Value of Soil Macro- and Micro-nutrient Balances in Predicting Fertilizer Needs of Irrigated Cotton-Wheat Aridisols?

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Sustained productivity of >3 million ha irrigated cotton (*Gossypium hirsutum* L.)-wheat (*Triticum aestivum* L.) in alluvial, low organic matter Aridisols of Pakistan is pivotal to its food security and economy. Both crops suffer with deficiency of nitrogen (N), phosphorus (P), boron (B) and zinc (Zn) (Rafique et al. 2012a). Despite N and P fertilizer use, productivity levels are low. We investigated effectiveness of apparent soil nutrient balances in predicting crop fertilizer needs.

METHODOLOGY

A 5-year field study was conducted at Multan, Pakistan (30° 11´ N, 71° 28´ E) on two predominant cotton-wheat soil series, (i) Awagat (Coarse loamy mixed, hyperthermic Fluventic Camborthid) (ii) Shahpur (Fine silty mixed, hyperthermic Fluventic Camborthid), with following nutrient treatments:

1) Farmers' fertilizer use (FFU*);
2) Recommended fertilizer use (RFU), soil test-based;
3) Integrated nutrient management (INM): RFU + farmyard manure (FYM).

* FFU – cotton, 110 kg N ha^{-1}; wheat, 80 kg N + 26 kg P ha^{-1}; RFU – cotton, 170 kg N + 26 kg P + 5 kg Zn + 1 kg B ha^{-1}; wheat, 140 kg N + 44 kg P ha^{-1}; INM – both crops, RFU + FYM.

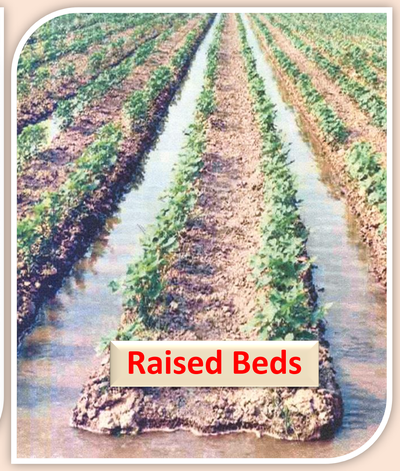
The treatments were tried with and without residue recycling (cotton stalks + wheat straw) in flat-bed and raised-bed cotton systems. In split-split plot layout, cotton sowing methods were in main plots, residue recycling in sub-plots, and nutrient managements in sub-sub-plots.

Table 1. Initial topsoil properties.

Property	Awagat soil	Shahpur soil
Texture	Coarse loamy	Fine silty
pH (1:1)	8.0	8.4
$CaCO_3$ (%)	2.2	3.7
Organic matter (%)	0.60	0.85
AB-DTPA P (mg/kg)	2.2	3.5
AB-DTPA K (mg/kg)	150	204
AB-DTPA Zn (mg/kg)	0.48	0.72
HCl B (mg/kg)	0.28	0.40

RESULTS

- Minimum yields (Mg/ha), obtained with FFU in flat beds without residue in year-1: Coarse loamy soil – cotton, 2.04; wheat, 3.09; Fine silty soil – cotton, 2.51; wheat, 3.77.



- Productivity potential of fine silty soil was greater; contrarily, yield increases with improved nutrient managements were lesser in this soil (Rafique et al. 2012a).
- Yield increases with RFU: Coarse loamy soil – cotton, 24%; wheat, 37%; Fine silty soil – cotton, 18%; wheat, 24% (P< 0.05); INM resulted in slightly higher yields. Crop residue increased yields on flat beds by 3−10% and raised bed by 9–10% (Rafique et al. 2012a).
- RFU and INM enhanced SOM (P≤0.05), more evidently in less SOM-having coarse loamy soil (Table 1; Rafique et al. 2012a).

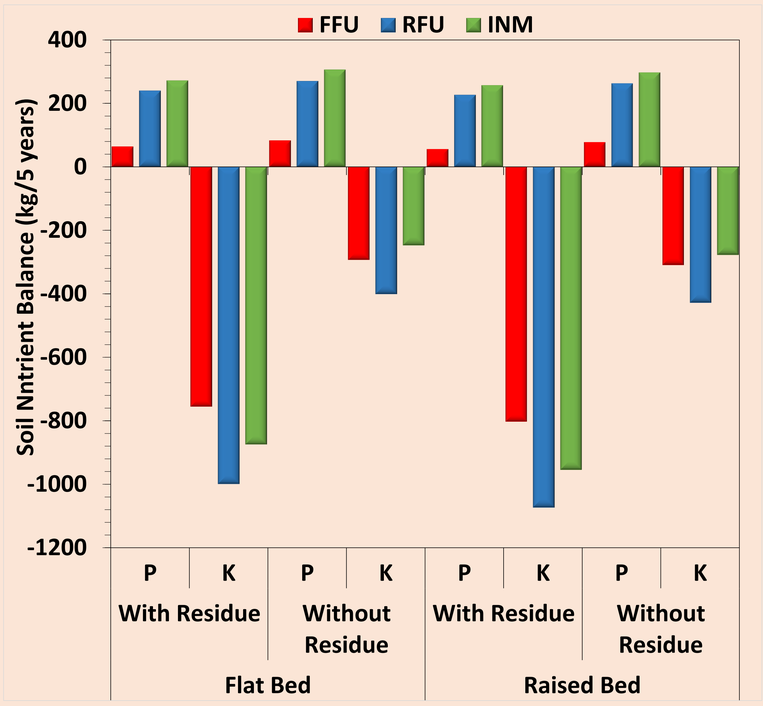


Fig. 1. Soil P and K balances in coarse loamy soil.

*__Apparent soil balances__: Inputs – fertilizer, FYM, crop residue, irrigation water, rainwater; Outputs – uptake by harvested plant parts (cotton seed, lint, bur, leaf and wheat grain & straw), crop residue removed, leaching, water erosion.

- Crop residue improved SOM and soil physical properties (Mahmood-ul-Hassan et al. 2013).
- Despite greater nutrient uptakes with improved nutrient managements and residue recycling, soil N, P, Zn and B status was also improved (P≤0.05; data not shown).
- With FFU, apparent soil K balances were negative; but P, B and Zn balances were positive (Fig. 1, 2).
- Despite positive P, B and Zn balances with FFU, both crops suffer with their deficiency.

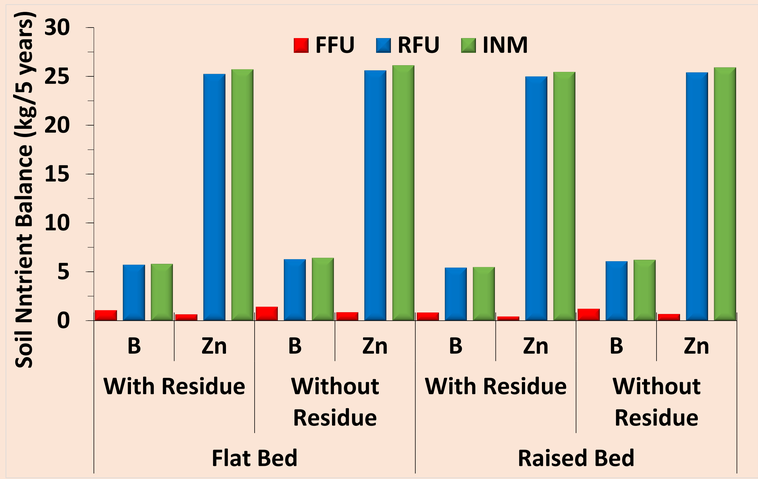


Fig. 2. Soil B and Zn balances in coarse loamy soil.

CONCLUSIONS

- Unlike soil K balances, P, B & Zn balances appear to be poor indicator of fertilizer needs. High fixation in the calcareous soils appears to cause the ambiguity.
- Soil test-based N, P, K, B, & Zn fertilizer use, along with FYM and crop residue, is recommended for sustaining crop productivity and the soil resource.

ACKNOWLEDGEMENTS

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