Food and Agriculture Organization of the United Nations

GLOBAL SYMPOSIUM on SOILS and WATER

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Soil and water: a source of life

Soil and water conservation in oil palm plantations

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itps INTERGOVERNMENTAL TECHNICAL PANEL ON SOILS

GLOBAL SOIL PARTNERSHIP

https://www.cifor.org/knowledge/photo/38802487905

Oil palm land area in Malaysia: 5.8 mil. ha (18% of the country's total land area)

Average size of a commercial oil palm plantation: >2400 ha

Malaysia is the second highest palm oil production, after Indonesia, in the world.

Malaysia's climate characteristics

- Humid tropical: wet and hot throughout the year
  - without strong seasons
  - uniform air temperature throughout year: 21 to 33 °C
- Erosion by water is more of a serious concern than by wind
- Heavy and large rainfall
  - 1100 to 5000 mm
  - average 2500 mm
  - middle of the year tends to be dry, and more rain early and late in year
- Low wind speed: <2 ms^{-1}

Nutrients lost via leaching in some Malaysian oil palm plantations

Soil order	Annual rainfall (mm)	Palms ha^{-1}	Palm age (years)	Leached (% of applied fertilizer) N	P	K	Mg	Source*
Oxisols	1909	145	1	26.5	trace	19.5	169.4	1
	1495		2	10.9	trace	3.4	8.4	
	2729		3	12.2	1.4	10.4	53.6	
	2787		4	16.8	5.8	5.6	47.6	
	2391		5	2.7	1.7	1.9	5.4	
	2193		6	4.8	1.4	3.3	6.6	
Ultisols	2352	na#	na	10.4	na	5.1	na	2
Oxisols	na	na	1-4	16.6	1.8	9.7	69.8	3
			5-8	1.2	1.6	2.5	11.5	
			9-14	3.0	1.5	2.9	15.5	

*# na – not available; * Sources: 1 – Foong et al. (1983), 2 – Chang and Zakaria (1986), 3 – Foong (1993)*

- 10-20% losses in applied N and K nutrients for palm ages 1 to 4 years, but these losses declined to 1 to 5% for palm ages 5-14 years
- P losses low (P is immobile in acidic soils); N & K losses high because both are mobile in soil

Nutrients lost via runoff and eroded sediments in some Malaysian oil palm plantations

Soil order	Transport	Losses by erosion (kg ha^{-1} yr^{-1})					Source*
		N	P	K	Mg	Ca	
Ultisols	Runoff	9.93	1.43	10.40	1.82	4.04	4
	Sediments	5.57	3.63	8.79	21.10	7.40	
Ultisols	Runoff	5.85	0.90	26.90	5.20	na#	5
	Sediments	0.65	0.90	trace	0.10	na	

*# na – not available; * Sources: 4 – Maena et al. (1979), 5 – Kee and Chew (1996)*

- Runoff and sediment losses can be high due to heavy, intensive rainfall
- 11% of applied fertilizer are typically lost due to runoff and sediment losses
- Greater losses observed in compacted and uncovered soils (*e.g.*, harvesting paths)
- Losses depend on soil texture, palm age (canopy closure), topography, rainfall intensity, soil infiltrability, and lag between fertilizer application and rainfall

Cover crops

- Legumes popular
  - *Mucuna bracteata*, *Pueraria phaseolodies/javanica*
  - grows fast, with uniform and thick cover
  - easy to care
  - fix N
  - Disadvantages
    - grows fast also means climbs up the palm trees fast
    - need to weed/clear around the palm trees
    - no yield
      - can be harvested for biomass but not too frequently or cut too much
      - once every 6 to 12 months

https://wphoet.blogspot.com/2021/01/what-are-legume-cover-crops-lcc-for-oil.html

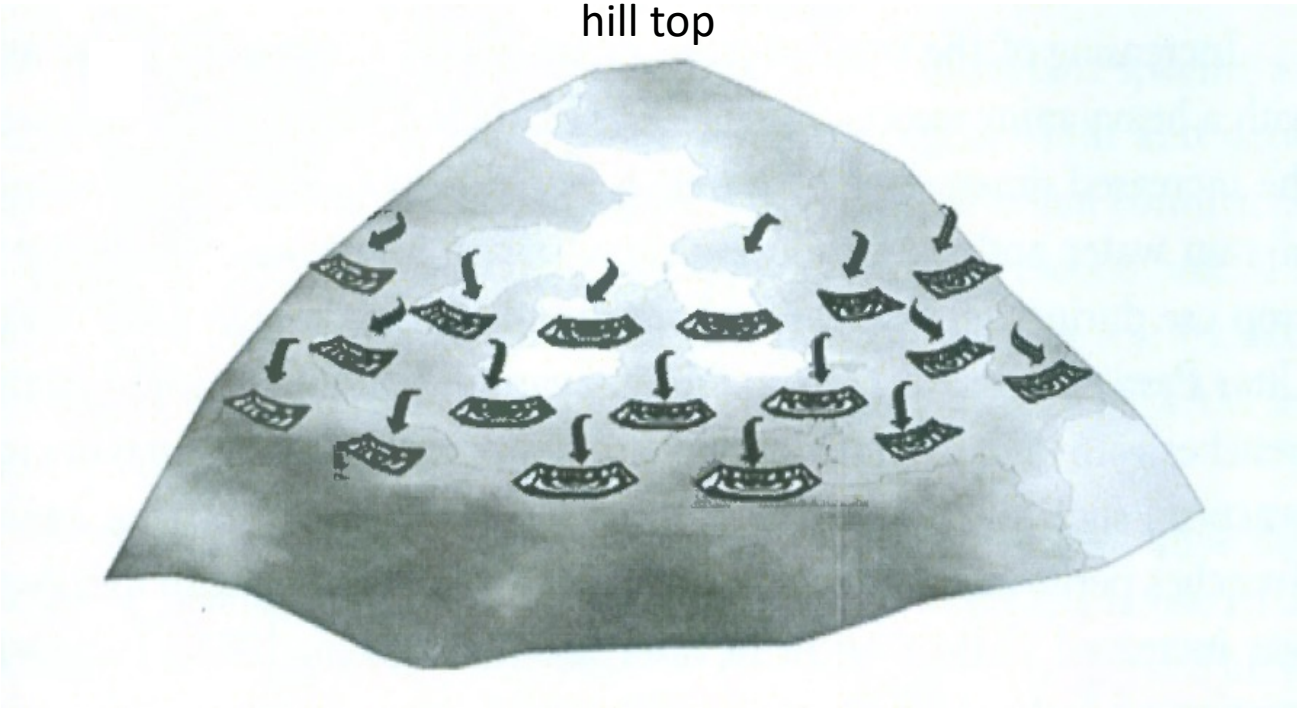
Surface mulching materials

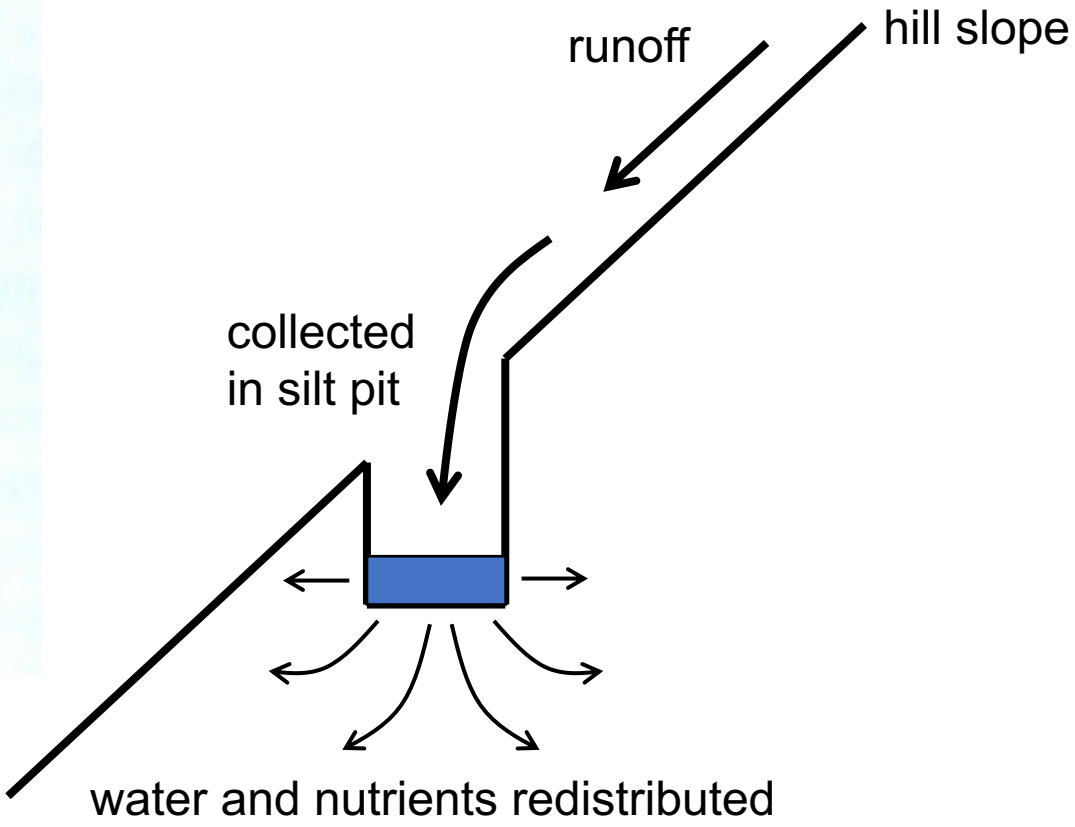
Empty Fruit Bunches (EFB)

pruned frond heap

silt pit

Silt pits (close-ended soil trenches)



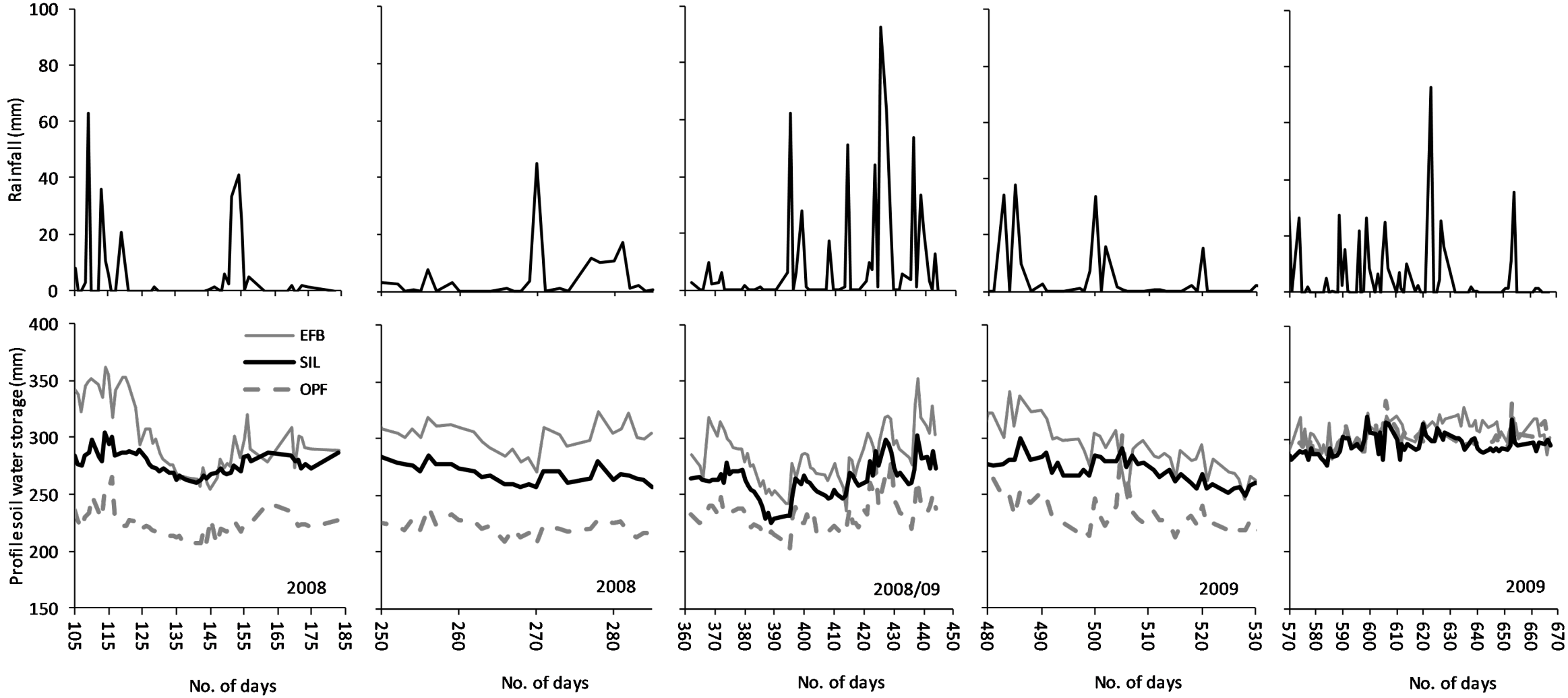


EFB vs Silt pits vs OP fronds

- Moraidi et al. (2012, 2014, 2015)
- Soil chemical properties, rather than soil physical properties, were more affected by addition of organic matter
- Soil physical properties, such as bulk density, total porosity, and water retention at saturation and permanent wilting point were not significantly affected by the conservation practices
- But compared to OP fronds, empty fruit bunches (EFB) significantly increased
  - soil aggregate stability by 32%
  - soil aggregation by 5%
  - soil water content at field capacity by 13%
  - soil available water content by 31%, and
  - relative proportion of soil mesopores by 14%

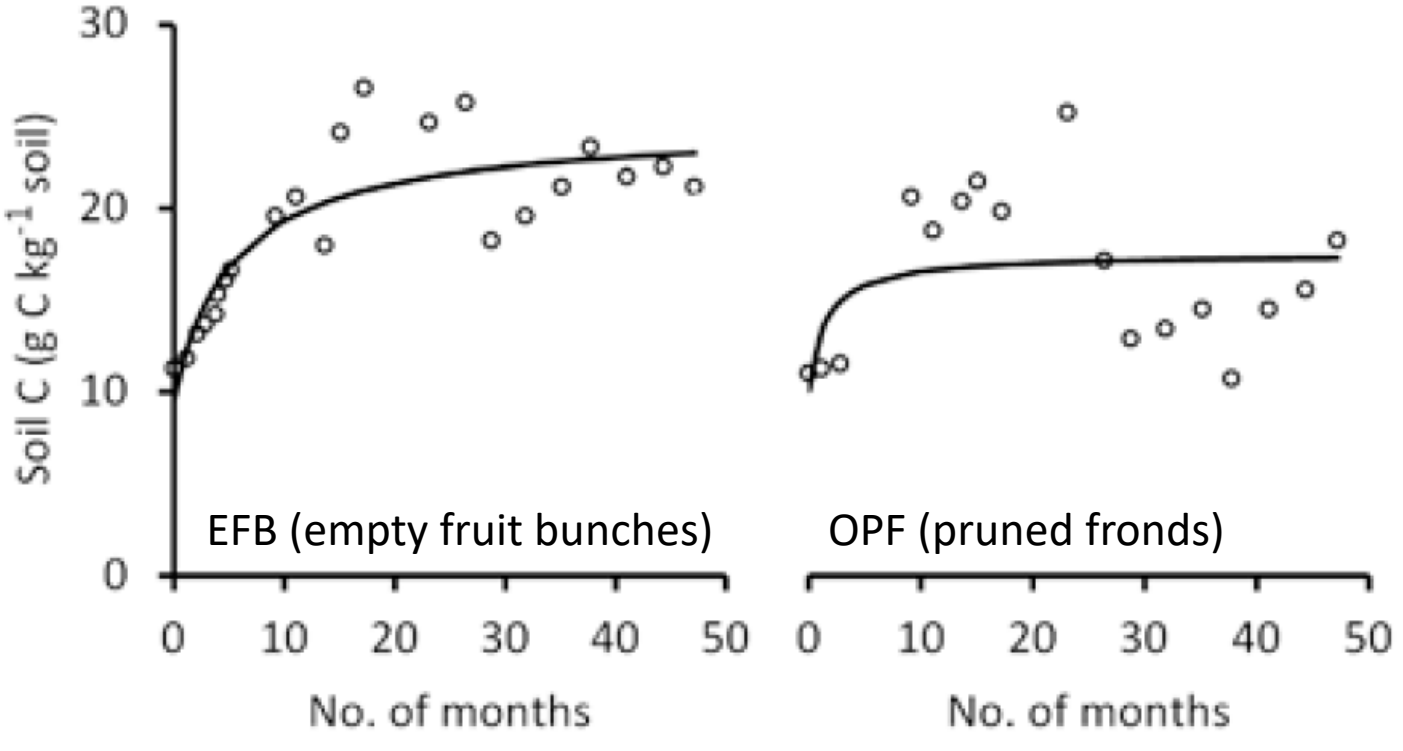
- Average daily water content in the whole soil profile (0-0.75 m depth) was 20 and 8% higher in EFB treatment compared with the OP fronds and silt pit, respectively
- Silt pit was not as effective as EFB in increasing the soil water content in the top soil layer where oil palm feeding roots would be mostly located
    - instead, silt pit tended to increase the soil water content in the lower soil layers due to the depth of the silt pit floor
- Overall, EFB was the best soil and water conservation practices on non-terraced oil palm plantations

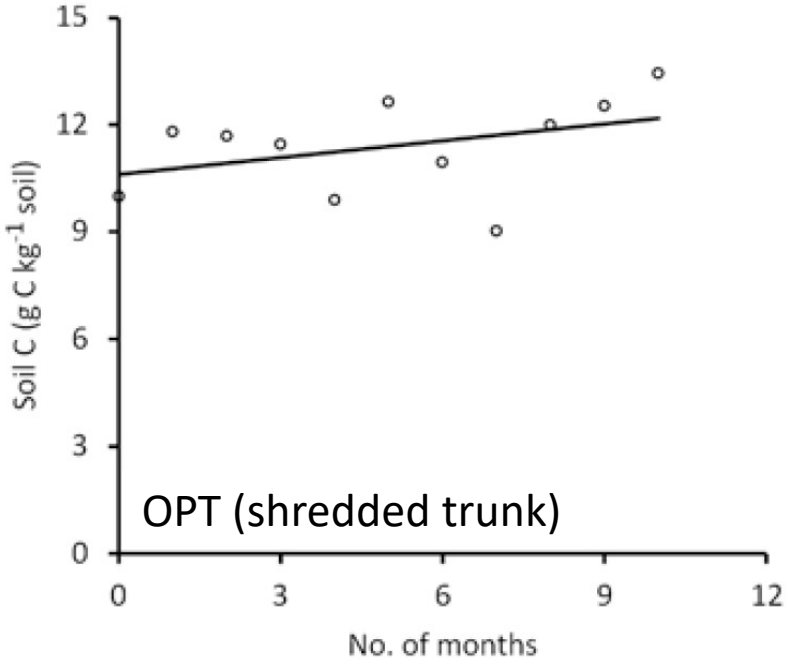
Mean over 2 years: EFB = 296 mm; SIL = 275 mm; OPF = 247 mm



Shredded OP trunk

soil C levels



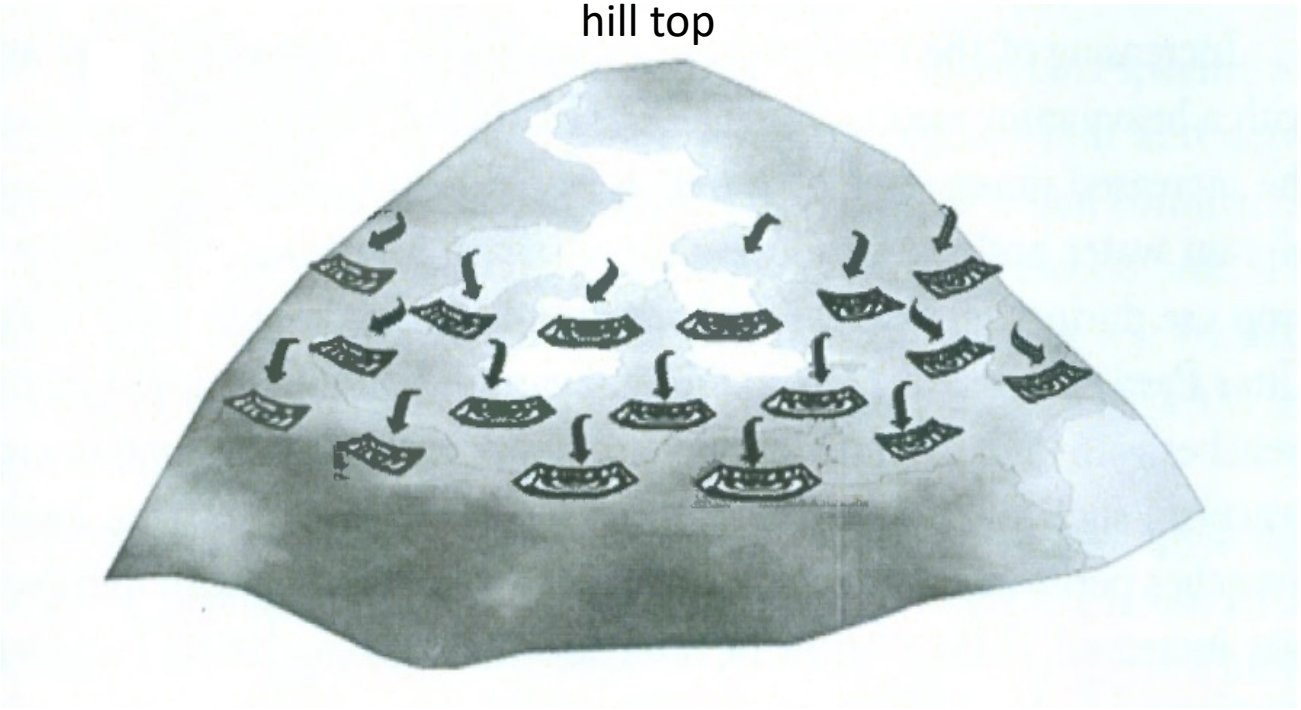


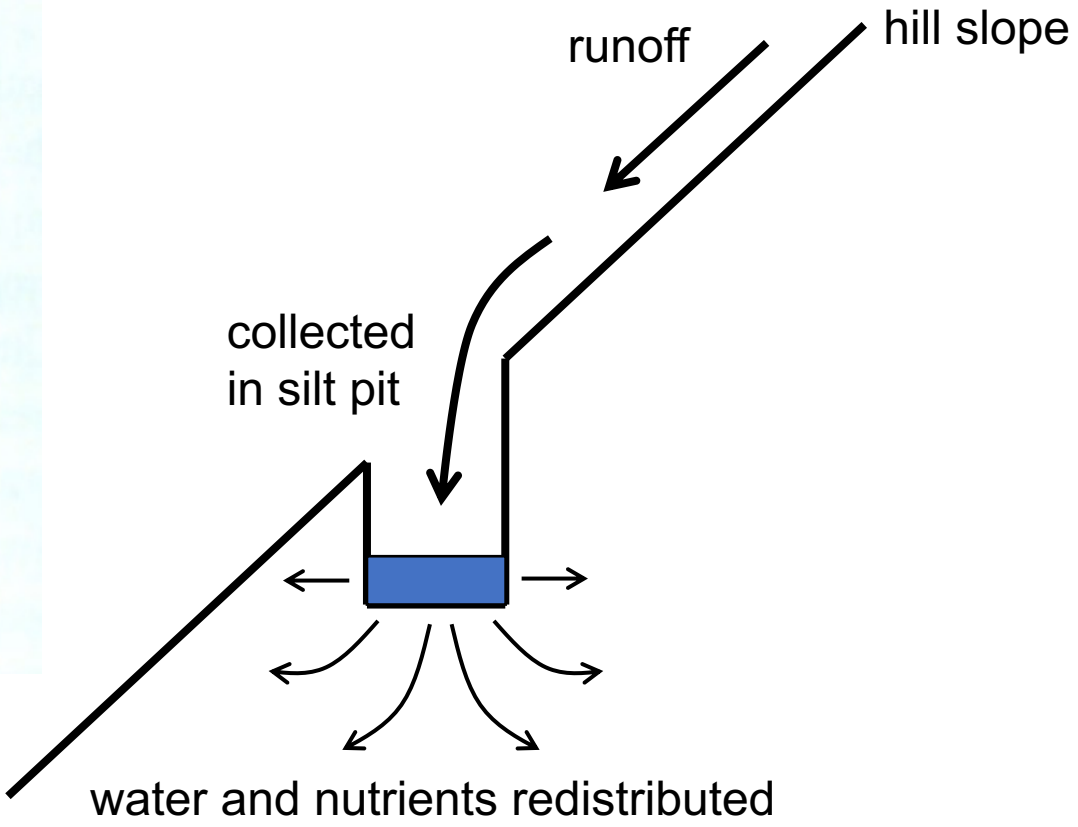
Increase soil C in the 0-0.15 m soil depth:

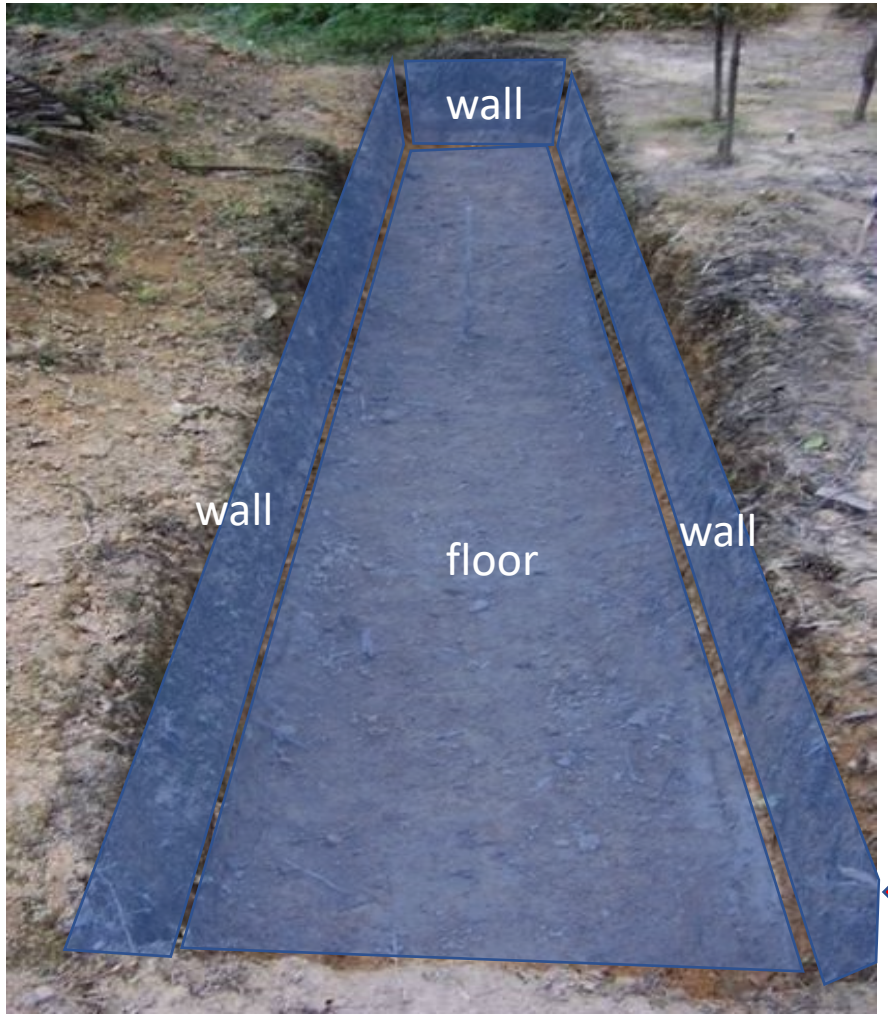
EFB: 9% of its C is sequestered in soil

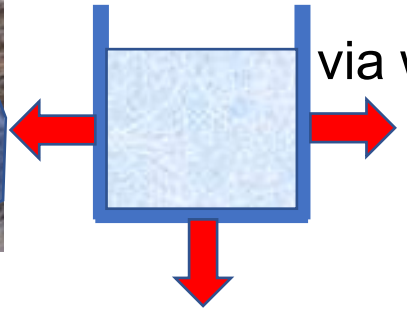
OPF: 5% of its C

OPT: 3% of its C


hill top
hill bottom

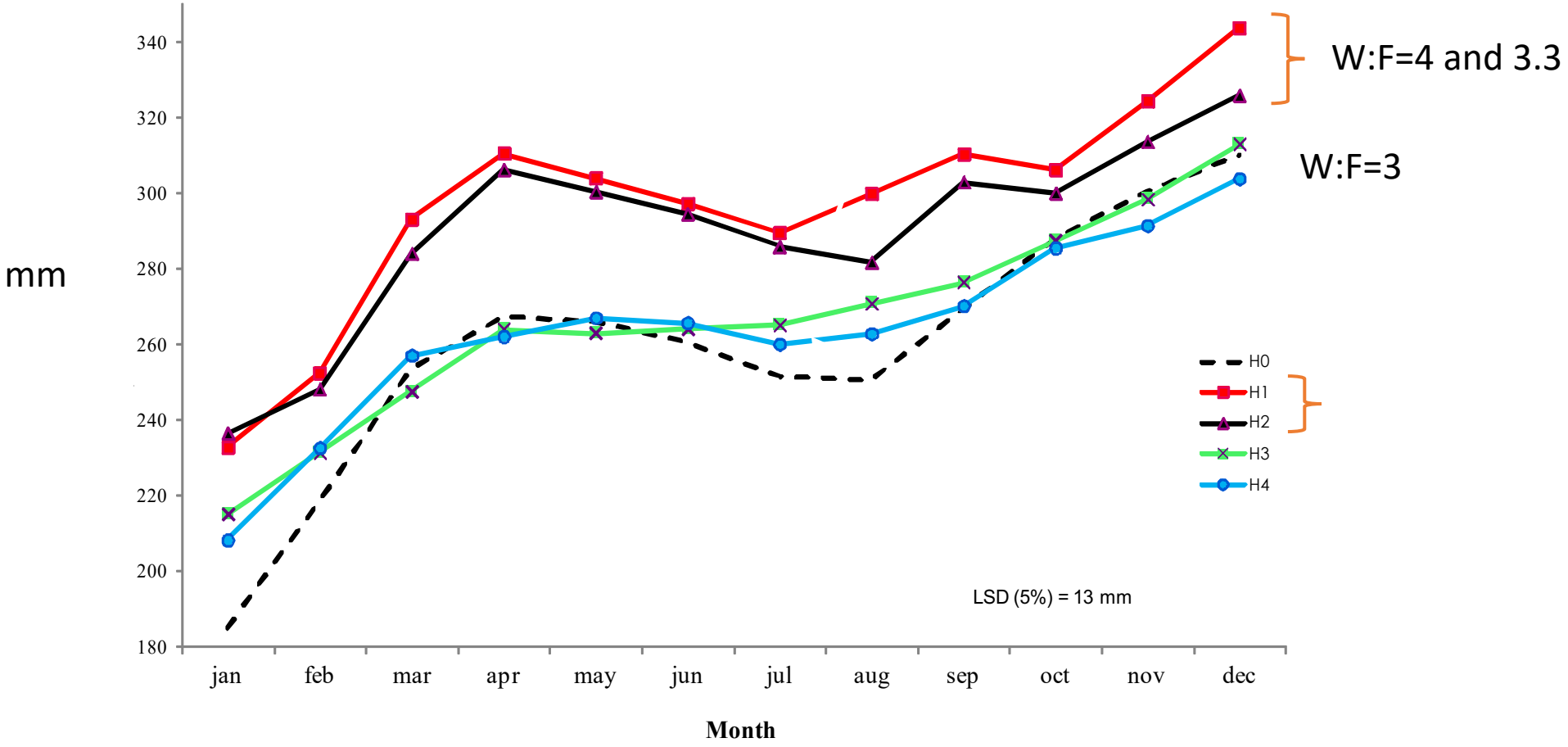

runoff
hill slope
collected
in silt pit
water and nutrients redistributed





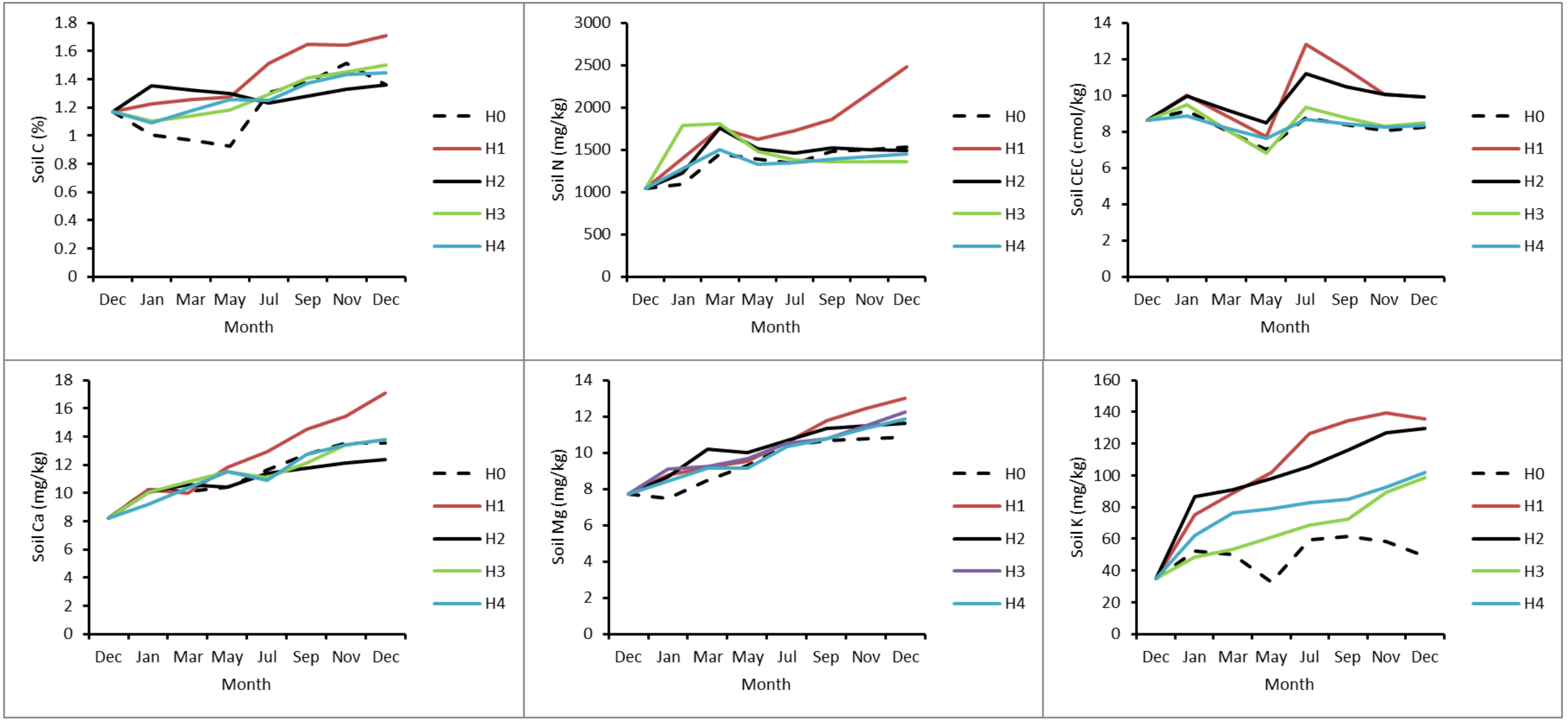
- Silt pits that are too large
  - high water loss by evaporation (through the pit opening) and percolation (through the pit floor)
- Silt pits that are too deep
  - water to flow out away from the root zone
- Wall-to-floor (W:F) area ratio of a pit is important
  - the larger the W:F ratio, the more effective the pit would conserve soil water and nutrients and enable them to return to the rooting zone

Volumetric soil water content



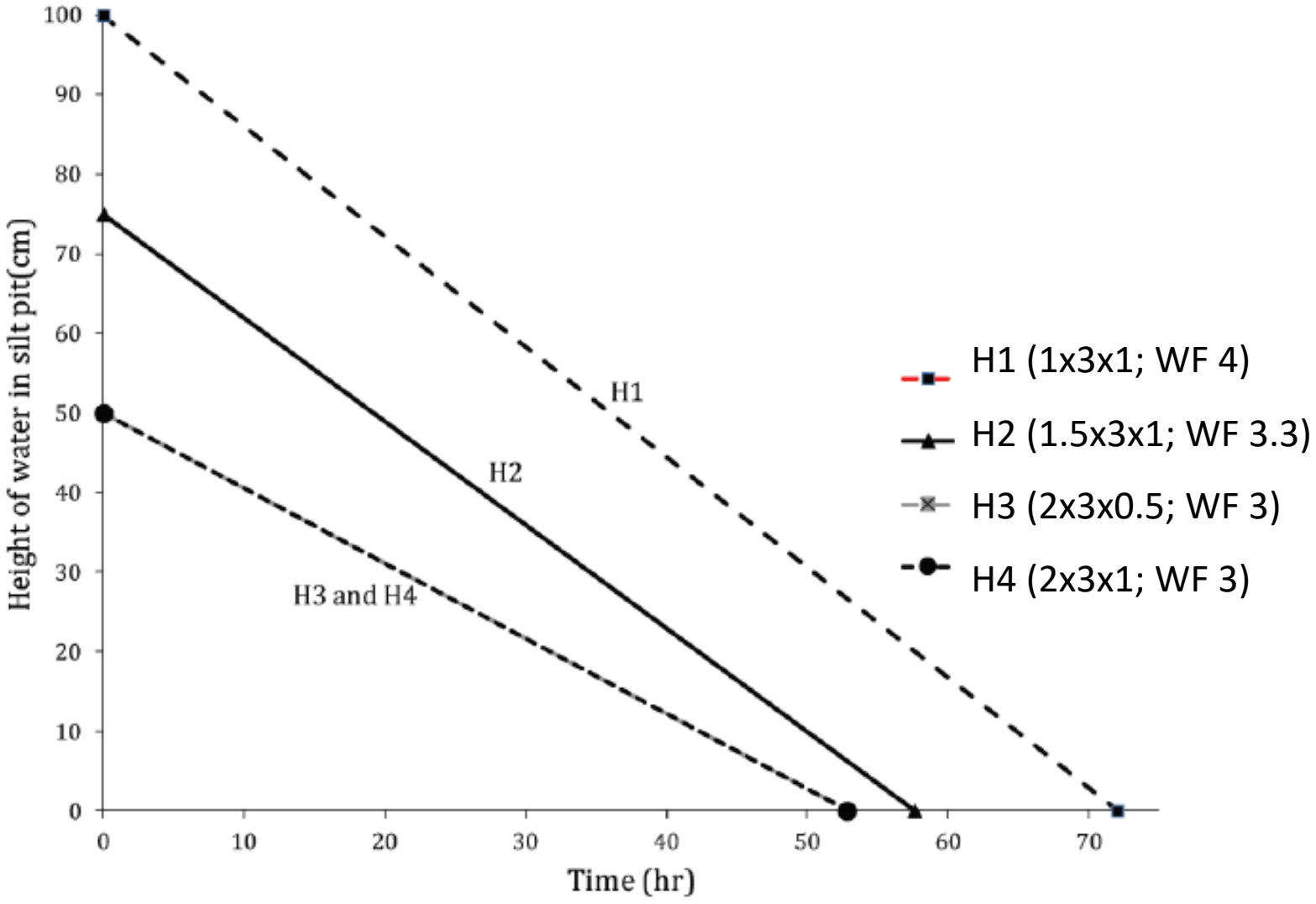
H0 (control); H1 (1x3x1); H2 (1.5x3x1); H3 (2x3x0.5); H4 (2x3x0.5)

Soil C and nutrient levels

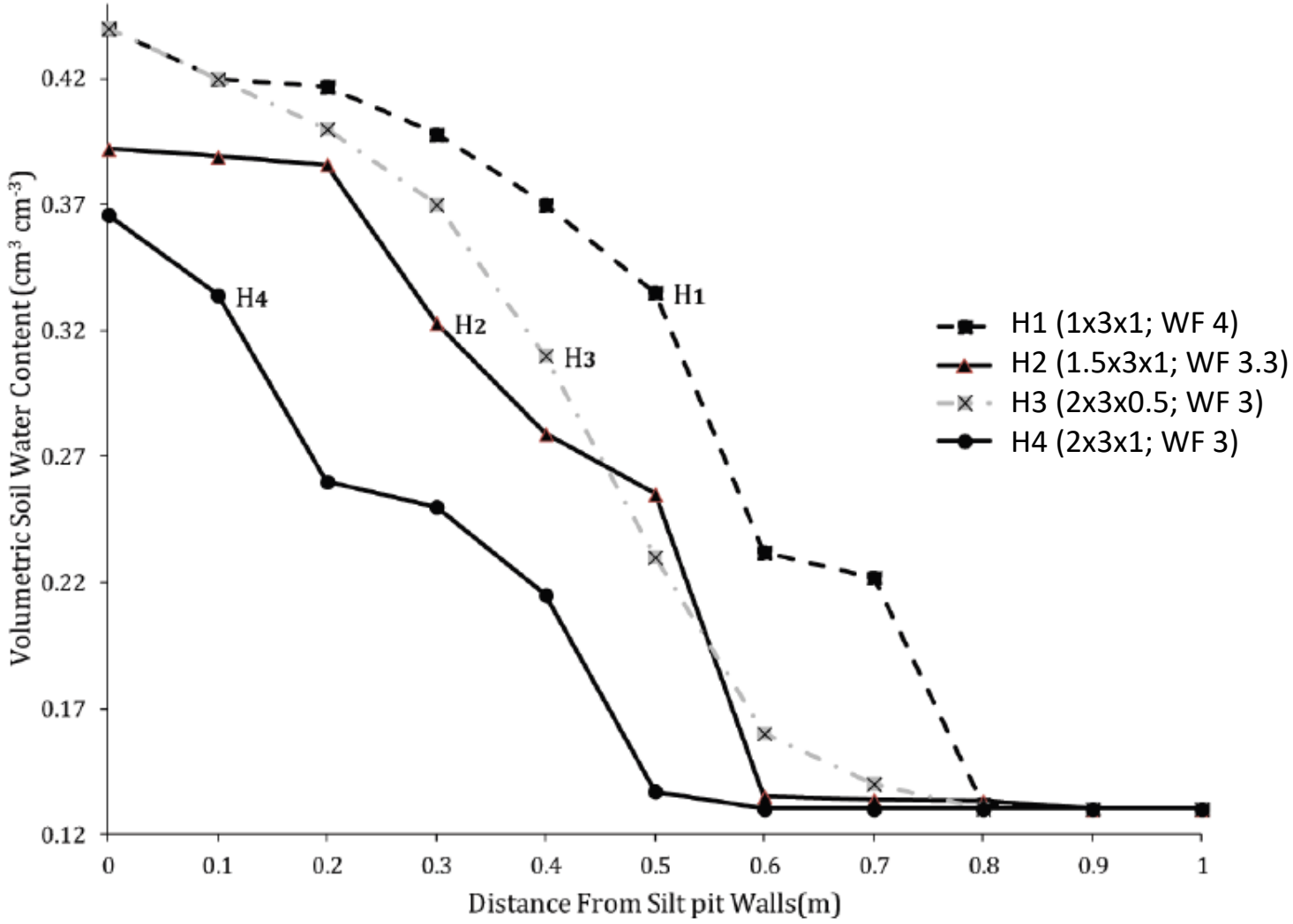


H0 (control); H1 (1x3x1); H2 (1.5x3x1); H3 (2x3x0.5); H4 (2x3x0.5)

Time to empty



Horizontal wetting front



soil water content at 0.5 m depth and at 72 hours

Silt pits are high maintenance

Walls can easily collapse or pits be completely filled within several months, depending on slope steepness, soil texture, and rainfall

Last between 3 to 6 months

“Holes” in the ground may also interfere field operations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