ON FARM EVALUATION of COVER CROPS for NITROGEN MANAGEMENT IN COTTON

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Project and Report completed and submitted to fulfill degree requirements and complete educational obligations as required for the acquirement of Online Master of Agricultural and Life Sciences in Plant Science and Pest Management.

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Abstract

Within the agricultural industry, producers are always inquiring and exploring for ways to limit risk, decrease inputs and increase yield and outputs. These novel agronomic practices such as cover crop are being examined to an entirely new and different level. One aspect of cover crops which has gained popularity and is now a hot topic within the agricultural community is that of cover crops usage as a green manure and its subsequent effects on nutrient cycling, with significant regard towards legume cover crops. Legumes are known for fixing their own nitrogen when sufficiently inoculated with Rhizobacterium, thus with their senescence or termination much of this nitrogen and other nutrients are released into the soil profile and made available for the following crops. With this study, cover crops, specifically legume cover crops, were studied to see what effects they had on nutrient cycling within cotton production and supporting benefits that yielded from the usage of this agronomic practice in real world applications.

Keywords: C: N Ratio, Cover Crop, Green Manure, Legume, Nutrient Management

Introduction and Literature Review

Within the agricultural industry, producers are always inquiring and exploring for ways to limit risk, decrease inputs and increase yield and outputs. Even though certain agricultural methods have been around for decades, improvement and advancement of such techniques regularly occur as researchers, producers and agricultural innovators strive to unlock the full potential of these methods. One such agricultural production method would be none other than the usage of cover crops. This is an integral concept, because nitrogen (N) fertilizer application constitutes a major portion of farmers' cost of production since N is the most applied nutrient in U.S. cotton production (Ofori, 2023). This has led to most cotton crop production systems over-utilizing nitrogen fertilizer within their cropping methods, which is not environmentally friendly, profitable, or sustainable over the long term; resulting in this excess being lost due to natural processes such as leaching, runoff, etc. Field crops will uptake approximately 50% of the N used within fertilizer however the residual N left after crop uptake is prone to gaseous volatilization and leaching (Bundy & Andraski, 2005).

Furthermore, cover crops have been promoted and utilized to improve soil health, in addition to providing many other ecosystem services (Blanco-Canqui et al., 2015). The term green manure and cover crops can be and are often used interchangeably, however, cover crops are a more mainstream term. Nevertheless, cover crops can have immense benefits when used effectively and properly. Cover cropping involves cultivating another crop which is not a cash crop, and is completed most of the time between cash crops, but most importantly this crop is not harvested. This is done with various equipment and for a multitude of reasons, such as nitrogen management, organic matter accumulation, erosion control among other things. All of these reasons which are environmentally beneficial from such green manure practices like cover crops as many agronomic studies have deduced. Cover crops can reduce N losses from agroecosystems because they recouple carbon and nitrogen cycles. Cover crops increase the length of time during which photosynthesis is occurring throughout the year, increasing carbon, nitrogen and soil organic matter stocks within the soil (Bressler, 2023). Usages of practices such as cover crops can improve soil quality, as indicated by increased plant available nutrients, carbon mineralization and microbial populations (Hux, 2023). This is one key component of cover crops that has many producers and agricultural innovators intrigued, and as inputs continue to increase in monetary price and increased advocation for more conservative practices to be implemented within the agricultural community, and their consumer base many producers are and will continue to try to figure out how and where cover crops fit into their operation. This is because cover crops maintain cotton yields without negatively affecting net returns (Delaune, 2020). In fact, the positive impacts from the utilization of cover crops can increase as cover crop usage is increased and maintained over a longer duration of time (Blanco-Canqui, 2020).

Although there are hundreds, if not thousands, of studies involving cover crops, the interpretation of their efficiency and effectiveness is often something of scholarly debate. Due to studies not only being different in nature, but also due to varying experimental conditions which can lead to various results. A study that explored how cover crops affected soil water, observed that crimson clover depleted soil water from 0 to 60 cm within the soil profile up to 55% of the time compared to fallow treatments, before corn planting in coastal North Carolina; this is in contrast, to another recent study in coastal South Carolina where it was observed that a rye (*Secale cereale* L.) cover crops enhanced plant-available water (St Aimee, 2020).

Cover crops do not produce a return like other agricultural methods or products. Thus, the result of cover crops is often cumulative rather than instantaneous, with many seasons or years needed for firm and concise results to be produced. Although there are some short-term rewards, most benefit from cover crops will show up in the seasons after the initial season of cover crops was implemented. With some improvements in soil health indicators observed after 2 yr. of cover crop utilization, long-term cover crop use may be necessary to observe more consistent soil health changes (Johnson 2021). Green manures such as cover crops affect nutrient management and cycling, as well as its overarching effect on cash crops such as corn, soybean or as in this study cotton. A study like this one revealed that a multispecies mixture of legumes, grasses, and *Brassica* spp. significantly increased soybean yield, gravimetric soil water content, and soil inorganic nitrogen as compared to the less-diverse treatments which did not produce the same results (Jadagamma, 2017).

The multiple species provided a habitat for more diverse and beneficial microbes and organisms, which led to more efficient bio-chemical processes and exchanges. This in turn led to more resources being available for crop uptake and utilization. Legumes can fix their own nitrogen, as it stands legume cover crops have the potential when utilized correctly to reduce or replace synthetic N fertilizer inputs through biological N_2 fixation carried out by symbiotic bacteria. Compared to synthetic N fertilizer inputs, legume nitrogen sources can better balance nitrogen inputs in fields where nitrogen is exported out of the field in harvested crops; thus, reducing nitrogen surpluses and potential for nitrogen leaching and loss (Blesh & Drinkwater, 2013). As such legume biomass inputs often provide an energetically favorable substrate that can stimulate microbial activity more efficiently, thereby increasing both internal N cycling and storage, which can result in lower nitrogen losses and by correlation less nitrogen inputs (Bressler, 2023).

Objectives

The study's prime objectives were to determine: 1) if the usage of legume cover crops could reduce the nitrogen fertilizer rate within row crop cotton production and 2) if legumes are an effective cover crop option for cotton production.

Materials and Methods

The environment for this study involved two farms in southeastern Virginia over three years; with the Edwards Farm location being in Carrollton, VA and the Lowe Farm located in Surry, VA. These farms are in southeast Virginia, in Surry and Isle of Wight County, respectively, within the coastal plains' province of the state. On both farms (Edwards Farm and Lowe Farm), twelve plots were randomly selected for the following treatments either fallow (the control); a legume mixture of both Dixie crimson clover and AU Merit hairy vetch; the previously mentioned legume mixture coupled along with rye or barley; or a solid rye or barley only treatment, respectively. These treatments were grown over the winter and then terminated in the spring with the use of herbicides, with the herbicides applied being Glyphosate or Glufosinate-ammonium.

A John Deere CCS1990 Air drill was utilized to plant the cover crop at both locations. The cotton crop was sowed via a 12 row John Deere planter at Edwards, and a 12 row Kinze planter at the Lowe location. The cotton crop at both locations were established on 36-inch rows and at the normal interval for sowing cotton in Virginia. However, the method of sowing was different with the Lowe Farm being no-till and the Edwards Farm being strip-tilled. However, while the Edwards trial area footprint stayed the same, the Lowes test area shifted between the study years. Nevertheless, the same management practices were consistently followed across the study areas. The study areas were then subjected to various random nitrogen fertilizer treatments of 60, 90 and 120 pounds of nitrogen, respectively, with the legume only mixture plots receiving 60 pounds of nitrogen, the legume and rye mixture plots receiving 90 pounds of nitrogen and the rye only plots receiving 120 pounds of nitrogen. Other nutrients such as Phosphorous and

Potassium were introduced at a rate that best corresponded with the need as determined via the soil samples. No cover crops were directly fertilized as a part of this study. Biomass samples were also taken with the wet weight and dry weight both measured and recorded individually of each other, with nitrogen uptake also being measured in the dried biomass. Samples were taken in one-fourth of a meter squares with all contents within the square cut, weighed, dried and ground down to pass through a 1mm (about 0.04 in) sieve. All other agronomic management, such as scouting and pest management were coordinated with Virginia Cooperative Extension guidance on cotton crop management.

Results and Discussion

There were many parameters observed in this study with primary and secondary nutrients being tracked, however for this situation, we will focus on the nitrogen data acquired from this study. The data was refined from its raw state into a quantifiable analysis for comparison with the dry biomass of the cover crop treatments, along with that of the cotton crop as well.

At Edwards Farm, the subsequent cover crop treatments fallow, legume mix, legume mix with rye and rye only acquired biomass of 574; 5,518; 4,976; 1,385 pounds per acre, respectively. The legume mix had the greatest amount of nitrogen per pound of biomass, with 196 pounds of nitrogen per acre within it, followed by rye blend with legume mix at 149 pounds per acre, and the solid stand of rye only at 29 pounds per acre, with the fallow at only 6 pounds of nitrogen per acre, respectively. The following year, however, saw the fallow treatment dropped, and the plots in the same order yielding 2,698; 2,589; 4,161 in pounds of biomass, respectively, with the legume mix again having an exceedingly high amount of nitrogen in it. As such, it is clear to see that a legume mix clearly has a lot of nitrogen within its biomass that could be sequestered by a following crop through soil organic matter mineralization and other natural processes that can be seen by its low C:N ratio, which means that the nitrogen was readily metabolized and utilized by the crop as noted by Table 3. In the second year, in the same order, the cotton planted after the treatments yielded 1,304; 1,519; and 1,550 pounds of lint per acre. As such, if we compare the three, we can see that the nitrogen from the legume mix as well as the legume mix with rye blend treatments invoked a yield response, which saw their lint yields increase well over that of just the rye alone. This would also be due in part to the increased amount of nitrogen within the treatments that was then left behind to be mineralized into substrates that the cotton could use more readily, again, in part to the low C:N ratio, which is easier for soil biota to mineralize than the higher rye alternative. It is also worth noting that the lower C:N ratio correlated in both years to greater cotton crop biomass, as can be gathered from Table 4.

At the Lowe Farm location, the cover crop treatments fallow, legume mix, legume mix with barley and barley acquired biomass of 603; 3,344; 4,799 and 4,108 pounds per acre, respectively. The amount of nitrogen within the biomass of these treatments saw the legume mix with the highest at 121 pounds per acre and fallow with the lowest with 9 pounds per acre, with the other treatments falling in between the two with the barley and legume mix at 85 pounds per acre and the barley at 50 pounds per acre, respectively. This led to the subsequent cotton planted after the cover crop acquiring biomass in the amount of 9,304; 9,656; 8,599; 9,171 pounds per acre, respectively. The legume mixture not only had the highest biomass, but also sequestered the highest amount of nitrogen at 156 pounds per acre, compared to 138 pounds per acre by the fallow treatment, and barley treatments respectively, and 136 pounds per acre from the barley and legume mixture treatment.

As for yield, the legume mix provided the highest amount of lint per acre, which yielded 1,165, followed by the barley and legume mix at 1,163, barley at 1,126 and fallow at 1,044, pounds per acre respectively as noted by Table 1. The following crop year, the biomass accumulated by the cover crop in the same treatment order amounted to 2,146; 3,542; 2,370; 3,186 pounds per acre in the respective treatments. Cotton planted after the cover crops acquired biomass in the amounts of 8,512; 10,394; 11,461; 11,628, respectively. Similar, the first year, the legume mixture had the greatest amount of nitrogen within its biomass at 55 pounds per acre. However, unlike the previous year, the rye only treatment and legume mixture had the same amount. This translated at harvest into 1,290; 1,285; 1,185; 1,130; in terms of lint yielded per acre in pounds. When both years are compared to each other, the legume mix by itself seems to have a contrasting effect. In year one, we saw the legume mix with the highest amount of yield, however in the following year, this was not the case, and this could be attributed to the amount of biomass accumulated by the cover crops. In 2021, the legume mixture and rye blend have a considerable amount of biomass, which was greater than that of the legume mixture. A similar development was noted at Edwards Farm and can be seen in Table 3.

When both data sets are compared to each other, it is clear to see that the treatments did contribute to a healthy amount of biomass in the cotton crop itself, proving that the cover crops can impact and improve the health of the cotton plants. As the treatments with multiple cover crop species within them positively influenced the biomass accumulation, it is the legume mixture treatments with the highest amount of biomass, thus indicating a positive correlation between the two. Nevertheless, at both study areas, when examining both years it is clear to see that environmental factors could be playing into the results such as soil type, soil biota and weather, which can influence natural processes that sequester and mineralize nutrients such as nitrogen.

However, between the values shown for Edwards and Lowe farms within the previously mentioned tables, the C:N ratios are the most significant figures within the tables. Due to the C:N ratios correlating with the cotton lint yield amounts, which is a notable development within this study, it can be rationalized that legume cover crops are leaner in their C:N ratio which is more beneficial to cotton plants than those with higher ratios. When the Tables 1 and 4 for the Lowe Farm are compared to each other, we see the C:N ratios are similar with more carbon dense material such as barley and rye having the highest, C: N loads. This shows that they are packed full of carbon, in contrast to the legume mixture which are very low in their C:N ratio with the blend of the two materials landing in the middle. In both situations, however, we see the legume mixture, has a lower C:N ratio, yield slightly better than the blend, and shows that there is correlation between a lean C:N ratio and cotton yield.

Summary and Conclusion

This study determined that legume species cover crop could reduce nitrogen fertilizer rate within row crop cotton production. Legumes were found to be an effective cover crop for cotton production because they increased soil organic matter and carbon to nitrogen ratios while decreasing nitrogen fertilizer requirements and thereby reducing needed applications.

At both study locations data was gathered that showed that legume crops, such as crimson clover and hairy vetch, can be beneficial within cotton production as they are packed with considerable amounts of nitrogen given the makeup of their biomass. However, further studies are still needed to determine how much should be planted, and the influences of weather and other environmental phenomena on the processes and the benefits that these cover crops can provide. Therefore, cover crops or green manures are a worthy addition to cotton production and do offer benefits to crop health and quality, as shown in this study. Legume mixtures are a decent choice as a cover crop preceding cotton, as also shown in this study.

Acknowledgements

Thank you to Dr. William Frame, my committee members, and the Suffolk AREC for overseeing the study, doing the field work, data analysis, and their insightful guidance. Without their hard work and dedication, this study and subsequent article would not have been possible. Once more thank you, your efforts are immensely appreciated.

Tables

Table 1: Cover crop and upland cotton dry biomass accumulation and nutrient uptake and lint yield following differing nitrogen application strategies based on N content of preceding cover crop at the Lowe on-farm replicated strip trial in 2020**.**

Cover Crop	Total Nitrogen Rate	Cover Crop Biomass and Nutrient Uptake						Cotton Biomass and Nutrient Uptake					Cotton Yield	
		Dry Biomass	N	P_2O_5	K_2O	S	C: N	Dry Biomass	N	P_2O_5	K_2O	S	Lint	Lint
	lb./ac	-------------------- lb./ac ---------------------						---------------- lb./ac ----------------					%	lb./ac
Fallow	120	604 c*	9 d	4 b	18 b	1 c	20 b	9,304	138	54	193	22	43.4	1,044
Legume Mix¶	60	3,344 b	121 a	19 a	113 a	7 a	11 c	9,656	156	64	206	21	43.0	1,165
Barley + LM¶	90	4,799 a	85 b	25 a	152 a	7 a	24 b	8,599	136	54	176	17	43.2	1,163
Barley	120	4,108 ab	50 c	17 a	109 a	4 b	34 a	9,171	138	54	176	18	43.5	1,126

*Means with the same letter are not significantly different at alpha = 0.1 within columns.
¶Legume Mix (LM) = 50% crimson clover and 50% hairy vetch seeding mix

Table 2: Cover crop and upland cotton dry biomass accumulation and nutrient uptake following differing nitrogen application strategies based on N content of preceding cover crop at the Edwards on-farm replicated strip trial in 2020.

Cover Crop	Total Nitrogen Rate	Cover Crop Biomass and Nutrient Uptake						Cotton Biomass and Nutrient Uptake				
		Dry Biomass	N	P_2O_5	K_2O	S	C: N	Dry Biomass	N	P_2O_5	K_2O	S
	lb./ac	-------------------- lb./ac --------------------						-------------------- lb./ac --------------------				
Fallow	120	574 d*	6 c	4 c	15 c	1 c	22.0 a	9,451	174	68	201 bc	21
Legume Mix¶	60	5,518 a	195 a	38 a	199 a	11 a	10.9 b	10,142	188	62	234 a	21
Rye + LM¶	90	4,976 b	149 b	37 a	191 a	9 a	13.4 b	10,027	189	67	233 ab	23
Rye	120	1,385 c	29 c	11 b	38 b	2 b	20.9 a	8,836	167	63	195 c	21

*Means with the same letter are not significantly different at alpha = 0.1 within columns.
¶Legume Mix (LM) = 50% crimson clover and 50% hairy vetch seeding mix

Table 3: Cover crop and upland cotton dry biomass accumulation and nutrient uptake and lint yield following differing nitrogen application strategies based on N content of preceding cover crop at the Edwards on-farm replicated strip trial in 2021.

Cover Crop	Total Nitrogen Rate	Cover Crop Biomass and Nutrient Uptake						Cotton Biomass and Nutrient Uptake					Cotton Yield	
		Dry Biomass	N	P_2O_5	K_2O	S	C: N	Dry Bio-mass	N	P_2O_5	K_2O	S	Lint	Lint
	lb./ac	-------------------- lb./ac --------------------						----------------- lb./ac -----------------					%	lb./ac
Rye	120	2,698 b*	37 c	13 b	46 b	2.5 b	30 b	8,498	138	55	177	16	40.7	1,304 b
Legume Mix¶	60	2,589 b	78 a	20 a	104 a	5.6 a	13 c	9,764	179	72	204	18	40.6	1,519 a
Rye + LM¶	90	4,161 a	66 b	27 a	102 a	5.3 a	26 a	8,997	153	63	185	16	41.2	1,550 a

*Means with the same letter are not significantly different at alpha = 0.1 within columns.
¶Legume Mix (LM) = 50% crimson clover and 50% hairy vetch seeding mix

Table 4: Cover crop and upland cotton dry biomass accumulation and nutrient uptake following differing nitrogen application strategies based on N content of preceding cover crop at the Lowe on-farm replicated strip trial in 2021.

Cover Crop	Total Nitrogen Rate	Cover Crop Biomass and Nutrient Uptake						Cotton Biomass and Nutrient Uptake					Cotton Yield	
		Dry Biomass	N	P_2O_5	K_2O	S	C: N	Dry Biomass	N	P_2O_5	K_2O	S	Lint	Lint
	lb./ac	-------------------- lb./ac -------------------						-------------------- lb./ac ------------------					%	lb./ac
Fallow	115	2,146 b*	53	14	60	13.4	17	8,512	135	48	185	24	40.7	1,290
Rye	115	3,542 a	55	17	65	4.2	27	10,934	185	68	247	34	40.9	1,285
Legume Mix¶	115	2,370 b	55	14	67	5.3	18	11,461	183	60	226	30	41.0	1,180
Rye + LM¶	115	3,186 a	49	13	58	3.7	27	11,628	211	68	258	35	40.9	1,130

*Means with the same letter are not significantly different at alpha = 0.1 within columns.
¶Legume Mix (LM) = 50% crimson clover and 50% hairy vetch seeding mix

References

Adeli, A., Brooks, J. P., Read, J. J., Miles, D. M., Shankle, M. W., & Jenkins, J. N. (2021). Impact of cover crop on nutrient losses in an upland soil. *Communications in Soil Science and Plant Analysis*, *52*(5), 536–550. https://doi.org/10.1080/00103624.2020.1862154

Bauer, P.J. and Reeves, D.W. (1999). A Comparison of Winter Cereal Species and Planting Dates as Residue Cover for Cotton Grown with Conservation Tillage. *Crop Science* 39: 1824-1830. https://doi.org/10.2135/cropsci1999.3961824x

Bergtold, J. S., Ramsey, S., Maddy, L., & Williams, J. R. (2019). A review of economic considerations for covering crops as a conservation practice. *Renewable Agriculture and Food Systems 34*(1), 62–76. https://doi.org/10.1017/S1742170517000278

Blanco-Canqui H, Ruis SJ. (2020). Cover crop impacts on soil physical properties: A review. *Soil Science Society of America Journal* 84: 1527–1576. https://doi.org/10.1002/saj2.20129

Blesh, J. and Drinkwater, L.E. (2013). The impact of nitrogen source and crop rotation on nitrogen mass balances in the Mississippi River Basin. *Ecological Applications* 23: 1017-1035. https://doi.org/10.1890/12-0132.1

Bressler, Alison, and Jennifer Blesh. (2023). “A Grass–Legume Cover Crop Maintains Nitrogen Inputs and Nitrous Oxide Fluxes from an Organic Agroecosystem.” *Ecosphere* 14(2): e4428. https://doi.org/10.1002/ecs2.4428

Chu, M., Jagadamma, S., Walker, F.R., Eash, N.S., Buschermohle, M.J. and Duncan, L.A. (2017). Effect of Multispecies Cover Crop Mixture on Soil Properties and Crop Yield. *Agricultural & Environmental Letters* 2: 170030. https://doi.org/10.2134/ael2017.09.0030

Delaune PB, Mbumba P, Fan Y, Bevers S. (2020). Agronomic and economic impacts of cover crops in Texas rolling plains cotton. *Agrosystems, Geosciences & Environment* 3: e20027. https://doi.org/10.1002/agg2.20027

Delaune, P. B., Mbumba, P., Ale, S., & Kimura, E. (2020). Impact of no-till, cover crop, and irrigation on cotton yield. *Agricultural Water Management 232*. https://doi.org/10.1016/j.agwat.2020.106038

Delaune, P. B., Mbumba, P., Lewis, K. L., & Keeling, J. W. (2019). Rye cover crop impacts soil properties in a long-term cotton system. *Soil Science Society of America Journal 83*(5), 1451–1458. https://doi.org/10.2136/sssaj2019.03.0069

de Souza, I. A., Daly, A. B., Schnecker, J., Warren, N. D., Lobo Jr, A. R., Smith, R. G., Brito, A. F., & Grandy, A. S. (2023). Short-term responses of soil carbon, nitrogen, and microbial biomass to cover crop mixtures and monocultures. *Agrosystems, Geosciences & Environment* 6, e20395. https://doi.org/10.1002/agg2.20395

Fan, Y., Liu, Y., Delaune, P. B., Mbumba, P., Park, S. C., & Bevers, S. J. (2020). Economic analysis of adopting no-till and cover crops in irrigated cotton production under risk. *Agronomy Journal 112*(1), 395–405. https://doi.org/10.1002/agj2.20005

Fan, Y., Liu, Y., Delaune, P. B., Mbumba, P., Park, S. C., & Bevers, S. J. (2020). Net return and risk analysis of winter cover crops in dryland cotton systems. *Agronomy Journal 112*(2), 1148–1159. https://doi.org/10.1002/agj2.20091

Hux, B. A., Delaune, P. B., Schirmacher, M. T, Gentry, T. J., & Mbumba, P. (2023). Winter cover crop impact on soil health in Texas rolling plains dryland cotton. *Agrosystems, Geosciences & Environment* 6, 1–14. https://doi.org/10.1002/agg2.20352

Johnson, A. M., Gamble, A. V., Balkcom, K. S., & Hull, N. R. (2021). Influence of cover crop mixtures on soil health in southeastern crop production systems. *Agrosystems, Geosciences & Environment* 4: e20202. https://doi.org/10.1002/agg2.20202

Kemper, R., Döring, T. F., Legner, N., Meinen, C., & Athmann, M. (2023). Oil radish, winter rye and crimson clover: root and shoot performance in cover crop mixtures. *Plant and Soil: An International Journal on Plant-Soil Relationships 1–16*, 1–16. https://doi.org/10.1007/s11104-023-06240-y

Korres, N. E., & Norsworthy, J. K. (2015). Influence of a rye cover crop on the critical period for weed control in cotton. *Weed Science 63*(1), 346–352. https://doi.org/10.1614/WS-D-14-00075.1

Ladoni, M., Kravchenko, A. N., & Robertson, G. P. (2015). Topography mediates the influence of cover crops on soil nitrate levels in row crop agricultural systems. *Plos One 10*(11), 0143358. https://doi.org/10.1371/journal.pone.0143358

Nouri, A., Lee, J., Yoder, D. C., Jagadamma, S., Walker, F. R., Yin, X., & Arelli, P. (2020). Management duration controls the synergistic effect of tillage, cover crop, and nitrogen rate on cotton yield and yield stability. *Agriculture, Ecosystems and Environment 301*. https://doi.org/10.1016/j.agee.2020.107007

Nouri, A., Lukas, S., Singh, S., Singh, S., & Machado, S. (2022). When do cover crops reduce nitrate leaching? A global meta-analysis. *Global Change Biology 28*(15), 4736–4749. https://doi.org/10.1111/gcb.16269

Price, A. J., Nichols, R. L., Morton, T. A., Balkcom, K. S., Grey, T. L., & Li, S. (2021). Effect of cover-crop biomass, strip-tillage residue disturbance width, and pre herbicide placement on cotton weed control, yield, and economics. *Weed Technology 35*(3), 385–393. https://doi.org/10.1017/wet.2021.8

Qin, Z., Guan, K., Zhou, W., Peng, B., Tang, J., Jin, Z., Grant, R., Hu, T., Villamil, M. B., Delucia, E., Margenot, A. J., Umakant, M., Chen, Z., & Coppess, J. (2023). Assessing long-term impacts of cover crops on soil organic carbon in the central us midwestern agroecosystems. *Global Change Biology* 29(9), 2572–2590. https://doi.org/10.1111/gcb.16632

St. Aime, R., Bridges, W. C., & Narayanan, S. (2023). Interseeded cover crops did not reduce silage corn performance in the sandy loam soils of South Carolina. *Agrosystems, Geosciences & Environment* 6, 1–11. https://doi.org/10.1002/agg2.20364

St Aime R, Zehnder GW, Talley C, Narayanan S. Differences in Biomass Production and Water Use Efficiency among Seven Different Cover Crops in the Wet Winter Seasons of 2016/17 and 2018 in South Carolina. *Agronomy* 2020; 10(4):463. https://doi.org/10.3390/agronomy10040463

Vann, R. A., Reberg-Horton, S. C., Edmisten, K. L., & York, A. C. (2018). Implications of cereal rye/crimson clover management for conventional and organic cotton producers. *Agronomy Journal* 110(2), 621–631. https://doi.org/10.2134/agronj2017.06.0246