Soil Surface Chemistry As Influenced By Long-Term Glyphosate-Resistant Corn and Soybean Production in the Central Great Plains

Augustine K. Obour[1], Phillip W. Stahlman[1], and Johnathon D. Holman[2]
[1]Kansas State University, Agricultural Research Center, Hays, KS
[2]Kansas State University, Southwest Research & Ext. Center, Garden City, KS

Introduction

Glyphosate [(N-phosphonomethyl) glycine] is the predominant herbicide used for weed control worldwide, largely due to widespread adoption of glyphosate-resistant (GR) crops. Growing GR crops and glyphosate application could have direct and indirect consequences on soil chemistry through changes in soil organic matter (SOM) accumulation and nutrient cycling. Glyphosate is known to chelate divalent metals and can form complexes with nutrient cations. Chelation of metal cations by glyphosate in the soil could affect nutrient availability and uptake by crops (Bott etal., 2008; Cakmak et al., 2009). Glyphosate competes for the same sorption sites on the soil exchange complex as phosphorus (P). This could affect P cycling in soils with long-term glyphosate usage. Despite the potential effect of GR crop production on soil chemical properties, limited research has been done to elucidate the impacts of glyphosate application on soil chemical properties.

Objectives

Determine crop residue quality, SOM content, soil chemical properties after long-term glyphosate use and GR crop production.

Materials and Methods

- Location: K-State University Northwest Research & Extension Center, Colby, KS.
- Design: RCBD with split-plot arrangement of treatments.
- Main plots- 2 crop rotations;
  Continuous corn (CC),
  Corn and soybean [corn-soybean (CS).
- Sub-plot – 4 herbicide treatments
  - I. Glyphosate at 0.42 kg a.e ha^{-1} + ammonium sulfate (AMS) at 2% w/v applied in-crop twice each year (TRT1);
  - II. Glyphosate at 0.84 kg ha^{-1} + AMS at 2% w/v applied twice in-crop each year (TRT 2);
  - III. Glyphosate at 0.84 kg ha^{-1} + AMS at 2% w/v applied twice in-crop every other year alternated with non-glyphosate herbicide treatment in both crops (TRT 3); and
  - IV. Non-glyphosate herbicide treatment for each crop in all years (TRT 4).
- Herbicides for the non-glyphosate treatments for both crops were changed infrequently in an effort to improve weed control.
- Soil samples were collected at the beginning of the study in spring of 1998 and fall 2013 at 0 to 15 cm soil depth, and analyzed for soil chemical properties following KSU standard soil test procedures.
- Surface residue samples were randomly collected from four 1-m^2 quadrats in the central rows and composited for each plot after harvest in 2013.

Results & Discussion

Table 1. Soil surface residue amounts and quality measured in 2013 as affected by crop rotation.

Crop Rotation	Residue	Total N	Total C	C:N ratio
	kg ha^{-1}	g kg^{-1}		
Corn-corn	5836 a	12.8 b	375 a	30.2 a
Corn-soybean	3727 b	15.2 a	381 a	26.1 b
Standard error	468	1.0	8.0	1.9

- Herbicide treatment had no effect on quantity or quality of soil surface residue measured in 2013. Residue amounts and quality differed between CC and CS crop production (Table 1). Greater surface residue in the CC crop production was expected because aboveground biomass production of corn is greater than soybean.
- Soil surface residue N content was greater in CS than the CC cropping system, probably due to higher N concentration of the soybean residue in the CS.

Table 2. Soil chemistry in the upper 0-7.5 cm depth measured in 2013 as affected by crop rotation.

Crop Rotation	pH	SOM	P	K	Fe	Mn
		g kg^{-1}	mg kg^{-1}			
Corn-corn	7.0 a	32 a	97 a	871 b	18.7 a	53.3 a
Corn-soybean	7.4 b	27 b	77 b	925 a	7.0 b	31.0 a
Standard error	0.1	1.4	6.2	25	1.2	3.2

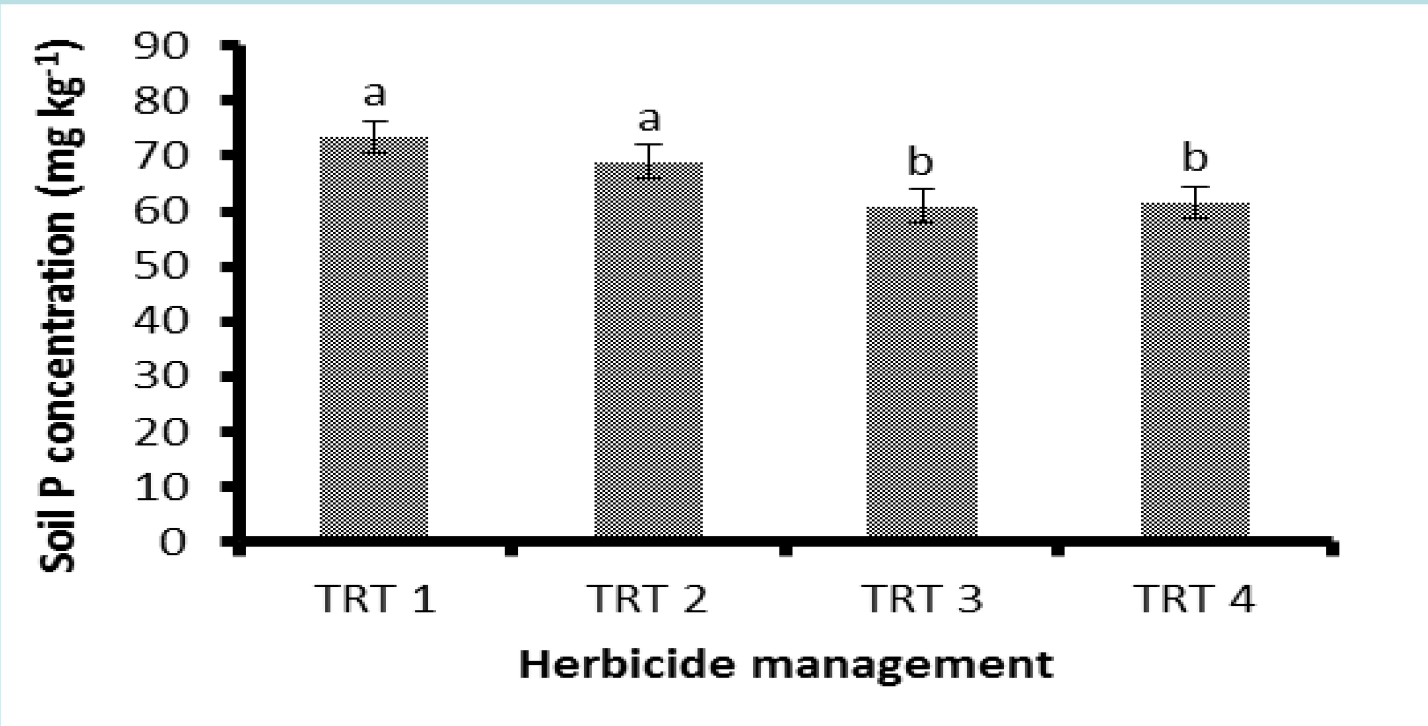

Fig. 1. Soil P concentration measured in 2013 as affacted by long-term herbicide application.

- Crop rotation and soil sampling depth affected pH, NO_3-N, exchangeable Ca, K, Mg, Fe, Mn, Zn, and P concentrations.
- Continuous corn production reduced soil pH, but SOM, and plant nutrient concentrations in the top 7.5 cm of the soil profile increased with CC production (Table 2).

Cont. Results & Discussion

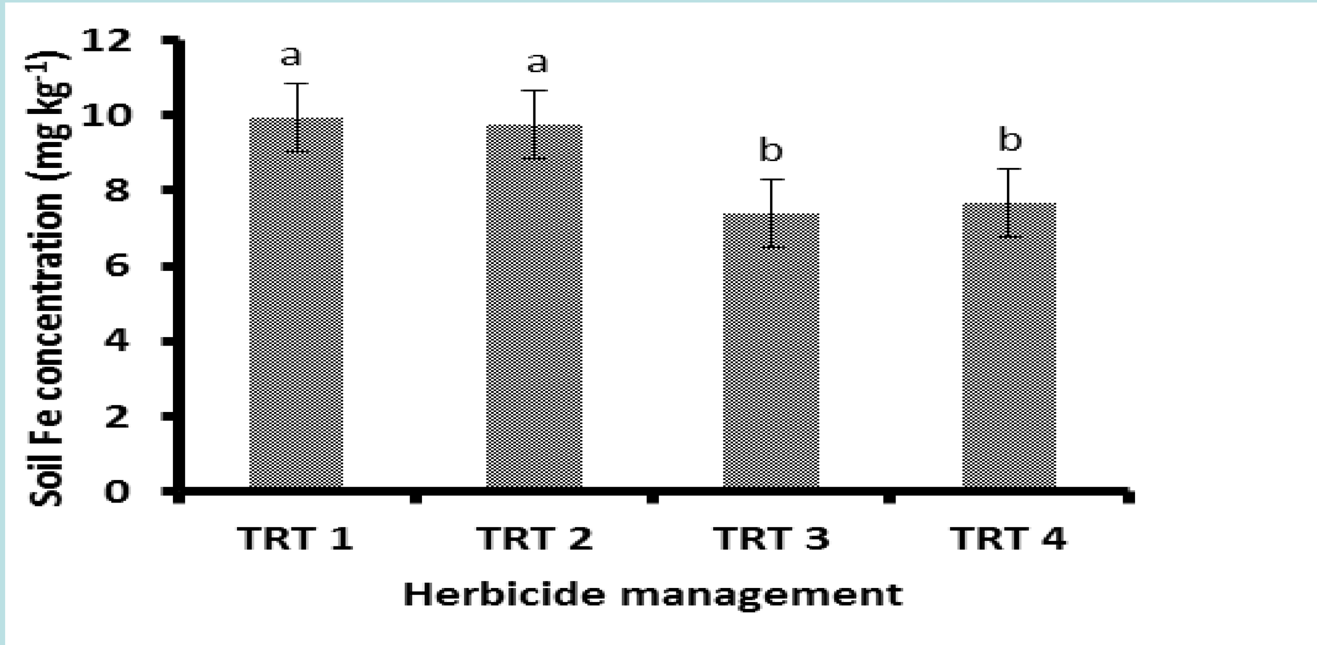

Fig. 2. Soil Fe concentration in 2013 as affected by herbicide application.

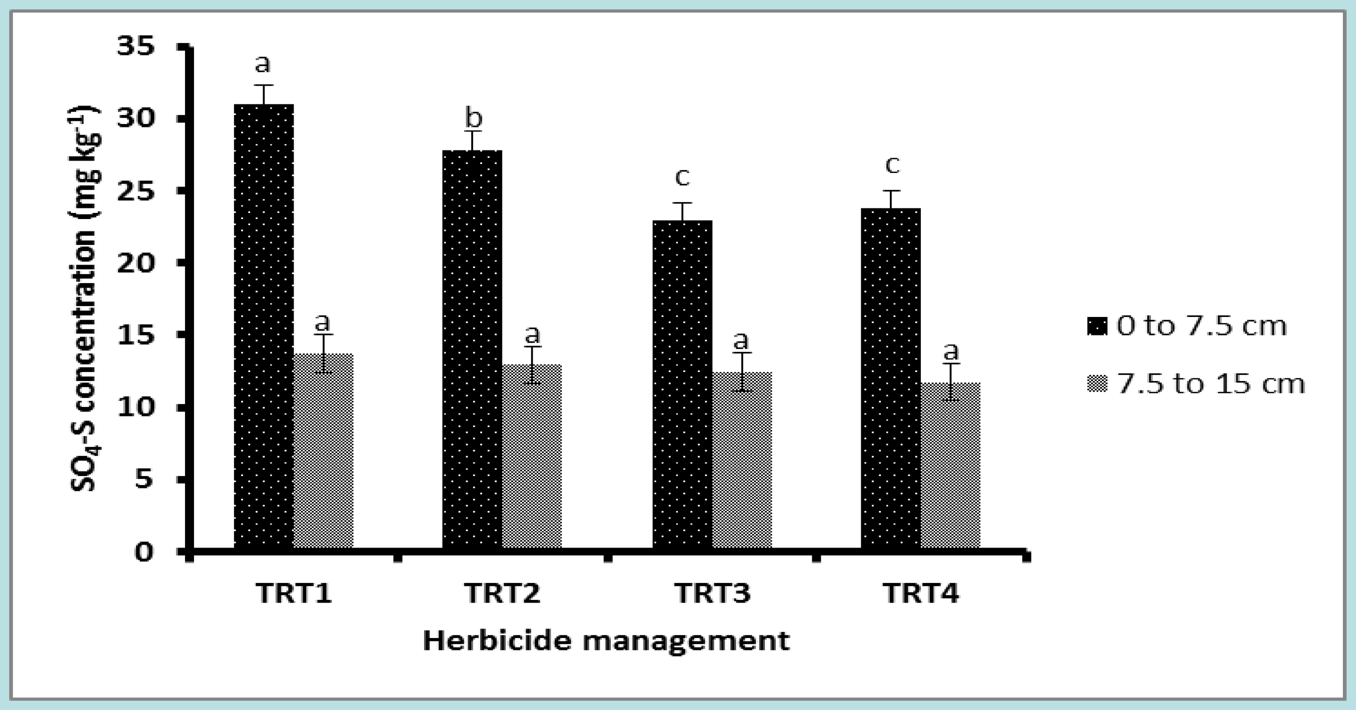

Fig. 3. SO_4-S concentration in 2013 as affected by long-term herbicide application.

- Herbicide treatments had no effect on soil pH, SOM, exchangeable Ca, K, Mg, Mn or Zn concentrations.
- Extractable soil P and Fe concentrations increased with long-term glyphosate application (Fig. 1 & 2).
- SO_4-S concentrations increased with glyphosate use (Fig. 3), probably due to addition of AMS in glyphosate tank mixes.

Conclusions

- Herbicide application and crop rotation could affect soil chemical properties in GR crop production systems.
- Crop type and cropping system seem to have more profound effect on soil chemistry compared to herbicide treatment.
- Overall, cropping systems with CC increased soil fertility in the upper surface compared to CS production.

References

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- Cakmak, I., Yazici, A., Tutus, Y., Ozturk, L., 2009. Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium, and iron in non-glyphosate resistant soybean. Eur. J. Agron. 31:114-119.