The effect of soil test P on export of P in overland and macropore flow from a tillage rotation

D Ryan
Teagasc, Crops Centre, Oak Park, Carlow, Ireland *Email: declan.ryan@teagasc.ie*

Introduction The export of phosphorus from grassland has been researched over several years but losses from tillage at field scale have not been recorded in Ireland. The phosphorus loss pathway from land to surface water is primarily by overland flow (OLF) but some P loss is in macro-pore flow (MPF) which is soil water flowing through cracks and wormholes to field drains. The object of this experiment was to monitor total P (TP) loss from a cereal rotation in a tillage farming system.

Materials and methods The trial was set up on free-draining silty sandy loam underlain by glacial sands and gravels. Three plots, 1, 2 and 3 with areas of 0.7, 1.0 and 1.0 ha respectively had gradients of 0.5 to 6 % towards a line of surface drains connected to V-notch flow meter/samplers measuring overland flow, one monitor set for each of the three plots. Eighteen macro-pore samplers, each with a straight 0.075 x 1.2 m tube with a water sampler close to the bottom and installed in the soil at 45^0, were installed on a grid pattern in the three plots. Overland flow was recorded continuously from the 1/1/2005 to 31/12/2007 but MPF sampling took place at weekly/fortnightly intervals during January to April and October to December each year. The main treatment in this trial, soil test P (STP) was determined from soil samples. Only limited statistics were used on account of data variability. Comparisons used annual-average and plot-average for most parameters. In regression, a similar number of mean values were used on each side. Mean values could not be calculated for MPF data due to incomplete data so the median and mode were used. Total number of samples for STP, OLF, TP, MPF and sediment were 54, 1141, 267, 146 and 285 respectively.

Results and discussion The target soil P index values of 2, 3 and 4 in plots 1, 2 and 3 respectively were not achieved as plot 3 reached soil P index 3 only. Significant overland flow was expected from this site due to observations of flooding in the previous years. However total flow averaged only 13.8 mm y^{-1} compared to over 100 mm y^{-1} at sites fifty miles away. The range in annual OLF exceeded 300% over the period of the trial (Table 1) while the range in annual rainfall was only 25%. This illustrates that even moderate increases in rainfall volume and intensity, predicted under climate change could give rise to large increases in flooding.

Table 1 Annual values for STP and overland flow parameters compared

Year	Rainfall (mm)	STP (mg l^{-1})	OLF (mm y^{-1})	TP (mg l^{-1})	TP Load (kg ha^{-1} y^{-1})	Sediment (kg ha^{-1} y^{-1})
2005	731	5.9	5.4	1.01	0.04	92.3
2006	911	5.4	17.5	0.64	0.11	117.3
2007	842	7.1	18.1	0.60	0.18	109.0
Average(+/-SEM)	828	6.13+/- 4.5	13.8+/-130	0.75+/-0.19	0.11+/-0.0032	106+/-6300

The TP recorded at this site averaged 0.75 mg l^{-1} for the three plots. Its trend over time was downward which corresponds with the upward trend in OLF over the same period and indicates dilution as the process controlling TP (Table 1). It was expected that when the soil was fallow in winter 2006 and spring 2007, TP would have increased but this effect was not evident, being masked perhaps by variation in overland flow. Total P Load at an average of 0.11 kg ha^{-1} y^{-1} was low compared to the average for Irish Agriculture, 0.4 kg ha^{-1} y^{-1} (Tunney *et al.*, 1998) and most European catchments 0.2 to 2 kg ha^{-1} y^{-1} (Kronvang *et al.*, 2005). Sediment volume was also low at 106 kg ha^{-1} y^{-1} when losses of the order of 1000 kg ha^{-1} y^{-1} are not uncommon in the USA. In regression analysis, OLF was found to be fairly closely related to TP, P load and sediment. (R^2 = -0.62, 0.53, 0.67 respectively) but less significance was found in the relationship between the main treatment STP and TP (R^2 =0.35). Macropore samplers were erratic in that they produced samples on only some days and not always the same sampler. This limited the analysis of TP in MPF that could be performed so the median (1.59 mg/l) and mode (0.82 mg/l) were calculated but not the mean. These values are higher than the corresponding statistics for TP in OLF (median; 0.34 mg/l, mode; 0.1 mg/l) suggesting that TP in MPF is higher than TP in OLF. This was expected as TP accumulates in macropores.

Conclusions The quantity of overland flow measured on this site was low compared to other sites. While this is good news for tillage in Ireland, the shortage of flood data limited the accuracy of the trial. The risk of pollution from this site was low but it was still possible to delineate tentative relationships between OLF and some other parameters but the relationship between STP, the main treatment, and TP was poor. The technique that was used for sampling MPF needs to be improved if TP loads are to be calculated. Overall the absence of pollution from this site suggests that tillage land is not a major source of P in surface water but more information is required to confirm this.

References

Tunney, H., Carton, O., O'Donnell, T. and Fanning, A. 1998. Phosphorus loss from soil to water. End of Project Report 4022, ISBN No. 1 84170 012 X.

Kronvang, B., Bechmann, M., Lundekvam, H., Behrendt, H., Rubaek, G.H., Schoumans, O.F., Syversen. N, Andersen, H. E. and Hoffmann, C.C., 2005. Phosphorus losses from agricultural areas in river basins: effects and uncertainties of targeted mitigation measures. Journal of Environmental Quality 34 6, 2129-2144.

https://doi.org/10.1017/S2040470010002359 Published online by Cambridge University Press