAT PLAINS

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ABSTRACT

Conservation tillage (minimum-till and no-till) crop production systems have not been developed for the northern Great Plains. For the most part, the emphasis of previous soil and water conservation research has been on studying two-factor interactions of which tillage and soil fertility, tillage and water conservation, soil fertility and crops, are examples. Recent advances in computer technologies now makes it possible to accommodate analyses for assessing the interaction and significance of many factors and research approaches. We have established a long-term field-plot size experiment on 63 acres to study multifactor variables involving cropping systems, conservation tillage, soil fertility, and cultivar variables in a single study. The experimental design, procedures and operational logistics for conducting this type of complex field scale experiment and the data sets being collected by the various research disciplines involved will be discussed.

INTRODUCTION

Soil erosion is recognized as a serious threat to man's well-being, and in some areas of the world, to his very existence. Although substantial advances have been made in erosion abatement, losses in areas of the United States continue to exceed the rate of soil renewal. In the northern Great Plains, soil losses to wind and water erosion exceeds 5 tons per acre on about 50% of the 28 million acres of cropland and exceeds 9 tons per acre on about 21% of it. Cost-effective minimum-till and no-till conservation tillage systems, adaptable to the region and if adopted by producers, potentially would reduce soil losses by wind and water erosion by, conservatively, 50%.

Crop residue management is a major factor in erosion control. Left on the soil surface, residues reduce wind speed and thereby wind erosion, and act as a barrier to water runoff and absorb impact energy imparted by falling rain and thereby reduce water erosion. The greatest deterrent to erosion is a vegetative cover, dead or alive, on the soil surface. Simultaneously, residues affect water conservation by suppressing water evaporation rate and effecting retention of precipitation (including snow) where it falls. In essence, the focal point of dryland agricultural research in semiarid and subhumid regions is to save as much water as possible from precipitation and use it as efficiently as possible for crop and livestock production. Conservation of soil and conservation of water are inseparable.

For the most part, the emphasis on previous soil and water conservation research has been on studying two-factor interactions such as tillage (residue and management) and soil fertility, tillage and water conservation, soil fertility and crops etc. The advent of computer technologies now makes it possible to accommodate systems analyses for assessing the interaction and significance of many factors, and therefore paves the way for a team research approach to conservation problems.

Current information on conservation tillage systems in the northern Great Plains is essentially limited to no-till production of winter wheat. Information is lacking for spring-sown cereal grain and oilseed crops. Soil erosion hazards of spring-planted crops, especially oilseed crops (sunflowers, safflower), is high compared to winter wheat because of the longer idle period between crops, particularly when summerfallow is used and because oilseed crops produce less crop residue.

OBJECTIVES

The research goal is to develop efficient and cost-effective conservation tillage (residue management) practices with emphasis on methods of increasing precipitation storage efficiency, improving crop residue management for erosion control, and using available soil water most efficiently. In addition, this systems experiment provides opportunities for multidisciplinary research in such areas as associated disease, insect and weed problems, N and P cycling, biotic and abiotic soil property changes, and soil productivity-crop response relationships.

PROJECT DESCRIPTION

The field research is conducted on a 63-acre site on Williams loam (fine-loamy, mixed, Typic Argiboroll) with a 2 to 4% southeasterly slope. The experimental variables in three replications are all combinations of (1) two cropping sequences; spring wheat-fallow and spring wheat-winter wheat-sunflowers [main blocks (450 x 240 ft.)], (2) three conservation tillage treatments; conventional tillage, minimum tillage, and no-till [main plots (150 x 240 ft.)], (3) three fertilizer nitrogen rates; 0, 20, and 40 lbs N/ac for crop-fallow and 30, 60 and 90 lbs N/ac for continuous cropping sequence (subplots 150 x 80 ft.) and (4) two cultivars, standard (check) and current "best" (sub-subplots, 75 x 80 ft.).

The experimental area had been in spring wheat in 1982 and in 1983 it was, the first year of the lease, uniformily cropped to sunflowers. We applied 1 lb/ac active ingredient (ai) of Treflan[1/] granular herbicide using a granular applicator mounted on an undercutter sweep which served as the first tillage. This was followed by a tandem disk operation ahead of planting. The site also received 40 lbs N/ac from ammonium nitrate before disking. The sunflowers yielded about 1500 lbs/ac and used all available soil water to a depth of 5 feet. The minimum soil water depletion point for the experimental site averaged 11.5% $\pm$ 0.5 by volume weight or 1.67 inches of water for each 1-foot increment to a depth of 5 feet. Therefore, the total soil water content at the minimum depletion point for the 5-foot soil profile is 8.4 inches. This value will serve as the base upon which available soil water and crop water use will be calculated in future years.

In the fall of 1983, we took soil samples (9 samples per main block) from the 0 to 3, 3 to 6, and 6 to 12 inch depths and by 1 foot increments from 2 to 5 feet for soil analysis to provide the base data for chemical and physical soil properties before treatment variables were initiated. Bicarbonate soluble P ranged from 8 to 12 ppm. We applied a uniform broadcast application of 40 lbs P/ac from concentrated superphosphate in October 1983. Soil test P in the 0 to 6 inch depth when sampled in the spring of 1984 ranged from 18 to 26 ppm. Soil NO_3-N averaged 46 lbs N/ac to a depth of 5 feet.

In 1984, we established the crop-fallow cropping sequence by planting spring wheat after sunflower in one block and fallowing a sunflower block. For the spring wheat-winter wheat-sunflower sequence, spring wheat was planted in the spring wheat

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[1/] Trade names of herbicides and farm equipment used in this report are given for the benefit of the reader and does not constitute endorsement or a recommendation of the product by USDA-ARS.

and winter wheat blocks and spring barley was planted in place of sunflower to void planting sunflower two years in a row in the same block.

By the 1985 crop season all cropping sequences, tillage treatments, N rates, and cultivar variables were in place. The conventional tillage treatment consists of using the undercutter sweep as needed between crop sequences and using a tandem disk once just ahead of planting. The minimum tillage treatment consists of using the undercutter only once or twice between crop sequences and using chemical weed control as may be needed thereafter. The no-tillage treatment consists of only herbicide spray operations as may be needed. A description of all tillage and spray operations being used in the two cropping sequences are shown in Table 1. Our tillage treatments may also be defined in terms of target crop residue levels at planting when the previous crop was spring wheat or winter wheat as follows: conventional tillage, 30% or less crop residue on the soil surface; minimum tillage, 30 to 60% residue cover; and no-till, 60% or greater crop residue cover. Therefore, we do not have a fixed number of tillage and/or spray operations but rather a system of tillage, plus spray and spray-only operations as may be needed for weed control and for obtaining target residue maintenance levels. Our combine is equipped with both a straw spreader and a chaff spreader. This spreads the straw and chaff over the width of the header.

The major soil fertility variable in this study is N rates, since P was uniformly applied at a one-time high rate to maintain available P at an adequate level for many years. All N rates are broadcast in the spring ahead of planting for the spring-planted crops and as a topdressing in late April for winter wheat. Soil samples are taken by 1-foot increments to a depth of 5 feet in the fall after harvest and again in early spring before planting to determine soil water and soil NH_4-N and NO_3-N contents. These data, along with total plant N in grain and straw, will provide the base data for determining the most optimum and cost-efficient N rates needed.

We hypothesize that interactions of crop cultivars and the tillage-nitrogen variables are important. Therefore, we are using a standard, or most popular, cultivar of a particular crop grown in the area as the check cultivar. The other cultivar is chosen for its expected, or known, improved performance in no-till cropping systems. Additionally, we are currently testing 5 to 10 cultivars of winter wheat and spring wheat in other no-till studies on large field scale basis to determine "best" cultivars for use in this study. Similar studies are being conducted on sunflower cultivars.

The major measurements being taken include: soil water at harvest, at soil freeze-up, and in the spring; residue quantity at harvest, in the spring, after planting, and periodically during fallow; plant population; plant growth and development; snow retention or trapping; soil physical properties (soil aggregate stability, bulk density, soil texture, etc.); soil test N and P; crop yield and quality; weed populations; plant pathogens and epidemiology; insect populations; soil and atmospheric environmental data; and crop canopy and residue spectral reflectance data. Long-term variables under investigation include changes in physical and chemical soil properties, N and P cycling and nutrient balance, and soil organic carbon.

Our goal is to use "best" management and cultural practices for each conservation tillage-cropping system. The planting equipment is very important for it is critical that the same plant population be attained in all treatments within each crop. Therefore we use the same drill for a given crop across all tillage variables. The Bettenson (Melroe) double disk no-till drill is used for planting spring wheat, a 8010 Haybuster no-till drill is used for planting winter wheat, and a 8000 IHC no-till 4-row unit planter is used for sunflower. These drills are capable of establishing a good plant population in crop residue levels up to 3000 lbs/ac.

The Haybuster undercutter with granular herbicide applicator is the principal tillage implement used in both conventional- and minimum-till systems. The 16-foot machine is equipped with 32-inch sweeps, and decreasing blade angle from toe to heel which permits consistent shallow depth (2-inch) operations. A 14-foot tandem disk is used ahead of planting in the conventional-till plots. Our sprayer was developed to perform as a ground-speed driven, pump injection system so that quantity of herbicide and water can be accurately regulated along with droplet size to provide optimum weed control. At the present time we are using Glean at 1/4 oz ai/ac, Roundup plus 2,4-D at 0.4 lb and 0.4 lb ai/ac, respectively, for long-term weed control in the no-till spring wheat-fallow sequence. In the spring wheat-winter wheat-sunflower sequence we are using Roundup + 2,4-D for grassy and broadleaf weeds on the no-till spring or winter wheat plots. For sunflowers we are using Treflan TR10 granules for conventional- and minimum-till sunflower production. For no-till sunflowers, we are currently experimenting with a fall application of Surflan at 1.25 lbs ai/ac plus a spring burn-down application of Roundup plus 2,4-D just before planting. We also applied Furadan insecticide at 1/2 lb ai/ac in the sunflower seed row to assist in insect control in all tillage systems. Broadleaf weeds within the spring wheat or winter wheat plots are controlled with a herbicide mixture of Brominal and 2,4-D ester each at 6 oz ai/ac.

The large size of the field plots in this study provide many advantages to the various research disciplines involved. (1) The plots are large enough, particularly the tillage (150 x 250 ft.) and N rate by tillage plots (150 x 80 ft.), to accommodate independent sampling sites for soil water and soil nutrients, plant growth and yield, weed populations, insect populations, plant and atmospheric sampling for pathogenic activities, etc. (2) The relatively large plot size provides additional border areas between treatments which can be used to reduce the confounding effects of one treatment on another in relation to plant pests (disease, insect and weed problems) associated with a given treatment. (3) This field size experiment also provides a potential for correlating spectral signatures from hand-held and satellite-mounted sensors with dry matter, crop yield and crop residue measurements to aid in land resources assessments of soil production and protection. (4) Since we are using field-size commercially available farming equipment for all operations, the applicability and acceptance of the results by producers has been enhanced appreciably.

Table 1. Description of tillage and spray operations used in the cropping sequences.

Cropping sequences	Conventional till	Minimum-till	No-till
Crop-Fallow			
Fallow	Undercut (3-4 times)	Undercut (2 times), spray	Spray (2 times)
Crop	Disk at planting	Spray at planting	Spray at planting
SpWH-WWh-Sunflower			
Spring wheat after WWh	Undercut at harvest Disk at planting	Undercut at harvest Undercut at planting	Spray at harvest Spray at planting
Winter wheat after SpWh	Undercut at harvest Disk at planting	Undercut at harvest Undercut at planting	Spray at harvest Direct planting
Sunflower after WWh	No fall treatment Undercut in spring[†] Disk at planting	No fall treatment Undercut w/TR10[‡] in spring[†] Undercut at planting	Fall spray (Surflan)[‡] Spray at planting (Glycophos.)[‡]

[†]Undercut early spring about 4 weeks ahead of planting sunflowers.

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