

EDAPHIC AND CROP PRODUCTION CHANGES RESULTING FROM PIPELINE
INSTALLATION IN SEMIARID AGRICULTURAL ECOSYSTEMS¹

Stanley D. Zellmer, John D. Taylor, and Ralph P. Carter²

Abstract.--The effects of pipeline installation on soil properties and crop production are being documented on three transects (pipe ditch, working side, and control) at four sites (dryland row crop, native pasture, dryland wheat, and irrigated cropland) in Beaver County, Oklahoma. Plant-cover data from the native pasture site show a 37% increase in cover on the pipe ditch during the initial growth season; no significant differences in cover were observed when the control and working side transects were compared. Wheat yield on the pipe ditch at the irrigated crop site was significantly higher, a fact attributed to increased moisture-retention capacity and lower bulk density of the pipe ditch soil. The significantly higher grain sorghum yield on the right-of-way at the dryland row crop site may have resulted from the reclamation practice of chisel plowing the right-of-way on croplands following pipeline construction. Data from the initial sampling and first year of monitoring of the Beaver County sites indicate pipeline installations in semiarid agro-ecosystems have either positive or negligible impacts on soil properties and crop production.

INTRODUCTION

Across the country, and particularly in the southern Great Plains, thousands of miles of small-diameter pipelines connect natural gas and oil wells to gathering stations before processing and transmission to markets in other regions of the country. Installation of these pipelines disturbs the soil profile and may cause temporary or permanent changes in soil productivity. In spite of the extent of the pipeline gathering and transmission system, only limited data are available on the effect of pipeline construction on soils properties, crop production, and agricultural ecosystems.

Information is available on the revegetation of pipeline rights-of-way. Long and Ellis (1985) describe a method for developing revegetation guidelines for rights-of-way in a variety of environmental settings. The recovery of

vegetation on pipeline rights-of-way that cross a coastal barrier island in Texas has been documented (Odegard et al., 1985). Several studies have been reported on the revegetation of the trans-Alaska pipeline system (Bliss, 1979; Hubbard, 1980; Johnson, 1981; Johnson, 1985). Published studies on how soil properties and crop production are influenced by pipeline construction are much more limited. De Jong and Button (1973) published the results of one such study done in southeastern Saskatchewan. They reported that both the physical and chemical characteristics of the soil were altered, but wheat yield either remained the same or increased after pipeline installation.

The study described in this paper was initiated in the fall of 1983 to investigate the edaphic and crop-production changes that occur following the installation of a pipeline in Beaver County, Oklahoma. The objectives of the study are: (1) to determine the extent to which the physical and chemical characteristics of the soil are altered by a typical single-ditch³ pipeline construction project, (2) to document

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²Stanley D. Zellmer, Agronomist; John D. Taylor, Field Ecologist; and Ralph P. Carter, Program Manager; Right-of-Way Research Project, Argonne National Laboratory, Argonne, Ill. 60439.

³In a single-ditching operation, no effort is made to separately remove, or maintain the integrity of, the topsoil or A horizon with respect to the subsoil or lower horizons during the trenching and backfilling operations.

crop production and the establishment of a pasture plant community on the right-of-way for several growing seasons, and (3) to relate crop production to edaphic changes caused by the pipeline installation. This study is scheduled to continue until after the crop harvest of 1987. The results of initial sampling efforts and the first crop harvest following pipeline installation are reported here.

BACKGROUND

The Floris trunk line, a part of Panhandle Eastern Pipe Line Company's collection system in Beaver County (the eastern one-third of the Oklahoma Panhandle), was selected for study for several reasons. The area is known for its large gas reserves (Hugoton gas field), and future pipeline installations under conditions similar to those found at the Floris project are probable. The semiarid climate and the soil characteristics are representative of the southern Great Plains region. The project route crosses native pastureland, as well as agricultural land where two major crops are grown (wheat and grain sorghum) and different production methods (irrigated and dry land) are used. The installation method (i.e., single ditch) and reclamation practices were typical of pipeline companies operating in the region.

In September 1983, a 20.3-cm pipe was laid in a 51-cm-wide ditch dug with a wheel trencher to a depth of about 1.3 m in order to maintain a minimum of 1.1 m of soil cover over the top of the pipe. No effort was made to separately remove or replace the topsoil or A horizon during the ditching and backfilling operations. The ditch was filled by a road grader and packed by the rubber tires of the grader. In irrigated fields, the ditch was water-packed to prevent the interruption and uneven distribution of irrigation water on parts of the field located down-slope of the ditch. In this procedure, the ditch was filled with soil to within 30 cm of the top and flooded with water provided by the property owner. Depending upon soil settlement in the pipe ditch, the operation was sometimes repeated. Following the ditch-filling operation on croplands, the right-of-way was chiseled to a depth of 20-30 cm. Special efforts were made in pastures to limit installation activities in order to keep disturbance of the surface and vegetation to a minimum. Following installation, pasture lands were seeded with a mixture of buffalograss and sand lovegrass.⁴

MATERIALS AND METHODS

The four study sites chosen for the Beaver County study represent four major land uses

⁴Newhouse, J.B., 1983, personal conversation, Panhandle Eastern Pipe Line Company, Construction Division, Liberal, Kans.

(i.e., dryland row crop, native pasture, dryland wheat, and irrigated cropland) found in the area. Sites were selected not only because of their land use, but because all sites under cultivation have a common soil type (Dalhart fine sandy loam). The native pasture site has been mapped as the Pratt-Tivoli loamy fine sand, a complex often associated with the Dalhart soil and similar to the Dalhart fine sandy loam in several respects (Allgood et al., 1962). Another important criterion in the selection of study sites was the willingness of the landowners to allow access to, and sample collection from, the sites and to provide necessary data for the study.

Because of the linear nature of the pipe installation and the right-of-way (ROW) itself, a systematic procedure was used to locate sampling sites. Three separate, parallel sampling transects (fig. 1) were established. The first of these, the pipe ditch (P) sampling transect, was within the width of the ditch where maximum soil disturbance occurred. The second sampling transect, working side or intermediate (I), was in the area where construction traffic occurred but the soil was not removed and replaced. The third sampling transect, control (C), was at the edge of the ROW and was unaffected by construction activities. Important considerations in selecting study-site locations were slope angle and aspect and location within the field (to eliminate edge effects).

At five points on each of the three transects, at approximately 7.5-m intervals, individual soil samples were collected and a neutron-probe access tube installed (fig. 1). Soil samples were taken with a hydraulic soil-coring machine using a 5.1-cm-diameter core corresponding to the soil horizons at each sampling point. On the control and working side transects, the A horizon, 0 to 25 cm; the B horizon, 25 to 76 cm; and the C horizon, 76 to 122 cm, were sampled. Because of the dry, unconsolidated condition of the profile on the P transect, the upper two depths (0 to 25 cm and 25 to 76 cm) were taken as one sample -- the M or mixed horizon, 0 to 76 cm. The lowest sample (76 to 122 cm) was not taken from the pipe ditch transect, because Panhandle Eastern had requested, for safety reasons, that a 30-cm zone around the pipe not be disturbed. A section of the core or clod at approximately mid-depth was taken, trimmed, and dipped in a fixing solution for determination of clod bulk density.

Neutron-probe access tubes were installed in each of the sampling locations. The tube is an aluminum conduit with a 5.1-cm outer diameter and a watertight plug in the lower end. The upper end of each tube was placed about 30 cm below the soil surface to prevent interference with normal agricultural tillage operation. During periods when measurements are not being taken, a rubber plug is put in the upper end of the tube to exclude moisture, and the rubber plug is covered with a 13-cm square steel plate. A metal detector is used to locate the steel plate when additional measurements are to be taken.

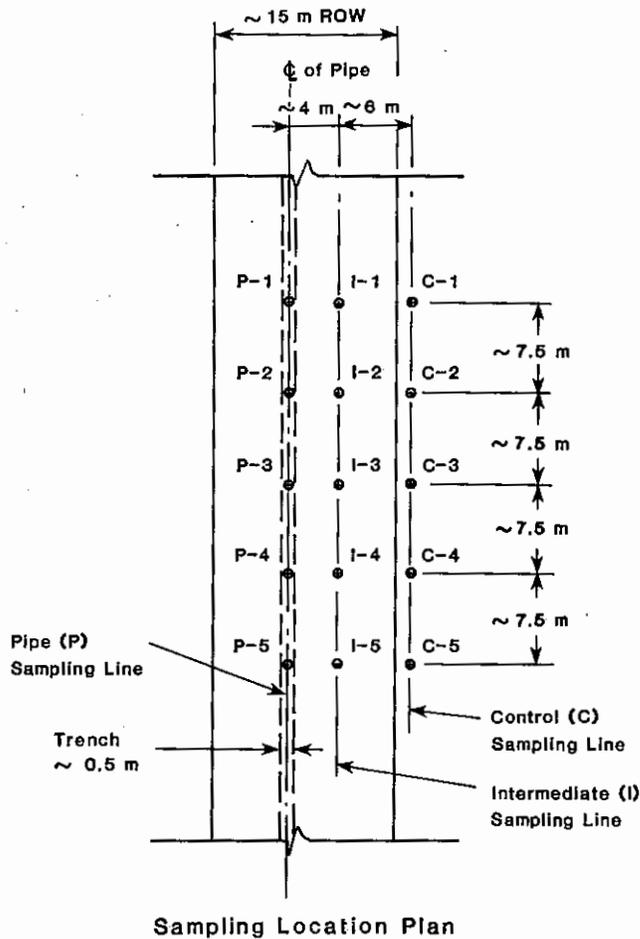


Figure 1.--Schematic Representation of the Sampling Locations and Neutron-Probe Access Tubes at the Beaver County Study Sites

series of measurements (five one-minute readings) was taken at two depths (51 cm and 102 cm) in each access tube to measure soil bulk density by the radiation method, as described by Blake (1965a). Additional surface-soil bulk-density measurements were made using a surface neutron probe at the 15-cm soil depth. These surface readings were taken in an area adjacent to the access tubes and undisturbed by the neutron-probe

access tubes. Both surface and depth bulk density measurements were taken seasonally (February, April, June, October) in conjunction with other sample and data collection from the study sites.

Soil samples were characterized by the following physical determinations: soil clod bulk density, using the Saran method (Sobek et al., 1978); particle density, using the pycnometer method (Blake, 1965b); particle size distribution or texture, by the hydrometer method (Day, 1965); and soil water-retention characteristics, by pressure plate (Klute, 1965). A theoretical maximum value for soil moisture retention was calculated for the average soil profile of each transect at each site. The theoretically available moisture content for each sample was calculated by subtracting the percent soil-moisture-retention value for -1.52 MPa (15 atm) from the percent value for -0.030 MPa (0.33 atm). The value, expressed as a decimal fraction, reflects the theoretical number of cubic meters of available water per cubic meter of soil for a given sample. By multiplying the decimal fraction by the depth of the individual horizon in meters, and then summing the values from the horizons from a profile, a value of available water for the profile is obtained. Depth values of 0.25 m for the A horizon, 0.51 m for the B horizon, and 0.31 m for the C horizon were used for the control and working side transects. A single depth of 1.07 m was used on the pipe ditch transect, representing the mixed (M) horizon. The 1.07-m depth was used for all transects and adjusted to one meter by multiplying by 0.935.

A second split of each soil sample was air-dried and processed for chemical laboratory analysis using methods adapted from Sobek et al. (1978). Chemical characteristics determined included the following: organic-matter content, by the Walkley-Black method (Nelson and Sommers, 1982); soluble-salts concentration, by conductivity of saturated extract (Rhoades, 1982); and soil pH 1:1 in water (Council on Soil Testing and Plant Analysis, 1974a). Available major plant nutrients determined included phosphorus, using Olsen's method (Council on Soil Testing and Plant Analysis, 1974b), and potassium, calcium, magnesium, and sodium, by ammonium-acetate extraction (Council on Soil Testing and Plant Analysis, 1974c). Total Kjeldahl nitrogen and total phosphorus were determined using industrial methods (Nos. 369-75A/B and 329-74W/B) developed for Technicon Industrial Systems (1977).

At the site in native pasture, six permanent 4-m plant data-collection lines were established on each of the three soil-sampling transects and, during the April, June, and November sampling trips in 1984, using the line intercept method adopted from Cook and Bonhan (1977), individual lengths of bare soil and plant cover by life form (grasses, leafy forbs, succulent forbs [cactus], and shrubs [sage]) were measured and recorded on each of the 18 separate lines.

The percent cover for each life form and bare soil on each monitoring line was calculated using the following equation:

$$C_x = \frac{\sum I_x}{L} \cdot (100)$$

where C_x = percent cover for cover type x,

I_x = length of cover type x (mm), and

L = total length of the line (4000 mm).

Total plant cover was calculated by summing the line lengths for all vegetation types from a given plant data-collection line. Cow dung was considered bare soil. A recording, tipping-bucket rain gauge was installed at the pasture site in October 1983 to measure precipitation received in the study area.

Samples from the wheat crop were collected from the irrigated site on June 24, 1984. Ten individual samples were taken from each of the three sample transects near and in line with the neutron probe access tubes. Thirty 1-m² quadrats of wheat were clipped, bagged, and returned to Argonne for processing. Samples were oven-dried at 65°C and threshed; grain weight per bushel was determined, and yields were calculated at a standard percent moisture (14.0%).

Grain-sorghum harvest samples were collected on November 7, 1984, from the dryland row crop and the irrigated site. Ten individual samples were collected from each of the three transects. The transect sampling lines were established on the row(s) of grain sorghum planted over the neutron access tubes. Two meters of row(s) were harvested for each sample. At the dryland site, the sorghum was planted as a row crop with 1.01 m between rows; individual samples represented a 2.032-m² area. At the irrigated site, the sorghum had been drilled with 25.4 cm between rows, and two rows were included in the sample; therefore, an individual sample represented a 1.016-m² area. As with the wheat samples, seed heads were dried and threshed, weight per bushel was determined, and yields were calculated at a standard moisture content (15.5%).

RESULTS AND DISCUSSION

Soil Physical Properties

Table 1 shows bulk density measurements, grouped by site and transect, made with the surface density gauge at the 15-cm depth during five site visits from October 1983 through November 1984. The means represent three separate one-minute readings made at each of the five sampling locations on a given transect at each study site. In 16 of 20 sets of observations, the mean soil bulk density is significantly lower on the pipe ditch transect than on the adjacent control and working side transects.

All four of the exceptions occur at the dryland wheat site. Abnormalities in soil bulk density reading and chemical analysis of soil samples from this site suggest the site had been graded or leveled some time before the pipeline was installed, and this action reduced or removed the topsoil from the area. This hypothesis has not been verified to date. In 60% of the data groups, the values from the working side transect are not significantly different from the observed values from the control transect. Again, three of the exceptions occur at dryland wheat sites.

Analyses of the density measurements taken at the 51-cm level within the soil profile indicate the general trend with significantly lower densities on the pipe ditch transects. Data from measurements of the 1.02-m level on the working side and control transects indicate no differences in soil bulk density. Results of the clod bulk density determination made on the samples collected in October 1983 support the surface and depth density measurements. These data support the hypothesis that soil bulk density is not increased by pipeline installation in a semiarid environment and that construction traffic does not increase soil bulk density on the rights-of-way.

The surface density data also show the influence of tillage operations and seasonal changes. The dramatic lowering of means between the April and June readings at the row crop site indicates the effect of the seedbed preparation and planting operations. A review of the mean values indicates the average bulk density is lower in the pasture site on all transects than in any of the cultivated sites. The root system, as found at the pasture site, tends to decrease soil bulk density, while intensive or continued cultivation usually increases soil bulk density (Brady, 1974). The data also show a general increase occurring from October through February and April in the surface-soil bulk density. This increase probably results from the winter and spring rainfall, which provides water to move and pack the soil particles closer together. The values of the November 1984 readings are generally very similar to those shown for October 1983, indicating that the rate of change in the surface bulk density of the soils at all sites is very low.

The surface soil at all sites is sandy, with the proportion of silt and clay increasing in the B and C horizons on the undisturbed transects. The ditching and backfilling operation during pipeline installation mixed the material from all horizons in the pipe ditch. The resultant soil texture of the pipe ditch soil reflects the inherent particle size distribution of the adjacent subsoil that makes up the major portion of the new pipe ditch soil. The mixing and redistribution of silt and clay throughout the soil profile in the pipe ditch also changes the moisture-retention potential of the pipe ditch soil. The theoretical moisture-retention potential for the soil profile on each transect was calculated using the technique described in

Table 1.--The Effect of Pipeline Construction on Surface-Soil Bulk Densities at Four Sites and Five Observation Dates in Beaver County

Site	Transect	October 1983	February 1984	April 1984	June 1984	November 1984
-----mg·m ⁻³ -----						
Row crop	Control	1.55*(0.071) [†]	1.61 (0.032)	1.64 (0.055)	1.50 (0.032)	1.58 (0.063)
	Working side	1.62*(0.032)	1.61 (0.032)	1.66 (0.045)	1.50 (0.000)	1.55 (0.089)
	Pipe ditch	1.35*(0.045)	1.38*(0.000)	1.37*(0.032)	1.33*(0.045)	1.34*(0.063)
Pasture	Control	1.46 (0.032)	1.45*(0.032)	1.47*(0.032)	1.44*(0.032)	1.46 (0.063)
	Working side	1.43 (0.055)	1.50*(0.063)	1.52*(0.032)	1.52*(0.032)	1.48 (0.045)
	Pipe ditch	1.19*(0.032)	1.24*(0.045)	1.27*(0.032)	1.34*(0.032)	1.29*(0.032)
Dryland Wheat	Control	1.52 (0.063)	1.54 (0.000)	1.56*(0.000)	1.56*(0.032)	1.53*(0.032)
	Working side	1.51 (0.105)	1.62 (0.032)	1.60*(0.000)	1.61 (0.045)	1.67*(0.055)
	Pipe ditch	1.42*(0.047)	1.61*(0.000)	1.65*(0.000)	1.64 (0.000)	1.59*(0.032)
Irrigated	Control	1.60 (0.000)	1.61 (0.032)	1.58 (0.045)	1.46*(0.055)	1.55 (0.032)
	Working side	1.59 (0.063)	1.59 (0.063)	1.58 (0.045)	1.51*(0.045)	1.58 (0.063)
	Pipe ditch	1.41*(0.055)	1.49*(0.055)	1.51*(0.045)	1.41*(0.032)	1.40*(0.109)

*Indicates significance at the 0.05 level of probability for the same data and site.

[†]Mean and standard deviation of 15-cm depth reading, n = 15.

the methods section. The products of these calculations are given in table 2. These data indicate that if water were available, a significantly larger volume of water could be stored in a given volume of soil. This fact, coupled with the significantly lower bulk density of the pipe ditch soils, could result in increased plant growth and crop yield on the pipe ditch transect.

Soil Chemical Characteristics

Soil samples from each horizon, sampling location, transect, and study site were analyzed for parameters chosen because of their known relationship to plant growth and crop yield. These data are given elsewhere (Zellmer and Taylor, 1984); their reproduction here would require considerable space.

Concentrations of exchangeable calcium, magnesium, and sodium in the pipe ditch samples reflect the levels found in the subsoil samples from the control and working side transects. Sodium levels in the pipe ditch soils generally increased when compared with A-horizon soil of the other two transects. However, soluble-salt concentrations, as measured by the electrical conductance of the saturated soil extract, remain well below levels that would adversely influence crop yields, 2.0 dS·m⁻¹ (Richards, 1954). Total phosphorus concentration follows the same trends as the bases and electrical conductance. Soil pH was relatively uniform through the soil profile, so pH values of the pipe ditch soils are very similar to those of the other soils. These data indicate that the chemical characteristics of the

pipe ditch soil reflect the inherent characteristics of the soil materials from the horizons that were mixed together during the ditching and backfilling operations to make the new pipe ditch soil.

Of particular interest in evaluating soils with regard to crop yield are the levels of extractable potassium, available phosphorus, and organic matter. Extractable-potassium values of the pipe ditch soil were significantly higher than adjacent surface-soil values at the dryland row crop site 2 but lower at the other three sites. This apparent inconsistency in the data can be explained when the potassium concentrations and relative volume of the subsoil are taken into account. At all sites, the relative volume of the B and C horizons is much greater in the new soil than the volume of A-horizon soil. The potassium concentration in the undisturbed soil profiles at the dryland row crop site increased significantly with depth, while at the other sites potassium level remained relatively unchanged or decreased slightly with depth. This same general relationship was observed in the available-phosphorus data, but differences in concentration were not as great and not significant. This illustrates that the relative volume and concentration of an element in soil materials that make up the pipe ditch soil control the chemical characteristics of the new soil.

The organic-matter data also support this volume-concentration relationship. At the cultivated sites, the surface-soil organic-matter content was less than 1% and did not change

Table 2.--Theoretical Moisture-Retention Capacity of Beaver County Soils as Altered by Pipeline Construction

Transect	Row Crop	Pasture	Dryland Wheat	Irrigated
-----m ³ ·m ⁻³ -----				
Control	9.02 (0.710)*	9.76 (0.360)	4.99 (0.504)	9.55 (0.394)
Working side	8.89 (0.509)	9.83 (0.269)	4.96 (0.353)	9.43 (0.104)
Pipe ditch	10.51 [†] (1.058)	12.16 [†] (0.811)	5.47 (0.927)	10.15 [†] (0.322)

*Mean and standard deviation, values x 10², n = 5.

[†]Indicates significance at the 0.05 level of probability for site.

greatly with increased depth. However, the organic-matter content of the A horizon at the pasture site was significantly higher than that of the subsoils. This resulted in a significantly lower organic-matter content in the pipe ditch soil when compared with adjacent surface soils.

Pasture Vegetation

Calculation of the percent plant cover and bare soil from the six data-collection lines on the three transects during April, June, and November of 1984 indicates that less than 2% of the 96 to 98% total plant cover was forbes or shrubs. A relatively low percentage (8.2 ± 4.7%) of bare soil on the working side transect in April indicates that the special efforts made to limit activities during construction resulted in only minor influence by the pipeline installation. The percent bare soil on the working side transect decreased and by November was about the same as the control transect. The percent total plant cover on the pipe ditch transect generally decreased during the first growth season: 20.8 ± 18.4% in April, 62.5 ± 24.2% in June, and 37.7% ± 29.6% in November. The spring and early summer rains ended in June, so the peak of vegetative growth (and a general increase in total plant cover on all transects) was recorded during the June data collection. The decline in total plant cover on the pipe ditch may have been due to the dry summer, when some number of the young grass plants did not survive the drought. Forbes and species other than grasses accounted for less than 3% of the total plant cover on pipe ditch soil, indicating weeds are not a problem in the establishment of a pasture vegetation community.

Plant cover, mainly grasses, on the pipe ditch was not equal to that in the rest of the pasture after one year. However, an increase, from 0% at the time of the pipeline installation in October 1983 to about 37% in November 1985, has occurred. If this trend continues, the pipe

ditch cover could be expected to equal the cover on the other transects in less than three years.

Crop Production

The mean yields and standard deviations of ten individual samples of winter wheat, corrected to 14% moisture and 773 g·L⁻¹ test weight and expressed as g·m⁻², collected from each of the three transects at the irrigated site are: control, 350.4 ± 60.3; working side, 329.4 ± 63.0; and pipe ditch, 525.0 ± 75.7. The farm operator reported an average yield of 3.44 Mg·ha⁻¹ (344 g·m⁻²); therefore, yields on the working side and control transects are representative of actual field conditions. The wheat yield on the pipe ditch transect was significantly higher than on the other two transects, and no significant difference existed between the control and working side transect yields. The significant increase in yield on the pipe ditch transect can be attributed to the significantly higher theoretical moisture-retention capacity (table 2) and significantly lower soil bulk density of the pipe ditch soil (table 1). The increased amount of moisture stored in the soil would result in more water being available for wheat growth. The decrease in bulk density could result in additional water entering the soil, more movement of water within the soil, and perhaps more and deeper root penetration by the wheat plants on the pipe ditch transect.

The mean yields, their standard deviations, and extension to Mg·ha⁻¹ of the ten grain sorghum samples collected from each of the three transects at the dryland row crop and irrigated sites collected in November 1984 are given in table 3. The grain sorghum yields at both sites were somewhat below the long-term county averages of 1.90 Mg·ha⁻¹ on dryland fields and 4.85 Mg·ha⁻¹ on irrigated fields. Two separate climatological factors played a role in lowering the average yield. At the dryland row crop site, only about 10 cm of precipitation -- instead of

TABLE 3.--The Influence of Pipeline Construction on the Grain Sorghum Yields at Two Sites in Beaver County

Site	Transect	Mean Yield* --- g·m ⁻² ---	Extended Yield -Mg·ha ⁻¹ -
Row crop	Control	124.9 [†] (47.3)	1.25
	Working side	185.1 (39.0)	1.85
	Pipe ditch	199.6 (24.7)	2.00
Irrigated	Control	115.1 (74.3)	1.15
	Working side	121.0 (47.7)	1.20
	Pipe ditch	127.8 (26.2)	1.28

*Mean and standard deviation, n = 10.

[†]Indicates significance at the 0.05 level of probability.

the average 24 cm -- was received at the site during the growing season. The field where the dryland row crop is located averaged only 1.44 Mg·ha⁻¹ rather than the 2.07 Mg·ha⁻¹ normally harvested from the field.⁵ A later-than-normal wheat harvest delayed the planting of the sorghum at the irrigated site until July 10, 1985. This late planting date, coupled with a killing frost on September 25 (about three weeks before the normal date of October 20), prevented the sorghum from maturing. The average yield from this field was only 0.38 Mg·ha⁻¹, and the owner-operator considered it a crop failure.⁶

A review of the yield data for the dryland row crop site given in table 3 indicates the mean yield of the control transect is significantly lower than those of both the pipe ditch and working side transects. A possible explanation of the differences in yield between the transects at the dryland row crop site is differing availability of moisture. Following installation of the pipeline, the right-of-way, pipe ditch and working side, was chiseled (cropland only) to a depth of 20-30 cm. This operation could have promoted precipitation infiltration and resulted in increasing the available moisture for sorghum growth. During a dry growing season, when moisture is the most limiting factor, an

advantage in terms of increased soil moisture would be reflected in the yield from the pipe ditch and working side transects and not from the control transect. The limited rainfall during the growth season probably did not provide the additional available moisture needed to produce a significant increase comparable with the increase in the wheat yield on the pipe ditch transect at the irrigated site in June.

The means of samples from the three transects at the irrigated site (table 3) indicate no significant difference exists among yields. On the irrigated field, additional water was applied, and a yield response like that experienced with the wheat crop could have been expected. In 1984, however, the killing frost that occurred on September 25 prevented the late-planted sorghum from maturing and greatly decreased the overall yield. This may have prevented the expected yield response in the grain sorghum on the pipe ditch transect that was noted in the wheat yield on this irrigated site.

CONCLUSIONS

Surface-soil bulk densities at the 12-cm depth, determined by a neutron soil-density gauge and by the clod method, are lower (in many cases significantly lower) in the pipe ditch soils compared with densities in the adjacent control areas. No significant differences were found between the bulk densities of surface soils from the working side (construction traffic area) and soils from the control area. Subsoil bulk densities, determined by the clod method and depth neutron soil-density gauge, show the same trends as the surface-soil bulk densities -- lower bulk densities in the pipe ditch, and no differences between the densities of soils from the working side and control areas.

Determinations of particle size distribution of samples for the pipe ditch and adjacent areas show the textural class of the pipe ditch soil reflects the inherent texture of the subsoils of adjacent samples. Alteration of this physical property is similar to the changes in chemical characteristics and is caused by the mixing of soil materials from different horizons during the trenching and backfilling operations. This redistribution of silt and clay within the pipe ditch soil profile has resulted in a significant increase in the theoretical water-retention capacity of the pipe ditch soil profile at three of the four study sites. This factor, coupled with a decrease in soil bulk density, could increase water infiltration, facilitate the movement of moisture within the soil profile, and provide an improved environment for root growth. The increased moisture-retention capacity would provide more water for crop growth.

The concentration of soil bases (Ca, Mg, and Na) was found to have increased in the pipe ditch soil when compared with that of the adjacent surface soil, and to reflect the inherent characteristics of the adjacent subsoils, but all

⁵King, G., 1984, personal conversation, farm owner-operator, Tyrone, Oklahoma.

⁶Franz, G., 1984, personal conversation, farm owner-operator, Turpin, Oklahoma.

remained within the acceptable range for good plant growth. Exchangeable potassium, available phosphorus, and percentages of organic matter of the pipe ditch soils also generally reflected the relationship. However, it was observed for these three parameters that the relative volume of the soil materials, as well as the concentration of the parameter, determined the characteristics of the new pipe ditch soil.

Measurements made at the native pasture site show an increase of about 37% in total plant cover on the pipe ditch during the first growing season. If this trend continues, the pipe ditch will be revegetated in three years or less. The plants becoming established are mainly grasses, similar to the plant community on the adjacent control area. Cover data, by plant life form, indicate that the working side of the right-of-way has not been adversely affected by pipeline construction activities.

Wheat yields over the pipe ditch at the irrigated site were significantly higher than the yields observed over the working side and control areas. Yields observed over the working side and the control area did not differ significantly and were similar to the yield for the field reported by the landowner. The higher yield of the pipe ditch is attributed to the increased moisture-retention capacity and lower soil bulk density of the pipe ditch soil.

The grain sorghum yield on the right-of-way (working side and pipe ditch) was significantly higher than on the adjacent control area at the dryland row crop site. This difference could have been the result of the chisel plowing of the right-of-way done as a part of the normal reclamation operations following pipeline construction. Chisel plowing may have increased precipitation infiltration during a year with below-normal rainfall. Other parts of the field, including the control area, were not chisel-plowed. The grain sorghum yield at the irrigated site was far below average because of a killing frost that occurred about three weeks before the normal date. No impacts, either positive or negative, due to the pipeline installation were observed at the irrigated grain sorghum site.

Data from the initial sample collection and analysis and results of the first year of monitoring at the Beaver County study sites indicate the single ditch method of pipeline installation has either positive or negligible impacts on semiarid agricultural ecosystems.

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