No-till mulch-based maize cropping on sloping lands in northern Vietnam reduces soil loss and surface runoff

Tran Sy Hai*[1], Didier Orange*[2], Tran Duc Toan*[1], Pham Dinh Rinh[1], Dorian Decraene[2], Delphine Zemp[2], Nguyen Duy Phuong[1], Jean-Louis Janeau[2], Pascal Jouquet[2], Christian Valentin[2]

[1] Soils and Fertilizers Research Institute, VAAS, MARD, Hanoi, Vietnam

[2] IRD, UMR211-BIOEMCO, University of Paris 6, France; posted at SFRI, Hanoi, Vietnam

Corresponding authors:

transyhai@gmail.com, didier.orange@ird.fr, toantransfri@gmail.com

In the Dong Cao experimental catchment in Tien Xuan Commune, Thach That, Hanoi District (Podwojewski et al. 2008; Valentin et al. 2008), we compared 'dead mulch/no-tillage' (DMNT) and farmers' traditional (FT) systems of maize cropping on sloping lands. The experiment was funded by the PAMPA/RIME project of l'Agence Française de Développement. The objective was to measure surface runoff and soil loss at the field scale and the microplot scale (Janeau et al. 2003; Phan et al. 2012).

Two fields (600 m² for FT and 1400 m² for DMNT) were each equipped with a concrete sediment trap at their foot slope to collect eroded soil and surface runoff after each rain event. In each field we set 3 erosion plots of 1 m² each to measure soil loss and surface runoff.

In the DMNT field, maize was planted 5 cm deep directly through mulch composed of rice straw and weeds equating to 5 Mg/ha of dry matter. In the FT field, the farmer tilled the soil to a depth of 10–15 cm, piled the weeds and then burned them.

Maize was planted in both fields along the contour (70 cm between rows, 30 cm between plants). The crops received 120 kg N, 52 kg P and 75 kg K/ha in 2010 and 2011, and 100 kg N, 44 kg P and 75 kg K/ha in 2012 (to reduce the quantity of weeds regrowing).

Compared with the 10-year average rainfall (975 mm), the rainfall during the cropping season (April to August) was very low in 2010 (660 mm), very high in 2011 (1310 mm; >25% above the average) and average in 2012 (at 1060 mm) (Bernard-Jannin et al. 2011). The soil moisture was measured monthly at three points in each field, the soil compaction twice a year (before and after the rainy season) and the soil loss and surface runoff after each rainfall event. Soil loss is the sum of the bed load (the quantity of sediment collected inside the sediment trap) and the suspended load exported by the surface runoff, adjusted for area (Valentin et al. 2008).

Soil moisture was always greater under DMNT, mainly at the beginning of the cropping season in May (by 10% to 100% of FT).

In August, just before harvest, the increase was only 3% to 6%. After 3 years, the resistance to shear strength, which reflects the resistance to rill and gully erosion, was slightly higher in DMNT (3.46 ± 0.84 kg/cm²) than in FT (2.79 ± 0.99 kg/cm²), possibly because annual tillage in FT loosens the soil. This difference shows that interpreting results from DMNT should include not only changes in organic matter content and faunal activity, but also changes in soil physics.

In the microscale plots, surface runoff was greater under DMNT (5 L/m²/y) than under FT (2 L/m²/y) (Fig. 1). Soil loss was similar between the two systems (0.8 g/m²/y; Fig. 2), implying more effective erosion under FT than under DMNT.

Figure 1. Mean annual surface runoff (L/m²/y) on 1-m² erosion plots under farmers' traditional system (FT) and dead mulch/no-tillage system (DMNT).

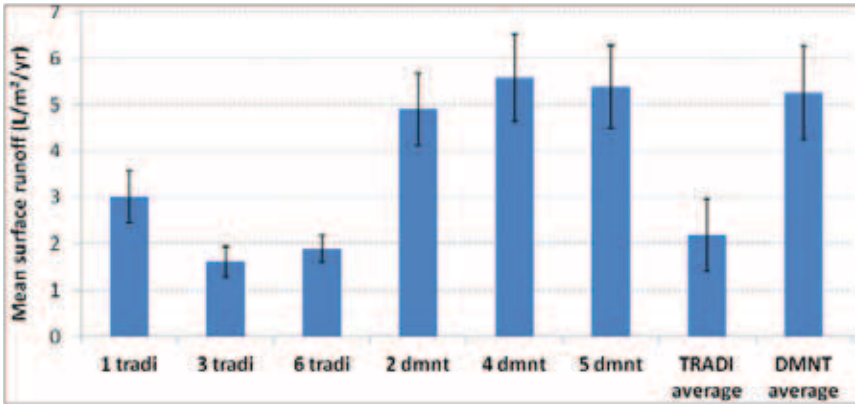
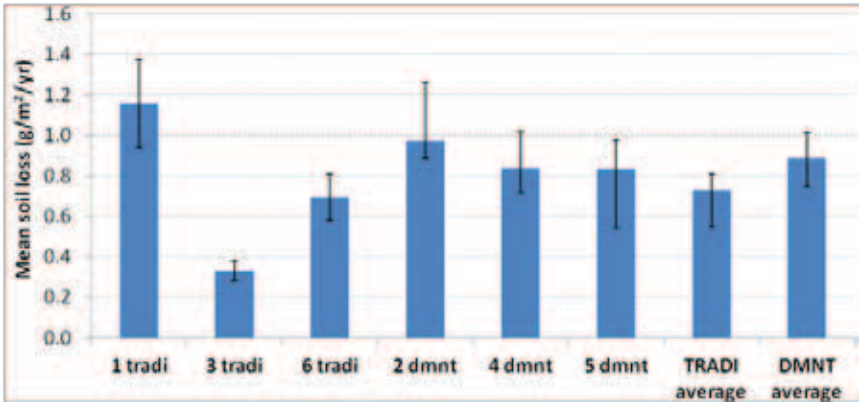


Figure 2. Mean annual soil loss (g/m²/y) on 1-m² erosion plots under farmers' traditional system (FT) and dead mulch/no-tillage system (DMNT).



Since soil moisture and soil compaction were greater under DMNT, we assume that soil saturation was reached faster under DMNT, which is why runoff was greater at the micro-scale than at the field scale, but this surface water was less erosive under DMNT.

At the field scale, soil loss was much greater under FT than under DMNT (Table 1), at >140 Mg/ha in 2010 and 2011 (The very low soil loss in 2012 was due to the absence of rain in April).

Table 1. Soil and nutrient losses under farmers' traditional system (FT) and dead much/no-tillage system (DMNT).

	2010		2011		2012	
Terms	FT	DMNT	FT	DMNT	FT	DMNT
Soil loss (Mg/ha)	145.13	1.35	150.57	0.03	0.421	0.033
OC (kg/ha)	4266.8	42.7	4381.6	0	12.2	1.04
N (kg/ha)	333.8	3.0	316.2	0	0.9	0.07
P (kg/ha)	56.38	0.57	60.44	0	0.2	0.02
K (kg/ha)	204.8	2.5	237.5	0	0.7	0.08

We assume that the soil loss was highest in 2010 in spite of the weak rainfall because of the soil preparation in FT and the weeding of shrubs in DMNT. At the field scale, surface runoff was much less under DMNT than under FT, the opposite of the results at the micro-scale. The difference between scales is explained by the appearance of more gullies along the slopes in FT (0.165 m/m²) than under DMNT (0.102 m/m²).

At the catchment scale, we measured significant differences between export of suspended load and bed load. Under FT, bed load was responsible for >95% of the soil loss, whereas under DMNT, suspended load was responsible for nearly 100% of the loss. Nutrient loss with eroded sediment was higher under FT compared to DMNT.

Our results show that erosion is due largely to surface runoff in response to rainfall pattern. The differences in soil compaction and soil cover explain the greater sensitivity of the soil under FT to erosion. This local process is emphasised at the field scale by the appearance of gullies.

Keywords

Soil erosion, surface runoff, dead mulch no tillage

References

Bernard-Jannin L, Orange D, Pham DR, Henry-des-Tureaux T, Laissus M, Jouquet P, Tran DT. 2011. The contribution of erosion in a small cultivated hilly catchment of north Vietnam due to an exceptional rainfall event. Geophysical Research Abstracts, EGU General Assembly 2011, 13, EGU2011-669.

Janeau J-L, Bricquet J-P, Planchon O, Valentin C. 2003. Soil crusting and infiltration on steep slopes in northern Thailand. European Journal of Soil Science 54: 543–553.

Phan HHA, Huon S, Henry-des-Tureaux T, Orange D, Jouquet P, Valentin C, De Rouwe A, Tran DT. 2012. Impact of fodder cover on runoff and soil erosion at the plot scale in a cultivated catchment of North Vietnam. Geoderma 177–178: 8–17. doi: 10.1016/j.geoderma.2012.01.031.

Podwojewski P, Orange D, Jouquet P, Valentin C, Nguyen VT, Janeau JL, Tran DT. 2008. Land-use impacts on surface runoff and soil detachment within agricultural sloping lands in Northern Vietnam. Catena 74: 109–118.

Valentin C, Agus F, Alamban R, Boosaner A, Bricquet JP, Chaplot V, de Guzman T, de Rouw A, Janeau JL, Orange D, et al. 2008. Runoff and sediment losses from 27 upland catchments in Southeast Asia: Impact of rapid land use changes and conservation practices. Agriculture, Ecosystems and Environment 128: 225–238.

The 3rd International Conference on Conservation Agriculture in Southeast Asia

Conservation Agriculture and Sustainable Upland Livelihoods
Innovations for, with and by Farmers to Adapt to Local and Global Changes
-
Proceedings

Hanoi, Vietnam
December 10-15, 2012
www.conservation-agriculture2012.org