A Comprehensive Soil Health Survey and Assessment in Yuma: Final Report

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Introduction

Soil health in commercial agricultural production systems of the desert southwest has not been explored enough to create a comprehensive assessment framework for commercial desert agricultural production systems. Our study aimed at collecting soil samples from commercial farms in Yuma, one of the largest contributors to agricultural production in the desert southwest. We measured well-established soil health indicators (SHI), recorded threshold levels for each SHI, and indicated future research needs for soil health management in the desert.

Materials and methods

We reached out to commercial growers who have an active commercial production system in Yuma and collected soil samples. We collected soil samples from 20 commercial fields twice during the summer and winter seasons, in 2022, to check if soil health indicators change following a winter crop. While selecting fields, the geographic locations of the fields were considered to strengthen the survey. Commercial producers were also asked to indicate a 'good' or 'healthy' field that is close to a 'bad' or 'unhealthy' field according to their experience and perception. This gave us the opportunity to sample a diverse range of soil samples and potentially can help us identify the parameters contributing to the productivity and stakeholders' perception of the field.

Figure 1. A crucial discussion going on before the soil sample collection. (Photo. Dr. Debankur Sanyal)

Soil samples were collected at 0-12" depth, using soil probes, and then samples were processed and analyzed at Sanyal Lab for SHIs. Soil samples were also sent to a commercial lab to measure basic soil chemical properties. A description of soil health indicators (SHI) measured are given below:

<u>Soil organic matter (SOM) percent:</u> a universal indicator of soil health that indicates major storage of nutrients and carbon in the soil, helps in storing plant-available water, and aids better soil aggregation.

Soil Organic Carbon (SOC): Soil organic carbon is a measurable component of soil organic matter. Organic matter makes up just 2–10% of most soil's mass and has an important role in the physical, chemical and biological function of agricultural soils. SOC is the key element that determines soil quality, fertility, agricultural profitability, and atmospheric carbon dioxide (CO_2) fixation

Active carbon or POX-C: an indicator of the small fraction of SOM, also known as permanganate oxidizable carbon (POX-C), that can serve as a readily available food and energy source for the soil microbial community, thus helping to maintain a healthy soil food web to support optimum microbial activity.

Potentially mineralizable nitrogen (PMN): an indicator of the capacity of the soil microbial communities to mineralize nitrogen (N) tied up in complex organic residues into the plant available forms of N.

Soil respiration: a measure of the metabolic activity of the soil microbial community. As they respire or decompose SOM, CO_2 is evolved, this test measures CO_2 evolved during microbial metabolism as an indicator for soil microbial activity.

Soil Protein: an indicator of the amount of protein-like substances in the soil. It's a large pool of organically bound N in the SOM, which soil microbes can mineralize, therefore, protein content is well associated with overall soil health status, especially the N and carbon in soil.

Figure 2. The Soil Health crew is collecting soil samples in summer 2022 (Photo. Dr. Debankur Sanyal)

Wet aggregate Stability (60 mesh screen): The wet aggregate stability is determined on the principle that unstable aggregates will break down more easily than stable aggregates when immersed in water. Determining aggregate stability will give information on the sensitivity of soils to water and wind erosion, which might be prevented e.g., by mulching the soil surface. While studying salinization problems, determining wet aggregate stability using wet sieving is advantageous to design control measures against the deterioration of soil structure or to determine possible impacts of amelioration practices on aggregate stability.

Results and discussion

We have found that most of the soil parameter values were very similar for the ‘good’ and the ‘bad’ fields, except for three parameters: soluble salts (1:1), sodium levels, and active carbon or POX-C (permanganate oxidizable carbon), when we calculated ranges and averages of these values from summer and winter sampling cumulatively. The ‘bad’ fields had higher soluble salts and sodium content and lower POX-C content, whereas the ‘good’ fields had lower soluble salts and sodium content, and higher active carbon content. Now, we think from our personal communication with farmers that a ‘bad’ field does not only produce less, but also poses challenges with agronomic management practices like irrigation (water infiltration).

The most concerning data that we recorded are SHI data as all the values are low, and some SHI values (PMN, POX-C, soil respiration, and wet aggregate stability) are zero or close to zero, see table 2. This is concerning because these parameters are stable, and indicators for how well the soils provide nutrition to soil biota and crops. However, there are no existing threshold values for soil health indicators in the deserts, and these outcomes at least provide a baseline for ranges of soil health indicator values for the desert southwest. Furthermore, our study indicates the need for future research to find potential solutions for building healthier desert soils through sustainable agronomic management.

Table 1: Ranges (maximum and minimum) and the average (mean) of measured values for basic soil properties

Basic Soil Properties	**Bad Soil**			**Good Soil**		
	Max	**Min**	***Mean***	**Max**	**Min**	***Mean***
Soil pH (1:1)	8.60	7.90	*8.24*	8.80	7.80	*8.31*
Soluble Salts 1:1 (dS/m)	**2.56**	**0.25**	***0.92***	**1.17**	**0.25**	***0.61***
Carbon-nitrogen ratio (Soil)	28.6	17.9	*23.5*	29.4	18.5	*23.4*
Nitrate-N (ppm)	63.9	3.00	*29.5*	117	1.50	*20.0*
Olsen Phosphorus (ppm)	50.4	10.4	*19.4*	74.9	12.3	*22.7*
Extractable Potassium (ppm)	467	106	*271*	376	137	*240*
Sodium (ppm)	**725**	**105**	***382***	**318**	**134**	***229***
Sodium Saturation (%)	**10.0**	**2.00**	***5.15***	**5.00**	**2.00**	***3.35***
Cation Exchange Capacity (me/100g)	44.1	20.1	*31.7*	41.5	23.1	*30.4*

The average values of pH in these soils were recorded above 8.2 (table 1), which indicated sodicity problems in these soils that cause poor aggregation and soil structure as the measured stability values indicated (stability value: 0.25 for bad fields and 0.27 for good fields, see table 2). Sodium saturation above 3 is generally considered a critical limit for initiation of sodium problems including poorly structured soils and declined water infiltration rate. Therefore, the ‘bad’ fields had poor soil structure (physical properties) and less available carbon for microbes as indicated by the POX-C values. These research outcomes strengthen the conceptual framework for soil health management in the desert environment and indicated future research areas to explore more options to ameliorate unhealthy soils.

Please refer to the supplementary material for all research data measured during this project.

Table 2: Ranges (maximum and minimum) and the average (mean) of measured values for the selected soil health indicators

Soil health indicators	**Bad Soil**			**Good Soil**		
	Max	**Min**	***Mean***	**Max**	**Min**	***Mean***
Soil Organic Matter (%)	2.50	0.70	*1.55*	2.40	1.00	*1.63*
Soil Organic Carbon (%)	1.18	0.34	*0.88*	1.22	0.46	*0.87*
PMN (μg N/gram soil/ week)	16.7	0.00	*4.37*	17.9	0.00	*4.00*
Active carbon or POX-C (mg/kg soil)	**422**	**0.00**	***248***	**412**	**28**	***278***
Soil Respiration (mg CO_2/g soil)	1.57	0.14	*0.47*	1.28	0.11	*0.50*
Soil protein (g/kg soil)	1.80	0.38	*1.00*	1.36	0.54	*0.90*
Wet aggregate stability (60 mesh)	0.80	0.00	*0.25*	0.79	0.00	*0.28*

Conclusion

Overall, this study demonstrates the existing soil health condition in the commercial fields of Yuma and indicates potential areas to improve soil health. It is well-known that salinity and sodicity issues exist and potentially make it harder to build healthier soil systems. We have also recorded soil organic matter values above 2% which indicates many of these selected farms are practicing soil health principles. But as a soil health research and extension team, we believe that there are areas to improve and build healthier desert soils in Yuma, and the larger desert southwest. Future research should study different soil health management approaches in commercial fields and measure soil health parameters to see if we can improve soil health following these approaches.