Poultry manure effects on soil minerals in a flood irrigated sandy-loam pastureland

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Introduction

Interest in the use of poultry manure as a soil amendment has grown along with increased concern of sustainable resource use and recycling on Arizona farms, particularly in organic production systems. According to Mpanga et al. (2020a), manure application in Arizona increased by 30% from 2012 to 2017. Application of poultry manure to soil has numerous benefits such as increasing soil fertility, improving soil texture and structure, and increasing soil water infiltration, organic matter content, and microbial activity (Koelsch K., 2018). However, poultry manure application could also have negative consequences including increased soil salt content, the potential for zoonotic disease transmission in vegetable production, and objectionable odors. This bulletin reports on an evaluation of the effects of poultry manure application on soil minerals on a Northern Arizonan sandy loam soil with flood irrigated pasture (Figure 1 and 2).

Figure 1: Pastureland with grazing cattle at the University of Arizona Cracchiolo DK Ranch Experiment Station, Cornville, Arizona. (Picture by Isaac Mpanga)

Study area and methods

Study Area and soil properties: The study was conducted at the University of Arizona Cracchiolo DK Ranch experiment station (Figure 1) at Cornville in the Verde Valley, Yavapai County, Arizona, USA. Based on the Natural Resources Conservation Service (NRSC) soil map, the area is under the soil survey name Black Hills-Sedona Area (Coconino and Yavapai Counties Soil Survey-AZ639). Area elevation is 3,000 to 5,000 feet with a slope range of 0 to 3 percent, annual precipitation of 12 to 16 inches, annual air temperature is about 59 to 67 oF (15-19 oC), and 180 to 220 frost-free days. The soil is *Swisshelm* with fine sandy loam (43-85% sand, 0-50% silt, and 0-18% clay) soil taxonomy classification. The soil is well-drained with slow run-off and moderate permeability, pH $_{(water)}$ range of 7.9-8.4, and cation exchange capacity of 0.1 – 16 meq/100g.

Manure source, mineral composition, and application rates, irrigation, and soil sampling: The poultry manure (sourced from Hickman's Family Farms, Buckeye, Arizona) with estimated mineral compositions as in table 1 was surface applied using a spreader at a rate of 2 tons acre^{-1} year^{-1} in split applications (first application in spring and the second application in September). Soil sampling for 2020 was done in March at 6 inches depth before the year's spring manure application.

The irrigation method used was flooding only in the late spring to late fall without winter irrigation. Water is let out from the open ditches through valves and allowed to gently flood fields completely (Figure 2).

Mineral analysis: All minerals analysis were done at the Texas A&M AgriLife Extension Service Soil, Water and Forage Testing Laboratory (http://soiltesting.tamu.edu/) using their standard protocols.

Table 1: Estimated mineral composition of the poultry manure. (Sourced from Hickman's Family Farms, Buckeye, Arizona).

Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total Na (%)	Total Zn (%)	Total Fe (%)	Total Cu (%)	Total Mn (%)	Total S (%)	Dry Matter (%)
3.84	2.63	2.21	11.93	0.76	0.70	654.08	132.04	63.77	557.79	6906.2	30.2

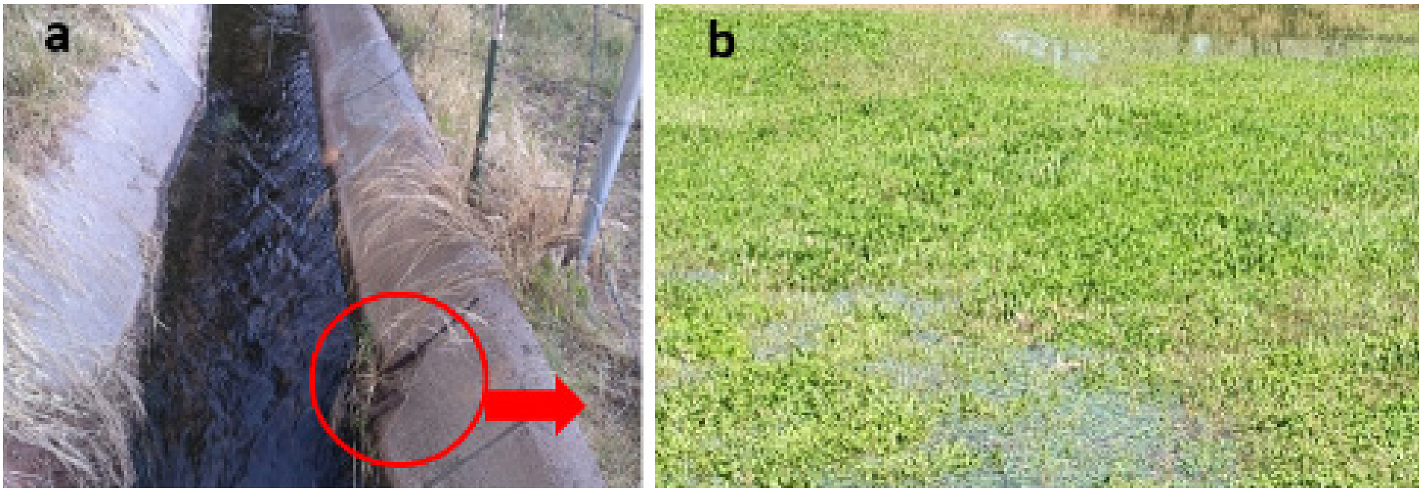

Figure 2: Open ditch with flowing water and valve (a-picture by Charlee Morgan Boroski) and flood irrigation field (b-picture by Isaac Mpanga) at the University of Arizona Cracchiolo DK Ranch Experiment Station. The red circle and arrow indicate the valve and direction of water flow from the ditch to the field.

Result and discussion

Manure effects on soil pH and cation exchange capacity (CEC), and soil nutrition: Poultry manure application did not impact soil pH, which remained unchanged three years after manure application (Figure 3a).

In contrast, CEC in the low CEC sandy loam soil was elevated (Figure 3b) by poultry manure application (Table 1). The application of poultry manure changed levels of some available soil nutrients from 2017 (prior to poultry manure application) to 2020 (after three years of annual poultry manure application) (Figure 3). Most notably, plant-available phosphorus increased from 4 to 25 ppm. Potassium, Ca, S, and Mg increased by 18, 45, 244, and 31%, respectively. The micronutrients Zn and Mn increased by 5 and 19%, whereas Fe and Cu levels decreased by 38 and 11%, respectively (Figure 3c-i). The reduction in Fe in the soil after three years

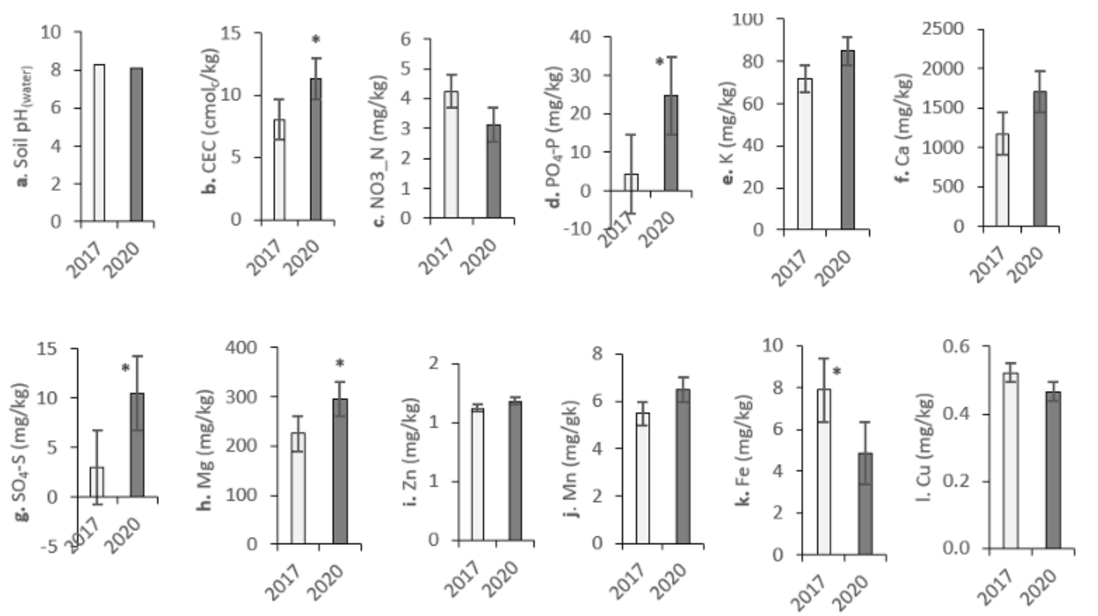

Figure 3: Soil chemical properties of organic transitioning fine sandy loam pastureland after three years poultry manure application under flood irrigation with no-till (Percentage figures above the bars represent the changes from 2017 to 2020; *=significant in t-test at p=0.05)

of poultry manure application with high Fe values (Table 1) can be associated with the high soil pH (8.1) since Fe is mostly available at low soil pH (Nanda et al., 2014).

Nitrate leaching from manure and compost applications: Nitrate is very mobile in the soil can easily be washed away by surface run-off or water infiltration into deeper horizons. For example, the Low nitrate (Figure 3c) in the soil could be associated with leaching (moving nutrients into deeper layers of the soil by rapid vertical water movement in the soil profile) because of the flood irrigation method (Figure 2; Hoover et al. 2019). The leaching is even more prominent in sandy soil due to the large particle sizes with high porosity. These can be reduced by; 1) planting cover and catch crops when the main commercial crops are not growing in the field. The cover crops hold up the nutrients in the plant tissue and prevent it from leaching or been wash away. The cover crops should have good deep root systems that will enable them to recycle deeper layers of nitrate onto the upper layer. 2) Avoid incorporating manure and compost too deep into the soil layers (not deeper than 5 inches). 3) Adding zeolite during composting or application of manure could also be a great way to reduce nitrate losses from manure and compost application in the field. Zeolite has a porous structure with a high cation exchange capacity that enables it to capture and minerals. It also improves water holding capacity and reduces run-off, which could help save nitrate losses (Nahkli et al., 2017; Mpanga, 2020b). 5) Use irrigation systems that allow slow movement of water across the soil profile, such as drip and sprinkler irrigation.

Conclusion

Poultry manure is a beneficial resource alternative to chemical fertilizers, especially among small-scale farmers and organic producers but needs to be managed well using best management practices to harness its fullest potentials without compromising human and environmental safety. Incorporate immediately after application, use irrigation systems that move water slowly through the soil profile such as drip and sprinklers with periodic flood irrigations to manage salt build-up in the soil if there are no occasional heavy rains in your area. Also, follow food and environmental safety recommendations such as meeting the application days before harvest (120 days for specialty crops and 90 for grains) or composting to avoid pathogen contaminations and environmental pollution.

References

1. Fageria N. K, Nascente A.S. (2014). Management of Soil Acidity of South American Soils for Sustainable Crop Production. Advances in Agronomy. 128, 221-275.
2. Hoover N. L., Ji Yeow Law, Leigh Ann M. Long, Ramesh S. Kanwar, Michelle L. Soupir (2019). Long-term impact of poultry manure on crop yield, soil and water quality, and crop revenue. Journal of Environmental Management 252. https://doi.org/10.1016/j.jenvman.2019.109582
3. Koelsch R. (2018). Does Manure Benefit Crop Productivity? Environment? https://water.unl.edu/article/animal-manure-management/does-manure-benefit-crop-yield-nitrogen-loss-or-soil-carbon
4. Mpanga, K. I, Neumann, G., Schuch, U. K., & Schalau, J. (2020a). Sustainable Agriculture Practices as a Driver for Increased Harvested Cropland among Large-Scale Growers in Arizona: A Paradox for Small-Scale Growers. Advanced Sustainable Systems, 4(4), [1900143]. https://doi.org/10.1002/adsu.201900143
5. Mpanga K. I., Walworth J, Braun H., (2020b). Zeolite application in crop production: Importance to Nutrient, Water, Soil Health, and environmental pollution management. University of Arizona Cooperative Extension bulletin, az1851.
6. Nakhli, S.A.A., Delkash, M., Bakhshayesh, B.E. et al. (2017). Application of Zeolites for Sustainable Agriculture: a Review on Water and Nutrient Retention. Water Air Soil Pollut 228, 464 (2017. https://doi.org/10.1007/s11270-017-3649-1

Further reading resources

Manure Use and Management. https://cals.arizona.edu/animalwaste/farmasyst/awfact8.html

Cornell University Produce safety alliance training manual (2019).https://producesafetyalliance.cornell.edu/curriculum/grower-training-manual-links/module-3/

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