Natural Resource Management in Hybrid Cotton in Rainfed Vertisols

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ABSTRACT

Twenty five percent of the world's total area is under vertisols and vertic inceptisols exist in India (Rao et al 1997). Over 60% of the cotton produced in India comes from these soils. Hybrid cotton is cultivated in about 3.8 m ha, the majority on vertisols, where cotton is primarily a rainfed monsoon crop (ICAC.1997). Vertisols are classified as problem soils and wide fluctuations in the productivity of hybrid cotton is a regular phenomenon. Improving and sustaining high productivity levels in vertisols is a daunting challenge owing to the inherent management problems of these swell shrink soils, unreliable rainfall, high retention of applied nutrients in clay complexes, severe erosion losses and low organic carbon content.

Characteristics of Rainfed Hybrid Cotton Growing Vertisols

Clay content of these soils ranges from 40 to 80% and remains uniformly high (more than 35%) throughout the profile to more than 50 cms depth. Soil depth ranges from shallow (<45 cm) to medium (45-90 cm) and deep (>.90 cm). The predominant clay type is Montmorillonite, giving them a characteristic of heavy swelling when wet and contraction or shrinking on drying. The optimum soil moisture range for tillage and interculture is narrow. The infiltration rate is low at about 0.2-0.3 mm/hour. They develop wide, deep cracks during the post monsoon season, coinciding with the critical peak water demand period of hybrid cotton. They are low in organic carbon (ranging from 0.21 to 0.8%) and the soil pH is neutral to slightly alkaline.

Soil and Climatic Optima for Hybrid Cotton

In order to efficiently utilize soil resources, it is essential to determine the soil-site suitability in terms of crop perpformance (Sehgal, 1993). Deep soils, fine textured soils, amenable to good drainage are ideal for growing hybrid cotton. In Central and Southern cotton zones of India, deep vertisols are suitable for growing long duration hybrids while vertic inceptisols are most suitable for early maturing hybrids (Sehgal and Yadav, 1995).

Through intensive field trials, Yadav *et al.* (1998) validated the soil site suitability criteria proposed for cotton by Sehgal and Yadav (1995) and identified eight important climate, soil and site parameters, that govern the yield of rainfed hybrid cotton (Table 1).

Efficient management of the natural resources is necessary to prevent deterioration in their quality and to enhance productivity of hybrid cotton. Some recent advances in this direction are highlighted.

Advanced Sowing and Early Crop Establishment

Rainfed hybrid cotton is essentially a monsoon crop in the Indian subcontinent. Early sowing in dry conditions, 10-15 days ahead of the expected date of monsoon rains is superior to sowing with the onset of monsoon. Early sown crop establishes faster, grows vigorously and develops a more extensive root system to support the crop during moisture stresses that frequently occurs towards the boll development phase. Early sowing of hybrids by the crowbar method, transplanting or dry sowing (planting in dry soil) increases seed cotton yields in vertisols of Central India (Table 2).

Optimization of Planting Geometry

Plant population and geometry of hybrids is a function of plant type, its soil fertility, depth and moisture availability. Highly branched monopodial hybrids require wider spacing than non-branched sympodial types. Hence location specific trials are needed to standardize optimum plant geometry and population for different hybrids (Table 3).

Results for hybrid DCH-32 indicated that for Malnad tract, the optimum spacing was 120 x 60 cm. For the central cotton zone of India 90 x 60 cm was found to be ideal in most locations while for the southern zone, slightly higher spacing was optimum.

Rain Water Management

Of the natural resources of water, soil and solar radiation that limit hybrid cotton production, efficient water resources management is very important. *In-situ* moisture conservation is an important component of rain-water management. Results indicate that contour cultivation along vetivar hedge increased cotton yields by 14.3% over sowing along/across the slope (Table 4). This also reduced soil loss by 71.6% (Bharad, 1994).

Vertisols are characterized by low infiltration rate and incur heavy runoff losses unless special conservation measures are adopted to improve *in-situ* moisture conservation. They also experience serious evaporation loss of stored soil moisture during the post-monsoon phase due to the development of cracks. The ridge and furrows method, broad bed method, tying ridges just before cessation of monsoon rains, use of straw or live mulch have been recommended to improve soil moisture storage and increase the productivity of rainfed hybrid cotton (Bonde and Shanmugham, 1990).

About 40-80% of the rainwater goes waste with annual soil loss of about 8-13 tonnes/ha from different cotton based cropping systems. Soil and water conservation measures by the watershed approach could help in a more efficient utilization of rain water. Stored runoff rain water could be collected and recycled at peak boll development stage of rainfed hybrid cotton. Such measures would boost seed cotton yields by 20-25% (Table 5).

Nutrient Management

Vertisols are generally deficient in N, low to medium in available P and high in available K. The estimated responses range from 2 to 12, 2 to 8 and 1 to 3 kg seed cotton/kg N, P and K per hectare respectively (Mannikar and Pundarikakshudu, 1990). The nutrient uptake, utilization efficiency response and consequently its requirement vary widely with the soil type, length of growing period and moisture availability. A representative uptake by H-4 in vertisols at Nagpur indicates the influence of soil depth (Table 6).

Rainfed hybrid cotton responded to N applications of up to 80-120 kg/ha at different locations. The response to P varies from 20-25 kg P/ha (Pundarikakshudu, 1989 and Solankey *et al.*, 1994). In vertisols, Ca-P was the dominant fraction contributing to the P. P application increased the length, spread and volume of roots (Table 7). The response to K application has been inconsistent.

The nutrient requirement of rainfed cotton is maximum during the period from flowering to peak boll development. Restricted root activity and limitations in soil moisture reduces root uptake of nutrients. Application of 6-10% of the N and 25% of the P total P requirement through foliar sprays of DAP or ammonium poly phosphate showed encouraging results. (Venugopalan *et al.*, 1995).

Intercropping in Rainfed Hybrid Cotton

Hybrid cotton, being a long duration crop (180-240 days), has a slow initial growth phase. The wide spacing requirement provides excellent opportunity to exploit its temporal and spatial complementarity with other crops. This aspect has been thoroughly investigated and several location specific intercropping systems have been developed. Black gram, soyabean and groundnut were identified as compatible intercrops.

At Nanded station in Central India, blackgram was found to be the ideal intercrop for cotton (Table 8). In the same study, the paired row system of planting improved utilization of resources more than normal row planting in intercropped cotton.

Vertisols will continue to possess sizeable acreage under hybrid cotton. Sustainable development of vertisols to support hybrid cotton production will continue to demand rational use of natural resources, avoiding over exploitation and promoting efficiency.

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Table 1. Important climate, site and soil optima for hybrid cotton in vertisols.

Characteristics	Degree of Limitation			
	0(None)	1(Slight)	2(Moderate)	3(Severe)
CLIMATIC				
Mean temperature(C)	22-28	28-32	> 32	
Rainfall in growing season (mm)	750-950	600-750	450-600	<450
Length of growing period (days)	> 240	180-240	120-180	< 120
SITE				
Slope (%)	< 1	1-2	2-3	3-5
Available water capacity (mm)	> 250	200-250	125-200	50-125
SOIL				
Depth (cm)	>150	100-150	60-100	30-60
Clay %	35-50	25-35	< 25	-
CEC (Canol (P+) kg-1	> 55	50-55	30-50	< 30

Table 2. Effect of planting methods and soil depth on the productivity of hybrid: (H-4) cotton (mean of 3 years).

Planting Method	Seed CottonYield (kg/ha)			Mean
	Shallow soil	Medium soil	Deep soil	(kg/ha)
Normal sowing	857	753	1587	1066
Crowbar method	1150	1390	2003	1514
Transplanting	1023	1020	1597	1154
Dry sowing	459	1000	1507	1154
Mean	997	1041	1673	

Table 3. Response of hybrid cotton to different spacings: in Malnad Tract (Karnataka).

Spacing	Plants/ha	SC yield (kg/ha)	Sympodia/ plant	Bolls/plant
90 x 60	18519	1652	21.3	40.6
90 x 90	12346	1668	26.7	44.0
120 x 60	13889	1808	31.0	51.9
120 x 90	9259	1603	32.8	60.1
150 x60	11111	1495	33.8	61.9
150 x90	7407	1390	36.6	65.0

Nayak *et al.*. (1997)

Table 4. Influence of in-situ moisture conservation measures on yield runoff and soil loss.

Conservation measure	SC yield (kg/ha)	% reduction in surface runoff	Mean soil loss (Tonnes/ha)
T1 Control (sowing along/across slope	1226	-	6.24
T2 Contour cultivation along leucaena hedge	1339	37.7	3.34
T3 Contour cultivation along vetivar hedge	1401	53.9	1.73

Bharad (1994)

Table 5. Effect of irrigation through harvested rainwater on the yield of rainfed hybrid cotton at CICR Nagpur, India (Mean of 3 years, 1995-97).

Treatment	Seed cotton yield (kg/ha)	
	Shallow soil	Medium deep soil
Control	1343	1548
Irrigation* at flowering stage	1753	1768
Irrigation* at early boll development stage	1331	1861
Irrigation* at peak development stage	2005	2058
Irrigation* at early and peak boll dev. stage	1675	1817

Bharad 1994

Table 6 . Nutrient uptake and nutrient utilization efficiency (kg / 100 kg seed cotton) by hybrid (H-4) cotton in Vertisols.

	Nutrient uptake			Nutrition utilization efficiency		
Soil	N	P	K	N	P	K
Deep (> 120 cm)	55.2	8.8	47.1	5.60	0.68	4.80
Med.deep(30-60cm)	44.0	5.7	36.2	4.54	0.58	3.73
Shallow(> 30cm)	44.0	5.3	37.7	3.38	0.53	2.88

Pundarikakshudu *et al.*, 1992

Table 7. Effect of rate of P application on root growth at maturity(Hybrid-4).

P levels (kg/ha)	Length (cm/plants)	Weight(g/plant)	Volume (cc/plant)	Spread (cm/plant)
0	51.0	15.4	39.4	76.0
17.5	75.0	24.1	53.1	104.7
35.0	69.4	21.3	46.6	56.6
52.5	65.4	20.2	45.3	94.2
SE	3.49	0.54	3.45	16.34

Pundarikakshudu (1989).

Table 8. Seedcotton yield and monetary returns in intercropped rainfed hybrid cotton.

Crop Combination	Yield (kg/ha)		Monetary Returns
	Cotton	Intercrop	(Rs/ha)
Cotton Alone	1005		4790
Cotton + Greengram	912	128	4640
Cotton + Blackgram	977	280	5301
Cotton + Groundnuts	825	212	4420