Agronomic and economic impacts of cover crops in Texas rolling plains cotton

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Abstract
Cover crops have been proposed as a resource that could enhance the effect of no-till (NT) cropping systems. Crop yield limitations due to cover crops in the U.S. Great Plains are a concern to potential adopters. This research determined the impact of cover crops on crop yield and economic return compared with conventional practices in dryland systems of the Texas Rolling Plains. The study conducted at the Texas A&M AgriLife Chillicothe Research Station evaluated the following treatments: (a) conventional till (CT); (b) NT, and NT with the following cover crops; (c) Austrian winter pea (Pisum sativum L.); (d) hairy vetch (Vicia villosa L.); (e) crimson clover (Trifolium incarnatum L.); (f) winter wheat (Triticum aestivum L.); and (g) a multi-species mixture. Cotton (Gossypium hirsutum L.) yields, expenses, and returns were determined over a 4-yr period (2013–2016). Cover crops increased total seed costs compared to CT and NT. Hairy vetch and the multi-species mixture increased total expenses over CT and NT. However, no significant treatment effect was determined for crop yield or net return among treatments. A multi-species mixture did not provide an agronomic or economic advantage compared to single species cover crop approaches. Under dryland conditions in the Texas Rolling Plains, these selected cover crops maintained cotton yields without negatively affecting net returns. Other ecosystem services should be considered prior to implementing cover crops in studied cropping systems. Site-specific research is warranted in regions of the southern Great Plains where water may be more limited than the Texas Rolling Plains.

1 | INTRODUCTION

Water is often the most limiting factor in crop production across the U.S. Great Plains. In dryland environments, management practices that conserve and most efficiently use water resources are highly desired and beneficial. The inability of a cropping system to efficiently use precipitation often decreases crop yields and subsequently farmer’s income (Nielsen, Unger, & Miller, 2005). Conservation tillage is a management practice that has been shown to efficiently capture and store water (Baumhardt, Johnson, & Schwartz, 2012; Shaver et al., 2002; Unger & Vigil, 1998). However, adoption of conservation tillage practices in Texas generally lags behind other areas of the United States.

Texas, within the southern Great Plains, is the leading producer of cotton (Gossypium hirsutum L.) in the United States (USDA-NASS, 2017). Compared to other crops, crop residue
remaining on the soil surface after harvest is low in cotton systems (USDA-ERS, 2012). Furthermore, planted cotton land under conservation tillage within the southern Great Plains region was less than 30% compared to nearly 70% in the southeastern United States (Claassen, Bowman, McFadden, Smith, & Wallander, 2018). Blanco-Canqui, Mikha, Pressley, and Claassen (2011) concluded that cover crops could enhance the effect of no-till systems through improved soil physical properties and soil organic C concentrations. For low residue systems such as cotton, addition of a rye (Secale cereale L.) cover crop has shown improved water infiltration and penetration resistance compared to conventional tillage (CT) without a cover crop (DeLaune, Mubvumba, Lewis, & Keeling, 2019). Hence, continuous cotton cropping systems could potentially benefit from cover crop implementation.

Within semi-arid environments, reduction in soil moisture by cover crops is a potential disadvantage (Balkcom et al., 2007; Dabney, Delgado, & Reeves, 2001). Water use by cover crops has been shown to greatly reduce yields of subsequent crops in semi-arid regions (Holman et al., 2018; Nielsen et al., 2016; Reicosky & Forcella, 1998; Unger & Vigil, 1998). Dabney et al. (2001) noted that adoption of cover crops in cropping systems is based on the perceived balance between advantages and disadvantages. Crop yield is often used as a major criterion to determine if a particular management practice provides an advantage or disadvantage. Daniel, Abaye, Alley, Adcock, and Maitland (1999) concluded that using winter annual cover crops in a Virginia no-till (NT) cotton production system provides greater soil moisture conservation during periods of drought, while producing lint fiber of similar yield and quality compared with a CT system. With past research in the Great Plains indicating reduced crop yields, doubts are cast as to the feasibility of cover crops under harsh environmental conditions.

Most research in cotton systems has focused on the use of small grain cover crops, which are planted at the end of the cotton-growing season or after cotton is harvested (September–December) and terminated prior to cotton planting the following season (March–April) in the southern Great Plains. In humid regions of the United States, research has shown that rye and wheat has maintained or improved cotton lint yields in conservation tillage cotton systems (Bauer & Bisscher, 1996; Marshall et al., 2016; Norsworthy, McClelland, Griffith, Bangarwa, & Still, 2011; Raper, Reeves, Burmester, & Schwab, 2000; Reeves, Price, & Patterson, 2005). Although studies have shown advantages of a legume/small grain cover crop mix on crop yields (Daniel et al., 1999; Ranells & Wagger, 1997), others have reported a higher risk involved with using legumes for winter cover crops in cotton systems (Reeves, 1994; Bauer & Bisscher, 1996). As these variable results have been conducted within humid regions, there is a great need to understand the impacts of cover crops in semi-arid regions that may experience great climatic variability.

Implementing cover crops in semi-arid Texas cotton systems has shown mixed results. Baughman, Keeling, and Boman (2007) reported that dryland cotton lint yields were reduced in the Texas Rolling Plains when a small grain cover crop was used in combination with NT cotton compared to CT and NT without a cover crop. However, they did not observe differences among treatments in the Texas High Plains. Segarra, Keeling, and Abernathy (1991) reported cotton lint yields were similar following a terminated wheat cover crop in the Texas High Plains compared to various tillage systems without a wheat cover crop under dryland conditions. Dozier, Morgan, and Sij (2008) concluded that legume cover crops do not provide adequate biomass or N contributions to justify the seed and planting costs in the Texas Rolling Plains. In addition, most of the reported research in the region has been conducted over a period of 1–2 yr. Thus, research is warranted to compare and contrast various cover crops impact on crop yield over multiple growing seasons. As crop yields may not be affected by cover crops, economic feasibility of implementation inevitably becomes paramount. While DeLaune, Sij, Park, and Krutz (2012) determined that NT cotton systems with a terminated wheat cover crop in the Texas Rolling Plains resulted in significantly greater net returns than a CT system, Lewis et al. (2018) found no gross margin differences between cover crop and non-cover crop treatments in the Texas High Plains. Zhou, Larson, Boyer, Roberts, and Tyler (2017) concluded that revenue gains from producing cotton following hairy vetch, crimson clover, and wheat cover crops in Tennessee did not offset the cost of cover crop establishment compared to cotton following no cover. In Alabama, rye and clover cover crops did not negatively impact net returns compared to fallow in Palmer Amaranth infested cotton systems utilizing inversion and noninversion tillage (Duzy, Price, Balkcom, & Aulakh, 2016). These studies have been conducted within humid regions or irrigated systems of semi-arid environments, highlighting the need for research under dryland production.

Core Ideas
- Cover crops increased total seed costs over conventional till and no-till.
- Vetch and mix cover crops had the greatest total expenses among treatments.
- Cover crops did not significantly impact cotton lint yields or net returns.
- A multi-species cover crop mix had similar lint yields and net returns as single species
There is limited information on the effect of winter cover crops on agronomic and economic viability in dryland cotton systems of the southern Great Plains. Longer-term studies evaluating varying single species and multi-species mixture cover crops are critical to understanding effects over time under adverse environmental conditions. In addition, multi-species cover crop mixtures have not been evaluated in dryland cotton systems of the southern Great Plains. The objective of this research was to determine the impact of grass, legume, and multi-species cover crops on crop yield and economic return compared with conventional practices in dryland systems of the Texas Rolling Plains over a 4-yr period.

2 | MATERIALS AND METHODS

The study was conducted under dryland conditions at the Texas A&M AgriLife Chillicothe Research Station near Chillicothe, TX (34°11′ N, 99°31′ W, 443 m elevation above sea level). The soil is classified as a Grandfield fine sandy loam (fine-loamy, mixed, superactive, thermic Typic Haplustalfs) with 0–1% slope. Average annual precipitation (1981–2010) for the region is 710 mm as recorded by NOAA 22 km Northwest of the Chillicothe Research Station (NOAA, 2018). The study site had historically been managed as a conventionally tilled small plot research site, with winter wheat as the immediate cash crop prior to study initiation. A continuous cotton system was implemented beginning in spring 2012.

In October 2011, the following treatments were initiated: (a) CT; (b) NT; and NT with the following cover crops; (c) Austrian winter pea (pea); (d) hairy vetch (vetch); (e) crimson clover (clover); (f) winter wheat (wheat); and in 2012; and (g) a multi-species mixture (mix) was added. Non-cover crop treatments served as controls in the study, from both a conventional and conservation standpoint. Treatments were arranged in a randomized complete block design with four replications. Each plot was eight rows wide (1 m row spacing) × 12.2 m long. Seeding rates were 16.8 kg ha⁻¹ for crimson clover, 22.4 kg ha⁻¹ for hairy vetch, 33.6 kg ha⁻¹ for wheat and the mix, and 39.2 kg ha⁻¹ for pea. The mix was planted at 44.8 kg ha⁻¹ in 2012 and clover was planted at 22.4 kg ha⁻¹ in 2016. The mix was comprised of pea, vetch, wheat, rye, clover, turnip (Brassica rapa L.), and radish (Raphanus sativus L.). However, the mix was reduced to wheat, rye, pea, and vetch in 2015 due to lack of performance from other species in previous years. Complete cover crop planting and biomass production details are provided in DeLaune and Mubvumba (2020). Generally, cover crops were drill-seeded (25.4-cm row spacing) after cotton harvest each year in late October through late November and chemically terminated in late April each year. No fertilizer was applied to cover crops or cotton during the study.

Cotton was planted each year at a rate of 96,807 seed ha⁻¹ using a four-row vacuum planter (1-m row spacing). Cotton plant dates were 12 June 2013 (DP 1219 B2RF), 13 June 2014 (NG 1511 B2RF), 22 June 2015 (NG 1511 B2RF); and 10 June 2016 (NG 1511 B2RF). Due to severe drought, no cotton was harvested in 2012 from any treatment due to crop failure. Two rows from each plot were mechanically harvested using a two-row cotton stripper. Grab samples of seed cotton were collected after weighing harvested samples. Grab samples were then ginned to calculate lint turnout and lint yield.

2.1 | Economic analysis

Using the experimental results, economic returns for each treatment were calculated on an average return per hectare basis. The economic profitability was calculated as the return (lint price × yield + seed price × seed yield) above total costs (e.g., operating and direct costs). Cotton lint prices paid to farmers ranged between US$1.27 and $1.70 kg⁻¹, and cotton seed prices ranged from $0.20 and $0.29 kg⁻¹ over the project period. The 4-yr average lint price (2013–2016) of $1.44 kg⁻¹ and average seed price of $0.24 kg⁻¹ was used to calculate revenue in this study. Operating costs were based on 2016 prices. Net returns were also calculated using low and high lint and seed prices each year. Thus, net returns were calculated each year using low, average, and high lint and cotton seed prices.

The economic returns were calculated by considering indirect and direct costs. Direct costs included the following production costs: cover crop seed, cotton seed, herbicide, pesticide, harvest aids, custom chemical application, fuel, lubrication and repairs, labor, interest, and custom harvest costs. Harvest and ginning costs were estimated based on crop yield using average cost per unit of crop yield ($ ha⁻¹). Indirect costs included depreciation of equipment associated with each practice. Insurance, taxes, and cash rent were assumed to be constant and were not considered in the fixed costs. Actual costs for cover crop seed, cotton seed, herbicide, pesticide, and harvest aids were recorded each year and used in the economic analysis. Crop insurance or cost share programs for cover cropping was not included in the economic analysis. The intensity of the CT treatment varied by year, but generally consisted of disking plots in the fall and spring with an in-season cultivation. In some years, CT plots were listed in the fall and reshaped in the spring. Herbicide treatments were similar among treatments each year. Herbicide applications for cover crop termination were also used as a pre-plant burndown application to non-cover crop plots. No-till without a cover crop served as the base conservation system. Thus, cover crop treatments differed in costs through cover crop seed costs, planting of cover crops, and depreciation of machinery specific to planting cover crops (NT drill). The CT
treatment differed from the NT treatment primarily though depreciation of tillage equipment and tillage operations.

3 | STATISTICAL APPROACH

Data were analyzed using Proc GLIMMIX using SAS version 9.4 (SAS Institute, Cary, NC). Generalized linear mixed models such as the GLIMMIX procedure combine the characteristics of generalized linear models and mixed models (SAS Institute, 2017). The effect of year and year × treatment was determined. There were no year × treatment interactions, thus cover crop treatment was treated as a fixed effect and replication and year was treated as a random effect. Means of significant effects were separated using the Tukey method.

4 | RESULTS AND DISCUSSION

4.1 | Precipitation

Dryland cotton, produced under rainfed conditions without supplemental water, is typically planted in late May through early June in the study region. Harvest aids, if utilized, are generally applied in October. The average historical precipitation for May through October is 458 mm. Climatic conditions were highly variable during the study period, which is common for the region (Figure 1). Relatively dry conditions were observed during the cover crop growing season October through March in 2013–2015. However, precipitation in May was well above average for 2014–2016 with record rainfall in 2015. These precipitation events were important toward potentially recharging stored soil moisture within the profile prior to cotton planting. While recorded precipitation during the cotton growing season was greater than the historical amounts in 3 of 5 yr, this was generally due to one or two large events resulting in above average monthly recordings. For example, 2013 and 2014 had significant rainfall events exceeding 110 mm in July just prior to flowering, a critical growth stage with high water demand. In 2015, hot and dry conditions followed above normal rainfall and below normal temperature in May and June that resulted in a late planting date (22 June 2015) along with soil crusting and difficult conditions for emergence and growth. The highly variable conditions experienced over the course of the study provided a broad range of water availability for quantifying crop yields.

4.2 | Cotton yield

Cotton lint yields were impacted by year (P < .0001). In contrast, no significant effects of treatment (P = .9351) or treatment × year (P = .3852) were found for cotton lint yields. Mean lint yields by year were 475 kg ha⁻¹ in 2013, 760 kg ha⁻¹ in 2014, 633 kg ha⁻¹ in 2015, and 812 kg ha⁻¹ in 2016. Lint yields were significantly lower in 2013 than all other years (mean separations not shown), which also recorded the lowest precipitation during the study (Figure 1). Lint yields were significantly greater in 2016 than all other years except 2014 (mean separations not shown). Although recorded precipitation was greater in 2015, increased precipitation did not correlate to increased lint yields as cotton was planted late and adverse environmental conditions were endured during the growing season. Mean cover crop biomass production from 2012–2017 was 748, 1,562, 2,301, 2,480, and 2,863 kg ha⁻¹ for clover, wheat, vetch, pea, and the mix, respectively (DeLaune & Mubvumba, 2020).

Mean lint yields over the 4-yr period ranged from 636 to 705 kg ha⁻¹ (Figure 2). Over the four-year average, lint yields were 662 kg ha⁻¹ for NT and 666 kg ha⁻¹ for CT (Figure 2). Similar lint yields between NT and CT systems were also observed for other dryland studies conducted within the region (Baughman et al., 2007; Segarra et al., 1991; Sij, Ott, Olson, Baughman, & Bordovsky, 2003; Varner, Epplin, & Strickland, 2011). Although yields were similar among NT and CT in our study and other studies within the region, a valid question expressed by producers has been “will this trend continue when cover crops are added to the system”? Within the central Great Plains, Nielsen, Lyon, Hergert, Higgins, and Holman (2015) reported wheat yields were on average 10% lower following a cover crop versus following fallow. Holman et al. (2018) determined wheat yields were reduced 0–34% when growing a forage or cover crop in place of fallow during an above average precipitation year; however, a 40–70% reduction in wheat yield occurred when growing a cover crop or forage crop in place of fallow during years of below average precipitation.

Cover crops did not significantly reduce lint yields across study years (Figure 2) nor in any single year (data not shown). Similar data have been reported for small grain cover crops in dryland systems in water limited environments. In our study, lint yields following wheat were 2.6 and 3.1% lower compared to NT and CT (Figure 2). Over a three-year period in the Texas Southern High Plains, a wheat cover crop reduced dryland lint yields by 6% compared with NT, but increased lint yield by 14% over CT (Segarra et al., 1991). A single year study evaluating wheat as a cover crop reported that lint yields were up to 38% lower than non-cover crop treatments in the Texas Rolling Plains but within the Texas High Plains yields were similar (Baughman et al., 2007). Interseeding rye as a cover crop in no-till and strip-till cotton systems of the Texas Rolling Plains also did not impact lint yields over a two-year period compared to reduced till and conventional till systems (Sij et al., 2003). Delaying the planting of a wheat cover crop until after wheat planting resulted in similar results as interseeding a rye cover crop in the Texas Rolling Plains.
Legume cover crops in cotton systems have been questioned due to poor stand establishment, costs, and/or lack of surface mulch (Bauer & Bisscher, 1996; Dozier et al., 2008; Keeling, Matches, Brown, & Karnezos, 1996; Reeves, 1994). Research in dryland cotton systems have concluded that legume cover crops were not as viable as small grains due to legume species failing due to inadequate soil moisture or providing adequate biomass or nitrogen contributions to justify the seed and planting costs (Dozier et al., 2008; Keeling et al., 1996). Results from this study found that yields were similar among treatments, including legume cover crops. Compared to NT without a cover crop, lint yields increased.
by 2.8% following a cover crop mix, 4.8% following peas, and 6.1% following vetch. As lint yields were not different following clover, DeLaune and Mubvumba (2020) reported that the clover cover crop had less biomass production and water use efficiency than the mix, peas, and vetch.

Cover crop mixtures, consisting of more than two species, have been proposed as strategy to augment services from cover crops. Nielsen et al. (2015) noted that mixtures have been promoted over single species cover crops due to better water use efficiency and enhanced microbial activity of mixtures that could offset yield reductions observed following single species cover crops in semi-arid environments. Similar to Nielsen et al. (2015), no significant crop yield differences were observed between the mix and single species cover crops in our study. In more humid regions, results have shown mixed results for corn and soybean yields following multi-species cover crops (Chu et al., 2017; Finney, White, & Kaye, 2016). In an irrigated cotton system of the Southern High Plains, Lewis et al. (2018) determined that a cover crop mixture in a long-term NT system did not impact lint yields compared to CT and NT with a rye cover crop. Results from our study did not indicate a lint yield advantage due to a cover crop mix compared to single species cover crops.

4.3 Economic returns

Although lint yields may not be impacted by cover crops, economic practicality must also be considered, particularly in low input, high risk environments. Lichtenberg (2004) presented how economic factors can have a substantial influence on conservation practice adoption. No treatments effects were determined for net return at low, high, or average lint and seed prices during the project period (Table 1). However, there was a significant treatment effect for total expenses (P < .0001; Table 1). Total expenses were $688 ha$^{-1}$ for NT and $716 ha$^{-1}$ for CT. These expenses are comparable to expenses reported for cotton systems in southwest Oklahoma for 2003-2008, which is adjacent to the Texas Rolling Plains ($459–540 ha$^{-1}$; Varner et al., 2011). Compared to NT, total expenses were significantly greater for all cover crop treatments with the exception of a wheat cover crop. Total seed costs for wheat was at least $29 ha$^{-1}$ less than any other cover crop treatment (Table 1). Vetch resulted in greater seed cost than any other treatment (Table 1). Vetch prices also increased from $3.48 to $3.96 kg$^{-1}$ during the project period. Through a survey of diverse producers across the US, survey respondents were most likely to see the cost of cover crops as always limiting the adoption of cover crops in their area (Dunn et al., 2016).

Nielsen et al. (2015) concluded that the greater expense associated with a cover crop mix compared with a single species is not justified in the central Great Plains. In our study, the mix did not differ in total expenses than other cover crop treatments (Table 1). In addition, the seeding rate for the mix was lower (34–45 kg ha$^{-1}$) compared to mixture rates used in other studies in the central Great Plains (57–174 kg ha$^{-1}$; Holman et al., 2018; Nielsen et al., 2016). In general, cover crop seeding rates in this study were lower compared with other studies evaluating cover crops. Government cost share programs for cover crops were not considered in this study. Cost share programs for cover crops were as much as $114 ha$^{-1}$ in the region during the time of the study, which would have paid for the cover crop seed costs. However, only mixtures consisting of four or more species would have qualified for such programs during the course of the study. Cost share payments have been shown to be an important determinant of cover crop adoption within the U.S. Corn Belt (Singer, Nusser, & Alf, 2007). More recent research has indicated that cost share or financial incentives are not necessary for cover crop adoption (Dunn et al., 2016; Roesch-McNally et al., 2017). Survey results from Dunn et al. (2016) indicated that only 8% of cover crop users planted with funding assistance compared to 63% who have never received funding assistance.

Net returns were similar among treatments, which ranged from $353 ha$^{-1}$ for clover to $475 ha$^{-1}$ for NT at average price points (Table 1). Segarra et al. (1991) also found comparable gross revenues among CT, NT, and NT with a wheat cover crop in Texas Southern High Plains cotton systems. Hanks and Martin (2007) predicted a $28 ha$^{-1}$ increase for NT cotton compared to NT cotton with a wheat cover crop in Mississippi cotton systems. In the studied environment, we observed a $79–$88 ha$^{-1}$ increase for NT cotton without a cover crop compared to NT cotton with a wheat cover crop (Table 1). Under irrigated conditions in the Texas High Plains, no significant differences in gross margins were determined among CT and NT with a rye or mixture cover crop (Lewis et al., 2018). Although wheat had lower seed costs among cover crop treatments, net return was not greater among treatments. Lewis et al. (2018) reported a $104 ha$^{-1}$ revenue increase due to a mixture over a rye cover crop under irrigated conditions. DeLaune et al. (2012) reported NT system with a wheat cover crop produced significantly greater returns than CT without a cover crop in an irrigated cotton system of the Texas Rolling Plains.

Zhou et al. (2017) determined NT cotton provided greater returns than cotton following wheat, vetch, or a cover crop (in order of decreasing revenue). Although not significant, vetch and pea resulted in increased net returns of at least $21 ha$^{-1}$ at average prices and $33 ha$^{-1}$ at high prices than other cover crop treatments. Varco, Spurlock, and Sanabria-Garro (1999) predicted a $97 ha$^{-1}$ advantage for NT cotton with vetch compared with NT without a cover crop in Mississippi. In contrast, NT without a cover crop yielded a $84, $59, and $38 ha$^{-1}$ advantage over NT with vetch at low, average, and high price points, respectively. As lint and seed prices increase, risks of economic losses decrease (Table 1).
**TABLE 1** Cover crop seeds cost, total seed cost, total expenses, and net return based on low, average, and high lint and seed prices for cover crop treatments over the course of the study at Texas A&M AgriLife Chillicothe Research Station (2013–2016)

| Treatment | Total seed cost $ | Total expenses $ | Net returna $/ha |
|-----------|------------------|-----------------|------------------|
| NT        | 125.59f          | 687.96c         | 197.85           |
| CT        | 125.59f          | 716.14bc        | 184.58           |
| Wheat     | 145.59e          | 753.40abc       | 118.51           |
| Pea       | 174.85d          | 808.40ab        | 122.31           |
| Clover    | 181.52c          | 787.37ab        | 80.34            |
| Vetch     | 206.70a          | 847.92a         | 113.91           |
| Mix       | 190.66b          | 819.35a         | 97.40            |
| P value   | <.0001           | <.0001          | .4930            |

Note. NT, no-till; CT, conventional tillage.

<sup>a</sup>Lint prices were US$1.27–$1.70 kg⁻¹ and seed prices were $0.20–$0.29 kg⁻¹. Average lint price was $1.44 kg⁻¹ and seed price was $0.24 kg⁻¹ for 2013–2016.

<sup>b</sup>Treatment means within a column followed by the same letter are not significantly different at P < .05.

Nouri, Lee, Yin, Tyler, and Saxton (2019) concluded that long-term incorporation of cover crops significantly improved agronomic and environmental benefits in Tennessee cotton systems although long-term economic profits for farm producers may not be met. Nouri et al. (2019) noted that the economic profits associated with cover crops may take an extended time to become evident.

### 5 | CONCLUSIONS

Winter cover crops were implemented in Texas Rolling Plains cropping systems without significantly affecting crop yield or net returns under variable climatic conditions over a 4-yr period. Our findings support other studies that have documented no significant yield effects on cotton due to implementation of a wheat cover crop in dryland cotton systems. Legumes, such as peas and vetch, were viable cover crops that result in similar lint yields and net returns than a wheat cover crop despite higher seed costs. Utilizing seed costs as a sole criterion would have been misleading in our study based upon yield and net returns. Inputs in this study may be considered minimum with low cover crop seeding rates and no fertilizer inputs. Adopters of winter cover crops in the Texas Rolling Plains could expect to maintain crop yields and net returns. Inputs in this study may be considered minimum with low cover crop seeding rates and no fertilizer inputs. Adopters of winter cover crops in the Texas Rolling Plains could expect to maintain crop yields and net returns. Inputs in this study may be considered minimum with low cover crop seeding rates and no fertilizer inputs.

Ecosystem services, such as reduced wind and water erosion, improved water infiltration, penetration resistance, and nutrient cycling, should be considered to determine the total value of cover crops to overcome a net return deficit that could range from $59 to $122 ha⁻¹ for NT with a cover crop compared to NT without a cover crop based on average price points. With a rapidly changing rainfall gradient within the southern Great Plains, site-specific research is warranted to justify long-term cover crop impacts on agronomic and economic production.

**CONFLICT OF INTEREST**

The authors declare no conflict of interest.

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