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Performances of BRIS Soils Genesis and Classification in Terengganu, Malaysia

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Abstract

The soils in the study area were found to be excessively well drained and too sandy. Thus, we wanted to determine how the BRIS soil in Merang is formed and how to improve its productivity. Intensive soil survey was applied in this research and soil sampling was taken and analyzed in laboratory for determining soil parameters. The research results showed that soil series are occurring side by side which relate the coexistence of beach ridges running parallel in different elevation to the seashore. Almost all profiles show no clear differentiation of horizons and are dominated by sand fractions (95-98 %), silt and clay contends are below 4%. According to soil taxonomy, Baging series are classified as Sandy, siliceous, isohyperthermic, typic, Quartzipsamments, Rhu Tapai is named as Sandy, siliceous, isohyperthermic, arenic, Alorthods, Rudua is identical with Sandy, siliceous, isohyperthermic, arenic, Alorthods and Jambu belongs to Sandy, siliceous, isohyperthermic, arenic, Alorthods.

Keywords: Performances, Genesis, Classsification, BRIS soils, Terengganu plain, Malaysia

1. INTRODUCTION

As much of high Spodosols and Entisols could be identified, the Malay Peninsula is found to be tectonically stable. Influenced by Pons *et al.* (1982) who believed that within 1000 years after the last glacier, sea level had risen 3-5 m above the present or there about. However, the South China Sea and the Sunda Shelf have been tectonically stable within 2 million years. About 6000 years ago the sea level rose to 3-5 m above the present. Base on the study of coastal sediments in Thailand; evident that the sea level there might have risen above the present sea level by 1.2 m (Woodroffe and Horton, 2005). Hence the genesis of sandy beach ridges along the coastal plains in Peninsular Malaysia.

The undulating processes which made up the ridges and swales, which is locally known as BRIS (Beach ridges interspersed with swales). Due to the immergence of spodic horizon at different level known as Spodosols and without the presents of Spodosols are call Entisols (Soil Survey Staff, 2010). De Coninck (1980) also emphasis that some horizon of Spodosols are cemented to form an impenetrate hard layers, where as some with many roots are loose, which may lead to soil structure becoming crumble and consistently fluffy when the texture are slightly clayey. However, the distribution and the properties of the BRIS soils in Malay Peninsula have been taxonomically classified as either Spodosols or Entisols (Lim, 1989).

Since these soils (BRIS) in the coastal region of Malay Peninsula are known to be successful in growing Tobacco, with the combination of waste products like chicken manures and palm oil extracts etc. can improve on the development of the soil quality, hence, to replace Tobacco with economical crops like paddy, maize, sorghum etc. will be of economical important to the people of area. Base on this study, the main objective of this study is to determine the BRIS soil in Merang is formed.

2. MATERIALS AND METHODS

The study area is in Merang-Terengganu plains of Malaysia (Fig. 1). It is located at 05^0 12’20 Norths and 103^0 12’21 East. With temperature of 29^oC, the vegetation of the area is mostly grasses and shrubs which provide the soils with their debris there by metamorphosed to form humus (acid humus). According to (Roslan *et. al*, 2011) who further acknowledge the fact of the soil, emphasis that, it is the humus that help promote the podzolization process, leading to the formation of the spodic horizon.

The study show the observation of this present work, when a comprehensive soil survey was carefully examine in the Merang plain that lead to the investigation of Beach ridges soils which was carried out continuously

throughout the study. The soil in the study area were found to be poorly drained or excessively drained land, as a results of the depressions and ridges that were identified during the map observation and the literature review, which further enhance the sand on the shoreline is believed to be alluvial soil which are normally found around river area.

After thoroughly observation during the field work, in contrast with the data available in the map (Fig. 1), the soil were found to have the presents of spodic horizon (Spodosols) in some location and absents in some, with the use of survey equipment like soil auger to collect some soil sample in the study site. In some location pits were dug base on their genetic profile and samples were taken using a special tools like sample box for analyses. This was done with the records of each and every profile site sample collected, in respect of the soil depth for analysis, example, 0-15, 15-30, 30-45, 45-60 cm and some times more depth have to be reach in order to get the preferred horizon. Hence all the sample locations are marked using the (GPS) map. Rhu Tapai and Rudua series are found on the intermediate ridge (second ridge) running parallel to the shoreline, while Jambu series was on the oldest (third series) (Fig. 2).

The standard chemical and physical analyses will be use in the laboratory to analyze the soil samples, while the soil collection is carefully adhere to during the field work. The sand, silt and clay fractions in the soils were separated by successive sedimentation. Soil pH was determined in water (at a soil solution with the ratio of 1:2:5), while electrical conductivity (EC) was determined using saturated paste. Cation electrical capacity (CEC) was determined using the 1 M NH_4OA_c buffered at pH 7 method. The basic cations which are (Ca, Mg, K, and Na) were determined using the NH_4OA_c extract with the help of atomic absorption spectrophotometer; the cations were regarded as exchangeable captions. Other analyses include the determination of exchangeable Al and free iron oxides (van Ranst *et al.*, 1999), organic carbon, total nitrogen (Kjeldahl method) and available P.

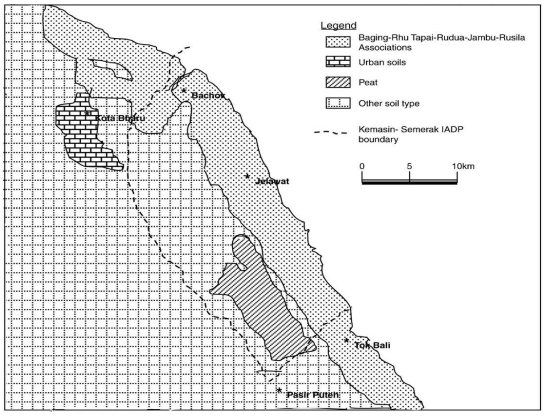

Fig.1. Soils on beach ridges in relation to other soil types in the Merang Plains

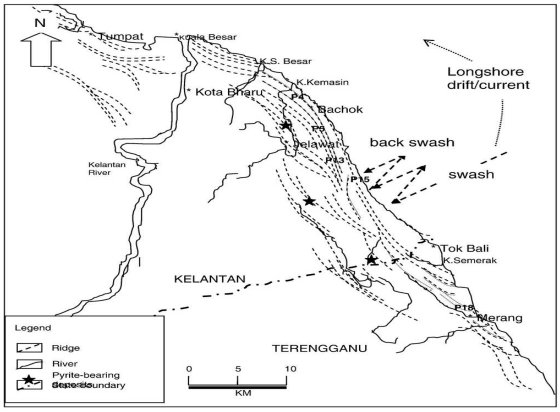

Fig. 2. The wave movement to shorelines in Merang and its surrounding (adopted from Roslan *et al.*, 2010).

3 RESULTS AND DISCUSSION

3.1 Genesis of BRIS Soils presented in Soil Catena

The South China sea play a greater role in the eustatic transformation of the seashore with the exposure of strong wave that run northwardly, washing away the fine particles of silt and clay and leaving behind a coarse fraction sand which is refers to as Beach Ridges, usually found in Merang-Terengganu Plains, as the sea level occurred, some 6000 years ago base on the carbonating (Yu and Chen, 2009).

The investigation of soil occurring side by side with the study carried out, which relate the coexistence of beach ridges running parallel in different elevation to the seashore (Fig. 3). However the youngest is the one close to the shoreline with 1m above the sea level, where as the one close to it is a bit higher with 2 m. The occurrences of other ridges frequently emerge at elevation of about 5 m above the sea level (Table 1). However Roslan *et al* (2010) stated that this ridge which is about 0.5 km wide is located some 4 km away from the shoreline. As result soil usually, swale run side by side with the ridge to create an elevation of different distribution away from the shoreline.

From the outcrop of the eustatic sea level, during the Holocene period as express by the findings of (Hutchison, 2004); hence, when the drop in the sea level occurred, a new ridge is form along the shoreline. This can further be express that some 6000 BP, the sea level in the domain of Merang-Terengganu was higher than the present. However the observation of pyrite-like sediments gives more prove that many years back, the area where merely onshore than present. Therefore this domain of Merang-Terengganu was once occupied by sea.

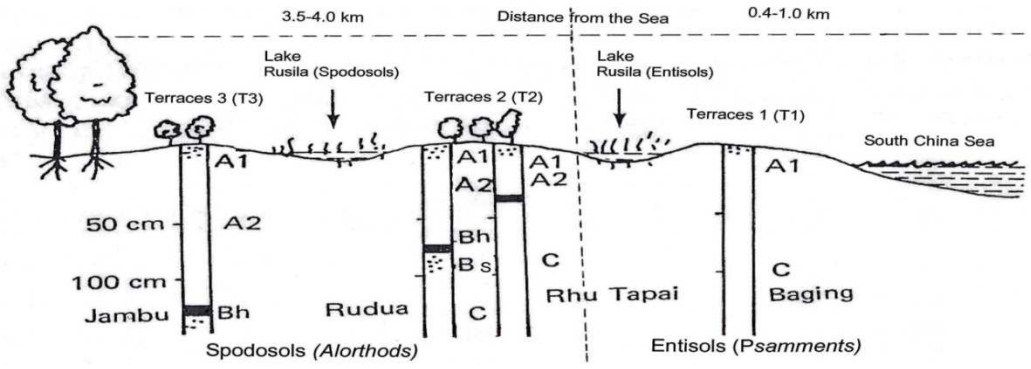

Fig.3. Soil catena of BRIS soils (T1, T2 and T3 represents the young, older and oldest beach ridges, respectively) adopted from Armanto *et al* (2013)

3.2. Development and Distribution of BRIS Soils

In order to undertand the development of BRIS Soils, we have to know distribution of soil series in relation to the local landscape (T1, T2 and T3 represents the young, older and oldest beach ridges, respectively).

T1 Soil

Due to human action in study area, the topography was found to be almost flat, with elevation of about 1m above sea level. Soil auger was use to identify the soil series in the ridges and the depression, and common features were recorded (Table 1). A very light grey (2.5Y7/2) to light yellowish brown (2.5Y6/3) was found during the field work with soil texture and the topsoil organic matter less than 5 cm thickness.

As the work progresses, there is no clear indication of strata with different colors, rather a single grain sand with find and coarse structures distributed along the horizon, silt and clay particles are below 4% in content. Hence (Paramananthan, 1987), the use of Malaysian soil classification to classified it as Bagging Series (Entisols), couple with the ease in soil penetration of plant found at the area along the Merang coastal plain, with the water table below 130 cm depth. However, the soil on these first ridges (R1) which is the youngest of them does not contain Spodosols, as podzolization requires much time to develop.

The physical and chemical properties of (P4) are more or less deficient as par their content in all ramifications for crop growth; hence the available P is better in terms of crop growth, where as the exchangeable bases are low and as well the N total and the organic C. However, the Baging soil indication of light yellowish to brown color does not give a clear detection of iron in the soil profile. Therefore, a soil administration is advised in order to increase crop production suitability.

T2 Soils

The Rhu Tapai soil on these ridge is second to the shoreline with subsoil consisting of spodic horizon of 0-50 cm depth, having structures and texture characterize to be brown (7.5YR3/2) coarse sand, loose topsoil with bright yellowish to brown (10YR5/8) and single grain sand. The occurrences of depression within the first and the second ridges which have common attribution to that of Baging series is occupied by the soil of Rusila Series (Entisols), where as the Rhu Tapai soil is moderately drained. It is suggested that the process of podzolisation took place in the parent materials, hence exposes atmospheric condition that lead to the deposition of an underlying soil layer with some mineral particles which leach out of an overlying soil layer.

The lateral or downward movement of dissolved or suspended materials within soil when rain fall exceeds evaporation can be seen in Rudua series, compare to Rhu Tapai series, which can be noticed between 50-100 cm

depth. Rudua series which is spodic in the horizon is dark grey (10YR4/1) coarse sand, loose topsoil with spodic horizon within 50-100 cm depth.

Rhu Tapai series with 2 m elevation above the sea level which has a Bs horizon is light yellowish to brown in color (7.5YR3/2) subsoil with the depth of 41-98 cm, which is different from Baging soil, due to its free iron in spodic horizon (Bs) analytically. A schematic representation these Spodosols and Entisols is shown in Fig. 3.

Rudua series is the most extensive among the BIS Soil in Peninsula Malaysia according to (Soo, 1975 and Lim, 1989). Despite the removal (excavation) of the topsoil by the rural farmer for the reason best known to them during the field work in some location, where as the topsoil in P13 is moderately rich in organic matter in some location and higher in free iron compare to other areas of study. It is further believed that the excavation was due to construction purpose and also, others to level the soil for agricultural activities. However, topsoil is obviously dark grey (5%Y 3/1), with reddish brown (5YR4/2) strata underlying, followed by light brown to dark brown color (10 YR4/3). Over 95% of sand particles of soil profile are believes to be excessively high at the subsoil; whereas the nutrient retention is very low. This is why the farmers remove the topsoil in order to reach the Bhs horizon where more nutrients are present and nutrient retention are higher than the horizon above or below it (Roslan *et al.*, 2010).

T3 Soils

The spodic horizon in this location known as Jambu series and it's the oldest among the ridges that can be found sparsely in Merang and also, can be found occurring or had been mapped as a small patch near downtown Bachok (Shamshuddin *et al.*, 2002). The deposition in an underlying soil layer at the horizon below 100 cm is strongly bleached in plant nutrients, colloid, soluble salts and mineral particles leached out of an overlying soil layer below the horizon which make it very difficult for plant to benefit from the nutrients and at the same time the only means out with more than (>100 cm) depth. R3 soil is 500 m far away from the shoreline; the topsoil is high in Ca with value of 2.85cmol$_c$/kg soil with 2.58% organic content (Table 2). It is also 16 to 110 cm depth in eluvial horizon having white color (10YR8/2). Bhs horizon with the depth of 110-150 cm with dark brown in color (10YR2/2) and Bs horizon started from 150 cm depth downwards with yellowish brown (10YR4/4).the soil pH H_20 is below 5 at the depth of about 15- 45 cm depth which explain the situation of exchangeable Al in the soil is solidly build

3.3

Table 1. Location, site description, elevation and approximate distance of the beach ridges from the shoreline

Sample	Location North	East	Site description	Elevation (m above sea level)	Distance (m)	Depth of spodic layer (cm)
Bagging series						
P1(kembara)	5° 57.288'	102°26.524	Shrubs	1		
P2(kembara)	5° 57.291'	102°26.527'	Coconut, shrubs	1	50	No spodic no
P3(suria)	6° 04.808'	102°23.359'	Coconut, shrubs	1	40	spodic
P4(suria)	6°04.967'	102°23.573'	Coconut, shrubs	1	60	No spodic
					50	No spodic
Rhu Tapai series						
P5(Kg mengabang lekar)	6°03.971	102°22.434'	Coconut, sweet potato, chili Bhs (0-50cm)	2	300	0-50
P6(Kg mengabang lekar)	6°05.092'	102°21.322'	Kenaf, Bs(30-50cm)	2	350	0-50
P7(Kg mengabang panjang)	6°06.493'	102°20.744'	Tobacco, brinjal, chili, Bhs(30-50cm)	2	350	0-50
P8(Kg mengabang panjang)	6°06.935'	102°20.640'	Coconut, sweet potato, chili, Bs(0-50cm)	2	300	0-50
Rudua Series						
P9 (Rhu sepulu)	5°53.082'	102°27.604'	Topsoil dredged, high water table, coconut, Bs(15-60cm)	3	400	50-100
P10(Rhu sepulu)	5°56.394'	102°25.120'	Topsoil dredged, pumpkins, Bhs (0-60cm)	3	350	50-100
P11(Kg mengabang bakong)	5°58.093'	102°24.055'	Topsoil, dredged, tapioca, Bs(0-15), Bhs (15-60cm)	4	400	50-100
P12(Kg mengabang bakong)	5°59.668	102°23.139'	Topsoil, dredged, coconut, Bhs (15-60cm)	4	500	50-100
P13(Kg mengabang bakong)	5°58.067	102°22.532'	Idle land, Bs>60cm depth	4	500	50-100
Jambu Series						
P17 (Merang)	5°36.920'	102°44.296	Shrubs, Bhs/Bs>100cmdepth	5	>500	>1.0m
P18 (Merang)	5°59.295'	102°23.010	Shrubs, Bhs/Bs>100cmdepth	5	>500	>1.0m

Note: Modified from Roslan *et al.* (2010).

3.4 Classification of the BRIS Soils according to Soil Taxonomy (2010)

As results of depleting soil nutrients and the undulating pattern of the landscape, ranging from the soil temperature of 21 to 43^{0}C, couple with the water deficit of dry months of February to May or June. The monsoon forces, acting on the shoreline of the beach is characterized by the coastal plain which was form by eustatic effects (Shamshuddin, 1990), combine with the sea waves and eustatic activities of marine deposit. Hence washing away light fragments like clay/silt upwards (northwards) and leaving behind sand deposit in the

plain. However the results of this action led to the ridges being elevated at the landscape where as the swales forming depression in the location (MARDI, 2010).Thus excessive undulating flooding force is not economically beneficial for agricultural output.

Mostly short shrub and grasses, like casuarinas species *(Casuarinas equisetifolia)* and *Zoysia matrala* were found growing side by side along the ridges and as well the beaches soil. As a result of low in nutrients uptake of these plants which might be the source of the organic materials in the soil, can be responsible for the emission of acidity, which lead to the development of acidic humus as describe by SSSA (2008), thereby forming moor humus at the soil surface i.e. topsoil in Horizon A with hydroxides activities deposited in B horizon. In addition, the study of (Roslan *et al.*, 2010), also vindicates that the main process of soil formation under this type of condition is believed to be podzolisation, resulting in horizon differentiation (formation of Spodosols). However this process can also be as result of biological degradation of Al and Fe, through the movement or adsorption of these chemical properties at B Horizon. When these hydroxides and or organic materials dissolved and move downward further an eluvial horizon could emerge, called E horizon (A2).

Table 2. The organic C and Fe contents in the spodic horizon of BRIS Soil Series

Soil Series	Organic Carbon (%)	Fe_2o_3 (%)
Rhu Tapai		
Ap (0-40 cm)	0.76	0.20
Bs (40-99 cm)	0.05	1.56
C (> 99 cm)	0.10	1.70
Rudua		
Ap (0-30 cm)	0.79	1.53
A1 (30-50 cm)	0.37	0.90
A2 (50-80 cm)	0.12	0.82
Bs (> 80 cm)	0.24	0.74
Jambu		
Ap (0-15 cm)	0.81	0.63
A2 (15-100 cm)	0.09	0.16
Bhs (100-150 cm)	1.00	0.10
Bs (> 150 cm)	0.60	0.35

Note: Adopted from Roslan *et al.* (2010) with some modification on the organic contents

Table 3. Physico-chemical properties of the soils on the beach ridges in the Merang–Terengganu Plains

Series location	Granulometric Composition (%)			pH		E.C	Exchangeable cations					B.S	Avail. P	O.C %	N %	C/N	Free Fe
	clay	silt	sand	H_20	KCl	(ds/m)	Ca	Na	Mg	K	CEC	%	(ppm)			Ratio	(ppm)
							(Cmol$_c$/kg)										
Baging (P4)																	
0-15	2.2	1.2	96.60	5.30	4.80	0.07	0.45	0.09	0.17	0.05	1.25	61	0.90	0.42	0.07	6	0
15-30	1.6	0.8	97.60	5.40	4.60	0.02	0.32	0.08	0.06	0.01	0.87	54	0.06	0.15	0.05	3	0
30-45	0.3	0	99.70	5.60	4.70	0.01	0.43	0.06	0.23	0.05	0.43	100	0.10	0.06	0.03	2	0
45-60	0	0	99.80	5.50	4.60	0.01	0.16	0.08	0.35	0.04	0.56	100	0.10	0.03	0.01	3	0
Rhu Tapai (P5)																	
0-15	2.2	1.3	96.50	5.10	4.60	0.01	1.32	0.03	0.45	0.02	2.12	86	10.40	1.8	0.36	5	0.01
15-30	0.5	1.3	98.20	5.10	4.50	0.01	0.04	0.02	0.01	0.05	0.32	38	5.60	0.52	0.06	9	0.17
30-45	0.6	0.8	98.60	4.90	4.50	0.01	0.03	0.02	0.04	0.02	0.16	69	2.10	0.08	0.04	2	0.15
45-60	0.9	1.2	97.90	5.00	4.80	0.01	0.02	0.05	0.02	0.03	0.09	100	15.30	0.07	0.05	1	0.01
Rudua (P13)																	
0-15	2.8	0.9	96.30	5.10	4.80	0.13	0.87	0.07	0.51	0.06	1.81	75	17.90	2.12	0.14	15	0.08
15-30	1.3	0.5	98.20	5.20	4.70	0.01	0.05	0.05	0.35	0.08	1.02	52	24.50	0.87	0.11	8	0.35
30-45	0.6	0.4	99.00	4.90	4.60	0.01	0.19	0.05	0.08	0.01	0.92	36	8.60	0.91	0.04	23	0.03
45-60	0.8	0.1	9910	5.00	4.90	0.01	0.01	0.06	0.03	0.01	0.31	35	1130	0.02	0.01	2	0.14
Jambu (P18)																	
0-15	1.8	0.5	97.70	5.00	4.00	0.0875	2.85	0.07	0.65	0.05	4.52	74	2.40	2.58	0.42	6	0.01
15-30	1.2	2.1	96.70	4.70	4.20	0.0051	0.87	0.07	0.03	0.02	2.51	39	0.90	0.43	0.05	9	0.01
30-45	0.8	2.3	96.90	4.80	4.20	0.0053	0.2	0.06	0.02	0.01	0.56	52	3.50	0.21	0.06	4	0.38
45-60	0.8	0.6	98.90	5.20	4.20	0.0079	0.05	0.06	0.02	0.01	0.38	37	6.20	0.15	0.02	8	0.02

Note: Adopted from Roslan *et al.* (2010) with some modification on the soil properties.

In the process of this work some observation were made as per the variation in the horizon base on time and degree of eluviations that exist among the accumulation of eluvial, indicating three soils (Table 3), Jambu series being the thickest among others.

Table 4 Classification of the soils according to soil taxonomy (Soil Survey Staff, 2010)

Profile	Sand (%)	Drainage class	Depth of Bh/Bhs (cm)	Series	Taxonomic classification
P4	97	Excessive	No spodic	Baging	Sandy, siliceous, isohyperthermic, typic, Quartzipsamments
P5	96	Moderately well	0-50	Rhu Tapai	Sandy, siliceous, isohyperthermic, arenic, Alorthods
P13	96	Excessive	50-100	Rudua	Sandy, siliceous, isohyperthermic, arenic, Alorthods
P18	97	Excessive	>100	Jambu	Sandy, siliceous, isohyperthermic, arenic, Alorthods

As the field work progresses observation are made continuously in the spodic horizon, which is termed as organic matter accumulation with some light-dark colored layer (Bhs), followed by light yellowish-red colored layer with little mixture of sandy/clay in some cases (Bs). No spodic activities present in the soil closer to the shoreline compare to the other two ridges that are different in terms of their horizon activities. Iron and other organic matters are the chief cementing agents that are responsible for the cementation process; as well the continual process of this action can lead to less drainage and penetration of rooting activities.

The BRIS soil of Terengganu plain and other soil series were not critically generalize according to their location, as the map used could not give a comprehensive detail on the delineation of each soil series. However, the underlying soil layers of mineral particles leached out of an overlying soil layer which also refers to as illuviation process and the movement of dissolved or suspended material within the soil (eluviations process), there by coursing the Baging soil with the youngest siliceous sediment to develop within a greater time frame, hence in (Table 4) the soil is classified as Entisols and as well, siliceous, isohyperthermic and sandy under the family of typic quartzipsament.

The Jambu series with spodic horizon found in Merang-Terengganu within the depth of 125 cm are classified as Spodosols, whereas the same Jambu series with spodic horizon within 150 cm is classified as Entisols according to soil taxonomy (Soil Survey Staff, 2010), this is vindicated in the finding of (Roslan *et al*, 2010).

Notwithstanding, the Rhu Tapai and Rudua series can be classified as Arenic Alorthods (Mohd Zainuri, 1981), as they both contain spodic horizon below 100 cm depth (Table 4). However it is the well to do soil that has the benefit of improving the standard of crop production in Malaysia, therefore in order to upgrade, sustain and increase agricultural production in these soils there is need for a specific soil management.

3.4. Ways to Improve the Soil for Increase Crop Production

To improve on the soil productivity, plant waste can be apply as mulching and as well manure when decomposed, while controlling the soil water loss (evaporation process). However plastic mulching can be used as well but with the introduction of fertigation to manage the nutrients and irrigation process.

The organic contents in Merang-Terengganu BRIS soil are insufficient for crop growth. In order to improve and sustain the soil production, a tradition of growing tobacco and crops in Merang-Terengganu plain has to be followed, (i.e. application of chicken dung and palm oil mills effluents). This process help to some extends in retaining soil nutrients and reduces water loss through the process of evaporation. With the application of chicken manures and inorganic fertilizer, Rudua and Jambu series (Spodosols) can be cultivated with chili and tomato with good output in harvesting.

Also the removal of eluvial horizon, a tradition that has gains little recognition in some part Rudua series (Table 5), of Merang plain. This is the process where the topsoil is removed to pave way for the subsoil (spodic layer), rich in organic contents which is suitable for crop nutrients uptake.

Table 5. Ways to improve the soil for increase crop production

Soil series	Crops	Ameliorant materials
Baging	Brijal, Maize.	Chicken dung and palm oil mills effluents)
Rhu Tapai	Bindih, Sweet potato	Fertigation, Mulching.etc.
Rudua	Coconut, Kenaf	Plastic mulching, Excavation, Chicken dung
Jambu	Tobacco, Pepper	Excavation, Palm oil mills effluents etc.

4. CONCLUTIONS

Soil series are occurring side by side which relate the coexistence of beach ridges running parallel in different elevation to the seashore.

All profiles show no clear differentiation of horizons and are dominated by sand fractions (95-98 %), silt and clay contends are below 4%.

According to soil taxonomy, Baging series are classified as Sandy, siliceous, isohyperthermic, typic, Quartzipsamments, Rhu Tapai is named as Sandy, siliceous, isohyperthermic, arenic, Alorthods, Rudua is identical with Sandy, siliceous, isohyperthermic, arenic, Alorthods and Jambu belongs to Sandy, siliceous, isohyperthermic, arenic, Alorthods.

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