Runoff phosphorus retention in vegetated field margins on flat landscapes

S.C. Sheppard, M.I. Sheppard, J.Long, B. Sanipelli & J.Tait (2006)
Presented by Bruno Bazzoni, Natalie Corrales & Adriana Rodríguez

Introduction

Vegetated buffer strips (VBS): any strip of vegetation between a river, stream or creek and an adjacent upland land use activity composed of native vegetation that is intentionally left intact, as well as vegetative buffers that are re-established, (Hickey & Doran, 2004).

- VBS are often recommended as a management practice that farmers can use to help mitigate the environmental effects of P runoff from agricultural fields.

- **The <u>objective</u> of this study was to obtain direct evidence of the efficacy of VBS on cropped land in south-east Manitoba (Canada).**

Advantages of establishing VBS :

- sorption of dissolved P or the fine soil particles that have accumulated in the VBS;
- uptake of P by growing vegetation;
- slowing the runoff flow rate to enhance infiltration of water and dissolved P and sedimentation of particulate P;
- filtration entrapment of particulate P from the runoff flow;
- improved soil permeability, because of root channels and earthworm activity, to enhance infiltration; and
- retention of snow, slowing runoff , and may indirectly enhance infiltration.

(Dabney *et al*., 2006; Syversen, 2005)

Disadvantages of VBS :

- the vegetation in the VBS becomes a source of dissolved P, which is a more problematic form than particulate P, because of leaching of P from living or senesced vegetation; and

- the P-retention capacity of the VBS is exceeded such that it no longer delivers an environmental benefit to offset the cost to the farmer.

(Hickey & Doran, 2004)

Methods & Materials

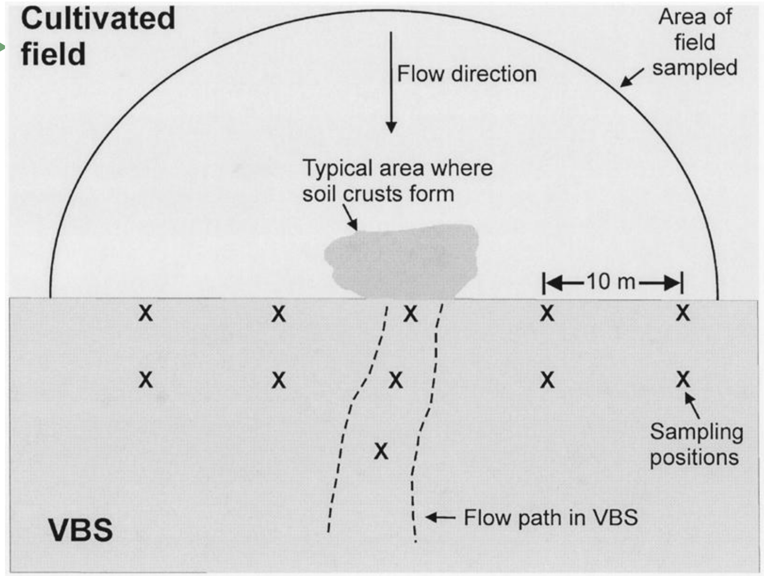
Research Design → 2 approaches:

1) decreased P concentrations in runoff passing through the VBS
2) soil P concentrations decreased with increasing distance from the field edge into the buffer strip.

Site Selection → 14 sites in 5 areas (different soil types, slope, neighbour crop, vegetation, manure application & available P content).

Run off sampling → sample sites included two or three weirs, one at the field edge and the others downstream along the apparent runoff flow path within the VBS. Sampling: from April to June of 2004 and 2005.

Soil sampling →



Analysis of Phosphorus in Runoff and Soils

Results & Discussion

• Field Observations

• For these flat landscapes rill and sheet erosion are rare or non-existent.

• Flow tends to focus toward relatively narrow outlets.

• The only runoff events successfully sampled were in the early spring prior to renewed plant growth.

• For the VBS to be effective, the initial P retention mechanisms could only be physical/chemical, such as filtration and infiltration, instead of plant uptake.

• The snow accumulation over the weirs was substantially more than in the cropped field, up to 1.5 m deep in April 2005. Thus, snow accumulation must be expected in VBS.

• There is an effect of flooding on VBS efficiency.

• The results for the sites S1 and S2 are presented and discussed in detail.

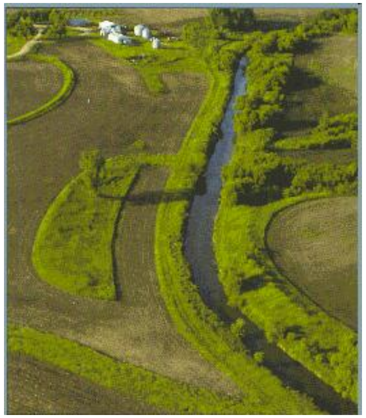
Effect on Runoff P Concentrations

Table 3. Runoff samples from sites S1 and S2, as an illustration of results. Site S1 on Apr. 01 and site S2 on Apr. 11 showed good VBS effectiveness with decreased P concentrations 5 m into the VBS compared to the edge of the field

Site	Date in 2005	Water source	Data source	Total P	Total dissolved P	Particulate P	Ortho P	Dissolved organic P
S1	Apr. 01	Snow	Edge (mg L^{-1})	3.01	2.92	0.09	2.76	0.16
S1	Apr. 01	Snow	5 m (mg L^{-1})	1.81	1.84	ND[z]	1.76	0.08
			Difference	1.20	1.08	0.09	1.00	0.08
			% reduction	40	37	100	36	50
S2	Apr. 04	Snow	Edge (mg L^{-1})	0.515	0.438	0.077	0.428	0.010
S2	Apr. 04	Snow	5 m (mg L^{-1})	0.517	0.466	0.051	0.449	0.017
			Difference	–0.002	–0.028	–0.026	–0.021	–0.007
			% reduction	0	–6	34	–5	–70
S2	Apr. 05	Snow	Edge (mg L^{-1})	0.302	0.238	0.064	0.237	0.001
S2	Apr. 05	Snow	5 m (mg L^{-1})	0.275	0.218	0.057	0.216	0.002
			Difference	0.027	0.020	0.007	0.021	–0.001
			% reduction	9	8	11	9	–
S2	Apr. 11	Rain	Edge (mg L^{-1})	0.256	0.14	0.116	0.095	0.045
S2	Apr 11	Rain	5 m (mg L^{-1})	0.102	0.082	0.020	0.041	0.041
			Difference	0.154	0.058	0.096	0.054	0.004
			% reduction	60	41	83	57	9

[z]ND, non-detectable, assumed to be zero for calculations of difference and % reduction.

- Sites S1 and S2 are on different fields of the same farm and presented low P concentrations in the VBS.
- Site S1 is in riparian grass and sedge and site S2 has mature trees with little groundcover vegetation.
- Site S1 on 2005 Apr. 01 and site S2 on 2005 Apr. 11 showed notable reductions in P concentrations.
- There was little or no difference in P concentrations in snowmelt runoff measured at the field edge and 5-m positions in S2 on Apr. 04 or Apr. 05.
- Note that the dissolved P (and total P) in the runoff decreased two- to threefold with time at this site from Apr. 04 to Apr. 11.
- A negative relationship between runoff P concentration and VBS effectiveness was not consistently evident.



Effect on Runoff P Concentrations

- 22 cases with valid paired samples were obtained.
- 11 cases showed that the VBS was effective in reducing P concentrations.
- **It is a concern** that in 4 cases, the VBS was an apparent source of P.
- For all sites, about 75% of the total runoff P was dissolved, mostly as ortho P, and about 25% was particulate.
- VBS were effective at lowering P concentrations in runoff in 50% of the cases, but appeared to be a source of P in about 18% of the cases.

Concentrations of Phosphorus in VBS Soil

•There was considerable spatial variation in available P in the VBS soils.

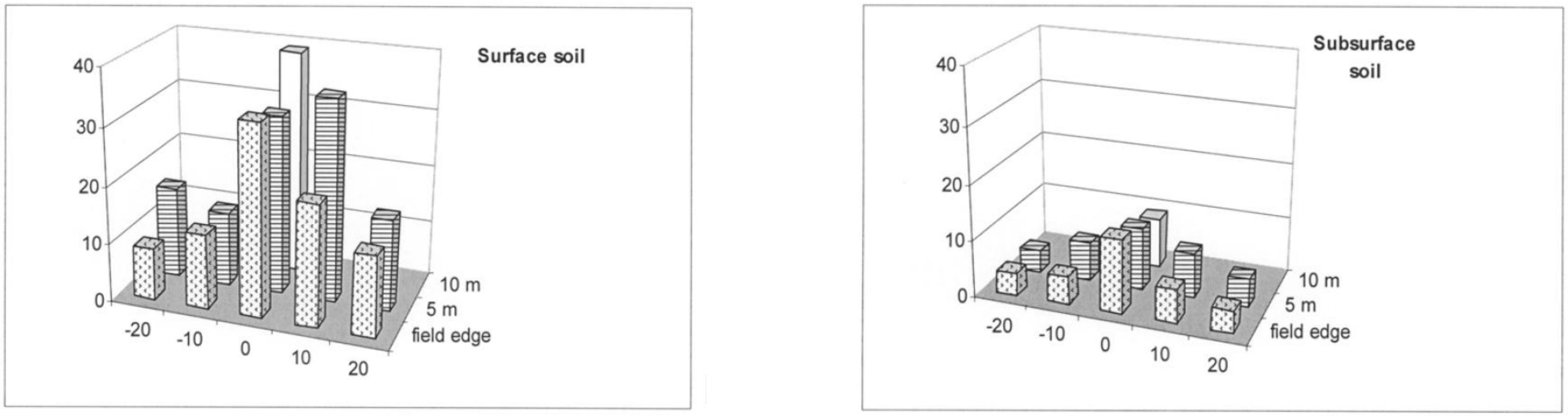


Fig. 3. Available P concentrations (vertical axis, mg kg^{-1}) in soils of the VBS at site S2. The x axis is distance from the runoff outlet (m) both directions along the field edge. The remaining axis is distance into the VBS (field edge, 5 m and 10 m). At 10 m into the VBS, only one sample was taken, in the flow path (as shown diagrammatically in Fig. 2). The surface soil is 0 to 2 cm and the subsurface is 8 to 10 cm

• There were notably higher available P concentrations at the runoff outlet and along the flow path into the VBS.
• Relatively small areas of the VBS actually play a role in mitigating P runoff. Additionally, this VBS was only about 15 m wide. Thus, a much longer flow path in the VBS would be required for the VBS soil P concentrations to be not elevated.

• Note that the soil was elevated in P concentration at 8- to 10- cm depth, therefore infiltration took place.

Concentrations of Phosphorus in VBS Soil

- There were cases in which the soil in the VBS at the field-to-VBS outlet had higher P concentrations than the bulk soil in the field (overall 33% higher but not statistically significant). Then there is potential for the VBS to become a source of runoff P.

- There were other cases where soil P concentrations decreased along the flow path into the VBS. Thus, the VBS show some ability to retain P; if the P-retention capacity of the VBS had reached its saturation value, the concentrations would not decrease with distance.

Conclusions

- **The VBS have potential to retain P from runoff. However, their effectiveness may be limited by at least two important factors:**

  1) Runoff flow on flat landscapes tends to occur along narrow flow paths, so that only very small portions of a VBS actually intercept runoff from the field edge.

  Vegetated swales that extend into the field along shallow gullies may prove more effective at retaining runoff P than a uniform-width VBS because of the increased contact between the vegetated soils in the swale and runoff.

  2) Effective VBS will necessarily be positioned in the topographic lows, these areas are prone to ponding of runoff water or flooding from connected surface water systems. In this way, increasing the prospect of loss of dissolved P from the VBS to the surface water systems.

Conclusions

- **The effectiveness of the VBS inevitably varies with time, on two scales:**

1) Within a year, the VBS probably functions to retain P both while under snow in the melt runoff, and later when there is active growth. However, the mechanisms involved and the relative effectiveness will vary with season. The mechanisms for retaining P during snowmelt may include that the VBS accumulates snow over winter and this snow slows runoff rates.

2) On another time scale of perhaps decades, as the VBS accumulates P the VBS may eventually become a source of P for runoff unless specifically managed to avoid this problem. Removal of vegetation seems the only effective management practice to remove P from the VBS.

Questions

1) What is the main findings of BS functioning in your paper?

2) Is there any doubts about the functioning of BS's as an ecosystem services given in your paper?

3) Can BS's in your opinion after reading the paper assist in reducing N and P loadings to surface waters (rivers, lakes and estuaries) – and how efficient?

4) If yes, to answer 3 is there any requirements about how to install and manage the BS's?

5) Can BS's assist in giving other services to ecosystems and if yes, please mention what kind of services and the eventual requirements of installation and management of BS's?