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Agro-Ecological Sub-region:

A wheel of technology transfer for crop planning

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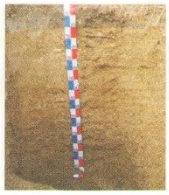
THE sustenance of food and nutritional security are the major challenges of the 21st century. The domestic food production needs to be increased at the rate of 2% for cereals and 0.6% for oilseeds and pulses per annum to meet the demand by 2030. Almost the entire coarse cereal and pulse are cultivated under rainfed condition. Besides, about 60% area under cotton and oilseed production are dependent on rainfall. Since irrigation potential is limited and expansion of irrigated area is tardy, rainfed agriculture holds promise to satisfy the future food demand. Frontline demonstrations of crop varieties and agro-technologies at many regions have shown that there is a large gap between the achieveable yields and the yields currently realized by farmers. This gap could be filled by adopting a scientific approach of managing the natural resources. Of late there is tremendous pressure of both biotic and abiotic stresses hindering the crop production and that warrants for a systematic appraisal of natural resources. To augment the rainfed production with available agro-technology it is necessary to determine the moisture availability period of soils occurring on different land forms and soil before any crop planning can be undertaken. Crop planning has always been a subject of interest among agricultural scientists. Judging by diverse ecosystem and requirement of people in farming community in the country and more so since soils and climate vary in different parts of the country, it seems prudent to divide the entire farming land into homogeneous units and study the crop performance in terms of its yield.

The IGP (with 52.01 mha area) stretches about 3000 km extending from Punjab in the west to West Bengal and Tripura in the East, having contrast climatic regime represented by arid, semi-arid, subhumid, humid, perhumid system with mean annual rainfall varying from less than 800 mm to more than 2000 mm. The fluvial deposits and landform of IGP is influenced by stress and is directed towards north-north-east resulting in gently sloping easterly plain with convexity towards south-east. The IGP shows a series of terraces, bars and meandering scars resulting in micro-high and micro-low on apparently smooth topography as evidenced by different types of soils with different cropping practice. High sodium and poor drainage in many places of IGP is critical limit for arable crop. The other cause of poor drainage of alluvial soils at places is due to the soil compaction caused by use of heavy machinery in rice-wheat rotation. The compact layer has higher bulk density (BD) to the extent that plant roots cannot penetrate resulting in relatively low productivity. While generating AESR map during 1994, poor saturated hydraulic conductivity (sHC) and the increase in BD were not considered due to paucity of sufficient data. During a revisit in 2010 in the IGP it was collated that ~400 soil profile data and the sHC data was generated. These new dataset helped in correcting and to redraw the boundaries of AESR. The black soil region (BSR) dominated by black soils (Vertisols) has been reported to be chemically degraded due to high sodium, pH and poor drainage. The BSR is represented by 425 pedons covering an area of 76.4 mha where each pedon covers an area of 1.8 lakh

To assist in the evaluation and transfer of agro-technology, the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) under the Indian Council of Agricultural Research (ICAR) divided the entire country into 60 agro-ecological subregions (AESRs) in 1994. This delineation was done by superimposing maps on natural resources like soils, climate and length of growing period (LGP) for crops and other associated parameters. With the passage of nearly 2 decades and the advent of modern facilities of database management and improved knowledge base on natural resources, a need was felt to revise the existing AESR map and make them more realistic in matching with the crop performance.

Soil Series	Soil Profile	Landscape	Crop
1. Zarifa viran (Typic Haplustalfs) • Land Use: Rice, wheat, mustard potato • Very deep and moderately well drained soils with silt loam to clay loam in texture and moderately to very strongly alkaline.			
2. Itwa (Typic Endoaqualfs) • Land Use: Rice, wheat, barley, gram • Very deep and imperfectly drained soils with silty loam to silty clay in texture and moderately to very strongly alkaline.			
3. Haldi (Mollic Hapludalfs) • Land Use: Maize, soybean, wheat, mustard • Very deep and well drained soils with sandy loam to silt loam in texture and neutral to strongly alkaline.			
4. Madhpur (Vertic Endoaqualfs) • Land Use: Rice, mustard, potato • Very deep and imperfectly drained soils with clay loam to clayey in texture and slightly to moderately acidic.			
5. Ekchari (Vertic Endoaqualfs) • Land Use: Rice, maize, wheat • Very deep and poorly drained soils with silty clay loam to silty clay in texture and slightly acidic to slightly alkaline.			

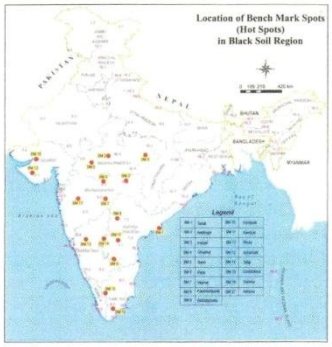
A pictorial illustration of landscape, soil and crops for some selected benchmark (BM) spots of Indo-Gangetic Plains

ha. Most of the pedons represent the Benchmark soils. The new database stored in Soil and Terrain digital database (SOTER) helped in modifying the AESR delineations of the BSR and the IGP. The estimated available water content (AWC), saturated hydraulic conductivity (sHC) and use of pedo-transfer functions (PTF) in assessing the drainage conditions and soil quality helped in computing the LGP with improved precision. The soil information system, generated in a NAIP (Component 4) sponsored project, helped in revising the AESR boundaries of the BSR and the IGP. This innovative exercise shall be useful for the future AESR-based crop planning. The agro-ecological subregions will also help to plan for i) alternate crops or ii) other land use or iii) find out soil potential and constraints, and their suggested management interventions.

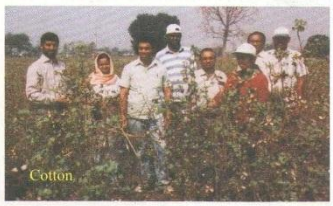
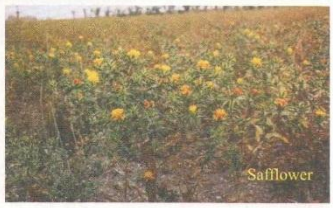
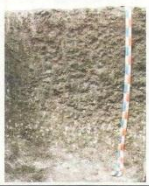
AESR-based Planning for Rice and Wheat in the Indo-Gangetic Plains

It has been shown that the rice growing areas are in the Indo-Gangetic plains. District level rice yield data was used divide to the rice growing areas in the Indo-Gangetic Plains into four number of regions such as low, medium, medium high and high representing areas with rice yield of <1000, 1000-2500, 2500-4000 and >4000 kg/ha rice. Nearly 33 % area falls under medium high to high category of rice yield while medium level of yield is observed in 63 % of the total rice growing areas.

District level wheat yield data



Total Geographical area	:	76.4 mha
Extent	:	
	:	17 (AP, Asom, Bihar, Chhattisgarh, Maharashtra, MP, Karnataka, Gujarat, TN, J&K, Rajasthan,, Odisha, Punjab, WB, Kerala, UP)
Topographic	:	
Major soil types	:	Clayey texture of Entisols, Inceptisols and Vertisols soil orders
Number of BM spots	:	17
Major crops	:	Cotton, soybean, sorghum, maize, groundnut, pigeonpea, gram, safflower, etc.

6. Soil Series	Soil Profile	Landscape	Crop
1. Nabibagh (Typic Haplusterts) • Land Use: soybean, maize, wheat • Very deep and moderately well drained soils with clayey in texture and moderately to strongly alkaline.			
2. Panjri (Typic Haplusterts) • Land Use: Cotton • Very deep and moderately well drained soils with clayey in texture and moderately alkaline.			
3. Kasireddipalli (Typic Haplusterts) • Land Use: soybean, maize, pigeonpea, safflower • Very deep and moderately well drained soils with clayey in texture and moderately alkaline.			
4. Kovilpatti (Gypsic Haplusterts) • Land Use: Cotton, maize, blackgram • Very deep and well drained soils with clayey in texture and moderately to strongly alkaline.			

A pictorial illustration of landscape, soil and crops for some selected benchmark (BM) spots of Black Soil Region

was used to divide the wheat growing areas in the IGP into 4 number of regions such as low, medium, medium high and high representing areas with wheat yield of < 1000, 1000-2500, 2500-4000 and > 4000 kg/ha. More than 64 % of the total wheat growing area is covered under medium high to high range of wheat yield. The authors used the georeferenced soil information system and the level of wheat yield to generate the theme map for wheat.

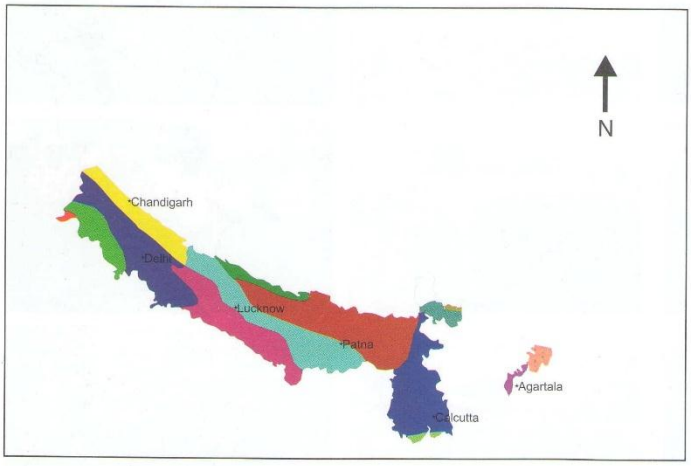
AESR-based Planning for Cotton and Soybean in the Black Soil Region

Based on productivity, the cotton growing areas in different AESRs of the BSR are mapped as a part of crop planning. Using all India district level crop yield data, the authors divided the entire BSR into four different regions such as low, medium, medium-high and high indicating <1000, 1000-1500, 1500-2000 and >2000 kg seed cotton/ha. It is interesting to note that merely 23% area under cotton produce >1.5 ha-1 yield which is

Table 1. Soil related constraints and the suggested interventions in selected agro-ecosubregions in the Indo-Gangetic Plains of India for rice and wheat

AESRs	Yield level kg/ha	Dominant soil	Soil related constraints	Interventions
4.1b	<1000	Zarifa Viran	High $CaCO_3$, sodicity	Soil amelioration using gypsum, phytoremediation, horticultural crops as alternate land use, using RDF with FYM
13.1a		Ekchari		
4.1a soil	1000-2500	Kalwa	High BD,	Gypsum application to better
4.1b		Zarifa Viran	sodicity,	physical conditions, ocassional
9.2a		Azamabad	poor drainage	stirring of subsurface layers to
9.1a		Khanpur		loosen soil and to ensure better
4.3b		Itwa		aeration immediately below the
13.2		Darwabari		surface, application of manures
9.2c		Dahiya		
13.1		Sangrampur		
12.3		Sankarpur		
15.3a		Binnaguri		

RDF: recommended doses of fertilizers; FYM: farmyard manure



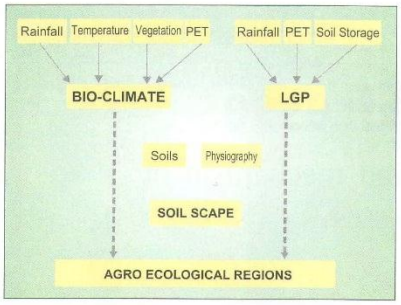
Total Geographical area	:	52.01 mha
Extent	:	21^0 45' to 31^0 0' N latitudes and 74^0 15' to 91^0 30' E longitudes
Number of states covered	:	9 (Punjab, Haryana, HP, Delhi, UP, Bihar, WB, northern parts of Rajasthan and Tripura)
Topographic	:	Alluvial plains dominated by three main rivers, the Indus, *Ganges*, and *Brahmaputra*. Overall topographic situation remains fairly uniform with elevations of 150 m above mean sea level in Bengal basin, and 300 m above mean sea level in the Punjab plain
Major soil types	:	Sandy to clayey texture of Entisols, Inceptisols and Alfisols soil orders
Number of BM spots	:	15
Major crops	:	Rice, wheat, *maize*, *sugarcane*, pulses, oilseeds and *cotton*

the national average. The distribution of cotton yield in different AESRs shows that there is a scope to push low to medium cotton yield areas to medium high or high yield categories in 77% area under cotton. Keeping crop variety and other management factors similar, we used georeferenced soil information system to find out exact soil related variables which can be ameliorated to improve the soil quality and can thus focus on soil-related constraints to plan cotton production in low and medium cotton yield areas for posterity.

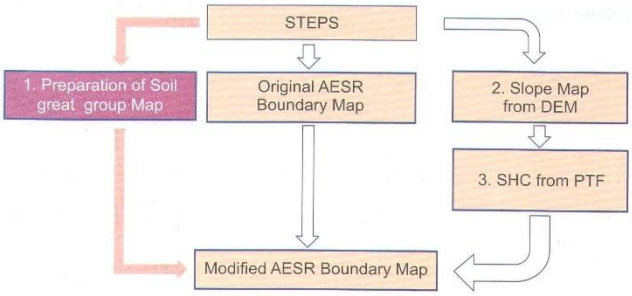
In the soybean growing areas in the black soil region, district level soybean yield data were used to divide the BSR into four regions such as low, medium, medium high and high representing areas producing < 500, 500-1000, 1000-1500 and >1500 kg/ha soybean. It may be noted that only 8% area is falling under low category, while ~ 56% areas fall under medium high to high yield category. The authors have used the georeferenced soil information system and the level of soybean yield, exact AESR and the locations of the districts to identify areas under low and medium soybean yield.

Information on crop yield in different AESRs representing various districts for cotton, soybean, rice and wheat respectively and also detail management interventions to improve crop yield in these AESRs are explained. The authors experience shows that keeping crop and management factors constant, the major parameters of soils which govern the crop performance also determine the soil and land quality. It has been found that BD, sHC and ESP mostly control the soil drainage which directly and indirectly influence physical, chemical and microbiological properties of soils. The low and medium yield might be a due to poor soil quality and therefore these soils require amelioration to reach the stage of medium high to high yield for these crops. The AESR-based crop planning can, therefore, helps identifying exact locations (districts) for soil management interactions as shown through this study. The present effort thus shows that at the national and regional level agro-ecological sub region concept can act as a technology transfer tool for agricultural crop.

The utility of AESR based soil information systems is also for estimating soil carbon stock using various models. Later it was shown how AESR can be utilized for prioritizing areas for soil carbon sequestration which can be used as



Methodolgy for Agro-Ecological Regionalization



Modification of Agro-Ecological Sub region map

an initial step for conservation agriculture. AESR was also used for developing status of available K for IGP and BSR.

SUMMARY

In the present study all the information which made the backbone of soil information system has been utilized for generating maps for cotton and soybean crops in BSR and rice and wheat in the IGP to find out various soil factors controlling their performance. For example, in the IGP the selected AESRs represented by the dominant soils producing <1000 and 1000-2500 kg/ha yield of rice and wheat have soil related constraints which can be rectified following management interventions. These interventions might push the AESRs with low to medium yield to medium high to high yield. And thus show the importance of soil information *vis-a-vis* AESRs in crop planning and management.

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