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Evaluating Forage Cover Crop Mixes for the Desert Southwest

Debankur Sanyal, Charles Stackpole, and Sharon B. Megdal

Introduction

Cover crops are essential tools to improve soil health and productivity[1]. Traditionally, cover crops are used as 'green manures' where the cover crops are not harvested but incorporated into the ground to boost soil health and fertility. Therefore, it has become a common perception that cover crops are meant to be incorporated into the soil. In the desert Southwest, water scarcity forces the producers to utilize water more strategically, and green manure cover crops may not be an economically sustainable option for farmers in the desert. Many recent studies have reported that green-manuring cover crops may not increase cash crop yield or farm profitability in commercial agricultural production systems[2,3]. Therefore, to reap benefits from cover cropping, such as protection against wind erosion, increased biodiversity, carbon sequestration, and efficient nutrient cycling supported by diversified soil biology (Figure 1), cover crops can be used as ***alternative forage crops*** to supplement the need for quality livestock feed. Additionally, growing forage crops like alfalfa or corn requires large quantities of water. With the current and upcoming reduced irrigation budgets[4], the commercial agricultural industry in the Southwest may need to find alternative forage crops to supplement the demand for livestock feed. This study was designed to evaluate different compositions of forage cover crop mixes for warm and cool growing seasons.

Materials and Methods

The University of Arizona Soil Health Research and Extension team led several on-farm trials in collaboration with commercial producers growing field crops like durum wheat, corn, sorghum, and alfalfa, who were interested in growing '*custom-designed*' cover crop mixes. The cover crop mixes were planted during spring/winter, summer, and fall seasons, depending on the crop rotations. Cover crop mixes were prepared by mixing different proportions of grass (Gr) and broadleaf species (BL). During the summer season, the grass species were sorghum-sudan, pearl millet, and teff grass, and the broadleaf species were cowpea, guar, mung bean, sunflower, buckwheat, and flax. During the cool season, the grass species were wheat, oat, ryegrass, and barley, and the broadleaf species were vetch, clover,

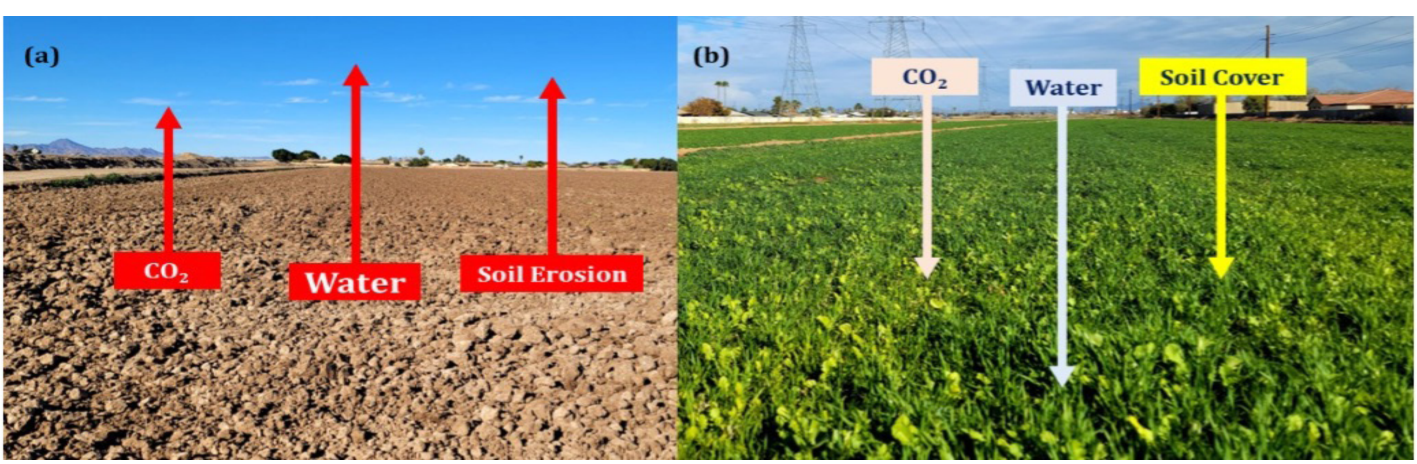

Figure 1. Fallow, bare grounds contribute to the losses of carbon, water, and fertile topsoil. Growing forage cover crops can sequester carbon, conserve water, and protect topsoils from wind erosion in the desert Southwest

Figure 2. The soil health team is collecting soil samples from the on-farm trials in central Arizona

pea, and fava bean. If we used 70% grass species and 30% broadleaf species, we tagged the mix as '70% Gr 30% BL'. If we used only grasses, we tagged the mix as '100% Gr' and so on; a '50% Gr 50% BL' had an equal proportion of grass and broadleaf species.

Soil samples were collected before the planting of cover crops and after the cover crop season (Figure 2). Composite soil samples were collected from the topsoil profile at a 0-6" depth where the rhizosphere lies, a region with the majority of roots. Soil samples were then brought to Sanyal lab, at Maricopa Agricultural Center, processed, and analyzed for soil health parameters. Forage cover crop biomass was also surveyed to measure the forage quality of the cover crop mixes and was tested at a commercial lab.

Soil Health Indicators

We measured several soil health indicators, but, for this discussion, we will be focusing on three indicators. Permanganate *Oxidizable Carbon or POXC* is an indicator for microbially available carbon. It designates a small fraction of total soil organic carbon (2-4%) and serves as a readily available food and energy source for the soil microbial community. *Soil Respiration* is a measure of the metabolic activity of the soil microbial community. This is measured as the amount of carbon dioxide (CO2) released when soil organic matter is decomposed by soil microbial communities. *Wet Aggregate Stability* measures a soil's resiliency against disturbance or erosion. Unstable aggregates break down more easily than stable aggregates against eroding agents like water and air. The values range from 0, which means no aggregation, to 1, which means perfect aggregation.

Forage Quality Indicators

Four major forage quality indicators are analyzed. *Crude Protein* is a measure of protein content in the feed that eventually regulates the quality of the livestock products like milk and meat. *Total Digestible Nutrients (TDN)* is the sum of the digestible fiber, protein, lipid, and carbohydrate components of a feed and represents the utilizable energy content. *Relative Feed Value (RFV)* is intended to reflect how well an animal (originally developed for cattle) will eat and digest a particular forage. *Relative Forage Quality (RFQ)* is an estimate of how much available energy a non-lactating animal will obtain daily from a particular forage.

Results and Discussion

Initial soil samples, collected before cover cropping, revealed the existing soil conditions, both for basic soil chemical parameters (data not presented) and soil health indicators (Table 1). All the fields under investigation recorded a high pH and potential sodicity problem. In the cover crop research sites, high residual nitrate contents (6-36 lbs./a) were recorded which may potentially become a source of groundwater pollution or greenhouse gas emissions. Cover crops can potentially deplete this residual nitrate by incorporating it into the biomass, diminishing chances for potential environmental pollution.

Cool season forage cover crops grown in the late fall and spring/winter seasons improved soil health indicators (Table 1), while in the summer, warm season forage cover crops improved aggregate stability which is an indicator of soil's resiliency against eroding agents. Evidently, forage cover crop mixes are showing indications of soil health improvement just in the first year of adoption. With time, these forage cover crop mixes are expected to improve soil health further.

The most exciting outcome of this study is the forage quality for the forage cover crop mixes. The preliminary data showed that the values were *very much comparable* to the traditional forage crops grown in the southwest such as corn, barley, alfalfa, etc. (Table 2). Although we did not

Table 1. Average values for soil health indicators, permanganate oxidizable carbon (POXC), soil respiration, and wet aggregate stability, before and after cover cropping (CC); improved soil health indicator values are shown in **bold**.

Cover Crop Mix	POXC (mg/kg soil)		Soil Respiration (mg CO2/g)		Wet Aggregate Stability	
	Before CC	After CC	Before CC	After CC	Before CC	After CC
	Summer Cover Crop					
100% BL	279	280	0.77	0.42	0.07	**0.17**
30% Gr 70% BL	262	201	0.73	0.71	0.00	0.00
70% Gr 30% BL	338	360	0.86	0.87	0.05	**0.11**
100% Gr	265	215	0.91	1.13	0.04	0.01
50% Gr 50% BL	160	160	0.70	0.52	0.03	**0.15**
	Late fall Cover Crop					
70% Gr 30% BL	364	**432**	1.55	0.63	0.35	**0.45**
70% Gr 30% BL	364	**576**	2.05	**3.04**	0.16	**0.44**
70% Gr 30% BL	590	**615**	2.81	**3.13**	0.17	**0.30**
	Spring/Winter Cover Crop					
100% Gr		**432**		0.39		**0.16**
80% Gr 20% BL	291	**451**	0.49	**0.62**	0.08	0.07
60% Gr 40% BL		**424**		**0.52**		**0.13**

conduct any comparison study, we still included a range of values for alfalfa hay, corn silage, and barley hay from existing literature for comparison[5,6,7]. These results provided us with preliminary information on the forage quality of the tested cover crop mixes.

The major opportunity lies in the consumption of irrigation water. These cover crops were grown in a fraction of the water consumed by contemporary forage crops. Growers used only 1.0-1.2 acre-feet of water/acre for the summer cover crop and 6-7 acre-inches of water/acre during the cool season. To grow corn silage and barley hay, growers use ~4.0 and 2.0 acre-feet/acre on average, respectively, while alfalfa may require ~6.0 acre-feet water/acre annually. However, during the study period, some late-season rainfall (~2.0 inches) helped the fall-season forage cover crops use less irrigation water.

Table 2. Average values for forage quality indicators, crude protein, total digestible nutrients (TDN), relative feed value (RFV), and relative forage quality (RFQ), for the forage cover crop mixes under study compared to forage value indicators found in the literature[5,6,7] for conventional forage crops. Comparable forage quality values from our trials are shown in **bold.**

Cover Crop mix	Crude Protein (%)	Digestible Nutrients %	RFV	RFQ
	Summer Cover Crop			
100% BL	**11**	**65**	**119**	**117**
30% Gr 70% BL	5	**58**	91	104
70% Gr 30% BL	7	**59**	89	**119**
100% Gr	3	**54**	78	95
50% Gr 50% BL	**21**	**68**	**113**	**110**
	Fall Cover Crop			
70% Gr 30% BL	**17**	**69**	**160**	**150**
70% Gr 30% BL	**14**	**67**	**136**	**145**
70% Gr 30% BL	**16**	**64**	**134**	**120**
Alfalfa Hay	*20-30*	*60-70*	*130-180*	*150-185*
Corn Silage	*7-9*	*50-60*	*150-170*	*140-160*
Barley Hay	*16-18*	*50-60*	*85-95*	*80-90*

Conclusion

Our preliminary research showed that forage cover crop mixes can be *custom-designed* to serve multiple purposes like a) providing soil cover to prevent wind erosion while improving air quality and b) low-water use forage crop alternatives to traditional forage crops. These trials will be continued as we need more information to optimize cover crop species compositions and find additional opportunities to improve soil health and reduce water use while maintaining forage quality and profitability.

References

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AUTHORS

Debankur Sanyal
Assistant Specialist - Soil Health

Charles Stackpole
Research Technician

Sharon B. Megdal
Director Water Resources Research Center

CONTACT

Debankur Sanyal
dsanyal@email.arizona.edu

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