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Evaluation of Regional Benchmark Soils and Agro-climate *vis-a-vis* Soils of Technology Generation Sites for Agrotechnology Transfer – A Case Study of Andhra Pradesh

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Bench mark soils have been identified in National Agricultural Research Project (NARP) zones of Andhra Pradesh based on extent of distribution using soil resource mapping information. Soils of most of agricultural stations of SAU/ICAR Institutes were studied and characterized. Long–term weekly rainfall data available for different locations from Indian Meteorological Department (IMD) and agricultural research stations were collected and analyzed for length of growing period for different locations of NARP zones for crop planning. Soil and agro-environments of research stations were compared with adjoining geographical areas of NARP zones to see soil homogeneity and transferability of agro-technology in farmer's fields. Length of crop growing period in each NARP zone is found highly variable which suggest the need for site specific varietal recommendation instead of currently followed recommendations. Similarly single fertilizer recommendation is being advocated for larger area but it needs more than one fertilizer recommendation based on bench mark soils in the state. Acharya N.G. Ranga Agricultural University (ANGRAU) has to refine or revalidate their agro-technologies considering crop growing period and soil variability.

Key words: Benchmark soils, length of growing period, NARP agro-climatic zones, agrotechnology transfer

Soil and climate of the particular site/location decides the genetic potential of any crop cultivar. Management strategies help in improving the potential of cultivar by overcoming the soil or climatic limitations. Therefore, soil information provides a sound basis for transfer of agro-technology. Kellogg (1961) stated that soil survey interpretations provide predictions about behavior of defined kind of soil under stated conditions and expected results of interaction between soil characteristics, crop requirements and management practices. In a review about Benchmark soils Project (BSP), the IBSNT (1983) concluded that the soil information at family level could be used to identify similar soil agro-environments for transfer of agro-technology. Crop performance and management responses were found similar on soils having similar texture, mineralogy, moisture and temperature regimes (Naidu *et al.* 1998). Soil classification at family level category intent to group the soils within a subgroup having similar physical and chemical properties that affect their responses to management. The responses of comparable phases of all soils in a family are nearly enough to meet most of our needs for practical interpretations.

State Agricultural Universities have adopted agro-climatic zoning concept under National Agricultural Research Project (NARP). Accordingly, each state was delineated into Agro-climatic Zones (ACZs). Each ACZ has a major research station viz. Zonal Research Station /Zonal Agricultural Research Station /Regional Agricultural Research station/ Regional Research station, for generating location specific technologies and transfer agro-technology. These research stations generated agrotechnologies for different crops and recommended uniformly throughout the NARP Zone. However, many of these recommendations are obsolete. Single blanket recommendation (variety/fertilizer dose) is adopted for entire zone with the assumption that each NARP Zone is homogeneous unit in respect of crop growing period and soils.

In the present study, the types of soils and length of growing period at technology generation sites

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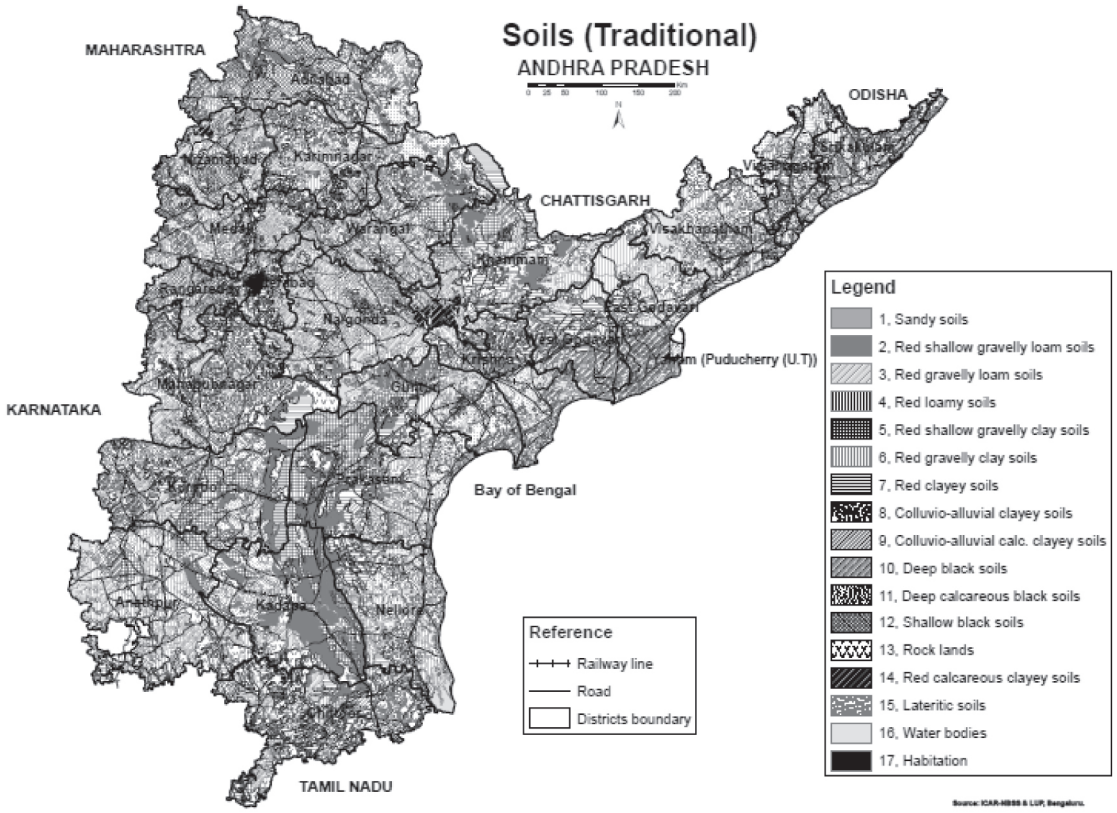

Fig. 1. Soil map of Andhra Pradesh

(research stations) was compared with major benchmark soils that occur across 9 ACZs to understand/explore the scope of transferability of agro-technologies within and across the ACZs.

Materials and Methods

National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) generated soil information (1:250,000 scale) for Andhra Pradesh State (Fig. 1) along with information on 22 themes (Reddy *et al.* 1996). Besides this, land suitability for four major crops relevant for the area was generated district wise (22) and 256 agricultural divisions (Naidu *et al.* 2004, 2006) and provided this information to Department of Agriculture and State Agricultural University for further use in agro-technology transfer. Soil information on 1:50,000 scale is available only for Anantapur and Medak districts. Parts of Kadapa district (*i.e.* Pulivendala, Simhadripuram, Lingala, Tondur, Vemula and Vempalli mandals) have information on 1:25,000 scale. Detailed soil information (1:10,000 scale) availability is very much limited. Only Kuppam mandal in Chitoor district and most of the Agricultural Research farms of Acharya N.G. Ranga Agricultural University (ANGRAU) have detailed soil information. The state is divided into 9 agroclimatic zones (ACZs) by ANGRAU *viz*. 1) Northern Telangana zone, 2) Central Telangana zone, 3) Southern Telangana zone, 4) Scarce Rainfall zone, 5) Southern zone, 6) Godavari zone, 7) Krishna zone, 8) North-Coastal zone, and 9) High altitude and Tribal zone, for generation and transfer of agro-technologies to farming community.

Soil resource mapping of Andhra Pradesh was done using remote sensing techniques with adequate ground truth. About 10,000 soil observations in the form of sample strips, grid points and random sites and also at many of agricultural research stations occurring in the state were studied and prepared soil map for the state. Based on the soil characteristics *viz*., depth, texture, slope, gravel and calcareousness, 132 soil families were identified and mapped into 285 soil map units. Further, these 132 soil families were reviewed and identified only 55 regional benchmark soils based on the criteria of occurrence in largest extent. Length of crop growing period (LGP) assessed for the state (Naidu *et al.* 1998) has been used as base information in assessing the suitability of different crops/varietal recommendation for each agro-climatic zone (Fig. 2). Soil and agro-climatic conditions of majority of the research stations of ANGRAU were compared with the soils and crop growing period of

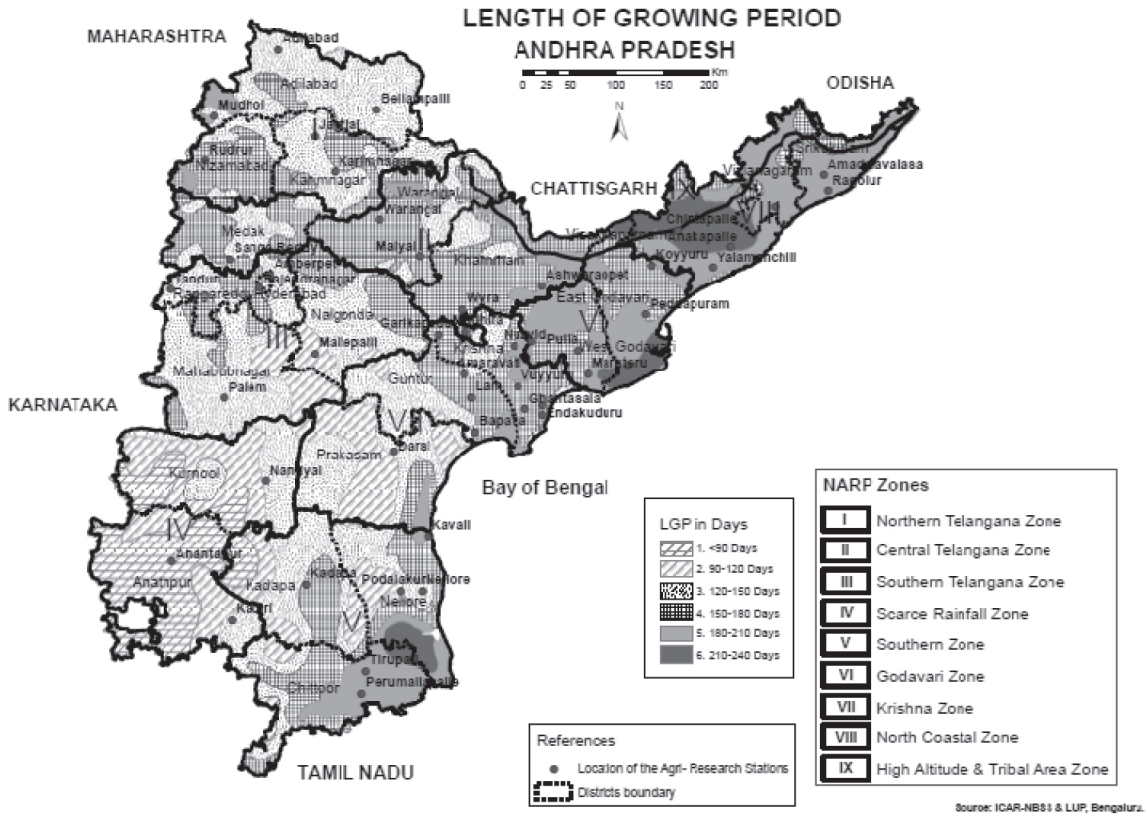

Fig. 2. Locations of ANGARU Research stations in different NARP zones

Table 1. Climatic conditions in different NARP zones

Agro climatic zone	S-W-Monsoon season			N-E-Monsoon season			Cold-Hot weather period		
	Temp (ºC)		RF	Temp (ºC)		RF	Temp (ºC)		RF
	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)
Krishna-Godavari Zone	32-36	23-24	550-750	29-32	16-21	200-260	29-38	16-24	80-110
N.E. Coastal Zone	33-35	26-27	650-750	29-36	18-24	260-310	29-36	27-28	110-160
Southern zone	36-40	23-25	310-425	28-33	15-27	250-600	30-39	13-25	90-140
Northern Telangana Zone	32-37	21-28	775-950	29-32	13-17	70-120	30-42	13-27	60-90
Southern Telangana Zone	28-34	22-23	550-700	28-30	16-21	90-120	28-37	16-26	55-90
Scarce rainfall Zone of Rayalaseema	32-36	24-30	330-420	30-32	13-22	150-240	32-40	17-27	65-85
High altitude tribal Zone	- No data -			- No data -			- No data -		

surrounding areas to see homogeneity in soil and agro-environments for technology transfer.

Results and Discussion

Agro-climatic Conditions in The State

The prevailing maximum and minimum temperature (Table 1) during different seasons (*kharif, rabi* and summer) were found closely similar in all ACZs (ANGRAU, 2013-14). Hence, temperature and light requirement for the most of the crops cultivated in different ACZs are found to have no limitation across the zones. On the contrary, rainfall with respect to amount and distribution is found highly varying from zone to zone, thereby resulting in wide differences in LGP for the most of the rainfed crops (Naidu *et al.* 1998). With regards to irrigated crops, climatic conditions prevailing in ACZs found to be similar and congenial for wide range of crops.

Characteristics of Different Bench Mark Soils and Soils of Agro-technology Generation Site (research station) in each ACZ

The ACZ-wise occurrence of bench mark soils and agricultural research stations (ARS) soils (Table 2) indicated that bench mark soils and soils of

different research stations in each ACZ and across the zones vary widely. Characteristics of bench mark soils and ARS soils in each zone are discussed below:

ACZ -1: Northern Telangana Zone

This zone covers Adilabad, Karimnagar and Nizamabad districts. The major bench mark soils occurring in this zone are Kurnool soils (very deep, cracking calcareous clay soils), Chittoor (medium deep, red clay), Sangareddi (very deep, cracking clay soils), Wanaparti (very deep, red clay soils) and Chintur (shallow, red gravelly clay soils). Wanaparti soils are occupying around 8.2 per cent of total geographical area of the zone followed by Chittoor, Sangareddi and Kurnool.

Wanaparti Soils: Very deep (>150 cm), dark yellowish brown to dark reddish brown, slightly acid to neutral (pH 5.9-6.9), red clayey soils and are classified as fine, mixed, isohyperthermic, Typic Haplustepts. Have high potential for growing mango and other horticultural, medicinal and aromatic plants.

Chittoor Soils: Moderately shallow (50-75cm), dark red to reddish brown, neutral (pH 6.6) sandy clay loam to clay subsoil and are classified as fine, mixed, active, isohyperthermic Typic Haplustalfs. Shallow rooting depth, moderate slopes (3-8%), moderate erosion and low nutrient status are the major constraints.

Sangareddi Soils: Very deep (>150 cm), very dark grayish brown slightly to moderately alkaline (pH 8.2-8.7), cracking clay soils. They are classified as fine, smectitic, isohyperthermic Typic Haplusterts. Slow permeability, high lime content, high shrink-swell potential and poor workability are the major limitations for crop production.

Kurnool Soils: Very deep (>150 cm), dark brown moderate to strongly alkaline (pH >9.0) cracking clay soils and are classified as Fine, smectitic, cal. Vertic Haplustepts. Slow permeability, high shrink-swell potential, poor workability, high lime content, with salinity and sodicity as the major constraints for crop production.

Chintur Soils: Shallow (<50 cm), reddish brown to yellowish red, slightly acidic to neutral (pH 6.5-6.7) soils and are classified as clayey-skeletal, mixed, isohyperthermic, Typic Haplustepts. Shallow rooting depth, high subsoil gravelliness, low available water capacity (AWC), moderate slopes, moderate erosion and low nutrient status are the major limitations for crop production.

In ACZ three crop growing situations exist *i.e.* areas with three LGPs *viz*., 120 to 150 days, 150 to 180 days and 180 to 210 days. The dominant crops of this zone are paddy (6.8 lakh ha), cotton (6.2 lakh ha), maize (2.0 lakh ha), pigeonpea (0.53 lakh ha) and sorghum (0.35 lakh ha) (Table 3). These crops are grown on wide range of soils and agro-environments.

Soils and Agro-climatic Situations of Different Research Stations under ACZ-I

ARS, Mudhol: The soils are medium deep black soils (50-75 cm) and technology development is mostly concentrated on cotton.

RARS, Jagityal: The predominant soils are red loamy and research is being carried on irrigated rice and rainfed groundnut.

ARS, Adilabad: Soils are very deep (>150 cm) cracking clay and research programmes are mainly focused on cotton and sorghum crops.

ARS, Rudrur: Soils are red coarse loamy calcareous and technology development programmes are mandated on sugarcane and rice, under irrigated conditions.

The soils and agro-environments of research stations in the zone are different from regional benchmark soils. Most of the research stations are located in the LGP ranging from 120-150 and 150-180 days (Table 2). Cotton and pigeonpea varieties currently recommended are long duration in nature, which are suitable to areas where LGP is 180-210 days. Major part of the zone experience 120-150 days, thereby it is observed that there is a mismatch of varieties with growing period. Most of the crops are grown on deep black, shallow to medium deep, red gravelly and non gravelly soil. The soil and crop technologies developed at research stations are not matching with the soils and agro-climatic conditions of farmers' fields in the zone to a large extent. Production technologies need to be developed for red soils of cotton growing areas as sizeable area is under cotton cultivation. Therefore, technologies developed at research stations often failed to show the same response in the farmers' fields due to mismatch in soil, climate and level of management. Crop performance and adaptability vary from soil types thereby indicating the need for soil type based management recommendations along with site specific varietal recommendation. This necessitates even delineation of technology target domain representing the technology generation site.

ACZ-II: Central Telangana Zone

This zone comprises of Medak, Warangal and Khammam districts. The Benchmark soils in the zone are belonged to Kurnool, Sangareddi, Wanaparti,

Table 2. Benchmark soils and Research station soils

Zone	District Covered	Benchmark soils	%TGA	Agricultural Research Station soils	LGP (days)
I	Adilabad, Karimnagar, Nizamabad (3587715 ha)	Wanaparti: Very deep, red clayey soils (Fine, mixed, Typic Haplustepts)	8.2	Mudhol: Fine, smectitic, Vertic Haplustepts Typic Haplusterts	150-180
		Chittoor: Mod. shallow, red clay soils (Fine, mixed, Typic Haplustalfs)	7.0		
		Sangareddy: Very deep, cracking clay soils (Fine, smectitic, cal, Typic Haplusterts)	6.7	Jagityal: Fine-loamy, mixed, cal, Typic Haplustepts	120-150
		Kurnool: Very deep,cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	6.6	Adilabad: Fine, smectitic, Typic Haplusterts	120-150
		Chintur: Shallow red gravelly soils (Csk, mixed, Typic Haplustepts)	4.6	Rudrur: Coarse-loamy, cal, Typic Haplustepts Rudrur	150-180
II	Medak,Warangal, Khammam (3690758 ha)	Kurnool: Very deep, cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	7.7	Sangareddy: Fine, smectitic, Typic Haplusterts	150-180
		Wanaparti: Very deep, red clayey soils (Fine, mixed, Typic Haplustepts)	6.1	Agr. College farm, Aswaraopet: Fine, mixed, Ultic Paleustalfs	150-180
		Sangareddy: Very deep, cracking clay soils (Fine, smectitic, cal, Typic Haplusterts)	4.4	Agr. College farm, Aswaraopet: Csk, mixed, Typic Haplustepts	150-180
		Nalgonda: Mod.deep, red gravelly loam (Lsk, mixed, Rhodic Paleustalfs)	3.5	Malyal: Fine-loamy, mixed, Typic Haplustalfs	150-180
		Chintur: Shallow red gravelly soils (Fine, mixed,Typic Haplustalfs)	3.3	Wyra: Clayey-skeletal, smectitic, cal. Vertic Calciustepts	150-180
III	Rangareddi, Mahabubnagar, Nalgonda (3999103 ha)	Kurnool: Very deep, cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	6.3	RARS, Palem: Fine, mixed, Typic Paleustalfs	120-150
		Suryapet: Deep. loamy soils of valleys (Fine-loamy, Fluventic Haplustepts)	5.9	CRIDA, farm: Lsk, mixed, Rhodic Paleustalfs	150-160
		Penukonda: Deep, gravelly red clay soils (Csk, mixed, Typic Rhodustalfs)	5.8	ARS Mallepale: Lsk, mixed, RhodicPaleustalfs	90-120
		Nalgonda: Mod. deep, red gravelly loam (Lsk,mixed, Rhodic Paleustalfs)	5.6	Rajendranagar: Very-fine, smectitic, cal. Typic Haplusterts	150-180
		Wanaparti: Very deep, red clayey soils (Fine,mixed,Typic Haplustepts)	5.6	Tandur: Fine, smectitic, cal. Chromic Haplusterts.	120-150
IV	Anantapur, Kurnool (3713363 ha)	Kurnool: Very deep,cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	10.4	Nandyal: Fine, smectitic, Typic Haplusterts	120-150
		Penukonda: Deep, gravelly red clay soils Csk, mixed, Typic Rhodustalfs	6.5	Kadiri: Csk,mixed, Rhodic Paleustalfs	120-150
		Anantapur: Shallow, red, gravelly clay soils (Csk, mixed, Rhodic Paleustalfs)	5.6	Anantapur: Clayey-skeletal, Rhodic Paleustalfs	<90
		Markapur: Shallow, red, gravelly clay soils (Csk, mixed, Lithic Haplustepts)	4.1		
		Rayadurga: Medium deep, red cal. gravelly loam (Lsk, Ustic Haplargids)	2.8		
V	Kadapa, Chittoor, Nellore (4405384 ha)	Kurnool: Very deep,cracking clay soils Fine, smectitic, cal, Vertic Haplustepts	6.9	S.V. Agricultural College farm: Fine-loamy, mixed, Typic Haplustepts	
		Kadapa: Very shallow, red gravelly loam soils (Lsk, mixed, Paraithic Ustorthents)	6.4	Thirupati: Csk, mixed, Typic Haplustalfs	150-180

Contd...

Zone	District Covered	Benchmark soils	%TGA	Agricultural Research Station soils	LGP (days)
		Mahabubnagar: Shallow, red, gravelly loam soils (Lsk, mixed, Lithic Ustorthents)	6.3	Kavali: Csk, kaolinitic, Typic Haplustalfs	150-180
		Visakhapatnam: Deep, red clayey soils (Fine, mixed, Typic Haplustepts)	6.0		
		Khammam: Mod, shallow, red loamy soils (Fine, mixed, Typic Rhodustalfs)	3.0	Pulla farm	150-180
VI	East Godavari, West Godavari (1800701 ha)	Visakhapatnam: Deep, red clayey soils (Fine, mixed, Typic Haplustepts)	14.9	Maruteru farm: Fine, smectitic, Typic Haplusterts	180-210
		Peddapuram: Very deep, red clayey soils (Fine,mixed, Rhodic Paleustalfs)	8.5	Pulla farm: Very-fine, smectitic, Vertic Haplustepts	150-180
		Kurnool: Very deep, cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	8.4	Vijay rai, APAU: Fine-loamy, Typic Paleustalfs	
		Bimavaram: Very deep, cracking clay soils (Very fine, smectitic, Typic Haplusterts)	8.0	Venkataramanagudem APAU, farm: Fine-loamy, Typic Haplustalfs	
		Praksam: Mod.shallow red loamy soils (Fine loamy, mixed, Typic Haplustalfs)	4.9		
VII	Krishna,Guntur, Prakasam (3861570 ha)	Kurnool: Very deep, cracking clay soils (Fine, smectitic, cal, Vertic Haplustepts)	9.7	Agri. College, Bapatla: Fine, smectitic, Vertic Haplustepts	
		Visakhapatnam: Deep, red clayey soils (Fine, mixed, Typic Haplustepts)	8.5	Vuyyur: Veryfine, Smectitic, Typic Haplusterts	150-180
		Markapur: Shallow, red, gravelly clay soils (Csk, mixed, Lithic Haplustepts)	6.9	Lam: Fine, smectitic, cal. Vertic Haplustepts mixed, Typic Haplustepts	150-180
		Prakasam: Mod, shallow red loamy soils (Fine-loamy, mixed, Typic Haplustalfs)	5.5		
		Kanigiri: Deep, red clayey soils (Csk, mixed, Typic Rhodustalfs)	4.4		
VIII	Visakhapatnam, Vijayanagaram, Srikakulam (1612192 ha)	Visakhapatnam: Deep, red clayey soils (Fine, mixed, Typic Haplustepts)	37.5	APAU Farm, Anakapalle: Fine, mixed, Typic Paleustalfs	210-240
		Srikakulam: Very deep, red clayey soils (Fine, mixed, Typic Haplustalfs)	11.9	APAU Farm, Anakapalle: Fine, smectitic, Vertic Haplustepts	
		Khammam: Mod, shallow, red loamy soils (Fine, mixed, Typic Rhodustalfs)	10.7	Samalkote Agricultural research farm: Fine, mixed, Typic Haplustepts	
		Shringavarapukota: Mod. deep, red gravelly loam (Lsk, mixed, Pachic Argiustolls)	8.7		
		Peddapuram: Very deep, red clayey soils (Fine, mixed, Rhodic Paleustalfs)	8.3		
IX	Part of Visakhapatnam, Vizianagaram, Srikakulam, East Godavari, Khammam and Warangal (1111843 ha)	Shringavarapukota: Mod, deep, red gravelly loam (Lsk, mixed, Pachic Argiustolls)	19.6	Chintapalle: Fine, mixed, Typic Paleustalfs	210-240
		Rampachodavaram: Mod, shallow red gravelly clay soils (Csk, mixed, Pachic Argiustolls)	18.7		
		Khammam: Mod, shallow, red loamy soils (Fine, mixed, Typic Rhodustalfs)	10.1		
		Peddapuram: Very deep, red clayey soils (Fine, mixed, Rhodic Paleustalfs)	8.8		
		Wanaparti: Very deep, red clayey soils (Fine, mixed, Typic Haplustepts)	7.0		

Nalgonda (moderately deep, red gravelly loam soils) and Chittoor. Kurnool soils occupying highest area (7.7%) followed by Wanaparti (6.1%). Kurnool, Sangareddi, Wanaparti and Chintur soils were earlier described in ACZ zone I.

Nalgonda Soils: They are moderately deep (75-100 cm), dark red to red, slightly acidic (pH 6.3-6.5) gravelly loam soils with 35 to 65 per cent gravels. They are classified as loamy-skeletal, mixed isohyperthermic, Rhodic Paleustalfs. Subsoil gravelliness, moderate slopes, low AWC, erosion hazard and low nutrient status are the major limitations.

In the ACZ II, the 3 crop growing situations exist *i.e.* areas with LGP 120-150 days, 150-180 days and 180-210 days. Overall, crop growing period in this zone is similar to zone-I, where predominantly soils are also more or less similar except occurrence of moderately deep red gravelly loam soils.

Soils and Agro-climatic Situations of Different Agricultural Research Stations (ARS) under ACZ-II

The Agricultural Research Stations located in this zone are Fruit Research Station (FRS), Sangareddi with deep cracking clay soils (fine, smectitic Typic Haplusterts) and deep red gravelly clay soils (clayey-skeletal, Typic Paleustalfs). Agriculture College Farm, Ashwaraopet soils which are deep, red clayey and shallow red gravelly clay. Malyal farm with (deep/medium/shallow) red loamy soils (Typic Haplustalfs) and Wyra farm with cracking calcareous black soils (Vertic Calciustepts). The major crops of the region are rice (5.3 lakhs ha), sugarcane (6.30 lakhs ha), cotton (5.3 lakhs ha), maize (2.1 lakh ha), green gram (0.66 lakh ha), groundnut (0.50 lakh ha), pigeon pea (0.50 lakh ha) and sorghum (0.35 lakh ha). The Research stations with mandated crops are vegetables (Ashwaraopet), rice/pulses (Warangal) mango/chilli (Malyal), pulses (Madhira), mango/sapota/guava/custard apple (Sangareddi) (Table 3).

Soils and agro-environments of the research stations are not varied much from the regional benchmark soils observed in the zone. In this zone mandated research activities are concentrated on pulses, vegetables, rice and horticultural crops. However, technologies related to sugarcane and cotton have to be adopted from the other zones. The cotton and pigeon pea varieties recommended are longer duration in nature, which are suitable to areas where LGP is 180-210 days. Major part of the zone experience 120-150 days indicating that there is mismatch of varieties with growing period. Hence,

Table 3. Area under major crops (ha) in different NARP zones

Sl.No.	NARP Zone	Rice	Sorghum	Maize	Groundnut	Castor	Cotton	Sugarcane	Greengram	Pigeonpea	Blackgram
1	Northern Telangana	6,79,357	35,679	2,01,665	20,580	-	6,19,564	-	33,414	52,956	23,170
2	Central Telangana	5,26,695	33,852	2,03,161	50,828	-	5,30,574	-	66,642	50,249	28,362
3	Southern Telangana	5,43,496	19,949	1,87,023	1,28,125	88,790	4,30,684	29,885	47,783	1,95,430	18,402
4	Scarce Rainfall Zone	1,55,390	99,767	61,157	11,50,545	1,45,295	1,15,320	61,157	3,719	1,00,766	13,060
5	Southern Zone	3,59,574	13,717	-	4,16,008	2,293	43,551	38,201	5,069	17,807	52,407
6	Godavari Zone	7,00,879	327	56,894	5,020	-	18,281	39,672	44,169	545	1,15,125
7	Krishna Zone	6,83,349	33,007	1,09,982	21,509	14,118	2,76,952	-	35,085	58,386	2,58,796
8	North Coastal Plain	44,71,108	1,339	39,521	82,929	-	18,685	61,909	47,583	5,359	61,567
9	High Altitude & Tribal area	-	-	-	-	-	-	-	-	-	-
	State	40,95,848	2,76,598	8,63,724	18,75,544	2,53,280	20,53,611	2,04,038	2,83,464	4,81,498	5,39,710

site specific varietal recommendation plays a major role in enhancing the productivity of crops.

ACZ-III: Southern Telangana Zone

This zone includes Rangareddi, Mahabubnagar and Nalgonda districts. The bench mark soils occurring in this zone are Kurnool (deep, calcareous black soils), Penukonda (deep, red gravelly clay), Wanparti (very deep, red clay), Nalgonda (medium deep, red grvelly loam) and Suryapet (very deep alluvial loamy). Kurnool soils are occupying large area (6.3%) followed by Suryapet (5.9%) and Penukonda (5.8%). Kurnool, Wanparti and Nalgonda soils are described in ACZ-I and II

Penukonda: They are deep (100-150 cm), dark reddish brown to dark red slight to moderately acid (pH 5.5 to 6.1), gravelly sandy clay to gravelly clay with 65 to 75 per cent gravel. They are classified as clayey-skeletal, mixed isohyperthermic, Typic Rhodustalfs. High subsoil gravelliness, moderate slopes, severe erosion, low AWC and low nutrient status are the major constraints.

Suryapet: They are deep (100 to 150 cm), very dark greyish brown to brown slightly alkaline to moderately alkaline (pH 7.8 to 8.6), alluvial loamy soils. Soils are classified as fine-loamy, mixed, isohyperthermic, Fluventic Haplustepts. Sodicity, stratified texture (sandy over clayey) and moderate erosion are the major constraints.

In ACZ-III, two crop growing situations exist *i.e.* areas with 120-150 days and 150-180 days growing periods. The major crops grown (Table 3) in this zone are paddy (5.43 lakh ha), cotton (4.30 lakh ha), pigeonpea (1.95 lakh ha), maize (1.90 lakh ha), groundnut (1.3 lakh ha), castor (0.89 lakh ha) and greengram (0.48 lakh ha). It is observed that these crops are grown on wide range of soil and agro-environments indicating the need for soil based fertilizer and site specific varietal recommendation.

Soils and Agro-climatic Situations of the ARSs under ACZ-III

The major research stations located in this zone are RARS, Palem with very deep, red clay soils, CRIDA Farm with medium deep, red gravelly loam soils, Mallepalle Arid Horticulture Research Station with medium deep, red gravelly loam, Rajendranagar and Tandur Research Stations have very deep, cracking clay soils. The LGP of these stations varied from 90 to 180 days (Table 2). The research stations falling under this zone mandated with research on sorghum, castor, sunflower, groundnut and pearlmillet (Palem), grape/rice (Rajendranagar), maize (Ammerpet), Arid Horticulture (Mallepalle). The cotton, castor and pigeonpea varieties recommended in this zone are longer duration in nature, which are suitable to areas where LGP is 180-210 days. Major part of the zone experience 120-150 days LGP. There is a mismatch between duration of varieties of cotton, pigeonpea, and castor with crop growing period of the zone. In this zone, short/medium duration varieties inconjuction with soil type based fertilizer recommendation is required.

ACZ-IV: Scarce Rainfall Zone

This zone includes Anantapur and Kurnool districts. The dominant benchmark soils are Kurnool, Penukonda, Anantapur, Markapur and Rayadurg. Kurnool soils are occupying highest area (10.4%) followed by Penukonda soils (6.5%) and Ananthapur soils (5.6%). The details of Kurnool and Penukonda soils are given in ACZ-I and III.

Anantapur soils: They are moderately shallow (50-75 cm), dark red, neutral to slightly acidic (6.4 to 6.7) gravelly sandy clay with 50 to 70 per cent gravel. They are classified as clayey-skeletal, mixed, isohyperthermic, rhodic paleustalfs. Subsoil gravelliness, gently to moderate slopes, low AWC, severe erosion and low nutrient status are the major constraints for crop production.

Markapur Soils: They are shallow (25-50 cm), dark reddish brown slightly alkaline (pH 8.2 to 8.3), gravelly clay loam with 60 per cent gravel. They are classified as clayey-skeletal, mixed, isohyperthermic, Lithic Haplustepts. Subsoil gravelliness, shallow rooting depth, low AWC, severe erosion and low nutrient status are the major constraints.

Rayadurg Soils: They are moderately shallow (50-75 cm), dark reddish brown, moderately alkaline (pH 8.6 to 8.8) gravelly sandy loam with 35-50 per cent gravels. They are classified as loamy-skeletal, mixed, cal, isohyperthermic, Ustic Haplargids. Subsoil gravelliness, moderate erosion, low nutrient status and shorter growing period (aridity) are the major constraints for crops.

In ACZ-IV**,** 3 crop growing situations exist *i.e.* 70-90, 90-120 and 120-150 days growing period. The dominant crops cultivated in this zone are groundnut (11.50 lakh ha), paddy (1.55 lakh ha), castor (1.45 lakh ha), cotton (1.15 lakh ha), pigeonpea (1.00 lakh ha) and sorghum (0.99 lakh ha) (Table 3). These crops are grown on wide range of soils and agro-environments within the zone.

Soils and Agro-climatic Situations of ARSs under ACZ-IV

The different research stations coming under this zone are RARS, Nandyal with deep, cracking clay soils, ARS, Kadiri with medium deep, red gravelly clay soils, ARS-Anantapur with medium deep red gravelly clay soils of ARS, Reddipalli. The different research stations falling under this zone with research priority crops are groundnut (Anantapur/ Kadiri) and rice/cotton (Nandyal). Soils and agro-environments of the research stations are not varying much from the regional benchmark soils observed in the zone except red calcareous gravelly loams. Very large area falls under LGP of 70-90 and 90-120 days. Anatapur research station is developing production technologies for groundnut and suitable varieties are developed from Kadiri with 120-150 days crop growing periods. Soil based fertilizer recommendation is given from ARS, Rekulakunta (AICRP for Dryland Agriculture centre), particularly P management in rainfed groundnut. Other research stations are focusing on rice, and cotton crops. Specific technologies need to be developed for red calcareous soils. Groundnut crop is grown extensively on red and black soils with different yield potentials. Now, throughout the state for rainfed and irrigated groundnut crop has separate fertilizer recommendations. However, it is necessary to develop soil based fertilizer recommendations. Large part of the zone has crop growing period of 70-90 days where groundnut is a preferred crop by the farmers even it is a unsuccessful under abnormal weather situations. In this zone emphasis should be given to crop diversification by introducing short duration cereals like millets and pulses.

ACZ-V: Southern Zone

This zone includes Kadapa, Chittoor and Nellore districts. The major benchmark soils are Kurnool, Kadapa, Mahabubnagar, Visakhapatnam, and Khammam. Kurnool soils occupy around 6.9% TGA area of the zone followed by Mahabubnagar (6.3%) and Vishakapatanam (6.0%). Kurnool and Kadapa soils were described in ACZ-I and IV.

Mahabubnagar Soils: They are shallow (25-50 cm), reddish brown to dark red, neutral to slightly acid (pH 6.4 to 6.6) gravelly sandy loam with 50 to 60 per cent gravel. Soils are classified as loamy-skeletal, mixed, isohyperthermic, Lithic Ustorthents. Subsoil gravelliness, shallow rooting depth, low AWC, moderate slopes, moderate erosion and low nutrient status are the major constraints for crop production.

Visakhapatnam Soils: These are deep (100-150 cm), strong brown to yellowish red, neutral to slightly alkaline (pH 6.5 to 7.8) gravelly clay. They are classified as fine, mixed, isohyperthermic, Typic Haplustepts.

Khammam Soils: The soils are moderately shallow (50-75), red to reddish brown, slightly acid to neutral (pH 5.7 to 7.1) sandy clay loam to sandy clay. They are classified as fine, mixed, isohyperthermic, Typic Rhodustalfs. Moderate slopes, moderate erosion and low nutrient status are the major constraints.

Kadapa Soils: The soils are shallow (<50 cm) and red loamy soils, calcareous ($CaCO_3$) in nature. They are classified as loamy-skeltal, mixed isohyperthemic, Paralithic Ustorthents. Moderate slopes, moderate erosion and low nutrient status are the major constraints.

In ACZ-V, five crop growing situations exist *i.e.* 70-90, 90-120, 120-150, 150-180 and 180-210 days crop growing periods. The main crops cultivated in this zone are groundnut (4.16 lakh ha), paddy (3.6 lakh ha), blackgram (0.52 lakh ha), cotton (0.43 lakh ha) and sugarcane (0.38 lakh ha) (Table 3).

Soils and Agro-climatic Situations of ARSs under ACZ-V

The major research stations located under this zone are Dry land farm, SV Agriculture College, Tirupati where the soils are very deep red gravelly clay and red loamy soils with LGP of 150-180 days. ARS, Kavali has moderately shallow, red gravelly loam and LGP is 150-180 days. The different research stations of this zone with mandated crops are groundnut (Tirupathi), sugarcane, (Perumallapalle) rice (Nellore), mango/citrus (Anantharaj peta). Soils and agro-environments of research stations are different from regional benchmark soils observed in the zone. In this zone, 5 crop growing situations exist *i.e.* 70-90, 90-120, 120-150, 150-180 and 180-210 days but most of the research stations are located in 150-180 and 180-210 days crop growing periods. Most of the crops like groundnut, cotton and pulses are grown under rainfed situation for which LGP is most critical factor to decide productivity. The LGP may not be critical for irrigated crops like paddy and sugarcane, however, soil characteristics plays an important role in deciding their productivity. All these crops are grown on deep black, shallow to medium deep red gravelly and non-gravelly soil. Technologies developed at research stations are not matching with the soil and agro-climatic conditions in farmers' fields.

Therefore, soil based and site specific technologies needed to be advocated to boost the productivity of these crops.

ACZ-VI: Godavari Zone

This zone includes East Godavari and West Godavari districts. The major benchmark soils of this zone are Visakhapatnam, Peddapuram, Kurnool, Bhimavaram and Prakasam. Almost 14.9% of TGA is occupied by Vishakapatnam soils followed by Peddapuram (8.5%) and Kurnool soils (8.4%). Kurnool and Visakhapatnam soils were described in ACZ-I and V.

Peddapuram Soils: The soils are very deep (>150 cm), dark red moderately acid to slightly acid (pH 5.2 to 6.3), sandy clay to clay. The soils are classified as fine, mixed, isohyperthermic, Rhodic Paleustalfs.

Bhimavaram Soils: The soils are very deep (>150 cm), very dark grayish brown slightly alkaline (pH 7.9 to 8.1) cracking clay. They are classified as very fine, smectitic, isohyperthermic, Typic Haplusterts. These soils are very slow permeable, high lime content, high shrink-swell potential, poor workability are the major constraints for crop production.

Prakasam Soils: The soils are moderately shallow (50-75), strong brown, neutral (6.8 to 7.2) sandy clay. The soils are classified as fine-loamy, mixed, isohyperthermic, Typic Haplustalfs. Moderate rooting depth, moderate erosion and low nutrient status are the major constraints for crop production.

In the ACZ-VI, two crop growing situations exist *i.e.* areas with 150-180 and 180-210 days for growing crops. The dominant crops grown in this region are rice (7.0 lakh ha), black gram (1.15 lakh ha), maize (0.56 lakh ha), greengram (0.44 lakh ha) and sugarcane (0.40 lakh ha). These crops are cultivated on wide range of soils and agro-environments in the zone.

Soils and Agro-climatic Situations of ARSs under ACZ-VI

The research stations located in this zone are Maruteru, Pulla, Ambajipet and Kovvuru farms which have deep to very deep, cracking clayey soils whereas Vijayrai and Venkataramanagudem farms are red loamy in texture. The mandated crops are rice (Maruteru) and banana (Kovvuru). The technologies developed in research station are mostly for deep soils and mandated on rice and banana crops only. The soils and agro-climate of the research stations is not having much deviation from that of zone and major research activities are concentrated on the major crops of the zone.

ACZ-VII: Krishna Zone

This zone includes Krishna, Guntur and Prakasam districts. The major benchmark soils are Kurnool, Visakhapatnam, Markapur, Prakasam and Kanigiri. Kurnool soils occupy largest area (9.7%) followed by Visakhapatnam (8.5%) and Markapur (6.9%). Kurnool soils are described in zone I, Visakhapatnam, Markapur soils in zone V and Prakasam soils are described in ACZ zone VI.

Kanigiri Soils: They are deep (100 to 150 cm), dark reddish brown to dark red slightly acid to neutral (pH 5.8 to 6.6), gravelly sandy loam to gravelly sandy clay with 30-40 per cent gravel. They are classified as clayey-skeletal, mixed, isohyperthermic, Typic Rhodustafs. Subsoil gravelliness, moderate to steep slopes, moderate to severe erosion, low AWC and low nutrient status are the major constraints. In the ACZ-VII, three crop growing situations exist *i.e.* areas with 120-150, 150-180 and 180-210 days growing period. The predominant crops grown in this region are rice (6.83 lakh ha), cotton (2.78 lakh ha), black gram (2.59 lakh ha), maize (1.10 lakh ha), pigeon pea (0.58 lakh ha) and green gram (0.35 lakh ha) (Table 3). These crops are grown on wide ranges of soil and agro-environments of the zone.

Soils and Agro-climatic Situations of ARSs under ACZ-VII

The different research stations located in this zone are Agriculture College Farm, Bapatla with moderately deep, cracking clay soils and sandy soils, whereas soils of Vuyuru and Lam are deep (100-150 cm), cracking clay and non deep gravelly red clayey soils respectively. The mandated crops are cotton/ pulses (RARS, Lam), Cashew (ARS, Bapatla) and Sugarcane (ARS, Vuyuru). The cotton cultivars recommended are long duration in nature, which require LGP of 180-210 days for successful cultivation. The major part of the zone experiences 120-150 days, indicating mismatch of varieties with crop growing period. This shows the need for the site specific varietal recommendation.

ACZ-VIII: North Coastal Zone

This zone includes Visakhapatnam, Vijayanagaram and Srikakulam districts. The major benchmark soils of this zone are Visakhapatnam, Srikakulam, Shrungavarapukota, Khammam and

Peddapuram. Visakhapatnam soil occupies around 37.5% followed by srikakulam (11.9%) and Khammam (10.7%). The details of Visakhapatnam soils are given in earlier ACZ zone V and Peddapuram soils are described in ACZ zone VI.

Srikakulam Soils: The soils are very deep (>150 cm), reddish brown to dark reddish brown slightly acidic (pH 6.0 to 6.2), clay loam to clay. These soils are classified as fine, mixed, isohyperthermic, Typic Haplustalfs.

Shrungavarupukota Soils: The soils are moderately deep (75-100 cm), dark reddish brown, slightly acidic (pH 6.1 to 6.3), gravelly sandy clay loam with 60-70 per cent gravels. The soils are classified as loamy-skeletal, mixed, isohyperthermic, Pachic Argiustolls. Subsoil gravelliness, steep slopes, severe erosion are the major constraints.

In ACZ-VIII, three crop growing situations in this zone *i.e.* with areas 150-180, 180-210 and 210-240 days growing period. Major crops grown in this zone are paddy (4.5 lakh ha), ground nut (0.8 lakh ha), sugar cane (0.6 lakh ha), black gram (0.6 lakh ha) and green gram (0.5 lakh ha).

Soils and Agro-climatic Situations of ARSs under ACZ-VIII

The major research stations located in this zone are RARS, ARS, Anakapalli with very deep, red clayey soils and moderately shallow, cracking clay soils. Whereas, Samalkot with soils are deep, cracking clay soils. The mandated research priority crops are sugarcane (Anakapalli), sesame (Yelamanchli), mesta (Amadalavalasa). Rice and sugarcane are the major crops grown in this zone and technologies developed for paddy in other zone are being adopted. There is a need to develop site specific technologies for rice.

ACZ-IX: High Altitude and Tribal Zone

It covers hilly tracts of Visakhapatnam, Vijayanagaram, Srikakulam, East Godavari, Khammam and Warangal district. The bench mark soils covered under this zone are Shrungavarupukota, Rampachodavaram, Khammam, Peddapuram, and Wanaparti. Shringavarapukota soils occupy highest area of 19.6% followed by Rampachodavaram soils (18.7%). Wanaparti soils are described in zone II, Khammam soils in zone V, Peddapuram soils in zone VI and Shrungavarupukota soils in zone VIII.

Rampachodavaram Soils: These soils are moderately shallow (50-75 cm), dusky red to very dusky red neutral to slightly acidic (pH 5.8 to 6.8) gravelly sandy clay. The soils are classified as clayey-skeletal, mixed, isohyperthermic, Pachic Argiustolls. Medium rooting depth, steep hill slopes, subsoil gravelliness and severe erosion are the major constraints. In ACZ-IX, 3 crop growing situations exist *i.e.* 150-180, 180-210 and 210-240 days growing period. The dominant crops in the zone are rice, fingermillet, maize, ginger, coffee, fineapple and small millets.

Soils and Agro-climatic Situations of ARSs under ACZ-IX

The research stations' located in this zone is Agriculture College Farm, Chintapalle with deep, red clay soils and mandated to conduct research on coffee and other food crops like rice and millets.The soils and agro-climate of the research stations is not having much deviation from that of zone and major research activities are concentrated on the major crops of the zone.

Soil Resource Information for Prioritizing Agricultural Research

Crops and Varieties Recommendation

There is a wide variation of LGP across and within ACZ's indicating 2 to 3 crop growing situations occur in each ACZ. The present blanket recommendation of crops and varieties (short/medium/long duration) will have critical moisture limitations in some pockets of ACZ where crop growing period is shorter than the duration of varieties, particularly for long duration and medium duration crops like cotton, pigeonpea, castor in Southern and Northern Telangana ACZs and groundnut, pigeonpea and cotton in scare rainfall zone. Though, the information of LGP is now available at a small scale across the zones for the state, the LGP information of soils of research stations available and the mismatch between the crop recommendations are indicative for site-specific / target domain specific crop and varietal recommendation.

Rationale of Crop and Fertilizer Recommendation in ACZs

There has been a blanket recommendations of crop production technologies (Vyavasaya Panchagam 2013-14) for adoption in farmer's fields across all the 9 ACZs. Scrutiny of these recommendations (Tables 4, 5) showed that no single criteria have been used for developing fertilizer recommendations for different crops. For example, in case of rice crop, season-wise (*kharif/rabi*/summer) as well as zone-wise

Table 4. Recommended fertilizer doses and cultivars for different agro-climate zones of Andhra Pradesh

Zone	Cultivars Recommended			Fertilizer Recommended			LGP (Days) of the zone
			Cotton				
	Desi	American Variety	Hybrid	Desi	American Variety	Hybrid	
Coastal	Mahanandi (180)		LAHH- 1 and 4 (170)	-	90:45:45	120:60:60	150-180 and 180-210
Scarce rainfall	Mahanandi (180) Srisailam (160)	NA 247 NA 920 (180)	LAHH- 1 and 4 (170) MECH- 12 (165)	20:20: 0	40:20:20 (RF) 90:45:45 (I)	120:60:60	90-120 and 120-150
Telangana	Mahanandi (180) Srisailam (160)	L- 603 (160)	LAHH-1 and 4 (170) MECH- 12, 1 and 4 (165)	40:20:20	90:45:45	120:60:60	120-150 and 150-180
			Groundnut**				
	Short	Medium	Long	Rainfed	Irrigated		
Scarce rainfall zone	Kadiri-4 (90-100)	Vemana (100-115) Tirupathi-2 (105-110) TMV-2 (105-110)	Tirupathi-1(100-105), 4 (100-110) Kadiri-4, 5 (105-110) Narayani (90-100)	20:40:50 gypsum 500 kg ha^{-1} and $ZnSO_4$ 25 kg ha^{-1} once in 3 years	30:40:50 gypsum 500 kg ha^{-1} and $ZnSO_4$ 50 kg ha^{-1} once in 3 years		
			Pigeon pea				
Throughout the state	Durga (115-125) Lakshimi (120-125)	PRG -100 (145-150) Maruti (155-160) PRG-158(150-155)	WRG-27 (180) LRG-38 (170) URG-66 (180) HY.3C (190-200) Asha (170-180) LRG 30 (170-180) Surya (165-180) Abhaya (160-165)	20:50:0	40:50:0		

* Figures in parentheses indicate LGP in days; RF=Rainfed; I= Irrigated; ** Fertilizer recommended for whole state

Table 5. Fertilizer recommendation for rice and sugarcane in different NARP zones

Zones	*Kharif*			*Rabi*		
	N	P	K	N	P	K
Rice						
Krishna delta /light textured soils	60-80	40-60	30-40	180	90	60
Godavari delta	90	60	60	180	90	60
North coastal	80	60	40-50	120	60	50
Southern zone	80	60	40	120	60	40
North Telangana	100	50	40	120	60	40
South Telangana	100-120	60	40	120	60	40
Scarce Rainfall	160	80	80	-	-	-
Tribal	80	60	50	-	-	-
Sugarcane						
North Coastal/ Central and North Telangana	110	100	120	-	-	-
Krishna /Godavari	165	100	120	-	-	-
Scarce Rainfall/ Southern Zone	225	100	120	-	-	-
Northern Telangana (Ekasali)	250	100	120	-	-	-
Northern Telangana (Adsali)	400	100	120	-	-	-

Zinc sulphate 50 kg ha^{-1}

fertilizer recommendations (Table 5) are advocated. For sugarcane, fertilizer recommendations are based on crop duration (*Eksali/Adasali* crop) and zone-wise separate packages are recommended whereas in cotton criteria followed was purely based on genotype *i.e.* Desi, American, Hybrid varieties under rainfed and irrigated situations in different regions/zones *i.e.* Rayalaseema, Telangana and Coastal Andhra Pradesh. For groundnut and pigeon pea, fertilizer recommendations are based on rainfed or irrigated crop growing situations (Table 4). However, efforts are made for soil test based P recommendation in rained groundnut from ARS, Rekulakunta /AICRPDA Centre, Anantapur. It is seen that a wide range of soils occur in each ACZ with different potentials, limitations and management responses based on their inherent soil characteristics. Soils with similar texture, mineralogy, moisture and temperature regimes are likely to behave in similar manner if they are occurring within and across the zones. Performance of rice crop was different on deltaic/ alluvial black soils (Typic Haplusterts/Vertic Haplustepts), alluvial clay (Typic Hhaplustepts) and red loamy/lateritic soils, (Typic Haplustalfs/Paleustalfs) irrespective of their occurrence in NARP zones indicating the need for more than single recommendation for each zone (Naidu *et al.* 2004). Performance of sugarcane crop was differed on alluvial black (Fine Vertic Haplustetps) and red gravely clay soils (Fine Kaolinitic Rhodic Paleustalf) in Belgaum district of Karnataka (Naidu 1999). Varied crop response of cotton was observed in deep black cotton (Fine Typic Haplusterts), medium deep black (Fine Vertic Haplusteps) and shallow black (Fine Lithic Ustorthents) soils (Ramamurthy and Gajbhiye 2005).

Soil based fertilizer application is a precision approach. Crop yield and management response study of rice on farmer's fields (Naidu *et al.* 1998) showed that rice crop is dominantly grown on 5 soil types across the state as discussed earlier. Varied response behaviour of soils indicated that more than one fertilizer recommendation needs to be adopted in each zone depending on the soil type variations. Overall, 3 levels of fertilizer recommendations may be sufficient for rice crop in entire state as against the existing 7 Zonal recommendations. For fertilizer and varietal recommendation, broad level soil (family level) / growing period information will be sufficient for making recommendations and transfer of technology in the absence of detailed soil information (1:10,000).

Soil Resource Information for Agricultural Development in Andhra Pradesh

Presently, many developmental programmes are being either undertaken or in operational at various levels (mandal and district) in the state. The Department of Agriculture, Govt. of A.P. has some important strategies for land based developmental programmmes: (Dept. of Agriculture 2008-09) as listed below:

Programme/scheme	Objective	Usefulness of land resource information to achieve the goal	Level of soil information
Correcting micronutrient (zinc) deficiency	To correct the micronutrient deficiency of major crops	The available zinc status is deficient in more than 53% area. Recommendation of zinc sulphate in rice, maize, sugarcane, groundnut and fruit crops is essential for increasing the productivity and higher yields.	Site-specific information (1:10,000)
Reclamation of problematic soils to restore productivity	To restore the productivity of problematic soils	Salinity/sodicity problems occur in 3% area mostly confine to valleys, plains and command areas particularly in Mehaboob Nagar, Warangal, Sanga Reddy, Kurnool, Anantapur, Krishna, East and West Godavari and Nalgonda districts.	
Calamity management in the event of drought/ flood/hail stones etc	To ensure livelihood security by contingent planning and proper natural resource managent	Anantapur, Kurnool, Mehboobnagar, Kadapa, Prakasam and Nalgonda districts (part or fully) are categorized as chronic to severe drought prone and Nellore, Guntur, Kurnool, Adilabad are grouped under moderate intensity. There is a need to take up continuous developmental programmes in these districts as a drought proofing measure to assure livelihood security to farmers.	Broad level information (1:50,000)
Natural Resource Management through Watershed approach (Hariyali)	Conservation of water and soil in rainfed areas for sustainable management of natural resources	About 7.3 Mha spread in Kadappa, Adilabad, Visakhapatinam, East Godavari, Chittor, Anantapur, Nizamabad and Vizianagaram districts is subjected to extremely severe erosion (>40 t h^{-1} yr^{-1}). Agriculture department should prioritize watershed development in these districts to conserve the soil.	Site-specific information (1:10,000)

Govt. of India has been undertaking many mission mode programmes/ schemes being operational with inter-ministerial and inter departmental convergence and operational in the states. Few important programmes with activities and how the land resource information could be used for strengthening the programmes are given below.

Programme/scheme	Core programme	Potential districts/areas with soil information to achieve the goal	Level of soil information for users
National Food Security Mission	To increase Food Production (Rice/ Pulses) in sustained manner to ensure food security	Potential areas for rice Production are Krishna, East and West Godavari, Guntur, Nellore, Warangal, Nalgonda, Sanga reddy districts. Strategies for area expansion and high input use are to be focused in these districts.	Site-specific information (1:10,000)
Integrated scheme of oil seeds, pulses, oilpalm and maize (ISOPOM)	To promote crop diversification and to encourage farmers to grow oilseed on a large scale	Potential areas for groundnut are Chitoor, Vizianagaram, Kurnool, for sunflower are Anathapur, Kurnool, Nellore, for castor are Mahaboobnagar, Nalgonda, for maize are Karimnagar, Nizamabad, Warangal, Adilabad and Khammam.	District/Mandal level (1:50,000/ 250,000 scale)
National Horticultural Mission	To encourage, promote stimulate and develop the growth of diverse horticulture	Krishna, Khammam, East and West Godavari, Chittoor, Vizianagaram for mango, Nellore, Nalgonda, Anantapur for citrus, Guntur, East and West Godavari for Banana, East and West Godavari for cashew are found potential districts for these fruit crops. Crop area expansion and high input use and expansion of micro irrigation will promote fruit production in the state.	District/Mandal level (1:50,000/ 250,000 scale)
Technology Mission on Cotton (TMC)	To increase production, productivity and improve the quality of cotton	The potential districts for cotton production are Adilabad, Guntur, Warangal, Khammam, Sangareddy, Karimnagar and Kurnool. Strategies for area expansion and high input use are to be focused in these districts.	
Integrated Cereal Development programme (ICDP)	To enhance the income under coarse cereal crops (Jowar and ragi) by suitable interventions	Adilabad, Sangareddy, Kurnool, Ranga Reddy. Strategies for area expansion and high input use are to be focused in these districts.	Site-specific information (1:10,000)

Conclusions

It is understandable that the concerted research efforts at various research stations/centres of State Agricultural Universities and ICAR Institutes resulted in developing soil and crop management doable technologies. However, in general, the natural resources, particularly soil characteristics are not matching with that of the technology generation sites of these research stations with those of the technology recommendation domain. This is also true that there is a limitation of spatial variability of soils at a research station that adequately represent the soils of the target recommendation domain. Therefore, it is necessary to consider the spatial variability of the soils within the target recommendation domain and match those of the research station while prioritizing the research and technology generation. Thus, the soil resource information not only helps in appropriate technology generation but also provides ample scope for technology up-scaling in the target domain. Further, this rational approach provides up-scaling of technologies in on a large scale in convergence with the programmes/ schemes of the state and central governments and helps in focused and right investments for agricultural development within and across ACZs. It is now very encouraging to note that many departments at central and state level are showing concern about availability of soil resource information for developing and executing their respective programmes, particularly in agriculture, rural development and water resources. However, there is also need for soil resource information at larger scale *i.e.* 1:25,000 or 1:10,000 for implementation of various agricultural developmental programmes even at micro-watershed level. Efforts are now needed in this direction. It is also time that soil information deserves due respect with appropriate institutional and policy support.

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