Final Report

USDA/NRCS Award 69-3A75-16-041 - Summer cover-crop effect on no-till and conventional till winter pasture production, stocker gain, soil health and soil physical properties.

Project Background and Rationale

In the southern plains, wheat is the main agricultural crop produced due to climate limitations. There are three main systems of wheat production in Oklahoma that are representative of a large portion of the wheat production region of the southern plains. These systems are wheat grown for grain only, a dual purpose system whereby excess wheat forage is grazed by young growing cattle (stockers) to the first hollow stem stage of wheat then cattle are removed and grain is then produced, or the forage only system where stocker cattle graze the forage produced in a period from November/December to April/May. The agronomics of the system traditionally has been to establish wheat in the fall (September for grazing, October for grain) apply nitrogen (N) for the desired yield goal then when the crop is completed, the land is fallowed through the summer until the next wheat crop is established. Rationale for the fallow period is to allow soil moisture to be maintained or accumulated for the next wheat crop. During the fallow period, weeds are controlled with tillage (Till) if the system is a traditional tillage system or chemically if in no-till (NT) production. In these intensive wheat production areas, often there is a lack of crop rotation which can limit soil microbial diversity. The fallow period also leaves the ground bare exposing it to wind and water erosion. There is also added production expense for fallow ground with weed control either mechanically or chemically with no potential source of revenue to cover costs.

There is then potential in wheat production systems to incorporate summer cover-crops to potentially increase soil microbial diversity, reduce erosion, provide an additional source of revenue, control weeds, and provide additional nitrogen to the system. While there are potential benefits of summer cover crops, the effect of these summer crops on water use and subsequent wheat system production need to be evaluated as wheat is the major source of income for producers in these systems.

To evaluate these effects we established a wheat forage-summer cover-crop grazing system in a whole plot/sub-plot replicated study where the whole plot is tillage (Till or NT) followed by summer fallow or summer cover-crop (TillCC or NTCC). In this study, both the wheat forage and the summer cover crops are grazed with stocker cattle. Soil physical, chemical, and biological properties are being measured.

Methods

The study is being conducted on 100 acres of predominately loamy upland to claypan upland soils. Location of the study is at the Noble Research Institute's Pasture Demonstration Farm west of Ardmore, OK. The land area is divided into ten 10-acre paddocks that had been previously assigned to either Till or NT tillage treatments with summer fallow followed by

wheat pasture that was grazed by stocker cattle. In the current study, these 10-acre paddocks serve as the whole plot for the tillage main effect. For the current study, whole paddocks were subdivided into 5-acre sub-paddocks and randomly assigned either a summer cover-crop or summer fallow treatment. Treatments are wheat established with tillage for forage followed by summer fallow (Till), wheat established with tillage for forage followed by summer cover crop established with tillage (TillCC), wheat established with no-till for forage followed by summer fallow (NT), and wheat established for forage with NT followed by summer cover crop established with no-till (NTCC). Each treatment is replicated five times. Treatment arrangement is shown in Figure 1.

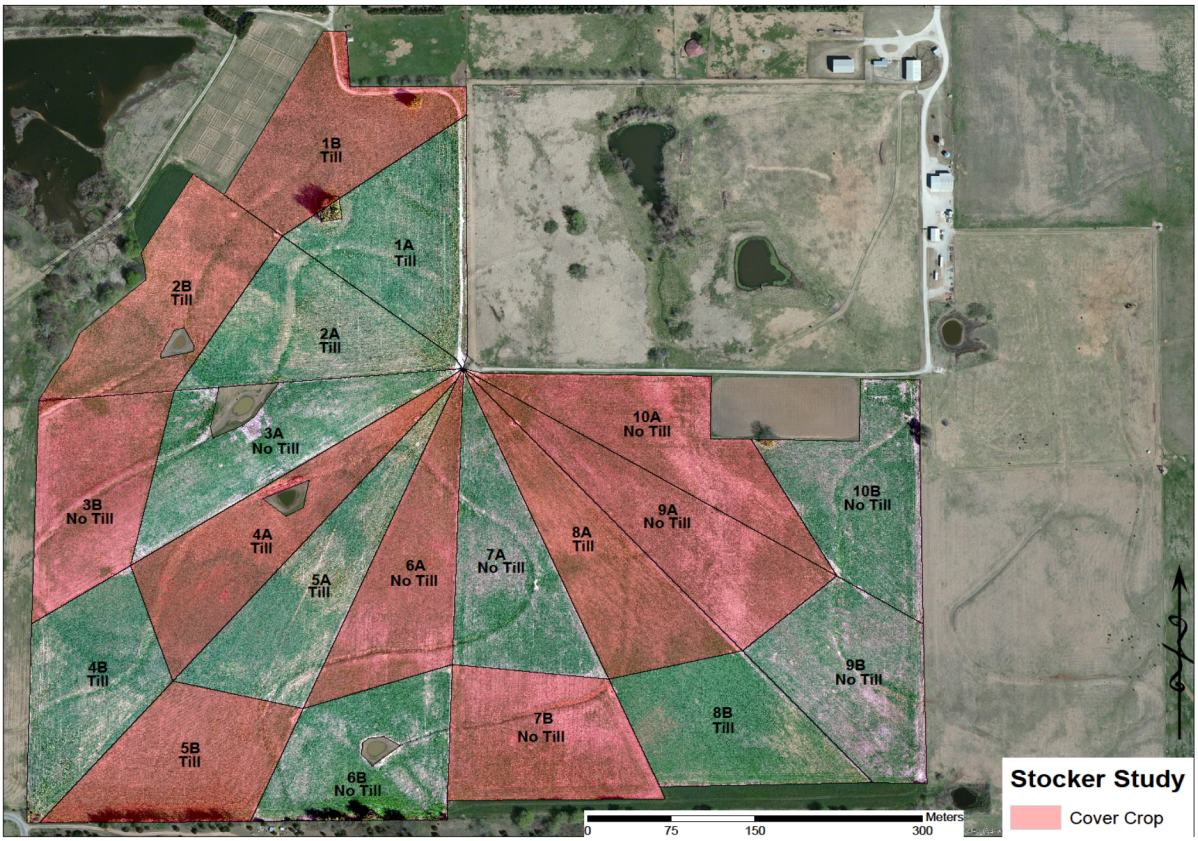


Figure 1. Summer cover crop study area and treatment design located at the Noble Research Institute's Pasture Demonstration Farm near Ardmore, OK.

Wheat is established according to treatment method in September at a seeding rate of 120 lb/ac using calibrated conventional (John Deere 8500) or no-till (John Deere 1590) grain drills. Prior to establishment, each paddock is soil tested and phosphorus, potassium and pH are corrected based on soil test results. Following wheat emergence, N is applied at a rate of 60-75 lb N/acre. Including residual soil nitrate levels, total plant available N will range from 70 to 100 lb N/ac depending upon the year and treatment. Stocker cattle (550 lb) are placed on pasture when average forage biomass has reached 1200-1400 lb/ac. Cattle are grazed to a point when forage dry matter becomes limiting to gain (grazeout) in late April or early May. Following grazeout, residual biomass is terminated either chemically (NT) or with tillage (Till). Chemical

termination is done using 2 qts/acre of glyphosate plus 1 pt/acre of 2,4-D plus dicamba. Cover crops are established as soon as possible following wheat termination. In years 1 and 2 of the study a cover crop mixture, of pearl millet, brown top millet, foxtail millet, buckwheat, sunnhemp, grazing corn, soybeans, and cowpeas was established at a seeding rate of 30 lb/acre. Soybeans, grazing corn, sunnhemp, buckwheat, browntop millet and foxtail millet were found to contribute very little to grazing and were eliminated from the mixture. In years 3 and 4 a mixture of pearl millet, okra, and cowpeas was used at a seeding rate of 30 lb/ac. The drills that were used to establish the wheat were also used for cover crop establishment. A cover crop mixture of 50% grass and 50% broadleaf was maintained through the course of the study. No N fertilizer is applied to the cover crops. Cover crops are grazed with summer stockers (650 lb) when cover crops reach 1200-1400 lb/ac dry matter. Cattle are removed from cover crops when approximately 50% of the total biomass has been removed or when it is planting time for wheat pasture. Animal weight gains were collected through the course of the study on both wheat and cover crops. Till fallow paddocks are fallowed with an offset disk 2-3 times over the summer. Chemical fallow areas are fallowed using the previously described chemical mix applied 2-3 times over the summer.

To evaluate soil moisture and temperature, sensors are placed in each paddock at depths of 3, 10, and 24 inches. Readings are taken hourly. Sensors are removed for crop establishment and replaced as soon as possible. Water infiltration rates are collected at the end of summer prior to wheat establishment and at grazeout using a mini-disk infiltrometer which measures saturated hydraulic conductivity. Soil bulk density is measured also at the end of summer and after grazeout at 2, 4, and 6 inch increments. Soil tests are also conducted twice per year at time periods corresponding to other soil measurements. Soil test conducted are the standard soil test and Haney soil test. Wheat forage biomass is measured weekly during the growing season using a calibrated rising plate meter which is calibrated monthly.

Results

Animal gain

Animal gain was good on both wheat pasture and cover crops. Tillage treatment had a significant effect ($P < 0.05$) effect on gain (Table 1) during the wheat pasture phase, while cover crop had no effect ($P > 0.05$). The interaction between tillage and cover crop was also not significant ($P > 0.05$) meaning that animal gain was always higher in Till established wheat pasture regardless of the presence or absence of cover crops (Table 1).

Table 1. Tillage and cover crop effect on winter pasture stocker gain averaged over three years.

					Tillage x Cover crop			
	Tillage		Cover Crop		Summer fallow		Summer Cover	
	Till	NT	Summer fallow	Summer Cover	Till	NT	TillCC	NTCC
Total Gain	294a*	257b	281	271	303a	259b	286a	255b
Grazing days	93a	89b	93a	90b	97A**	90B	91Ba	89Bb
Stocking rate	0.75	0.74	0.77a	0.73b	0.78A	0.75B	0.72B	0.73B

*Within row and main effect column, treatment means with different lower case letters are significantly different at $P < 0.05$.

**Differing uppercase letters signify significant differences for interaction effects at $P < 0.05$.

Animal gain during the cover crop phase was also good with a significant tillage effect, however the tillage effect was opposite (Table 2) of the wheat phase with total gain being higher for NTCC ($P < 0.05$) compared to TillCC. This can be explained by fewer grazing days in the TillCC. Typically, cover crops established in the Till system are planted up to 30 days later than NT due to tillage operations and soil moisture. The earlier planting date for NT allows for cover crops to generate greater biomass earlier than the Till system.

Overall grazing days in both wheat and cover crops have been low. In the wheat system only 1 year out of 3 has been normal due to drought in year 2 and excessive moisture in year 3 delaying grazing to February. In the cover crop systems, grazing days have averaged less than 40 which is too few for cover crop grazing to be profitable

Table 2. Tillage effect on summer cover crop stocker gain.

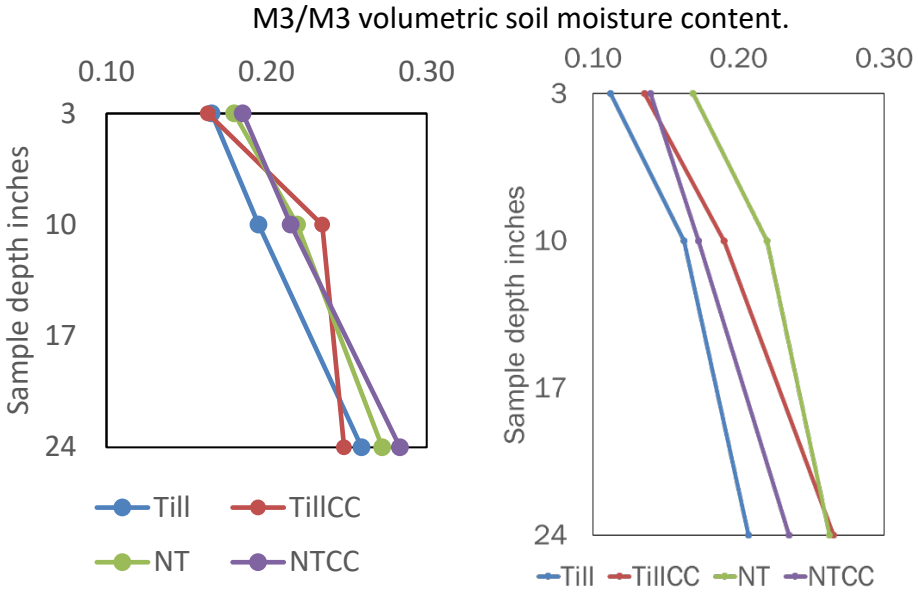
Treatment	Total Gain (lbs)	Stocking rate (hd/acre)	Gain/acre (lbs)	Grazing Days
NTCC	84a*	0.94a	79a	39a
TillCC	70b	0.81b	57b	33b

*Within column, means followed by different letters are significantly different at $P < 0.05$.

Soil moisture

A summary of soil moisture results is provided in the Figure 2 below. In general, we are seeing NTCC wheat pasture forage production lag behind other treatments but this effect is not being explained by soil moisture. Over the course of the study, a large amount of soil moisture data has been generated and is in the process analysis.

Figure 2. Volumetric soil water content following wheat pasture or summer cover crops.



Mean soil moisture following wheat. Mean soil moisture following summer cover crops

Till summer fallow soils contain less soil moisture compared to other treatments both in spring and fall Figure 2. Cooler soil temperatures and shading provided by cover crops in the TillCC treatment reduces evapotranspiration rates resulting in higher soil moisture content compared to Till. Summer cover crops in the Till system appear to be advantageous from a soil moisture standpoint. NT summer fallow soils have higher moisture content following the summer period and are similar in spring to cover crop treatments. In general, soil moisture content is higher in NT soils and lowest in Till soils with cover crops falling between the extremes of NT and Till. Compared to Till system soils the higher moisture levels in the NTCC soils has not translated into additional forage production.

Water infiltration

Water infiltration rates are collected at the end of summer following summer cover crops and at the end of the wheat pasture phase. Infiltration rates are higher at the end of summer when soils are warm and dry and lower in the spring following wheat when soils are wetter and cooler Figure 3. Readings were taken using a mini-disk infiltrometer with data readings taken every minute for five minutes. Five data collection points were taken in each paddock.

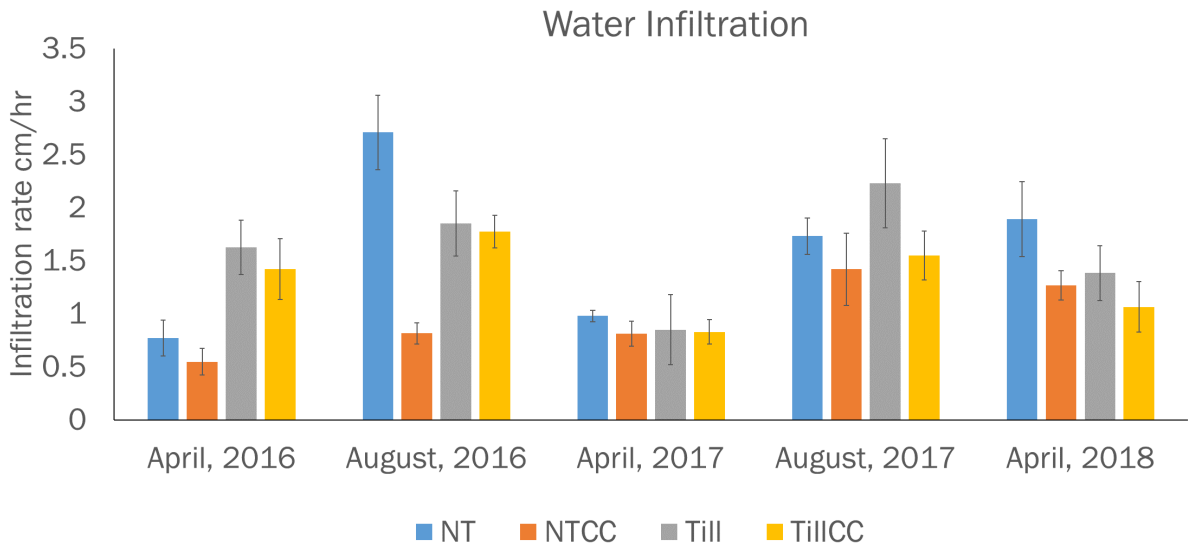


Figure 3. Water infiltration rates collected over time using a mini-disk infiltrometer.

Cover crops are not improving water infiltration rates compared to summer fallow paddocks (Figure 3). There also does not appear to be a clear advantage to NT for water infiltration as well. In the till paddocks, soil is loosened by the tillage process and while water can potentially move into these soils at a higher rate it may not penetrate the plow pan layer and move deeply into the soil horizon compared to NT soils. This effect is noted in the soil moisture data in Figure 2 as soil moisture content is higher at greater depths compared to the Till soils. Additionally we have begun generating soil moisture retention curves and preliminary data indicates that NT soils release moisture at a slower rate than Till soils.

Soil Nitrate, organic matter, and organic carbon

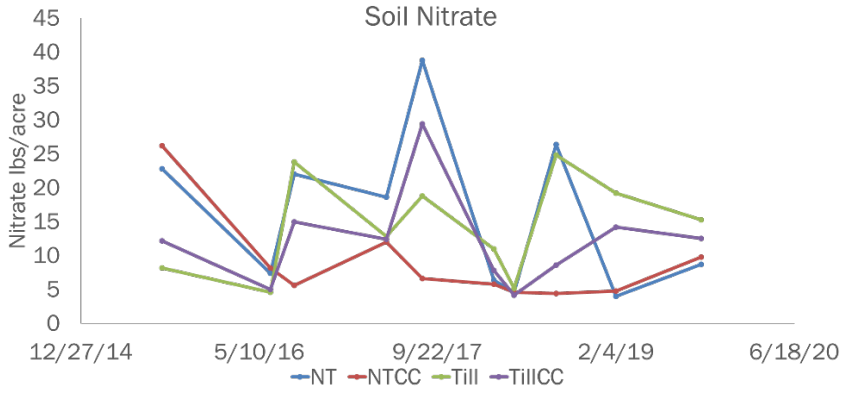


Figure 4. Soil nitrate levels over time.

NTCC soils have been consistently low in soil nitrate which has had a greater effect on

wheat pasture production than soil moisture (Figure 4). This would indicate that the NTCC system needs additional nitrogen injected into the system in order for production levels to equal other systems. NT soils appear to be mineralizing nitrogen through the summer and have higher levels of nitrate available in the fall for the wheat crop. The addition of summer cover crops which contain a high percentage of legume are not adding nitrate to the system as would be expected.

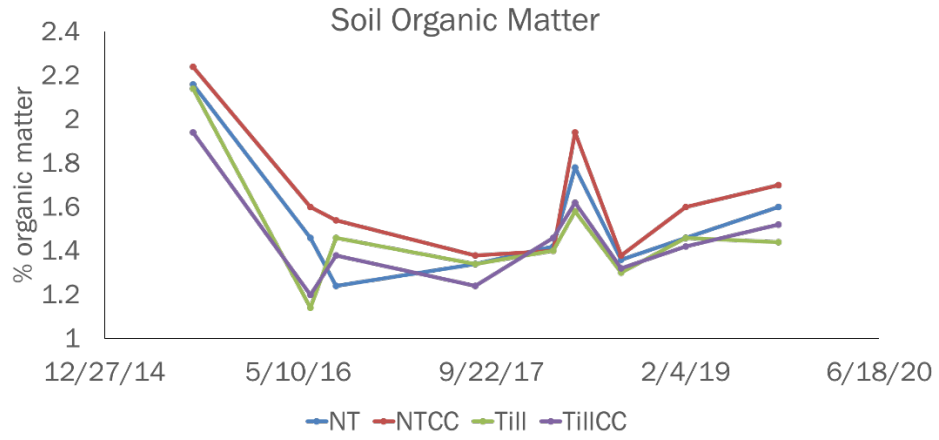


Figure 5. Soil organic matter levels over time.

NTCC soils tend to have a higher levels of soil organic matter compared to other treatments (Figure 5). However, these levels are not translating into higher levels of production and appear to be binding soil nitrate. NT soils are similar to NTCC soils but the effects are slow to develop and vary with year, and biomass production.

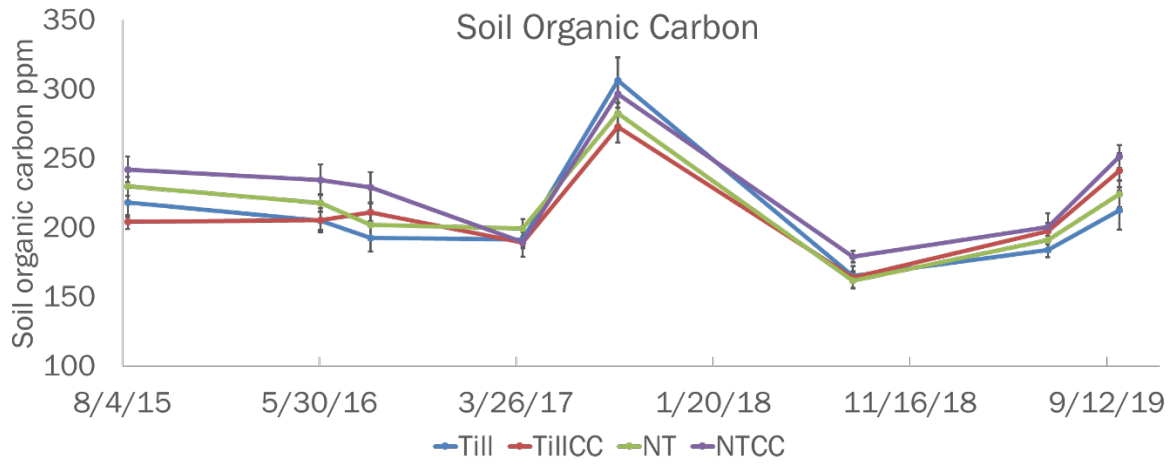


Figure 6. Soil organic carbon levels over time.

Soil organic carbon levels are inconsistent and difficult to interpret indicating the need for additional data. Over the last year of data, it appears that the cover crops treatments may beginning to separate from the fallow treatments but, additional data will need to be collected

in order to verify the direction of this trend. If so, we would then expect soil microbial activity to increase.

Soil bulk density

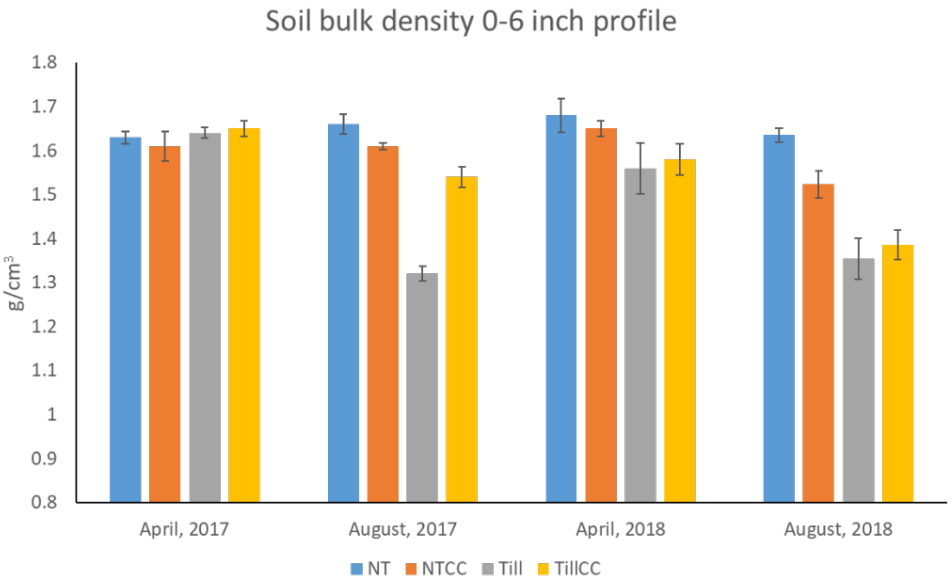


Figure 7. Soil bulk density over time.

In general the NT soils are higher in bulk density that the Till soils but these levels are not high enough to be restrictive to root growth and development. Cover crops to this point have not lowered soil bulk density measurements.

Challenges

The execution of this project has gone very smoothly. Challenges have occurred. Weed pressure has been a problem in the Till systems. Pigweed is prevalent in the study area and it has been difficult to plow often enough in the Till fallow system to keep it controlled. In the TillCC system, if the cover crop can be established early enough, the cover crop can suppress the pigweeds. If not pigweeds have been problematic. A second issue had been volunteer warm season annual grasses in the NTCC paddocks. These grasses have suppressed production of the planted cover crops. While these grasses are weeds in the cover crop system, some like crabgrass are quality forages. In such instances it would be advantageous to allow a cover crop to simply volunteer rather than incurring the expense of establishing a planted cover crop. Timing of cover crop establishment is also a challenge if grazing is part of the program. We have not been able to achieve more than 40 days of grazing on the summer cover crops which helps to offset but not cover the costs of cover crop establishment. NT cover crops are timelier to establish compared to Till because of fewer trips across the field for seedbed preparation. However, in our environment, cover crops need to be established in early May or late April which cuts into wheat pasture grazing. An option may be to not establish all wheat pasture acres with a summer cover crop each year but rather a portion each year which is rotated

across acres. A final challenge has been erosion in the Till system. Though wheat forage production has been higher in the Till system it has come at a cost of soil erosion. Over time we seem to be experiencing increased intensity of rainfall events. This has caused several of our terraces to breech resulting in severe erosion in some paddocks. As a result of this issue Noble Research has decided to terminate the Till system, repair the terraces and move to an all NT system.

Outputs

Publications:

Rogers, J.K. and S. Robertson. 2019. A case for no-till. Hay and Forage Grower. Vol. 34. No. 5. PP 30-31. August/September. 2019.

Rogers, J.K. 2019. Offsetting winter supplementation with pasture. Grazing Lands News. The National Grazing Lands Coalition. Vol. 24, Issue 2.

Rogers, J.K. 2018. Offsetting winter supplementation with pasture. Noble News and Views. Noble Research Institute Press. October.

Rogers, J.K. 2017. Wheat and summer fallow: Is that the only option for stocker systems in the Southern Plains? Progressive Forage. Issue 2. February 1.

Rogers, J.K. 2017. Searching for 365 days of grazing. Hay & Forage Grower. Vol. 32. No. 3 March.

Rogers, J.K**.** 2017. Summertime cover crops for cattle. Legacy. Winter 2017. Noble Research Institute Press. December.

Presentations:

Rogers, J.K. Ripple effects on your forage system. Presented at the Pasture Management Workshop. Decatur, TX. March 7, 2019.

Rogers, J.K. Ripple effects on your forage system. Prepared for and presented to the Louisiana Cattlemen's Association Cattlemen's College. West Monroe, LA. January 19, 2019.

Rogers, J.K. Soil health and no-till small grains research. Prepared for and presented to the General Mills sustainability group. Noble Research Institute. Ardmore, OK. December 11, 2018.

Rogers, J.K. Summer cover crop impact on winter pasture production. Prepared for and presented to the Meredith Agrimedia group. Noble Research Institute. Ardmore, OK. November 15, 2018.

Rogers, J.K. Cover crop and cow/calf forage system research. Prepared for and presented to the Oklahoma Agricultural Leadership Group. Noble Research Institute. October 25, 2018.

Rogers, J.K. Summer cover crop research and implications. Prepared for and presented to the RIZOMA Brazil group. Noble Research Institute. Ardmore, OK. September 14, 2018.

Rogers, J.K. Incorporating summer cover crops into a Southern Plains winter pasture stocker system. Oral presentation at the ASA, CSSA Annual Meeting. Baltimore, MD. November 5, 2018.

Rogers, J.K. Summer cover crop effects on winter pasture production. Prepared for and presented to the RIZOMA group. Noble Research Institute. September 14, 2018.

Rogers, J.K. Integrating summer cover crops into a winter pasture system. Invited. Prepared for and presented to the AGRI-AFC Pasture and Range Meeting. Prattville, Ala. September 6, 2018. Invited.

Rogers, J.K. Winter forage research update. Prepared for and presented at the Farm Credit meeting. Noble Research Institute. August 21, 2018.

Rogers, J.K. Systems approach to pasture management workshop. Prepared for and presented at the Noble Research Institute Pasture Demonstration Farm Field Day. July 24, 2018. Ardmore, OK.

Rogers, J.K. Summer and winter forage crops for stocker cattle grazing. Prepared for and presented to the Noble Research Institute stocker producer group. Noble Research Institute. Ardmore, OK. April 27, 2018.

Rogers, J.K., S.G. Robertson, G.R. Sweeten, and R.T. Hicks. 2017. No-till or tillage established wheat pasture production following a summer cover crop. ASA, CSSA, and SSSA Annual Meeting. Tampa, FL. October 22-25.

Rogers, J.K., S.G. Robertson, G.R. Sweeten, and R.T. Hicks. 2017. Stocker cattle performance grazing wheat pasture established following a summer cover crop. ASA, CSSA, and SSSA Annual Meeting. Tampa, FL. October 22-25.

Integration of grazing cover crops into small grain stocker systems. Texoma Cattlemen's Conference. Ardmore, OK. February 24, 2017.

Robertson, S. G., J.K. Rogers, and G.R. Sweeten. 2017. Tillage and summer cover crop effects on soil moisture, soil temperature, and winter pasture production. Oklahoma Natural Resources Conference. Tulsa, OK. February 22-24.

Rogers, J.K., S. G. Robertson, and G.R. Sweeten, and R.T. Hicks. 2017. Summer cover crop effect on wheat pasture and stocker cattle performance. Southern Pasture and Forage Improvement Conference. Knoxville, TN. June 5-7.

Rogers, J.K., S. G. Robertson, and G.R. Sweeten. 2016. Tillage and soil moisture effects on winter pasture production and stocker average daily gain. ASA, CSSA, and SSSA Annual Meeting. Phoenix, AZ. November 6-9.

Rogers, J.K. Invited presentations to the Mississippi Cattlemen's College. Hattiesburg and Batesville, MS. October 27-28, 2016.

Rogers, J.K. Noble Foundation cover crop study. Winter Pasture Seminar. Ardmore, OK. August 2, 2016.

Rogers, J.K. Noble Foundation cover crop study. Agriculture Division Update. Ardmore, OK. July 28, 2016.

Rogers, J.K. Regional grazing practices and forage measurement technology. Presented to the American Farmers and Rancher LEAD Tour. The Noble Foundation Oswalt Ranch. Marietta, OK. May 27, 2016.

Rogers, J.K. Cover grazing research. King Ranch Institute for Ranch Management Endowed Fellows Tour. Ardmore, OK. April 6, 2016.

Rogers, J.K. Cover crops in Oklahoma. Oklahoma Seed Trade Association. February 11, 2016.

Rogers, J.K. Noble Foundation cover crop studies. Southern Soil Health Conference. Ardmore, OK. January 13, 2016.

Rogers, J.K. Cover crop research and the Noble Foundation. Winter Pasture Seminar. Ardmore, OK. July, 2015.

Rogers, J.K. Cover crop and cow-calf research at the Noble Foundation. Wise County, Texas Cattlemen's Association Tour. June, 2015.

Potential next steps

The current study will continue on but, with NT treatments only. We also have a collaborative study with Oklahoma State University where we are evaluating the effect of additional N inputs into NTCC systems. We are also interested in looking at the legume component of our system and the amount of N being fixed by the legume component and the loss of nitrogen from the system. We also would like to evaluate the timing of the establishment of summer cover crops and different methodologies in the utilization of the cover crops.