Phosphorus budgets in four irrigated grain-tomato systems

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INTRODUCTION

Phosphorus (P) inputs are required to replace soil P removed at harvest and avoid soil P depletion. However, the recovery of P inputs in crops is often low, resulting in inefficient P use. Many factors affect P input requirements and the P budget of a farm, including crop type, input rate and types (manures, composts, fertilizers), and internal recycling (e.g., by cover crops). We computed farm-gate P budgets for four grain-tomato systems to identify the long-term effects of different management practices on P cycling.

METHODS

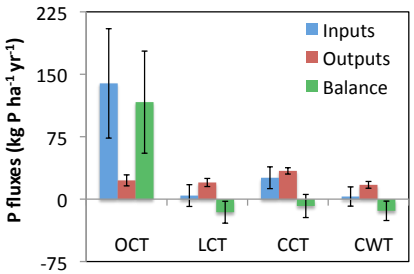
We computed farm-gate P budgets for four irrigated systems at Russell Ranch between 1993 and 2011:

OCT: Organic corn-tomato, with poultry manure and cover crops;
CCT: Conventional corn-tomato, with mineral fertilizers and without cover crops;
LCT: Mixed corn-tomato, with lower rates of mineral fertilizers than CCT and cover crops;
CWT: Conventional wheat-tomato, with mineral fertilizers and without cover crops.

Inputs: fertilizers, manure, plant seeds, and transplants;
Outputs: crop removal (= yields * P concentration);
Cover crops: P uptake and transfer to cash crops;
Fluxes ignored: weathering, dust, erosion, runoff, leaching.

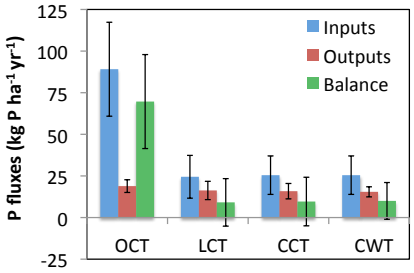
P use-efficiency (PUE) = Yield / P inputs
P recovery (%) = P uptake / P inputs * 100

RESULTS



Grains

- Highest inputs in OCT
- Similar crop removal among systems (higher in CCT)
- Large P surpluses in OCT vs. P deficits in other systems



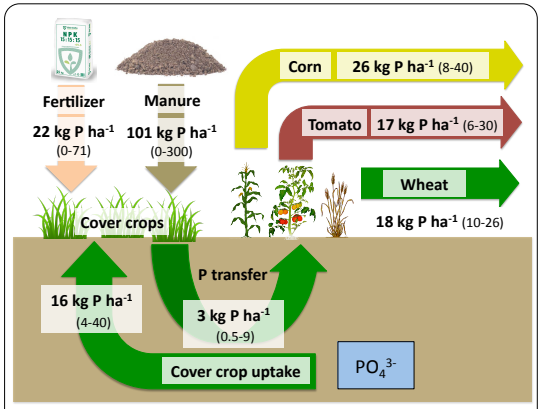
Tomato

- Highest inputs in OCT but smaller than grains
- Similar crop removal among systems (higher in OCT)
- P surpluses in all systems (larger in OCT)

Cumulative effects after 18 years

System	Balance	P use-efficiency	P recovery
	kg P ha^{-1}	kg yield kg^{-1} P	% inputs
OCT	1484	49	19
LCT	-37	350	121
CCT	19	301	97
CWT	-36	357	119

- Large P surplus in OCT vs. roughly balanced in other systems
- 6-7 fold lower PUE in OCT
- Low recovery of P inputs for OCT
- Only CCT avoids over- and under-fertilization



- Cover crop P uptake variable but comparable to fertilizer P inputs and cash crop P removal.
- P transfer to cash crops < 20% of other P fluxes, including P removal in cash crops.

CONCLUSIONS

- Large P surpluses in OCT by using poultry manure to meet crop N requirements;
- Increasing N inputs with N-fixation, urea or feather meal could lower P surpluses in OCT;
- Small deficits in LCT and CWT via insufficient P inputs during the grain phase - inputs could increase to reach P balance, similar to CCT;
- Cover crops have a minor but non-negligible contribution to P cycling in these systems.

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