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Effects of Phosphorus on No-Till, Minimum-Till, and Conventional Till Irrigated Field Corn

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EFFECTS OF PHOSPHORUS ON NO-TILL, MINIMUM-TILL, AND CONVENTIONAL TILL IRRIGATED FIELD CORN

by

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John A. McKay

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ABSTRACT

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and Conventional Till Irrigated Field Corn

by

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Utah State University, 1987

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Department: Soil Science and Biometeorology

This investigation involved three tillage treatments, fall plowed (conventional) (moldboard 15-centimeter depth), fall chiseled (ripped) (25-centimeter depth), and no-tillage (zero tillage) replicated four times on an established alfalfa field. Rye was planted in the fall and harvested prior to planting the corn. Soil samples contained an average of 5.9 ppm phosphorus in the 0-30 centimeter soil layer, indicating the need for additional phosphorus. Within each tillage treatment, six rows received 11 kilograms/hectare phosphorus with the seed and 34 kilograms/hectare phosphorus side-dressed. Six rows received 45 kilograms/hectare phosphorus side-dressed, and four rows received 0 phosphorus. All 16 rows received 64 kilograms/hectare of nitrogen to ensure it was a non-limiting factor.

Yields were significantly higher in every tillage plot that received phosphorus compared to the 0 kilograms phosphorus/hectare treatments in the plots. There was a trend of higher yields with the treatments of 11 kilograms/hectare + 34 kilograms/hectare side-dressed compared to the 45 kilograms/hectare phosphorus side-dressed treatments. However, these were not significantly higher.

The no-till plots yielded higher than the ripped or plowed in each tillage treatment. The differences between the no-till and ripped plots were not significant. However, the no-till plots yielded significantly higher than the plowed plot. The no-till 11 kilograms phosphorus + 34 kilograms phosphorus plots averaged 3.1 Megegrams/hectare higher silage yield than the plowed 11 kilograms phosphorus + 34 kilograms phosphorus plots and 2.5 Megegrams/hectare higher in the 45 kilograms phosphorus side-dressed plots.

Phosphorus uptake was measured by leaf sampling and found to be significantly higher in the no-till plots compared to the ripped and plowed plots. TDN and protein were also determined, however, no significant differences existed between any tillage treatments.

The rye was intended to be cut prior to planting for forage use in a dairy or cattle feeding program. Although the average dry weight was only 598 kilograms/hectare due mainly to late planting, this method has great economical potential.

(56 pages)

INTRODUCTION

Farming has always involved a multitude of decisions. Today's farmer faces a very important one: which tillage system to use and, is subsurface tillage needed at all to produce a profitable crop?

Modern technology has given farmers many tillage systems from which to choose. These range from what is termed conventional tillage (plowing, disking, harrowing, etc.) to several forms of conservation tillage, such as reduced tillage (in which one or more tillage operations are eliminated) and no-tillage (in which all major tillage operations are left out). Conservation tillage farming is more than just a new farming technique. Conservation tillage is any form of reduced tillage technique that leaves substantial amounts of residue on the soil surface to reduce erosion and conserve moisture. It is a totally different approach to the basic task of planting and tending crops. The concept challenges many practices that farmers have believed-in and followed for generations.

The Conservation Tillage Information Center Report (1985) ranked Utah 38th of the 51 states on the basis of acres of no-till and 24th on the basis of percent no-till to total planted acres. In the same study, Utah is ranked 26th on the basis of acres of reduced-till and 19th on the basis of percent reduced-till to total planted acres. This report indicated that of the 265,099 hectares used for crop production in Utah, 15.69% were under some form of conservation tillage practice.

No one has a greater stake in soil conservation than farmers themselves, for whom the land is both a livelihood and a legacy. Yet, while long-term soil conservation is important, farmers are faced with the short-term problem of producing a profitable crop at today's high production expenses.

Corn was the first crop to be no-tilled on a large-scale basis in the United States. Sixty percent of the Nation's 1982 corn crop was produced in a conservation tillage system, 8.4% in a no-till system (Timmons et al., 1981).

The majority of corn grown in the U.S. is in the Midwest. Hence, that is the area where the greatest amounts of research have been performed on the responses of corn to different tillage and fertility conditions. A great deal can be learned from the research performed in these areas and applied to the western U.S. However, some western conditions are unique.

The acreage of corn grown in western states (like Utah) is relatively insignificant compared to the Midwest. However, for many western dairy farmers and cattlemen, field corn (cut for silage) makes up an important part of their feed ration, and large portions of their farms are rotated into a short-season corn crop annually.

Because the West is drier during the growing season, irrigation is required to meet the water requirements. Western soils tend to be calcareous compared to the midwestern soils which are generally acidic (requiring the addition of lime). The majority of corn grown in midwestern and eastern states is grown for seed or grain. In Utah, the majority of corn is cut for silage.

All of these differences indicate a contrasting environment and crop use in Utah and the western states, compared to the Midwest. It is felt that these differences indicate a need for further research on alternative corn tillage and fertility practices in the western U.S.

LITERATURE REVIEW

Previous Crop and Residue Management

Corn yields on some soils may be significantly increased or decreased by the previous crop depending on soil and weather conditions. Barber (1959) showed that on a Chalmers silt loam (Typic Argiaquolls) in Indiana, corn yielded more when grown after alfalfa (Medicago Sativa L.) and smooth bromegrass (Bromus inermis Leyss) than when grown after corn. He felt that differences due to water or nutrient levels were small since the soil was always at field capacity or higher in the spring and adequate fertilizer was applied. In a second report, Barber (1972) found that corn yields decreased progressively with years away from a forage crop.

On a Cecil sandy loam (Typic Hapludults) in Georgia, Adams et al. (1970) found that corn yields after sod and annual green manure crops were greater than continuous corn even though as much as 180 kg N/ha had been applied to the soil. The beneficial effects were apparent for 3 to 4 years after the sod.

Corn yields in drier areas may be decreased after forage crops due to lower soil water or nutrient levels in the soil (Shrader and Pierre, 1966). Vorhees and Holt (1969) showed that the depressions in corn yield after alfalfa could be eliminated by killing the alfalfa in the summer or fall before the corn and thus allowing time for the soil to be recharged with water.

Mannering et al. (1968) found that water infiltration rates into soils during first and second year corn after a grass-legume meadow were

32 and 25% greater, respectively, than during continuous corn but were not different from continuous corn in subsequent years. Soil losses by erosion from first, second, third, and fourth year corn after meadow were 53, 83, 90, and 97% respectively, of that from continuous corn. Greater soil aggregation accounted for most of the greater infiltration rate and decreased soil loss. The experiment was conducted on a Russell silt loam (Typic Hapludalfs) with a 5% slope.

Residues like corn stalks and grain straw, which are low in P, temporarily reduce the amount of available phosphorus similar to the way they reduce nitrates. Legumes and manure, which decay more rapidly than straw and corn stalks, release phosphorus shortly after they are added to the soil. This explains why lower response to phosphorus fertilizer is observed when a legume crop is plowed under. Legume residues contain more P, they rot more rapidly, and they have a narrower carbon-to-phosphorus ratio (Aldrich and Leng, 1969). Concerning the residual effect of a previous alfalfa crop, James (1978) stated, "The first-year residual effect of alfalfa may be sufficient to obviate the need for additional nitrogen fertilizer. At most, a 56 kilogram N/hectare treatment would be applied to corn to assure a near maximum yield following alfalfa" (p. 2).

Phosphorus Placement

Nutrient placement using a starter or "pop-up" fertilizer generally involves locating nutrients close to the plant at seeding. This improves the chances of root interception of nutrients early in the growing season (Richard, 1977). Use of phosphorus (P) as a starter is improved by reduced soil contact, slowing the rate of fixation, which lowers availability (Murphy, 1983).

In P banding it is important to locate the band where the largest portion of roots will encounter the band. Foth (1962) described the stages of corn root growth and location in the soil as:

1) downward-diagonal root growth,
2) root "filling" in the upper soil layers,
3) vertical root growth in deeper soil layers,
4) completion of brace roots,
5) no significant growth of root systems.

Root weights in the first stage were greatest in the 7-15 cm depth, followed by the 15-23 cm range and finally the 0-7 cm level. The plant's life cycle is 1/3 complete before roots fill the upper 7 cm of the soil in Stage 2. Top dressing the soil would result in P movement into only the top 2 or 3 cm of the soil. Roots would not grow into the surface soil between the rows. Any P in that area would not be used by the plants (Foth, 1962).

Deep banding locates the fertilizer in an area of higher soil moisture. The extra moisture increases the solubility of P fertilizer (Murphy, 1982). The moisture is also necessary for the diffusional movement which is the most important mechanism of P movement to the root absorption sites (Tisdale et al., 1985).

A study begun in 1981 at Iowa State University involving three tillage systems and four methods of N, P, and K application indicates that deep placement is generally more effective than other placement combinations (Timmons et al., 1981). Differences favoring deep placement tended to be more consistent under no-till conditions.

Applying N with P in the band gives higher yields than if P and N are banded separately (Leikman et al., 1978). The N promotes extra root proliferation in the banded area thus providing more surface area for P uptake. The use of NH_4^+ compounds the effect in calcareous soils as the plants were able to exclude excess protons into the rhizosphere lowering the pH to increase P solubility. In acid soils NO_3-Nitrogen gives the same desired results without the acidification of the rhizosphere as the optimum pH range for P uptake is between 6 and 7 or above 8.5 (Brady, 1974).

Timing of Phosphorus Application

Seatz and Sterges (1963) studied the effects of initial and supplemental additions (at one-week intervals) of phosphorus to corn in the greenhouse. They found that early applications generally resulted in the maximum yield of dry matter in 10-week-old corn. At each phosphorus-fertilization combination, the yield was less if the supplementary phosphorus was applied after rather than before a certain date or critical period in physiological development of the corn plant. Apparently, a critical period exists in the growth of the corn plant during which time phosphorus must be available to the plants if it is to be reflected in higher yields.

Critical Period for Irrigation

Assuming that sufficient moisture is available for germination, the tasseling and pollination period is the most critical growth stage in terms of water availability. Robins and Domingo (1953) observed that wilting for 1 or 2 days during this stage reduced yields 22%. Allowing the stress to continue 6 to 8 days reduced yields about 50%.

The importance of readily available water at critical growth stages was further documented by Gard et al. (1961) on a clay loam soil in

Illinois. Two 5-cm irrigations 10 to 14 days apart during the tasseling and shooting stages resulted in sizeable yield increases 3 years out of 4. Water stored below two feet in this soil was of very limited direct value to the corn crop. Irrigation of other than critical tasseling and shooting stages had little influence on yield.

Planting for Silage

For silage production the objective usually is to maximize total digestible nutrient (TDN) production per unit area. Since corn will continue to photosynthesize, dry matter will continue to accumulate until maturity. Proteins and starches are translocated from the stalks to the grain. Because the grain is the most digestible portion of the plant, maximum TDN is greatest when the corn is mature (black-layer stage). At the "black-layer stage" (grain maturity), corn may be too dry for best ensiling and sometimes the leaves may have senesced (Sprague, 1977). Whitaker et al. (1969) found a longer-season hybrid can be used for silage than for grain production since drying of the grain is not necessarily needed for silage. A hybrid that is physiologically mature at the average frost date should be used. Hybrids that yield well under high populations are preferred for silage.

Populations

Cummins and Dobson (1973) found that total dry matter production of corn was greatest in 51-cm as compared with 102-cm rows and increased from 49,000 to 86,000 plants per hectare (pph) in the Piedmont area of Georgia. Rutger and Crowder (1967) reported maximum dry matter yields at 88,000 pph in New York but did not find 46-cm wide rows to be superior to 92-cm rows at the 88,000 pph level. Optimum populations vary from about 40,000 pph (plants per hectare) to over 100,000 pph. The most favorable populations tend to be lower in areas of the south and west of the eastern Corn Belt and higher in the north and east (Sprague, 1977).

Planting Date

A decided trend toward earlier corn planting in the central and northern states has been evident because research has shown grain yield advantages. Earlier planting has become more practical because of effective weed control from herbicides, seed treatment, and improved seed quality (Rossman and Cook, 1966). However, the best guide for choosing a corn planting date is to plant when the soil temperature at the 7.6-cm soil depth has reached 15C for several days. Even though soil temperatures are adequate, wet soil conditions may prohibit implements from entering fields and delay planting beyond the desirable time. A general guide for optimum corn planting dates in the United States is given in Figure 1 (Sprague and Larson, 1966).

Planting Depth

Corn planting depth varies widely with soil conditions and climate. Usually the objective is to plant at a soil depth that will optimize soil temperature and soil water and result in rapid high percentage germination and emergence.

Alessi and Power (1971) found in growth room experiments that from 4 to 24 days were required to achieve 80% emergence depending upon seed depth and temperature. Temperature had a more pronounced effect than seed depth.

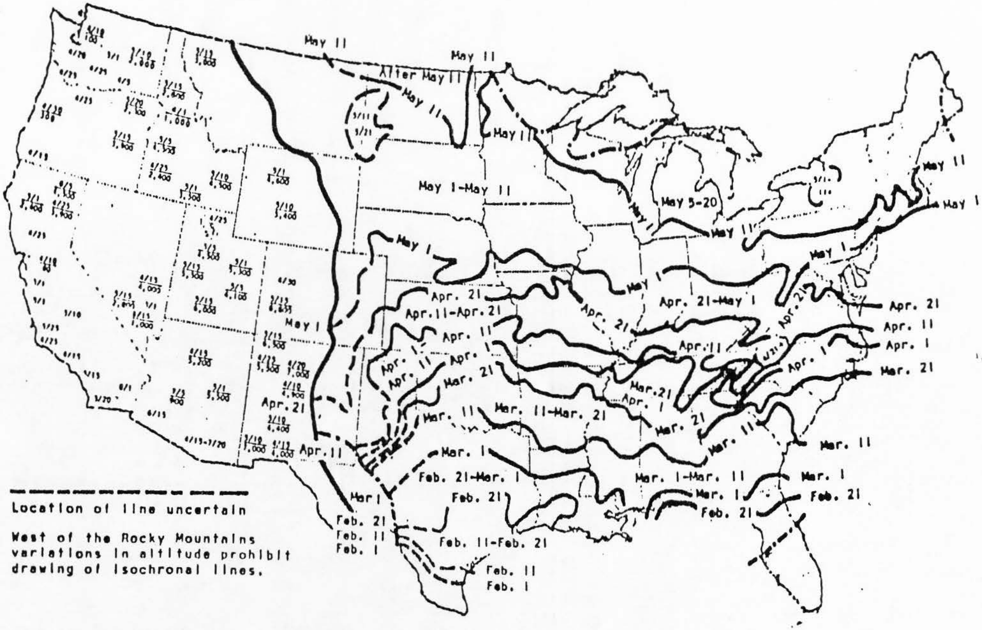

Fig. 1. Average dates when corn should be planted in the United States (Sprague and Larson, 1966).

Usually, the seedling depth and soil conditions are manipulated by the grower to enhance water absorbtion by the seed and to decrease evaporation. While much is known about water conditions required for seed germination, plant emergence, and water loss by evaporation, the situation in the field is so complex that judgement and experience in a given situation is important.

Conservation Tillage

Conservation tillage is perhaps the most significant technology developed for producing crops and simultaneously controlling soil erosion and conserving water for crop use. But an understanding of conservation tillage is requisite to its successful use and to further advances in the technology. Larson et al. (1983) indicate that if soil erosion is excessive, it is important to consider whether control practices are for preventing on-site damage in terms of productivity, off-site damage, or both. In addition, conservation tillage may be used primarily for water conservation, or it may serve both soil and water conservation purposes.

Soil loss rates alone are not good indicators of loss of soil productivity due to erosion. Loss of plant nutrients, for example, is a major consequence of soil erosion.

Larson et al. (1983) also cite national losses of nitrogen (N), phosphorus (P), and potassium (K) via erosion at $677 million, $17 million, and $382 million a year, respectively. Because the availability of these nutrients for recycling through subsequent crops is lost and the long-term availability of these nutrients as well as downstream impacts are not considered, the overall costs might be considerably higher.

Conservation tillage will reduce soil erosion and downstream pollution. While these are the best documented and most widely accepted benefits of conservation tillage, others include potentially higher economic returns on some soils, increased soil organic matter, reduced fuel use, less soil compaction, improved storage of soil moisture, and more timely cultural operations that permit multiple cropping (Amemiya, 1977).

OBJECTIVES

1. Determine if a positive or negative yield response exists to a split application of 11 kg/ha starter P and 34 kg/ha side dressed P, compared to 45 kg/ha side dress P and 0 kg/ha starter P in no-till, minimum till, and conventionally tilled field corn.

2. Determine the differences in the amount of P uptake in no-till, minimum till, and conventionally tilled field corn by taking leaf samples prior to harvest from each treatment in each replication and analyzing them.

3. Determine the differences in protein content and TDN of the corn from each tillage and fertility treatment.

4. Determine the feasibility of growing rye for forage and erosion control between growing seasons.

METHODS AND PROCEDURES

The experiment was conducted at the Utah State University Greenville Experiment Farm. The field was 3-year-old established alfalfa.

Tillage Treatments

The alfalfa was killed with an application of two liters/ha of glyphosate (Roundup) and a half liter/ha dicamba (Banvel) per acre on October 11, 1985, on all tillage plots. Three tillage treatments consisted of fall plowed or conventional (moldboard 15 cm depth), fall chiseled or ripped (25 cm depth), and no tillage. Each tillage treatment was replicated four times for a total of twelve plots. The plots were 12 meters wide by 105 meters long (see Figure 2).

A cover-crop of rye was planted at 143 kg/ha with 25 cm spacing in the no-till plots on November 5, 1985. A Tye Pasture Pleasure no-till drill was used. The alfalfa was 5 cm to 8 cm when it was treated with glyphosate (Roundup). The main purpose of the rye was to control soil erosion on land that would otherwise remain dormant by growing a crop that could be harvested prior to spring planting for forage use.

The rye samples were harvested on May 15, 1986, from each of the no-till plots. Ten 1 meter by 1 meter samples were randomly taken from each of the four no-till plots. The adjusted dry weight was calculated to determine the average yield per acre of forage. The rye was approximately 20 to 25 cm in height at harvest.

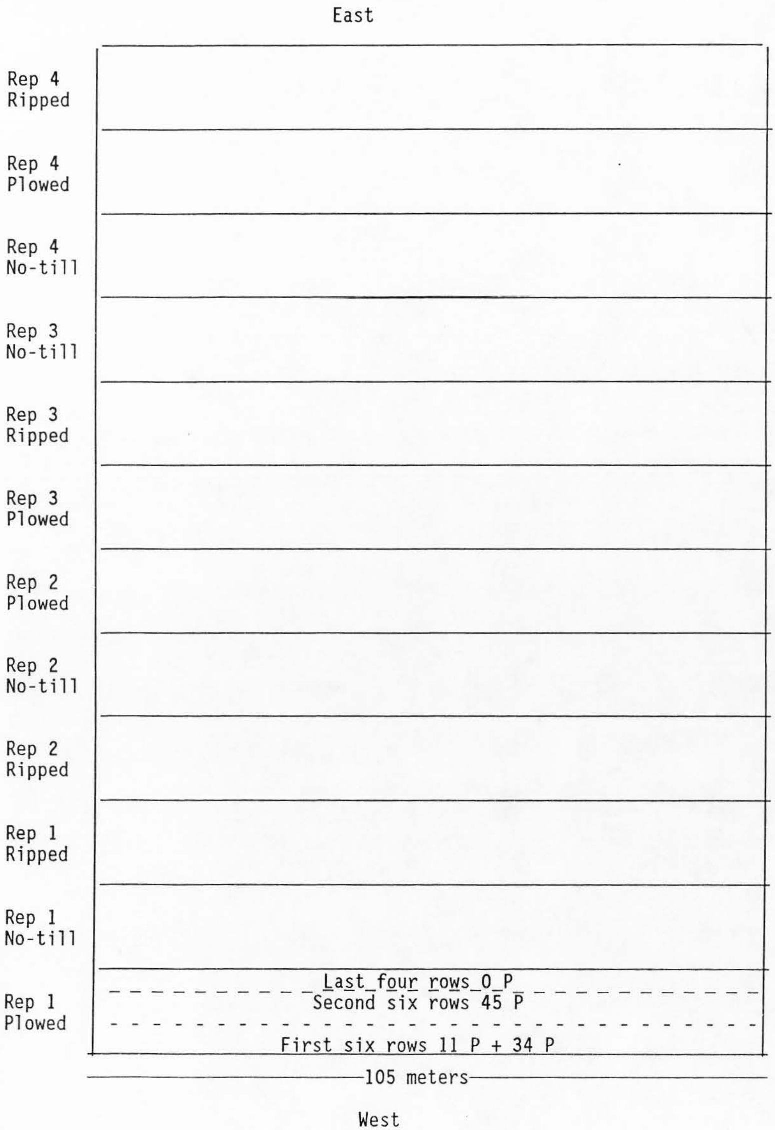

Fig. 2. Plot layout design.

Nine soil samples were randomly taken from the plowed plots at 30-cm increments to a depth of 90 cm on May 6, 1986. The samples were submitted to the Utah State University Soils Testing Lab for analysis of No_3^-N, P, and K content.

The plowed and ripped plots were harrowed with a roller harrow on May 16, 1986. These plots were treated with two liters/ha metolachlor (Dual) and harrowed with the roller harrow on May 17, 1986. The no-tillage plots were treated with glyphosate (Landmaster) and metolachlor (Dual) at two liter/ha each on May 17, 1986.

Planting and Fertility Treatment Procedures

The corn planting date, May 23, 1986, was delayed by cool, wet spring weather. A two-row John Deere flex planter was modified to plant all the plots. An electrically controlled Gandy box fertilizer spreader was attached behind the planter to band fertilizer with the seed. Shank openers were added to a front tool bar to create a preliminary furrow path for flood irrigation.

Each plot was planted at 76-cm row spacings with 16 rows per plot. The seed was planted 8 cm deep at 30-cm spacings. Each of the twelve plots received the following fertility treatments:

1. The first six rows had 11-52-0 banded with the seed at 11 kg P/ha and 6 kg N/ha. These rows were side-dressed with 0-45-0 at 34 kg P/ha on June 18, 1986.
2. The second six rows were side-dressed with 0-45-0 at 45 kg P/ha on June 18, 1986.
3. The last four rows received no P.

4. All 16 were side dressed with 34-0-0 at 64 kg N/ha on June 18, 1986.

The fertility treatments were not randomized; they were implemented in a continuing sequence. However, since plots were randomized and large, the bias is assumed to be low. Figure 2 depicts the plot design used in this experiment.

By attaching an additional Gandy box spreader, removing the planter, and adjusting the fertilizer shank, both the nitrogen and phosphorus were side-dressed together in one operation. Adjustments were made between treatments to change the delivery rate of the fertilizers. The fertilizer was placed 8 cm deep and 6 cm to the side of the corn plants.

Irrigation

The plots were furrowed on June 26, 1986, to facilitate flood irrigation. The plots were irrigated five times at two-week intervals beginning on June 30 and July 1, 1986. The plots all received six hours of irrigation each time they were watered. Each irrigation required two days to complete. There was never enough rain to justify altering the two-week interval watering schedule. The final irrigation was September 3 and 4, 1986.

Plant Phosphorus Content Analysis Procedure

Two middle stalk leaves were randomly selected from the middle two rows of each fertility treatment from each tillage plot on September 19, 1986. The leaves were dried, ground, and sent to the Utah State University Soil and Plant Testing Lab. The samples were analyzed for phosphorus content.

Yield Procedures

The middle two rows of each fertility treatment from each plot was harvested with a two-row corn chopper. The chopped corn from each treatment was weighed directly after harvest in trucks to determine tons/acre yield.

Protein and TDN Analysis Procedure

A sample of the chopped corn was taken from each plot treatment. The samples were dried, ground, and also sent to the Utah State University Soil Testing Lab for protein and TDN analysis.

RESULTS

Soil Test Results

The soil test results indicated a deficiency of phosphorus. At the 0-30 cm depth the average P content was 5.9 ppm. The USU Soil and Plant Testing Lab's recommendation of applied P_2O_5 for this test value is 67 to 89 kg/ha for irrigated corn. The NO_3-Nitrogen test also indicated the need for additional fertilizer. Taking into account the residual effect of the alfalfa on the nitrogen supply and based upon the recommendations of James (1978) concerning the addition of N for corn following alfalfa, 64 kg/ha of N was side-dressed to all plots.

Based upon communication with a local university agronomist, it was felt that the potassium soil test did not exceed the critical level to merit the need for additional potassium fertilizer. Table 1 provides a summary of the soil test results taken at three depths.

Yield Results

The results of the yield data, Figure 3, show a significant difference in yield within each tillage treatment between the treatments that received P and those that received no P. There was no significant difference between the treatments that received 11 kg/ha P starter plus 34 kg/ha P side-dressed compared to those that received 54 kg/ha P side-dressed and no starter.

Figure 4 shows a significant yield difference in tillage treatments between the no till 11 P + 34 P and the conventional 11 P + 34 P. Also the no-till 45 P yielded significantly higher than the conventional 45

Table 1. Soil test results in PPM

	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample	Average
NO_3 - N										
0 cm - 30 cm	2.6	2.0	5.9	3.3	2.1	2.0	1.8	2.4	3.1	2.8
30 cm - 60 cm	3.5	7.6	8.0	3.1	3.8	2.6	2.5	2.7	2.4	4.0
60 cm - 90 cm	25.6	16.7	10.5	6.7	6.2	5.1	4.7	4.2	3.8	9.3
P										
0 cm - 30 cm	7.3	4.3	3.2	4.0	7.5	11.0	6.4	5.0	4.6	5.9
30 cm - 60 cm	2.4	4.6	1.2	1.0	1.8	2.2	1.1	1.0	.7	1.8
60 cm - 90 cm	1.3	.8	.6	1.1	1.6	1.4	1.6	.7	.6	1.1
K										
0 cm - 30 cm	75.0	58.0	49.0	55.0	58.0	63.0	48.0	54.0	69.0	58.8
30 cm - 60 cm	61.0	51.0	44.0	40.0	52.0	52.0	31.0	33.0	44.0	45.3
60 cm - 90 cm	44.0	40.0	38.0	41.0	42.0	42.0	31.0	30.0	30.0	37.6

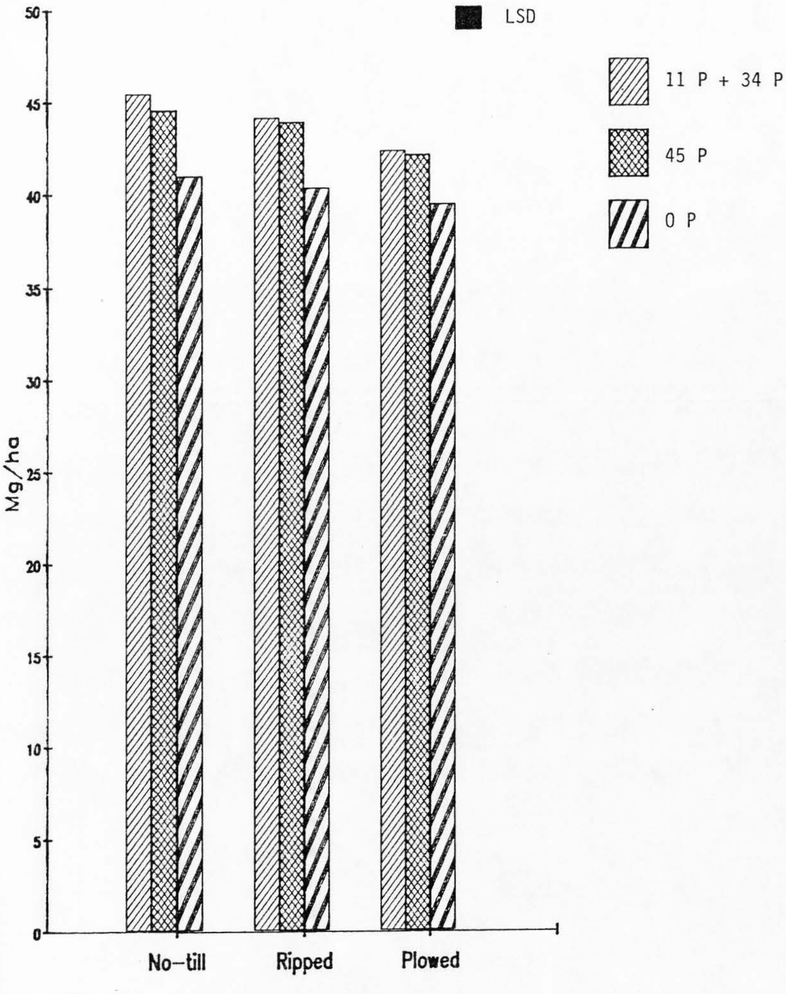

Fig. 3. Yield fertility comparisons within each tillage treatment.

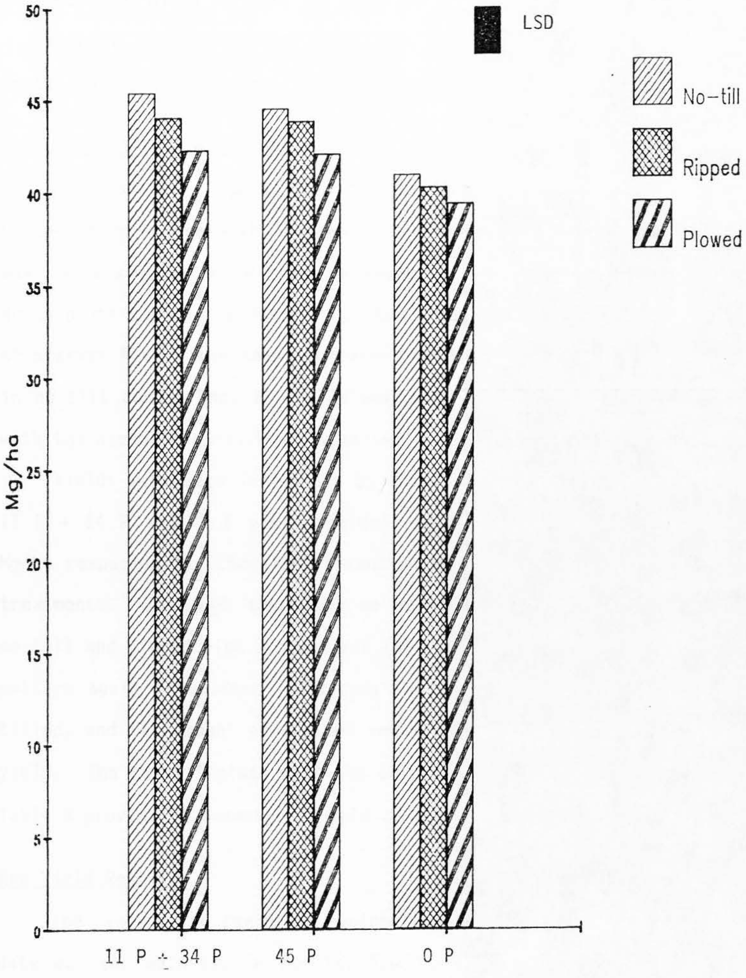

Fig. 4. Yield tillage comparisons within each fertility treatment.

P. There was no significant yield difference between the ripped and conventional plots or the no-till and ripped plots. Table 2 shows significant differences due to tillage and fertility but not a tillage fertility interaction significance.

Discussion of Yield Results

The no-till, ripped, and plowed plots all showed significantly higher yield response to the application of phosphorus. Although there was not a significant difference between the starter 11 P + 34 P side-dress plots and 45 P side-dress plots, a pattern is evident that the use of starter P with the seed increases yield. This seems especially true in no-till conditions, as yields were increased an average of .9 Mg/ha with the use of a split P application.

Yields were also influenced by the tillage treatment. The no-till 11 P + 34 P and 45 P plots yielded significanlty higher, 3.1 and 2.5 Mg/ha respectively, than the conventionally tilled plots, with the same treatments. Although there was no significant difference between the no-till and ripped plot and between the ripped and conventional plots, a pattern again is evident indicating the degree to which the ground was tilled, and the amount of residue remaining at planting time influenced yield. The no-till plots were the only plots that had the rye residue. Table 3 provides a summary of yield averages.

Rye Yield Results

The average rye forage dry weight was 599 kg/ha. The late planting date was the main reason for the low forage yield. Growing rye as a forage between corn crops has the potential to be economically valuable to farmers who would otherwise leave their land dormant between crops.

Table 2. Two-way analysis of variance for silage yield

Code	Source	Degrees of Freedom	Sum Squares	Mean Squares	F Value	Prob.
1	Rep	3	10.12	3.374	7.91	.016
2	Tillage	2	7.30	3.651	8.56	.017
-3	Error	6	2.56	0.426		
4	Fertility	2	19.22	9.608	80.50	.000
6	TXF	4	0.66	0.166	1.39	.277
-7	Error	18	2.15	0.199		

$s_{\bar{y}}$ for means group 1 = .2176614 number of observations = 9

$s_{\bar{y}}$ for means group 2 = .1885003 number of observations = 12

$s_{\bar{y}}$ for means group 4 = .0997295 number of observations = 12

$s_{\bar{y}}$ for means group 6 = .1727366 number of observations = 4

Fertility LSD = 1.1

Tillage LSD = 2.5

Table 3. Combined measured average data values

Treatments	Yield in Mg/ha	Percent Leaf Phosphorus Content PPM	Percent Protein Content	% TDN Content
No-till 11 P + 34 P	45.47	.177	7.05	68.71
No-till 45 P	44.58	.175	6.95	68.83
No-till 0 P	40.99	.167	6.93	68.02
Ripped 11 P + 34 P	44.13	.123	6.90	69.68
Ripped 45 P	43.90	.130	6.45	69.73
Ripped 0 P	40.32	.105	6.35	69.22
Plowed 11 P + 34 P	42.34	.127	6.93	70.27
Plowed 45 P	42.11	.127	6.38	69.99
Plowed 0 P	34.42	.102	6.63	69.43

Phosphorus Leaf Tissue Content Results

From the results graphed in Figure 5, it is apparent that significant differences exist within tillage treatments. There does appear to be a trend of higher P in the treatments that received P versus those without the P treatment. The noticeable difference is found between the no tillage treatments and the reduced-tillage and conventional plots. The no-till plots showed a significantly higher P content in the plants from approximately .04 to .07 higher than the ripped or conventional plots. The .167 P content in the no-till 0 P plots is only .01 less than the highest P content of .177 in the 34 P + 11 P no-till plots (see Figure 6).

It seems apparent that the phosphorus treatments added to the tillage plots did not have a significant effect on the amount of P accumulated in the leaf tissue. There was some effect due to the tillage treatment of the no-till plots that influenced P uptake. From the two-way analysis of variance, Table 4, there is significant differences in leaf tissue phosphorus content due to tillage but not to fertility treatments. Again there is no significance due to the fertility tillage interaction.

TDN and Protein Results

No significant differences or apparent trends in the data results from these measurements were found. The author will not attempt to draw conclusions from the way these data related to the treatments applied in this study. Table 3 provides the average values measured in each treatment; figures are located in Appendix A.

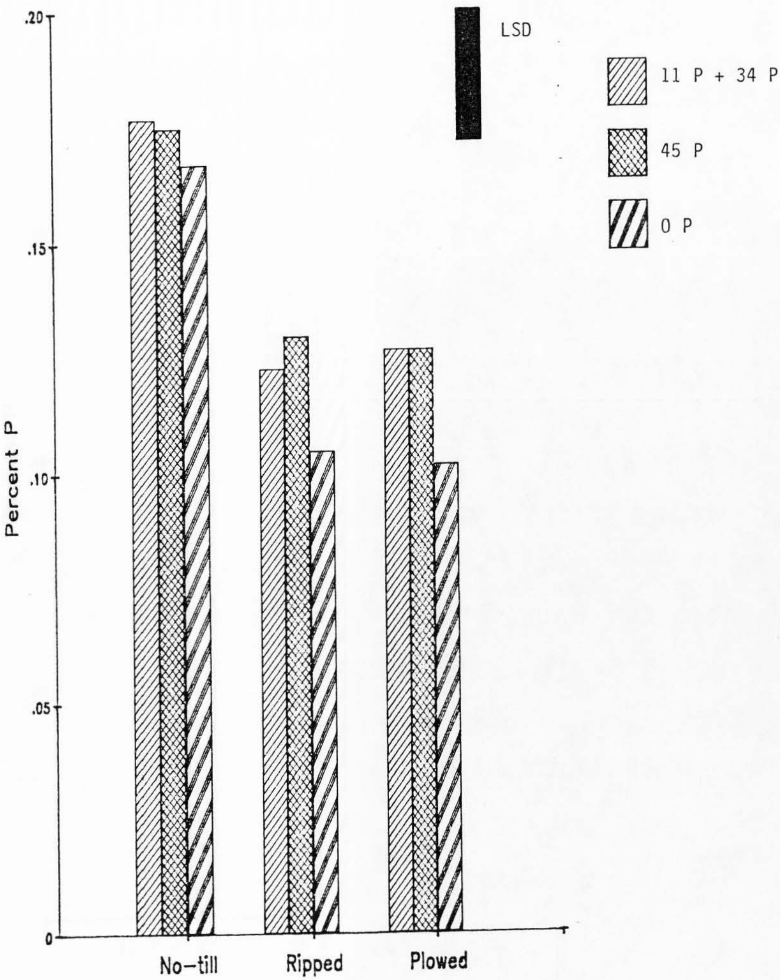

Fig. 5. Percent leaf tissue phosphorus content fertility comparisons within each tillage treatment.

Fig. 6. Percent leaf tissue phosphorus content tillage comparisons within each fertility treatment.

Table 4. Two-way analysis of variance for percent leaf tissue phosphorus content

Code	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob.
1	Rep	3	0.04	0.012	0.19	
2	Tillage	2	2.35	1.174	17.83	.002
-3	Error	6	0.39	0.066		
4	Fertility	2	0.27	0.135	3.73	.054
6	TXF	4	0.05	0.012	0.34	
-7	Error	18	0.65	0.036		

$s_{\bar{y}}$ for means group 1 = 8.552668E-02 number of observations = 9

$s_{\bar{y}}$ for means group 2 = 7.406829E-02 number of observations = 12

$s_{\bar{y}}$ for means group 4 = .0549972 number of observations = 12

$s_{\bar{y}}$ for means group 6 = 9.525794E-02 number of observations = 4

Tillage LSD = .054

Fertility LSD = .028

SUMMARY AND CONCLUSIONS

One of the objectives of this study was to determine if a yield response to a split application of 11 kg/ha starter P and 34 kg/ha side-dressed P exists, compared to 45 kg/ha side-dressed P and 0 starter P in no-till, minimum-till, and conventionally tilled irrigated field corn. Within each tillage treatment there were no significant differences shown between yields that resulted from 11 kg/ha P starter, 34 kg/ha side-dressed, and 45 kg/ha P side-dressed.

Although yields were not significantly influenced by the method of P application, there was a significant yield increase due to P use within each tillage treatment. Yields from the no-tillage and ripped plots were significantly larger than the plowed plots which also indicate yields were influenced by the method of tillage.

Another objective was to determine the differences of P uptake within each tillage and fertility treatment by leaf sampling prior to harvest. The author is not sure for the reason that the no-tillage fertility treatments showed significantly higher P contents than the other tillage treatments. The no-tillage plots had significantly higher amounts of residue due to the rye that was grown on these plots exclusively. Speculation can be made that this additional residue had an effect on soil properties that enhanced P uptake.

Another objective was to determine the differences in protein content and TDN of the silage samples from each tillage and fertility treatment. No significant differences existed in protein content or the TDN between any treatments. It should be noted that TDN was figured on a percent basis which means that treatments with higher yields would produce a greater amount of total TDN per acre.

The final objective was to determine the feasibility of growing rye for forage between growing seasons. The study met this objective by showing that a substantial crop of rye forage could be produced between growing seasons. The average yield per acre was low due to the lateness of the planting date. Growing rye for forage between growing seasons could prove to be an economical advantage for dairy farmers and ranchers in Utah.

SUGGESTIONS FOR FURTHER RESEARCH

The results from this study indicate that further study could be beneficial to determine the following: (1) the influence of corn yields in no-till plots with and without a forage crop grown prior to planting; (2) the yield potentials of a continuous no-till, minimum-till, and conventional tillage rotation from corn to a small grain crop to a forage crop; (3) the influence of sprinkler irrigation on corn to control soil erosion as opposed to furrow irrigation; (4) the influence of liquid fertilizer on corn yield.

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APPENDIXES

Appendix A: Percent Protein
and TDN Figures

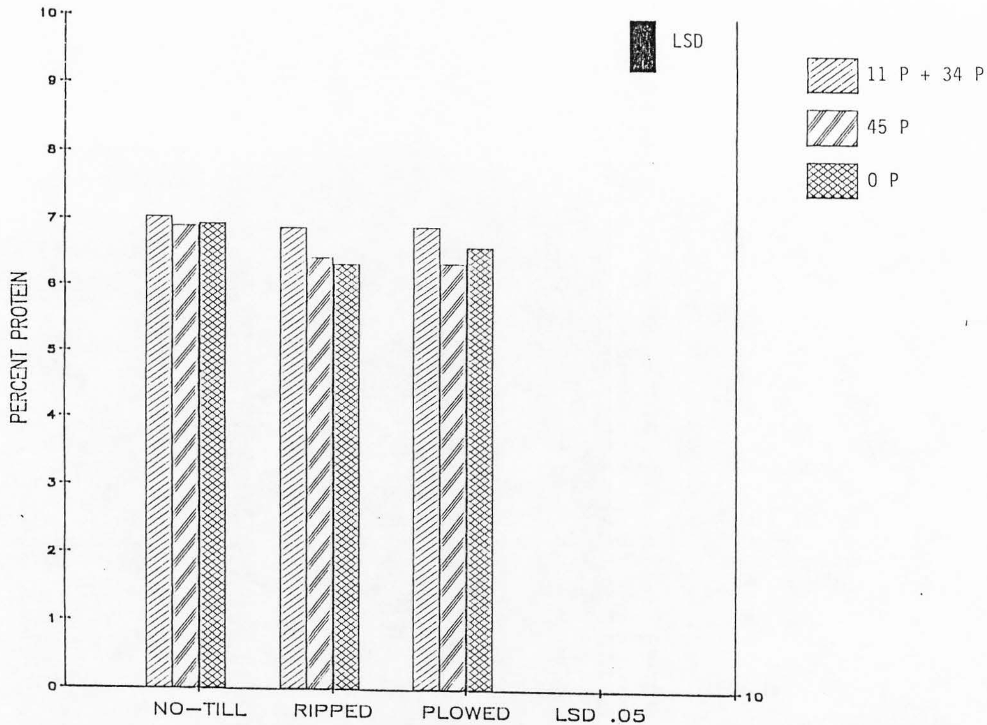

Fig. 7. Percent protein content.

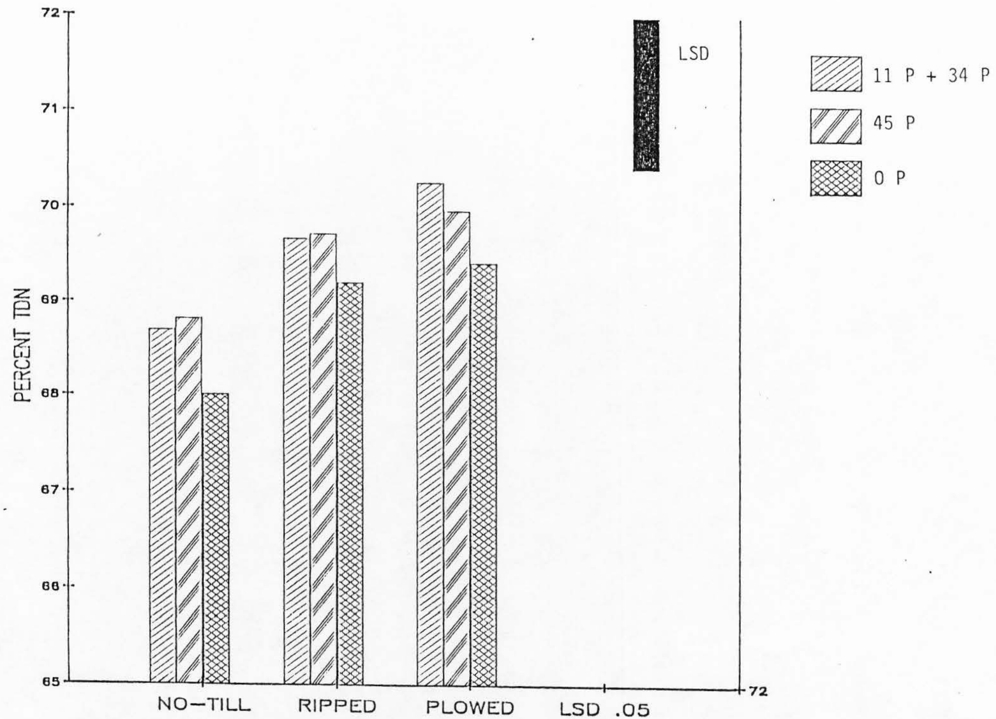

Fig. 8. Percent TDN content.

Appendix B: Percent TDN and Protein One Way Analysis of Variance

Table 5. One way analysis of variance for corn yields on tons per acre

Source of Variance	Degrees of Freedom	Sum of Squares	Mean of Squares	F Test
Among Samples	8	27.9316	3.49145	6.60408
Within Replications	27	14.2744	0.52868	
Total	35	42.2061		

The probability for an F of 6.60408 with
8 degrees of freedom in numerator and
27 degrees of freedom in denominator is: 0.999913

Table 6. One way analysis of variance for plant percent phosphorus content

Source of Variance	Degrees of Freedom	Sum of Squares	Mean of Squares	F Test
Among Samples	8	02.66732	003.33415	8.29747
Within Replications	27	01.08493	0004.01828	
Total	35	03.75226		

The probability for an F of 8.29747 with
8 degrees of freedom in numerator and
27 degrees of freedom in denominator is: 0.999988

Table 7. One way analysis of variance for percent TDN

Source of Variance	Degrees of Freedom	Sum of Squares	Mean of Squares	F Test
Among Samples	8	16.2031	2.02539	1.74732
Within Replications	27	31.2969	1.15914	
Total	35	47.5000		

The probability for an F of 1.74732 with
8 degrees of freedom in numerator and
27 degrees of freedom in denominator is: 0.867298

Table 8. One way analysis of variance for percent protein

Source of Variance	Degrees of Freedom	Sum of Squares	Mean of Squares	F Test
Among Samples	8	2.46460	0.308075	1.14111
Within Replications	27	7.28943	0.269979	
Total	35	9.75403		

The probability for an F of 1.14111 with
8 degrees of freedom in numerator and
27 degrees of freedom in denominator is: 0.631071

Appendix C: Climatic Data

Table 9. Climatic data for May, 1986, Utah State University Greenville Experiment Station Farm

	24 Hour Observation Air Temperature °F			Wind	
Date	Max.	Min.	24 Hour Amounts of Precipitation in Inches and Humidity	Anemometer Dial Reading (Miles)	24 Hour Movement
1	63	41		989.2	3
2	73	45			6
3	80	53			27
4	80	45			2
5	51	35	.54		0
6	52	41	T		0
7	46	35	.18		0
8	46	32	.78		2
9	45	34	.11		1
10	48	32	.05		24
11	53	30	.19		20
12	54	31	.01		3
13	53	35			5
14	64	41			2
15	59	32			2
16	61	37	.01		7
17	59	34			9
18	65	38			6
19	72	44			4
20	80	47			1
21	82	50			1
22	75	33	.30		8
23	50	32	.01		1
24	65	40			0
25	73	43			0
26	79	47			0
27	84	55			47
28	84	56			19
29	84	56			44
30	84	52			7
31	85	52			2

Table 10. Climatic data for June, 1986, Utah State University Greenville Experiment Station Farm

	24 Hour Observation Air Temperature ^oF			Wind	
Date	Max.	Min.	24 Hour Amounts of Precipitation in Inches and Humidity	Anemometer Dial Reading (Miles)	24 Hour Movement
1	88	56		249	2
2	88	55			48
3	87	55			3
4	85	55			4
5	84	57	.05		6
6	85	53			14
7	83	52			2
8	81	50	T		4
9	60	49	.04		2
10	63	45	.02		3
11	75	47			3
12	80	42			2
13	85	56	T		6
14	81	55	T		2
15	86	55			8
16	85	53			7
17	90	53			11
18	90	68			33
19	89	53			28
20	80	53			4
21	83	49			10
22	80	47			7
23	85	54			1
24	90	55			3
25	91	58			6
26	88	54			3
27	90	58			3
28	94	67			22
29	94	63			21
30	86	52			7

Table 11. Climatic data for July, 1986, Utah State University Greenville Experiment Station Farm

Date	24 Hour Observation Air Temperature °F Max.	Min.	24 Hour Amounts of Precipitation in Inches and Humidity	Wind: Anemometer Dial Reading (Miles)	Wind: 24 Hour Movement
1	84	53		525	3
2	88	55			1
3	94	65			6
4	90	68			16
5	86	39	.21		21
6	70	49			3
7	81	55	T		2
8	82	61	T		12
9	85	59	.01		24
10	84	58			5
11	76	61	T		2
12	81	48	.01		1
13	83	55			1
14	88	58			5
15	90	62			10
16	73	59	T		17
17	82	49	.28		21
18	76	53			1
19	85	51			22
20	87	53			2
21	90	55			6
22	87	64	.01		0
23	73	59	.05		5
24	74	57	.45		8
25	76	55	.76		5
26	82	59	.14		19
27	78	48	.07		11
28	79	52	.02		2
29	85	55			11
30	83	53			11
31	83	52			1

Table 12. Climatic data for August, 1986, Utah State University Greenville Experiment Station Farm

	24 Hour Observation Air Temperature °F			Wind	
Date	Max.	Min.	24 Hour Amounts of Precipitation in Inches and Humidity	Anemometer Dial Reading (Miles)	24 Hour Movement
1	88	61		777	1
2	88	54			0
3	91	64			9
4	89	56	T		3
5	88	58			0
6	90	58			5
7	89	66			2
8	88	61	T		20
9	87	54			2
10	90	59			21
11	91	57			11
12	89	60	T		5
13	88	48			5
14	80	49			1
15	83	52			1
16	91	50			10
17	92	64			5
18	91	63			2
19	92	63	T		1
20	89	63			1
21	84	62	.61		37
22	80	58			14
23	83	57	T		4
24	86	58			2
25	80	57			1
26	88	55			0
27	91	54			2
28	90	55			1
29	86	62			13
30	85	57	.10		6
31	84	57	.03		5

Table 13. Climatic data for September, 1986, Utah State University Greenville Experiment Station Farm

	24 Hour Observation Air Temperature ^oF			Wind	
Date	Max.	Min.	24 Hour Amounts of Precipitation in Inches and Humidity	Anemometer Dial Reading (Miles)	24 Hour Movement
1	77	46		978	11
2	76	53			1
3	75	48			7
4	79	50			3
5	83	52			4
6	87	51			5
7	85	59	T		6
8	85	51	T		8
9	85	51	.25		39
10	62	47	.12		2
11	64	44			2
12	71	43			3
13	78	50			17
14	79	46	.09		37
15	76	41			5
16	75	44			14
17	71	39			14
18	71	42	.14		2
19	53	38	.20		5
20	60	39	.03		3
21	60	36	.01		2
22	65	31			1
23	69	36			1
24	69	48	.10		4
25	49	37	1.81		12
26	51	36	.60		7
27	44	32	.27		18
28	49	29	.40		12
29	51	32			0
30	57	30	.05		3