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Spatial Variation in Soil Nutrient Status under Intensively Jute Cultivated Areas of the Coastal Ecosystem

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ABSTRACT

Jute is a significant fibercrop in Eastern India, where it plays an essential role in people's livelihoods. The crop's production has been dropping in recent years due to a variety of abiotic issues, the most prominent of which is poor soil nutrient management. To address the issue,surface soil samples were taken from four blocks in Odisha's Kendrapada district to determine the status and extent of soil major and micronutrient deficiency, as well as the relationship between soil attributes and nutrient availability, including the temporal changes in nutrients over 12 years periods. The result showed that the extent of NPS deficiency in this jute-growing region was 97.5, 34.58, and 70.83% respectively. The multi-nutrient deficiency was highest for N+S (29%) and lowest for N+P+S (12%). Among micronutrients Fe, Mn, Cu, and Zn varied from 53.32 to 225.36, 40 to 167, 2.57 to 8.10, and 0.76 to 2.20 mg/kg, respectively. A regression study revealed that basic soil parameters such as pH, EC, and OC, etc. influenced soil nutrients to the greatest amount (59.8% for Fe, followed by K).When present soil nutrient status was compared to data from 12 years ago, N and S levels had fallen, but other major and micronutrient levels had stayed essentially stable. According to the findings, jute farming requires management to restore long-term output and soil health.

Keywords: *Fiber crop,micronutrients,jute,surface,subsurface,coastal environment,plant nutrient*

1. INTRODUCTION

After cotton, jute is the second most important commercial fiber-producing crop in India. Jute is a natural fiber that is known as India's"goldenfiber." Jute is a long natural fiber made of the plant's cellulose and lignin and produced by plants of the Corchorus genus. Jute is environmentally sustainable, biodegradable, and has a far greater CO2assimilation rate, making it a viable option for the jute industry's survival and expansion in this period of environmental concern. Jute is produced in large quantities in India, Bangladesh, and China.IndiaranksfirstinjuteareaandproductionfollowedbyBangladeshandgeneratesaboutRs.1400 crores per year from the export of jute commodities, primarily diversi fied jute products (JDPs). Jute crops typically remove 35.2 kg N, 20.4 kg P2O5, 63.4 kg K2O, 55.4 kg CaO, 13.2 kg MgO, 425 g Fe, 119 g Mn, 24 g Cu, and 181g Zn from the soil to generate one tonne of fiber[1]. As a result, a critical understanding of the level of nutrient depletion in soils is vital, not only for optimal jute production but also for long-term productivity in a growing country like India, given rapid socio-economic changes. Micro nutrients, in addition to the major (NPK) nutrients, are required in very small amounts for optimal plant growth and are engaged in a variety of enzymes [2] and have a specialized role in plant growth and microbial processes. Different Jute based cropping systems influence the soil's Nutrient status by carbon cycling through the addition of fresh green Jute leaves up to 15t/ha per annum. Jute also influences nutrient recycling as its root draws nutrients from the lower layer to the upper layer of soil. To know the influence of Jute based cropping systemson the soil nutrient status and its impact onthe next crop, a study was conducted in intensively jute-cultivated pockets to assess the subsurface and surface available nutrient status of Jute growing soils and plant nutrient concentration of Kendrapara district Odisha and impact of cropping system on soil nutrient transformation.

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2. MATERIALS AND METHODS

Surface soil samples were collected from four jute growing blocks in the district of Kendrapara. The soils of Kendrapara mostly belonged to the soil ordersAlfisols, and Entisols.From the study region, a total of 62 soil surface samples were collected. The latitude and long itude data of the locations were recorde dusing Global positioning system (GPS) equipment. Soil samples were taken using a phaurah from a depth of 15 cm. For the Jute rhizosphere, a sampling depth of 15 cm was sought. Three pedons representing soil profiles were opened in the study region of Kendrapara district based on land type and elevation: upland, middle land, and lowland. Following the selection of sites for profile analysis, rectangular pits of 1m length, 1m width, and 1m depth were dug and soil layer samples from 0-20 cm intervals upto 1m were collected to know the vertical nutrient distribution pattern. Basic properties like pH, and EC were determined as per [3].The soil's available sulphur was assessed using a turbidimetric method [4]usinga0.15 percent CaCl2 extractant. Available Fe, Mn, Cu, and Zn were determined following standard protocol [5].The hot water extractable method described by [6] was used to determine available boron.

3. RESULTS

Soil samples from the surface as well as pedon soils and plant tissue analysis data are presented in tables and results are discussed.

3.1. Impact of jute-based croppings on soil nutrient

Data interpretation from Table 1 revealed an increasing trend of bulk density, particle density, and clay content, and a decreasing trend in porosity and WHC were observed in soil layers irrespective of soil type due to an increase in compaction and finer inorganic fractions with an increase in soil depth.

Available Nitrogen, sulphur content was observed to be decreasing from surface to subsurface layers with a deficiency in a status where as averagepotassium, exchangbleCa showed a reverse trend.The pH of the surface soils of Kendrapara district varied from 4 to 5.53 with a meanvalue 4.57indicatingverystronglyacidicsoilandwerenonsalineinnature.Jute litter can transfer basic cations from the subsoil to the top, lowering surface acidity and improving micro and macronutrient availability [7].

3.2. Impact of Jute cultivation on Surface soil nutrient distribution

To know the Horizontal distribution of soil available nutrients 80 no of surface soils were collected with help of GPS from jute-based cropping systems from waterlogged and coastal alluvial soils. Analyzed for basic properties as well as soil available nutrients and presented in table 3-5.

Thesoilorganic carbon content was high in the surface soils of Kendrapara district with a mean value of 1.04%. High organic carbon status in surface soils might be duetothe additionoffreshJuteleavestothetuneof15tannuallyrestoringthe carbonstatus. SimilarfindingswerealsoreportedinWestBengal' seasternIndo Gangeticplain [8] and in certain soils of the West Central Tableland CatenainOdisha[9].Thesetypesoffindings werealsocitedinCRIJAF, Barrackpore [10, 11]. To increase jute fibre strength, the ideal S dose for Olitorius was 45 kg/ha, whereas a higher dose was required for capsular[12].Jute fibre strength is greatly improved when S and N are applied. N application enhanced fibre strength [13]. Calcium was more than the Magnesium and the ratio varied from 2.81 to 4.42. No Calcium deficiency was observed but Magnesium deficiency was observed in 7.5% of thesoil.SufficiencyofCalciumin surfacesoilduetoan abundanceofcalciuminthesoilas 4th important mineral in the earth crust or farmers might be using calcium. Similar findings were also reported inthe jute soils of west Bengal[14]. Magnesium deficiency in surface soil might be attributed to the leaching of Magnesium beingmore compared to the Calcium or Jute crops requiringmore Mg than Ca for fibre development [15]. The distribution of cationic micronutrients Cu, Zn, Fe, Mnwasquite sufficient in the surface soils of all the blocks of the Kendrapada district. Iron dominated among the micronutrients followed by Mn, Zn, Cu.

3.3. Plant nutrient content

Alongwith the soil analysis plant samples were collected to correlate soil status with plant nutrient deficiency and sufficiency level and presented in table 6.From jute plant tissues analysis deficienciesof P,S,Cu,Zn were observed with optimum levels of other nutrients K, Ca,Mg ,Fe,Mnwhich is related to the nutrient uptake pattern by the fiber crop, inherent soil status as well as management practices such as the use of organics,inorganics, etc.

3.4. Statistics

Regression equations were developed and presented in table no 7to find out the relationship between soil properties on available nutrient status and presented in table 7.

From the regression equation it was found that basic parameters influenced 55.6% variation in available K, 59.8% variation in DTPA Fe Content, 42.6% variation in available S. Available Nitrogen was less influenced up to 26.3%.

3.5. Temporal change in soil nutrient status under jute cultivation

Since the soils of Kendrapada district is suitable for jute cultivation and the cropping system affects soil nutrient depletion or supplementation,hence present soil nutrient status was compared with 12-year back soil status to ascertain temporal variation and presented in table 8.It was revealed except Zn and Bfor all other micronutrients wider variation of differencewasobservedinmeanvaluesfrom2008to2021.Forothernutrients,anincreasing trendfor2008to2020 wasobserved, exceptforSwherethe statusdeclinedupto22.99 ppm.Iron, and Manganese showed a maximum increase of 68-72.74 mg/kg and the lowest for Zn(+0.36).The order of nutrient deficiency existing in the surface soils of Kendrapara (2020-21) is presented graphically in Fig. 1.Major nutrient deficiency started from 100 % for N then gradually it decreased for secondary nutrients followed by micronutrients Fe, Mn, Cu, Ni having no deficiency. Though the organic carbon status of surface soils is quite good but due to low mineralization under the coastal ecosystem highest deficiency wasobserved.

Table 1. Physical properties of profile soil under Jute cultivation

Land situation	Soil Layer (cm)	BD (Mgm^{-3})	PD (Mgm^{-3})	Porosity (%)	WHC(%)	Clay (%)	Textural class
Upland	U1(0-20)	1.14	2.55	55	45.89	29.75	loam
	U2 (20-40)	1.21	2.55	53	43.40	32.25	loam
	U3(40-60)	1.29	2.59	50	40.10	29.75	loam
	U4(60-80)	1.29	2.59	50	41.23	27.25	loam
	U5(80-100)	1.33	2.60	49	39.60	29.75	loam
Mid land	M1(0-20)	1.21	2.55	53	47.01	32.25	Silty clay loam
	M2(20-40)	1.29	2.59	50	46.50	29.75	loam
	M3(40-60)	1.33	2.60	49	45.92	29.75	loam
	M4(60-80)	1.38	2.60	47	45.23	29.75	loam
	M5(80-100)	1.38	2.61	47	44.01	32.25	loam
Lowland	L1(0-20)	1.24	2.60	52	47.05	39.75	Silty clay loam
	L2(20-40)	1.29	2.60	50	45.20	37.25	Silty clay loam
	L3(40-60)	1.39	2.61	47	44.01	34.75	Silty clay loam
	L4(60-80)	1.40	2.65	47	43.21	34.75	Silty clay loam
Range		1.14-1.40	2.55-2.65	47-55	39.6-47.05		

Table 2. Status of major nutrients in the profile soil

Land situation	Soil Layer	Length (cm)	Av. N	Av. P_2O_5	Av. K_2O	Exch.Ca $^{2+}$	Exch. Mg^{2+}	Ca/Mg ratio	Av. S (mg/kg)
			(kg/ha)			cmol (p^+)/kg			
Upland (0-100cm)	U1	0-20	189.8	6.2	168.6	7.0	6.8	1.02	7.90
	U2	20-40	179.2	6.4	152.3	7.8	1.8	4.33	2.70
	U3	40-60	123.2	3.0	135.5	7.4	3.8	1.94	2.08
	U4	60-80	123.2	3.2	274.9	9.6	3.8	2.52	2.29
	U5	80-100	89.6	5.5	378.0	9.0	2.8	3.21	2.29
Mid land (0-100 cm)	M1	0-20	100.8	6.2	240.8	9.8	6.0	1.63	4.16
	M2	20-40	99.0	6.2	133.3	5.2	6.2	0.83	2.91
	M3	40-60	78.4	6.3	150.6	5.6	2.4	2.33	1.45
	M4	60-80	89.6	5.1	154.6	5.8	2.4	2.41	3.74
	M5	80-100	80.0	2.2	253.7	4.6	8.0	0.575	2.91
Lowland (0-100 cm)	L1	0-20	134.4	9.6	233.5	6.4	10.4	0.615	5.40
	L2	20-40	130.0	3.1	176.9	6.2	7.8	0.79	2.70
	L3	40-60	67.2	6.2	178.1	6.6	10.4	0.63	0.62
	L4	60-80	65.0	6.7	189.3	6.0	9.4	0.63	1.45
Range			189.8-65.0	9.6-3.0	378.0-133.3	9.8-4.6	10.4-1.8	0.575-4.33	7.90-0.62

Table 3. Soil organic carbon content of Kendrapara district

Name of the Blocks	pH	OC (%) Range	Mean	% High (>0.75)
Kendrapara	4.0-5.53	0.48-1.32	0.99	95
Rajkanika	4.10-4.63	0.5-1.38	0.97	95
Mahakalapada	4.52-5.49	0.85-1.33	1.09	100
Marsaghai	4.19-4.90	0.97-1.33	1.10	100
Overall	4.0-5.53	**0.48-1.38**	**1.04**	**97.5**
Std dev. (±)			0.07	
C.V. (%)			16.95	

Table 4. Exchangeable Calcium and Magnesium content in jute growing pockets

Block Name	Exch. Ca^{2+} cmol(p+)]/kg		Exch. Mg^{2+}			Ca/Mg ratio
	Range	Mean	Range	Mean	PSD	
Kendrapara	7.0-9.8	8.28	0.6-7.4	3.34	5	2.47
Rajkanika	7.8-10.2	9.15	0.2-4.6	2.07	15	4.42
Mahakalapada	7.6-9.8	8.8	0.8-4.6	2.83	10	3.10
Marsaghai	7.2-10.0	8.6	1.6-4.8	3.06	0	2.81
District status	7.0-10.2	8.7	0.2-7.4	2.8	7.5	
Std dev.(±)		0.365		0.545		
C.V. (%)		9.67		49.80		

Table 5. DTPA Zn and Cu status of Jute growing soils of Kendrapara district

Block Name	DTPA Cu(ppm)		DTPA Zn(ppm)		DTPA Fe(ppm)		DTPA Mn(ppm)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Kendrapara	1.10-2.20	1.59	2.57-5.62	4.48	80.28-225.36	132.07	40-119	77.6
Rajkanika	0.76-1.96	1.50	5.26-8.10	6.72	97.9-221.08	185.15	64-125	82
Mahakalapada	1.36-1.78	1.56	4.51-5.53	5.0	64.40-121.5	95.17	118-167	135

Marsaghai	0.76-2.20	1.54	2.68-5.80	4.56	53.32-96.68	78.56	40-167	98.0
Overall	0.76-2.20	1.55	2.57-8.10	5.19	53.32-225.36	122.74	40-167	98.15
Std dev. (±)		0.033		0.905		47.2		26.1
C.V. (%)		15.18		23.70		38.80		30.63

Table 6. Primary and Secondary Nutrients content in Jute Plant leaf samples

Nutrients	Range	Mean	Optimum conc. (ppm)	PSD (%)
P (%)	0.14-0.41	0.26	0.2	20
K (%)	1.5-2.5	2.07	1.4	0
Ca (%)	0.2-0.9	0.6	0.2	0
Mg (%)	0.24-0.94	0.61	0.2	0
S (%)	0.05-0.37	0.29	0.2	5
Fe(ppm)	108.6-455.1	281.85	50	0
Mn(ppm)	62.8-392.8	277.34	45	0
Cu(ppm)	1.2-13.7	8.93	5-7	10
Zn (PPM)	4.7-53.3	38.8	20	5

Table 7. Multiple Regression equation

Dependent variables	Multiple regression equation	R^2value	R^2×100
AV. N	211.742*-18.9149pH-99.2831 EC +33.25 OC+1.263	0.263	26.3
AV. P	-63.8665+19.31022 pH *+ 76.47131 EC*-9.98 OC	0.344	34.4
AV. K	-199.0357+10.14508 pH+388.5736 EC*-123.576 OC+166.8339Zn**	0.556	55.6
AV. S	19.78045*-3.5351pH*+9.55487EC+2.325603	0.426	42.6
DTPA Fe	448.7263**-72.374pH**+39.7712 EC-1.11908 OC+ 0.28779P2O5	0.598	59.8
DTPA Zn	1.574*-0.04395 pH-0.0823EC+0.20236 OC	0.154	15.4
DTPA Mn	44.47821-0.19302 pH-39.3879 EC + 60.56187 OC**	0.400	40.0

Table 8. Temporal variation in the micronutrients content under Jute cultivation in Kendrapara

Nutrients	2008		2020-2021		Increase or decrease
	Range	Mean	Range	Mean	
	mg/kg				
Zn	0.26-2.20	1.19	0.76-2.20	1.55	+ 0.36
Fe	9-136	50	53.32-225.36	122.74	+ 72.74
Mn	15.6-62.8	30	40-167	98.15	+68.15
Cu	0.1-5.11	1.9	2.57-8.10	5.19	+3.29
B	0.15-1.86	0.62	0.28-5.84	1.77	+1.15
S	5.6-11.0	31	1.25-21.82	8.01	-22.99

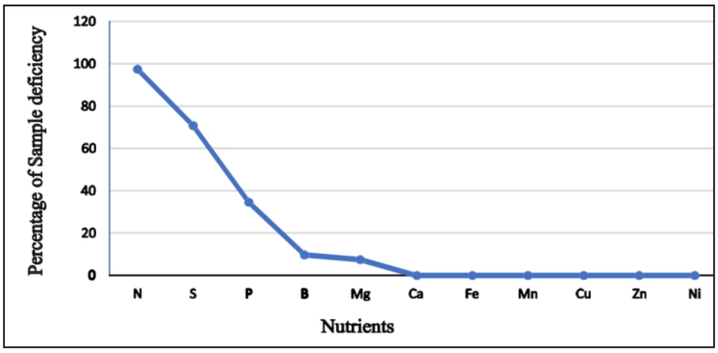

Fig 1. Order of nutrient deficiency in soils under jute cultivation

CONCLUSION

It may be concluded from the present study extent of N,P,S deficiency in soils inthe jute-growing region was 97.5, 34.58, and 70.83% respectively. The multi-nutrient deficiency was highest for N+S (29%) and lowest for N+P+S (12%).Regression study revealed that basic soil parameters such as pH, EC, and OC, etc. influenced soil nutrients to the greatest amount (59.8% for Fe, followed by K).When present soil nutrient status was compared to data from 12 years ago, N and S levels had fallen, but other major and micronutrient levels had stayed essentially stable. According to the findings, jute farming requires management to restore long-term output and soil health.Deficiency of nutrients followed the order N > S > P > B > Mg. The maximum multi-nutrient deficiency was Nitrogen and Sulphur followed by N+P andN+P+S. Since S,P,Mgarerequired for fiberstrength hence nutrient managementpractices in jute-growing soils need to be taken careof to restore the soil health and good quality fiber production.

Future scope

Further research is required to investigate the impact of various micronutrients and organics on jute fibre quality. There is a lot of study being done in the field on jute as a phytoremediation option, but there is still a lot of work to be done to explore the commercial value of natural fibre composites.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

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