REGENERATION NATION: ALFALFA'S ROLE IN SUSTAINABLE AGRICULTURE

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ABSTRACT

In recent years, there has been a resurgence in sustainable farming practices and related research, driven mostly by increased interest in improving soil health, nutrient recycling, and carbon sequestration. A vast majority of that research has focused on utilization of cover crops, or annual crops that are cultivated primarily for their soil health benefits. These crops are often terminated at the end of the season, with more economically important row crops following. However, the benefits of alfalfa have been largely overlooked, even though we have known for many years its vast soil health and ecosystem benefits. From improving soil structure, decreasing erosion, increasing carbon sequestration in soil, to decreasing nitrogen fertilizer requirements of subsequent crops, alfalfa is a valuable crop that should be incorporated into cropping rotations for a multitude of reasons. Increased utilization of alfalfa will not only help to reach our goals of improving soil health and increasing carbon sequestration, but it will also help in improving wildlife habitat and biodiversity, critical in improving overall agricultural sustainability, while providing a highly nutritious feedstuff for livestock.

Key Words: alfalfa, sustainability, carbon, regenerative agriculture, nitrogen

ALFALFA'S IMPACT ON SUSTAINABILITY

Sustainability in agriculture has become an important talking point across the government, production, and industry landscape. With documented changes in climate affecting everything from temperatures to rainfall, it is important that we highlight agriculture's important role in mitigating climate change. While utilizing sustainable farming practices has always served the best business interests of farmers and ranchers, we now recognize that promoting such practices also helps to achieve our climate goals.

In recent years, researchers, growers, industry professionals, and government organizations have increased their efforts to define sustainable agriculture and research best management practices that can help to reach those goals. From improving the many facets of soil health to ecosystem benefits, a shift in focus has been placed on methods that can help improve carbon sequestration while also improving overall habitat and ecosystem function. Much of the research to date has focused on the many different species that fall under the classification of "cover crops," typically annual crops that are grown specifically for their role in improving soil health. However, alfalfa is an impressive crop whose contributions towards meeting those sustainability goals have

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largely gone unnoticed. This may have resulted, largely, from the erroneous exclusion of perennial crops, such as alfalfa, from the traditional classification of a "cover crop."

As shown in Table 1, while many are aware of the vast benefits that support using cover crops, alfalfa has many of the same benefits to offer, if not more. From its documented ability to sequester carbon in the soil, to its ability to decrease nutrient leaching into adjacent soils and watersheds, alfalfa deserves more attention for its contributions towards improving on-farm practices when included in a cropping rotation.

Table 1. Comparison of alfalfa's sustainability benefits to cover crops and two commonly planted row crops, soybean and corn.

Sustainability Benefit	Alfalfa	Corn	Soybean	Cover Crops
Carbon Sequestration	+	0/-	0/-	+
Improved Soil Structure	+			+
Nitrogen credits	++		+	+*
Water Use Efficiency	+	+	+	+
Decreased Erosion	+			+
Decreased Nutrient Leaching	+			
Increased Soil Microbial Diversity	+			+

From Meccage, 2021. Alfalfa economics and cropping rotation benefits. CROPLAN Virtual Alfalfa Training Event.

Carbon sequestration

Perhaps one of the most touted aspects of agricultural sustainability is the ability of plants to increase carbon sequestration through photosynthesis. Again, much of the focus has been placed on other resources such as hardwood forests, perennial grasslands, and even annual crops, with limited focus on alfalfa's ability to sequester carbon.

Historical data suggests that alfalfa can sequester significant amounts of carbon in the soil, and even better, sequester carbon deeper in the soil because of its deeper root structure, than many of the other crops that are commonly evaluated. Jarecki et al. (2005) found that when compared to continuous corn cropping, alfalfa sequestered 22% more soil organic carbon (SOC), in agreement with Cates et al. (2016) which found that alfalfa sequestered 26% more SOC than rotations that included only annual crops (corn and soybean).

Saliendra et al. (2018) found that when comparing perennial alfalfa to perennial grassland, the amount of SOC was greater in the alfalfa, even when the aboveground biomass was harvested as

hay. The amount of C sequestered increased in this study if the alfalfa was irrigated, correlating to the amount of both aboveground and belowground biomass that was produced. The ability of alfalfa to sequester more C than other perennial crops is important to note and should also be a talking point when considering programs to implement increased C sequestration.

Just as important as total amount sequestered, several of these studies evaluated where the SOC was placed in the soil layers. With many of the other closely studied crops, most of the sequestered carbon is stored in the top 10 cm of soil, close to the soil surface. However, it appears that alfalfa has the ability to place carbon deeper in the soil, with gains found at 30-60 cm (Cates et al., 2016). Interestingly, in that same study the corn-soybean rotation found losses in SOC in those deeper layers.

As carbon markets begin to become more established, it is critical that we bring focus to the importance of utilizing alfalfa in cropping rotations. More emphasis needs to be placed on utilization of alfalfa by these carbon market platforms if the objective is to maximize carbon sequestration potential. Thanks to its improved ability to sequester carbon compared to many other crop options, producers are more likely see a financial benefit if they choose to enter the carbon markets by incorporating alfalfa on-farm.

Soil health benefits

A broad term that is commonly used in the sustainability discussion is “soil health”, which has many different definitions depending on which source is referenced. In this discussion, we will utilize this term to encompass soil’s structure and ability to grow crops, along with its microbial biome.

Previous studies have found that multi-year use of alfalfa in cropping rotations leads to improvements in the size of soil aggregates (Angers, 1992), which helps to improve moisture and nutrient movement throughout the soil. This also leads to more stable soils that are resilient to changes in climate such as periods of drought or heavy rains. Another important benefit is that it helps to decrease erosion, a benefit that has been shown by research studies that included alfalfa (Wu et al., 2011). Wu et al. found that soils that had been in rotation with alfalfa had infiltration rates that were 1.77 times that of bare soil, and sediment transportation rate away from the field decreased by 78.4%, a marked improvement in soil structure.

Included in soil health benefits are qualities such as alfalfa’s ability to decrease nutrient leaching, critical in mitigating runoff into water sources. Due in large part to its deep taproot system, alfalfa can “soak up” large amounts of nutrients in the soil that otherwise have the potential to contaminate nearby water sources. Other options such as many species of cover crops are also able to decrease significant amounts of nutrient contaminants; however, alfalfa can reach deeper levels in the soil. It is also efficient at decreasing levels of toxic metals in the soil and has been used in soil remediation and reclamation efforts.

Nitrogen benefits

An important system and financial benefit of utilizing alfalfa is the fact that it is a legume, meaning it can fix nitrogen through its symbiotic relationship with *Rhizobium* bacteria. Cropping

rotations that include corn after alfalfa often do not require synthetic inputs of nitrogen for at least one year, with many fields requiring decreased nitrogen fertilizer the second year out of alfalfa as well (Creech et al., 2019; Undersander and Barnett, 2008; Sheaffer, 2004). This leads to significant financial savings, as nitrogen inputs represent a large portion of the input costs in row crop production. Furthermore, nitrogen presented to the soil in the form of legume synthesized nitrogen, versus the more mobile form from synthetic nitrogen fertilizer, likely decreases the potential for nitrogen leaching into groundwater and aquifers.

Another important consideration is the environmental cost of using synthetic nitrogen fertilizers. Most reports estimate that industrial production of urea produces approximately 3 T carbon per T of urea produced, and 2 T carbon per T of ammonium nitrate produced. That is also accompanied by the amount of carbon that is produced during the transport and application process, representing a large financial and environmental cost to growing that crop. Utilizing alfalfa decreases the dependence on synthetic fertilizers, saving both dollars as well as carbon emissions.

Ecosystem benefits

It would be remiss to discuss the benefits of alfalfa without considering the ecosystem benefits. Alfalfa is a great habitat for many species of wildlife, from large herbivores like elk and deer, to smaller mammals such as rodents, as well as soil-dwelling organisms and pollinators. While this may not always be a positive for farmers, it is important to consider as more focus is placed on environmental stewardship.

Pollinators are critical for a healthy food production system, and alfalfa is very attractive to many species of pollinators. It plays an important role in food source and habitat and can be utilized very well to help improve pollinator numbers. In the same vein of preserving pollinator habitat, alfalfa can also be utilized to interrupt pest cycles, decreasing the need for pesticides which also improves pollinator habitats.

Alfalfa is often not host to many of the same pests that occur in popular row crop options, and inclusion of alfalfa into cropping rotations can help to reduce damaging pest populations. Whether it be insect species, diseases or weeds, alfalfa can be utilized to disrupt growth cycles, and decrease the overall negative impact they have on production.

CONCLUSION

When looking to maximize agriculture's impact on improving carbon sequestration, it is important to highlight alfalfa's important role. Not only can alfalfa significantly increase carbon sequestration, but it also has the potential for so many other beneficial impacts for our ecosystems. The ability to decrease the reliance on nitrogen fertilizers can significantly help at the farm-gate by reducing input costs, as well as decrease emissions. It also is an important crop to help improve soil's resilience in a changing climate, which can help to maximize production on a per acre basis. Finally, it has many benefits to offer wildlife, pollinators, and soil-dwelling organisms, which all play a critical role in a healthy ecosystem. It is important that more focus is

placed on utilizing alfalfa's many benefits at the producer level and potentially in funded sustainability programs.

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