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Soil-site and Rainfall Characterization for Land Use Planning under Coastal Agroecosystem in North Coastal Andhra Pradesh

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Regional Agricultural Station, Anakapalle - 531 001, Andhra Pradesh

The National Agricultural Technology Project on "Land Use Planning for Management of Agricultural Resources under Coastal Agroecosystem" has been taken up at S. Rayavaram *mandal*, Visakhapatnam district (Andhra Pradesh state) which falls under 18.4 Agroecological subregion. The operational area of the pilot project has been executed in two hamlet villages (Kothapolavaram and Kotharevupolavarm) of Gudivada village, S.Rayavaram *mandal*, covering nearly 300 ha area. Detailed soil survey (NBSS & LUP, Bangalore) conducted in the pilot site (June 2002) showed two major land forms viz., transitional plains and marine plains which were categorized into five (A, B, C, D and E) and three (F, G and H) soil series, respectively. The soils in transitional plains were very deep, clay to sandy clay (or) fine loam in texture, formed from alluvium deposit with soil constraints of imperfectly to very poor drainage and soil salinity having substratum with salt encrustation. The soils of marine plains are also very deep, but well to excessively drained, sandy soils formed from marine sand. The annual characterization over 25 years (1978-2003) showed that the mean annual rainfall was 774.7 mm, out of which more than 50% rainfall (443.2 mm) was received during South West monsoon (June-September) and 28.1% (217.7 mm) was received during North East monsoon period (October-December). Land use pattern over 13 years (1999-2003) indicated a gradual shift from growing crops like paddy, pulses, millets used to be grown earlier to orchards at present by the farmers. Taking this shift of crops into consideration and keeping in view the soil-site characteristics and rainfall characterization in the study area, sustainable land use plans involving new cropping systems and farming systems were suggested in transitional and marine plains soils for increasing economic returns of the farmers.

*(**Key words** : Soil-site characterization, Rainfall characteristics, Land use planning, North coastal Andhra Pradesh)*

North coastal zone is one of the seven agroclimatic zones of Andhra Pradesh state (Subba Rao, 1995). Grouping of geographical area on the basis of some criterion similarity is an important step in a number of studies like agroecology, soil suitability crop distribution, etc. (Patel *et al.*, 2000, Subramaniam, 1983, Sehgal *et al.*, 1989). The zonal classification done based on a diverse set of inputs although showed similarity in many physical features on a broad sense, the distribution of rainfall, biophysical constraints such as, soil and water constrains and socioeconomic condition of the farmers play a major role for successful land use plan in a given region. Where irrigation sources are limited, the rainfall characterization constrains like erosion, salinity and inundation, etc. in making plans for efficient land use models. The task is more complex in coastal agroecosystem, which is fragile since climate plays a crucial role for making strategies for sustainable land use and increasing productivity of crops.

MATERIALS AND METHODS

The study area was selected at S. Rayavaram *mandal* falling under 18.4 agroecological subregion. The latitude and longitude of the region is 17°24' and 82°49', respectively. In the selected subregion the major watershed (block) consists of two villages viz., Gudivada and PedaUppalam along with hamlet villages, covering two hamlet villages of Gudivada i.e., Kothapolavaram and Kotharevupolavaram, situated near the sea coast (within a radius of 0.5 km from sea). Detailed soil survey was conducted using 1:8000 scale in the pilot site with the help of NBSS & LUP, Bangalore and soil-site characteristics were studied in different soil series. The rainfall data over 25 years (1978-2003) were collected at S. Rayavaram *mandal* and the data were computed for annual characterization of rainfall and seasonal distribution of rainfall. Moisture availability index (MAI) was also calculated taking into consideration the rainfall, temperature, wind velocity and relative humidity of the area. The land utilization over 13 years (1990-91 to 2002-03) was studied and shifting of crops from one state to the other pilot site was estimated through transitional probability matrix (TPM).

RESULTS AND DISCUSSION

The detailed soil survey conducted at the pilot project site (Fig. 1) showed that two distinct landforms namely, transitional plains and marine plains existed. The soils of transitional plains were categorized into five soil series (A, B, C, D and E) and marine plains into three soil series (F, G and H) (Table 1). The soils of inland plains (transitional plains) were deep, imperfectly to very poorly drained, having clay and clay loam soils, formed from alluvium deposits. The substratum was partially gleyed layer with shells or salt encrustation. The slope in these lowlands varied from 0-3% (gently sloping land). The soils of marine plains were deep, well to excessively drained, sandy soils formed from marine sand. The slope in marine plains ranged from 1-5%, gently sloping to undulated land. The soil constraints identified in these soil series included occurrence of saline and alkali soils in the transitional plains (Soil series A, B and C); water stagnation in transitional plains (Soil series E); low fertility status of soils in marine plains (Series F, G and H); monocropping of paddy in transitional plains, leaving the field fallow for *rabi* season and poor land use efficiency in marine plains raised with pure coconut and cashew orchards.

The annual rainfall characterization over 25 years (1978-2002) at S. Rayavaram *mandal* showed that the mean annual rainfall was found to be 774.7 mm. The annual rainfall deviation percent from the mean annual rainfall over 25 years is shown in Fig. 2. The initial probability analysis showed that the amount of rainfall is 937, 770 and 549 mm at 30%, 50% and 75% probability, respectively. The conditional probability (the probability level at which a particular amount of rainfall is anticipated) analysis showed that there is 61% probability of getting rainfall of 700 mm. The probability accidence of annual rainfall over 25 years was shown in Fig. 3. Seasonal distribution of rainfall (Fig. 4) and

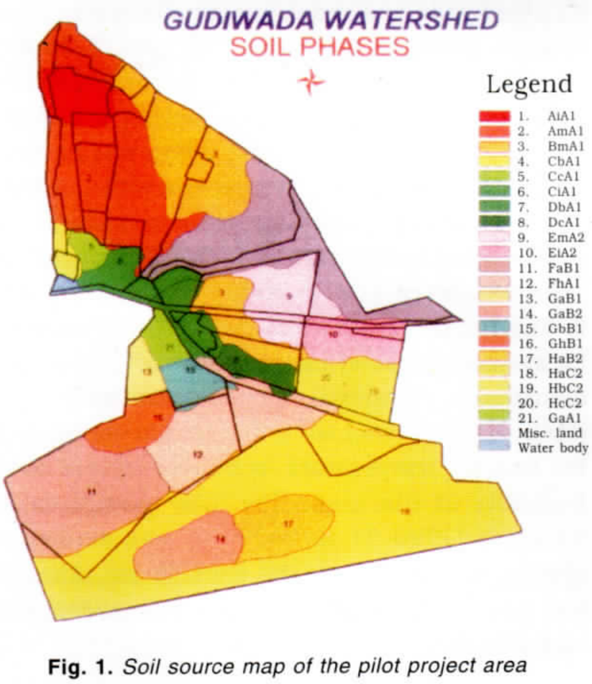

Fig. 1. *Soil source map of the pilot project area*

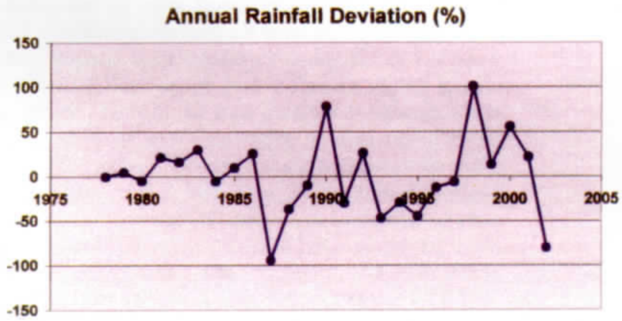

Fig. 2. *The annual rainfall deviation (%) from the mean annual rainfall over 25 years*

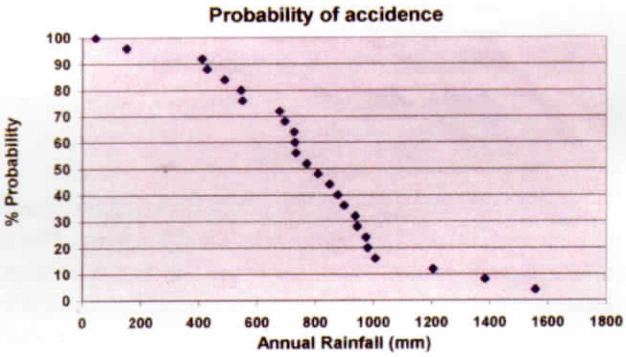

Fig. 3. *The probability of accidence of annual rainfall over 25 years*

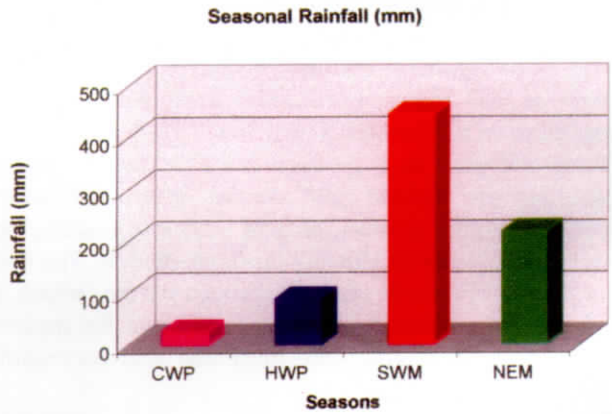

Fig. 4. *Seasonal distribution of rainfall (Average over 25 years) (1978-2002) at S. Rayavaram mandal, Visakhapatnam (dt.)*

CWP- Cold weather period (January-February); HWP- Hot weather period (March-May); SWM- Sowth West mansoon (June-September) and NEM- North East mansoon (October-December)

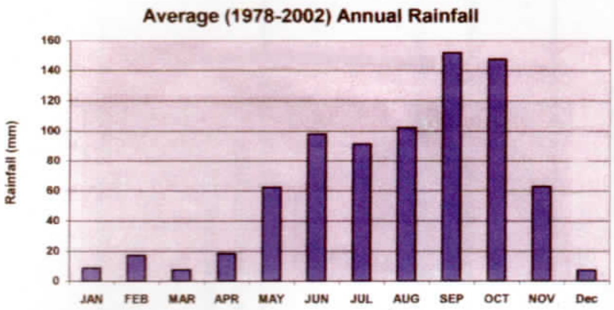

Fig. 5. *Average monthly rainfall over 25 years (1978-2002)*

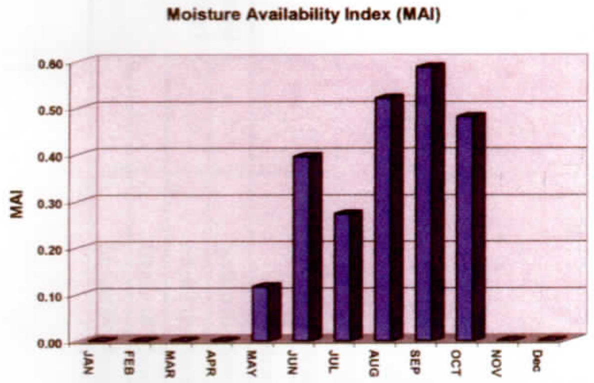

Fig. 6. *Moisture avaiability index at S. Rayavaram mandal (1978-2002) of Visakhapatnam district*

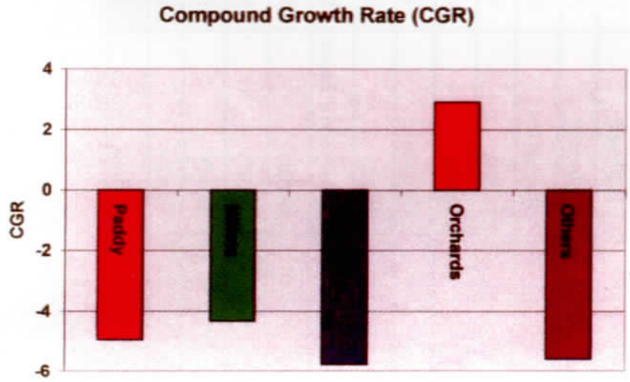

Fig. 7. *Land use pattern (expressed in terms of Compound Growth Rate) over 13 years (1990-91 to 2002-03) at S. Rayavaram mandal, Visakhapatnam district*

monthly distribution of rainfall (Fig. 5) (average over 25 years) showed that more than 50% rainfall (57.2%) was received during South West monsoon followed by North East monsoon (28.1%). A meagre amount of rainfall was received during cold weather period (Jan-Feb) (3.3%) and hot weather period (Mar-May) (11.4%). Moisture availability index was calculated taking into consideration of 75% Dependable Precipitation (PD) and Potential Evapotranspiration (PET). Higher moisture availability index was observed during June-October with excessive moisture available in the month of September (Fig. 6). Present land use pattern studied over 13 years (1990-91 to 2002-03) showed (Table 2) that there was a gradual decline in the area under paddy, pulses and millets over years and showing a gradual shift towards raising orchard crops at present. This was expressed in terms of Compound Growth Rate (Fig. 7). Shift in cropping pattern over years was better expressed in terms of "Transition Probability Matrix" (TPM) (Table 3).

Keeping in view the soil-site characteristics, rainfall characterization and present land use pattern, and taking into consideration the soil constraints in the pilot site, some of the following land use plans are suggested for improving the economic returns of the farmer and for sustainable land use under coastal agroecosystem in North Coastal Andhra Pradesh.

1) Growing of saline resistant varieties of paddy like Deepthi.
2) Introduction of rice based cropping system in monocropping of paddy areas where supplementary irrigation facilities are available and the soils are free of salinity at least in surface layers. This is because, the Detailed Soil Survey results indicated free of soil salinity in some of the soils in surface layers and showed problem of salinity only in subsurface layers, showing the possibility of introduction of short duration *rabi* crops.
3) Growing of silivipasture crops after taking up 'Soil resource management' in some of the inland soils where the soils showed high salinity (due to intrusion of seawater and deposited salts on the surface soils) coupled with inundation due to subsurface ill drainage making the soil very problematic for raising any crop.
4) Growing intercrops in coconut and cashew orchards in marine soils by following proper agronomic management practices like regular application of organic manures, mixing of clay and tank silt for improving soil fertility and physical condition of soils.
5) Introduction of farming system in marine coastal sands by introducing animal component like goat rearing in orchard areas (cashew and coconut orchards) besides raising intercrops in these orchards for increasing the income of the farmers, since mostly the area in marine coastal sands are occupied by small farmers.

Table 1. *Soil-site characteristics of pilot project area*

Sl. No.	Series	Phases	Soil characteristics						
			Soil texture	Slope (%)	Depth (cm)	Erosion	Drainage	CEC [cmol(p+) kg⁻¹]	Classification
1.	A	AiA1	Sandy clay	<1	>150	Slight	Moderately well drained	28.2	Fine, Montmorillonitic, Isohyperthermic, Vertic, Haplustepts
		AmA1	Clay	<1	100 to 150	Slight	Moderately well drained	-	
2.	B	BmA1	Clay	<1	100 to 150	Slight	Moderately well drained	-	Fine, Mixed, Isohyperthermic, Yypic, Haplustepts
3.	C	CbA1	Loamy sand	<1	>150	Slight	Somewhat poorly drained	-	Fine, Mixed, Isohyperthermic, Fluventic, Haplustepts
		CcA1	Sandy loam	<1	>150	Slight	Somewhat poorly drained	-	
		CiA1	Sandy clay	<1	>150	Slight	Somewhat poorly drained	-	
4.	D	DbA1	Loamy sand	<1	>150	Slight	Somewhat poorly drained	-	Fine loamy, Mixed, Isohyperthermic, Typic Haplustepts
		DcA1	Sandy clay	<1	>150	Slight	Somewhat poorly drained	-	
5.	E	EmA2	Clay	<1	>150	Moderate	Poorly drained	-	Fine, Mixed, Isohyperthermic, Aquic Haplustepts
		EiA2	Sandy clay	<1	>150	Moderate	Poorly drained	-	
6.	F	FaB1	Sandy	1 to 3	100 to 150	Moderate	Well drained	15.9	Mixed, Isohyperthermic, Typic Ustipsamments
		FhA1	Sandy clay loam	1 to 3	100 to 150	Slight	Well drained	-	
7.	G	GaB1	Sandy	1 to 3	>150	Slight	Well drained	1.5	Sandy over loamy, Mixed, Isohyperthermic, Typic Ustorthents
		GaB2	Sandy	1 to 3	>150	Moderate	Well drained	-	
		GbB1	Sandy	1 to 3	>150	Slight	Well drained	-	
		GhB1	Sandy clay loam	1 to 3	>150	Sandy clay loam	Well drained	-	
		GaA1	Sandy	<1	>150	Sandy	Well drained	-	
8.	H	HaB2	Sandy	1 to 3	>150	Sandy	Excessively drained	1.3	Mixed, Isohyperthermic, Typic Ustipsamments
		HaC2	Sandy	3 to 8	>150	Sandy	Excessively drained	-	
		HbC2	Sandy	3 to 8	>150	Sandy	Excessively drained	-	
		HcC2	Sandy	3 to 8	>150	Sandy	Excessively drained	-	

Table 2. *Percent area under different crops at pilot project area over 25 years (1990-2003)*

Category	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03
Paddy	19.20	5.52	15.29	0.00	2.05	13.81	15.58	9.92	14.78	7.08	17.09	4.14	0.00
Pulses	1.49	4.14	3.02	4.58	3.23	3.12	5.05	5.01	3.25	2.15	5.89	5.75	6.24
Millets	10.67	11.03	4.07	4.18	7.33	10.93	0.00	0.00	0.58	9.68	7.33	4.24	9.51
Sugarcane	0.60	8.28	7.16	3.35	10.25	1.85	0.79	2.32	1.02	0.91	0.82	0.91	0.89
Oilseeds	15.15	15.40	5.92	7.78	6.54	4.15	4.96	3.88	5.04	5.48	5.31	6.96	6.84
Chillies	2.56	0.00	5.11	3.20	0.92	0.66	3.82	3.83	1.11	4.57	0.21	0.20	0.10
Casuarina	1.49	1.84	1.74	4.82	4.27	3.21	3.29	3.31	0.00	0.00	0.00	0.00	0.00
Orchards	48.85	53.79	57.68	72.10	65.42	62.27	66.52	71.74	74.22	70.12	63.34	77.80	76.41
Total	937.6	870	1033.2	812.8	917.2	973.2	911.6	846.4	825.6	875.6	971.2	792.8	807.2

Table 3. *Transition probability matrix over 13 years (1990-2003)*

	Paddy	Millets	Oilseeds	Orchards	Others
Paddy	0.0381	0.2704	0.0945	0.4079	0.1891
Millets	0.0000	0.0975	0.1768	0.7257	0.0000
Oilseeds	0.6014	0.1692	0.2294	0.0000	0.0000
Orchards	0.0899	0.0000	0.0000	0.8513	0.0588
Others	0.0000	0.1636	0.3457	0.0000	0.4907

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Soil-geomorphic Relationship and the Soil Variability over a Basaltic Terrain – A Case Study along the West Coast of Maharashtra

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Morphological and selected physicochemical properties of the soils of a basaltic terrain representing different landform units identified based on the interpretation of IRS – IA LISS II FCC imagery on 1:50,000 scale in conjunction with Survey of India topographical (SOI) map on 1:50,000 scale and adequate ground truth survey in the area around Madhalikhurd in Raigad district, Maharashtra were studied. Significant variations in soil depth, drainage, colour, texture were observed in relation to toposequence. Soils occurring on upper elements of the topography were shallow to moderately shallow, somewhat excessively drained, sandy clay loam in texture, and dark reddish brown in colour while, soils occurring on lower elements of topography were moderately deep, moderately well drained to poorly drained, clayey in texture, and very dark greyish brown in colour. The influence of topography was manifested on properties like pH, clay content, organic carbon and cation exchange capacity. Ca^{2+} and Mg^{2+} dominated the exchange complex. Based on the field morphology and other characteristics, soils of the area have been classified according to Soil Survey Staff (1992) into two orders namely, Entisol and Inceptisol.

(***Key words*** : *Basaltic terrain, Landform, Topography*)

Modern research is increasingly demonstrating the close dependence of soil on landform and a new discipline, soil geomorphology or pedo-geomorphology has developed (Conacher and Dalrymple, 1977). The intimacy of the soil – geomorphic relationship was studied and established by several pedologists and geomorphologists in India and abroad during the past several years (Kantor and Schwertmann, 1974, Daniels *et al.*, 1971, Parsons, 1978, Sharma and Roy Chowdhury, 1988, Glassman *et al.*, 1980, Muhs, 1982 and Sharma *et al.*, 2001). Soils are an integral part of the land surface and any change in the geomorphic processes influences the pedologic processes (Gerrad, 1981). It is known that soil properties vary in vertical and lateral directions and that such variations follow systematic changes as a function of the landscape position and the soil forming factors. Hence, integrating approach between soils and landform is vital in any aspects of land management. Keeping this in view, an attempt was made to study the salient morphological and selected physicochemical properties of the soils of Madhalikhurd area in Raigad district, Maharashtra and classify them into taxonomic units.

MATERIALS AND METHODS

The study area represents a part of Raigad district, Maharashtra (Fig. 1) located between 73° 6' 0" to 73° 9' 20" E longitude and 18° 26' 10" to 18° 28' 50" N latitude covering an area of about 100 sq km. This area falls in the Survey of India toposheet no. 47F/3 on 1:50,000 scale. The area falls under topical humid climate and is located along the west coast of India. The average annual rainfall of the area is about 3000 mm and it increases rapidly from western to eastern portion of the study area. The rainfall is received mainly during monsoon period i.e., June to October. The mean monthly temperature ranged from 20° to 22° C in January and reaches upto 40°C in May being the hottest month. Deccan basalt is the major geological formation in this area with few outcrops of laterites on the top of the hills. The hill slopes are covered with a wet mixed deciduous forest of Teak (*Tectona grandis*), Ain (*Terminalia tomentosa*), Sissum (*Dalbergia latifolda*), Dhavda (*Anageissus latifolia*), Khair (*Acacia cotechu*), etc. Agriculture is concentrated in the plain occupying both sides of the Kundalika river. Rice is the main crop, coconut, palms, mango, vegetables are also grown in this area.

IRS 1A LISS II FCC imagery on 1:50,000 scale in conjunction with Survey of India topographical (SOI) map referred above on 1:50,000 scale were used to identify the various landforms units such as upper hillslope, middle hillslope, lower hillslope, footslope and gently sloping plain.

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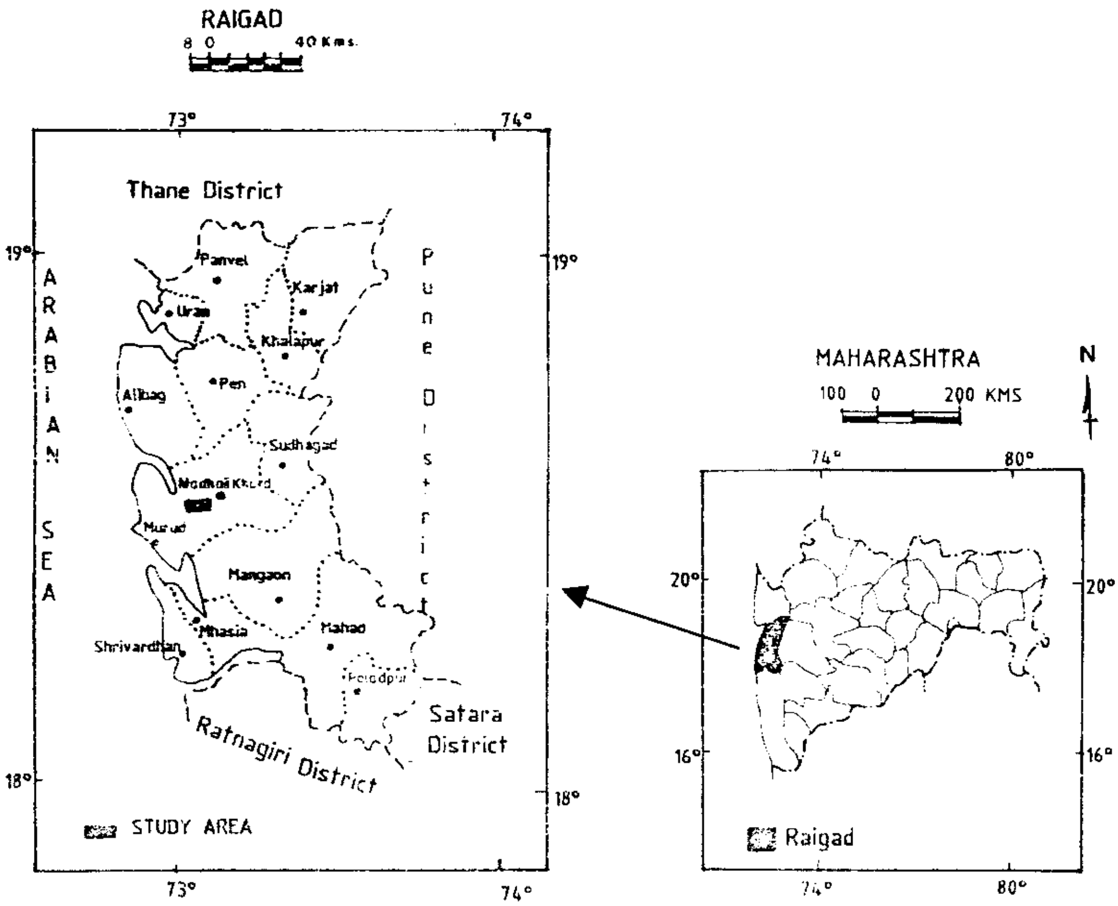

Fig. 1. *Location map of the Madhali Khurd area*

Six typical pedons occurring on different landforms in a toposequence were studied for morphological characteristics (Soil Survey Staff. 1951). The schematic diagram depicting the location of each pedon on different landform units are shown in Fig. 2, and the site and morphological characteristics are presented in Tables 1 and 2. The horizonwise soil samples were collected from each landform unit for laboratory analyses. Processed soil samples (<2mm) were analyzed for various properties following standard laboratory procedures (Jackson. 1973) and their physicochemical properties are presented in Table 3. The soils were classified by following soil taxonomy (Soil Survey Staff, 1992).

RESULTS AND DISCUSSION

Soil features, associated with different landform units, discussed earlier, indicate that soil developed on different geomorphic situations differ widely in their properties (Tables 2 and 3). Field investigation indicates that there are significant differences among the soils occurring on various topographic units. Laboratory data support the field observations. Major properties are discussed below.

Morphological properties

Changes in the soil colour in various pedons seem to be controlled by topography and drainage. The soil colour in Madhalikhurd area on higher topographic positions viz., hillslope which are somewhat excessively drained (Tables 1 and 2, Fig. 2. pedons 1 to 3) exhibit bright matrix colour in hue 5 YR. In these soils, the colour was dark reddish brown (5 YR 5/4 M) / dark reddish brown (5 YR 3/ 4 M). The reddish colour is due likely to the release of iron oxide as a result of weathering under relatively well drained conditions (Gerrad, 1981). The soils occurring on the lower topographic positions viz., footslope and plain (Tables 1 and 2, Fig. 2, pedons 4 to 6) which have impeded drainage conditions exhibit more subdued shades as grays in hue 2.5 Y. In these soils, the colour varies from dark greyish brown (2.5 YR 4/2 M) to very dark greyish brown (2.5 YR 3/2 M) in the lower topographic position. This dark greyish brown colour may be due to reduction of iron under poorly drained conditions. Similar gradational changes in soil colour in the same toposequence order also have

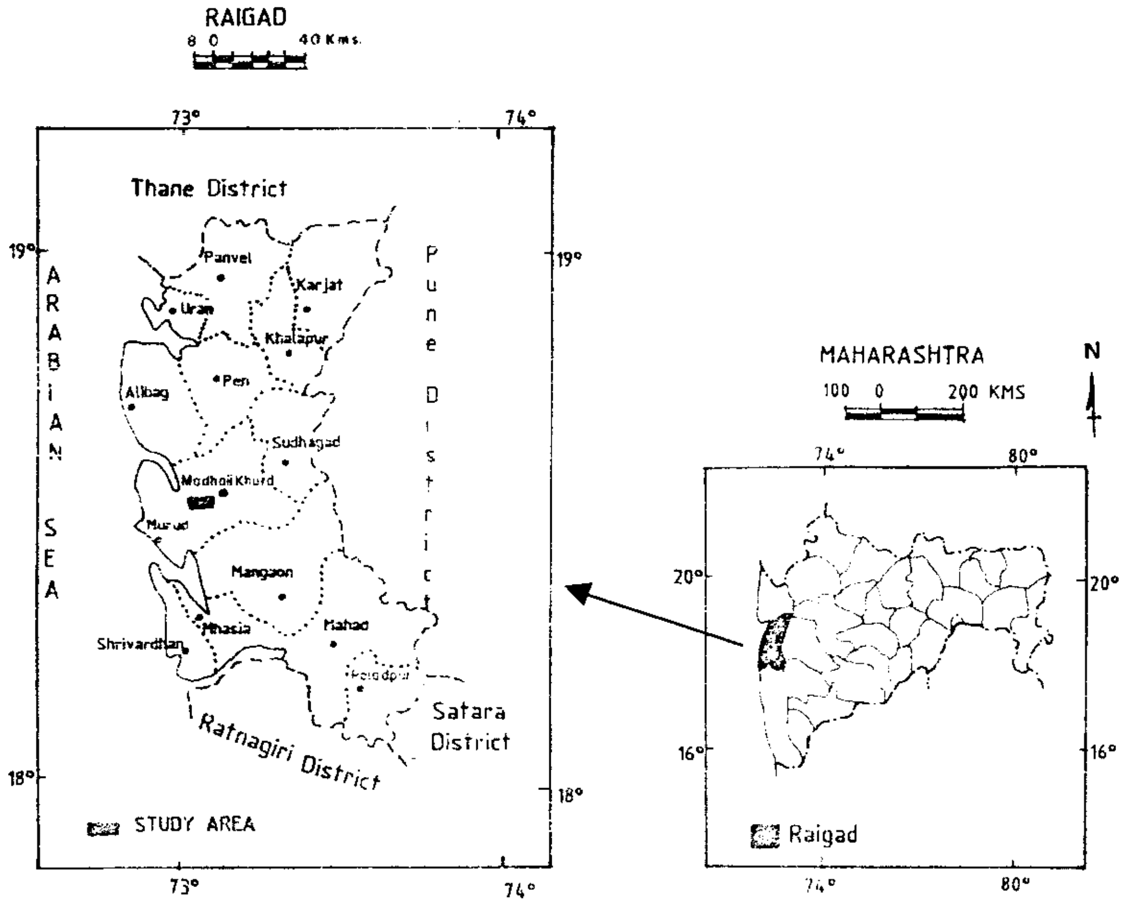

Fig. 1. *Location map of the Madhali Khurd area*

Six typical pedons occurring on different landforms in a toposequence were studied for morphological characteristics (Soil Survey Staff. 1951). The schematic diagram depicting the location of each pedon on different landform units are shown in Fig. 2, and the site and morphological characteristics are presented in Tables 1 and 2. The horizonwise soil samples were collected from each landform unit for laboratory analyses. Processed soil samples (<2mm) were analyzed for various properties following standard laboratory procedures (Jackson, 1973) and their physicochemical properties are presented in Table 3. The soils were classified by following soil taxonomy (Soil Survey Staff, 1992).

RESULTS AND DISCUSSION

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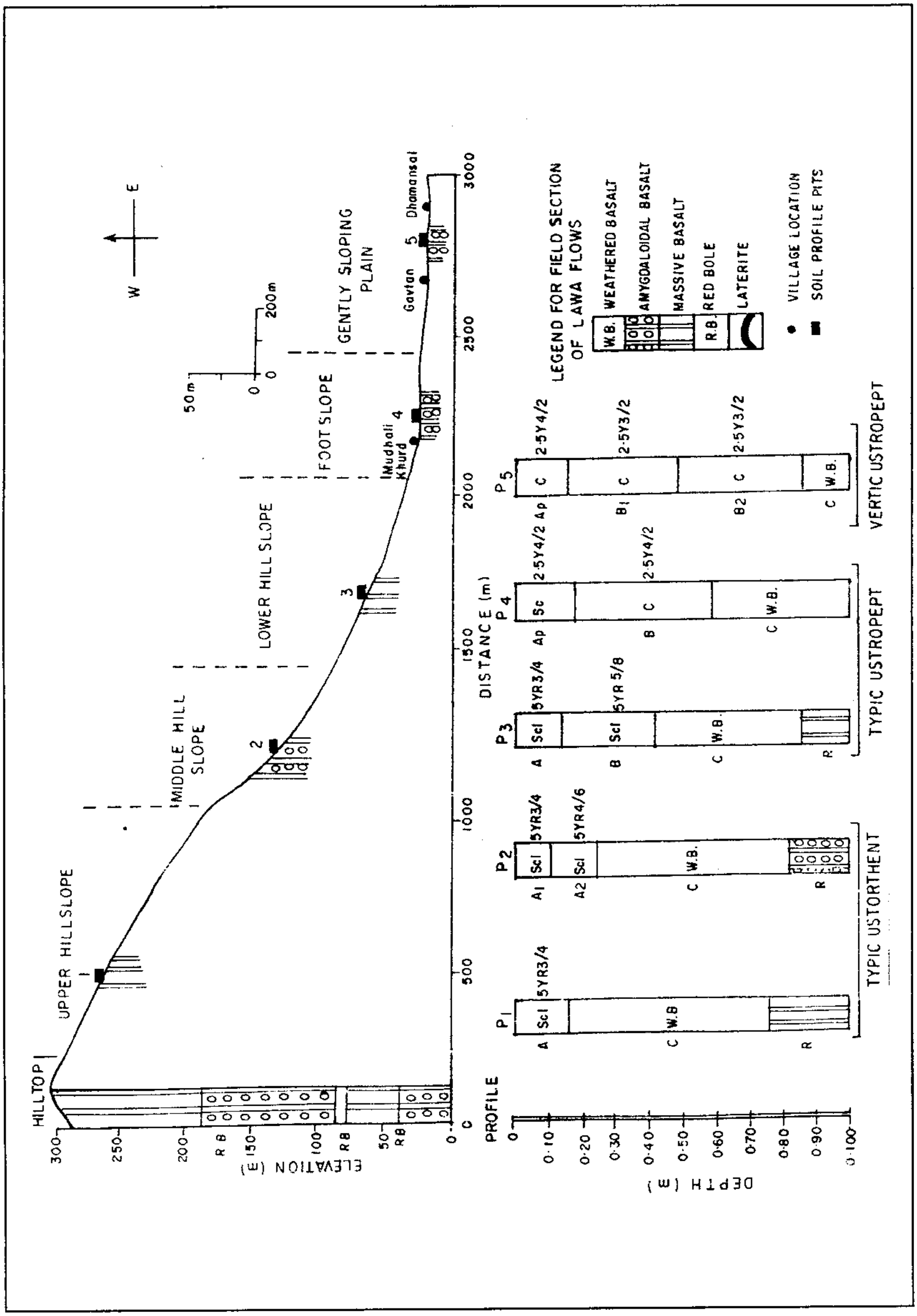

Fig. 2. *Catena showing landform soil relationship around Mudhali khurd area*

Table 1. *Site characteristics of various landforms around Madhalikhurd area*

Profile	Landform	Classification[a]	Depth[b] (cm)	Elevation (m)	Slope (%)	Erosion	Drainage	Land use Land cover
1	Upper hillslope	Typic Ustorthent	16	240	25.9	Severe	Excessively drained	Mainly Teak with Ain and Dhavda
2	Middle hillslope	Typic Ustorthent	24	100	30.6	Severe	Excessively drained	Mainly mixed deciduous forest with Ain, Khair and Sissum
3	Lower hillslope	Typic Ustropept	42	40	24.5	Severe	Excessively drained	Mainly Teak with Ain and Khair
4	Footslope	Typic Ustropept	59	20	3.5	Moderate	Well drained	Tropical thorney bushes and grasses
5	Gently sloping plain	Typic Ustropept	86	Less than 20	2.2	Slight	Moderately well drained	Rice, coconut palm, mango, trees, vegetables

a : sub group level, **b** : solum depth

Table 2. *Field data for catena on Madhali Khurd area*

Landform unit	Profile	Horizon	Depth (cm)	Colour (moist)[a]	Texture	Structure[b]	Boundary
Upper hill slope	1	A	0-16	5YR3/4	Sandy clay	mlgr	Gradual
		C	16-76		Weathered basaltic material		
		R	76+		Massive basalt		
Middle hill slope	2	A1	0-10	5YR3/4	Sandy clay	m2gr	Gradual
		A2	10-24	5YR4/6	Sandy clay	m2gr	Abrupt
		C	24-82		Weathered basaltic material		
		R	82+		Amygdaloidal basalt		
Lower hill slope	3	A	0-14	5YR3/4	Sandy clay	m1gr	Gradual
		B	14-42	5YR5/8	Sandy clay	flgr	Abrupt
		C	42-85		Weathered basaltic material		
		R	85+		Massive basalt		
Foot slope	4	Ap	0-17	2.5Y4/2	Sandy clay loam	m2gr	Gradual smooth
		B2	17-59	2.5Y4/2	Clay	m2gr	Clear, smooth
		C	59+		Weathered basaltic material		
Gently sloping plain	5	Ap	0-15	2.5Y4/2	Clay	m2sbk	Gradual, smooth
		B1	15-48	2.5Y4/2	Clay	m2sbk	Clear, smooth
		B2	48-86	2.5Y4/2	Clay	m2sbk	Gradual, smooth
		C	86+		Weathered basaltic material		

a : According to the munsell notation, **b** : Symbols from soil survey staff (1951)

been reported by Nye (1964) for the Catenary soils in the humid region of Africa and by Tamhane and Karale (1977) in the soils of Bombay Deccan.

The morphology of the profiles shows that with decrease in gradient of slope, the depth of the solum increases. The thicker solum and higher clay content were observed in the soil of footslope and plain (59 to 86 cm and 36.8 to 58.6%, pedons 4 and 5, Fig. 2, Table 3) compared to the soils of hillslope (16 to 42 cm and 24.5 to 34.3%, Pedons 1 to 3, Fig. 2, Table 3) of Madhalikhurd. Thus these variations in soil depth on different landforms may be due to erosion in some places and their deposition in other places. Thus it is obvious that soil depth is negatively correlated with slope. These observations are similar to those reported by Muhs (1982) and Sharma and Roy Chowdhury (1988).

The soils showed conspicuous textural variation from upland to lowland situation. Soils occurring on hillslope (Table 3, Fig. 2, pedons 1 to 3) are medium textured (sandy clay loam) with abundant (11.6 to 16.2 percent) coarse fragments (>2mm) while those on the footslope and plain (Table 3, Fig. 2, Pedons 4 and 5) are fine textured (clayey) with

Table 3. *Physicochemical properties of the soils of the Madhalikhurd area*

Profile	Depth (cm)	Coarse frag-ment %	Particle size distribution %			P^{Ha}	Organic Carbon (%)	C.E.C. [cmol (p+)kg-1]	Exchangeable cations [cmol(p+)kg-1]				Ca/ Mg	Base saturation %
			Sand	Silt	Clay				Ca	Mg	Na	K		
1	0-16	16.2	49.2	26.3	24.5	5.5	1.29	20.4	8.2	6.3	0.4	1.4	1.3	79.9
2	0-10	14.5	58.1	19.2	22.7	5.6	1.31	18.9	7.5	5.9	0.5	1.2	1.3	79.8
	10-24	12.3	51.3	18.5	30.2	5.7	0.96	16.5	5.9	6.4	0.3	0.9	0.9	81.8
3	10-14	15.2	63.0	16.4	20.6	5.7	1.10	19.5	7.1	6.5	0.5	1.3	1.1	79.4
	14-42	11.6	44.2	21.5	34.3	5.8	0.93	22.4	8.7	7.3	0.4	0.8	1.2	76.7
4	0-17	12.1	48.6	14.6	36.8	6.6	1.14	21.7	8.6	7.1	0.4	0.9	1.2	78.3
	17-59	10.8	42.1	13.4	44.5	6.4	0.87	23.2	9.3	8.4	0.3	0.7	1.1	80.6
5	0-15	8.5	28.5	16.2	55.3	6.5	0.95	26.4	9.1	10.2	0.5	0.7	0.9	77.6
	15-48	10.3	30.7	12.5	56.8	6.6	0.87	27.6	11.5	9.7	0.5	0.5	1.2	80.4
	48-46	11.6	24.2	17.2	58.6	6.5	0.62	29.2	12.2	12.7	0.4	0.5	1.1	81.5

less coarse fragments (8.5 to 12.1 percent). This indicates that on the upper topographic position of the catena, the chemical weathering of the coarse material takes place less rapidly and there is a considerable loss of finer materials by chemical weathering due to free drainage, resulting in the accumulation of more coarse fragment in the soils. It is noticed that the coarse fragments increased with depth. In general, the coarse fragments decreases down the slope and the above findings indicate that the percentage of coarse fragment is related to landform position (Sharma and Roy Chowdhury, 1988).

Soils occurring on different geomorphic units in the study area indicate varying degree of structural development. The structure on the excessively drained higher topographic positions (Pedons 1 to 3, Fig. 2, Table 2) is weak to moderate, medium and granular. On the poorly drained lower topographic positions (Pedons 4 and 5, Fig. 2, Table 2) the soils have at least vertic characteristics such as cracks and wedge shaped structure breaking into moderate, medium, sub-angular blocky peds. The horizon differentiation is restricted to only one layer in the higher topographic position followed by a decomposed parent rock. This may be due to excessive relief position, which results in quick removal of weathering products. Likewise there is no horizon differentiation in the moderately deep black soils occurring at the lower topographic positions. Desai (1942) has reported similar observations.

Physicochemical properties

The effect of various topographic position on different physicochemical properties such as soil reaction, cation exchange capacity, exchangeable cations, organic carbon and calcium carbonate are discussed below.

The soil occurring around Madhalikhurd area are distinctly acidic (pH 5.5 to 6.6, Table 3) irrespective of the elevation. The high rainfall prevailing in Madhalikhurd favours leaching and removal of the bases and thus makes the soils more acidic. The pH of Madhalikhurd soils gradually increases down the slope and this is due to leaching as a result of variable drainage conditions. Thus it may be mentioned that the pH of the soils increases with decreasing elevation. Such relationship between soil pH and leaching has also been reported for other areas (Godse and Tamhane, 1966 and Joshi *et al.*, 1961).

The cation exchange capacity in respect of Madhalikhurd soil profiles is given in Table 3 and the value ranges from 16.5 to 29.2 [cmol(p^+)kg^{-1}] soil. The CEC value is higher when the fine clay fractions is high. Joshi *et al.* (1961) and Karale *et al.* (1969) reported similar findings.

The exchangeable cations of the soils related to Madhalikhurd area are presented in Table 3. Soil development in this area from basalt under high rainfall conditions and severe leaching with rapid and ready removal of bases from the profile brings down the base status of the weathering complex. The decrease, principally in the Ca^{2+} and Mg^{2+} ions, imparts acidic reaction in the weathering complex which favours partial or complete breakdown of the montmorillonitic minerals initially formed. Calcium dominates on the exchange complex followed by magnesium, potassium and sodium. Similar findings were reported by Karale *et al.* (1969) and Joshi *et al.* (1961).

The soils occurring around Madhalikhurd located in the tropical humid climatic region (Table 1) have higher organic carbon (0.62 to 1.29 percent, Table 3). In general, the organic carbon distribution is mainly associated with geomorphic units and land use. That is why the hillslope and the footslope soils which are under forest/grass cover in Madhalikhurd area have higher organic carbon (1.14 - 1.29%, Table 3, Fig. 2, pedons 1 to 4) than the cultivated soils (0.62 - 0.87%, Table 3, Fig. 2, pedon 5), where the crop residue is not generally returned to the soils. Similar findings were reported by Joshi *et al.* (1961).

CLASSIFICATION

An attempt was made to classify these soils using the differentiating criteria given in Soil Taxonomy, the USDA Soil Classification System (Soil Survey Staff, 1992). The soils studied in the present investigation were classified into two soil orders namely, Entisol and Inceptisol.

The Madhalikhurd area experiences ustic soil moisture regime though the climate is classified as humid. The annual rainfall is high but received within a short period of 3 to 4 months and therefore the soils remain moist only for a period of 180 or more cumulative days and remain dry for 90 or more cumulative days. The pedons 1 & 2 are classified as Typic Ustorthent (Entisol) as the soils do not have well developed horizonation. The pedons 3 & 4 are classified as Typic Ustropept (Inceptisol) as the soils have Cambic horizon, a hyperthermic temperature regime and a ustic moisture regime. The pedon 5 is classified as Vertic Ustropept as the soil has a Cambic horizon wherein the ped surfaces exhibit stress cutan. They also develop deep wide cracks in the summer months and have ustic moisture regime and hyperthermic temperature regime.

CONCLUSION

The study has revealed that landform and soils are closely associated with each other and the soil properties vary in vertical and lateral directions and that such variations follow systematic changes as a function of landform position and the soil forming factors. It is apparent that the slope gradient plays a vital role in developing soil properties and on most of the slopes, soil types and properties vary systematically with slope angles and positions. There is a gradual change in the characteristics of profiles during the traverse down the slope from the higher to the lower topographic position. The profile features appear to be a function of topography.

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Land Capability and Irrigability Classification of Coastal Regions of Prakasam District, Andhra Pradesh

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On traversing the coastal regions of Prakasam district, a representative area was selected and surveyed in detail to classify the soils into capability and irrigability units. The soils were grouped into different orders and proposed as five series. Based on variations in surface features like slope, texture, salinity, etc. different mapping units were identified and were classified for their capability to produce crops and irrigability for surface irrigation. Mapping units BhA1, ChA1 and ChB1 were grouped under capability class II, whereas the other units of series A, B and C were classified under capability class III due to moderate limitations of soil. Units of series D and E were placed under capability class IV due to severe limitations to texture and/or fertility and/or topography. As per the irrigability classification units of series A, B and C were grouped under S2/S3 class i.e., moderately/ marginally suitable, whereas soils of series D and E were placed under N2 i.e., unsuitable for surface irrigation.

(**Key words :** *Land capability, Irrigability classification, Coastal soils*)

Growing crops according to the capability of the land and using available resources in a planned manner is the current motto for sustainable agriculture. Prakasam district has about 113 km long coastal line along its eastern border, facing the Bay of Bengal. The coastal belt comprises of different landforms. Some landforms have provision for irrigation while others are rainfed. Land capability and irrigability studies help in identifying the best lands for agriculture and their suitability for surface irrigation, respectively. This sort of information for the coastal areas of the district is lacking. Hence a study was made to classify the area according to its capability to produce crops and irrigability to surface irrigation.

MATERIALS AND METHODS

For the present study, ground traversing of coastal region of Kothapatnam *Mandal* was done and a representative area was selected for detailed survey. The study area is located between the geographical co-ordinates of 15°2'30" and 15°22'30" N latitudes and 80°5' and 80°7'E longitude. Based on soil survey four landforms were identified.

Representative profiles were opened upto 2m depth and were described for their morphology. Horizonwise profile samples were collected from different landforms and analyzed for their physical, physicochemical and chemical properties following standard procedures. Based on the properties, the soils were grouped under suitable taxonomic units (Soil Survey Staff, 1998) and were proposed under different series. Further, based on the variations in the surface properties different phases were identified. Land capability classification was done as per the guidelines given by Sehgal (1996), which is based on inherent soil characteristics, external land features and environmental factors that limit the use of the land. For this, the soil characteristics considered were soil depth, texture, salinity and calcareousness. The land features were slope, erosion and drainage. In capability classification system, the mapping units are generally grouped at three levels viz., capability class, subclass and units. Land suitability for surface irrigation was done as per the procedure outlined by Sehgal (1996). This is based on parametric approach for computing the capability index (Ci) of Sys (1976).

RESULTS AND DISCUSSION

Soils

Based on the detailed survey, the four landforms identified viz., inland plains, transitional alluviums, dune sands and beach sands were proposed at 5 series. Further, based on the variations in surface they were grouped into different mapping units. Each mapping unit was described for its properties (Table 1). Units representing series A were moderately well to imperfectly drained, nearly flat to very gently

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Table 1. *Soil site characteristics of different mapping units*

Mapping unit	Depth (cm)	pH	EC (dSm^{-1})	CEC {cmol(p^{+})kg^{-1})}	CaCo$_3$ (%)	Organic carbon (%)	Texture	Slope (%)	Erosion	Drainage
I. Series A										
AmA1	>150	8.28	1.38	40.7	4.19	0.92	c	<1	slight	mod.
AmB2	>150							1-3	mod.	well
AmS2B2	>150							1-3	mod.	poor
II. Series B										
BhA1	100-150	8.17	0.58	16.2	2.63	0.59	scl	<1	slight	mod. well
BiA1	100-150						sc			
BmA1	100-150						c			
III. Series C										
ChA1	100-150	7.98	0.56	22.5	1.68	0.75	scl	<1	slight	mod. well
CiA1	100-150						sc	<1	slight	
ChB1	100-150						scl	1-3	slight	
ChC2	100-150						scl	3-8	mod.	
IV. Series D										
DaA1	>150	7.9	0.21	1.3	0.00	0.31	s	<1	slight	excessive
DaB2	>150							1-3	slight	
DaC1	>150							3-5	slight	
DaC2	>150							3-5	mod.	
DaC3	>150							3-5	mod.	
DaD3	>150							8-15	slight	
V. Series E										
EaA1	>150	7.15	0.37	1.00	0.00	0.10	s	<1	slight	excessive
EaB1	>150						s	1-3	slight	
EaB2	>150						s	1-3	mod.	
EaC2	>150						s	3-8	mod.	
EcA1	>150						s	<1	mod.	

sloping, clayey, high in cation exchange capacity (CEC) and organic carbon. Transitional soils represented by series B and C were moderately well drained, texture varied between sandy clay loam and clay, medium in organic carbon content, low in CEC, and were non-saline. Mapping units of series B were almost plain while in series C, the topography varied from gently sloping to undulating (3-8%). Dune sand and beach sand lanforms covered by mapping units of series D and E were somewhat excessively drained, slope varied between 1 and 15 percent, sandy in texture, very low in CEC, organic carbon and electrical conductivity values.

Land capability classification

Land capability classification for the pilot area is presented in Table 2. Mapping units BhA1, ChA1 and ChB1 (comprising of 6.1 percent area) were grouped under IIs, which are good cultivable lands and have slight limitations in texture. A variety of crops can be grown on these soils, but these should be cultivated with care and following simple management practices. Units Am A1, Am B2, Bi A1, Bm A1 and Ci A1 covering 25 percent of the study area are moderately good cultivable lands and were placed in land capability subclass IIIs due to the moderate limitation of texture that may result in imperfect drainage. Mapping unit ChC2 (0.74 %) was categorized under capability subclass IIIst due to moderate limitation of texture and topography. Land covered by AmS2B2 (1.88%) was grouped under capability class IIIsw due to limitation of clay texture and high swell shrink potential, low hydraulic conductivity and imperfect to poor drainage. These soils vary in their suitability to different crops and should be cultivated with intensive care. The land capability classes worked out for Purna valley of Vidarbha, Maharashtra are IIsw and IIIsw (Padole and Deshmukh, 1998).

Units DaA1, DaB2, DaC1, DaC2, EaA1, EaB2, EaC2 and EcA1 occupying major area (64.35%) had severe limitations of texture and very low fertility (low CEC and organic carbon) and hence grouped under capability subclass IVsf. Units DaC3 and DaD3 (1.8%) were grouped under IVsfe due to the presence of severe limitations like sandy texture, very low fertility and susceptibility to erosion. These problems reduce the choice of the crop. These soils may not be economical to cultivate, as they need intensive management practices.

Suitability for surface irrigation

As per the results, the suitability of the study area for surface irrigation are given in Table 3. The soils comprising units AmA1, AmB2, BhA1, BiA1, BmA1, ChA1 and CiA1 were grouped under moderately suitable S2s class as their Ci values are between 60 and 80. They have moderate limitations of texture.

Unit AmS2B2 was grouped under S3sd, marginally suitable class (Ci values ranging between 40 and 60) due to severe limitations of texture and drainage, whereas, units ChB1 and ChC2 were classified under marginally suitable class, S3s as their Ci values were 58.32 and 51.80, respectively having severe limitations of only texture. The

Table 2. *Land capability classification of the soils of study area*

Land capability subclass	Description	Mapping unit	Area	
			Percent	Hectare
IIs	Good cultivable land with slight limitation of texture	BhA1, ChA1 and ChB1	6.10	12.35
IIIs	Moderately good cultivable land having moderate to severe limitations of texture	AmA1, AmB2, BiA1, BmA1 and CiA1	25.00	50.50
IIIsw	Moderately good cultivable land having moderate to severe limitations of texture and wetness	AmS2B2	1.88	3.80
IIIst	Moderately good cultivable land having moderate to severe limitations of texture and topography	ChC2	0.74	1.50
IVsf	Fairly good land with severe limitation of soil texture and fertility	DaA1, DaB2, DaC1, DaC2, EaA1, EaB1, EaB2, EaC2 and EcA1	64.35	130.00
IVsfe	Fairly good land with severe limitation of soil texture, fertility and erosion	DaC3 and DaD3	1.8	3.57

Table 3. *Land suitability for surface irrigation*

Mapping unit	Texture A	Depth B	$CaCO_3$ C	Gypsum D	EC E	Drainage F	% Slope G	Ci Values	Range Ci	Suitability class
I. Series A										
AmA1	80	1	1	1	1	0.9	1	72	60-80	S2s
AmB2	80	1	1	1	1	0.9	0.9	64.8	60-80	S2s
AmS2B2	80	1	1	1	1	0.8	0.9	57.6	40-60	S3sd
II. Series B										
BhA1	70	0.9	1	1	1	0.9	1	64.8	60-80	S2s
BiA1	70	0.9	1	1	1	0.9	1	64.8	60-80	S2s
BmA1	80	0.9	1	1	1	0.9	1	64.8	60-80	S2s
III. Series C										
ChA1	70	0.9	1	1	1	0.9	1	64.8	60-80	S2s
CiA1	70	0.9	1	1	1	0.9	1	64.8	60-80	S2s
ChB1	70	0.9	1	1	1	0.9	0.9	58.32	40-60	S3s
ChC2	70	0.9	1	1	1	0.9	0.8	51.8	40-60	S3s
IV. Series D										
DaA1	40	1	1	1	1	0.4	1	16.6	<20	N2sd
DaB2	40	1	1	1	1	0.4	0.9	14.4	<20	N2sd
DaC1	40	1	1	1	1	0.4	0.8	12.8	<20	N2sd
DaC2	40	1	1	1	1	0.4	0.8	12.8	<20	N2sd
DaC3	40	1	1	1	1	0.4	0.8	12.8	<20	N2sd
DaD3	40	1	1	1	1	0.4	0.6	14.4	<20	N2sd
V. Series E										
EaA1	40	1	1	1	1	0.4	1	16.6	<20	N2sd
EaB1	40	1	1	1	1	0.4	0.9	16.0	<20	N2sd
EaB2	40	1	1	1	1	0.4	0.9	16.0	<20	N2sd
EaC2	40	1	1	1	1	0.4	0.8	12.8	<20	N2sd
EcA1	40	1	1	1	1	0.4	1	16.6	<20	N2sd

Capability Index (Ci) = AxBxCxDxExFxG; S2: moderately suitable, S3: marginally suitable, N2: unsuitable; s=limitation of soil (texture); d=drainage

remaining units covered under soil series D and E were grouped under unsuitable class, N2sd because of their sandy texture and excessive drainage. *Theri* soils of Tamil Nadu having sandy texture were grouped under non-irrigable class due to very severe limitations of rapid permeability (Janakiraman *et al.*, 1997). But these soils can effectively be irrigated through sprinkler or drip irrigation.

By following suitable management practices like providing drainage in fine textured soils, adding amendments to excessively drained sandy soils and leveling of undulating areas, the capability of lands can be improved. The sandy soils were classed in capability class IV due to their low water and nutrient retention and excessive drainage. A wide variety of crops can be grown on these soils by giving irrigation through sprinkler or drip irrigation along with split application of fertilizers.

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Impact of Prevention of Natural Saline Washing on the Nutrient Dynamics of Kuttanad Ecosystem, Kerala

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An investigation was carried out in the acid saline rice soils of Kuttanad, which has been protected from the annual saline water intrusion during summer by constructing a regulator across the Vembanad lake. The regulator was kept closed during the summer season to prevent saline water intrusion from the Lakhadweep Sea and this was a regular phenomenon for the past three decades. The present paper attempts to reveal the impact of closure of the regulator in the nutrient dynamics of these rice soils by analyzing 97 surface soil samples collected before and after the closure of the regulator and comparing the present values with that of pre-barrage/pre-regulator period. It was observed that the annual closure of the regulator has resulted in an increase in soil acidity and availability of N and Fe and a decrease in salinity, CEC, ECEC, and available K, Ca, Mg and Mn during the period of closure (December to mid-April) compared to the period when the regulator was kept open. However, the availability of all nutrients except P was above deficiency level. Fe was present in toxic quantities. On comparing the above values with that of pre-barrage period, the area experienced a reduction in organic carbon content and salinity while an enhancement was observed for acidity and availability of K, Ca, Mg and Cu. The Na content was reduced considerably in response to reduction in salinity. The exchangeable and water soluble cations followed the same trend as that of available cations. Among the cations, Ca was the dominant basic cation instead of Na, which occupied the same place during the pre-barrage period.

(**Key words:** *Acid saline, Nutrient dynamics, Nutrient deficiency & toxicity*)

Kuttanad, the rice granary of Kerala is a lowlying deltaic alluvium (0.5-2.6 m below mean sea level) situated on the western coast of Kerala. The Vembanad lake which has been connected with the Lakshadweep Sea through the Kochi bar mouth forms the core region of Kuttanad. The rice fields are located in and around this lake. The past glory of Kuttanad is slowly vanishing and now the tract experiences a severe decline in rice production. The rice cultivation in Kuttanad was always risky because of the flood submergence during monsoons and the saline water intrusion during summer. In order to protect rice crop from salinity, a regulator was constructed across the Vembanad lake at Thanneermukkom and kept closed during the months, December to mid-April, which was a regular phenomenon from 1976 onwards and thereby preventing the natural saline washing of the tract by tidal flushing. This led to deterioration soil health, crop productivity as well as human health. The present paper reveals how the closure of the regulator has influenced the nutrient dynamics of the area.

MATERIALS AND METHODS

Out of the 55000 ha of acid saline soils on the upstream side of the regulator, North Kuttanad, the most benefited area due to the construction of the barrage/regulator was selected for the study. North Kuttanad comprises of 10200 ha of rice fields. The region has a humid tropical climate with mean annual rainfall of 2963 mm, out of which 80 percent occurs during June to September, often resulting in flood. After the cessation of monsoons the saline water from the Lakshadweep Sea enters into the lake and from there spreads to entire Kuttanad, making the soils predominantly acid saline. The moisture regime of the tract is aquic and the temperature regime is hyperthermic. From the 27 randomly selected polders of the area 97 surface soil samples (0-15 cm) were collected before the closure of the regulator during the month of May-June and after the closure during February-March. Standard methods were followed for determining pH, EC, organic carbon (Jackson, 1958), available N (Subbiah and Asija, 1956), available P, K, Na, Ca, Mg, Fe, Mn, Cu and Zn, and CEC, ECEC, water

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soluble and exchangeable cations as described by Page (1982). The results obtained were compared between the periods (before and after the closure of the regulator) and with the nutrient status of the pre-barrage/pre-regulator period.

RESULTS AND DISCUSSION

General soil properties

The general soil properties are presented in Table 1. The soils of Kuttanad are termed as acid saline soils. They recorded a mean pH of 4.4 and EC of 1.35 dS m^{-1} before the closure of the regulator and decreased to 4.0 and 0.67 dS m^{-1}, respectively after the closure. The higher values for pH and EC before the closure were definitely due to the effect of saline water which entered into the tract as well as the impact of early monsoon showers received during the month of June. The closure of the regulator and the advancement of summer initiated the lowering of water table and the consequent drying resulted in increase in soil acidity. On comparing the pH with that reported during the pre-barrage period (Money, 1961, Kabeerathumma, 1969, 1975, Nair and Money, 1972) an increase in soil acidity was observed during the post-barrage period. The prevention of saline water washing blocked the removal of Al^{3+} ions from exchange sites for basic cations, resulting in a decrease in soil pH. The closure of the regulator prevented the saline water entry into the tract and thereby reduced EC considerably. The magnitude of saline water intrusion considerably reduced after the construction of regulator at Thanneermukkom (Nair and Pillai, 1990). Presently the EC values were very low compared to the values reported by Money (1961), Kabeerathumma (1969, 1975), Nair and Money (1972), Money and Sukumaran (1973) during the pre-barrage period.

Like pH and EC organic carbon content was also higher before the closure of the regulator. The mean value dropped from 3.66 percent to 3.45 percent after the closure. The reduction was mainly because of the enhanced rate of organic matter decomposition due to continuous cultivation activities during the *punja* season. A considerable reduction in organic matter content of the area during post-barrage period has been reported (Kabeerathumma and Patnaik, 1978, Amma *et al.*, 1979, Mathew, 1989). In the present study also a similar trend was observed.

CEC of the study area varied from 16.6 to 38.8 cmol (p^+) kg^{-1} after the closure. The decrease was due to the reduction in organic carbon content and soil pH. The ECEC also followed the same trend.

Available nutrient

The available N content was 286 mg kg^{-1} before the closure and it increased to 324 mg kg^{-1} after the closure of the regulator (Tables 2 and 3). In general the available N status of the area was high. Construction of regulator has not altered the available N status of the area, since present values agree with those reported by Pillai (1964) and Kabeerathumma (1969) during the pre-barrage period.

Table 1. *General properties of soil during different periods*

Particulars	Organic carbon %		pH		EC dS m^{-1}		ECEC cmol (p^+) kg^{-1}		CEC cmol (p^+) kg^{-1}		Base saturation, %	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Mean	3.66	3.45	4.4	4.0	1.35	0.67	16.1	13.8	25.8	19.6	45.5	41.1
Range	1.98-5.29	1.55-6.78	3.2-5.4	3.0-5.0	0.43-4.00	0.23-1.71	8.9-23.5	7.1-25.2	16.6-38.8	9.7-33.5	30.9-48.6	31.9-42.7
CD (P=0.05)	NS		0.291		0.366		1.74		2.02		4.27	

SI = Before the closure of Thanneermukkom regulator, SII = After the closure of Thanneermukkom regulator

Table 2. *Available N, P, K, Ca, Mg and Na contents of soil during different periods (mg kg^{-1})*

Particulars	N		P		K		Ca		Mg		Na	
	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII	SI	SII
Mean	286	324	3.17	5.50	293	179	2271	1519	575	229	1983	501
Range	185-431	175-489	0.26-7.09	1.12-17.8	175-539	84-349	1133-4032	684-2634	309-1570	75-618	608-5158	194-1496
CD (P=0.05)	28.07		1.32		30.6		291		113		340	

SI = Before the closure of Thanneermukkom regulator, SII = After the closure of Thanneermukkom regulator

Table 3. *Available Fe, Mn, Cu and Zn contents of soil during different periods (mg kg^{-1})*

Particulars	Fe		Mn		Cu		Zn	
	SI	SII	SI	SII	SI	SII	SI	SII
Mean	358	421	9.76	8.65	5.51	4.40	2.85	2.95
Range	183-511	141-592	3.11-19.35	2.3-20.5	1.5-10.9	0.76-10.31	1.03-8.38	1.22-7.72
CD (P=0.05)	46.8		NS		NS		NS	

SI = Before the closure of Thanneermukkom regulator, SII = After the closure of Thanneermukkom regulator

The Kuttanad soils are deficient in available P due to their high P fixing capacity. A very marginal increase in available P was noted during the period when the regulator was closed. The data were almost similar to that reported during pre-barrage period (Money, 1961, Kabeerathumma, 1969, 1975, Nair and Money, 1972).

Kuttanad soils were relatively deficient in available K during the pre-barrage period as per the report of Nair and Money (1972), the range being 35 to 78 mg kg^{-1}. As per the studies of post-barrage period the range is about 124-216 mg kg^{-1} (Mathew, 1989). In the present study the mean values for available K was 293 mg kg^{-1} before closure and it decreased to 179 mg kg^{-1} after the closure of the regulator. The higher concentration of K before the closure was evidently due to the influence of saline water which entered into the area. The available Na content before the closure was 1983 mg kg^{-1} and it decreased to 501 mg kg^{-1} after the closure due to the prevention of saline water entry. There was a considerable decrease in Na content during the post-barrage period (Nair and Pillai, 1990).

The mean value of available Ca was 2271 mg kg^{-1} before the closure of the regulator and decreased to 1519 mg kg^{-1} after the closure. Among the basic cations, the decrease in concentration was comparatively lower for Ca indicating its better absorption on exchange complex. Compared to the pre-barrage period (Sreedevi and Aiyer, 1974, Aiyer *et al.*, 1975) there was an increase in available Ca content during the post-barrage period. Addition of liming materials and the leachates brought down from the upper fringes of Western Ghats might have played a major role in increasing the Ca content. Among the bases, Ca recorded the highest value. The behaviour of Mg was similar to that of Ca.

Fe toxicity has been identified as the most serious nutrient disorder of the area. The present study confirmed the presence of large quantities of available Fe, which was many times greater than the concentration of other micronutrients. Apart from the large quantities of native iron, the persistence of soil reaction below pH 5.0 and reduced soil conditions due to submergence have kept Fe in soluble form resulting in its high availability. The low base status of the area aggravates the above situation. Thampatti *et al.* (2001) reported the extent of iron toxicity and favourable influence of K and Ca nutrition in alleviating the ill effects of iron toxicity in Kuttanad soils. The mean value of available Fe (DTPA) before the closure of the regulator was 358 mg kg^{-1} and it increased to 421 mg kg^{-1} after the closure. The increase observed was of about 17.6 percent. The interruption of free drainage by closing the regulator aggravated the situation. The soils were high in available Fe. The comparison of present Fe status with that of pre-barrage period was not possible due to want of data.

Kuttanad soils were adequately supplied with available Mn. The mean values for available Mn and Cu were 9.76 and 5.51 mg kg^{-1}, respectively before the closure of the regulator. After the closure these values droppted to 8.65 and 4.40 mg kg^{-1}, respectively. Adoption of intensive cropping, loss of soluble nutrients through drainage/flood water and the dominance of Fe in the area might have reduced the availability of above nutrients. Compared to Fe, Mn was present in small quantitites and Mn toxicity was not yet reported from the area. The comparison of present Mn status with that of pre-barrage period was not possible due to want of data. However, an increase in available Cu was observed during the post-barrage period. The continuous use of copper fungicides in the area and the increased rate of organic matter decomposition would have contributed towards this increase. The available Zn content was 2.85 mg kg^{-1} before the closure and it increased to 2.95 mg kg^{-1} after the closure. The study area was not deficient in Cu and Zn as per the critical levels suggested by Aiyer *et al.* (1975). Almost all cationic elements except Fe and Zn showed a decrease in concentration after the closure of the regulator.

Water soluble K, Na, Ca and Mg

The behaviour of water soluble fractions of K, Na, Ca and Mg was similar to that of their available fractions during both the periods (Table 4). Nearly half of the available K and more than 80 percent of available Na were present in water soluble form. Among the basic cations, percentage contribution of water soluble form to available form was least for Ca. Mg also followed the same trend as that of Ca but nearly more than half of the available Mg was in water soluble form.

Exchangeable K, Na, Ca and Mg

The behaviour of exchangeable fractions of K, Na, Ca and Mg was similar to that of their available fractions during both the periods (Table 5). Among the exchangeable bases, K was present in smallest quantity. The exchangeable Na, though present in very small proportion, constituted 8.1 percent of total exchangeable bases before the closure of the regulator and it decreased to 3.6 percent after the closure. Ca was the dominant cation among the exchangeable bases. Greater adsorption on exchange complex and lower solubility in water mainly contributed to the dominance of Ca in the exchange complex. The mean value of exchangeable Ca was 8.32 cmol (p^+) kg^{-1} before the closure and it decreased to 6.47 cmol (p^+) kg^{-1} after the closure of the regulator. It contributed 70.8 and 80.4 percent, respectively of total exchangeable bases during the above two periods. Mg occupied a position next to Ca among the exchangeable bases.

Table 4. *Water soluble cations of soil during different periods (mg kg^{-1})*

Particulars	K		Na		Ca		Mg	
	SI	SII	SI	SII	SI	SII	SI	SII
Mean	167	81	1764	438	605	247	313	104
Range	82-360	35-202	502-4845	163-1675	294-1303	134-486	89-854	34-235
CD (P=0.05)	20.1		322		90.1		59.0	

SI = Before the closure of Thanneermukkom regulator. SII = After the closure of Thanneermukkom regulator

Table 5. *Exchangeable cations of soil during different periods (cmol (p^+) kg^{-1})*

Particulars	K		Na		Ca		Mg		Total exchangeable bases	
	SI	SII	SI	SII	SII	SII	SI	SII	SI	SII
Mean	0.324	0.259	0.96	0.26	8.32	6.47	2.32	10.5	11.8	8.1
Range	0.13-0.1	0.09-0.58	0.11-2.41	0.09-0.58	3.34-18.0	2.44-11.1	0.45-6.33	0.16-3.74	6.3-21.9	3.4-13.9
CD (P=0.05)	0.049		0.206		1.49		0.738		1.47	

SI = Before the closure of Thanneermukkom regulator, SII = After the closure of Thanneermukkom regulator

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Effect of Phosphorus and Zinc on Yield Contributing Characters and Uptake of Nutrients in Rice on Lateritic Soil of Coastal Region of Konkan

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Field experiment was conducted to study the response of rice to zinc and zinc x phosphorus interaction in lateritic soil of Konkan region during *kharif*, 2003. There were 16 different treatment combinations consisting of four phosphorus levels viz., 0, 25, 50, 75 kg P_2O_5 ha^{-1} and four zinc levels viz., 0, 3, 6, 9 kg Zn ha^{-1}. Phosphorus was applied through SSP, zinc was applied through $ZnSO_4$. The different levels of phosphorus significantly increased the plant height and number of tillers. The grain yield of rice was increased significantly due to application of 50 kg P_2O_5 ha^{-1} (53.46 q ha^{-1}). The uptake of phosphorus and zinc by rice grain and straw showed significant increase with increasing P levels. Available phosphorus content in soil increased significantly due to P application. The grain yield also increased significantly with 6 kg Zn ha^{-1} (46.37 q ha^{-1}). The treatment combination of 50 kg/ha P_2O_5 + 6 kg/ha $ZnSO_4$ significantly increased the grain and straw yield of rice.

(***Key words*** : *Phosphorus and zinc interactions, Grain and straw yield, Uptake of nutrients in rice*)

Micronutrients play an important role in plant growth and development. With the intensive use of high analysis fertilizers, micronutrient deficiencies are likely to become more acute in the absence of their application. Due to increased phosphate application plant may suffer from induced zinc deficiency. Therefore present experiment was conducted to study the effect of phosphorus and zinc on growth and yield contributing characters and uptake of nutrients in rice on lateritic soil of Konkan region.

MATERIALS AND METHODS

Field experiment was conducted with rice on lateritic soil (Typic Ustropepts) at Botany Farm College of Agriculture. Dapoli during *kharif* season (2003). The soil was acidic in reaction and high in organic carbon content (1.21%). It contained 321.18, 8.17 and 220.99 kg ha^{-1} available N, P_2O_5 and K_2O, respectively and 0.48 mg kg^{-1} available Zn. The field experiment was laid out in a factorial randomized block design comprising of sixteen treatment combinations replicated thrice. Phosphorus was applied as a basal dose through single superphosphate in four levels @ 0, 25, 50, 75 kg P_2O_5 ha^{-1}. Zinc was applied as a basal dose through zinc sulphate in four levels i.e., zinc @ 0, 3, 6, 9 kg ha^{-1}. After manual threshing and sun drying of the produce yield data were recorded. The representative grain and straw samples were collected for chemical analysis. The content of Zn and P in plant grain and straw samples collected at harvest was determined by using diacid mixture for digestion and Zn was determined by atomic absorption spectrophotometer as described by Johnson and Ulrich (1950). Plant samples were digested in diacid mixture of HNO_3 and $HClO_4$ (2:4) for deterimination of Zinc and P as described by Richards (1954). The total phosphorus from the plant was determined by the method described by Jackson (1967) and from the soil as described by Bray's II procedure (Black, 1965). Available Zn was determined by using DTPA extract on Atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Plant height and tillers

The application of P_2O_5 @ 50 kg ha^{-1} has shown highest plant height (88.13 cm) as compared to other P treatments (Table 1). A graded and significant response of application of P levels was seen upto 50 kg ha^{-1} P_2O_5 applied. Treatment of P_2 was significantly superior over P_0 and P_1 in increasing plant height and at par with P_3. P plays an important role in stimulating growth of plant. Similar results were obtained by Rao (2003). Zn also increased the plant height but differences were not significant.

Phosphorus at P_2 level receiving 50 kg ha^{-1} was found significantly superior over rest of the treatments i.e., P_0 and P_1 level in increasing the number of tillers (Table 1). The application of Zn at Zn_2 level was found significantly superior over Zn_0 and Zn_1 levels and it was at par with Zn_3 level. Similar results were obtained by Salam and Subramanian (1993) and Kulandaivel *et al.* (2003). Treatment combination Zn_2P_2 was found significantly superior over rest of the treatment combinations.

Grain and straw yield

The grain yield of rice was highest at P_2 level receiving P_2O_5 @ 50 kg ha^{-1} (53.46 q ha^{-1}) which was significantly superior over P_0 and P_1 and at par with P_3 (Table 2). Phosphorus stimulates root formation, it also helps in cell division, stimulates growth and increases the grain yield. Similar results were obtained by Rao (2003). The grain yield of rice was highest at Zn_2 level which was significantly superior over Zn_0 and at par with Zn_1 and Zn_3 levels. Similar results had been reported by Modak (1997). The treatment combination Zn_2P_2 recorded highest grain yield (55.35 q ha^{-1}).

Straw yield in treatment P_2 receiving 50 kg P_2O_5 ha^{-1} was significantly superior over P_0 and P_1 and was at par with P_3 level. Zn increased straw yield significantly over control.

Phosphorus uptake

The data in Table 3 indicated graded and significant response for P application in P uptake in rice grain. P_3 level was significantly superior over rest of the treatments. Similar results were obtained by Singh and Singh (1986). There was significant effect of Zn levels on P uptake. Zn at Zn_1, Zn_2 and Zn_3 were significantly superior over control. Similar results were obtained by Prasad *et al.* (1995). No significant effect of Zn x P interactions was observed in respect of P uptake.

There was significant effect of P uptake in rice straw. P_2 was significantly superior over rest of the treatments i.e., P_0, P_1 and P_3. Similar result were obtained by Reddy and Yadav (1994). There was non-significant effect of Zn x P interaction.

Zinc uptake

Data shown in Table 4 indicated that there was significant effect of P level in increasing Zn uptake in

Table 1. *Effect of different levels of zinc and phosphorus and their interaction on plant height (cm) and no. of tillers*

Levels	Plant height					No. of tillers				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
P_0	64.67	62.27	65.47	66.20	66.65	7.40	7.97	8.43	10.33	8.53
P_1	76.40	85.13	87.47	82.20	82.80	7.30	8.40	8.40	9.30	8.35
P_2	90.80	87.93	81.40	92.40	88.13	8.30	8.40	13.87	10.67	10.31
P_3	85.73	89.20	90.47	84.80	87.55	8.50	8.87	9.07	9.43	8.97
Mean	79.40	81.13	81.20	81.40		7.87	8.41	9.94	9.93	

	Zn	P	Zn x P	Zn	P	Zn x P
SEm (±)	1.70	1.70	3.41	0.42	0.42	0.84
CD (P=0.05)	N.S.	4.92	N.S.	1.22	1.22	2.44

Zn_0 = No Zn, Zn_1 = 3 kg Zn ha^{-1}, Zn_2 = 6 kg Zn ha^{-1}, Zn_3 = 9 kg Zn ha^{-1}
P_0 = No P_2O_5, P_1 = 25 kg P_2O_5 ha^{-1}, P_2 = 50 kg P_2O_5 ha^{-1}, P_3 = 75 kg P_2O_5 ha^{-1}

Table 2. *Effect of different levels of zinc and phosphorus and their interaction on grain and straw yield of rice (q ha^{-1})*

Levels	Grain yield					Straw yield				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
P_0	30.94	31.58	29.91	32.58	31.25	25.07	26.55	25.53	27.98	26.28
P_1	36.83	45.33	43.57	43.88	42.40	31.60	37.83	34.63	35.94	34.99
P_2	48.19	51.77	58.52	55.35	53.46	38.72	40.47	44.52	44.08	41.95
P_3	49.99	52.27	53.24	52.99	52.13	38.99	42.58	41.60	39.46	40.66
Mean	41.49	45.24	46.31	46.20		33.59	36.86	36.57	36.86	

	Zn	P	Zn x P	Zn	P	Zn x P
SEm (±)	0.71	0.71	1.41	0.94	0.94	1.88
CD (P=0.05)	2.04	2.04	4.08	N.S.	2.71	N.S.

Treatments same as in Table 1.

rice grain. There was graded response of phosphorus application upto P_2 level. The P_2 level was found to be significantly superior over rest of the treatments i.e., P_0, P_1 and P_3. Application of Zn increased the Zn uptake significantly over control. Zn_3 level increased the Zn uptake significantly over Zn_0, Zn_1 and Zn_2. Similar result was obtained by Prasad *et al.* (1995). Treatment combination Zn_3P_2 was significantly superior over rest of the treatment combinations. Similar result was obtained by Patil (2001).

There was significant effect of Zn uptake on rice straw. P_2 level was significantly superior over rest of the treatments. Similar result was obtained by Reddy and Yadav (1994). Zn_3 level was significantly superior over rest of the treatments i.e., Zn_0, Zn_1, Zn_2. Similar result was obtained by Das (1986). He reported increased uptake Zn in rice straw with increasing dose of $ZnSO_4$. Treatment combination Zn_3P_2 was significantly superior over rest of the treatments. Similar results were obtained by Prasad *et al.* (2000).

Available P and Zn after harvest

Soil samples were analysed for P and Zn content after harvest of crop and data are presented in Table 5. In respect of available P, P_3 level was at par with P_2 and was significantly superior over P_0 and P_1, however P_2 and P_1 were significantly superior over control which indicated addition of P build up. Zn and Zn_0 were at par with Zn_1 and Zn_2 levels. The data reveal that increasing level of Zn decreases the available P content in soil. Similar result was obtained by Tiwari *et al.* (1977). Interaction does not show any significant effect.

Available Zn in soil at harvest under P_0 and P_1 were at par, however, increasing dose of P viz., P_2 and P_3 significantly lowered the available Zn than P_0. Increasing dose of P decreased the Zn content in soil. Increasing level of Zn increased the Zn content in soil. Zn_3 level was significantly superior over rest of the treatments. Similar results were obtained by Ingle *et al.* (1977). Interaction did not show any significant effect.

CONCLUSION

From the results obtained it can be concluded that applied P and Zn at varied level showed significant positive influence on plant height, number of tillers, grain and straw yield, uptake of P and Zn. The residual effect of applied P and Zn

Table 3. *Effect of different levels of zinc and phosphorus and their interaction on uptake of P (kg ha⁻¹) by rice grain and straw*

Levels	Uptake of P by rice grain					Uptake of P by rice straw				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
P_0	2.89	4.10	3.79	3.99	3.69	1.59	1.85	1.99	2.07	1.88
P_1	3.79	5.59	5.07	4.67	4.78	2.63	3.62	3.22	3.22	3.17
P_2	6.60	6.90	6.23	6.25	6.49	4.38	4.35	5.43	5.01	4.79
P_3	5.67	8.01	7.07	7.76	7.13	3.64	4.27	4.33	3.82	4.01
Mean	4.74	6.15	5.54	5.67		3.06	3.52	3.74	3.53	

	Zn	P	Zn x P	Zn	P	Zn x P
SEm (±)	0.21	0.21	0.43	0.18	0.18	0.35
CD (P=0.05)	0.62	0.62	N.S.	N.S.	0.51	N.S.

Treatments same as in Table 1.

Table 4. *Effect of different levels of zinc and phosphorus and their interaction on uptake of Zn (kg ha⁻¹) by rice grain and straw*

Levels	Uptake of Zn by rice grain					Uptake of Zn by rice straw				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
P_0	29.99	65.16	62.67	106.65	66.12	31.49	42.56	81.06	17.17	68.07
P_1	45.77	106.31	101.63	146.26	99.99	44.49	60.13	116.76	155.77	94.29
P_2	62.43	160.51	148.72	200.63	143.07	56.04	57.37	154.14	198.55	116.53
nP_3	73.62	114.99	131.01	164.27	120.97	43.54	60.35	139.34	164.73	101.99
Mean	52.95	111.74	111.01	154.45		43.89	55.10	122.82	159.06	

	Zn	P	Zn x P	Zn	P	Zn x P
SEm (±)	3.32	3.32	6.63	3.46	3.46	6.92
CD (P=0.05)	9.58	9.58	19.15	10.00	10.00	20.00

Treatments same as in Table 1.

Table 5. *Effect of different levels of zinc and phosphorus and their interaction on available P_2O_5 (kg ha^{-1}) and zinc (mg kg^{-1}) in soil at harvest*

Levels	Available P_2O_5					Available Zn				
	Zn_0	Zn_1	Zn_2	Zn_3	Mean	Zn_0	Zn_1	Zn_2	Zn_3	Mean
P_0	8.56	8.36	8.11	7.86	8.22	0.45	0.84	1.46	2.35	1.27
P_1	9.88	9.66	9.46	8.13	9.28	0.47	0.78	1.38	2.12	1.19
P_2	11.86	11.57	11.12	9.46	11.00	0.42	0.72	1.24	2.08	1.12
nP_3	12.67	12.18	11.86	10.06	11.69	0.40	0.68	1.25	2.04	1.09
Mean	10.74	10.44	10.14	8.88		0.43	0.76	1.33	2.15	

	Zn	P	Zn x P	Zn	P	Zn x P
SEm (±)	0.29	0.29	0.59	0.03	0.03	0.06
CD (P=0.05)	0.85	0.85	N.S.	0.09	0.09	N.S.

Treatments same as in Table 1.

indicated that there is increase in both the nutrients at harvest of the crop in the treatment plots. Treatment combination 50 kg P_2O_5 + 6 kg Zn ha^{-1} is significantly superior and very much useful for increasing the grain and straw yield of rice and building up P and Zn status of lateritic soil of coastal Konkan.

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City Compost–An Alternative Technology for Sustainable Agriculture

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Combined use of inorganic fertilizer (urea) and city compost as integrated plant nutrient management practice was introduced in nine farmers' fields of Dumki village in coastal region (Sundarbans) of West Bengal. The findings of the years 2003 and 2004 with rice cultivation revealed that the yield was much higher with combined use of city compost and inorganic N fertilizer compared to the farmers' practice (low dose of urea alone). But, due to the higher cost of city compost the benefit : cost ratio was higher under farmers' practice compared to combined use of city compost and urea. The microbiological analysis of soils (i.e., microbial biomass carbon, basal soil respiration, dehydrogenase activity, fluorescein diacetate hydrolyzing activity) revealed that the benefit of applying city compost will have augmenting effect over a period of time and it will lead to enhanced soil productivity and sustainability in crop production.

(***Key words*** : *City compost, Microbial biomass, Soil respiration, Dehydrogenase activity, Fluorescein diacetate hydrolyzing activity, Coastal saline soil*)

The salt affected coastal soils of the country are known for their poor and non-sustainable crop yield. Organic amendments, such as compost, may benefit soil fertility as well as microbiological and biochemical processes of soil (Lalande *et al.*, 1998). Since the traditional organic manures are becoming scarce the use of non-traditional organic resources is becoming more and more essential. Municipal solid waste (MSW) composts are gaining familiarity in respect of the pressing need for waste disposal and resource recovery. Investigations have ascertained both beneficial and adverse effect of MSW compost. A laboratory study by Perucci (1990) indicated positive influence of MSW compost on soil microbial biomass carbon and enzyme activities. Combined use of organic manures and fertilizers has gained a major thrust in abating the capacity of soil to sustain the level of production. Bandyopadhyay and Rao (2001) reported that combined use of MSW compost and urea was beneficial in respect of crop yield through augmentation in the soil properties of coastal saline soil.

Tripathi *et al.* (2001) suggested that the soil quality parameters as determined by microbial biomass carbon (MBC), basal soil respiration (BSR), dehydrogenase activity (DHA) and fluorescein diacetate hydrolyzing activity (FDHA) were seriously affected due to soil salinity. The authors opined that organic supplements were needed to counteract the effects of stress due to soil salinity on microbial components of soil quality. The present study was conducted on the farmers' fields of the coastal saline region (Sundarbans) of West Bengal to test the research outcome generated under NATP programme of ICAR on the combined use of bulky organic resources and chemical fertilizer for higher crop production.

MATERIALS AND METHODS

Nine farmers' fields were selected for the experiment at Dumki village, Canning, West Bengal where the Technology Assessment and Refinement through Institution Village Linkage Programme (TAR-IVLP) project was functioning. City compost derived from Kolkata municipal waste was used as bulky organic source of nitrogen and was applied @ 5 t ha^{-1} (fresh weight basis). Suitable quantity of urea as inorganic fertilizer was applied to balance the nitrogen dose of 100 kg N ha^{-1} being the recommended dose for rice in the region. The combined application of city compost and urea was designated as recommended treatment (RT) and this was compared with the farmers' practice (FP) involving application of urea @ 20 kg N ha^{-1} only. The city compost contained 16.6 % organic carbon, 0.9 % total nitrogen with C/N ratio of 11.8. Rice (cv. Swarna) was grown in the *kharif* seasons of 2003 and 2004. The grain yields of rice were recorded.

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After rice harvest surface soil samples (0-20 cm) were collected randomly from each farmer field, dried, ground and sieved (2 mm) after removing plant debris, visible fauna, stone, etc. as required. Microbial biomass carbon (MBC) (Joergensen, 1995), basal soil respiration (BSR) (Alef, 1995a), dehydrogenase activity (DHA) (Casida *et al.*, 1964) and fluorescein diacetate hydrolyzing activity (FDHA) (Alef, 1995b) of soils were determined with the sieved (2 mm) field moist soil samples in triplicate. Physicochemical properties of soils and the compost were measured with the air-dried soil by standard methods.

RESULTS AND DISCUSSION

The pH of the soils from different farmers' fields varied between 6.2 and 7.6. The electrical conductivity of saturation extract of the studied soils was between 3.5 to 5.8 dSm^{-1}. The water holding capacity of soils ranged from 56 to 63 %. The organic carbon level of the soils under study varied between 8.4 and 10.2 g kg^{-1}. There was a considerable variation in soil MBC between the farmers (FP) and the treated plots (RT).

The mean MBC for FP plot was 57.1 and that of recommended treatment (RT) plot was 192.4 (Table 1). This indicated that the microbial population of soils increased due to combined addition of city compost and urea. It was reported by Kumar *et al.* (1999) that when organic and inorganic sources were applied in conjunction, soil microbes were invigorated thus allowing a farther release of nutrient due to enhanced decomposition rate.

Brookes *et al.* (1987) suggested that not only the microbial biomass but also its activity should be studied for proper appreciation of ecosystem functioning and the soil disturbances due to natural and anthropogenic stress. In the present study the BSR in RT plots increased considerably than that in FP plots, indicating greater microbial activities

Table 1. *Effect of farmers' practice and recommended treatment on soil quality parameters (mean of 2003 and 2004)*

Farmer field	Treatment	Microbial biomass carbon (μg g^{-1}oven dry soil)	Basal soil respiration (μg CO_2-C g^{-1} oven dry soil h^{-1} at 24°C)	Dehydrogenase activity (μg TPF g^{-1} dry soil h^{-1} at 37°C)	Fluorescein diacetate hydrolyzing activity (μg fluorescein g^{-1} oven dry soil h^{-1} at 24°C
F1	FP*	51	1.1	5.4	25
	RT**	198	2.3	16.4	102
F2	FP	49	0.95	3.1	33
	RT	205	2.5	17.3	130
F3	FP	62	1.3	2.3	36.5
	RT	180	2.6	17.7	120
F4	FP	43	1.2	4.2	29.3
	RT	187	2.8	18.1	98
F5	FP	55	1.05	5.05	23.5
	RT	214	2.9	18.1	119
F6	FP	70	0.9	5.05	19.5
	RT	160	2.1	18.1	92
F7	FP	61	1.4	3.6	21
	RT	179	2.7	16.9	98
F8	FP	57	1.5	4.8	19
	RT	188	2.4	19.1	108
F9	FP	66	1.2	3.9	27
	RT	221	·2.7	19.8	124
Mean	FP	57.1	1.18	4.15	25.98
	RT	192.4	2.55	18.02	110.11

*Farmers' practice

** Recommended treatment

due to compost addition. The mean DHA activity of RT plots was 18.02 which was much higher than that of FP plots (4.15). According to Batra and Manna (1997) dehydrogenase activity is widely used as a generalized comparative index of soil microbial activity. The hydrolysis of fluorescein diacetate has also been found to be an index for the overall microbial activity in coastal saline soil (Tripathi *et al.*, 2001). Due to addition of compost the FDHA activities were also increased (Table 2). The active microbial cells transport FDA inside the cell where it is hydrolysed to polar flourescein (Alef, 1995 b). When the storage capacity of the cells with respect to flourescein exceeds, it is released out (Schnurer and Rosswell, 1982). The results thus clearly indicated that both the microbial population and activity in the amended soils were far better than that of non-amended soils.

The Table 2 suggested that there was a remarkable improvement in grain yield with the application of the recommended treatment in all the farmers' fields over the farmers' practice. In a field study, Bhattacharyya *et al.* (2003) observed 49 % increase in grain yield with integrated application of urea alongwith MSW compost derived from Kolkata municipal solid waste compost compared to their respective single application. The costs of cultivation for FP and RT were Rs. 10450 and 18400, respectively at field sites. The mean total value of produce was much higher (Rs. 24611) in RT than that of FP (Rs. 18700) owing to higher grain yield in the former treatment. However, the mean benefit : cost ratio for the RT (1.33) were lower than the FP (1.79). This was due to higher cost of city compost.

The results, thus, indicated high enhancement of microbial population and activity in soils when combined sources (bulky organic + inorganic) of nutrients were applied. Although the benefit : cost ratio for the RT was lower than that of FP the gross and net profits were much higher in RT plots. The RT treatment would certainly benefit the soil quality parameters in the long run. The soil ecological upgradation due to city compost addition will help to produce higher yield in a sustainable manner in the long run.

Table 2. *Grain yield and economics of the treatments in different farmers' field (mean of 2003 and 2004)*

Farmer field	Treatment	Grain yield (q/ha)	Total value of produce (Rs/ha)	Benefit: cost ratio
F1	FP*	26.5	17588	1.68:1
	RT**	34.2	22914	1.24:1
F2	FP	27.20	18224	1.74:1
	RT	37.25	24958	1.36:1
F3	FP	27.50	18425	1.76:1
	RT	38.25	25628	1.39:1
F4	FP	28.50	19095	1.83:1
	RT	35.0	23450	1.27:1
F5	FP	28.25	18593	1.81:1
	RT	34.7	23651	1.26:1
F6	FP	27.75	18593	1.78:1
	RT	35.3	23651	1.28:1
F7	FP	28.00	18760	1.79:1
	RT	39.4	26398	1.43:1
F8	FP	28.75	19263	1.84:1
	RT	37.00	24790	1.35:1
F9	FP	29.00	19430	1.86:1
	RT	36.50	26465	1.44:1
Mean	FP	27.91	18700	1.79:1
	RT	39.5	24611	1.33:1

*Farmers' practice, cost of cultivation Rs. 10450.00/ha

** Recommended treatment, cost of cultivation Rs. 18400.00/ha

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Effect of Flooded and Non-flooded Water Regimes on Nitrogen Fixation and Free Living Nitrogen Fixing Microorganism in Soil

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The effect of flooded and non-flooded water regimes on nitrogen fixation and free living nitrogen fixing microorganism was studied both in laboratory and pot culture experiments. In the sandy loam surface soil (Oxic Haplustult) of Bhubaneswar the cultures of Azotobacter, Azospirillum, BGA and Azolla were used for laboratory and pot culture experiments. Moisture was maintained at 60% water holding capacity (WHC) and under standing water situation. The highest percent increase in total nitrogen was 25.90 to 36.93 by Azotobacter and Azospirillum in non-flooded and 20.00 to 32.97 by BGA, Azolla and mixed culture in flooded situation. The highest Azospirillum count of 41.10 X 10^3 and 18.10X10^3 were observed in non-flooded and flooded conditions, respectively. The dry matter, grain yield along with nitrogen uptake followed the same pattern.

(**Key words :** *Flooded & non-flooded soil nitrogen fixation, Free living nitrogen fixing microorganism*)

The rice soils subjected to alternate flooded and non-flooded water regimes registered several fold increase in nitrogenase activity under flooded than non-flooded conditions (CRRI, 1981). Watanabe *et al.* (1981) stated that nitrogen from BGA contributes to the nutrition of deepwater rice. Inoculation of Azotobacter in rice field reduced requirement of fertilizer N by about 20 to 40 kg N ha^{-1} (Rangaswami, 1966). The amount of N fixed by BGA in deepwater rice is almost six times than that of the value obtained from shallow water wetland rice fields (Martinez and Catling, 1981). Srinivasan (1983) opined that incorporating Azolla into soil fertilized with nitrogen gave significantly higher yield of rice than nitrogen alone. The experiment was designed to assess the ability of different free living nitrogen fixing microorganism under various water regimes.

MATERIALS AND METHODS

The exprimental soil Oxic Haplustults collected from Bhubaneswar was analysed as per the procedures advocated by Jackson (1973). The soil was sandy loam having pH 5.3, EC 0.1 dS m^{-1}, WHC 35.56 percent, organic carbon 4.3g kg^{-1}, CEC 3.7 cmol (p^+) kg^{-1}, total N 0.33g kg^{-1}, available N 136 kg ha^{-1}, P (Olsen's) 9.2 kg ha^{-1} and NH_4 OAc extractable K 140 kg ha^{-1}. Three hundred gram of sieved soil was taken in 500 ml glass beaker. Phosphorus and molybdenum were applied @ 50 and 1 ppm salt, respectively and mixed well. Peat based culture of Azotobacter, Azospirillum and dried flakes of blue green algae (BGA) and mixed culture (combination of three each of 0.1g) were added to the soil. Moisture was maintained at 60 percent water holding capacity and with water height of 3 cm maintained in different treatments. Treatments were incubated under laboratory condition for three months and the loss of moisture was compensated from time to time during the course of investigation. At one month interval soil samples were drawn for determination of total nitrogen and were expressed on moisture free basis.

A pot culture experiment with 10 kg soil in each pot was also set up to correlate the results of laboratory experiments. The soil was inoculated with different biofertilizers. Rice (cv. IR36) seedlings were transplanted and the moisture was maintained at 60% water holding capacity and with standing water height of 3 cm. Soil samples were drawn after 30, 60 and 90 days of incubation to determine the total nitrogen as per the method of Jackson (1973) and to enumerate the nitrogen fixing microorganism viz., Azotobacter (Subbarao, 1982), Azospirillum (Day and Dobereiner, 1976) and Blue green algae (Subbarao, 1982) in soil. All the results were expressed on oven dry basis by estimating moisture of the corresponding soil samples. The harvested grain and straw samples were analysed for total nitrogen (Black, 1965) and the uptake of nitrogen was assessed. The statistical analysis (factorial RBD) was made following the procedure of Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

It was observed from Table 1 that higher amount of nitrogen (26.01 %) was fixed by Azospirillum culture followed by 24.5% by Azotobacter culture at 60%

WHC over control. Whereas, Blue green algae and mixed culture fixed less amount of nitrogen. Under flooded situation the trend was reversed. It was observed that BGA and mixed culture performed better than Azotobacter and Azospirillum. The percentage increase in total nitrogen by the mixed culture was 24% followed by 22.6% by BGA. From Table 2 it was found that at 60% WHC, Azospirillum fixed higher amount of nitrogen by 33.15 and 36.93% over control at 60 and 90 days of incubation, respectively. The higher amount of nitrogen fixed at 60% WHC may be due to associative symbiotic nature of Azospirillum which multiplied and fixed atmospheric nitrogen at root zone of rice plant as outlined by Rao and Rao (1984). Whereas, under anaerobic condition the BGA, Azolla and mixed culture fixed more quantity of nitrogen viz., 41.38, 40.99 and 41.76%, respectively over control at 60 days of incubation than Azotobacter and Azospirillum. The BGA fixed more quantity of nitrogen under submerged condition (Watanable *et al.*, 1981, Saha and Mandal, 1980) because of its faster proliferated nature. Azolla can also contribute nitrogen to a considerable amount due to its symbiotic nature (Ramasamy *et al.*, 1984). In this study the mixed culture showed higher percentage of nitrogen fixation probably due to associative symbiotic nature with other microorganism.

Table 1. *Effect of moisture on nitrogen fixation by free living organism in soil (laboratory incubation)*

Treatments	**Days of incubation**						
	30		60		90		Mean
	Total N (g kg^{-1})	Increase (%)	Total N (g kg^{-1})	Increase (%)	Total N (g kg^{-1})	Increase (%)	Total N (g kg^{-1})
Non-flooded (60% WHC)							
Control	0.533	-	0.546	-	0.548	-	0.542
Azotobacter	0.664	24.57	0.672	23.07	0.690	25.90	0.675
Azospirillum	0.668	25.32	0.690	26.37	0.690	25.90	0.683
BGA	0.585	9.75	0.600	9.89	0.590	7.66	0.592
Mixed culture	0.600	12.57	0.580	6.22	0.595	8.57	0.592
Flooded							
Control	0.500	-	0.512	-	0.525	-	0.512
Azotobacter	0.520	4.00	0.528	3.12	0.535	1.90	0.528
Azospirillum	0.535	7.00	0.538	5.08	0.536	2.09	0.536
BGA	0.620	24.00	0.635	24.02	0.630	20.00	0.628
Mixed culture	0.628	25.60	0.639	24.30	0.636	21.14	0.634

C.D (P=0.05) for treatment = 0.024, Inoculant = 0.009, Moisture = 0.006, Inoculant X Moisture = 0.017

Table 2. *Effect of moisture on nitrogen fixation by free living organism in soil (pot culture studies)*

Treatments	**Days of incubation**			
	60		90	
	Total N (g kg^{-1})	Increase (%)	Total N (g kg^{-1})	Increase (%)
Non-Flooded (60% WHC)				
Control	0.552	-	0.555	-
Azotobacter	0.700	26.81	0.725	30.63
Azospirillum	0.735	33.15	0.760	36.93
BGA	0.610	10.50	0.613	10.45
Azolla	0.620	12.32	0.622	12.07
Mixed culture	0.630	14.13	0.635	15.03
Flooded				
Control	0.522	-	0.558	-
Azotobacter	0.600	14.94	0.610	9.32
Azospirillum	0.621	18.96	0.623	11.64
BGA	0.738	41.38	0.739	32.43
Azolla	0.736	40.99	0.738	32.25
Mixed culture	0.740	41.76	0.742	32.97

C.D (P=0.05) for Treatment=0.02, Inoculant=0.01, Moisture=0.005, Inoculant X Moisture=0.014

From Table 3 it was observed that, under non-flooded situation the highest yield of 11.63 and 8.39g pot^{-1} of dry matter and grain, respectively and corresponding N uptake of 98.85 and 105.20 mg pot^{-1} were observed in Azospirillum treatment. Similar results were also reported by Sanoria *et al.* (1982). But under flooded situation the highest yield of 12.82 and 9.46g pot^{-1} of dry matter and grain, respectively and corresponding N uptake of 117.94 and 134.54 mg pot^{-1} were found in mixed culture treatment. The results were also in agreement with the findings of Rao *et al.* (1983) and Singh *et al.* (2002).

Table 3. *Effect of moisture and free living organism on nitrogen uptake by crop*

Treatments	Dry matter		Grain	
	Yield (g pot^{-1})	N Uptake (mg pot^{-1})	Yield (g pot^{-1})	N Uptake (mg pot^{-1})
Non-flooded (60% WHC)				
Control	4.53	28.26	3.52	36.79
Azotobacter	11.18	92.85	7.68	93.62
Azospirillum	11.63	98.85	8.39	105.20
BGA	10.75	77.77	6.72	78.46
Azolla	9.31	69.04	6.36	72.02
Mixed culture	10.91	83.64	6.69	82.46
Flooded				
Control	8.11	51.36	5.05	54.40
Azotobacter	8.60	55.63	5.50	60.40
Azospirillum	9.31	67.36	5.87	66.03
BGA	12.46	107.62	8.91	119.69
Azolla	11.89	103.49	8.76	116.12
Mixed culture	12.82	117.94	9.46	134.54
C.D (P=0.05)				
Treatment	0.08		0.28	
Inoculant	0.057		0.20	
Moisture	0.033		0.117	
Inoculant X moisture	0.08		0.28	

Table 4. *Effect of moisture and inoculant in soil on the population of free living N fixing microorganism*

Treatment	Population (1x10^{3}g^{-1} soil)		
	Azotobacter	Azospirillum	BGA
Non-flooded (60%WHC)			
Control	1.66	7.1	1.0
Azotobacter	15.10	7.8	2.3
Azospirillum	3.20	41.1	2.6
BGA	3.10	8.3	6.7
Azolla	3.20	7.6	5.3
Mixed culture	12.07	37.1	5.6
Flooded			
Control	1.00	6.30	1.2
Azotobacter	3.30	7.10	1.1
Azospirillum	2.10	18.10	3.4
BGA	2.00	7.30	9.3
Azolla	1.07	8.07	6.1
Mixed culture	2.30	13.30	8.3
C.D (P = 0.05)			
Treatment	0.58	0.87	0.63
Inoculant	0.41	0.62	0.44
Moisture	0.24	0.35	0.26
Inoculant X moisture	0.58	0.87	0.63

Table 4 indicated the highest counts of 15.10, 41.10 and 6.70 (x 10^{3}g^{-1} soil) of Azotobacter, Azospirillum and BGA under non- flooded and 3.30, 18.10 and 9.30 (x 10^3 g^{-1} soil), respectively under flooded situation. Watanabe *et al.* (1981) also got similar results from their studies.

From the present study it may be concluded that under upland low moisture regimes, inoculation of Azotobacter and Azospirillum and in lowland submerged conditions inoculation of BGA, Azolla, and mixed cultures should contribute to nitrogen budget in soil.

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Nutrient Content, Uptake and Yield of Rainfed Groundnut (*Arachis hypogaea* L.) as Influenced by Moisture Conservation Practices and Nutrient Management

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An experiment was conducted during *kharif* 1999 and 2000 to study the effect of land configurations, mulches and nutrient management on the content and uptake of nutrients and yield of groundnut. Moisture conservation practices involving alternate furrow and bed, ridges and furrows, plastics and straw mulches had significant influence in terms of NPK content at 60 DAS and at harvest and uptake of the same nutrients at harvest over control. Similar results were also registered due to moisture conservation practices in terms of pod and haulm yields. Full recommended dose of fertilizer + Indole Butric Acid (IBA) @ 50 ppm + Urea @ 1% spray at 40 and 60 DAS (N_3) recorded significantly higher NPK content at 60 DAS and at harvest and uptake of the same nutrients at harvest over other treatments. Further, N_3 recorded higher pod yield (1724 kg ha^{-1}) and it was at par with 100% RDF (N_2), and was significantly superior to other treatments.

(**Key words** : *Nutrient content, Moisture conservation, Rainfed groundnut*)

The major area (87.7 percent) under groundnut cultivation in India remains under rainfed condition and is confined to varying types of soils having different fertility levels which are low in organic matter and poor in water holding capacity. Further, the region of Saurashtra in Gujarat is highly influenced by the vagaries of monsoon, which results in low and unstable yields. The region faces twin problems of poor fertility and inadequate moisture availability for successful crop production which often result in partial or total failure of crop with occurrence of mild to severe drought.

The most efficient and cheapest way of conserving rainwater is *in-situ* land configurations and use of mulches for sustainable crop production (Singh and Das, 1988). Further, balanced applications of nutrients through organic and inorganic sources besides biofertilizers and growth hormones should enhance the groundnut yields.

In Gujarat, especially in the region of Saurashtra, meagre information is available on the effect of moisture conservation practices in combination with nutrient management for stabilizing the groundnut yields. Keeping in view the above situation the present investigation was undertaken.

MATERIALS AND METHODS

An experiment was conducted at the Instructional Farm, Gujarat Agricultural University, Junagadh during 1999-2000. The soils were clayey in texture, slightly alkaline in reaction and low in phosphorus. The soil contained 0.62 to 0.68 percent organic carbon, was medium in available nitrogen (223.00 kg N ha^{-1}) and potash (235.00 kg K_2O ha^{-1}) and low in phosphorus (21.40 kg P_2O_5 ha^{-1}). The pH and EC of the soil were 8.10 and 0.27 dSm^{-1}, respectively. Thirty-six treatment combinations in total were evaluated in split plot design with three replications including three levels of land configurations (L_0=flatbed, L_1=ridges and furrows, L_2=alternate furrows and beds) and mulches (M_0=control, M_1=wheat straw @ 5 t ha^{-1} and M_2=plastic mulch 8μ thick) as main treatments, and four levels of nutrient management (N_0=control, N_1=recommended dose of fertilizer (RDF) i.e., 12.5 kg N + 25.0 P_2O_5 kg ha^{-1}, N_2=50% RDF + 5t FYM + rhizobium + phosphorus solubulizing mycorrhiza (PSM), N_3=100% RDF + indole butric acid (IBA) @ 50 ppm + urea @ 1% at 40 and 60 days after sowing (DAS) as sub-treatments. Groundnut cv. GG20, a semi-spreading type, was sown at a spacing of 60 x 10 cm.

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Nitrogen and phosphorus were applied as basal in the form of urea and single superphosphate, respectively, while FYM was applied before sowing as per the treatments. The seed treatment with biocultures was also done as per the treatments before sowing. Land configurations and mulches were applied at 20 DAS as per the treatments. Indole Butric Acid (IBA) and Urea were together sprayed as per the treatments twice at 40 and 60 DAS. Plant analysis was done by using standard methods for N, P and K content at 60 DAS and at harvest, and the total uptake of the same nutrients was determined by using appropriate formula.

RESULTS AND DISCUSSION

The data (Tables 1 and 2) indicate that alternate furrow and bed resulted in significantly higher nutrient (N, P and K) content at 60 DAS and at harvest and uptake of the same nutrients at harvest. Alternate furrow and bed resulted in maximum N (95.34 kg ha^{-1}), P (12.24 kg ha^{-1}) and K (51.72 kg ha^{-1}) uptake at harvest as compared to flatbed method. Further alternate furrow and bed recorded higher pod yield (1665 kg ha^{-1}) which was at par with ridges and furrows, and was significantly superior to flat bed method. Alternate furrow and bed and ridges and furrows resulted in 16.76 and 11.78 percent increase in pod yield over flat bed method. Almost similar trend was observed in case of haulm yield. Alternate furrow and bed and ridge and furrows resulted in loose seedbed, which helped to retain more soil moisture leading to increased root proliferation, thereby probably absorption of more nutrients. Higher moisture also helped to increase microbial activity resulting in more nutrient availability and hence more nutrient content in plants. Consequent to higher dry matter accumulation, pod and haulm yield, higher nutrient content in plants led to higher N, P and K uptake by groundnut crop. Desai (1989) and Venkateswarlu (1999) also reported similar results with altered land configurations.

Wheat straw and plastic mulches were at par with each other in respect of N, P and K content at 60 DAS and at harvest and uptake of the same nutrients at harvest. Further, wheat straw produced maximum yield (1624 kg ha^{-1}), which was at par with plastic mulch and was significantly superior to control. Haulm yield also followed the same trend as was observed in case of pod yield. The favourable effect of plastic and wheat straw mulch in terms of pod and haulm yield could be attributed to beneficial growth parameters and yield attributes due to improved physical parameters and increased soil moisture content, which finally enchanced the N, P and K content and uptake of major nutrients. The results are in confirmation of Kh'staria *et al.* (1994) and Basu (1999).

Nutrient management

Full dose of RDF + IBA @ 50 ppm + urea @ 1% (N_3) resulted in significantly higher N, P and K content in plant at 60 DAS and at harvest, and uptake of the same nutrients at harvest followed by N_1 and N_2, while control (N_0) without fertilizer application resulted in significantly lower values for all nutrients. Similarly, N_3 resulted in significantly higher uptake of nitrogen (97.50 ka ha^{-1}), phosphorus (12.01 kg ha^{-1}) and potash (54.35 kg ha^{-1}) in pooled analysis at harvest as compared to control. Further, 100% RDF + IBA @ 50 ppm + urea @ 1% (N_3) recorded higher pod and haulm (1724 and 2489 kg ha^{-1}, respectively) in pooled analysis, white it was at par with 100% RDF (N_1) in individual years. The percentage increase in pod yield with N_3 and N_1 over control (N_0) was 39.92 and 25.75, respectively. The nutrient application might have resulted in increasing their concentration in the soil solution, thereby increased their availability and absorption by the plants. N fixing bacteria enhance the soil nitrogen and PSM produces the organic acids, which also might be responsible for quick release of nutrients. Foliar spray of urea and growth regulators enchances the chlorophyll content in leaves which might have helped in higher uptake of NPK by plants. Further, the increase in total uptake of N, P and K nutrients could be attributed to cumulative effect of increased photosynthetic activity, yield attributes and yields. The results are in conformity with close vicinity of Kachot (1999) and Rao (1998). The amount and distribution of rainfall was good in 2000 (529.8 mm) as compared to 1999 (394.5 mm), hence the growth, yield attributes and yield level were better in 2000.

Based on the results, it is evident that land configurations such as alternate furrow and bed and ridge and furrows with wheat straw or plastic mulch and 100% RDF + IBA @ 50 ppm + urea @ 1% spray at 40 and 60 DAS helped in increasing the nutrient status of the soil and productivity of rainfed groundnut crop.

Table 1. *Nutrient content in plant at 60 DAS and at harvest of rainfed groundnut as influenced by moisture conservation practices and nutrient management*

Treatments	Nitrogen content (%)						Phosphorus content (%)						Potash content (%)					
	60 DAS			At harvest			60 DAS			At harvest			60 DAS			At harvest		
	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled
Land configurations																		
L_0=Flat bed	2.205	2.067	2.046	2.194	2.278	2.236	0.296	0.302	0.299	0.264	0.251	0.257	1.235	1.255	1.245	1.211	1.206	1.209
L_1=Ridges and Furrows	2.131	2.145	2.138	2.226	2.357	2.292	0.322	0.334	0.333	0.276	0.273	0.274	1.294	1.304	1.299	1.250	1.247	1.248
L_2=Alternate Furrow & Bed	2.137	2.158	2.148	2.244	2.365	2.305	0.339	0.343	0.341	0.294	0.301	0.297	1.320	1.333	1.326	1.249	1.248	1.248
SEm±	0.026	0.008	0.015	0.008	0.009	0.011	0.002	0.003	0.003	0.002	0.002	0.003	0.005	0.006	0.004	0.010	0.010	0.006
CD (P=0.05)	0.078	0.026	0.042	0.025	0.028	0.033	0.007	0.008	0.008	0.006	0.005	0.009	0.015	0.018	0.013	0.028	0.028	0.016
Mulches (M)																		
M_0=Control	2.035	2.077	2.056	2.161	2.282	2.222	0.314	0.317	0.315	0.273	0.259	0.266	1.260	1.276	1.268	1.215	1.214	1.215
M_1=Wheat straw @5 t ha^{-1}	2.130	2.142	2.136	2.247	2.359	2.303	0.325	0.331	0.328	0.280	0.287	0.283	1.291	1.314	1.303	1.252	1.248	1.250
M_2=Plastic mulch 8μ	2.128	2.151	2.140	2.257	2.360	2.308	0.329	0.332	0.330	0.281	0.278	0.279	1.297	1.302	1.299	1.242	1.238	1.240
SEm±	0.026	0.008	0.015	0.008	0.009	0.011	0.002	0.003	0.003	0.002	0.002	0.003	0.005	0.006	0.004	0.010	0.010	0.006
CD (P=0.05)	0.078	0.026	0.042	0.025	0.028	0.033	0.007	0.008	0.008	NS	0.005	0.009	0.015	0.018	0.013	0.028	0.028	0.016
Nutrient management																		
N_0=Control	1.921	2.045	1.983	2.144	2.269	2.206	0.295	0.301	0.298	0.254	0.252	0.253	1.109	1.122	1.115	1.079	1.074	1.077
N_1=100%RDF (12.5 N + 25.0 P_2O_5 kg ha^{-1})	2.158	2.147	2.153	2.250	2.358	2.304	0.332	0.336	0.334	0.286	0.282	0.284	1.341	1.358	1.350	1.292	1.287	1.289
N_2=50%RDF + 5 t FYM + Rhizobium + PSM	2.153	2.145	2.149	2.245	2.347	2.296	0.330	0.334	0.332	0.283	0.280	0.281	1.337	1.348	1.343	1.288	1.284	1.286
N_3=100%RDF + IBA @ 50 ppm + Urea 1% spray at 40 & 60 DAS	2.160	2.157	2.158	2.247	2.362	2.305	0.333	0.336	0.335	0.289	0.285	0.287	1.345	1.361	1.353	1.287	1.289	1.288
SEm±	0.028	0.008	0.033	0.009	0.008	0.007	0.002	0.002	0.003	0.002	0.002	0.003	0.005	0.007	0.005	0.001	0.001	0.005
CD (P=0.05)	0.085	0.026	NS	0.027	0.025	0.019	0.006	0.006	0.008	0.006	0.006	0.009	0.015	0.020	0.013	0.029	0.028	0.015

N.S. = Non significant

Table 2. Nutrient uptake at harvest and yield of rainfed groundnut as influenced by moisture conservation practices and nutrient management

Treatments	Total nitrogen uptake (kg ha^{-1})			Total phosphorus uptake (kg ha^{-1})			Total potash uptake (kg ha^{-1})			Pod yield (kg ha^{-1})			Haulm yield (kg ha^{-1})		
	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled	1999	2000	Pooled
Land configurations															
L_0=Flat bed	68.93	92.50	80.71	8.25	10.22	9.24	38.25	49.10	43.67	1246	1606	1426	1889	2416	2152
L_1=Ridges and Furrows	76.61	105.11	90.86	9.51	12.21	10.86	43.18	55.81	49.49	1387	1800	1594	2046	2621	2333
L_2=Alternate Furrow & Bed	81.80	108.88	95.34	10.73	13.75	12.24	45.69	57.74	51.72	1463	1866	1665	2170	2727	2449
SEm±	1.33	1.90	1.16	0.19	0.30	0.18	0.84	0.82	0.59	30.88	34.45	23.13	46.90	52.19	35.08
CD (P=0.05)	3.99	5.68	3.34	0.57	0.89	0.51	2.51	2.45	1.69	92.61	103.29	66.67	140.60	156.48	101.11
Mulches (M)															
M_0=Control	69.04	93.17	81.11	8.71	10.49	9.60	39.01	49.73	44.37	1280	1649	1464	1908	2425	2167
M_1=Wheat straw @5 t ha^{-1}	79.73	107.01	93.37	9.98	13.12	11.55	44.62	56.94	50.78	1419	1830	1624	2118	2698	2408
M_2=Plastic mulch 8μ	78.58	106.31	92.45	9.81	12.58	11.20	43.48	55.99	49.73	1398	1794	1596	2079	2641	2360
SEm±	1.33	1.90	1.16	0.19	0.30	0.18	0.84	0.82	0.59	30.88	34.45	23.13	46.90	52.19	35.08
CD (P=0.05)	3.79	5.68	3.34	0.57	0.89	0.51	2.51	2.45	1.69	92.61	92.61	66.67	140.60	156.48	101.11
Nutrient management															
N_0=Control	63.13	85.97	74.55	7.52	9.57	8.54	31.76	40.64	36.20	1147	1446	1297	1795	2261	2028
N_1=100%RDF (12.5 N + 25.0 P_2O_5 kg ha^{-1})	78.87	106.51	92.69	10.04	12.77	11.40	45.27	58.11	51.69	1416	1847	1631	2082	2669	2376
N_2=50%RDF + 5 t FYM + Rhizobium + PSM	77.78	104.52	91.15	9.80	12.52	11.16	44.68	57.19	50.94	1392	1796	1594	2067	2640	2353
N_3=100%RDF + IBA @ 50 ppm + Urea 1% spray at 40 & 60 DAS	83.34	111.66	97.50	10.63	13.39	12.01	47.78	60.93	54.35	1507	1941	1724	2196	2782	2489
SEm±	1.23	1.72	1.06	0.21	0.26	0.17	0.73	0.91	1.00	34.69	36.92	25.33	40.90	55.54	34.49
CD (P=0.05)	3.50	4.88	2.97	0.59	0.74	0.47	2.06	2.59	4.49	94.40	104.72	71.08	116.03	157.54	96.78

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Effect of Substitution of K of Muriate of Potash by Na of Common Salt on the Growth Characteristics of Banana, Variety 'Robusta'

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A field experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani to study the effect and extent of substitution of K of muriate of potash by Na of common salt in banana var. Robusta. The recommended dose of muriate of potash as per the package of practices of the Kerala Agricultural University (320 g K per plant per annum) was taken as T_1 (100% K as MOP). Other treatments were T_2 (25% K as MOP), T_3 (50% K as MOP), T_4 (75% K as MOP), T_5 (75% K as MOP plus 25% Na as common salt), T_6 (50% K as MOP plus 75% Na as common salt), T_7 (25% K as MOP plus 75% Na as common salt), and T_8 (100% Na as common salt). The results revealed significant differences in growth characteristics such as plant height, girth of plant, number of leaves and LAI at all stages of growth. The chlorophyll content increased with application of common salt. RLWC was also higher in Na treated plants. The treatment which was given K and Na in 50:50 proportions registered the highest values of growth parameters producing the highest dry matter and yield.

(***Key words*** : *Banana, Growth characteristics, Leaf area index, Chlorophyll content, Relative leaf water content, K substitution by Na)*

Potassium is recognized as the key element in crop nutrition, the effect of which being manifested equally on the qualitative and quantitative aspects of the crop. Banana is a crop having high K requirement. But, K fertilizers are expensive in India. Hence, it would be highly economical if any indigenous fertilizer can be used at least as a partial substitute for K. Na, another univalent cation, is known to replace K at least in some of its functions in plants. Several works indicate that Na of common salt can substitute K of muriate of potash (MOP) at least partially in the crops tested (George, 1995, Devi and Padmaja, 1996a, Lekshmi, 2000). If common salt is used as a partial substitute for MOP, it can save a part of the import cost of K fertilizers. Hence, this study was undertaken to find out the extent of substitution possible in banana to obtain maximum yield without affecting quality.

MATERIALS AND METHODS

A field experiment was conducted in the oxisols of the Instructional Farm, College of Agriculture, Vellayani from August 1999 to June 2000 in banana 'Robusta' with eight treatments and three replications in randomized block design. The recommended dose of muriate of potash as per the package of practices of the Kerala Agricultural University (320 g K per plant per annum) was taken as T_1 (100% K as MOP). Other treatments were T_2 (25% K as MOP), T_3 (50% K as MOP), T_4 (75% K as MOP), T_5 (75% K as MOP plus 25% Na as common salt), T_6 (50% K as MOP plus 50% Na as common salt), T_7 (25% K as MOP plus 75% Na as common salt), and T_8 (100% Na as common salt). The soil of the experimental site belonged to the family of Loamy Skeletal Kaolinitic Isohyperthermic Rhodic Haplustox. The soil was acidic in reaction with low status of N, P and K. Biometric observations of the plant under different treatments were recorded at two months interval at early vegetative stage i.e., 2 month after planting (MAP), late vegetative stage (4 MAP), shooting stage (6 MAP), bunch maturation stage (8 MAP) and harvest stage (at harvest). Observations were taken from plants selected from each plot. Height of the plant was measured from the base of the pseudostem to the base of unopened leaf. Girth of the plant was measured at 10 cm above ground level. The total number of functional leaves in the plant at the sampling time was counted. LAI was determined as leaf area per plant / land area per plant (Watson, 1952). Chlorophyll estimation was done in samples from the index leaf (third opened leaf from top) by colorimetric method as described by Arnon (1949). Relative Water Content in leaves was determined by the method proposed by Weatherley (1950) which was modified by Slatyer and Barrs (1965). Index leaf samples were taken and RLWC was determined as :

RLWC = [(Fresh Weight - Oven dry weight)/ Fresh weight] x 100

RESULTS AND DISCUSSION

Significant treatment differences were noted in the case of plant height at all growth stages (Table 1). Maximum plant height was recorded in Treatment T_6 where K and Na were supplied at equal concentrations (50:50). The treatment T_1 (100%K) recorded a significantly lower value when compared with T_6. In treatments receiving K alone at 25, 50 and 75% of the recommended level, these parameters were lower indicating that K supply was not sufficient in these treatments for the normal growth of the plants. The treatment received Na alone (T_8) also registered a lower value. Increased plant height by combined application of K and Na at equal proportions was reported by Devi and Padmaja (1966a) in cassava and Lekshmi (2000) in banana cv. Nendran.

Table 1. *Plant height (cm) at different growth stages*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	103.17	150.67	181.00	194.00	195.33
T_2	98.33	143.33	174.33	186.33	186.83
T_3	101.00	146.67	176.33	188.33	189.50
T_4	102.17	149.33	177.00	190.33	191.50
T_5	102.33	151.67	178.33	191.00	192.33
T_6	104.67	152.83	183.67	196.00	197.83
T_7	102.50	150.33	180.00	194.00	194.83
T_8	100.67	148.00	175.33	187.67	188.33
CD (P=0.01)	1.38	1.44	1.59	1.15	1.54

The girth of plants (Table 2) also showed a similar trend as plant height. It has been reported that the girth of pseudostem and yield of plants in banana were positively correlated (Mathew, 1980). Therefore, a high value of girth at early stages of growth is very important as far as crop yield is concerned. In the treatment where K and Na were added at 50:50 proportions, the girth and height of plants were significantly higher than in the treatment with 100 percent K at 4, 6 and 8 months after planting and at harvest.

Height of the banana plants has a direct relationship with the number of leaves produced by it (Summerville, 1944). T_6 i.e., 50% substitution by Na recoded maximum values for number of leaves (Table 3) and LAI (Table 4) at all stages of growth. But, with increase in substitution above 50% there was a reduction in leaf number and LAI. Girth of the pseudostem also has a direct bearing on the number of leaves produced as the pseudostem in banana is made up of tightly packed leaf sheaths. One hundred percent substitution of K by Na was found to have adverse effects on growth by reducing the leaf number and LAI. Leaf production in banana is related to increased rate of plant growth. The increased photosynthetic efficiency by means of producing more number of leaves, greater height and pseudostem girth increase the potential for producing heavier bunches (Barker and Steward, 1962). Common salt application along with muriate of potash at equal K : Na proportion was found to stimulate the growth parameters. Prema *et al.* (1992) recorded maximum number of leaves in experiment with coconut when K and Na were supplied at 50:50 proportion. Devi and Padmaja (1996a) reported that at all stages of growth, the treatment receiving K and Na in 50:50 proportions recorded maximum LAI

Table 2. *Girth of plants (cm) as influenced by Na substitution*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	38.67	50.17	58.83	63.83	66.67
T_2	31.83	41.33	47.67	51.17	52.83
T_3	36.00	47.00	55.50	60.00	62.50
T_4	37.33	48.00	57.17	61.17	64.00
T_5	38.17	49.83	58.50	63.17	65.83
T_6	39.83	51.67	61.83	67.00	71.17
T_7	37.67	45.67	54.00	59.67	62.00
T_8	35.33	42.83	50.33	54.50	56.50
CD (P=0.01)	2.15	1.22	1.71	2.00	1.70

Table 3. *Number of leaves under different treatments*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	9.67	9.00	9.00	8.67	4.00
T_2	8.00	8.00	8.00	7.33	3.00
T_3	8.67	8.00	9.00	8.00	4.00
T_4	9.33	8.67	9.67	8.67	4.00
T_5	9.67	8.67	9.67	8.67	4.00
T_6	10.00	9.00	9.67	9.00	4.00
T_7	8.67	8.33	8.67	8.67	3.67
T_8	8.33	8.00	8.00	7.67	3.33
CD (P=0.01)	0.93	0.60	0.95	0.80	0.49

Table 4. *LAI under different treatments*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	1.01	1.48	2.04	2.26	1.71
T_2	0.71	1.02	1.39	1.53	0.82
T_3	0.83	1.22	1.49	1.63	0.98
T_4	0.91	1.33	1.61	1.82	1.24
T_5	0.96	1.52	1.89	2.04	1.49
T_6	1.05	1.58	2.12	2.38	1.79
T_7	0.91	1.49	1.84	2.03	1.45
T_8	0.76	1.09	1.47	1.59	1.00
CD (P=0.01)	0.10	0.09	0.07	0.09	0.15

in cassava. Lekshmi (2000) also observed similarly in banana cv. Nendran.

The chlorophyll contents in T_1 (100% K) and T_6 (50 percent substitution of K by Na) were at par at all but harvest stage (Table 5). Even at 100 percent substitution by Na, there was high chlorophyll production. Treatments T_2, T_3 and T_4 recorded lesser chlorophyll content with T_2 recording the lowest value. When the balance quantity of K in these treatments was substituted by Na (treatments T_7, T_8 and T_5, respectively) the chlorophyll content was found to increase. This shows that Na is playing a role in chlorophyll production. Sodium is found to increase the chlorophyll content of plants (Ando and Oguchi, 1990). It participates in chlorophyll biosynthesis after 5-amino laevulinic acid synthesis. Devi and Padmaja (1996b) also observed an increase in total chlorophyll content with Na substitution in cassava. The total amount of chlorophyll was also the highest in plots where 50 percent K was substituted by Na of common salt.

The RLWC also showed significant variation due to the treatments. In general, there was an increase in

Table 5. *Chlorophyll content (mg g^{-1}) under different treatments*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	0.969	3.024	2.171	1.629	0.991
T_2	0.844	2.063	1.789	0.983	0.764
T_3	0.907	2.163	2.122	1.027	0.831
T_4	0.936	2.373	2.138	1.335	0.878
T_5	0.964	2.604	2.161	1.656	1.031
T_6	0.977	3.174	2.192	1.699	1.105
T_7	0.985	3.180	2.239	1.705	0.934
T_8	0.993	3.015	2.229	1.707	0.932
CD (P=0.01)	0.01	0.2	0.05	0.09	0.05

leaf water content by the addition of sodium (Table 6). Banana, being a mesophyte requires large amount of water because of the large foliage area and high moisture content of the pesudostem. Krishnan and Shanmughavelu (1980) conducted studies on water requirements of banana seedling cv. Robusta. The height and grith of the pseudostem, total leaf area and number of leaves per plant at shooting stage increased significantly with increase in moisture absorption. The high relative water content in Na treated plants at all growth stages showed that the water use efficiency of the plants increased with Na supply. Leaf moisture content in banana especially cv. Robusta is crucial in determining the plant growth, development and yield. Thus the addition of sodium helped the plants to maintain a relatively high leaf water content which led to a high water use efficiency and ultimately higher dry matter production. This is achieved by a reduction of transpiration rate. Na and Cl ions accumulate mainly in the vacuole rather than in the cytoplasm (Greenay and Munns, 1980), their accumulation therefore being conducive to osmotic adjustment and turgor maintenance. Gorham *et al.* (1985) reported that reduction of transpiration rate is a characteristic response to salinity Devi and Padmaja (1996b) observed that when 50 percent of K was substituted by Na, there was higher RLWC up to harvest stage in cassava.

Table 6. *RLWC(%) under different treatments*

Treat-ment	2MAP	4MAP	6MAP	8MAP	At harvest
T_1	85.48	83.77	89.65	88.83	69.63
T_2	82.59	84.54	83.13	82.42	72.69
T_3	87.05	91.25	87.45	84.31	69.66
T_4	84.95	90.00	85.98	89.11	72.66
T_5	90.52	92.11	87.77	91.79	84.38
T_6	91.81	90.48	85.35	92.71	77.23
T_7	90.10	91.23	85.90	90.82	72.91
T_8	91.11	91.36	85.26	90.09	70.01
CD (P=0.01)	2.34	2.82	NS	2.55	4.95

NS = Not significant

The comparatively high rate of growth as a result of application of K and Na at equal concentrations resulted in comparatively high biomass accumulation rates leading to high rates of dry matter production. Highest dry matter production (Fig. 1) was recorded in T6 (50% substitution of K by Na) (19839 kg ha^{-1}). With increase in Na substitution beyond 50 percent level, the dry matter production was found to decrease.

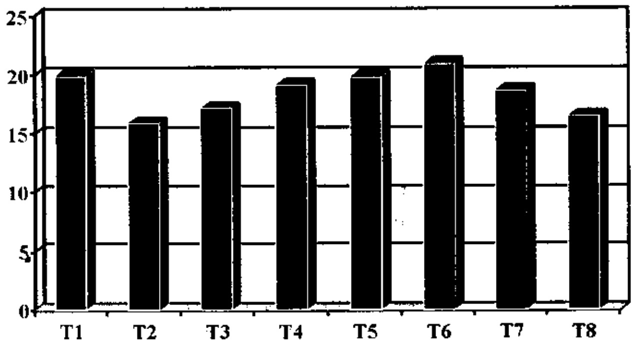

Fig. 1. *Drymatter production as influenced by K-Na substitution*

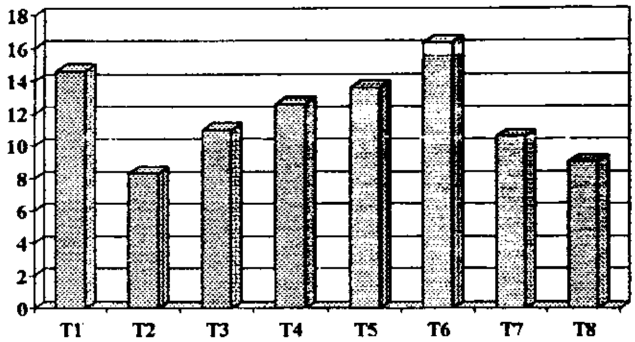

Fig. 2. *Effect of K-Na substitution on the bunch yield of banana*

The yield (Fig. 2) was also higher (16.33 kg $plant^{-1}$) in T6 due to 50% substitution of K by Na. With increase in substitution above this level there was a reduction in yield.

Thus the results obtained from the experiment revealed that substitution up to 50% is possible in banana cv. Robusta. Substitution at this level did not affect any of the growth characteristics. This level of substitution stimulated growth resulting in higher bunch yield.

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Effects of Different Modes of Application of Zinc Sulphate on Productivity and Quality of Potato under Coastal Saline Zone of West Bengal

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A field experiment was carried out during 2001-02 and 2002-03 under medium land situation in coastal saline soil at Kakdwip, West Bengal. The experiment was laid in randomized block design (RBD) replicated four times with 5 treatments. The treatments were soaking of seed tuber in 0.25%, 0.50%, 0.75% $ZnSO_4$ solution for 3 hours, soil side dressing of $ZnSO_4$ @ 20 kg ha^{-1}, and spraying of the potato crop with 0.2% $ZnSO_4$ solution twice (40 and 60 days after planting). The parameters judging the growth, yield and quality of potato were recorded. Highest yield and superior quality of tubers were obtained with the soaking of seed tubers in 0.50% $ZnSO_4$ solution for 3 hours.

(***Key words*** : *Potato, Growth, Yield and quality of tuber, Zinc sulphate, Mode of application*)

Among all the essential micronutrients, deficiency of Zn is the most wide spread not only throughout India but also the world over. Soil characteristics exercise a dominant influence on Zn availability to crops. The deficiency of Zn is mainly associated with soils having coarse texture, high pH, low organic carbon and high calcium carbonate (Takkar *et al.*, 1989). Zinc sulphate is most common source of Zn although other sources such as zinc oxide, Zn-EDTA, etc. have been tested (Rattan *et al.*, 1997). Soil application, foliar spray, seed treatment, root dipping in Zn solution or suspension, and pushing galvanized nails or pieces of metallic Zn into tree trunks are the methods of Zn application (Katyal and Randhawa, 1983). Of these, soil and foliar application on crops are the most widely used methods. But most of the zinc applied to the soil is fixed, resulting in low efficiency. Thus, there is need to test other methods of zinc application to meet the zinc needs of potato. The present study was undertaken to evaluate effectiveness of the modes of zinc application on productivity and quality of potato under coastal saline zone of West Bengal.

MATERIALS AND METHODS

A field experiment was carried out during 2001-02 and 2002-03 under medium land situation on coastal saline soil having BD 1.24 g cm^{-1}, sand 22.5%, silt 39.6%, clay 37.9%, pH 7.2, ECdSm^{-1} 2.15, available Zn 1.01 mg kg^{-1}, total N 0.04%, P_2O_5 281.8 kg ha^{-1}, K_2O 486.7 kg ha^{-1}, and organic matter 0.52% at the Regional Research Station (Coastal Saline Zone), Bidhan Chandra Krishi Biswavidyalaya, Kakdwip, West Bengal. The experiment was laid out in a randomized block design (RBD) replicated four times with 5 treatments. The treatments consisted of three methods of zinc application viz., soaking of seed tubers in 0.25% (T_1), 0.50%(T_2), $ZnSO_4$ (T_3) solution for 3 hours, soil side dressing of zinc at the rate of 20 kg ha^{-1} (T_4) and foliar spray of the potato crop with 0.2% $ZnSO_4$ solution twice (40 and 60 days after planting, (T_5). To correct the acidic nature of $ZnSO_4$, lime was mixed with it as a precautionary measure during direct spraying on leaves to avoid schorching of leaves. Taking into account the problem of adverse effect of wetness of tubers on plant emergence, utmost care was taken in planting the soaked tubers after proper drying in shade for few hours. Seed tubers were planted in the last week of November at 60 cm x 20 cm spacing following recommended irrigation schedule. A uniform dose of N, P_2O_5 and K_2O (150:100:100) was applied to potato (cv. Kufri Jyoti) through urea, SSP and muriate of potash, respectively. Three-fourth dose of N and full dose of P_2O_5 and K_2O were applied as basal and rest one-fourth of N was applied at the time of 1st earthing-up for top dressing. Representative leaf samples, fourth from the top of main shoot of potato crop, as reported to be the best plant part for tissue analysis (Grewal *et al.*, 1990), was taken from each plot at 60 days after planting for chemical analysis. Likewise, composite samples of freshly harvested tubers were collected and analysed for different biochemical constituents. The characters judging the quality of potato like starch, crude protein, true protein, total sugar and reducing sugar were properly measured by the Anthrone method, Microkjeldahl method, Rapid photometric method, Anthrone method and Somogyi Nelson method, respectively.

RESULTS AND DISCUSSION

The growth and yield of tubers are given in Table 1.

The highest dry matter accumulation at all the growth stages like 60, 80 and 100 DAP was obtained when the seed tubers were soaked in 0.5% zinc sulphate solution for 3 hours. These were also statistically at par with the treatment of soaking seed tubers in 0.75% zinc sulphate solution for 3 hours. Foliar application twice (40 and 60 days after planting) and side dressing of zinc also had significant effects on dry matter accumulation but it was always less than that obtained under tuber soaking methods.

The highest tuber dry weight was obtained in the treatments T2 and it was statistically at par with T3 at 60, 80 and 100 DAP. Foliar application and side dressing gave lower amount of tuber dry weight but those were statistically at par with the tuber soaking treatments.

The highest tuber bulking rate was observed in the treatment T2 which was statistically at par with T1 at 60 to 80 DAP. In case of 80 to 100 DAP the maximum tuber bulking rate was recorded in the treatment T2 which was statistically at par with the treatments T3 and T4.

Table 1. *Effects of different methods of zinc application on dry matter accumulation, tuber dry weight, tuber bulking rate and tuber yield of potato*

Treatment	Dry matter accumulation (g/m^2)			Tuber dry weight (g/m^2)			Tuber bulking rate ($g/m^2/day$)		Tuber yield (qha)
	60 DAP	80 DAP	100 DAP	60 DAP	80 DAP	100 DAP	60-80 DAP	80-100 DAP	
T_1	351.2	601.9	775.8	202.3	439.1	603.5	11.82	8.25	282.3
T_2	369.6	624.2	801.5	218.6	455.8	632.5	11.86	8.82	300.8
T_3	375.7	625.1	795.2	225.2	452.3	620.4	11.39	8.45	298.5
T_4	312.4	568.5	742.8	222.3	442.5	615.1	11.07	8.60	275.8
T_5	306.5	564.1	727.2	210.4	435.1	603.1	11.29	8.37	285.3
SEm(±)	6.54	8.21	12.53	4.53	7.49	11.31	0.132	0.155	5.11
CD (P=0.05)	19.88	24.95	38.09	13.77	22.89	33.75	0.402	0.472	15.67

The zinc application had positive significant effect on tuber yield. The highest tuber yield and maximum zinc response were obtained with the soaking of seed tubers in 0.50% zinc sulphate solution for 3 hours. The soaking of seed tubers in 0.75% $ZnSO_4$ solution was at par with the treatment T2. The foliar application twice (40 & 60 DAP) and side dressing gave significantly lower yield as compared to tuber soaking treatments. The similar results was also reported by Dwivedi and Dwivedi (1992). They opined that 0.50% tuber soaking treatment gave 301.2 q ha^{-1} tuber yield which was 9.2% more than the lowest potato tuber yield. This statement was also supported by the findings of Javed *et al.* (1995). As per their opinion Zn application increased tuber yields of potato by 8.4 - 11.7%.

The chemical analysis showed that starch and crude protein percentage in tubers were lower in the tuber soaking treatments as compared to foliar and side dressing treatment (Table 2). But in case of true protein percentage, total sugar and reducing sugar such types of variation were not found.

Table 2. *Effect of different methods of zinc application on tuber quality of potato*

Treatments	Percentage composition		
	Starch	Crude protein	True protein
T_1	13.1	1.59	0.48
T_2	13.3	2.02	0.51
T_3	13.5	2.06	0.54
T_4	13.7	2.17	0.52
T_5	13.9	2.17	0.54

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Effect of Bio-fertilizer on the Yield, Protein, N Uptake and Soil Properties in Soybean (*Glycine Max*) in Coastal Medium Black Soil

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A field experiment was conducted during the *rabi*/summer season of 2000 and 2001 in medium and black soil to study the integrated effect of bio and chemical fertilizers on *rabi*/summer soybean {*Glycine max* (L.) *Merr.*}. Significantly highest grain and straw yield of soybean was recorded under the recommended dose ($N:P_2O_5:K_2O$ = 60:40:30 kg ha^{-1}) of fertilizers. However, it was found to be at par with application of rhizobium + vesicular arbuscular micorrhizae (VAM) + 50% N + full dose of P_2O_5 and K_2O i.e., 30:40:30 kg ha^{-1} resulting in 50% saving of fertilizers. Significantly higher protein (%) and uptake of N (kg ha^{-1}) in soybean crop and organic carbon (%) in soil was recorded due to the application of chemical fertilizers (RDF) only. Rhizobium + phosphobacterium + 50% N + full dose of P_2O_5 and K_2O (30:40:30 kg ha^{-1}) recorded the higher available N in soil. Growth parameters in soybean crop were found to be non-significant except for dry shoot weight per plant. Biofertilizers recorded higher harvest index and agronomic efficiency over the control. Dual application of fertilizers alongwith chemical fertilizers improved the quality of seeds, uptake of N by soybean and soil fertility.

*(**Key words** : Soybean, Integrated nutrient management, Bio Fertilizers, Yield, Growth, Seed quality, Soil fertility)*

Soybean {*Glycine max* (L.) *Merr.*}is one of the grain legumes which not only helps in maintaining the soil fertility but is also a well known rich source of protein and fats. It is recognized that attempt to find a juditious combination of bio and chemical fertilizers become worthwhile to improve soil health, crop productivity and cost effectiveness in soybean. It was felt necessary to study use of biofertilizrs with mineral fertilizers for maintainance of soil productivity (Biswas *et al.*, 2001). In view of this, this work was undertaken to study the effect of biofertilizers without and with chemical fertilizers on soybean since such information was meagre.

MATERIALS AND METHODS

A field experiment was conducted during *rabi*/ summer seasons of 2000 and 2001 at Regional Agricultural Research Station, Karjat. The soil of the experiment site was medium black clay loam with pH 6.2, electrical conductivity (EC) 0.20 dSm^{-1}, organic carbon 1.12%, available nitrogen 180 kg ha^{-1}, available phosphorus (P_2O_5) 29 kg ha^{-1}. available potassium (K_2O) 416 kg ha^{-1}. The experiment was laid out in randomized block design with three replications and ten treatments. The treatments were: T_1 = Control (No manures and fertilizers), T_2 = Recommended dose of chemical fertilizers (RDF) N: $P_2O_5:K_2O$ = 60:40:30 kg ha^{-1}, T_3 = Rhizobium (R) 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}, T_4 = Phosphobacterium (PSB) + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}), T_5 = Vesicular arbuscular micorrhizae (VAM) + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}, T_6 = Azospirillum + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}. T_7 = R + PSB + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}, T_8 = R + VAM + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}, T_9 = PSB + VAM + 50% N + Full dose of $P_2O_5:K_2O$ = 30:40:30 kg ha^{-1}, T_{10} = R only (No N, P_2O_5, K_2O). The species of microorganisms used in the experiment were : Rhizobium = *Bradyrhizobium japonicum*, soybean group, VAM = *Glomus fasciculate*, PSB = *Psedomonas striate*. The biofertilizer cultures @ 16.60 g kg^{-1} soybean seed were used. The required quantity of healthy and bold soybean seeds (var. MACS-57) were smeared following proper procedure. Crop was sown in the first fortnight of January at 30 x 20 cm spacing. The 70% N and full dose of P and K of RDF were applied as basal at the time of sowing and remaining N was applied at one month of sowing. N. P and K were applied through urea, single superphosphate and muriate of potash, respectively. Irrigation and need based plant protections were made as per recommendations. Growth observations were recorded at maximum growth stage of crop. It was harvested at maturity.

Yield data were recorded. Harvest index and agronomic efficiency (AE) were worked out. Soil and plant analyses were done following standard procedures.

RESULTS AND DISCUSSION

Yield attributes

The yield attributes viz., height, branches, pods, dry shoot weight, root length and 1000 grain weight, except dry shoot weight, were found non-significant (Table 1). Highest harvest index was recorded by only rhizobium culture followed by control due to very low straw yield whereas, RDF has shown the lowest harvest index which may be due to its higher grain to straw yield. Highest AE was noticed in RDF followed by T_3 but T_{10} recorded the lowest AE (Saxena *et al.*, 2001).

Soil fertility

Soil pH, organic carbon content and available nitrogen content were significantly higher than control (Table 2). Application of NPK fertilizers only showed significantly highest content of organic carbon which may be due to rapid decomposition of organic matter in the soil. But it was at par with T_4, T_5, T_6 and T_{10}. It was noticed that biofertilizers with or without addition of chemical fertilizers increased organic carbon in the soil than the control. Application of rhizobium + phosphobacterium + N, P_2O_5 and K_2O @ 30:40:30 kg ha^{-1} fertilizers (T_8) showed significantly highest content of available N in the soil. However, it was at par with rhizobium + VAM + N, P_2O_5 and K_2O @ 30:40:30 kg ha^{-1} fertilizers. Thus, conjunctive use of biofertilizers along with chemical fertilizers was found to be benefitial for improving the soil properties.

Table 1. *Effect of biofertilizers on yield attributes (average of two years)*

Treatments	Height (cm)	Branches/ plant	Pods/ plant	Dry shoot wt/plant (g)	Root length/ plant (cm)	1000 grain wt. (g)	Harvest index (%)	Agronomic efficiency (AE) (%)
T_1	47	27	26	6.53	11.93	96.66	65.0	-
T_2	58	28	46	19.22	15.03	103.33	46.8	60.3
T_3	56	26	41	17.80	14.10	98.33	48.9	43.3
T_4	62	29	51	17.30	14.30	101.33	52.4	41.4
T_5	55	27	47	15.60	15.30	104.00	50.4	35.9
T_6	56	26	45	12.86	14.66	100.33	50.5	38.4
T_7	57	26	50	13.88	15.40	98.00	49.6	36.4
T_8	55	24	44	20.94	15.60	101.33	50.3	38.0
T_9	63	28	49	21.94	15.40	102.00	49.7	35.3
T_{10}	51	29	39	10.73	14.60	97.00	69.1	17.7
CD (P=0.05)	NS	NS	NS	5.50	NS	NS	-	-

NS = Non-significant

Table 2. *Yield, protein, N uptake of soybean and effect on soil properties influenced by biofertilizers*

Treatments	Grain (q/ha) 2000	Straw (q/ha) 2000	Grain (q/ha) 2001	Straw (q/ha) 2001	Pooled mean (q/ha)		Protein (%)	N uptake (kg/ha)	pH	EC (dS/m)	OC (%)	Available N (kg/ha)
					Grain	Straw						
T_1	7.55	3.26	6.46	4.47	7.00	3.76	31.6	35.3	6.3	0.18	1.13	125.4
T_2	13.29	14.62	14.35	16.94	13.82	15.78	41.7	92.3	6.1	0.24	1.38	212.8
T_3	10.74	8.58	13.74	13.32	12.42	10.95	39.1	76.5	6.2	0.21	1.25	205.9
T_4	10.80	7.96	13.57	14.16	12.18	11.06	40.6	79.2	6.2	0.22	1.34	199.4
T_5	10.49	7.06	12.50	15.55	11.49	11.30	39.3	72.2	6.3	0.22	1.31	202.0
T_6	11.16	8.37	12.46	14.71	11.81	11.54	38.4	72.6	6.2	0.21	1.27	206.4
T_7	11.83	9.90	13.10	15.40	12.46	12.65	40.4	80.6	6.2	0.23	1.27	226.3
T_8	12.41	11.42	13.02	13.60	12.71	12.51	40.7	82.7	6.1	0.23	1.28	225.8
T_9	11.97	9.89	12.63	14.99	12.30	12.44	41.3	81.2	6.2	0.23	1.23	214.1
T_{10}	9.52	5.71	13.37	12.49	11.44	5.10	35.3	64.4	6.1	0.21	1.30	154.9
CD (P=0.05)	2.08	2.93	0.64	2.01	1.13	1.85	1.9	7.5	0.17	NS	0.091	5.0

NS = Non-significant

Grain and straw yield

It was revealed from the data (Table 1) that application of N, P_2O_5 and K_2O @ 60:40:30 kg ha^{-1} (RDF, T_2) to soybean crop produced significantly higher grain and straw yield over rest of the treatments except in T_8 with R + VAM + 50% N + full dose of P_2O_5 : K_2O @ 30:40:30 kg ha^{-1} resulting in 50% saving in N fertilizers in case of the latter. The results are in agreement with the findings of Bagyaraj *et al.* (1979) and Dubey (1998). This may be due to the fact that rhizobium might increase the available N and VAM increase the availability of phosphorus with synergized the activity of N in soil for soybean being a legume capable of meeting its own requirements of N. However, dual inoculation of soybean with VAM and rhizobium may increase its nodulation and N_2 fixation substantially compared with inoculation alone. The results are in conformity with the findings of Badr-EL-Din and Moawad (1988) and Pacovasky *et al.* (1986). Similarly, T_7, T_3, T_9, T_4 and T_6 were found to be at par with T_8. But single application of rhizobium resulted in the lowest grain yield which was significantly higher than control (Vara *et al.*, 1994). The treatment T_2 also produced significantly higher straw yield than all the treatments. The remaining treatments were found to be at par except T_{10} and T_1. The significantly highest protein (%) was found in case of T_2. However, it was at par with T_9, T_8, T_4 and T_7.

N uptake

Significantly highest uptake of N over all the treatments was recorded by application of only chemical fertilizers (RDF). It may be due to immediate availability of nutrients in this case. Treatments T_8, T_9, T_7, T_4 and T_3 were at par.

Thus, instead of only single or dual, integrated use of biofertilizers viz., rhizobium and VAM plus 50% N + full dose of P_2O_5 and K_2O kg ha^{-1} of RDF (30:40:30) was found to be superior to others in soybean in coastal medium black soil for higher yield and quality.

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Advances in Genetic Management in Lowlying rice : An Andaman – Nicobar Perspective

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Andaman and Nicobar Islands posses the longest coastline in India measuring about 1962 km. The impact of coastal agriculture in shaping public life in the coasts can hardly be overemphasized. Most of the coastal area is unundated with tidal influx and increases the salinity of the nearby lowlying lands. These Islands posses about 4000 ha of salt affected lands, which are found to be unsuitable for agriculture. In addition to salinity, toxicities of Al and Fe too complicate the problems of lowlying areas. In this context genetic management of agriculture offers a great scope in mitigating the stresses associated with these lowlying marshy lands. Since nineties efforts have been initiated towards management of problem soils with conventional and biotechnological approaches which have been reviewed in this article.

*(**Key words** : Lowlying rice, Conventional breeding, Biotechnology, Abiotic stress tolerance)*

Coastal agriculture occupies an important position in the agricultural production of the country. Andaman and Nicobar Islands have a coastal length of about 1962 km. Salinity due to tidal influx and associated mineral toxicities and deficiencies are rampant in these soils, which are lowlying marshy and rich in organic matter (Mandal *et al.*, 1990). However, the submerged soil coupled with anoxic/hypoxic condition is found to be compatible for rice cultivation in wet condition. In contrast to costly recurrent soil reclamation and major engineering works to avert tidal influx genetic management through deployment of salinity tolerance is a more useful approach and reported to be a relative permanent measure (Mandal, 1998). To specially deal with the coastal salinity in Andaman and Nicobar Islands a major research programme was launched at Central Agricultural Research Institute, Port Blair. The present article encompasses the achievements of both conventional breeding research as well as the highlight of research findings from the research attempts employing modern plant biotechnology. It is mentionable that the promising lines developed so far are doing extremely well towards attaining self sufficiency in rice production in these remote locality of the country.

MATERIALS AND METHODS

The programme targeted for genetic improvement of rice with special reference to abiotic stress management was started in 1991. Major emphasis was given for biotechnological approaches for increased abiotic stress tolerance. The experiment was conducted at the Biotechnology Section for *in vitro* screening and exploitation of somaclonal variation by undertaking tissue culture experiments. *Ex-vitro* experiments were carried out at Field Crop Experimental Research Farm, Bloomsdale, CARI, Port Blair as well as in farmer's plots at Guptapara, Bimbiltan, Chouldari in South Andaman, Sitapur in Middle Andaman, and Deshbandhugram in North Andaman. The soil salinity of all these areas ranged from 6 to 10 dSm^{-1} during cropping season.

RESULTS AND DISCUSSION

Development and characterization of salt tolerant Pokkali somaclones

One thousand one hundred and ninety primary regenerants of a tall traditional salt tolerant cultivar Pokkali were produced through *in vitro* culture from mature seed derived calli of fourth subculture. Out of 35000 SC_2 regenerants, 26 promising lines with superior agronomic characters were chosen initially for evaluation. SC_3 and SC_4 generations were stringently evaluated under hydroponics with excess salt stress as well as under field conditions across two growing seasons in Bay islands. Promising somaclones were further evaluated in SC_5 and SC_6 of which BTS2, BTS 13, BTS 18 and BTS 24 were found to be promising. In SC_7 and SC_8 yield trials in research farm, BTS 24 was found to produce an average yield of 36.3 and 45.9 q ha^{-1} under saline and normal soil conditions, respectively (Mandal *et al.*, 1999). The somaclones differed significantly from the parent with respect to yield and yield attributes. However they did not deviate much from their parent in respect of disease and insect pest resistance pattern. Grain quality and biochemical parameters of all the elite somaclones were found to be different from the parent. Similarity indices based on SDS-PAGE profile of salt soluble grain polypeptides of the selectants revealed remarkable genetic divergence from parental base population (Mandal *et al.*, 2000). Besides, differences were observed at genomic level by using randomly amplified polymorphic DNA (RAPD) among somaclones (Elanchezhian and Mandal, 2003). This work advocates ample scope for exploitation of somaclonal variation in rice genetic improvement. BTS 24 has emerged as one of the favourite varieties of the farmers for cultivation on saline soil in Andaman. Besides salt tolerance it possesses moderate level of tolerance to yellow stem borer, a major insect threat in South and Southeast Asia.

Manipulating abiotic stress tolerance through *in vitro* selection

NaCl tolerance

With a view to develop salt tolerant variety, *in vitro* screening with varying levels of NaCl was attempted (Mandal *et al.*, 1993, Mandal and Pramanik, 1996). Different protocols e.g., subjecting calli to low levels of salt stress, creating high levels of salt stress in the regeneration medium, transferring salt stressed calli to non-stressed regeneration medium were tried. A total of 25 salt tolerant lines have been established and grown to maturity. They were also assessed under saline soil condition in the field. The parental line was B116. Among those lines BT-SB-9, BT 151-SB-2 and BT 14-SB-B were found to be promising.

Al toxicity tolerance

In vitro screening of C14-8 and IR 18351-229-3 at cellular level was performed to develop Al tolerant lines (Chowdhury *et al.*, 1998). MS fortified with varying concentrations of Al (30, 60, 90 ppm) in the form of $AlCl_3.6H_2O$ was used to impart Al stress. A total of 30 plants in C14-8 and 9 plants in IR 18351-229-3 were generated. The putative Al tolerant somaclones evolved through *in vitro* screening of C14-8 were further screened under hydroponics supplemented with 30, 60 and 90 ppm Al stress that led to identification of true tolerant lines. They were profiled for a few important isozymes viz., Glucose 6 Phosphate isomerase, Esterase, Peroxidase, Malate dehydrogenase, Glucose 6 phosphate dehydrogenase, Isocitrate dehydrogenase, Lactate dehydrogenase and Alcohol dehydrogenase to underpin their involvement in governing Al toxicity tolerance. Prominent differences in acitivity/band intensity, mobility shift and number of polymorphic loci with respect to Al toxicity were evident.

Fe tolerant rice somaclones

Efforts were made to develop Fe tolerant rice genotypes from C14-8 and HYV viz., IR 18351-229-3 through in vitro screening with FeNa EDTA at cellular level. Fe tolerant lines were further tested through screening under hydropnics in Hogland solution supplemented with $FeSO_4.7H_2O$ and citric acid. Tolerant regenerants were isolated upto 40 ppm Fe in both the varieties. One of the regenerants matured 35 days earlier when co-assessed with the parental stock under field trial. This is of great advantage to the farmers cultivating C14-8 and vegetables/pulses in the rice fallow by exploiting residual moisture under the rainfed condition. However, no major changes was observed in productivity, disease and insect pest tolerance profiles. Howver, the somaclone turned to be photosensitive, which is a major advantage over C14-8 cultivation.

In vitro screening for drought tolerance

Two elite HYV, two salt tolerant lines, two Basmati varieties, and indigenous local cultivar C14-8 were screened for drought tolerance. Calli were induced and grown with PEG stress (MW 6000). Drought tolerant lines were recovered in all except in one HYV. The stability of the induced characters and their underlying genetics are being studied.

The present study offers ample scope for identifying suitable *in vitro* culture methods, isozyme markers and RAPD markers for suitable breeding strategies for abiotic stress tolerance in rice. *In vitro* culture and somaclonal variation could thus be useful in abiotic stress tolerance improvement programme.

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Genetic Studies on Yield and Yield Contributing Characters in Cowpea (*Vigna unguiculata* (L.) Walp)

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Diallel analysis conducted with ten genotypes of cowpea revealed predominance of additive gene action for length of pod and breadth of pod and non-additive gene action for plant height, primary branches, flowers per plant, peduncles per plant, pods per peduncles, pods per plant, seeds per pod, seed weight per pod, protein content, seed yield per plant and yield realization index. Among the parents RCV-326 and Pusa Komal were found to be the best general combiners. The hybrid RCV-326 x Pusa Komal was found to be relatively good specific combiner for the characters, pods per peduncle and seed yield per plant.

(***Key words***: *Combining ability, Yield realization index, Protein, Cowpea*)

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important vegetable grown in many regions of India in the summer and rainy seasons. However, the present day cowpea varieties are low productive and genetic variability is low. There is a need to develop varieties with high productivity, determinate structure and early maturity. Therefore, it is imperative to generate newer gene combinations from diverse parents leading to high heterotic combination for higher seed yield. The situation necessitates the selection of parents with high per se performance with significantly high general combining ability and screening the heterotic combinations generated from target oriented and systematically planned breeding programme. The present research was, therefore, undertaken to estimate the general and specific combining ability effects in a 10 x 10 diallel hybrids involving genetically diverse cowpea genotypes.

MATERIALS AND METHODS

The ten diverse cultivars of cowpea viz., BCS-1 (Bhubaneswar), Arka Garima (Banglore), RCV-326 (Durgapur), IVRCP-1 (Varanasi), RCV-395 (Durgapur), IIHR Sel.11 (Banglore), IIHR Sel.16 (Banglore), Konkan Safed (Dapoli), Pusa Komal (Delhi) and Pusa Dofasali (Delhi) were crossed in all possible combinations excluding reciprocals in *rabi* 2003. The resultant 45 F_1's along with their ten parents were grown in randomized block design with three replications during summer, 2004 at research farm of Agricultural Botany, College of Agriculture, Dapoli (Maharashtra). Three rows of ten plants were grown with 30 x 30 cm spacing between rows and plants. The crop was raised with recommended fertilizer dose of 25:50:25 kg NPK per ha and other management practices to ensure good crop growth and to maintain uniform plant populations. The observations were recorded on five randomly selected plants for plant height, primary branches per plant, peduncles per plant, flowers per plant, pods per peduncle, pods per plant, seeds per pod, length of pod, breadth of pod, seed weight per pod, protein content, seed yield per plant and yield realization index. The analysis of variance of the data for combining ability and estimation of various effects was done following the model I and model II of diallel analysis suggested by Griffing (1956).

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that variances due to general combining ability (G.C.A) and specific combining ability (S.C.A) were significant for all the characters (Table 1). The characters, length of pod and breadth of pod were found to have high gca effects than units governed by additive gene action as indicated by their gene action and these characters can be improved by selection and progeny testing. Mallikarjun *et al.* (1995) and Durgaprasad and Patel (1978) obtained similar results for pod length. For the traits viz., plant height, primary branches, number of flowers, peduncles per plant, pods per plant, seeds per pod, seed weight per pod, seed yield per plant, protein content and yield realization index (YRI) the GCA:SCA ratio was found to be below 1 indicating the performance of non-additive gene action (Table 1).

Table 1. *Analysis of variance for combining ability in cowpea*

Sl. No.	Character	GCA (d.f.=9)	SCA (d.f.=45)	Error (d.f.=108)	σ^2g	σ^2s	σ^2g/ σ^2s
1.	Plant height (cm) per plant	53.59**	13.85**	1.34	3.17	12.51	0.25
2.	Primary branches per plant	2.50**	0.76**	0.13	0.13	0.63	0.20
3.	Number of peduncles per plant	10.79**	26.52**	1.10	-1.25	25.42	-0.04
4.	Number of flower per plant	75.23**	63.02**	9.44	0.97	53.68	0.018
5.	Numbers of pods per peduncle	0.04**	0.06**	0.02	0.001	0.04	0.025
6.	Number of pods per plant	43.87**	23.33**	1.06	1.64	22.27	0.07
7.	Number of seeds per pod	8.34**	1.03**	0.11	0.58	0.92	0.63
8.	Length of pod (cm)	67.12**	4.93**	0.30	4.97	4.63	1.07
9.	Breadth of pod (cm)	0.07**	0.007**	0.02	0.005	0.004	1.25
10.	Seed weight per pod	30.35**	13.95**	16.34	0.002	0.05	0.04
11.	Seed yield per plant	72.14**	37.53**	0.94	10.97	133.15	0.08
12.	Protein (%)	1.35*	0.49*	0.34	0.25	11.48	0.02
13.	Yield realization index (%)	23.71**	20.54**	9.060	0.63	34.02	0.01

** Significant at 1% level * Significant at 5% level

The non-additive gene action exhibited by above characters suggests that such characters could be improved through heterosis breeding. These results are in agreement with those published earlier for plant height (Ponmariammal and Das, 1996), number of banches (Thiyagarajan *et al.*, 1990), pods per plant and seed yield per plant, and protein content (Gupta, 1982).

In addition to the information on gene effects, combining ability analysis helps in identifying the better combining parents and in selected best specific hybrid combinations. The gca effects for parents and sca effects of hybrids are presented in Tables 2 and 3, respectively. Results revealed that none of the genotype was found good for all the characters studied. The parent RCV-326 and Pusa Komal had highest significant gca effects for number of flowers (3.29) and yield realization index (2.24). The parents Konkan Safed, IIGR Sel.11 and IVRCP-1 showed desired gca values for number of flowers per plant (3.11), yield realization index (1.51) and plant height (4.51), respectively.

The hybrid BSC-1 x RCV-326 (6.77) showed highest positive significant sca effects for plant height. RCV-326 x IIHR Sel.11 (2.5) showed maximum positive significant sca effects for primary branches per plant followed by IIHR Sel.16 x Konkan Safed (1.80). The hybrid IIGR Sel.11 x IIHR Sel.16 (4.60) had maximum significant sca effect for the character, peduncles per plant. The hybrid RCV-395 x IIHR Sel.11 (1.90) showed maximum positive significant sca effects for the character, seeds per pod. The hybrid RCV-326 x Konkan Safed (3.36) indicated maximum positive significant sca effect for the character, pod length. The hybrid RCV-326 x Pusa Komal exhibited maximum positive significant sca effect for the characters, pods per peduncle (13.47) and seed yield per plant (16.94). The hybrids Konkan Safed x Pusa Dofasali (0.96) and Pusa Komal x Pusal Dofasali (0.95) indicated maximum sca effects for protein content. None of the hybrid showed significant sca effects for the characters, flowers per plant, pods per plant, breadth of pod, seed weight per pod and yield realization index. The high sca effects represent dominance and epistatic components of variation which are non-fixable in natural. In these, hybrid vigour could be exploited for specific characters. In present study, the hybrid RCV-326 x Pusa Komal recorded high and positive sca effects for seed yield and pods per peduncle.

Based on these studies it is revealed that the parents RCV-326, Pusa Komal and Konkan Safed have shown high gca effects for seed yield. The hybrid RCV-326 x Pusa Komal, RCV-326 x IIHR Sel.11, RCV-395 x IIGR Sel.11, IIHR Sel.11 x IIHR Sel.16 have been found to be promising due to their high mean performance and high sca effects. It is also concluded that the characters pod length and pod breadth exhibiting additive gene action could be improved through the simple progeny selection in the pedigree method of breeding. However, the

Table 2. *Estimation of general combining ability effects of parents of 13 characters in cowpea*

Sl. No.	Parents	Plant height per plant	Primary branches per plant	Flowers per plant	Peduncle per plant	Pods per peduncle	Pods per plant	Length of pod per plant (cm)	Breadth of pod per plant (cm)	Seed per pod	Seed weight per pod (g)	Seed yield per plant (g)	Protein content per plant	Yield Realization index per plant
1.	BCS-1	-0.607**	-0.271**	1.620**	-0.17*	0.028**	-0.19*	3.367**	0.142**	1.188**	0.063**	1.488**	-0.35**	-0.418
2.	Arka Garima	0.826**	0.766**	-0.486*	-1.00**	-0.002*	-1.87**	2.192**	0.047**	1.118**	-0.04**	-2.65**	0.782**	-1.682*
3.	RCV-326	0.443**	-0.187**	3.291**	1.299**	0.087**	2.91**	1.453**	0.025**	-0.82**	0.26**	3.879**	-0.15**	2.242**
4.	IVRCP-1	4.518**	0.832**	-1.426*	-1.09**	-0.08**	-1.54**	2.817**	0.075**	-0.86**	0.18**	-2.21**	-0.34**	-1.881**
5.	RCV-395	2.307**	-0.096**	-3.033**	-0.32**	0.045**	-1.61**	0.422**	0.044**	1.04**	0.206**	-2.58**	-0.02**	0.464
6.	IIHR Sel.11	-2.396**	0.041**	-0.759*	0.932**	0.045**	1.70**	-2.52**	-0.06**	-0.45**	-0.17**	1.83**	-0.04**	1.518**
7.	IIHR Sel.16	-0.979**	0.099**	-3.554**	-0.087	-0.07**	-2.15**	-0.87**	-0.008*	0.28**	0.015**	-2.19**	0.08**	-0.632
8.	Konkan safed	-0.616**	-0.337**	3.114**	1.388**	-0.03**	1.87**	-3.15**	-0.06**	-0.42**	0.273**	1.83**	0.09**	-0.574
9.	Pusa Komal	-0.618**	-0.398**	2.597**	0.174*	0.048**	1.92**	-2.04**	-0.12**	-0.68**	-0.141**	2.11**	0.22**	1.716**
10.	Pusa Dofasali	-1.877**	-0.448**	-1.362	-1.11**	-0.05**	-1.04**	-1.65**	-0.07**	-0.38**	-0.120**	-1.49**	-0.26**	0.176
	SE (gi)±	1.100	0.009	0.70	0.08	0.001	0.08	0.02	0.0002	0.008	0.001	0.07	0.02	0.67
	CD (P=0.05)	0.196	0.017	1.372	0.156	0.00196	0.156	0.039	0.00039	0.015	0.0019	0.137	0.039	1.313
	CD (P=0.05)	0.258	0.023	1.80	0.20	0.00258	0.206	0.051	0.00051	0.020	0.0025	0.180	0.051	1.728

** Significant at 1% level * Significant at 5% level

Table 3. *Estimates of specific combining ability effects for 13 characters in crosses in cowpea* [Vigna unguiculata *(L.) Walp.*]

Sl. No.	Crosses	Plant height	Primary branch	Flowers per plant	Peduncle per plant	Pods per peduncle	Pods per plant	Seeds per pod	Length of pod	Breadth per pod	Seed weight per pod	Seed yield per plant	Protein content	Yield realization-index
1.	BCS-1x Arka Garima	1.091	-0.16	1.258	0.789	0.217	1.586	-0.810**	-0.628*	0.050	0.536	5.656**	0.161	8.988
2.	BCS-1x RCV-326	6.775**	1.793**	-5.335	-1.611	-0.072	-4.339	1.031**	-0.389	0.006	0.062	-2.739**	0.710	-1.519
3.	BCS-1x IVRCP-1	-2.500*	1.140	7.015	1.278	0.403	1.758	0.773**	-2.953**	-0.144	-0.465	4.838**	-0.697	-1.766
4.	BCS-1x RCV-395	0.911	-0.632	2.456	1.347	-0.430	2.094	-1.433**	0.708**	-0.013	0.030	-1.213	0.511	-0.043
5.	BCS-1x IIHR Sel.11	-1.820	-0.235	12.362	0.622	0.336	3.308	1.159**	2.553**	0.092	0.014	11.279**	-0.048	0.818
6.	BCS-1x IIHR Sel.16	-5.803**	1.207**	-0.887	0.241	-0.278	1.464	-0.513**	-0.528*	-0.127	0.185	6.185**	-0.672	0.601
7.	BCS-1x Konkan Safed	-3.767**	-0.157	-4.708	-1.300	0.145	-1.461	0.670**	1.883**	0.098	-0.511	-4.414**	0.253	0.573
8.	BCS-1x Pusa Komal	-3.364**	-0.629**	-8.378	-0.720	-0.033	-3.614	0.459**	3.275**	0.089	-0.247	-4.791**	0.272	0.867
9.	BCS-1x Pusa Dofasali	-4.506**	-0.213*	0.789	-0.095	0.072	0.192	0.756**	2.286**	0.170	-0.104	-2.620**	-0.475	-0.953
10.	Arka Garima x RCV-326	1.575	1.323**	-4.304	1.214	0.092	-2.892	0.767**	-0.714**	0.34	0.115	-5.765**	2.778	-4.192
11.	Arka Garima x IVRCP-1	-0.500	-0.196	6.591	1.141	-0.400	2.472	1.009**	-2.745**	-0.083	0.015	0.659	-0.150	0.730
12.	Arka Garima x RCV-395	0.278	-0.168	10.408	0.244	0.200	3.575	-0.796**	-0.784**	0.081	-0.241	2.721**	-0.251	-1.303

Contd.

Sl. No.	Crosses	Plant height	Primary branch	Flowers per plant	Peduncle per plant	Pods per peduncle	Pods per plant	Seeds per pod	Length of pod	Breadth per pod	Seed weight per pod	Seed yield per plant	Protein content	Yield realization-index
13.	Arka Garima x IIHR Sel.11	-5.153**	-0.038	1.790	1.447	-0.233	-2.178	0.395**	2.528**	0.053	-0.126	-2.807**	0.046	-2.832
14.	Arka Garima x IIHR Sel.16	-5.503**	-0.229*	-7.378	0.795	0.186	0.344	-0.077	0.047	-0.066	0.231	0.039	-0.131	-2.239
15.	Arka Garima x Konkan Safed	-3.934	-0.260*	-2.929	1.570	0.075	-1.914	0.540**	1.791**	0.026	0.206	-0.450	-0.342	1.927
16.	Arka Garima x Pusa Komal	-1.297	0.001	2.014	0.489	-0.033	-0.800	0.595**	2.350**	0.017	-0.207	-0.497	0.026	2.713
17.	Arka Garima x Pusa Dofasali	-6.206**	0.518**	6.510	1.839	0.103	0.406	0.392**	1.794**	-0.002	0.106	1.191	-1.281	-2.480
18.	RCV-326 x IVRCP-1	-3.117**	-1.910**	-3.610	0.308	0.245	1.747	-0.049	3.239**	-0.027	0.051	2.730**	0.776	-2.036
19.	RCV-326 x RCV-395	-1.406	-0.315**	3.277	4.011	-0.322	2.083	-1.421**	0.478	-0.097	0.005	3.695**	-1.068	6.337
20.	RCV-326 x IIHR Sel.11	-0.170	2.582**	10.513	-0.481	0.211	9.131	-0.130	2.466**	0.009	-0.347	11.824**	-0.348	3.618
21.	RCV-326 x IIHR Sel.16	0.847	-1.110**	2.802	-1.195	-0.069	-0.714	-0.935**	1.053**	0.023	-0.176	-1.033	0.151	7.707
22.	RCV-326 x Konkan Safed	-5.350**	0.260*	-4.760	3.897**	-0.247	-4.672	1.181	3.364**	0.048	-0.035	-5.535**	-0.047	2.290
23.	RCV-326 x Pusa Komal	-3.647**	-0.146	12.544	1.611	0.509	13.475	0.070	0.178**	0.073	0.172	16.944**	-0.905	0.970
24.	RCV-326 x Pusa Dofasali	-1.622	-0.163	-7.960	-1.231	0.0407	-2.386	0.067	1.800**	0.087	0.245	-0.832	-0.781	9.610
25.	IVRCP-1 x RCV-395	-0.881	0.665**	-2.492	-0.634	0.020	0.281	-0.913**	1.025**	0.087	-0.018	-0.484	0.864	0.716
26.	IVRCP-1 x IIHR Sel.11	-4.778**	0.196	-0.362	-1.725	-0.347	-3.039	0.812**	2.436**	0.059	0.093	-3.712**	0.024	-2.116
27.	IVRCP-1 x IIHR Sel.16	-0.761	0.137	7.409	-0.906	0.372	0.083	-0.394**	1.755**	0.106	0.187	-0.013	-0.360	-2.963
28.	IVRCP-1 x Konkan Safed	-1.292	0.073	-6.949	-1.714	-0.105	-3.208	-0.177	2.566**	0.064	-0.208	-1.431	-0.987	-2.664
29.	IVRCP-1 x Pusa Komal	0.944	0.901**	-3.302	-0.034	0.150	-2.328	0.145	2.758**	-0.077	-0.011	-0.892	0.574*	-2.001
30.	IVRCP-1 x Pusa Dofasali	0.936	0.651**	5.837	0.958	-0.378	1.878	-0.391**	2.403**	-0.030	0.288	1.339	0.511	-1.347
31.	RCV-395 x IIHR Sel.11	1.200	-0.143	-11.535	-1.489	0.286	-4.736	1.906**	1.230**	-0.011	0.184	-1.967*	0.640*	-5.189
32.	RCV-395 x IIHR Sel.16	0.916	-0.268*	0.336	0.030	0.206	2.219	0.534**	-0.917**	-0.030	0.028	2.456**	0.193	2.557
33.	RCV-395 x Konkan Safed	1.052	0.168	-4.219	-2.211*	-0.172	-2.206	0.417**	1.928**	-0.038	0.053	-2.063**	0.291	1.382
34.	RCV-395 x Pusa Komal	-1.678	0.062	-8.425	-0.331	0.184	-4.358	1.773**	1.619**	0.053	0.187	-3.610**	-0.463	-0.634
35.	RCV-395 x Pusa Dofasali	1.214	0.646**	-4.122	0.128	0.189	-0.386	1.70**	0.030	0.067	0.146	0.764	-0.010	-1.541
36.	IIHR Sel.11 x IIHR Sel.16	-1.481	-0.78**	-7.201	4.605**	-0.294	-2.667	-1.608**	-0.406	-0.058	0.006	-5.792**	0.183	-2.429
37.	IIHR Sel.11 x Konkan Safed	4.622**	0.232**	15.381	-0.736	0.328	11.075	-0.158	-0.761**	0.067	0.007	10.886**	-0.365	1.420
38.	IIHR Sel.11 x Pusa Komal	2.591*	-0.007	14.784	-1.422	0.017	9.756	0.331**	-2.436**	0.026	0.241	6.542**	-0.280	9.864
39.	IIHR Sel.11 x Pusa Dofasali	0.583	-0.090	-18.660**	-0.364	0.122	-6.131	-0.505**	-2.292**	0.039	0.307	-5.977**	-0.186	5.800
40.	IIHR Sel.11 x Konkan Safed	-1.328	1.807**	-0.831	-1.384	0.181	-0.936	1.270**	1.492**	0.048	0.094	-3.448**	-0.556*	-2.837
41.	IIHR Sel.11 x Pusa Komal	2.041	1.135**	3.526	-0.270	0.164	-1.189	1.392**	-1.450**	0.006	0.505	-1.372	0.103	-2.524
42.	IIHR Sel.11 x Pusa Dofasali	3.066**	0.185	4.182**	0.189	-0.125	1.884	1.623**	1.061**	0.120	0.134	1.556	0.626*	-3.300
43.	Konkan Safed x Pusal Komal	1.078	-0.029	9.635**	3.055*	-0.008	5.919	-0.191**	-3.539**	0.064	0.500	8.940**	0.158	-3.125
44.	Konkan Safed x Pusa Dofasali	0.636	0. 154*	8.884	0.441	-0.264	9.325	-0.327**	-3.595**	-0.055	0.162	11.314**	0.962**	9.622
45.	Pusa Komal x Pusa Dofasali	0.705	0.514**	-7.502	0.461	-0.080	-4.528	-1.438**	0.230	-0.097	0.094	-3.390	0.954**	-5.455
	SE (sij)±	1.14	0.11	8.01	0.93	2.12	0.90	0.10	0.25	2.90	2.14	0.80	0.28	7.68
	CD (P=0.05)	2.23	0.21	15.69	1.83	4.15	1.76	0.19	0.49	5.68	4.19	0.56	0.54	15.40
	CD (P=0.01)	2.94	0.28	20.66	2.39	5.46	2.32	0.25	0.64	7.48	5.52	2.06	0.72	19.81

** Significant at 1% level * Significant at 5% level characters viz. plant height, primary branches, flowers per plant, peduncles per plant, pods per plant, seed yield per plant, protein content and yield realization index showing non-additive gene action could be improved through modified recurrent selection or repeated crossing in segregating generations.

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Comparative Economics of Rice and Shrimp Farming: The Plight of Agricultural Labour in Coastal Districts of Tamil Nadu

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Most of the shrimp farming in India was developed in the rice farms situated for the coastal areas. This paper analyses the comparative economics of rice and shrimp farming, estimates the factor shares and study the plight of agricultural and female labour in the coastal areas of Tamil Nadu. Total cost of cultivation for shrimp was Rs. 258449.25 per ha and it was Rs. 19986.34 per ha for rice cultivation. Variable cost and fixed cost constitute about 96 percent and 4 percent of total cost, respectively for shrimp and it was 76 percent and 24 percent, respectively for rice cultivation. The gross income was Rs. 457977.22 per ha for shrimp and Rs. 27356.25 per ha for rice with a benefit-cost ratio of 1:1.77 and 1:1.37, respectively. Factor share of labour in shrimp farms was 0.23 percent while it was 29.11 percent in rice farming, indicating the adverse impact of shrimp farming on agricultural labour. Women participation is much higher in rice based cropping system with 43.64 percent of total labour requirement compared to 33.97 percent in shrimp culture.

(***Key words*** *: Comparative economics, Factor share analysis, Employment opportunities, Women labour, Rice farming, Shrimp farming)*

The World Watch Institute has emphasized the high potential for aquaculture in developing countries with about 85 percent of the fish farming emanating from developing countries. India is the second largest aquaculture producer next to China with 6 percent of world output. Indian fishery sector has the potential for employment generation and export earnings and the rate of return on shrimp farming has been estimated at about 600 percent depending on cultural operations. The experience of many South East Asian countries and their shrimp output through brackish water aquaculture attracted the Indian entrepreneurs to venture into this industry on a commercial scale. Most of the shrimp farming in India was developed in the rice farms situated in the coastal areas replacing rice cultivation. In this context, this paper analyses the comparative economics of shrimp farming in Tamil Nadu, especially (i) to study the cost and return of shrimp and rice cultivation, (ii) to estimate the share of output for different inputs, and (iii) to study the plight of agricultural labour and female labour in the coastal areas.

METHODOLOGY

A sample of 75 farmers was selected at random based on the total number of shrimp farms in the two districts and Union Territory of Pondicherry. Data were collected from the farmers by personal interview using a pre-tested interview schedule.

Average and percentage analyses were used to examine the initial investment made on shrimp farm and cost and returns from shrimp and rice farms.

Factor share analysis

Factor shares are the ratio of costs of factor inputs used in production process to the total value of output. Factor income of land is rent, of labour is wage, and of capital is interest. Factor share for different inputs used in the production are calculated as follows :

$$\text{Current Inputs (CI)} = \frac{\text{Input Prices x Quantity}}{\text{Output values}} \times 100$$

$$\text{Capital} = \frac{\text{Interest x Amount}}{\text{Output values}} \times 100$$

$$\text{Labour} = \frac{\text{Numbers x Wage}}{\text{Output values}} \times 100$$

$$\text{Residual} = \frac{100.00 - (\text{CI + Capital + Labour})}{\text{Output values}} \times 100$$

$$\text{Land} = \frac{\text{No. of acre x Rental value}}{\text{Output values}} \times 100$$

$$\text{Surplus} = \text{Residual - Land}$$

RESULTS AND DISCUSSION

General characteristics of the sample farms

Features of farm family

It could be seen from the Table 1 that average size of family was 5.29 of which 19 farmers lived in joint family and 56 farmers lived as nuclear family. In the selected farms 7.81, 17.38 and 33.25 percent have completed primary, higher secondary and graduate education, respectively whereas, the remaining 41.56 percent were illiterate.

Table 1. *Family details of the sample shrimp farms*

Sl. No.	Particulars	Number	Percent[1]
1.	Number of farms	75	100.00
2.	Joint family type	19	25.33
3.	Nuclear family type	56	74.77
4.	Average family size	5.29	–
5.	Total family members	397	100.00
6.	Primary education	31	7.81
7.	Higher Secondary education	69	17.38
8.	Collegiate	132	33.25
9.	Illiterate	165	41.56

[1]Percent of family type to total number of farms and percent of education level to the total family members

Features of shrimp farms

Total area owned by the sample farmers was 470.85 ha with a water spread area of 321.75 ha (Table 2). The average water spread area per farm was 4.29 ha while average number of ponds per farm was 5.69. The stocking density was 58266.67 per ha with the survival rate of 80.80 percent. The average output was 1.22 ha^{-1} with an average price of Rs. 356.87 per kg.

Table 2. *Selected feautures of sample shrimp farms*

Sl. No.	Particulars	Total
1.	Area of the farms (ha)	470.85
2.	Water spread area (ha)	321.75
3.	Average water spread area per farm (ha)	4.29
4.	Total number of ponds	427.00
5.	Average number of ponds per farm	5.69
6.	Stocking density (number of shrimps per ha)	58266.67
7.	Survival rate (%)	80.80
8.	Output (t/ha)	1.22
9.	Average price (Rs/kg)	356.87

Cost and returns of rice and shrimp cultivation

One of the important consequences of proliferation of shrimp farms is conversion of

Table 3. *Cost of cultivation for shrimp and rice farms (Rs/ha/crop)*

Sl. No.	Particulars	Shrimp	% to total cost	Rice	% to total cost
1.	Man	828.80	0.32	5740.00	28.72
2.	Woman	239.85	0.09	2222.50	11.12
3.	Bullock	0.00	0.00	875.00	4.38
4.	Machine	2435.17	0.94	1600.00	8.01
5.	Liming	4223.97	1.63	0.00	0.00
6.	Seed	43922.21	16.99	865.20	4.33
7.	Feed	125450.50	48.54	0.00	0.00
8.	FYM	0.00	0.00	1315.00	6.58
9.	Fertilizers	1156.32	0.45	1482.55	7.42
10.	Insecticides	40562.30	15.69	140.00	0.70
11.	Irrigation charges	5145.00	1.99	632.70	3.17
12.	Rouging	869.42	0.34	0.00	0.00
13.	Reservoir treatment	12046.67	4.66	0.00	0.00
14.	Equipment maintenance	6589.19	2.55	0.00	0.00
15.	Interest on variable cost at 12.5%	5002.80	1.94	268.20	1.34
16.	Total variable cost	248472.18	96.14	15141.15	75.76
17.	Rent on lown land	4500.00	1.74	2825.00	14.13
18.	Rent on leased land	3750.00	1.45	1500.00	7.51
19.	Land revenue	150.00	0.06	97.92	0.49
20.	Depreciation at 5%	1415.72	0.55	350.34	1.75
21.	Interest on fixed capital at 10%	161.35	0.06	71.93	0.36
22.	Total fixed cost	9977.07	3.86	4845.19	24.24
23.	Total cost	258449.25	100.00	19986.34	100.00

Table 4. *Return from shrimp and rice farm (Rs/ha)*

Sl. No.	Particulars	Shrimp	Rice
1.	Yield (kg/ha)	1224.80	4200.00
2.	Price per kg in Rs.	373.92	6.00
3.	Value of main product	457977.22	25200.00
4.	Value of by-product	0.00	2156.25
5.	Gross income	457977.22	27356.25
6.	Total variable cost	248472.18	15141.15
7.	Gross margin (5-6)	208505.03	27356.25
8.	Total cost	258449.25	19986.34
9.	Net income (5-8)	199527.96	7369.91
10.	Cost of production (Rs/kg) (8/1)	211.03	4.76
11.	Benefit- Cost ratio (5/8)	1:1.77	1:1.37

agricultural lands into shrimp farms. To compare the relative profitability of rice and shrimp farms cost and return were worked out and the results are presented in Tables 3 and 4, respectively.

It could be observed from Table 3 that total variable cost was higher for shrimp cultivation with Rs. 248472.18 per ha while it was Rs. 15141.15 per ha for rice cultivation. The higher variable cost in shrimp farm was due to the extra cost on reservoir treatment, liming, rouging, feed and equipment maintenance. Total fixed cost was also higher for shrimp cultivation than rice cultivation due to higher establishment cost incurred on shrimp cultivation. Altogether, total cost of cultivation for shrimp was Rs. 258449.25 per ha and it was Rs. 19986.34 per ha for rice cultivation. Variable cost and fixed cost constitute about 96 percent and 4 percent of total cost, respectively for shrimp, and it was 76 percent and 24 percent, respectively for rice cultivation.

Returns

The gross income was higher for shrimp with Rs. 457977.22 per ha and it was Rs. 27356.25 per ha for rice, while the net return was Rs. 199527.96 and Rs. 7369.91 per ha in that order. Cost of production per kg of shrimp was Rs. 211.03 and it was Rs. 4.76 per kg of rice with a benefit-cost ratio of 1:1.77 and 1:1.37, respectively.

Results of factor share analysis

An analysis of factor shares provides useful insights into how output is distributed among the various factors of production. Factor share analysis throws light on the relative changes in factor incomes when their use is shifted from one enterprise to another. Hence it is more appropriate to examine which factor gained/lost more relative to others due to the shift from rice production to shrimp production. Factor shares of one ha of rice production and shrimp production are presented in Table 5.

Factor share analysis revealed that in rice production, the residual, which is the return for the use of land and marginal inputs of farmers, gain the largest factor share. When rent for use of land is subtracted from residual, it is called as surplus. It is the reward for the risk taken by rice producers which is about 32 percent of gross value of rice production. Share of labour in total value of rice output was 29.11 percent followed by current inputs

Table 5. *Factor payments (Rs/ha) and factor share (%)*

Sl. No.	Details	Rice production		Shrimp production	
		Value	% to value of output	Value	% to value of output
1.	Current inputs	4435.45	16.21	233376.38	50.96
2.	Capital	3255.00	11.90	12057.19	2.63
3.	Labour	7962.50	29.11	1068.65	0.23
4.	Land	2825.00	10.33	4500.00	16.45
5.	Surplus	8878.30	32.45	206974.99	29.73
6.	Value of output	27356.25	100.00	457977.22	100.00
7.	Residual (4+5)	11703.30	42.78	211475.99	46.18

(16.21 percent), capital (11.90 percent) and land (10.33 percent). In the case of shrimp production, share of current inputs was higher than all other factors and it accounted for 50.96 percent of gorss returns followed by share of residual (46.18 percent), share of operator (surplus) (29.73 percent), land (16.45 percent), capital (2.63 percent) and labour (0.23 percent).

In general, income distribution among factors is evenly distributed in rice farming. Income distribution was worsened with the introduction of shrimp farming. Particularly the factor share of labour in shrimp farm is very low, constituting 0.23 percent while it was 29.11 percent in rice farming. This indicates the adverse impact of shrimp farming on agricultural labour.

Employment opportunities

One of the negative consequences of shrimp culture was displacement of labour. Usage of labour per hectare of shrimp production and rice production are presented in Table 6.

Table 6. *Labour use per hectare rice and shrimp production (man-days/ha)*

Sl. No.	Sex	Shrimp production	Rice production
1.	Male	10.36 (66.03)	82.00 (56.36)
2.	Female	5.33 (33.97)	63.50 (43.64)
3.	Total	15.69 (100.00)	145.50 (100.00)

Average labour requirement for paddy cultivation was 145.50 man-days per ha while in shrimp farming it was 15.69 man-days per hectare under the existing conditions. It shows that labour requirement in crop cultivation was about 9 times higher than in shrimp production.

In many cases rich farmers convert their rice farm into shrimp farm to get huge profit and thereby reducing the employment opportunities. In shrimp farming, digging of ponds was an important labour intensive operation. But in sample farms, digging was mainly carried out through machine labour. Labour requirement for maintenance in shrimp culture was mostly hired. Evidently, expansion of shrimp culture in the study area is likely to have adverse effects on employment of small and agricultural labourers.

The most serious situation was when entrepreneurs acquire the land from marginal and small farmers and convert them into shrimp farms, creating a huge number of unemployed landless agricultural labour. Further, the use of saline water in shrimp culture affects neighbouring rice fields. Continuous salinization of paddy fields would force the farmers to abandon cultivation which may affect not only the farmers but also the employment opportunity of landless agricultural labour.

Women participation is much greater in rice based cropping system with 43.64 percent of total labour requirement and they play a major role in production, post-harvest processing and marketing. Moreover, much of women labour in rice cultivation is hired but shrimp culture does not provide employment for women. Elimination of rice production may severely affect the employment and empowerment of women.

CONCLUSIONS

The study revealed that, in general, income distribution factors are evenly distributed in rice farming while income distribution was worsened with the introduction of shrimp farming. Particularly the factor share of labour in shrimp farm is very low, constituting 0.23 percent while it was 29.11 in rice farming which indicates the adverse impact of shrimp farming on agricultural labour. Thus, introduction of shrimp farming in the coastal belt of Tamil Nadu and Pondicherry is a threat to the employment opportunities particularly for the landless agricultural labour living in these areas. Conversion of paddy lands into shrimp may also severely affect the employment and empowerment of women in these areas.

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Short Communication

Characteristics and classification of coastal soils of North Karnataka

India has a coastline of 8129 km and the coastal ecosystem of the country supports the food and livelihood security of several million rural poor. Out of the total coastline of India, 310 km coastline is in Karnataka and its coastal region accounts for 6.09 percent of the area of the state. The problem of resource evaluation and management in the coastal region is strikingly different from those of hinterland. For the planned development of coastal areas reliable information on soils with respect to their nature, potential and limitation is very essential. In the present study an attempt was made to characterize and classify some coastal soils of North Karnataka.

The study area lies in Kumta *taluk* of Uttara Kannada district of Karnataka and lies between 14° 20' to 14° 36' N latitudes and 74° 17' to 74° 41' E longitudes with a total area of 582 sq. km. The area receives a mean annual rainfall of 3522 mm. The mean annual temperature is 27.6°C with an average annual maximum and minimum temperatures of 31.7°C and 23.5°C, respectively. The soil temperature regime is isohyperthermic and moisture regime is ustic.

Reconnaissance survey was carried out using survey of India toposheets and IRS-ID imageries. Sample strip was selected, pedons were examined and morphological characteristics were studied (Soil Survey Staff, 1951). Three typical pedons were selected for the detailed study. Particle size analysis of the soil samples was carried out by international pipette method as described by Jackson (1979). pH, electrical conductivity, organic carbon, cation exchange capacity, exchangeable bases and exchangeable acidity were determined following standard methods (Black, 1965). The soils were classified as per Soil Taxonomy (Soil Survey Staff, 1992).

The pedons were deep and developed on coarse textured alluvium. The colour of the surface horizons of the pedons was dark brown for Kadekode and Honehalli pedons and it was dark yellowish brown for Aghanashini pedon (Table 1). Hue remained same for all the pedons (10 YR) except in the lower solum of Aghanashini pedon (5 GY) due to the presence of deposited marine materials. The texture ranged from sandy to sandy loam. These soils exhibited single grained structure or a very weakly developed sub-angular blocky structure. The better developed structure of Aghanashini pedon in comparison to other pedons was due to high organic matter content accumulated by way of estuarine process. Yellowish brown to red coloured mottles were observed in Kadekode and Honehalli pedons. These soils lacked distinct horizonation.

In terms of physical characteristics the content of coarse fragments was very low (Table 2) and sand fraction dominated the particle size classes. These fractions were inert and were of no consequence in further weathering. The clay content was very less and irregularly distributed in Honehalli pedon whereas in Aghanashini pedon it was uniform. The particle size distribution data of pedons indicated that these pedons had uniform lithology (Kaswala *et al.*, 1999) with lack of the process of illuviation. The high clay content in Ap and A_2 horizon of Kadekode pedon may be due to depositional differences of coastal alluvium.

Table 1. *Morphological characteristics of the soils*

Horizon	Depth (m)	Soil colour (moist)	Tex-ture	Structure (moist)
Pedon 1 (Kadekode)				
Ap	0-0.13	10 YR 3/3	cl	m1sbk
A2	0.13-0.45	10 YR 5/6	scl	vf1sbk
C1	0.45-0.58	10 YR 6/3	s	sg
C2	0.58-0.74	10 YR 6/3	s	sg
Pedon 2 (Honehalli)				
Ap	0.0-0.12	10 YR 3/3	ls	vf1sbk
A1	0.12-0.26	10 YR 3/3	s	sg
C1	0.26-0.52	10 YR 5/3	s	sg
C2	0.52-0.74	10 YR 7/3	s	sg
C3	0.74-0.99	10 YR 6/6	s	sg
C4	0.99-1.25	10 YR 6/3	ls	vf1sbk
Pedon 3 (Aghanashini)				
Ap	0.0-0.9	10 YR 3/4	Sl	m2sbk
A1	0.09-0.14	10 YR 3/4	Sl	m1sbk
A2	0.14-0.23	10 YR 4/4	Sl	flsbk
A3	0.23-0.37	10 YR 4/6	Sl	vf1sbk
C1	0.37-0.56	10 YR 5/3	Sl	m1sbk
C2	0.56-0.73	5 GY 4/1	Sl	week
C3	0.73-0.82	5 GY 4/1	Sl	week

The chemical properties show that the A horizons of Kadekode and Honehalli pedons and all the horizons of Aghanashini pedons were acidic in reaction (Table 2). Such acidic pH range was due to regeneration of the inherent acidity of these soils after washing off of the salinity by heavy rains (Varghese *et al.*, 1970). In the lower horizons of Kadekode and Honehalli pedons the pH shifted to neutral range. Electrical conductivity was less than 1.0 dSm^{-1} except in C_3 horizon of Aghanashini pedon. The irregular distribution of organic carbon content was due to estuarine processes and the high content of organic carbon at C_3 horizon of Aghanashini pedon was due to the presence of deposited materials there.

Cation exchange capacity was generally low and varied from 0.75 to 5.25 cmol (p+) kg^{-1}. The low EC was due to low clay content in these soils. In all the pedons calcium was the dominant cation followed by magnesium, sodium and potassium. The high $Bacl_2$-TEA extractable acidity indicated that these soils contained more proportion of pH dependent changes and the high $BaCl_2$-TEA acidity could be attributed to aluminium hydroxyl compounds that were held tenaciously on the exchange complex and due to non-exchangeable aluminium embedded between crystal lattice which came into the solution due to buffering and complexing nature of $BaCl_2$-TEA (De Alwis and Pluth. 1976). The base saturation percentage was very low in these soils.

Classification of the soils suggests that because of the absence of any diagnostic horizons these pedons could be classified under the order Entisol. The Kadekode and Aghanashini pedons were characterized as Aquents due to hue of 10 YR and chroma of 2 in case of Kadekode pedon and presence of gleyed horizon (5 GY) in case of Aghanashini pedon.

Both pedons were classified as Psammaquents at great group level due to loamy sand and sandy particle size classes. The Aghanashini pedon had an Ap horizon with a colour value moist of 3, dry value of 5, and a base saturation (by NH_4oAC) of less than 50 percent throughout the profile, and therefore classified as Humaqueptic Psammaquents and Kadekode pedon qualified for Typic Psammaquents due to absence of gradation in properties.

The Honehalli pedon qualified for Ustipsamments due to loamy sand to sandy textural class and ustic moisture regime. At subgroup level it may be classified as Typic Ustipsamments.

Limitations and management

To discuss on limitation and management these coastal soils pose severe physical constraints associated with their inherent site characteristics such as climate, texture and single grained structure. The coarse textured nature of these soils leads to high percolation resulting in loss of added nutrients to deeper depths.

The lifting of sand is intensified during heavy wind period and causes severe damage to the standing crops in coastal dune areas. Adopting erosion control and other ameliorative measures such as, stabilization of sand dunes, pasture development, moisture conservation practices, incorporation of organic manures, water harvesting, and control of surface crusting would enhances the productivity. Plantation of casuarinas on the sandy foreshore can minimize the problem of shifting sand.

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Table 2. *Physicochemical properties of soils*

Horizon	Particle size analysis[1]					pH	EC	Organic	CEC	Ca	Mg	Na	K	1N	$BaCl_2$-
	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Coarse frag-ments %	(1:2.5 soil/ water)	dSm^{-1}	carbon (%)						KCl	TEA acidity
									cmol (p+) kg^{-1}						
Pedon 1 (Kadekode)															
Ap	0-0.13	30.6	33.4	35.9	0.2	5.5	0.57	0.45	4.8	1.9	0.75	0.79	0.04	0.50	11.8
A2	0.13-0.45	56.0	19.6	24.4	-	6.8	0.10	0.30	3.3	1.5	0.98	0.12	0.05	0.25	8.9
C1	0.45-0.58	87.5	10.8	1.6	-	7.6	0.10	0.12	2.1	0.80	0.30	0.09	0.03	0.16	9.9
C2	0.58-0.74	95.2	3.0	1.8	-	7.9	0.07	0.85	3.0	1.5	0.68	0.11	0.02	0.19	8.9
Pedon 2 (Honehalli)															
Ap	0.0-0.12	83.8	12.2	4.0	4.6	4.7	0.03	0.24	5.0	2.9	0.90	0.14	0.02	0.18	16.5
A1	0.12-0.26	90.6	6.5	2.5	2.8	5.4	0.03	0.03	3.2	2.0	0.45	0.08	0.02	0.12	14.5
C1	0.26-0.52	94.4	3.7	1.9	0.5	6.5	0.03	0.15	3.2	0.98	1.65	0.59	0.03	0.12	9.9
C2	0.52-0.74	95.5	2.7	1.7	-	6.9	0.04	0.60	2.5	0.75	0.60	0.59	0.03	0.07	9.4
C3	0.74-0.99	96.1	2.4	1.5	0.6	7.0	0.06	0.48	2.5	0.83	0.45	0.08	0.02	0.10	9.4
C4	0.99-1.25	89.5	7.1	3.5	-	7.0	0.08	0.24	2.1	0.90	0.75	0.09	0.03	0.17	8.5
Pedon 3 (Aghanashini)															
Ap	0.0-0.09	58.4	26.0	17.3	6.3	4.7	0.06	1.59	9.0	4.3	2.3	0.99	0.15	0.30	15.0
A1	0.09-0.14	54.5	30.1	15.3	7.5	5.1	0.83	1.23	8.6	3.5	2.0	1.1	0.77	0.30	14.1
A2	0.14-0.23	83.5	6.5	10.0	6.6	6.2	0.31	0.09	8.1	4.0	2.4	0.77	0.01	0.25	10.3
A3	0.23-0.37	76.8	13.8	9.5	1.1	6.0	0.42	0.45	7.9	2.5	2.9	0.89	0.07	0.30	13.6
C1	0.37-0.56	77.2	12.2	10.7	0.8	5.4	0.42	0.57	8.6	5.3	1.1	0.90	0.10	0.30	12.2
C2	0.56-0.73	73.3	14.6	12.1	0.9	6.7	0.40	0.58	6.6	2.1	1.1	0.81	0.01	0.23	16.9
C3	0.73-0.82	76.8	12.1	11.1	2.3	5.9	1.14	0.40	9.4	3.3		1.1	0.13	0.25	19.7

[1]Particle size analysis according to USDA classification

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J. Indian Soc. Coastal agric. Res., 23(1), 65-66, 2005 **Short Communication**

Integrated zinc management for *kharif* rice in coastal alluvial (Entisols) of Orissa

Intensive cultivation of high yield genotypes of rice coupled with continuous use of high analysis zinc free chemical fertilizers under medium and lowland situation caused deficiency of zinc in coastal alluvial soils of Orissa (Sahu *et al.*, 1990) for which rice yield is unexpectedly reduced. Response of rice to Zn in alluvial and black soils of Orissa through various sources of Zn has been reported by Sahu *et al.* (1989, 1994). Chemical source of zinc is costly and application at high dose may cause antagonism with some other chemicals (Nayyar and Chhibba, 1992). Hence, an attempt was made to study the integrated management of zinc in rice in alluvial soils of Orissa.

Field experiments on response of rice to integrated Zn application were taken up at Regional Research Technology Station, Ranital, OUAT during the wet seasons of 1998 and 1999. The treatments included lone soil application of Zn @ 2.5 and 5.0 kg ha^{-1} or Zn integrated with green manure (*Sesbania aculeata*) or with FYM @ 5 t ha^{-1}. Lone green manure and FYM @ 5 t ha^{-1} were compared with foliar application of 0.1% Zn-EDTA twice at 10 days interval after maximum tillering. Altogether ten treatments (Table 1) including one control (no Zn) were replicated thrice in a randomized design. Rice variety Lalat was the test crop. The crop received a common dose of N, P (P_2O_5) and K (K_2O) @ 80, 40 and 40 kg ha^{-1}. Full dose of P and K alongwith 25% N were applied at transplanting. Out of the rest 75% of N, 50% was applied at maximum tillering and the balance 25% at panicle initiation stage. Sources of N, P, K and Zn were urea, diammonium phosphate, muriate of potash and zinc sulphate, respectively. The soil of the experiment site was loam (Haplaquept) with 7.5 pH, 0.62% organic carbon and 0.51 mg kg^{-1} DTPA extractable Zn.

Application of lone Zn at either dose of 2.5 or 5.0 kg ha^{-1} and green manure or FYM significantly increased the grain and straw yields of rice over control (Table 1). The grain yield increased in the order of 8.0, 17.0, 7.5 and 10.4, respectively. Application of lone Zn @ 5.0 kg ha^{-1} showed the maximum yield increase among the sources applied. Similar was the trend in case of straw yield. Integrated use of Zn at either dose with green maure or FYM showed further yield increase than their lone application. Integration of Zn with green manure showed higher yield increase than integration of the same with FYM. Integration of Zn at either dose with FYM did not show yield increase between themselves. Integration of Zn @ 5.0 kg ha^{-1} along with green manure exhibited the highest yield increase (23.0%) over all treatments followed by foliar spray of Zn-EDTA (18.9%) two times at 0.1% concentration.

Table 1. *Integrated management of Zn in terms of grain and straw yield in rice*

Treatments	Grain yield (q ha^{-1})			% increase over control	Straw yield (q ha^{-1})			% increase over control
	1998	1999	Mean		1998	1999	Mean	
T_1 Control (no Zn)	30.0	28.8	29.40	-	35.8	30.2	33.00	-
T_2 Zn (@ 2.5 kg ha^{-1})	31.5	32.0	31.75	8.0	39.3	33.2	36.25	9.9
T_3 Zn (@ 5.0 kg ha^{-1})	34.0	34.8	34.40	17.0	42.0	34.7	38.35	16.2
T_4 Green manure (GM)	32.5	30.7	31.60	7.5	39.0	31.2	35.10	6.4
T_5 GM + Zn (@ 2.5 kg ha^{-1})	35.5	33.1	34.30	16.7	46.1	33.8	39.95	21.1
T_6 GM + Zn (@ 5.0 kg ha^{-1})	37.0	35.3	36.15	23.0	45.6	35.3	40.45	22.6
T_7 FYM (@ 5 t ha^{-1})	32.0	30.9	32.45	10.4	37.0	31.8	34.40	4.2
T_8 FYM + Zn (@ 2.5 kg ha^{-1})	34.0	34.7	34.35	16.8	40.3	35.5	37.90	14.9
T_9 FYM + Zn (@ 5.0 kg ha^{-1})	35.0	33.1	34.05	15.8	41.8	35.7	38.75	17.4
T_{10} Zn EDTA (0.1%) (Foliar spray)	36.0	33.9	34.95	18.9	48.0	34.2	41.10	24.5
CD (P=0.05)	1.48	2.07			3.21	1.81		

Application of Zn at either dose or green manuring or application of FYM showed significant higher uptake of Zn by grain, straw or both over control (Table 2). Application of Zn @ 5.0 kg ha^{-1} alongwith green manure accumulated maximum Zn by grain followed by soil application of Zn at the same rate. In case of straw absorbtion of Zn was maximum where Zn @ 5.0 kg ha^{-1} was integrated with FYM followed by integration with green manure. Straw part retained higher Zn than grain part. Highest total uptake of Zn was recorded by integration of Zn @ 5.0 kg ha^{-1} with green manure followed by FYM which was influenced by higher biomass yield.

Table 2. *Integrated management of Zn in terms of uptake of Zn by rice*

Treatments	Zn uptake by grain (gha^{-1})			Zn uptake by straw (gha^{-1})			Total uptake (gha^{-1})
	1998	1999	Mean	1998	1999	Mean	
T_1	45.2	40.8	43.0	51.3	44.1	47.7	90.7
T_2	79.0	76.5	77.7	86.0	106.5	96.2	173.9
T_3	104.7	98.9	101.8	96.0	115.5	105.7	207.5
T_4	59.3	50.7	55.0	61.3	71.5	66.4	121.4
T_5	93.7	95.1	94.4	100.7	126.3	113.5	207.9
T_6	109.7	122.8	116.2	109.7	165.5	137.6	253.8
T_7	60.0	52.2	56.1	60.7	71.0	65.8	121.9
T_8	98.3	92.1	95.2	126.3	123.0	124.6	219.8
T_9	84.7	110.3	97.5	151.3	142.1	146.7	244.2
T_{10}	80.3	101.5	90.9	81.0	144.5	112.7	203.6
CD (P=0.05)	18.21	11.89		22.3	26.55		

Treatments same as in Table 1

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Effect of weed management practices in direct seeded drilled rice

Out of 41 million hectare land under rice in India, rainfed upland (mostly direct seeded) rice constitutes about 16 percent of the area, where the productivity of rice is only 0.5 to 6 tonnes per hectare. Severe weed competition is the major hurdle which competes with rice plant for light, nutrient and moisture causing reduction in yield to the extent of 80 percent (Sinhababu *et al.*, 1992). Manual weeding is costly and uneconomical. Hence efforts are made to study the performance of different combinations of weed management practices in controlling the weeds in direct seeded drilled rice under agroecosystem of Konkan, Maharashtra.

A field trial was conducted during *kharif* 2002 at the Agronomy Farm, College of Agriculture, Dapoli representing Konkan region. Six treatments as mentioned in Table 1 were replicated six times in the randomized block design. The gross and net plot sizes were 6 x 5m and 5.5 x 4.6m, respectively. Experimental soil was lateritic, sandy clay loam in texture. The available N, P_2O_5 and K_2O content of the soil were 297.16, 12.43 and 188.64 kg ha^{-1}, respectively. After thorough land preparation, rice variety Ratnagiri-1 was drilled at a spacing of 20cm between two lines. Well decomposed FYM @ 5 t ha^{-1} was incorporated at the time of land preparation. The crop was fertilized with 100 kg N, 50 kg P_2O_5 per hectare. Out of this 40 percent nitrogen and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing. Remaining 30 kg N was applied at 30 days after sowing and 30 kg N at panicle initiation stage. The sowing of both rice and blackgram (cv. TPU-4) was done in the 2nd week of June. Pre-emergence spray of butachlor and anilophos was given next day after sowing. Hoeings were also followed as per the treatments. Data on dry matter of weeds, grain yield and uptake of nutrients by the crop and weeds was obtained and analyzed statistically.

The dominant weed observed were : *Echinochloa colona*, *Ischaemum globosa*, *Eragrostis major* and *Eragrostis minor*. among grasses; *Cyperus iria* and *Cyperus difformis*, among sedges; *Mimosa pudica*, *Ammonia baccifera*, *Corchorus acutangularis* and *Celocia argentia* among major broad leaved weeds.

Pre-emergence spray of butachlor followed by one hand weeding at 40 days after sowing (DAS) produced significantly higher grain yield of rice as well as total rice equivalent grain yield as compared all other treatments under study (Table 1). Similar results in respect of butachlor + one hand weeding were reported by Singh and Patel (1989). All the weed management practices recorded significantly higher rice equivalent grain yield as compared to weedy check. Performance of blackgram as an intercrop with rice was poor due to the high rainfall in the region.

Table 1. *Effect of weed management practices on the weed growth , N uptake and grain yield of direst seeded rice*

	Treatments	Grain yield (q ha^{-1})		Rice equivalent yield (q ha^{-1})	Dry weight of weeds (q ha^{-1})	WCE (%)	N uptake (kg ha^{-1})	
		Rice	Black gram				by crops	by weeds
T1	Unweeded control	8.89		8.89	39.47	-	12.40	34.40
T2	Hoeing (20DAS) + HW (40 DAS)	26.48		26.48	16.95	57.06	54.10	13.16
T3	Butachlor @ 1.5 a.i./ha + HW (40 DAS)	32.51		32.51	5.60	85.81	66.67	4.17
T4	Anilophos @ 0.5 kg a.i./ha + HW (40 DAS)	28.75		28.75	10.57	73.22	41.37	8.63
T5	2:1 Rice and blackgram intercropping + HW (40 DAS)	16.15	1.09	19.44	21.12	46.49	44.94	17.79
T6	2:2 Rice and blackgram intercropping + HW (40 DAS)	10.37	1.21	14.01	17.55	55.54	44.92	14.62
	SEm±	0.62		0.63	1.09		1.75	1.18
	CD (P=0.05)	1.87		1.91	3.29		5.75	3.56

Pre-emergence application of butachlor followed by one hand weeding at 40 DAS also recorded minimum dry matter of weeds i.e., 5.6 q ha^{-1} with 85.81 percent weed control efficiency. The dry matter of weeds due to integration of butchlor spray with hand weeding was significantly less as compared to all weed control measures and weedy control as well. The excellent control of weeds in case of butachlor and hand weeding resulted into good crop growth which significantly increased nitrogen uptake in rice crop as compared to all other treatments and also the weedy check. Conversely, the nitrogen uptake by weeds was significantly less under this treatment. These results are in conformity with those reported by Moorthy and Mittra (1990).

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J. Indian Soc. Coastal agric. Res., 23(1), 69-70, 2005 **Short Communication**

Effect of salinity and PEG stress on agromorphological parameters and water relations in tomato varieties

Productivity of tomato may be constrained by unfavourable physicochemical environment. The major bottleneck in achieving the desired yield in tomato has been the susceptibility of crop to biotic and abiotic stresses. Andaman and Nicobar Islands posses about 4000 ha of saline land, which are lying vacant owing to salinity (Elanchezhian and Mandal, 2001, Elanchezhian and Mandal, 2003). The lowlying saline land is frequently inundated with seawater which renders the area unsuitable for agriculture (Mandal, 1998, Mandal *et al.*, 1999). Hence, an attempt was made to evaluate the HYV's of tomato for their tolerance to coastal salinity. The present work was aimed at identifying suitable HYV's for this coastal saline ecosystem.

Three HYV's of tomato viz., Kerala Shakthi, Arka Abhijeet and LE 3704 were grown at the glass house of Biotechnology Section, CARI, Port Blair. The varieties were stressed with two levels of salinity regime viz., 8 and 16 dSm^{-1} and PEG stress of 0.75 MPa and 1.5 MPa applied at 30 DAP (days after planting), 45 DAP and 60 DAP. Various agromorphological parameters including water relation parameter (Relative Water Content) were observed during crop growth. Standard package of practices for fertilizer and pesticide application were followed for raising the crop.

Among all the varieties plant height and number of primary branches decreased with imposition of salinity and PEG stress (Table 1). The decrease was more with increase in stress levels. Fifty percent flowering was delayed with both the stress treatments. A maximum of 15-day and 13-day delay in flowering was observed in Kerala Shakthi stressed with 8 dSm^{-1}. However, 50% flowering was shortened at higher stress levels of salinity (16 dSm^{-1}) and PEG (1.5 MPa) in Kerala Shakthi and LE 3704. In Arka Abhijeet delay in flowering occurred with increase in salinity to higher levels only. The number of flowers and fruits was found to decrease with increase in stress levels. Maximum number of flowers (13.0) and fruit (11.5) was observed in LE 3704 under 0.75 MPa PEG stress. The yield per plant was found to be highest in Arka Abhijeet (83.60 g) under 8 dSm^{-1} but decreased to 31.48 g with 16 dSm^{-1} of salinity. However, Kerala Shakthi exhibited highest yield per plant (74.50 g) with PEG stress of 0.75 MPa. The Mean relative water content (RWC) of the varieties varied from 28.87% to 72.27%. Among the varities RWC decreased with increase in stress levels of both salinity and PEG. With PEG stress maximum reduction in RWC was observed in LE 3704 (28.87%) at 1.5 MPa and minimum reduction in Kerala Shakthi at 0.75 MPa (72.27%). The decrease in RWC was relatively less in the latter variety at 0.75 MPa PEG stress. At higher salinity level (16 dSm^{-1}) too the decrease in RWC was relatively less in Kerala Shakthi. However, there was little difference in plant yield at higher salinity treatments among the three varieties. Since tomato is susceptible to both salinity and water stress, the maintenance of turgor as measured by the RWC may contribute to maintenance of plant growth at higher water stress which may thereby lead to lesser reduction in plant yield.

Similar kind of result was already observed in solanaceous vegetables viz., tomato and bell pepper (Rao and Bhatt, 1993). In the present study variety Kerala Shakthi and Arka Abhijeet was found to retain higher RWC, which may be due to better osmotic adjustment. The variety, which tolerates salinity and water stress was most appropriate for the coastal salinity ecosystem observed in Andaman and Nicobar Islands. In this case Kerala Shakthi and Arka Abhijeet were found to be superior to LE 3704 and were better suited for cultivation in these islands.

Table 1. *Effect of salinity and PEG stress on agromorphological parameters and water relations in tomato*

Variety	Stress	Plant height (cm)	Primary branches	50% flowering	No. of flowers	No. of fruits	Yield/ plant (g)	Yield ton/ha	RWC (%)
Kerala Shakthi	Control	57.5	4.75	64.5	13.75	3.33	103.6	25.90	80.00
	8 dSm^{-1}	37.38	5.50	80.0	2.80	2.33	72.40	18.10	62.79
	16 dSm^{-1}	23.83	4.67	66.0	2.67	2.0	29.62	7.40	53.95
	0.75 MPa	39.00	5.90	78.0	2.57	2.33	74.50	18.63	72.27
	1.5 MPa	32.33	5.67	71.0	3.50	3.0	30.24	7.56	60.86
Arka Abhijeet	Control	77.67	4.00	60.0	11.50	3.0	150.80	38.0	80.00
	8 dSm^{-1}	55.00	7.50	60.0	7.00	3.5	83.60	20.90	55.99
	16 dSm^{-1}	47.53	5.50	72.67	4.00	8.0	31.48	7.87	49.72
	0.75 MPa	54.00	5.50	66.0	3.67	4.33	64.84	16.21	51.77
	1.5 MPa	44.50	5.50	76.0	3.33	6.0	56.39	14.09	38.53
LE 3704	Control	47.33	4.00	60.0	15.0	4.5	120.13	30.03	80.00
	8 dSm^{-1}	49.25	5.00	64.5	6.75	3.5	68.12	16.78	51.30
	16 dSm^{-1}	45.75	5.00	71.33	5.5	4.0	30.84	7.83	49.17
	0.75 MPa	57.00	6.00	68.0	13.0	11.5	59.28	14.82	59.06
	1.5 MPa	43.50	4.75	72.25	5.5	6.0	30.14	7.53	28.87
CD (P=0.05)	Var	2.28	0.22	0.47	0.67	N.S.	0.32	0.23	1.25
	Stress	2.95	0.28	0.60	0.86	N.S.	0.41	0.30	1.62
	Var/Stress	5.10	0.49	1.05	1.49	N.S.	0.71	0.51	2.80
SEm(±)	Var	1.12	0.11	0.23	0.33	N.S.	0.16	0.11	0.61
	Var/Stress	1.44	0.14	0.30	0.42	N.S.	0.20	0.14	0.79
	Var/Stress	2.50	0.24	0.51	0.73	N.S.	0.35	0.25	1.37

NS = Non-significant

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Short Communication

Evaluation of subsurface irrigation system in little gourd (*Coccinia indica* L.) in lateritic soils of Konkan region

Konkan region has been bestowed with diversified natural resources. Inspite of a very high annual rainfall of about 3500 mm, scarcity of water remains a normal phenomenon after the month of November. The advanced irrigation methods like drip and sprinkler systems have limited applicability in the hilly terrain due to poor financial conditions of farmers and erratic nature of electricity. Various researchers tried subsurface irrigation method in the past. Narda and Lubana (1999) studied the growth dynamics of tomatoes under subsurface drip irrigation at Ludhiana (Punjab). The low quality water can also be used through drip. Oran *et al.* (2001) used surface and subsurface drip irrigation systems with the reclaimed waste water in a vineyard orchard near the city of Arad (Israel). Due to poor economics and electricity constraint the applicability of the surface and subsurface drip systems becomes limited and hence effort was made for designing and testing of new techniques of low-cost subsurface irrigation methods.

Field trials on little gourd (*Coccinia indica* L.) were conducted during *rabi* 1997-98, 1998-99 and 1999-2000 at the Water Management Scheme, Central Experimental Station Wakawali, Dist. Ratnagiri (M.S.). The treatments included four levels of irrigation based on daily pan evaporation viz., I_1: Irrigation with 80% pan evaporation through clay mud diffuser: I_2: Irrigation with 60% pan evaporation through clay mud diffuser; I_3: Irrigation with 40% pan evaporation through clay mud diffuser; I_4: Irrigation with 100% pan evaporation by conventional method (basin).

The treatments were replicated five times in the randomized block design (R.B.D.). The plot size was 4m x 2m. The soil of the experimental field was lateritic, sandy clay loam in texture with acidic (pH 6.6) in reaction. The organic carbon content was 0.72 percent. The available nitrogen, phosphorus and potassium content of the soil were 326.66, 5.03 and 185 kg ha^{-1}, respectively. The field capacity and permanent wilting point values of the soil were estimated at 32 and 17.82 percent, respectively. The measured quantity of water as per the irrigation treatments was given twice a week both for subsurface and surface irrigation system (basin). *Pucca* clay mud diffuser (pot) having 3 litre capacity as shown in Fig. 1 with five holes at the bottom for water to diffuse into the root zone of the crop was installed. Manuring @ 5 kg Farm Yard Manure and 100 g superphosphate was done at the bottom of each clay diffuser so as to restrict the percolation losses. The plantation of little gourd was done at a spacing of 2m x 1m, one year before the start of experiment. After establishment of little gourd the treatments were applied and the fruit yield was recorded.

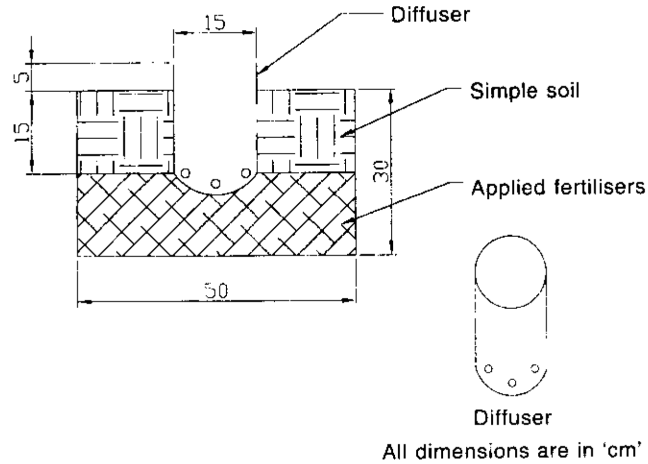

Fig. 1. *Line diagram of installed diffuser*

Effect on fruit yield

Data presented in Table 1 reveal that during 1997-98 the irrigations at 80 percent pan evaporation (I_1) gave the maximum fruit yield of little gourd (29.98 t ha^{-1}), whereas the basin method of irrigation (I_2) resulted in production of minimum fruit yield. Superficial roots of newly established little gourd plantation might have responded better under higher water availability with irrigations at 80 percent pan evaporation through diffuser. In general the fruit yield due to irrigation through diffuser was better as compared to conventional

***Table 1.** Fruit yield (t/ha) as affected by various levels of irrigation (1997-2000)*

Treatments	Fruit yield (t/ha)			Pooled mean
	1997-98	1998-99	1999-2000	
I_1	29.978	16.682	26.570	22.807
I_2	27.874	21.506	33.446	27.610
I_3	27.444	22.838	33.690	27.990
I_4	22.572	27.572	38.282	29.473
S.E ±	2.434	1.433	2.957	1.468
C.D at P = 0.05	N.S.	4.416	N.S.	4.070

N.S. = Non significant

method. However, the yield difference due to different irrigation levels during 1997-98 were non-significant. During 1999-2000 also the yield differences due to different irrigation levels were non-significant. During 1998-99 and as per the pooled data, conventional method of irrigation gave the significantly higher fruit yield over all other irrigation levels. As per the pooled data, conventional method of irrigation gave the maximum fruit yield of little gourd which was at par with the yield recorded due to irrigations given at 60 percent and 40 percent pan evaporation through diffuser. The high quantity of water applied through irrigations at 80 percent pan evaporation through diffuser resulted into production of significantly less yield as compared to other irrigation levels.

Effect on water saving and water use efficiency

The quantity of water applied in different treatments, water saving vis-à-vis basin method + WUE in different treatments are presented in Table 2. Irrigation at 40 percent pan evaporation recorded the maximum water saving to the tune of 59.49 percent as compared to basin irrigation. The water use efficiency was also higher (952.68 kg fruit^{-1}ha-cm^{-1}) under this treatment. This clearly indicated that the irrigations at 40 and 60 percent pan evaporation through clay mud diffuser provided the optimum moisture conditions for little gourd which has reflected into maximum water use efficiency and statistically comparable yield with the basin method. However, this method (60 percent pan evaporation) required 20 percent higher water and had less water use efficiency as compared to irrigation at 40 percent pan evaporation through diffuser. By using the diffuser for little gourd the farmer can irrigate more than double area with same quantity of irrigation water.

Effect on Benefit : Cost (B:C) ratio

The data on comparative economics of the treatment are reported in Table 3. Conventional method of irrigation with irrigation at 100 percent pan evaporation recorded maximum gross (Rs. 1,76,838/- ha^{-1}) and net returns (Rs. 77,197/- ha^{-1}) with highest B:C ratio of 1.77. Irrigation with 40 percent pan evaporation through clay mud diffuser was the second highest which recorded the gross and net returns of Rs. 1,67.940/- ha^{-1} and Rs. 72,932/- ha^{-1}, respectively. However, as far as B:C ratio were concerned this method was equally good with the conventional method.

CONCLUSION

Three years pooled results revealed that conventional irrigation with 100% pan evaporation gave significantly higher fruit yield of little gourd over the irrigations at 80% pan evaporation through diffuser in lateratic soils of Konkan region. However,

***Table 2.** Total quantity of water applied, water saving and water use efficiency under different irrigation treatments (1997-2000)*

Treatments	Total quantity of water applied (lit/vine)	Total water applied (cm)	Percent saving of water over basin method	Water use efficiency kg/ha-cm
I_1	2785	58.02	19.83	394.45
I_2	2108	43.91	39.34	627.36
I_3	1409	29.35	59.49	952.68
I_4	3466	72.38	-	402.69

***Table 3.** Comparative economics of different irrigation treatments (1997-2000)*

Treatments	Yield of fruits (t/ha)	Total cost (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
I_1	22.807	88,838	1,36,842	48,004	1.54
I_2	27.610	95,241	1,65,660	70,419	1.74
I_3	27.990	95,008	1,67,940	72,932	1.77
I_4	29.473	99,641	1,76,838	77,197	1.77

the basin treatment was at par with the irrigations given at 60 and 40 percent pan evaporation through clay mud diffuser. Irrigations at 40 percent pan evaporation through clay mud diffuser recorded the maximum water saving to the tune of 59.49 percent ac compared to basin irrigation and resulted in highest water use efficiency (W.U.E) of 952.68 kg ha-cm^{-1} of water.

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INDIAN SOCIETY OF COASTAL AGRICULTURAL RESEARCH

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This is to invite nominations for the award of **'Fellow of Indian Society of Coastal Agricultural Research'** for the year 2005-06. Two scientists will be awarded the **Fellow** of the society from among the nominations received.

The nominated scientist should either be a life member of the society or annual member for the last 10 years. Nominations must be proposed and seconded by a member of the society. Nominations must reach the office of the society latest by **30-09-2005**. All nominations in the prescribed proforma (enclosed) must be accompanied by a bio-data of the nominated member and also a brief outline of his/her contributions to the development of agriculture in the coastal areas.

As per existing rules, nominations received within the due date will be scrutinized by a selection committee headed by the President of the society and the award will be conferred on the selected member at the 8th. National Seminar of the society to be held at CTCRI, Thiruvananthapuram, Kerala from 21-24 December, 2005.

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FOR 2005-06

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....

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....

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Seconded by :

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....

.... *(Signature of Seconder)*

....

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I do hereby agree to the above proposal.

(Signature of nominee)

N.B: All proposals must be accompanied by the bio-data of the nominee and his/her contributions to the development of agriculture in the coastal areas.

FIRST ANNOUNCEMENT

8th NATIONAL SEMINAR

On

STRATEGIES FOR IMPROVED FARMING AND ECOLOGICAL SECURITY OF COASTAL REGION

at

Central Plantation Crops Research Institute Kasargod, Kerala
on 21 - 24 December, 2005

The coastal ecosystem spread over about 11 million hectare area of the country is impregnated with a variety of problems leading to lowered agricultural productivity. This calls for attention from all stakeholders engaged in improved productivity in the coastal ecosystem to deliberate and interact on a common platform for which Indian Society of Coastal Agricultural Research was founded in 1983 at Central Soil Salinity Research Institute, Regional Research Station, Canning Town, West Bengal. besides a variety of problem in agriculture and related fields there are serious concerns for security to ecology of the ecosystem. 'Tsunami', for example, was a horried experience in the recent past leading to loss of large number of lives and wealth. Scientists have very little knowledge about its behaviour and the government and other agencies engaged in this sector have no idea to mitigate this problem. These form the background for scientists, planners and representatives of developmental agencies to deliberate and interact during the 8th National Seminar of Indian Society of Coastal Agricultural Research to be held at Central Tuber Crops Research Institute. Thiruvananthapuram, Kerala.

VENUE

The seminar will be held at CTCRI, Sreekariyam, which is located at Thiruvananthapuram, a beautiful and small seaside city and the capital of Kerala. The city gets its name from the word, Thiruvananthapuram (Thiru-anantha-puram), meaning the city of Anantha or the abode of the sacred serpent Anantha, on which Lord Vishnu, the preserver of Hindu trinity reclines. Thiruvananthapuram is a Southern most district of Kerala state and situated between north latitudes 8° 17′ and 8° 54′ and east longitudes 76° 41′ and 77° 17′. Thiruvananthapuram has all the modern amenities and the place is well connected to most of the other major cities of India through rail, road and air network. Thiruvananthapuram International Airport/Domestic Airport is well connected with other International Airport and Domestic Air ports. December-January being the tourist season in Kerala, participants are strongly advised to make their travel arrangements at the earliest. Dry weather sets in by the end of December. In the days of December-January the weather is pleasant with mean maximum and minimum temperature being 30°C and 22°C, respectively. Kerala has a humid climate and light clothing would be suitable.

ACCOMMODATION (Hotel tariff tentative)

	Single		Double	
	A/C (Rs.)	Non A/C (Rs.)	A/C (Rs.)	Non A/C (Rs.)
Maria Rani Centre	–	150	–	200
Sivada	–	107.50	–	172
Chinnu	–	–	–	275
Venkateswara	805	393	920	447
Keerthi	–	300	950	510
Chaithram	1035	605	1265	805
Arya Nivas	948.75	550	1092.50	660
Regency	862.50	483.75	1035	660

DATE

The Seminar will be held on 21-24 December 2005. The last day will be reserved for field trip.

SEMINAR SESSIONS

Session 1 : Inventorisation and integrated management of soil and water resources

Session 2 : Advanced research in nutrient and crop management including horticulture and plantation crops and their utilisation

Session 3 : State-of-art technologies for higher production in aquaculture and animal husbandry including integrated farming system

Session 4 : Mangroves, forests, agroforestry and ecological security

Session 5 : Integrated farming with resource recycling and extension initiatives for sustainable economy

Brain Storming Session : **Natural disasters vis-a-vis stability of coastal ecosystem**

Sub-theme I : Past experiences and future threats

Sub-theme II : Recent Tsunami tide waves and their effect on soil and water quality, life and agricultural losses

Sub-theme III : Combating Tsunami damages and mitigation options

Sub-theme IV : Proactive strategies including disaster warning systems

CALL FOR PAPERS

All papers in concise form (Abstract, Introduction, Materials and Methods, Results and Discussion and References, limited to 4 neatly typed pages of size 8½ X 11" with 12 pt font, Times New Roman, and 1" margin on all sides in double space) may be submitted in duplicate hard copy alongwith CD as well as through e-mail to the following address. Papers indicating the relevant sessions and written as per style of the latest issue of the Journal of ISCAR may be submitted by 31.09.05. There will be both oral and poster sessions. Any paper received after 31.09.05 will not be considered for oral presentation. The acceptance of paper(s) will be communicated by 01.11.2005. Participation is open to both members and non-members of the ISCAR. The e-mail address(s) of the author(s) must be provided for quick correspondence.

Hony. Jt. Secretary (ISCAR)
Central Soil Salinity Research Institute, Regional Station Canning
P.O. Canning Town, Dist. South 24 Parganas, WB, Pin : 743 329
Tel : (03218) 255 084, 255 085, Fax : (03218) 255 084
Email: iscar@rediffmail.com, cssri@wb.nic.in

REGISTRATION

A registration fee of Rs.1000/- per participant will be charged payable in advance on or before 20.11.2005 in the form of DD or MO (outstation cheques will not be acceptable) in favour of "INDIAN SOCIETY OF COASTAL AGRICULTURAL RESEARCH" payable at State Bank of India, Canning Town (Code no. 1993), West Bengal. Late fee @ Rs. 50/- per person will be levied for delayed payment of registration fee after 20.11.2005.

Note : Papers and registration fees should be sent only to the Hony. Jt. Secretary, ISCAR at Canning Town, WB (address above). For all other communications related to local matters (registration, accommodation, transport, etc.) please contact the Organizing Secretary at Thiruvananthapuram, Kerala (address below).

Organising Secretary
National Seminar ISCAR
C/O Director
CTCRI
Thiruvanthapuram - 695 107, Kerala

REGISTRATION FORM

8th NATIONAL SEMINAR

Strategies for improved farming and ecological security of coastal region

To
Organizing Secretary,
National Seminar ISCAR,
C/o. Director, Central Tuber Crops Research Institute,
Thiruvananthapuram - 695 107, Kerala

Sir,

I wish to participate in the National Seminar on "Strategies for improved farming and ecological security of coastal region" to be held at CTCRI, Thiruvanathapuram, Kerala

I have forwarded the following manuscript(s) to the Hony. Jt. Secretary (ISCAR) :

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Please arrange accommodation/transport from Railway Station/Airport/Bus Stand as per details below.

Yours faithfully,

Signature

Name ....

Designation ....

Address ....

Tel : .... Fax ....

E-mail : ....

Member of Society	Yes	No
(If yes, membership No.)		
Accommodation required	Yes	No
Nature of accommodation :	Single	Double
Moderate/Deluxe	M	D
Spouse :	Yes	No
Arrival schedule (Train/Flight/Bus No.)		
Presentation of paper	Oral	Poster
Registration Fees submitted	Yes	No

*Please send this Form on or before **20.11.2005**.*