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Study on spatial variability of Soils using GIS

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ABSTRACT
Spatial variability of soil properties within or among agricultural fields is inherent in nature due to geologic and pedologic soil forming factors, but some of the variability may be induced by tillage and other management practices due to human activities. Determining such soil variability is important for precise agriculture and management of natural resources. Hence, it is important to study the extent of surface spatial variability for efficient input management and to achieve higher yield. In this regard, the spatial variability study was conducted in Pandit Jawaharlal Nehru College of Agriculture & Research Institute, Karaikal for which 77 geo referenced soil samples were collected from the East farm (A, B, C, D, E and F blocks) and analysed for the soil properties like pH, EC, Organic Carbon, Available Nitrogen (N), Available Phosphorus (P_2O_5), Available Potassium (K_2O) using standard procedures. With the available data the spatial maps of basic soil properties were prepared from which the properties are known in unsampled areas and with this map through linkage, spatial variability maps can be generated for other properties.
Keywords:Spatial variability, Spatial maps, Soil properties.

I. INTRODUCTION

Soil properties change with time and space continuously (Jose Maria*et al.*,2009). Heterogeneity may be occurred at large scale (region) or at small scale (community), even in the same type of soil or in the same community (Ceddia*et al.*, 2009). Despite the temporal and spatial changes of soil characteristics in small and large scales, awareness of how are these changes for increasing profitability and sustainable agriculture management, is necessary (Ayoubi, 2008). Determining soil variability is important for ecological modeling, environmental predictions, precise agriculture and management of natural resources (Kavianpoor, 2012). For a long time, spatial changes of soil characteristics have been attended by soil scientists and also nowadays the access means to precise and quantitative information about these changes is essential for environmental assessment of soil quality, risk of soil pollution and retro gradation of soil characteristics and soil erosion studies. Soil organic matter, nitrogen and phosphorus are the most important functions of soil ecosystems because they play a direct role in ecosystem processes such as plant growth and carbon cycle. So, temporal and spatial investigation of data is essential for understanding of soil spatial variability which is an important issue in agricultural and environmental research.

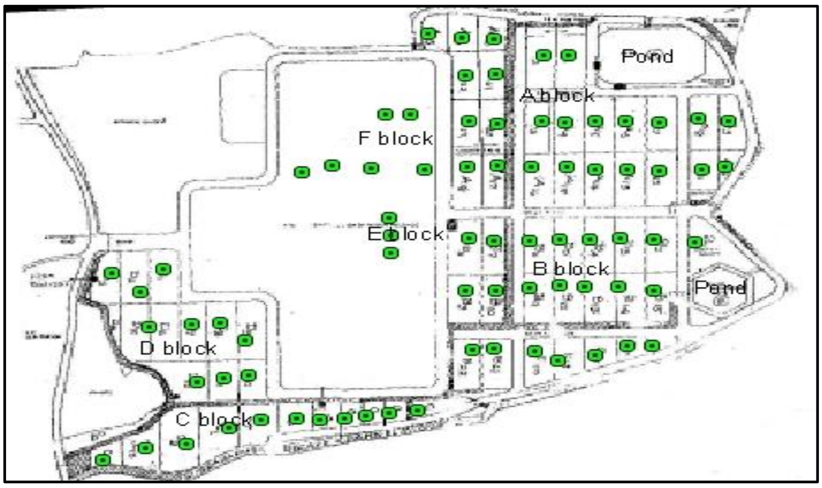

Fig 1. East farm map of PAJANCOA & RI, Karaikal with sampling points

II. MATERIALS & METHODS

The spatial variability study was conducted in the Pandit Jawaharlal Nehru College of Agriculture & Research Institute, union territory of Puducherry. It is about 9 Km northwest to karaikal and lies between $10^0$49' and $11^0$00'N latitude& between $78^0$43' and $79^0$52' E longitude. Study area is situated 4m above mean sea level having maximum & minimum of 31.95^0C & 25.52^0C temperature with annual rainfall intensity of 1566.87mm. Institute has two farms one at east and another at west and the total geographical area of the farm is 200 acres. The study was conducted in the east farm where the acre is 70.65 acres. East farm is divided into 6 blocks namely A, B,C,D,E& F. Each block is having several fields which is shown in the **Fig 1.** Block 'A' having 23.25 acres of area with 25 fields, block B having 22.20 acres of area containing 22 fields, block C having 11 fields in 7.30 acres of area, block 'D' having 10 number of fields in 7.50 acres of area, block E having 3 fields in 3.10 acres of area and block F having 6 fields in 7.30 acres of area respectively. The latitude & longitude of each field was noted using GPS (Geographical Positioning System). The GPS reading for four permanent reference points were taken to fix the boundary of farm for mapping.

Collection of surface soil sample:

To study the spatial variation in soil, the surface soil samples were collected from each field of the east farm which is considered as separate sampling unit. The soil samples were collected during December, spring season. The samples were collected for top 15 cm depth using cup type soil auger following standard procedure. Totally 77 samples were collected and analysed for soil properties like pH, EC, organic carbon, Available nutrients (N, P, K) following the standard procedures.

III. RESULTS AND DISCUSSION

With the results of soil analytical data given below, different soil maps were prepared using GIS software.

Table 1: Soil properties of A Block (A1 TO A25)

Block	Field no	X	Y	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
A	A1	79.7831	10.95358	6.87	0.112	0.677	65.86	92.33	341.38
	A2	79.7835	10.95346	6.45	0.103	0.692	72.13	58.99	611.52
	A3	79.7836	10.95237	7.05	0.178	0.631	87.81	30.78	254.02
	A4	79.7837	10.95248	7.16	0.255	0.615	72.13	38.47	239.23
	A5	79.7841	10.95237	7.50	0.114	0.677	72.13	30.78	216.38
	A6	79.7845	10.95236	6.88	0.088	0.600	84.67	30.78	460.99
	A7	79.7850	10.95251	7.46	0.127	0.600	62.72	12.82	208.32
	A8	79.7853	10.95240	7.35	0.076	0.646	62.72	7.69	391.10
	A9	79.7859	10.95157	6.75	0.063	0.308	62.72	7.69	385.73
	A10	79.7850	10.95154	6.35	0.104	0.615	56.45	10.26	204.24
	A11	79.7858	10.95158	6.91	0.068	0.585	59.58	28.21	670.66
	A12	79.7849	10.95160	7.39	0.114	0.385	59.58	28.21	256.70
	A13	79.7846	10.95156	7.96	0.156	0.615	56.45	25.65	600.77
	A14	79.7842	10.95121	8.01	0.160	0.462	65.86	20.21	201.60
	A15	79.7838	10.95142	8.04	0.176	0.692	31.36	64.12	413.95
	A16	79.7834	10.95144	8.55	0.194	0.385	53.31	41.04	618.24
	A17	79.7829	10.95130	7.14	0.070	0.538	94.08	15.39	249.98
	A18	79.7826	10.95137	8.45	0.130	0.662	206.98	12.82	258.05
	A19	79.7827	10.95236	7.74	0.069	0.385	69.99	30.78	442.18
	A20	79.7828	10.95237	7.00	0.054	0.554	72.13	48.73	219.07
	A21	79.7830	10.95304	7.76	0.073	0.431	59.58	17.95	537.60
	A22	79.7825	10.95310	7.47	0.085	0.600	62.72	10.26	577.92
	A23	79.7822	10.95374	7.70	0.078	0.615	62.72	28.21	510.72
	A24	79.7822	10.95376	7.25	0.190	0.615	56.45	25.65	210.42
	A25	79.7828	10.95362	6.09	0.038	0.538	56.45	69.25	524.16

Table 2: Soil properties of B Block (B1 TO B22)

Block	Field. no	X	Y	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
B	B1	79.7854	10.950	5.72	0.066	0.723	62.72	82.07	504.00
	B2	79.7848	10.950	6.28	0.112	0.615	62.72	58.99	405.24
	B3	79.7845	10.950	7.43	0.059	0.815	65.86	28.21	411.26
	B4	79.7841	10.950	7.68	0.130	0.677	59.58	12.82	424.70
	B5	79.7837	10.950	7.74	0.150	0.662	75.26	20.52	202.94
	B6	79.7834	10.950	7.72	0.141	0.675	65.86	4.04	322.56
	B7	79.7829	10.950	6.95	0.066	0.675	50.18	164.15	268.80
	B8	79.7826	10.950	7.30	0.063	0.300	59.58	110.29	555.07
	B9	79.7825	10.949	7.05	0.052	0.765	31.36	53.86	532.22
	B10	79.7828	10.949	8.02	0.116	0.210	40.77	25.65	541.63
	B11	79.7834	10.949	7.26	0.075	0.675	31.36	128.24	584.64
	B12	79.7838	10.949	7.92	0.099	0.600	31.36	125.68	533.57
	B13	79.7841	10.949	7.23	0.081	0.675	31.36	102.59	517.44
	B14	79.7845	10.949	7.68	0.049	0.225	68.99	470.40	564.48
	B15	79.7848	10.995	5.62	0.112	0.450	59..58	41.04	604.80
	B16	79.7848	10.948	6.57	0.077	0.315	53.31	92.33	635.71
	B17	79.7844	10.958	6.91	0.109	0.525	34.50	97.46	439.24
	B18	79.7842	10.948	6.50	0.079	0.600	53.31	48.73	639.74
	B19	79.7837	10.948	7.95	0.104	0.525	50.18	2.56	645.12
	B20	79.7834	10.948	6.15	0.084	0.390	53.31	30.78	315.84
	B21	79.7829	10.948	6.55	0.520	0.660	50.18	92.33	577.92
	B22	79.7826	10.948	7.38	0.075	0.600	53.31	33.34	666.62

Table 3: Soil properties of C Block (C1 TO C11)

Block	Field. no	X	Y	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
C	C1	79.7818	10.94757	7.33	0.099	0.780	47.04	41.04	501.31
	C2	79.7815	10.94753	7.55	0.089	0.570	43.90	30.78	520.13
	C3	79.7812	10.94746	7.70	0.850	0.750	50.18	61.56	530.88
	C4	79.7809	10.94740	7.43	0.118	0.675	62.72	28.21	225.79
	C5	79.7805	10.94741	7.48	0.135	0.555	47.04	35.91	432.77
	C6	79.7807	10.94748	7.52	0.081	0.675	37.63	58.99	645.12
	C7	79.7800	10.94742	7.63	0.039	0.855	43.90	76.94	551.04
	C8	79.7796	10.94730	6.95	0.056	0.675	43.90	105.16	577.92
	C9	79.7793	10.94705	6.59	0.054	0.570	34.50	84.64	333.31
	C10	79.7790	10.94697	7.60	0,064	0.615	50.18	30.78	631.68
	C11	79.7786	10.94659	7.47	0.063	0.630	56.45	15.39	649.15

Table 4 : Soil properties of D Block (D1 TO D12)

Block	Field. no	X	Y	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
D	D1	79.7787	10.94993	8.43	0.105	0.645	50.18	23.08	618.24
	D2	79.7785	10.94954	8.32	0.093	0.570	43.90	179.55	618.24
	D3	79.7781	10.94985	8.72	0.143	0.555	43.90	153.89	456.96
	D4,D5,D6	79.7788	10.95904	8.04	0.068	0.450	37.63	30.78	645.12
	D7	79.7791	10.94900	8.08	0.092	0.525	34.50	53.86	658.56
	D8	79.7795	10.94903	8.10	0.040	0.645	25.09	17.95	658.56
	D9	79.7798	10.94874	7.12	0.620	0.480	37.63	30.78	497.28
	D10	79.7799	10.94817	7.55	0.032	0.270	56.45	5.13	604.8
	D11	79.7795	10.95813	7.14	0.055	0.600	53.31	12.82	648.12
	D12	79.7792	10.94805	8.23	0.059	0.660	28.22	33.34	618.24

Table 5 : Soil properties of E Block (E1 TO E3) and F Block (F1 TO F6)

Block	Field no	X	Y	pH	EC (dSm^{-1})	Organic carbon (%)	Available N (kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
E	E1	79.7801	10.950	7.36	0.139	0.705	32.13	20.52	463.68
	E2	79.7816	10.950	5.66	0.045	0.375	12.54	17.95	658.56
	E3	79.7817	10.950	7.86	0.052	0.645	84.67	35.91	255.36
F	F1	79.7818	10.951	5.93	0.040	0.675	28.22	12.82	631.68
	F2	79.7813	10.951	7.15	0.061	0.600	62.72	33.34	185.47
	F3	79.7808	10.951	6.65	0.039	0.75	47.04	58.99	288.96
	F4	79.7805	10.951	6.12	0.037	0.375	59.58	28.21	258.05
	F5	79.7819	10.952	5.83	0.026	0.525	21.95	28.21	651.84
	F6	79.7816	10.952	7.81	0.153	0.330	81.54	23.08	517.44

The spatial map prepared for soil pH (**Fig 2**) showed alkaline pH in southern part of ‘A’ block,.

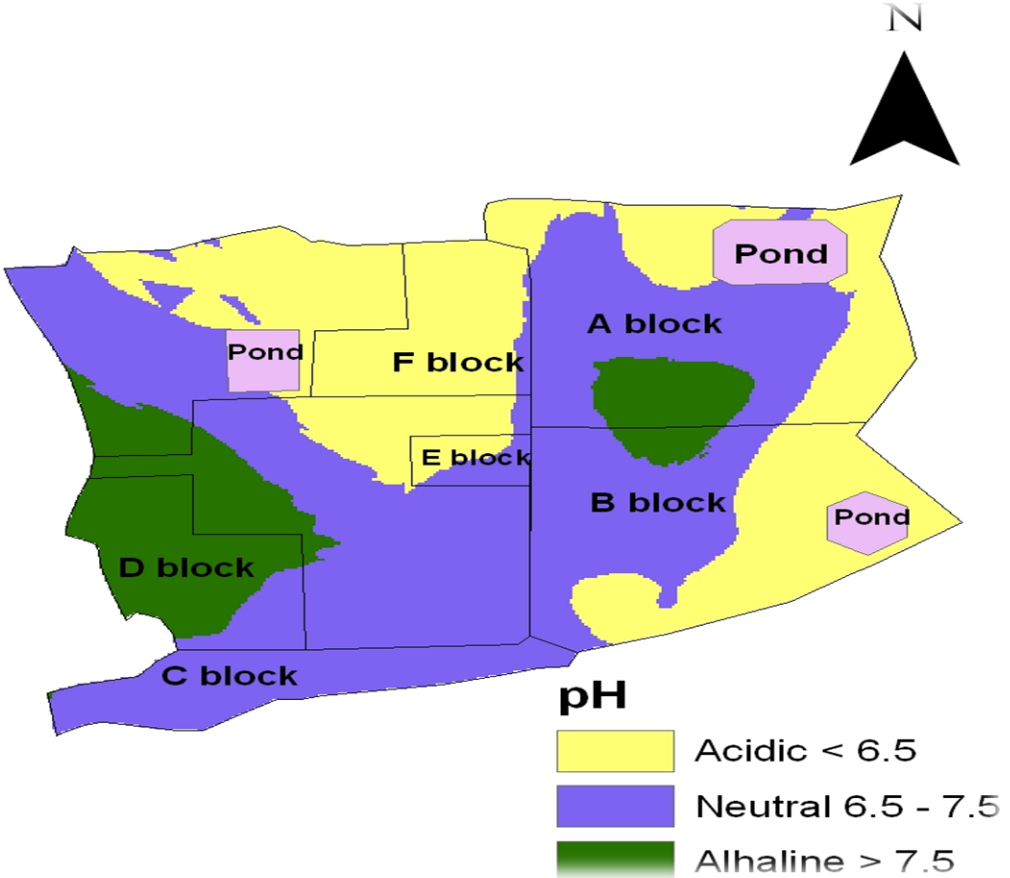

Fig.2. Soil pH variability in East farm of PAJANCOA & RI, Karaikal

northern part of B block and almost 75 percentage of ‘D’ block

These areas are to be reclaimed or managed to get maximum yield. The acidic pH was seen in the fields of ‘A’, ‘B’, ‘E’ and ‘F’ block which are nearer to the ponds. Hence, these fields are to be suitably managed or reclaimed for good crop.

The alkaline pH in these soils might be resulted due to precipitating of secondary carbonates in the soil and increase in exchangeable sodium at the exchange complex which can be reclaimed by application of gypsum and organic manures (Brady and Weil, 1999). Nearly 14 per cent of the field shows acidity which might be due to the high application of ammonium producing fertilizers, mono cropping especially low land paddy. Such soils could be reclaimed by application of lime and also by including a garden land crops in the cropping system

Electrical conductivity

The Electrical conductivity (EC) of 77 soil samples ranged from 0.026 to 0.52 dSm^{-1}(**Fig 3**)

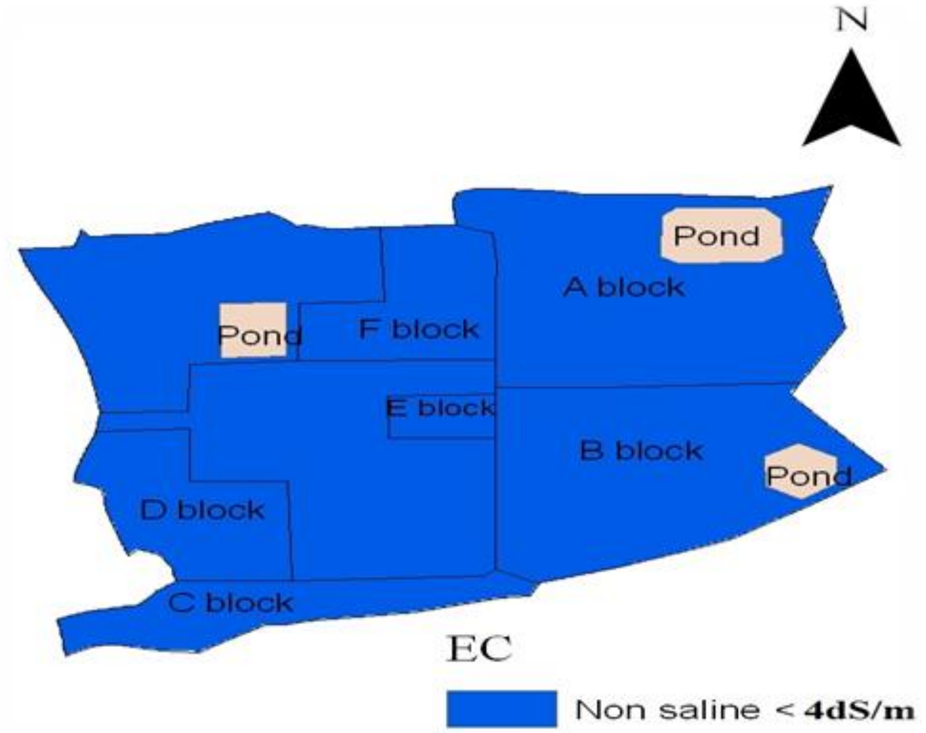

Fig.3. Electrical conductivity variability in East farm soils of PAJANCOA & RI, Karaikal

The low EC in soil sample indicates the very low amount of soluble salts in the soilsand therefore the soils of east farm does not require any special management practices for salinity.

Organic carbon

The spatial variability map for organic carbon (**Fig** 4) showed low organic carbon status in northern part of 'F' block, western part of 'D' block, eastern part of 'B' block respectively, which implies that these fields require periodic organic manure addition to improve the soil fertility.

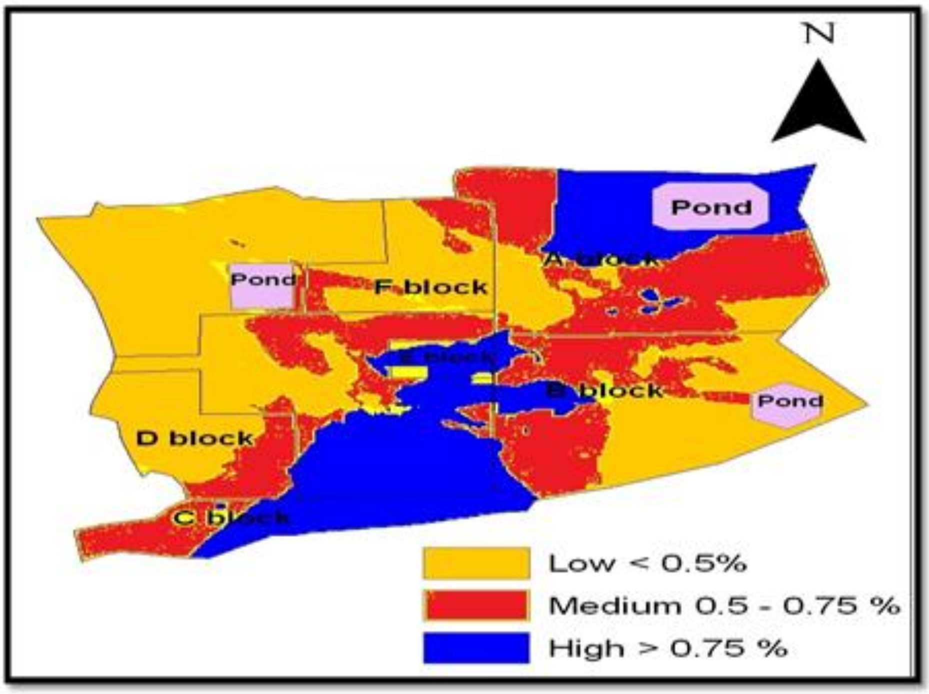

Fig.4. Organic Carbon variability in East farm soils of PAJANCOA & RI, Karaikal

Available Nitrogen

The Available Nitrogen in all the fields of east farm registered very low status (**Fig 5**). Low nitrogen status in this soil might be due to presence of low organic matter and low nitrogen supplying power of the soils. Low nitrogen status in the soil will leads to poor yield so adequate nitrogen by means of adding nitrogenous fertilizer or by improving the organic matter status through organic manure addition could be recommended.

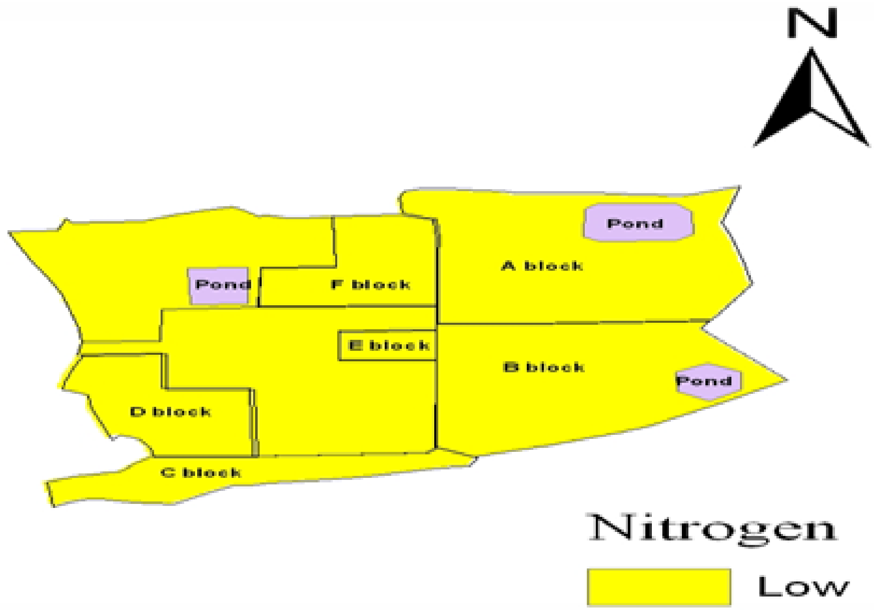

Fig.5. Available Nitrogen variability in East farm soils of PAJANCOA & RI, Karaikal

Available Phosphorous

The variability map of soil available phosphorous (**Fig 6**) showed low status in northern part of 'F' block, eastern part of 'A' block and these areas are to be adequately fertilizer with organic or inorganic phosphorus..

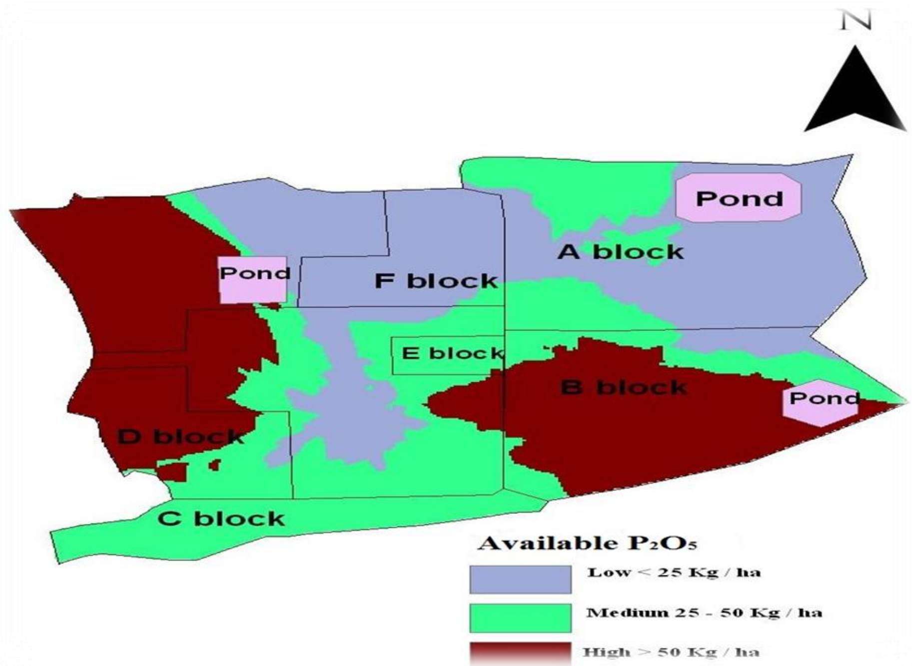

Fig.6. Available Phosphorus variability in East farm Soils of PAJANCOA & RI, Karaikal

The 'D' block and 'B' block almost showed high status where the phosphorus fertilization can be reduced

Available potassium

The spatial variability map for available potassium (**Fig 7**) showed low status in almost all fields of 'A' block, most of the fields of 'F' and 'E' block. The northern part of 'B' block and eastern side of 'C' block recorded medium potassium status. The western part of 'C' block, entire 'D' block and southern part of 'B' block showed high potassium availability which implies that in these fields, the potassium fertilizer recommendation can be tailored according to the crops to be grown.

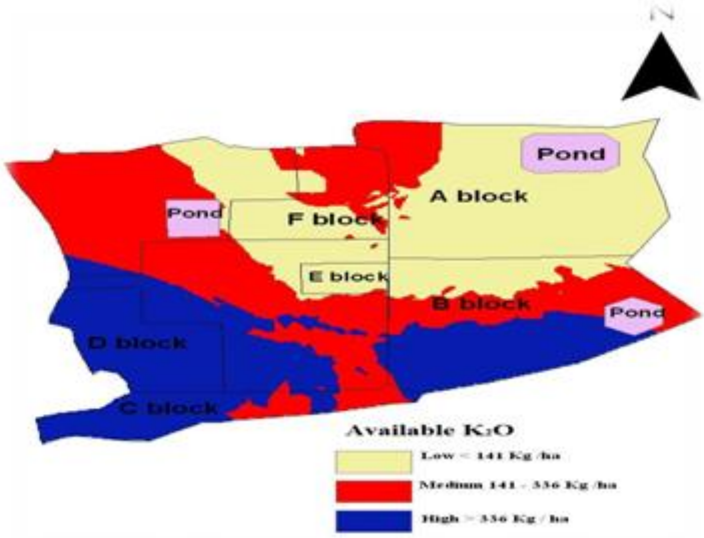

Fig.7. Available Potassium variability in East farm Soils of PAJANCOA & RI, Karaikal

IV. CONCLUSION

- Based on the study, spatial variation of soil variables were characterizedwhich provides an important implication in water and nutrient management for agriculture production.
- Through spatial variability map soil properties were estimated inunsampled places and mapping the same can be used as a reference for nutrient management in future.
- The farmers can be grouped based on the spatial variabilityand the specific management (nutrient, water etc.,) practices can be provided based on the soil variability.
- Precision in nutrients application can be achieved through spatial variability study which in turn reduces the cost of cultivation, saving the edaphic and aerial environment and the valuable foreign exchange of the country by reducing the fertilizer input.

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