Apparent Zinc Balances in Irrigated Cotton-Wheat Aridisols: Significance in Predicting Soil Resource Sustainablity?

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INTRODUCTION

Widespread zinc (Zn) deficiency in cotton (*Gossypium hirsutum*, L.) and wheat (*Triticum aestivum* L.) is well established in alkaline-calcareous soils of Pakistan (Rashid, 2005; Rafique et al., 2006). The >3.0 million ha irrigated cotton-wheat soils – predominantly Aridisols – are no exception (Rashid, 1996; Ahmed et al., 2010). Fertilizer Zn use is recommended for both crops (Rashid, 2005). However, the consequence of crop Zn mining and Zn addition by fertilization is inadequately understood/reported.

In a 5-year study, the impact of balanced and integrated nutrient managements was investigated on cotton-wheat productivity and apparent major nutrient (i.e., N, P, K) balances in two irrigated Aridisols. During the process, apparent soil Zn balances were also estimated.

MATERIALS AND METHODS

A 5-year permanent layout cotton-wheat field experiment was conducted at Multan (30° 12 N, 71° 28") on two irrigated Fluventic Camborthids to compare the impact of farmers' fertilizer use (FFU, i.e., Cotton - 110 kg N ha^{-1}; wheat, 80 kg N ha^{-1}, 26 kg P ha^{-1}), balanced nutrient management (BNM, i.e., Cotton - 170 kg N ha^{-1}, 26 kg P ha^{-1}, 5 kg Zn ha^{-1}, 1 kg B ha^{-1}; wheat, 140 kg N ha^{-1}, 44 kg P ha^{-1}) and integrated nutrient management (INM, i.e., BNM + FYM), with and without crop residue (cotton stalks and combine-harvester left-over wheat straw) receycling, on crop productivity and soil nutrient balances. Both soils were calcareous ($CaCO_3$, 2.2, 3.7%), and low in organic matter (0.60, 0.85%), P (AB-DTPA P, 2.2, 3.5 mg kg^{-1}), Zn (AB-DTPA Zn, 0.48, 0.72 mg kg^{-1}), and B (HCl B, 0.28, 0.40 mg kg^{-1}). Surface soil texture of site no. 1 was coarse loamy mixed and of site no. 2 was fine silty mixed.

For apparent balances, we considered Zn input through canal and tubewell irrigation, rainwater, farm yard manure (FYM), crop residue, and fertlizer. Soil Zn removals pertained to harvested crop products and residue removed from the field. Mean Zn concentrations were used.

RESULTS

- 5-year mean yields (Mg ha^{-1}) with FFU were: cotton – coarse loamy soil , 2.19; fine silty soil, 2.49; wheat – coarse loamy soil, 3.03; fine silty soil, 3.94.
- With BNM, 5-year mean yield increases were substantial: cotton – 24% in coarse loamy soil, 18% in fine silty soil; wheat – 37 % in coarse loamy soil, 24% in fine silty soil.
- With INM, yield increases were 3–5% more than with BNM. INM also improved soil organic matter (SOM).
- Crop residue recycling increased the yields futher, 2-7% of cotton and 2-10% of wheat.
- All nutrient management treatments, including FFU, resulted in positive Zn balances in both soils (Table 1).

CONCLUSIONS

Despite year after year positive Zn balanaces – even with Farmers' Fertilizer Use practices, the prevalence of widespread Zn deficiency in cotton and wheat crops on >3 million ha calcareous soils in Pakistan suggests that added Zn is rapidly fixed into non-available pools.

Though nutrient balances are considered useful for understanding soil sustainability for supplying N, P, K, etc, apparent balances appear to be of little value in terms of predicting Zn deficiencies.

Table 1. Apparent Zn balances (kg ha^{-1}) in two irrigated Aridisols under a cotton-wheat system.

	Crop res.	Total Zn input*	Total Crop uptake	5-year apparent balance	Crop res.	Total Zn input*	Total Crop uptake	5-year apparent balance
Flat bed	**Coarse loamy soil**				**Fine silty soil**			
Without residue								
FFU		1.41	0.85	0.56		1.41	0.85	0.56
BNM		26.41	1.25	25.16		26.41	1.25	25.16
INM		27.01	1.34	26.67		27.01	1.34	25.67
With residue								
FFU	0.38	1.79	0.91	0.88	0.38	1.79	0.91	0.88
BNM	0.55	26.96	1.36	25.60	0.55	26.96	1.36	25.60
INM	0.61	27.62	1.47	26.15	0.61	27.62	1.47	26.15
Raised beds								
Without esidue								
FFU		1.27	0.92	0.35		1.27	0.92	0.35
BNM		26.27	1.35	24.92		26.27	1.35	24.92
INM		26.87	1.46	25.41		26.87	1.46	25.41
With residue								
FFU	0.40	1.67	0.97	0.77	0.40	1.67	0.97	0.70
BNM	0.60	26.87	1.47	25.40	0.60	27.87	1.47	26.40
INM	0.65	26.92	1.58	25.34	0.65	27.52	1.58	25.94

*5-year Zn input: Fertilizer (in BNM & INM treatments), 25 kg ha^{-1}; Irrigation water (all treatments) – flat bed, 1.32 kg ha^{-1}; raised bed, 1.18 kg ha^{-1}; rainfall (all treatments), 0.09 kg ha^{-1}

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