CONVENTIONAL AND NO-TILLAGE SYSTEM EFFECTS ON PLANT COMPOSITION AND YIELD

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CROPPING SYSTEMS

COR/COR	CONTINUOUS CORN	
SOR/SOR	CONTINUOUS SORGHUM	
SOY/SOY	CONTINUOUS SOYBEANS	
WH/WH	CONTINUOUS WHEAT	
COR/SOY	CORN-SOYBEAN	(2YEAR ROTATION)
SOY/COR	SOYBEAN-CORN	" "
SOY/SOR	SOYBEAN-SORGHUM	" "
SOR/SOY	SORGHUM-SOYBEAN	" "
SOY/WH	SOYBEAN-WHEAT	" "
WH/SOY	WHEAT-SOYBEAN	" "
WH/WH/WH	CONTINUOUS WHEAT	(3YEAR ROTATION)
SOR/SOR/SOR	CONTINUOUS SORGHUM	" "
WH/SOR/WH	WHEAT-SORGHUM-WHEAT	" "
WH/SOR/FAL	WHEAT-SORGHUM-FALLOW	" "
SOR/WH/SOR	SORGHUM-WHEAT-SORGHUM	" "
SOR/FAL/WH	SORGHUM-FALLOW-WHEAT	" "
FAL/WH/SOR	FALLOW-WHEAT-SORGHUM	" "

FERTILIZER AND HERBICIDE APPLICATION METHODS

BAND	BAND APPLIED AT SEEDING
B'CST	BROADCAST ON THE SOIL SURFACE
B'CST STUBBLE	BROADCAST FOLLOWING HARVEST
KNIFE	KNIFED INTO SOIL-ANHYDROUS AMMONIA SHANKS
PP	PREPLANT APPLICATION
POST	POST PLANT-AFTER EMERGENCE
PRE	PRE-EMERGENCE APPLICATION
TOP DRESS	APPLIED BROADCAST EARLY SPRING
UAN	UREA-AMMONIA-NITRATE SOLUTION
NH3	ANHYDROUS AMMONIA

YIELD AND GRAIN

% C.P.	PERCENT CRUDE PROTEIN
% D.M.	PERCENT DRY MATTER
D.M.GM/UNIT	GRAMS OF DRY MATTER PER HARVEST UNIT
1 HARVEST UNIT:	
(CORN)	4 PLANTS FROM 2 ROWS 76CM APART
(SORGHUM)	6 PLANTS FROM 2 ROWS 76CM APART
(SOYBEAN)	12 PLANTS FROM 2 ROWS 76CM APART

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INTRODUCTION

Since man began to cultivate crops for food, various tillage practices have evolved. They range from the hoe to the complex tillage practices in use today, (Musick, 1973). During the past 25 years, we have seen great changes in tillage practices and in our understanding of tillage needs by crops and soils (Larson, 1972). The trend 25 years ago was to increase the amount of tillage of the soil--both by the number and intensity of operations (Larson, 1972). Researchers were already wondering whether all the trips over the fields were necessary. Concepts of soil compaction, available soil moisture, and wind and water erosion were of prime importance to researchers and concerned farmers alike.

In the semi-arid wheat lands of the Great Plains, use of stubble-mulch tillage marked the beginning of a trend toward minimum and no-tillage techniques. Along with the various reduced tillage techniques there were major changes occurring in the size and type of equipment and machinery. Also, new tillage terminology began to appear such as zero-tillage, no-tillage, minimum tillage, ecofallow, and chemical fallow to name a few. The term conservation tillage has been accepted as a broad term encompassing such tillage terminology. Farmer interest in tillage problems has increased substantially since 1974. Primary interest in these systems can be described as threefold: 1) to control erosion and water runoff; 2) to save fuel and thereby reduce farming expenses; 3) to enhance yields for larger profit returns.

Oschwald (1973) describes a tillage system as a set of interrelated components that constitute a subsystem of a higher order, the crop production system. The tillage system also interacts with other subsystems and with the environment. The overall objective of tillage is to improve soil conditions for crop production. These ideas form the basis of the following questions:

(a) Are all the customary tillage operations necessary?

(b) What effects will reduced tillage have on grain yield and quality?

(c) What types of problems can be expected to be encountered and of what magnitude of importance will they be?

This type of questioning from farmers and researchers led to the formulation of a set of tillage studies dealing with corn (*Zea mays*, L), grain sorghum (*Sorghum bicolor*, Moench), soybeans (*Glycine max*, L., Merr.), and wheat (*Triticum aestivum*, L). The objective of the first set of studies was to determine the effect of three tillage treatments on plant composition and grain yield. The second and concurrent study was designed to study the response of irrigated corn and dryland grain sorghum to four methods of nitrogen application, and three methods of phosphorus application under a no-tillage system.

LITERATURE REVIEW

Linford (1973) stated that since early man first disturbed the soil in an attempt to improve the environment for the seed he planted, he has been and is today, seeking more effective and efficient methods to do this job.

Wiese and Staniforth (1973) reported that Cates and Cox summarized 125 tests from 28 states in 1912 and concluded that cultivation of corn was only beneficial if it eliminated weeds. Oschwald (1973) stated that the overall objective of tillage is to improve soil conditions for crop production.

The possibility of eliminating both tillage and cultivation from crop production came about with the advent of herbicides. This concept was first evaluated in California orchards in 1944. Early attempts to eliminate tillage from cropland with herbicides were made in the western Great Plains. This practice, called chemical fallow, was viewed as an additional opportunity beyond stubble mulch according to Wiese and Staniforth (1973). Initial studies in Montana in 1948 concluded that when chemical fallow controlled weeds, grain yields were comparable to yields from conventional tillage.

Van Doren et al. (1976) reported that long term studies have shown few differences in tillage methods over a wide range of soil types, cropping systems and climates. It was also reported by Van Doren et al. (1976) that if no-tillage was to be effective on poorly drained soils, it should be accompanied by a crop rotation and techniques which provide for desirable plant density and weed control.

Tillage Equipment

The kind, quantity, and quality of residues, number of weeds present, moisture conditions, soil texture, length of fallow and time of operation should be considered when selecting tillage tools (Fenster, 1973). Specialized tillage equipment has been a major deterrent to widespread acceptance of the no-tillage systems. Specialized equipment is not only expensive but is not readily available to the consumer. Robertson et al. (1976) stated that high costs of labor, fuel and machinery are some of the factors considered in the trend towards no-tillage methods.

Management

Management, a major factor in any tillage system, is beginning to be looked upon as the key to the entire no-tillage concept. Sanford et al. (1973) noted that no-tillage in double cropping systems requires a high level of management and continuous supervision to anticipate unusual problems and to perform each operation at the most appropriate time. A grower will choose the best combination of crop rotation, tillage, cultivation, and herbicides that will allow him to get the greatest return from his farming operation (Wiese et al., 1973). Fink (1974) stated, "By utilizing proper

cultural and management practices, the problems associated with zero-tillage corn can be overcome. Satisfactory yields can be produced by this method on a variety of soil types."

Environment

With more reduced tillage being practiced, Musick et al. (1973) noted that no-tillage agriculture will change the microenvironment of insects, weeds and plant diseases. Minor pests may suddenly become serious, while major pests may decrease in importance.

Soil Temperature:

Fenster (1973) reported that soil temperatures are lowered considerably at a depth of 2.5 cm under a stubble mulch system. Bennett (1973) reported soil temperatures in no-till corn averaged about 10°C less than under conventional tillage methods.

Soil Moisture:

Jones (1968) and Jones et al. (1969) showed that surface mulches effectively conserved soil water and reduced runoff. Their data also indicated that soil water in the major root zone area was the primary factor causing plant growth and yield differences among the four tillage treatments. Studies by Triplett et al. (1963) indicate that stover mulch had a beneficial effect on no-tillage corn yield and that the greater yields were associated with increased water infiltration and soil moisture.

Blevins et al. (1971) noted that under no-tillage conditions the decreased evaporation and greater ability of the soil to store moisture results in a water reserve which can carry the crop through periods of short-term drought without detrimental moisture stress developing in the plants. This phenomena was also observed and reported by Bennett (1973).

Fertilization Practices

Methods of fertilizer application have to be modified when operating with a no-tillage system. Most P and K fertilizers will be either surface broadcast and/or banded at planting time. Nitrogenous fertilizers may be broadcast or knifed into the soil either preplant, at planting or post-plant. The advent of nitrogen solutions further enhances the alternatives available for nitrogen application.

Moschler et al. (1972) applied equal amounts of N, P, and K fertilizer to the soil surface of a conventional and no-tillage corn culture. The results indicated the no-tillage culture was more efficient in utilizing the applied nutrients in that higher yields and some increase in residual soil nutrients were obtained. Lutz et al. (1973) and Moschler et al. (1972) established that P and K broadcast on the surface for no-tillage corn are just as available to the plant as when these elements are incorporated into the soil.

Movement of surface applied P and K was slow but sufficient to provide adequate nutrition for corn plants (Fink, 1974). Triplett et al. (1969) reported that most of the

P applied to the soil surface between rows of no-tillage treatments remained in the surface 2.5 cm of soil. Shear et al. (1969) also observed that surface applied phosphate tended to accumulate in the upper 5 cm of untilled soil. Also, K availability was not affected by tillage or method of application.

Findlay et al. (1964) noted that P concentrations in ear shoot leaves of hybrid corn were influenced by season, soil type, levels of applied N and P and method of placement (band/broadcast) of P, but not of N. Adriano et al. (1970) reported that banded applications of P resulted in higher plant concentrations of P than did broadcast P applications.

Work performed by Robertson et al. (1954) showed that nitrogen and potassium fertilization had a striking effect on fertilizer phosphorus utilization. The uptake of band applied P rapidly decreased as the season progressed. Bates (1971) reported that tillage and fertilizer placement interacted significantly, although the interactions were not consistent. Bates (1971) also observed that P banded with the seed increased seedling weight and initiated silking earlier than non-banded treatments.

Plant Responses

Plant analysis can be a powerful tool in the diagnosis of yield depressions. Generally, plant composition is a more sensitive indicator of crop response to environmental changes than is yield, and at the same time is much more difficult to interpret. Plant composition can vary widely, especially in the range of luxury consumption, without having any measurable or visible influence on growth and yield. (Melsted et al., 1969).

Shear et al. (1946) stated, "Leaf analysis is based on the functioning assimilating leaves as the central 'laboratories of nutrition.' The concentration of nutrients in leaves is regulated by the absorption power of the roots. The growth of the whole plant, including the formation of the seed, is controlled by the transformation of the nutrients proceeding in roots and leaves." All other factors being constant, plant growth is a function of two variables: 1) plant nutrition, 2) nutrient intensity and balance as they are reflected in the composition of leaves when the plants are in the same stages of growth and development (Shear et al., 1946).

According to Estes (1972), uptake of applied nutrients (N, P, K, Ca, Mg) could be efficient if the root system is near the surface. The growth rate of corn without tillage was significantly higher at all measuring dates than that of corn grown with conventional tillage (Moody, 1961). Further observations by Moody (1961) were that soil structure was destroyed by tillage and that runoff and evaporation was increased. Moschler and Martens (1975) observed that maturity was hastened by no-tillage culture, and that N, P, and K concentrations in the corn were not much changed by tillage methods. Other studies by Moody et al. (1961) showed no significent differences in plant population with different tillage treatments, i.e., conventional and no-till. Furthermore, the N, P, and K content of the leaves at silking showed no differences between treatments.

Garg and Welch (1967) found that additional P influenced the percent N in corn plants, to the extent that a positive relationship between percent N and percent P appeared in plant analysis. Belcher et al. (1972) reported that the percentage of P in the plants increased with increasing rates of applied P.

Triplett et al. (1969) reported that P and K concentrations in leaves of corn grown without tillage were equal to plants grown with conventional tillage when sampled at tasseling, and significantly higher when sampled at the 8 to 10 leaf stage. In the no-tillage system, broadcast applications of P and K tended to accumulate near the soil surface with K moving to a greater depth than P. Under these circumstances, immobile elements become positionally available to crop plants. Ellis et al. (1956) found that applied P was reflected primarily in the early growth stages. Also, the content of P in leaves decreased with plant aging.

Ellis et al. (1956) also reported a close relationship between the content of exchangeable K in soil and leaf content of K. Estes (1972) found higher levels of tissue K in a no-tillage system than in a conventional tillage system. This phenomena was explained by the fact that Ca and Mg uptake is governed by their movement and solubility. Since the no-tillage condition hindered these processes, the reduced Ca and Mg tissue concentrations may have resulted from the increased K uptake and represent an example of the classic K:Ca:Mg interaction.

Close relationships of N, P, and K concentrations in leaves and yield were observed by Tyner (1947), in that highly significant correlation and regression coefficients were obtained for the relation of yields to percentage of N, P, and K. Amer et al. (1964) and Fuehring (1966) both working with conventionally tilled corn, observed that with increasing amounts of nitrogen, the total P content of the leaves was increased significantly. Amer et al. (1964) found a linear relationship between yield and N content of leaves.

Simple correlations between nutrient concentrations and yield revealed that the concentrations of nitrate N or percent N in the whole plant at either date were as good or better predictors of grain yield as were N concentrations in the sixth leaf (Stangel, 1964). Work conducted by Viets et al. (1954) produced results showing that total N content of leaves selected prior to silking gave lower correlations with yield than those selected at silking.

Singh et al. (1966) reported early leaf tissue samplings (49 and 61 days after planting), gave significantly higher total phosphorus concentration than did later tissue samplings of 84 and 99 days after planting. They speculated that the low available phosphorus content of the soil might be responsible for low phosphorus content of the tissue. Adriano and Murphy (1970) stated that in the presence of adequate zinc, concentrations of P in young plant tissues were positively correlated with grain yields.

In research conducted by Miller et al., (1961), fertilizer (P and K) treatments were reflected in the content of P and K in soybean plant parts when grown on a soil that was low in available P and very low in exchangeable K. An increase in yield was more closely related to an increase in K content than to P content of the plant parts i.e., upper and lower leaves and petioles. Yields also were closely associated with P and K content of the upper leaves sampled in growth stage 7.

METHODS AND MATERIALS

CONSERVATION TILLAGE STUDY

Conservation tillage studies were initiated in 1974 to study the effects of three tillage systems (chemical, chemical/mechanical, mechanical) on continuous and rotation cropping systems. The crops being studied were soybeans, grain sorghum, wheat, and corn. Not all crops were used at all sites. Table 1 indicates the location, crop rotation and soil types of the various sites.

The study was replicated four times with seven contiguous plots each being 18.3 meters square. Each plot involved one crop, either continuous cropping or rotation, with three subplots (6.1 m by 18.3 m) representing the randomly situated tillage treatments. The seven main plots were randomized with respect to crop within, but not across replicates.

Initial soil samples were collected to a depth of 15 cm, forced air dried at 60°C, ground to a uniform fineness of 2 mm, and analyzed for pH, available P, exchangeable K, and organic matter. Procedures used for ammonium and nitrate were those of Bremner (1965a). Extractable phosphorus was determined by the Bray-1 method developed by Bray and Kurtz (1945). Extractable potassium was determined by measuring the K concentration in a 1 N ammonium acetate extract. Organic matter was determined with the modified Walkley-Black chromic acid method of determining oxidizable carbon. All

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