Impact of long-term wheat production management practices on soil acidity, phosphorus and some micronutrients in a semi-arid Plinthosol

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Introduction

Disposal of crop residues either by burning or removal, has become a common practice in many countries including South Africa due to their nuisance effect during tillage operations. Owing to unprecedented price hikes for fertilizers as well as dwindling purchasing power and limited credit facilities to farmers, proper crop residue management in agro-ecosystems has been tipped to be a potential replacement for chemical fertilizers. Of course burning is another form of recycling nutrients intact in crop residues, but has been deemed unsustainable to soil quality, resulting in its termination in some countries. Proper crop residue management can improve soil fertility for sustainable crop production, especially in arid to semi-arid zones where evaporation rates are high and rainfall is low and erratic.

Aims

- To evaluate the influence of different wheat production management practices on acidity and some essential nutrients from a long-term trial.
- To establish whether differences in wheat grain yield occurred as a result of the applied wheat production management practices.

Material and Methods

This study was conducted in a long-term wheat trial that was established in 1979 at the ARC-Small Grain Institute (28°9'S, 28°9'S; 1680 m above sea level) near Bethlehem in the Eastern Free State. The trial is on the land type Ca6n defined as a plinthic catena with Plinthustalfs .

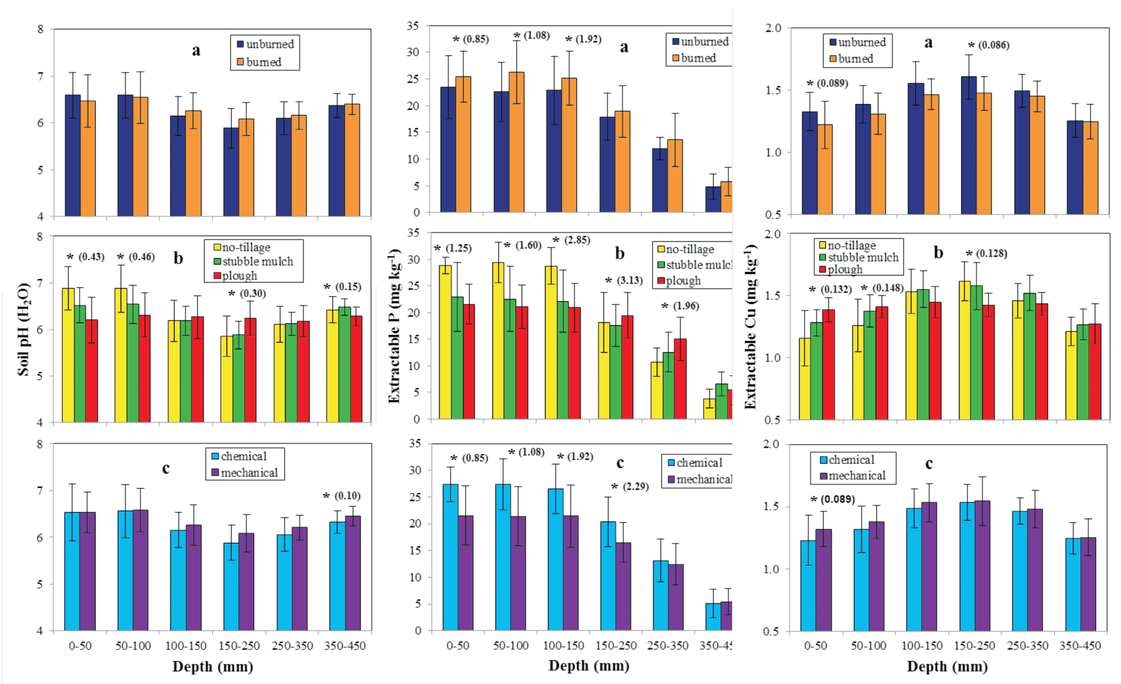
A randomized complete block design was used to layout the experiment, with each block comprising 36 field treatments: two straw management methods (unburned and burned), three tillage methods (no-tillage, stubble mulch and ploughing), two weed-control methods (chemical and mechanical) and tree levels of N fertilization (30, 40 and 60 kg N ha-1). Soil samples were collected in 2010 from plots that received 40 kg N ha-1 at depth intervals of 0-50, 50-100, 100-150, 150-250, 250-350 and 350-450 mm and analyzed for pH (1:2.5 soil to water suspension), P (1 mol NaHCO3 dm-1 at pH 8.5) as well as Cu, Fe, Mn and Zn (DTPA method).

Every year from 1979-2010, immediately after harvesting wheat straw in no-tilled, stubble mulched or ploughed plots was burned or left unburned. In the cultivated treatments, the burned straw was disked with a two-way disc to 150 mm followed by ploughing to 250 mm; stubble mulch was no disked but roots were cut to 100-150 mm with a V-blade and then ripped with a 50 mm width chisel plough at 300 mm spacing; no-tilled plots were not ploughed. Weed control was carried out by mechanical cultivator or by spraying a chemical – Paraquat, which was used in place for Roundup. All plots were disturbed slightly with a combined seeder-fertilizer used for planting Triticum aestivum L. cv. Betta/Elands and 3:2:0 (25) + 0.75% Zn fertilizer application.

Results and Discussion

The field treatments applied for 32 consecutive years showed a strong influence on some of the measured parameters at various soil depths:

- Burned wheat straw increased P and Mn but not Cu when compared to unburned straw. Burning releases nutrients tied up in plant biomass more quickly than decomposition, meaning the response of P and Mn to straw burning did not come as a surprise. Cu however, behaved differently from both P and Mn.
- No-tillage and to a certain extent stubble mulch resulted in a higher soil pH, P and Zn relative to mouldboard ploughing, especially in the surface layers. In contrast, mouldboard ploughing improved Cu to a 100 mm depth compared to the other two tillage systems. In these two tillage systems, organic matter concentration was higher in the upper layers but dropped with increasing soil depth. Therefore high organic matter affinity for Cu could be the cause of lower Cu concentration in no-tilled and stubble mulched plots.
- Chemical weeding increased P concentration, presumably due to application of Paraquat but resulted in a lower pH and Cu values when compared to mechanical weeding.
- Irrespective of the applied field treatments all the measure nutrient concentrations, including Fe that was not influenced by any of these treatments, and pH values were within acceptable ranges for wheat growth and yield. This was demonstrated by the calculations of the weighed means in the 0-150 and 0-250 mm soil depths (Data not presented). Despite that, burned straw, no-tillage and stubble mulch resulted in a lower wheat grain yield compared to unburned straw and mouldboard ploughing. This came as a surprise because nutrient accumulations in the former three treatments were higher than in the latter. Rainfall could not be attributed to this phenomenon as it remained almost the same throughout the period of this trial. Soil fertility levels are also out of question. Therefore a multidisciplinary approach is needed to identify and rectify problems that led to lower yields in the said treatments.



Effect of straw management (a), tillage (b) and weed control (c) methods on soil pH, P, Cu, Mn and Zn. HSD_T-values are shown where applicable. Vertical capped lines indicate standard deviation.

Effect of straw management, tillage and weeding methods on wheat grain yield (t ha-1) over 32 years

Period	Straw			Tillage				Weeding		
	Unburned	Burned	HSD_T	No-tillage	Mulch	Plough	HSD_T	Chemical	Mechanical	HSD_T
1979-2010	2.28	2.12	0.04	2.11	2.19	2.28	0.07	2.20	2.19	ns
1979-1990	2.19	1.99	0.07	2.04	2.07	2.16	0.11	2.07	2.17	ns
1991-2000	1.94	1.90	ns	1.85	1.90	2.02	0.15	1.94	1.90	ns
2001-2010	2.47	2.25	0.08	2.33	2.29	2.46	0.11	2.38	2.35	ns

HSD_T significant at $P < 0.05$
ns = non -significant

Conclusion

- The tested wheat production management practices have shown a great potential in improving soil fertility.
- More work needs to be done to rectify problems associated with yield especially in conservation tillage systems.
- Correction of such problems hopefully can accelerate adaptation of these tillage practices in South Africa.

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