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# Integrating Cover Crops into Soybean Systems in the Southern Great Plains: Impacts on Yield and Yield Components

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**Abstract:** The implementation of cover crops in crop rotation is a suggested soil health practice. As cover crops are not harvested and sold, they do not directly provide monetary gain to producers. Therefore, it is imperative that planting cover crops does not negatively affect the subsequent cash crop. However, there is no overall consensus in the literature regarding the effects of cover crops on cash crop yield. To better understand the effects of cover crops on soybean growth and yield in Oklahoma soybean systems, trials were conducted in Bixby, OK, in 2019 and Perkins, OK, in 2019, 2020, and 2021. The objectives of these trials were to (1) determine how different cover crop mixes affect soybean growth parameters and (2) determine if cover crops significantly influence soybean seed yield. Treatments within the trials included six cover crops and a fallow treatment. Soybeans were planted after the termination of the cover crops. Yield and growth parameter data were collected after harvest. No significant differences or consistent trends were detected in the yield among treatments. While cover crops had a significant impact on the number of three- and four-bean pods, no other differences in the growth parameters existed, and they never translated into significant yield differences. Based on our data, cover crops would not benefit the overall cash crop production in the continuous cover crop soybean system in Oklahoma. However, the fact that cover crops did not consistently or significantly reduce soybean yield allows growers to explore other benefits, such as weed management or soil health improvement.

**Keywords:** cover crops; soybean; conservation



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## 1. Introduction

Cover crops have historically been used as a conservation tool during fallow seasons to provide ground cover and underground root biomass. More recently, cover crops have been widely integrated as a means to improve soil health. From a soil health perspective, single species or mixes of different species are planted to add diverse benefits to the system, such as deep roots, high aboveground biomass, and nitrogen fixation, among other aspects [1–3]. Chen and Weil [1] noted that cover crops with deeper tap-root crops could break through even highly compacted soils. This could result in better root penetration for successive cash crops [2]. Not only does this biotillage have environmental and potential agronomic benefits: cover crops can also decrease the nitrate-N present during the fallow seasons, which can be a major environmental concern [2]. Furthermore, the presence of certain cover crops, particularly legumes, can decrease the N demand for the following cash crop [3,4]. However, if the addition of cover crops reduces grower profitability, the continuation of the practice is not viewed as a sustainable operation, regardless of soil health benefits. Due to this, maintaining cash crop yield is imperative to the success of cover cropping.

The effects of cover crops on cash crop growth and yield are inconsistent throughout the literature. Several studies have found that the use of cover crops had no effect on soybean yield [5–7]. Hunter et al. [5] noted that cover cropping with cereal rye reduced yields compared to those that primarily contained legumes; however, other cover crops had little impact on yield compared to fallow treatments. This potential decrease in cash crop yields following cover crops has been well documented [6,7]. Based on a database analysis, an overall 4% reduction in crop yields was identified [8]. The negative effects associated with cash crop production following cover crops can include excess residue biomass at planting, causing stand issues and a lack of soil moisture from cover crop growth, affecting germination. Certain studies have observed significant decreases in yield with the introduction of cover crops to the system [9–11]. In contrast, Unger et al. [12] found that when implemented and managed properly for the promotion of greater water infiltration and reduction in evaporation, subsequent crop yields can be improved. Zhang et al. [13] highlighted that moisture dynamics under cover crop systems in dryland settings were all dependent on the management of cover crops. If terminated early, moisture efficiency can be as good as or improved compared to fallow systems. However, a late termination resulted in a moisture depletion that resulted in up to 60% reduction in yields. However, Rosa et al. [14] noted that termination timing had no impact on the cash crop following cover crops, with all covers decreasing yields compared to fallow systems. This finding is especially true in semi-arid dryland systems [15]. Additionally, Reddy [9] noted that net returns of cover crop systems were consistently lower compared to fallow systems due to higher input costs.

Due to the inconsistent findings throughout the literature and the importance of cover crop management practices on cash crop yield, further research would be beneficial to this region. To better understand the effects of cover crops on soybean growth and yield in Oklahoma soybean systems, trials were established to (1) determine how different cover crop mixes affect soybean physiological growth parameters and (2) determine if cover crops significantly influence soybean seed yield when managed in accordance with common Oklahoma soybean production practices. Based on the previous literature on semiarid conditions, it was hypothesized that cover crops grown in these resource-limited conditions would negatively impact soybean production.

## 2. Materials and Methods

Field experiments were established at the Cimarron Valley Research Station in Perkins, Oklahoma, from 2018 to 2021, and the Mingo Valley Research Station in Bixby, Oklahoma, in 2018; both locations were maintained in a rainfed environment. Both locations were established following soybean production, with the Bixby location being continuous soybean for the previous five years and the Perkins location being a rotation of fallow, grain sorghum, and soybean for the previous five years. Table 1 includes the dominant soil series and their descriptions, as well as the geographic coordinates for each location in this study. Climatic conditions for each site year are given in Figures 1–4. All soil analyses for the sites were conducted prior to planting of the cash crop and are summarized in Table 2. A total of 15 soil cores were collected across the plot area between the cover crop and soybean crop each season. Samples were collected and held in semipermeable soil sample bags. Samples were dried at 65 °C for 24 h. The soils were then ground to pass a 2 mm sieve, and chemical analysis was started within 48 h.

**Table 1.** Locations, soil series, and soil descriptions for Oklahoma trials. Soil series and soil description were from the USDA NRCS Web Soil Survey and associated soil descriptions (https://websoilsurvey.nrcs.usda.gov/app/; accessed on 15 August 2022; verified on 20 June 2024).

| Location | Latitude and Longitude | Soil Series | Description |
|---|---|---|---|
| Perkins, OK | 35°59′08.9″ N 97°02′50.3″ W | Teller | Fine-loamy, mixed, active, thermic udic argiustolls |
| Bixby, OK | 35°57′49.8″ N 95°51′42.0″ W | Wynona | Fine-silty, mixed, active, thermic cumulic epiaquolls |

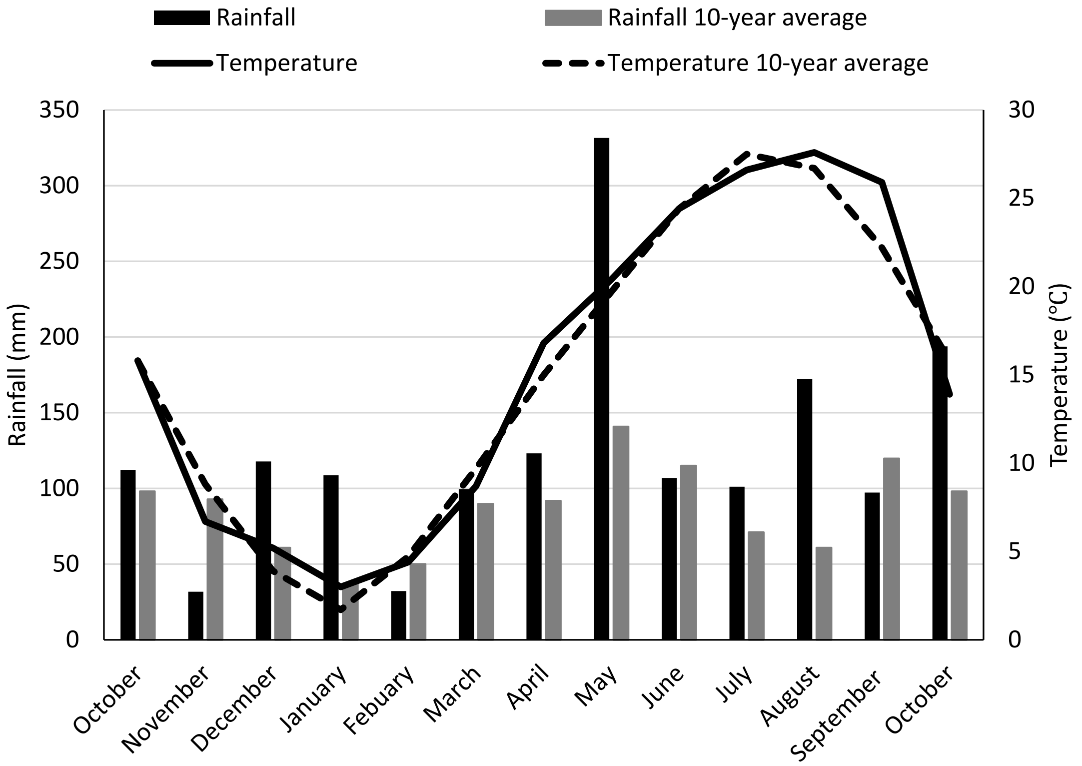


**Figure 1.** Total rainfall and average daily temperature for each month of the 2018–2019 cover crop and soybean season in Bixby, Oklahoma. Monthly temperature and moisture were collected using the Oklahoma Mesonet, and averages were determined from NOAA information collected on-site.

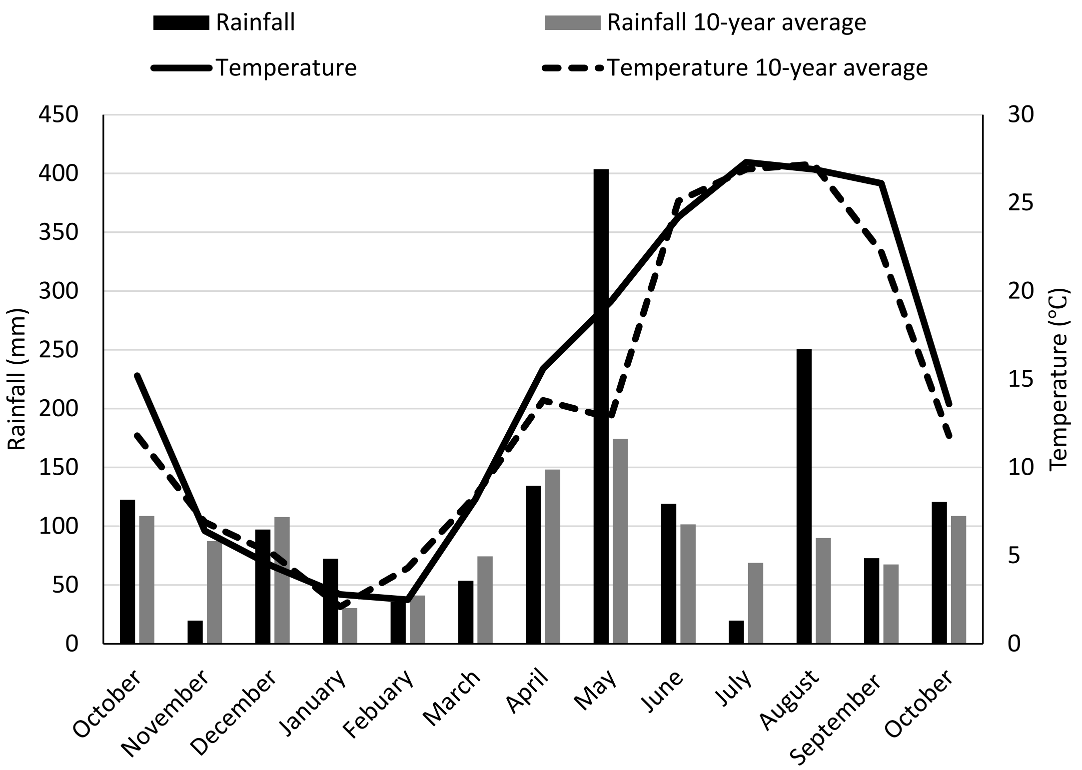


**Figure 2.** Total rainfall and average daily temperature for each month of the 2018–2019 cover crop and soybean season in Perkins, Oklahoma. Monthly temperature and moisture were collected using the Oklahoma Mesonet, and averages were determined from NOAA information collected on-site.

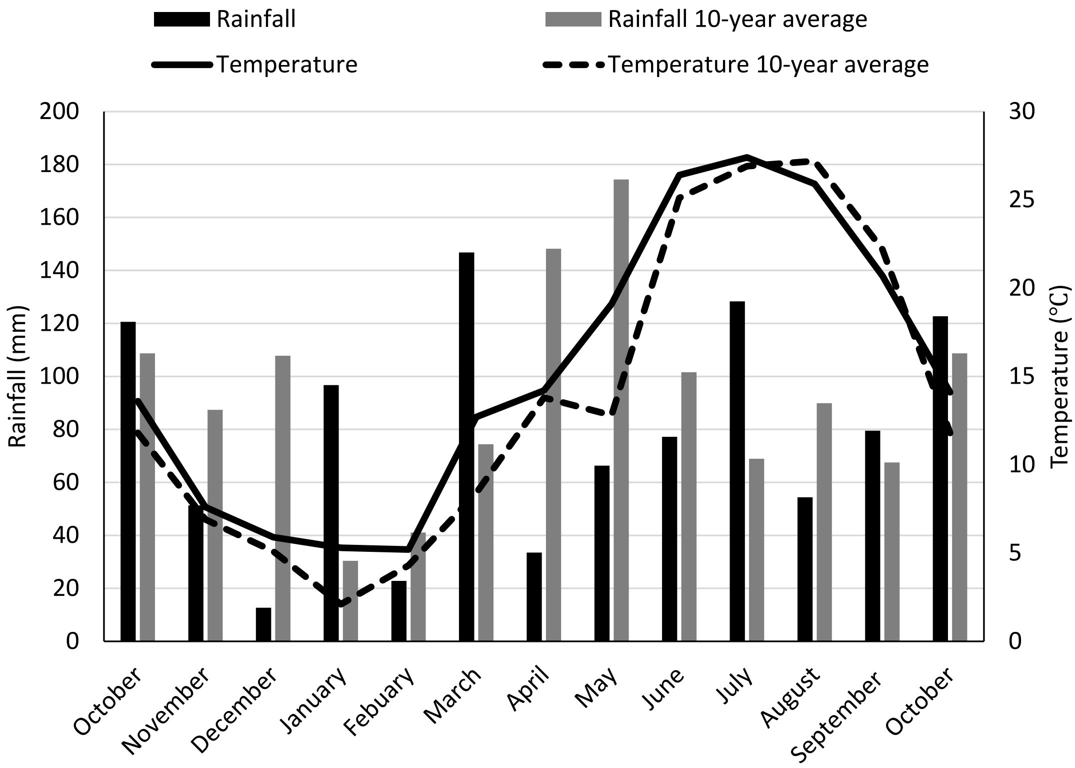


**Figure 3.** Total rainfall and average daily temperature for each month of the 2019–2020 cover crop and soybean season in Perkins, Oklahoma. Monthly temperature and moisture were collected using the Oklahoma Mesonet, and averages were determined from NOAA information collected on-site.

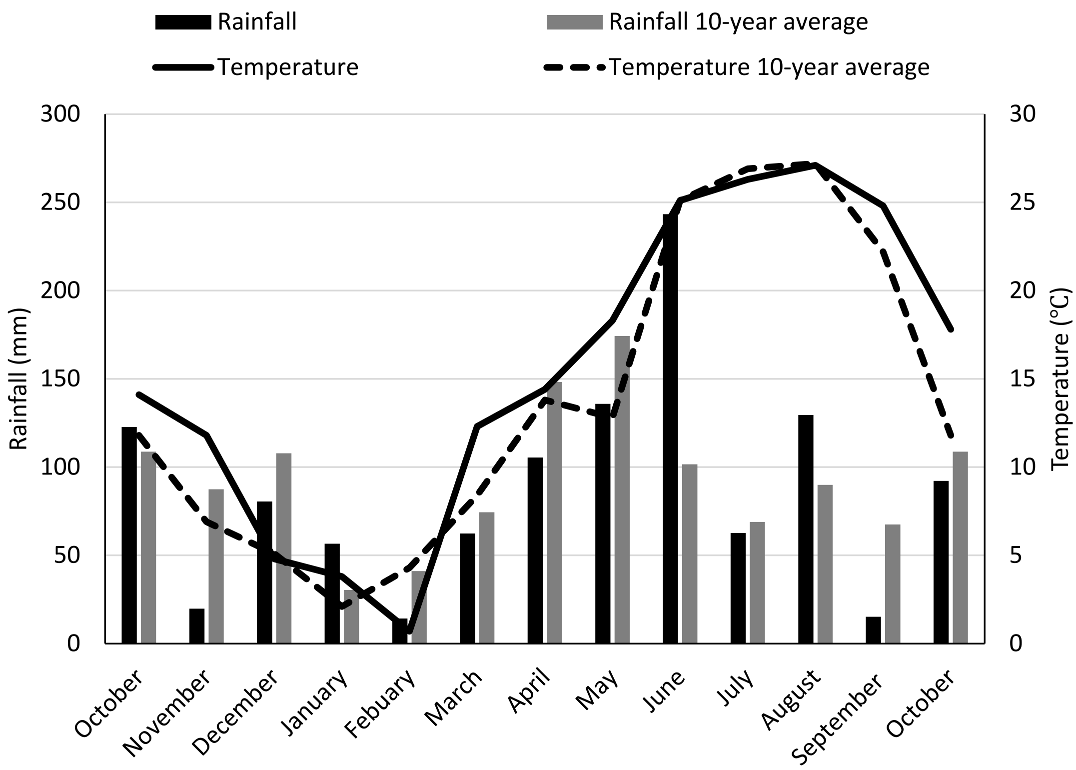


**Figure 4.** Total rainfall and average daily temperature foreach month of the 2020–2021 cover crop and soybean season in Perkins, OK. Monthly temperature and moisture were collected using the Oklahoma Mesonet, and averages were determined from NOAA information collected on-site.

**Table 2.** Baseline soil test results for the trials each year. All analyses were conducted at the Soil, Water, and Forage Analytical Laboratory on the Oklahoma State University campus.

| Site Year | pH | Inorganic N [1] (kg ha$^{-1}$) | P [2] (kg ha$^{-1}$) | K (kg ha$^{-1}$) |
|---|---|---|---|---|
| Bixby 2018 | 6.6 | 12.7 | 77.6 | 298.3 |
| Perkins 2018 | 5.9 | 8.7 | 76.5 | 394.1 |
| Perkins 2019 | 6.0 | 7.4 | 104.8 | 401.4 |
| Perkins 2020 | 5.8 | 10.1 | 84.7 | 395.8 |

[1] Nitrogen was determined using a Lachat with calcium sulfate extractant. [2] Phosphorus and potassium were determined using a Mehlich-3 extractant and inductively coupled plasma (ICP).

The trials were arranged in a randomized complete block design with a one-way factorial treatment structure plus a control. The seven treatment levels consisted of six different cover crop mixes and a control that was left fallow. The fallow treatment was maintained weed-free through tillage or chemical applications throughout the season. Each treatment was replicated four times. Trials at the Perkins location were in the same location within the field each year. Due to flooding, the second replication at Bixby was removed from in-season and harvest analysis because the soybean stands were inconsistent throughout the block. Similarly, for each year of the trial, the first replication at the Perkins location had consistently higher weed pressure and lower stands for both the cover crops and cash crop that did not present an issue in the remaining three replications. Therefore, all in-season and harvest data were removed from analysis for this replication. Wheat served as a base for all cover crop mixes because rye, a commonly planted cover crop in other regions, is a major weed pest within the Oklahoma wheat systems. The treatments consisted of fall-planted cover crops. The cover crop treatments, mix ratios, and planting rates are presented in Table 3.

**Table 3.** Cover crop treatment mixes, mix ratios, and seeding rates for 2018–2019, 2019–2020, and 2020–2021 trials in Oklahoma.

| Treatment Mixes | Mix Ratios | Seeding Rate (kg ha$^{-1}$) |
|---|---|---|
| Fallow | - | - |
| Wheat–Rye–Oats (Rye–Oats) | 1:1:1 | 63.7 |
| Wheat–Canola (Canola) | 6:1 | 41.4 |
| Wheat–Buckwheat (Buckwheat) | 6:1 | 41.4 |
| Wheat–Sunn Hemp (Sunn Hemp) | 3:1 | 41.4 |
| Wheat–Rye–Oats–Chicory (Chicory) | 2:2:2:1 | 63.7 |
| 7-way mix | Wheat-5: Rye-5: Oats-5: Canola-1: Buckwheat-1: Sunn hemp-2.5:Chicory-1 | 63.7 |

*2.1. Cover Crop Management*

Soils were cultivated before the first year of the cover crops was planted. Cover crops were planted using a 1.52 m Truax Drill (Truax Company; New Hope, MN, USA) pulled by a T5040 New Holland Tractor (New Holland Agriculture; New Holland, PA, USA). The drill was set on 0.19 m rows. Each plot was 6.10 m long and 3.05 m wide. The cover crops did not receive any inputs before establishment or throughout the season such as fertilizer, insecticide, herbicide, or irrigation. Termination of cover crops was achieved by spraying 1728 g a.e. ha$^{-1}$ of glyphosate (Roundup PowerMAX; Monsanto; St. Louis, MO, USA) mixed with 1.2 L ha$^{-1}$ of dicamba (XTENDIMAX; Bayer; St. Louis, MO, USA). Dates of all activities for each trial are given in Table 4.

**Table 4.** Dates of field activities for field trials throughout the trial period.

| Location and Year | Planted Covers | Terminated Covers | Planted Soybean | Desiccated Soybean | Collected Yield |
|---|---|---|---|---|---|
| Bixby 2018–2019 | 10/29/18 | 5/16/19 | 5/21/19 | 10/4/19 | 10/23/19 |
| Perkins 2018–2019 | 10/30/18 | 5/13/19 | 5/17/19 | 9/30/19 | 10/7/19 |
| Perkins 2019–2020 | 10/14/19 | 4/24/20 | 5/18/20 | 9/30/20 | 10/16/20 |
| Perkins 2020–2021 | 10/22/20 | 4/9/21 | 5/3/21 | 9/17/21 | 9/29/21 |

### 2.2. Soybean Management

After termination of the cover crops, soybean was planted into the standing residue. The Asgrow variety AG48X7 (MG 4.8) was planted in 2019 and 2020, while, due to the inability to source the same soybean variety, LGS 4808XF (MG 4.8) was used in 2021. Both of these cultivars were Xtend Flex varieties. All trials were planted using a four row Monosem vacuum planter (Monosem Inc., Edwardsville, KS, USA) set on 76.2 cm spacing at a rate of 258,362 seeds ha$^{-1}$. Soybean plot sizes were identical to cover crop plot sizes, at 6.10 m long and 3.05 m wide. In-season weed and insect management was conducted in accordance with the Oklahoma Cooperative Extension Service's best management practices. Similar rates as discussed above of glyphosate (Roundup PowerMAX; Monsanto; St. Louis, MO, USA) and dicamba (XTENDIMAX; Bayer; St. Louis, MO, USA) were applied when needed based on label suggestions and size of targeted weeds. At physiological maturity, soybeans were desiccated using 0.7 L ha$^{-1}$ of paraquat (Solera; Yuma, Arizona). Two weeks later, the middle two rows of each plot of soybeans were mechanically harvested using a Wintersteiger plot combine (Wintersteiger; Ried im Innkreis, Austria). Plot weights were used to estimate yield on a per-hectare basis.

### 2.3. Soybean Performance

To understand the effects of the different cover crop treatments on soybean production, data were collected on growth parameters and yield. Soybean plant populations were estimated by counting each plant within 1 m of row from two rows in each plot. The counts were averaged between the two rows and within like treatments to attain one average plant population value for each treatment. This value was used for comparison between different treatments.

After chemical desiccation of the soybeans at physiological maturity, physiological measurements including plant height, height to first harvestable node (HFN), number of nodes per plant, number of nodes per mainstem, total number of pods per plant, and number of 0-, 1-, 2-, 3-, and 4-bean pods per plant were taken from each plot. The number of 0-, 1-, 2-, 3-, and 4-bean pods per plant are presented as percent of total pods for each bean number category and are referred to as detailed harvest pod counts. Plant height measurements were taken from the soil surface to the top node of five random plants per plot. On those same five plants, HFN was recorded as the measurement from the soil surface to the lowest seeded pod. Additionally, five plants, independent from the previous measurements, were subsampled from each plot prior to soybean harvest. These plants were subject to total mainstem node counts; and nodes of the entire plant before pods were removed, separated into the appropriate 0-, 1-, 2-, 3-, and 4-bean groups, and counted.

Soybean seed yield was determined 14 days following chemical desiccation along with a subsample of seeds from each plot. The seeds collected were then used to attain 100 seed weight. The 100-seed weight value was determined by counting 100 randomly selected seeds from each subsample and weighing them.

### 2.4. Data Analysis

All data were analyzed using SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA) to determine impacts of cover crop treatments on successive cash crop yields. Cover crop treatment was considered a fixed effect, and replication was considered a random effect. Site–year (i.e., location and year) did not have a significant influence on treatment impact;

therefore, all site–years were combined into a single analysis. The combined data satisfied all tests for normality. Analysis of variance (ANOVA; Table 5) was conducted using the a mixed procedure (PROC MIXED). Post hoc analysis was conducted with a Tukey adjustment to determine differences between individual mean values. All post hoc as well as the subsample data analyses were conducted on the combined data. α = 0.05 was used for all analyses.

**Table 5.** Analysis of variance (ANOVA) table for soybean yield influenced by cover crop treatment, as well as location and location by treatment interactions for Bixby 2019 and Perkins in 2019 through 2021.

| ANOVA | *p*-Value |
|---|---|
| **Fixed effects** | -- |
| Treatment | 0.278 |
| **Random effects** | -- |
| Location | 0.121 |
| Location × treatment | 0.072 |

## 3. Results

### *3.1. Seed Yield*

No significant differences existed among any of the cover crop treatments. This included no significant differences compared to the fallow. Even though the statistical analysis noted that the yields could be pooled for site–year, the differences in the level of yields between site–years did vary. Across cover crop treatment, average yields were 6039, 2332, 2285, and 1549 kg ha$^{-1}$for Bixby 2019 and Perkins 2019 through 2021, respectively. This shows that regardless of yield potential levels, the cover crops did not positively or negatively impact short-term soybean yields. Additionally, the coefficient of variation (CV%; ratio of standard deviation compared to mean) was never above 20%, a typical critical level for agronomic field trials (Figure 5).

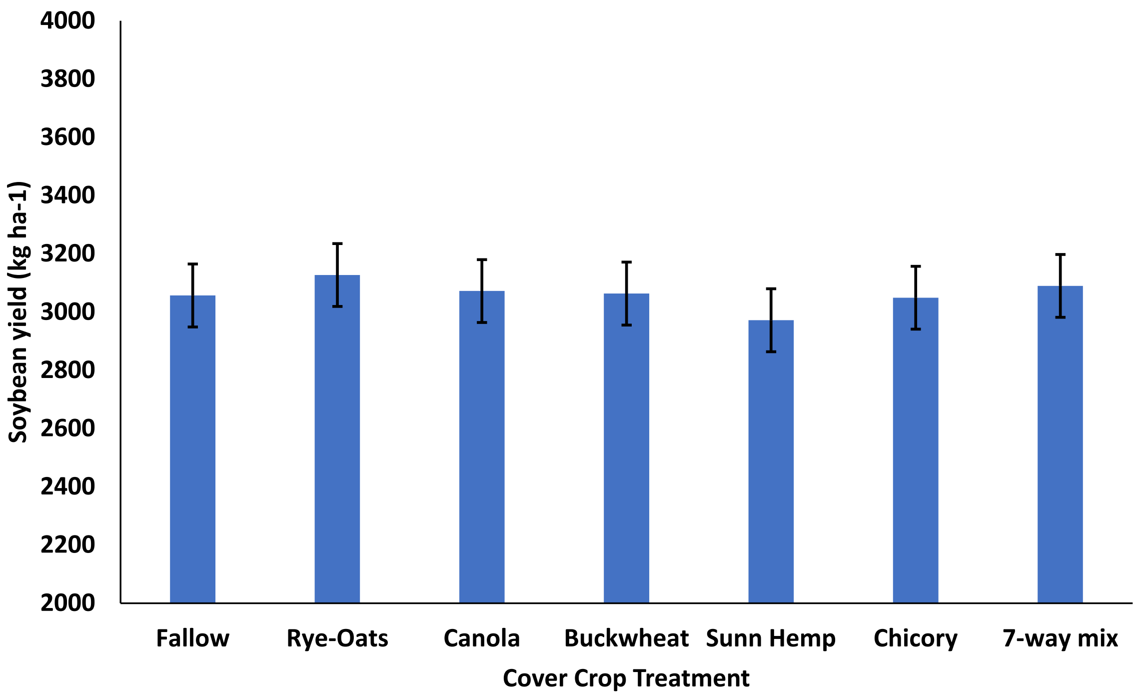


**Figure 5.** Soybean seed yield (kg ha$^{-1}$) for averaged across all site–years (Bixby in 2019 and Perkins in 2019–2021). No significant differences were detected. Error are based on the critical Tukey values that determined the significance.

### 3.2. Harvest Plant Measurements

As no significant differences were noted for soybean yield, having a significant difference for any in-season or harvest measurements would not be expected. For the most part, this is exactly what was seen, with no significant differences in plant height, HFN, or estimated 100-seed weight of the cash crop between any cover crop treatment at either location in any year (Table 6). The lack of significant differences in these parameters further documents that cover crops, especially only integrating cover crops for three years, may not have a significant negative or positive impact on successive cash crop growth.

**Table 6.** Stand count, plant height, height to first node, and 100-seed weight for each treatment averaged across site–year.

| Cover Crop Treatment | Stand Count | Planting Height | Height to First Node | 100-Seed Weight |
|---|---|---|---|---|
| | Plants ha$^{-1}$ | cm | cm | g |
| Fallow | 11.4 | 74.0 | 10.9 | 13.1 |
| Rye-Oats | 10.5 | 75.1 | 10.2 | 12.9 |
| Canola | 11.4 | 71.5 | 10.6 | 13.3 |
| Buckwheat | 11.0 | 71.7 | 9.9 | 13.3 |
| Sunn Hemp | 11.6 | 71.3 | 10.3 | 13.0 |
| Chicory | 11.7 | 71.3 | 10.2 | 13.0 |
| 7-way mix | 11.7 | 73.3 | 10.9 | 13.7 |
| Critical value | 2.1 | 5.7 | 1.4 | 1.9 |
| Significance | NS | NS | NS | NS |

### 3.3. Detailed Harvest Pod and Node Counts

As yields were not significantly impacted by cover crop treatment, it was expected that none of these parameters would show significant trends (Table 7). Two significant differences did exist between the number of three- and four-bean pods. The fallow treatment had a significantly lower number of three-bean pods compared to both canola and buckwheat cover crop treatments, with no other significant differences. However, this was nearly offset by the fallow treatment having a significantly higher number of four-bean pods compared to all cover crop treatments. While this was significant, the differences were so minor that this was potentially the reason why no significant impacts on yields were noted.

**Table 7.** Average percent of total pods and average number of total pods, mainstem nodes, and total nodes of cover crop treatments averaged across site–years.

| Treatments | Percent of Total Pods (%) | | | | | Total Pods (Pods Plant$^{-1}$) | Mainstem Nodes | Total Nodes |
|---|---|---|---|---|---|---|---|---|
| | 0-Bean Pods | 1-Bean Pods | 2-Bean Pods | 3-Bean Pods | 4-Bean Pods | | | |
| Fallow | 9.0 | 12.2 | 37.2 | 39.4 B [1] | 2.3 A | 79.0 | 19.2 | 41.1 |
| Rye-Oats | 5.8 | 11.0 | 36.9 | 45.5 AB | 1.0 BC | 75.3 | 19.6 | 45.1 |
| Canola | 4.5 | 11.4 | 36.5 | 46.8 A | 0.9 BC | 80.7 | 18.3 | 42.9 |
| Buckwheat | 4.4 | 10.4 | 36.6 | 48.1 A | 0.6 C | 77.0 | 25.2 | 45.0 |
| Sunn Hemp | 3.6 | 13.5 | 38.7 | 43.4 AB | 0.9 BC | 68.9 | 18.9 | 44.0 |
| Chicory | 6.1 | 13.2 | 37.8 | 42.3 AB | 0.6 C | 71.7 | 18.9 | 41.8 |
| 7-way mix | 4.4 | 14.2 | 38.5 | 41.7 AB | 1.3 B | 80.2 | 19.5 | 45.6 |
| Critical value | 7.1 | 5.3 | 4.9 | 8.6 | 0.5 | 17.4 | 8.3 | 7.9 |
| Significance | NS | NS | NS | 0.02 | 0.03 | NS | NS | NS |

[1] Different letters within the same column indicate significant differences between the cover crop treatments.

## 4. Discussion

Production agriculture operations, like any business, are only sustainable if their overall net income is positive. This happens when an operation's total revenue exceeds its total expenses. Although planting cash crops includes similar or additional expenses compared with cover crops, the difference between the two lies in the fact that cash crops produce revenue, while cover crops do not. Because cover crops are not harvested and sold, they must provide benefits worth their expense, such as increased cash crop yield or reduction in fertilizer or herbicide applications to cash crops. However, the literature suggests that the effects of cover crops on cash crop yields are inconsistent, with several studies finding reductions in cash crop yields following cover crops [7,8]. If this occurs, producers are not only adding expenses to their operation but also reducing the total revenue from their cash crop. In this circumstance, cover crops are often considered to be uneconomical [8].

The results of this 3-year study did not show significant gains or declines in soybean yield following any of the cover crop mixes. In fact, the cover crops did not significantly influence cash crop yield in any way. These results are not surprising, as similar studies found that cover crops did not affect cash crop yield. Hunter et al. [16] evaluated the effects of multispecies mixes on soybean, corn silage, and wheat yields and found that implementing cover crops into the rotation did not significantly affect the yield of the cash crops. They acknowledged that the lack of yield response in cash crops to multispecies mixes can allow for greater ecological and agronomical benefits to the system without being a detriment. Moore et al. [17] found that different treatments of cover crop mulches did not affect the yield of subsequently grown soybean when weeds were not present. However, one noted exception was at a location with a high weed presence, which showed a yield increase associated with cover crops due to diminished weed pressure in those plots [13]. Williams II et al. [18] found that when soybean stands were not reduced by the implementation of cover crops, the soybean yield were not diminished.

Soybean yield is influenced by several growth traits including, but not limited to, plant stand, mass of seed, node number, and plant height [18,19]. Within this study, stand count, plant height, and height to first node showed no significant differences among treatments. The lack of differences observed in these plant growth parameters helps corroborate the lack of differences in the yield results that were observed. According to Williams II et al. [18], a significant yield reduction would not be expected in the absence of a significant preceding stand loss. Supporting this notion, Reddy et al. [9,10] observed significant yield loss due to cover crops and attributed the loss to a significant reduction in stand loss. In contrast, Moore et al. [17] observed significant stand reductions due to the emergence issues caused by the cover crop mulch, though this did not result in a significant yield loss. The lack of significant difference in yield for the treatments that had lower stand counts could be attributed to yield recovery through significantly increased soybean leaf area, number of branches per plant, and number of nodules per plant [16]. Although the growth parameters collected within this study were different than those mentioned above, the results do not suggest that any treatments were helping to recover yield. In a different study, the yields under both no-till and conventionally tilled treatments without cover crops were higher than those under seven cover crop treatments [8]. The yield decline was partly attributed to reduced soybean stands and plant heights resulting from the cover crop biomass and possible chemicals released from the residues [8].

Total node number, pod number, and seed number are often considered the overall determining factors of soybean yield [20,21]. Kokubun and Watanabe [22] found that during flowering and early seed development, the ability of leaves to produce photosynthate and act as an energy source primarily determined soybean yield potential but that it eventually shifted to the sink capacity (number of pods or seeds) throughout seed development. Research conducted by Board [23] showed a high correlation between total number of seeds, number of pods, and number of nodes. Similarly, Egli [21] determined that node numbers below a certain threshold can result in reduced seed yield; however, above that threshold, the number of pods are determined by the ability of the canopy to undergo photosynthesis and increase seed fill. In addition to the total number of seeds, the mass of the established seeds directly affects overall soybean yield. Van Roekel, Purcell, and

Salmeron [24] suggested that planting the soybean crop early allows for longer seed-filling periods, leading to greater seed weights and increased yields. The only significant differences in any plant growth parameters within this study were seen in the percent of three-bean pods in two site years; however, this did not result in a significant difference in the total number of seeds or pods. Once again, since no significant differences existed in the total node number, mainstem node number, pod number, seed number, or 100-seed weight in this study, the lack of differences in yield between cover crop treatments is justified.

While not statistically significant, there were numerical differences in the yield between cover crops. All cover crop treatments at the Bixby location in 2019 and nearly all at the Perkins locations in 2019 resulted in lower yields than what was obtained from the fallow treatment (Table 8). These differences, however, were nearly reversed in the next two years at Perkins. When yield loss does occur, significant or not, overall net revenue is decreased, resulting in lower net income. This study does not provide evidence suggesting that planting cover crops results in consistent yield loss, as this was not the case every year, and neither yield nor growth parameters were significantly different. Regardless of net revenue made from the different treatments, the cost of seed should be considered before choosing a cover crop mix. Table 9 gives the price per hectare (USD ha$^{-1}$) of seed planted for each cover crop mix.

**Table 8.** Numerical comparison of soybean yield and gross revenue between fallow treatment and cover crop mixes. Simulated prices of soybean used was 0.44 USD kg$^{-1}$.

| Treatment | Difference in Yield from Fallow Treatment | Difference in Net Returns from Fallow Treatment |
|---|---|---|
| | kg ha$^{-1}$ | USD ha$^{-1}$ |
| Fallow | 0 | 0.00 |
| Rye–oats | 75.25 | −14.82 |
| Canola | −79.75 | −99.42 |
| Buckwheat | 11.75 | −34.32 |
| Sunn hemp | −180.5 | −149.54 |
| Chicory | 97 | −118.74 |
| 7-way mix | 69.5 | −109.74 |

**Table 9.** Cost of seed for each cover crop treatment.

| Cover Crop Mix | Cost (USD ha$^{-1}$) | Cost (USD ac$^{-1}$) |
|---|---|---|
| Rye–oats | 47.93 | 19.41 |
| Canola | 64.16 | 25.97 |
| Buckwheat | 39.38 | 15.94 |
| Sunn hemp | 69.84 | 28.27 |
| Chicory | 161.68 | 65.46 |
| 7-way mix | 140.39 | 56.84 |

## 5. Conclusions

Cover crops have been shown to benefit cropping systems through soil conservation, soil health improvement, and weed management. However, the impacts of cover crops on the subsequent cash crop yields are inconsistent in the literature. As cover crops do not provide financial revenue for producers, it is imperative that they do not reduce the yield of the revenue-producing crop. This study was conducted to determine if the implementation of cover crops into a continuous cover crop/soybean rotation affected soybean growth and yield. The results of this study did not show a significant effect of cover crops on soybean growth parameters or yield. While cover crops did significantly increase the percentage of three- and four-bean pods, these differences did not translate into yield differences. The addition of cover crops did not result in higher yields compared to the fallow treatment. This could be considered a valuable finding for producers who are considering implementing cover crops into their system. Although yield differences were not significant, the effects on revenue could be real and greatly impact the overall operation. Based on the data from this, cover crops would not benefit the overall cash crop production in the continuous cover crop soybean system in Oklahoma. However, the fact that cover crops did not consistently or significantly reduce soybean yield allows the growers to consider other benefits of cover crops, such as weed management or soil health improvement.

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