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Soil characteristics and available nutrient status of surface and sub-surface soils of KVK, bellampalli, mancherial for sustainable land use planning

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Abstract
Detailed soil survey was conducted at Krishi Vigyan Kendra, Bellampalli in Mancherial district of Telangana state which is newly established on 17th, March, 2018. In this study, field wise geo-referenced, physico-chemical characteristics and nutrients status of soils were studied. The soils are very shallow to moderately deep. The surface soils are neutral to strongly alkaline in reaction (6.95-8.89) with non-saline in nature (0.11to 0.51 d Sm^{-1}), low to medium in organic carbon (3.1- 6.6 g kg^{-1}) and $CaCO_3$ (1.9- 8.0 g kg^{-1}). The surface and subsurface soils (0-15 and 15-30 cm) are low in available N (127.48 to 251.25 and 102.5 to 209.37 kg ha^{-1}), low to medium in available P (10.15 to 18.76 and 7.15 to 14.35 kg ha^{-1}), low too high in available K (287.48-368.32 and 136.95 to 178.29 kg ha^{-1}) and available S (6.63 to17.8 and 2.42 to 9.8 mg kg^{-1}) respectively. Further, the soils are deficient to sufficient in available Zn (0.25to 0.82 and 0.11 to 0.56 mg kg^{-1}), Fe (0.86 to 11.76 and 0.06 to 8.28 mg kg^{-1}), Mn (0.51to 6.77 and 0.23 to 4.53 mg kg^{-1}), B (0.17 to 1.26 and 0.10 to 0.72 mg kg^{-1}) and sufficient in available Cu (0.57 to 1.98 and 0.11 to 1.24 mg kg^{-1}) in the surface and sub-surface samples respectively. The land evaluation for soil suitability indicates that these are high to moderately suitable for cultivation of irrigated dry crops such as sorghum, maize, redgram, greengram, sunhemp, blackgram, soybean, groundnut, sunflower, sesame, high density cotton and horticultural crops. Soil productivity can be improved by providing irrigation, addition of organic matter, tank silt, black clay soils and erosion control practices.

Keywords: Physico-chemical characteristics, available nutrient status, soil site suitability and crop plan

Introduction
Krishi Vigyan Kendra, Bellampalli was established on 17th, March, 2018 by Hon'ble Prime Minister of India Shri Narendra Modi through web casting and has been allotted 50 acres of land vide Survey No. 170PP situated at Bellampalli circle (Fig.1) which is a *Knowledge Hub* and *Farm Science Centre* for dissemination of new innovative technologies to the farming community through On Farm Trails, Front Line Demonstrations, Cluster Front Line Demonstrations, Tribal Sub Plan, SC Sub Plan, Capacity building programmes and skill development programmes keeping in view of doubling of farmers income. In addition to the above, the KVK Instructional Farm is keeping with the concept of *"seeing is believing"* by maintaining different innovative live demonstrations units on Agri and allied sectors activities which includes fish farm ponds, Permanent Pandal farming, Apiculture (Honeybee rearing), Shade net nursery, Micro irrigation units, Mulching units, Organic farming, Vermi composting, Crop Cafeteria on Pulses, Millets, Oilseeds and Fodder crops etc., in 50 acres of farm land with some income generating activities by providing and producing the good quality seeds such as Rice, Greengram, Redgram, Sunhemp, Jowar and Sesame and supplying same to the farmers. The climate is generally hot and dry in summer and cold in winter. The main feature about the climate is the seasonality of rainfall allowing for annual wetting and drying of the solum leading to many unique physical properties of soils. In Mancherial district, the major portions of the irrigated and rainfed crops were sown in the month of June and July and the productivity of irrigated dry crops and rainfed crops such as cotton, pulses, groundnut, sunflower, sesame and

maize is slowly increasing.

Knowledge of the soils and their distribution is necessary for proper appraisal of their productivity, potential and their rational use. It is also necessary to relate the information on crop requirements to units delineated on the soil map for agro technology transfer. Keeping this in view, a detailed study on physico-chemical characteristics and available nutrients status of the soils was taken up for better scientific utilization of lands by identifying the potentials and limitations and to suggest suitable crop plan and management options for higher productivity.

Materials and Methods

Location and site characteristic of study area

The Mancherial district is located in northern part of Telangana state, spread over an area of 4016 km^2, the geographical area is carved out from erstwhile Adilabad district. It lies in between eastern latitude (18.875595) and northern longitude (79.459138). The district is surrounded by Kumaram Bheem in north, Peddapalli in South, Gadchiroli district of the Maharasthra in east and Jagtial in West. It has two revenue divisions sub-divided into 18 mandals comprising 382 revenue villages. Rivers Godavari and Pranahita pass through this district with Natural Resources such as Famous Singareni Collieries (Coal mines), Limestone and Jannaram Forest (kavval). Average rainfall of the district is 1092 mm with major crops in the district are cotton, rice, horticulture and pulses. There are three major types of soils in Mancherial District. Black soils, both shallow and deep types, occupy 26 percent of geographical area. Calcareous natured black soils are also present substantially in the district (7%). Red soils with gravel, loam and clay textures occupy 63 percent of the district. The natural vegetation existing in the study area are dry deciduous deep forest, grasses, shrubs, thorny bushes etc. In order to delineate the detailed field wise physico-chemical characteristics, available nutrients status in the surface and sub-surface soils, 36 surface (0-15 cm) and 36 sub-surface (15-30 cm) soil samples were collected from 9 different blocks of KVK, Bellampalli Mancherial. The soil samples were air-dried in shade, processed and screened through a 2mm sieve and analyzed by using standard procedures.

Results and Discussions

The pH ranges between 6.95-8.89 and 7.10 to 9.23 in surface and subsurface soils respectively. Majority of these soils (60%) are moderately alkaline in soil reaction and appeared to be related to the nature of the parent material, climate, and topography. Increasing trends in pH are observed in subsurface soils caused by an increase in $CaCO_3$ in subsurface soils (Rajeshwar and Mani, 2014) [11]. The soils were non saline and the EC values varied from 0.11 to 0.51 d Sm^{-1} at surface and 0.27-0.56 dS m^{-1} subsurface soils. The organic carbon content ranged from low to medium (3.1- 6.6 g kg^{-1}) in surface soils and low (1.5 to 4.9 g kg^{-1}) in subsurface soils. Relatively more organic carbon content was recorded in surface soils as compared to subsurface soils (Table 1). The amount of organic carbon decreases with depth. The organic carbon content seems to be strongly related to grassland vegetation and prevailing environments (Rajeshwar and Mani, 2013) [12].

Soil Fertility Status

Available macronutrients

The soil fertility status exhibits the amount and availability of nutrients essential for plant growth (Table 2). The available nitrogen content of all the soils were low ranging from 127.48-251.25 kg ha^{-1} in surface soils and 102.52-209.37 kg ha^{-1}. in subsurface soils. However, available N content was found to be high in surface soils and decreased in sub surface soils, which might possibly be due to decreasing trend of organic carbon with depth. These observations are in accordance with the findings of Prasuna Rani *et al.* (1992) [9]. The available P content of soils was medium and varied from 10.15-18.76 kg ha^{-1} in surface soils and low to medium (7.15-14.35 kg ha^{-1}) in the sub surface soils. The reason for higher P in surface soils might possibly be the confinement of crop cultivation to the rhizosphere and supplementing of the depleted phosphorus through external sources i.e., fertilizers. Similar results were reported by Rajeshwar and Mani (2014) [11] and Thangasamy *et al*. (2005). The K availability of these soils was medium to high in range and varied from 287.48-368.32 kg ha^{-1-} in surface soils and medium (136.95-178.29 kg ha^{-1}) in subsurface soils. The available K was more in surface soils could be attributed to release of labile-K from organic residues, application of K fertilizers and upward translocation of K from lower depths along with capillary rise of ground water. Similar results were reported by Pal and Mukhopadyay (1992) [6]. The available S content of soils was low to high and ranged from 6.63-17.8 mg kg^{-1} and 2.42-9.8mg kg^{-1} in both the surface and sub-surface soil respectively. Soil sulphur is continuously cycled between inorganic and organic forms of sulphur (Pasricha and Fox, 1993) [7]. Similarly, the organic sulphur is also in equilibrium with inorganic counterpart and if there is any decline in inorganic $SO^{4-}S$ level by means of crop uptake or leaching loss, it will be adequately replenished by the organic fraction (Rajeshwar and Mani, 2014) [11].

Fig 1: Location map of KVK, Bellampalli, Mancherial

Table 1: Physico-chemical characteristics of surface and sub-surface soils of KVK, Bellampalli, Mancherial

S. No.	Block	No of soil samples	Depth (cm)	pH (1:2.5)	EC (d Sm^{-1})	OC (g kg^{-1})	$CaCO_3$ (g kg^{-1})	Latitude	Longitude
1	A	8	0-15	7.03	0.41	5.5	2.0	19.074064	79.505182
2			15-30	8.24	0.54	2.5	4.0		
3			0-15	7.61	0.19	5.2	2.4	19.074197	79.505158
4			15-30	8.37	0.27	3.0	3.9		
5			0-15	8.05	0.39	4.9	2.8	19.073780	79.505236
6			15-30	8.68	0.56	2.4	5.6		
7			0-15	7.91	0.26	4.2	2.5	19.074012	79.505688
8			15-30	8.56	0.38	3.1	5.0		
9	B	8	0-15	7.58	0.23	5.1	4.0	19.073721	79.504661
10			15-30	8.43	0.46	3.8	8.0		
11			0-15	7.65	0.31	5.5	3.0	19.073439	79.505807
12			15-30	8.23	0.45	3.7	5.6		
13			0-15	7.84	0.11	5.6	2.0	19.073631	79.505657
14			15-30	8.97	0.35	3.9	4.5		
12			0-15	7.65	0.15	4.5	2.7	19.073072	79.505595
16			15-30	8.68	0.34	3.1	4.5		
17	C	8	0-15	7.51	0.17	5.6	3.8	19.070954	79.505609
18			15-30	8.57	0.36	3.3	6.8		
19			0-15	7.59	0.24	4.5	3.3	19.071750	79.505445
20			15-30	8.65	0.41	3.9	7.0		
21			0-15	7.80	0.27	4.2	3.2	19.072337	79.504935
22			15-30	9.00	0.36	3.4	8.5		
23			0-15	7.70	0.24	5.3	3.9	19.071364	79.506008
24			15-30	8.57	0.39	4.1	9.5		
25	D	8	0-15	8.68	0.31	4.8	8.0	19.072104	79.504347
26			15-30	9.05	0.38	1.5	12.1		
27			0-15	8.89	0.27	3.9	5.5	19.070637	79.505326
28			15-30	9.23	0.36	2.1	8.5		
29			0-15	8.00	0.26	4.1	7.2	19.071474	79.504832
30			15-30	8.90	0.38	1.6	9.0		
31			0-15	7.79	0.39	3.1	7.3	19.070798	79.505184
32			15-30	9.21	0.48	1.6	8.6		
33	E	8	0-15	7.68	0.25	5.0	3.5	19.074284	79.505800
34			15-30	8.75	0.34	3.8	5.0		
35			0-15	7.18	0.28	4.1	2.7	19.073949	79.505495
36			15-30	8.29	0.37	2.6	8.0		
37			0-15	7.25	0.36	4.8	2.1	19.073811	79.504724
38			15-30	8.49	0.47	3.1	4.6		
39			0-15	7.86	0.27	4.9	4.2	19.073525	79.504927
40			15-30	8.95	0.39	3.5	8.5		
41	F	8	0-15	8.37	0.35	4.4	3.7	19.073988	79.505356
42			15-30	8.48	0.42	1.9	7.5		
43			0-15	8.69	0.38	4.7	4.8	19.073748	79.505344
44			15-30	8.84	0.41	1.8	7.8		
45			0-15	8.41	0.28	4.6	3.3	19.073823	79.506164
46			15-30	8.62	0.51	2.5	7.0		
47			0-15	7.71	0.36	4.3	3.2	19.073771	79.505384
48			15-30	8.82	0.41	2.2	8.0		
49	G	8	0-15	7.64	0.14	5.2	3.1	19.073767	79.505400
50			15-30	8.76	0.29	2.6	4.6		
51			0-15	7.49	0.25	5.0	3.5	19.073880	79.505299
52			15-30	8.54	0.31	2.9	5.8		
53			0-15	7.43	0.21	5.8	4.2	19.073907	79.505331
54			15-30	8.51	0.39	4.6	5.1		
55			0-15	7.10	0.25	5.4	3.0	19.073918	79.505308
56			15-30	7.37	0.31	2.9	4.9		
57	H1		0-15	7.50	0.22	4.3	2.0	19.074025	79.505424
58			15-30	7.73	0.38	3.1	4.0		
59			0-15	7.22	0.32	5.0	2.7	19.074123	79.505866
60			15-30	7.86	0.45	3.7	3.1		
61			0-15	7.57	0.29	5.1	2.3	19.074090	79.505658
62			15-30	8.10	0.49	3.3	3.5		
63			0-15	7.95	0.26	4.9	3.2	19.074006	79.505492
64			15-30	8.26	0.45	3.6	4.2		
65	H2	8	0-15	7.17	0.29	6.2	1.9	19.073745	79.505629

66			15-30	8.25	0.37	4.9	2.5		
67			0-15	6.95	0.31	5.5	2.4	19.074339	79.505998
68			15-30	7.43	0.45	3.4	2.6		
69			0-15	6.98	0.26	6.6	2.1	19.074764	74.506372
70			15-30	7.10	0.37	3.1	2.4		
71			0-15	7.59	0.35	5.4	3.0	19.075375	79.506793
72			15-30	8.34	0.48	3.0	3.5		
Overall range	Surface soil		0-15	6.95-8.89	0.11-0.51	3.1-6.6	1.-8.0		
Mean			0-15	7.70	0.27	4.92	3.46		
Overall range	Sub – Surface soil		15-30	7.10-9.23	0.27-0.56	1.5-4.9	2.4 12.1		
Mean			15-30	8.47	0.40	3.04	5.93		

Table 2: Available nutrient status of surface and sub-surface soils of KVK, Bellampalli, Mancherial

S. No.	Block	No. of soil samples	Depth (cm)	Available Macronutrients (kg ha^{-1})			Available S (mg kg^{-1})	Available Micronutrients (mg kg^{-1})				
				N	P	K		Zn	Cu	Mn	Fe	B
1	A	8	0-15	181.43	12.89	350.25	16.01	0.44	1.34	6.77	11.76	0.93
2			15-30	176.26	07.58	149.35	08.19	0.37	1.15	4.53	8.28	0.71
3			0-15	209.64	16.17	296.89	10.21	0.39	1.28	5.41	4.05	0.81
4			15-30	194.25	14.35	147.29	08.45	0.35	1.04	2.27	3.82	0.40
5			0-15	180.63	15.89	309.47	14.32	0.46	1.91	4.92	3.50	0.72
6			15-30	145.15	12.58	159.28	09.08	0.29	1.24	1.34	2.24	0.53
7			0-15	209.68	15.53	287.48	13.36	0.82	1.45	3.40	4.65	0.57
8			15-30	204.25	13.89	139.75	07.02	0.11	1.08	1.27	4.40	0.24
9	B	8	0-15	173.41	15.02	356.41	14.75	0.41	1.56	4.10	4.67	0.76
10			15-30	115.35	08.05	155.69	05.44	0.36	0.89	1.51	3.88	0.25
11			0-15	241.64	10.15	305.83	12.56	0.67	1.61	5.84	7.45	0.85
12			15-30	159.37	07.25	152.38	06.49	0.55	0.43	3.61	5.14	0.63
13			0-15	163.25	14.46	298.42	14.38	0.52	1.05	6.08	4.27	0.96
14			15-30	118.26	08.27	139.65	08.02	0.43	0.96	2.05	3.95	0.42
12			0-15	173.73	16.98	333.93	13.59	0.34	1.31	3.68	4.73	0.68
16			15-30	129.64	11.37	169.21	09.80	0.21	0.40	1.05	3.81	0.47
17	C	8	0-15	200.04	18.76	300.89	13.41	0.47	1.56	3.39	3.99	0.72
18			15-30	154.69	12.59	139.76	05.21	0.42	0.28	1.76	2.38	0.21
19			0-15	208.42	15.19	306.22	14.72	0.51	1.51	3.91	4.07	0.76
20			15-30	149.23	12.54	153.94	05.82	0.39	0.34	0.59	3.84	0.49
21			0-15	168.35	16.08	355.72	06.63	0.25	1.76	4.44	4.46	0.62
22			15-30	117.33	13.52	153.26	02.42	0.21	0.72	2.18	1.80	0.11
23			0-15	156.49	14.31	331.93	16.11	0.46	1.65	3.07	3.36	0.67
24			15-30	115.69	11.44	161.56	08.63	0.32	0.88	0.67	2.23	0.49
25	D	8	0-15	179.38	12.53	315.47	13.22	0.55	0.57	0.51	2.89	0.46
26			15-30	141.43	07.15	158.42	07.95	0.31	0.11	0.29	1.46	0.41
27			0-15	188.32	15.59	365.35	14.15	0.49	1.27	1.23	0.86	0.60
28			15-30	141.15	12.42	178.29	07.51	0.29	0.41	0.29	0.06	0.25
29			0-15	179.38	13.53	315.47	11.62	0.52	1.05	1.78	3.09	0.51
30			15-30	111.43	07.15	158.42	05.85	0.41	0.75	0.48	1.17	0.10
31			0-15	195.27	16.53	325.47	16.10	0.53	1.71	1.84	3.45	0.17
32			15-30	111.39	12.15	158.42	08.61	0.27	0.84	0.29	2.06	0.12
33	E	8	0-15	162.41	14.39	300.65	13.40	0.45	1.17	4.10	4.67	0.76
34			15-30	128.18	09.67	149.28	03.42	0.21	0.72	2.48	1.17	0.49
35			0-15	152.13	12.58	314.25	14.33	0.36	1.02	4.90	4.43	0.52
36			15-30	138.92	09.28	159.81	09.15	0.14	0.89	2.35	2.34	0.25
37			0-15	173.91	11.43	305.24	12.21	0.56	1.20	5.39	4.48	0.58
38			15-30	159.58	10.04	162.19	06.15	0.34	0.69	2.35	2.34	0.24
39			0-15	169.13	15.26	317.48	15.83	0.52	1.87	4.24	4.96	0.62
40			15-30	148.82	10.48	149.85	05.03	0.35	0.78	2.25	2.87	0.27
41	F	8	0-15	130.61	14.59	295.67	15.13	0.57	1.71	1.46	3.45	0.67
42			15-30	119.47	11.58	136.95	06.67	0.42	0.47	0.38	1.08	0.28
43			0-15	127.48	17.25	315.39	11.72	0.32	1.84	1.17	3.61	0.95
44			15-30	118.23	11.87	156.28	05.28	0.28	0.67	0.58	2.17	0.54
45			0-15	145.67	14.25	295.67	14.84	0.51	1.40	1.05	3.99	0.97
46			15-30	102.52	11.58	136.95	09.42	0.47	0.56	0.39	3.81	0.72
47			0-15	130.61	12.68	315.96	15.86	0.45	1.48	1.04	3.77	1.26
48			15-30	116.75	09.53	147.53	08.48	0.41	0.27	0.23	2.11	0.50
49	G	8	0-15	197.43	13.58	312.58	14.23	0.36	1.17	5.56	4.77	0.51
50			15-30	126.32	09.87	156.37	05.34	0.32	0.58	2.56	2.11	0.46
51			0-15	209.21	12.49	322.26	15.51	0.60	1.84	4.36	2.86	0.68
52			15-30	126.79	09.34	147.21	08.15	0.56	0.57	2.45	1.95	0.33
53			0-15	217.43	13.58	312.58	16.63	0.57	1.98	5.04	4.89	0.61
54			15-30	146.32	09.87	156.37	09.48	0.45	0.68	2.23	2.11	0.55
55			0-15	169.21	12.49	322.26	16.01	0.53	1.74	5.81	2.13	0.61
56			15-30	126.79	09.34	147.21	07.17	0.27	0.57	1.37	1.69	0.25
57	H1	8	0-15	186.42	16.29	329.93	17.80	0.58	1.87	5.24	5.96	0.62

58			15-30	128.58	13.83	169.47	05.03	0.45	0.78	1.25	2.87	0.55
59			0-15	196.49	15.64	335.76	15.60	0.55	1.76	4.28	4.46	0.52
60			15-30	177.36	12.46	169.37	09.40	0.41	0.72	2.25	2.80	0.41
61			0-15	216.28	12.31	356.24	16.35	0.68	1.80	5.86	4.24	0.76
62			15-30	175.26	09.32	158.46	07.58	0.32	0.57	2.45	2.27	0.26
63			0-15	196.42	14.28	339.75	13.40	0.66	1.89	4.51	3.88	0.49
64			15-30	176.41	12.27	163.42	09.50	0.37	0.61	2.84	2.45	0.25
65	H2	8	0-15	246.82	14.17	294.89	15.21	0.39	1.28	3.41	4.05	0.34
66			15-30	204.28	12.35	149.29	06.45	0.35	1.24	1.27	3.82	0.18
67			0-15	251.25	11.15	309.82	15.50	0.67	1.61	5.84	7.45	0.85
68			15-30	209.37	08.25	156.35	08.40	0.35	0.43	3.61	5.14	0.33
69			0-15	248.34	15.59	368.32	15.10	0.59	1.17	4.23	4.86	0.50
70			15-30	151.19	13.42	164.25	07.50	0.39	0.91	2.29	2.06	0.25
71			0-15	229.23	11.49	312.28	14.50	0.60	1.84	5.36	2.86	0.58
72			15-30	136.71	08.34	157.26	09.15	0.56	0.57	3.45	1.95	0.43
Overall range	Surface soil		0-15	127.48-251.25	10.15-18.76	287.48-368.32	6.63-17.8	0.25-0.82	0.57-1.98	0.51-6.77	0.86-11.76	0.17-1.26
Mean			0-15	187.8	14.31	320.33	14.28	0.51	1.51	3.98	4.36	0.67
Overall range	Sub – Surface soil		15-30	102.52-209.37	7.15-14.35	136.95-178.29	2.42-9.8	0.11-0.56	0.11-1.24	0.23-4.53	0.06-8.28	0.10-0.72
Mean			15-30	144.52	10.69	154.68	7.26	0.35	0.69	1.76	2.76	0.37

Available Micronutrients

The DTPA extractable Zn content varied from 0.25-0.82 mg kg^{-1} and 0.11-0.56 mg kg^{-1} in surface and subsurface soils (Table 2). Considering 0.6 mg kg^{-1} as critical level (Lindsay and Norvel, 1978) [2], it was found that 80% of the surface soils are deficient in availability. The availability was more in surface soil which might be due to accumulation of comparatively more amount of organic matter and supplementing $ZnSO_4$ through external sources. Similar results were reported by Jalali *et al.*, (1989) [1], Nayak *et al*., (2000) [5] and Rajeshwar *et al*., (2009) [13]. The DTPA extractable Cu content varied from 0.57-1.98 mg kg^{-1} and 0.11-1.24 mg kg^{-1} in surface and subsurface soils respectively. Considering 0.2 mg kg^{-1} as critical level (Lindsay and Norvel, 1978) [2], it was found that all the soils are sufficient which might be due to its association with organic carbon affecting its availability in surface layers (Rajeshwar and Ariff khan, 2008) [10].

The available Mn content of these soils varied from 0.51-6.77mg kg^{-1} and 0.23-4.53 mg kg^{-1} soil in both the surface and sub-surface soils respectively. Considering 2.0 mg kg^{-1} as critical level (Lindsay and Norvel, 1978) [2], it was found that 90% surface subsurface soils are high in availability. The high availability in the surface soils and gradual decrease in sub surface soils might be due to its presence in the reduced forms in surface and subsurface soils and higher biological activity and organic carbon in the surface soils. These observations were in agreement with the findings of Murthy *et al*. (1997) [4] and Nayak *et al.* (2000) [5]. The DTPA extractable Fe content found to be deficient and varied from 0.86-11.76 mg kg^{-1} and 0.06-8.28mg kg^{-1} soil in both the surface and sub-surface soils respectively. It was high in the surface soils when compared to the sub surface soils which might be due to accumulation of humic material in the surface soils besides prevalence of reduced conditions in sub surface soils (Prasad and Sakal, 1991) [8]. The hot water-soluble Boron content varied from 0.17-1.26 mg kg^{-1} and 0.10-0.72 mg kg^{-1} soil in both the surface and subsurface soils respectively. Considering the critical limit of 0.52 mg kg^{1}, the soils were high in availability of Boron. It was high in the surface soils when compared to the sub surface soils which might be due to accumulation of organic matter (Rajeshwar and Mani, 2014) [11].

Major soil constraints and recommendations for crop production: Soil constraints were identified using soil test data. Major constraints for crop production in red soils are shallow to moderately deep with coarse loamy texture, slope, erosion, high coarse fragments, low available water holding capacity, high pH, low organic carbon, soil calcareousness, low availability of macro nutrients (N) and deficiency of micronutrients (Zn). As the rainfall is high during rainy season, runoff and erosion are the main problems. Similar observations were made by Reddy *et al*. (1998) [14], Mahesh *et al*. (2018) [3] and Rajeshwar and Mani (2013) [12]. Improved soil management practices by green manuring, application of organic manures such as farmyard manures, composted coir pith; press mud (25 t ha^{-1} per year), tank silt and black clay soils conserves soil moisture and crop rotation with legumes to enhance the crop productivity on these soils.

Conclusion

High soil productivity could be achieved by decreased runoff, soil erosion in rainy season, dry sowing ahead of the monsoon, providing of irrigation facilities in *rabi* season, development and use of high-yielding varieties/hybrids, enrichment of organic matter, maintenance of enhanced soil fertility, using improved seed-cum-fertilizer drills to ensure proper seed placement for legumes and cereal crops and a good crop stand, appropriate plant protection and timely harvesting was essential to sustain the soil health as well as crop yields.

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