Sustainable Production on SAT Vertisols through Watershed Management

Background

Vertisols are one of the major soils in SAT occupying 131 m ha area. In India about 28 m ha is under Vertisols.
At ICRISAT Center, small agricultural watersheds have been used since 1976 to carry out strategic research leading to the development of sustainable technologies for the SAT Vertisols. These watershed units provide a logical framework for the management and control of water, a major limiting natural resource for crop production in the SAT.

Major constraints to production on Vertisols

Cultivation practices on Vertisols are affected by the sticky nature, poor infiltration, and impeded internal drainage of the soils while wet, as well as excessive hardness and difficult workability while dry.

Objectives

To increase systems productivity through adoption of improved soil, water, crop, nutrient and pest management practices.
To assess the long-term sustainability of agricultural productivity and changes in soil and water quality.

Components of improved management

- Cultivating the land immediately after the previous post-rainy season crop harvested along with summer cultivation
- Construction of field and community drains and grassed waterways
- Land smoothening, and layout of broadbed and furrows (150-cm apart) at 0.4-0.8% gradient
- Dry sowing or early sowing of rainy-season crops
- Use of improved seed and a moderate amount of fertilizer with intercropping and sequential cropping
- Improved placement of seeds and fertilizer using tropicultor and
- Timely plant protection measures.

Salient findings

- The average productivity of the improved system is 5.4 t ha^{-1} compared to 1.1 t ha^{-1} in the traditional system (Fig.1)
- The improved system had a carrying capacity of about 21 persons compared to 5 persons ha^{-1} yr^{-1} in traditional system (Fig.1)
- The improved system sequestered more carbon (335 kg ha^{-1} yr^{-1}) leading to improved in soil and environmental quality (Table 1)
- Enhanced rainwater use efficiency in the improved system was 71% for crop production compared to only 36% in the traditional system (Table 2), and
- Mean annual soil loss in the improved system was only 1.5 t ha^{-1} compared to 6.4 t ha^{-1} under the traditional system resulting in retaining more clay in improved system (51vs 46%)
- Improved benefits for physical properties such as increased porosity (52 vs 42 %), increased cumulative water infiltration (347 vs 265 mm in 1 hour) and reduced penetration resistance were observed over a period of 30 years

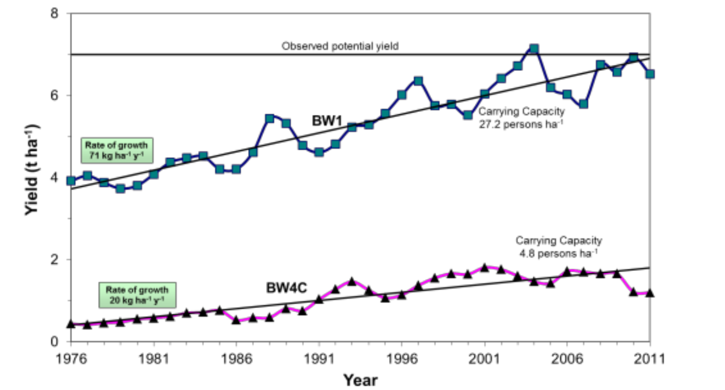

Figure 1. Three year moving average of grain yield under improved (A) and traditional (B) technologies on a Vertisol watershed at ICRISAT (1977-2011).

Table 1. Biological and chemical properties of semi-arid tropical Vertisols under improved and conventional systems in a watershed at ICRISAT Center, Patancheru, India.

		Soil depth (cm)	
Properties	System	0–60	60–120
Soil respiration	Improved	723	342
(kg C ha^{-1})	Conventional	260	98
Microbial biomass	Improved	2676	2137
(kg C ha^{-1})	Conventional	1462	1088
Organic carbon	Improved	27.4	19.4
(t C ha^{-1})	Conventional	21.4	18.1
Mineral N	Improved	28.2	10.3
(kg N ha^{-1})	Conventional	15.4	26.0
Net N mineralization	Improved	-3.3	-6.3
	Conventional	32.6	15.4
Microbial biomass N	Improved	86.4	39.2
(kg N ha^{-1})	Conventional	42.1	25.8
Non-microbial organic N	Improved	2569	1879
(kg N ha^{-1})	Conventional	2218	1832
Total N	Improved	2684	1928
(kg N ha^{-1})	Conventional	2276	1884

Table 2. Annual water balance and soil loss (t ha^{-1}) for traditional and improved technologies in Vertisol watersheds, ICRISAT Center.

Farming system technology	Water-balance components: Annual rainfall (mm)	Water used by crops (mm)	Water lost as: surface runoff (mm)	Water lost as: bare-soil evaporation and deep percolation (mm)	Soil loss (t ha^{-1})
Improved system: Double cropping on broadbed and furrows (BBF)	904	602 (67)[1]	130 (14)	172 (19)	1.5
Traditional system: Single crop in post-rainy season and cultivation on flat	904	271 (30)	227 (25)	406 (45)	6.4

1. Values in parentheses are amounts of water used or lost expressed at percentage of total rainfall.

Benefits of Watershed Development

Improved watershed management benefits all the stake holders

For the farmer:

- Lower land-development costs.
- Increased production and higher profit
- Improved soil tilth and better drainage
- Improved soil quality through increased organic matter content
- More efficient use of rainfall, with excess water stored for supplemental irrigation
- Reduced runoff and soil loss resulting in minimizing land degradation

For the local community:

- Increased carbon sequestration
- Reduced flooding and waterlogging
- Reduced soil erosion.
- Increased agricultural productivity.
- A more dependable, clean water supply for domestic and industrial use and increased groundwater recharging.

For the larger cross section of society:

- Less danger from floods to downstream cities and farmlands.
- Reduced sedimentation of costly irrigation projects.
- Better conservation of natural resources.

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