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Maize Crop Production Constraint in Coastal Soil of Terengganu Region, Malaysia

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Abstract: *Coastal soils are regarded as marginal soils because the soils are too sandy (82-99 %), weakly structured, soil nutrient deficiency, having low water holding and retention capacity, limited ability to support plant growth and having a relatively high soil temperature. The research sites consist of three selected locations in the Setiu area of Terengganu, Malaysia lies at the elevations between 0-5m above sea level. Almost all profiles shows 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 is classified as sandy, siliceous, isohyperthermic, typic, quartzipsamments, RhuTapai 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. The results of land suitability evaluation using land characteristics for maize with actual class suitability of Baging (N1;w,f) suitable for growth and Rhu Tapai(S3;f), Rudua (S3;w,f) and Jambu (S3;f) marginally suitable class. While the potential classes of these soil improved with soil ameliorants, the following potential classes were achieved; Baging (S3;f), indicates that this soil (Rhu Tapai: S3;f) cannot be easily improve due to the fertility and soil physical characteristic surrounding it as well as Rudua (S3;f) and Jambu is (S3;f). With regard to the potential results. These finding can act as best practice for the rural dwellers.*

Key words: *Coastal soil, Soil Evaluation, Suitability of Maize Crop, Spodic zone.*

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1. INTRODUCTION

With limited resources and poor access to inputs, management of coastal soil quality is indispensable to strengthen and sustain ecosystem services. The suitability evaluation of these soil is usually determined by the robust success of produce cultivated in the study area. Undoubtedly, the assessment has often been used in reference to the term evaluation and attributes to the summary of a particular situation, thereby contributing to adequate experimental or analytical information about the soil. However, the basis criteria for a particular crop suitability classification is mainly aimed on the soil physical properties. Thus, in view of many constraints that are very common in the field of soil science, the study has continued to emulate the basis of soil science experts in the system, in order to produce a comprehensive soil classification.

Hence, Coastal soil is a challenging soil and as such should be handle traditionally in terms of the physical capability classification, knowing very well the constraints like, limited ability to support crop growth, poorly structured, low water retention, this is as a results of excessive accumulation of sediments and sand from undulating sea during the monsoon seasons that carries along coarse sand particles. Therefore, Coastal soils in Peninsular

Malaysia are mostly found near the coastal area in Terengganu with area of 67,582.61 ha, in Pahang around 36,017.17 ha, and in Kelantan about 17,806.20 ha (Mohd Ekhwan *et al.,* 2009). Therefore, the main objective of this article is to evaluate the physical properties of BRIS soil and the effort to increase of maize crop production.

2. MATERIALS AND METHODS

Description of Study Area

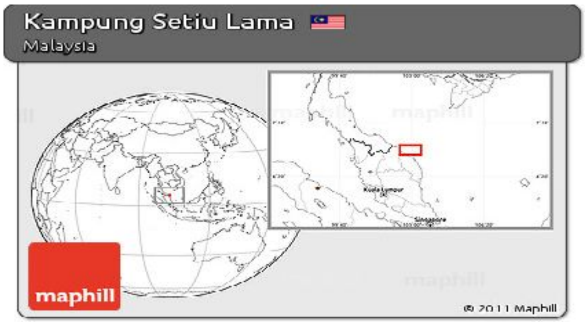
The research sites located in the Setiu area of Terengganu, Malaysia and the study was conducted around March to December 2013. The study area lies at the elevations in a range between 0-5 m a.s.l (m above sea level).The slope steepness is 0-3 % with a mean value around 2%. It is located at 05^0 12'20 norths and 103^0 12'21 easts, with temperature of 29^0c, the vegetation of the area is mostly grasses and shrubs. Some of the selected locations have soil parent materials of sand sediment by using geological maps with 1:50,000 scale. Most of soils are classified as BRIS (beach ridge intersperse with soils) soils (Entisol and Spodosols). Landsat images help to characterize the boundaries of the locations. The topographic characteristics included slope while the soil properties included soil texture, depth, salinity, and drainage and carbon materials. Also, soil properties such as Cation Exchange Capacity (CEC), organic matter (%OM) and pH were considered in terms of soil fertility (Sys et al., 1991). A soil profile pit was digged in land unit, and described using soil description guideline (FAO, 1990). Soil classification was made based on FAO (1998).

The Study Site

The research sites consist of some randomly selected locations in the East coast area of Terengganu, Malaysia (Figure 1 and 2. All the sites have the same natural condition except the vegetation (Adzemi, Armanto, and Zain, 2012). All the selected locations have the same soil parent materials of sand sediment by using geological maps with 1:100,000 scale. Topography map (Figure 2) help to characterize the boundaries of four locations. The topographic characteristics included slope and elevation while soil properties included soil texture, depth, salinity, drainage and carbonate content.

During the field visit, the soil descriptions were carried out for 3 soil profiles one per selected locations. The field descriptions of pits, borings and landscapes were divided into three categories for all intensities. General Field description was carried out according to American convention standards using vegetation, land use, climate, elevation and relief form (USDA, 1998 and Blume *et. al.,* 2011). After the conventional profile descriptions, the pits and the landscapes were photographed. Specific descriptions such as, designation of horizon depths, soil colors and mottles, depths of krokos (iron concrations), bulk density, gravel content, texture and roots were recorded.

All the individual soils tested were classified on soil descriptions corresponding to the analytical data and relief form with the help of the location map. The major horizons were identified using capital letter indicating master horizons and lower case letters qualifying as suffixes of the master horizons. A combination of capital letters was used for transitional horizons. The moist soil colors and mottles (abundant and size of mottles) were described using standard color notations (Hue, Value, Chroma) giving in the munsell soil color charts (2009). Krokos depths were determined in the field by observations of the auguring profile. Roots amount were calculated in dm^2. Gravel contents were estimated using a comparison table according to (Blume *et. al.,* 2011).



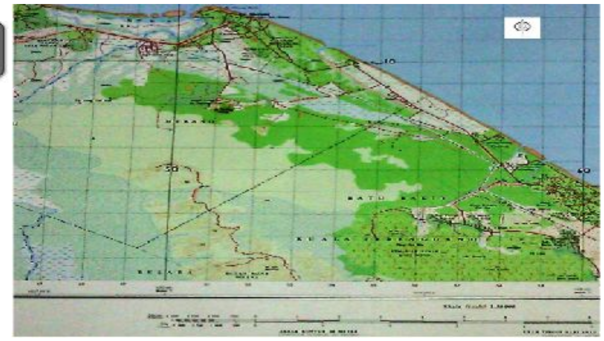


Fig. 1: location of study area, (Source: maphill 2011).

Fig. 2: Topography map of study area (Source: Dept. of Survey and Mapping Malaysia, 1992, modified).

Analytical Methods

Soil data collected at the revisited site of Roslan et.al (2010) was dried at 40^{o}C in a forced drought oven for 7 days and sieve to pass a 2mm mesh. Bulk density was determined using ring samples taken at the 3 horizons identified at the depths of 7-12 cm, 40-45cm and 90-95cm with each with four replications. A fragment greater than 2mm (gravel) was separated by sieving. Bulk density was measured gravimetrically from horizon samples taken with a hand- operated coring device. Particle size distribution was determined by wet sieving for sand, silt and clay fraction using the pipette method after pretreatment with HCL and H_2O_2 (Blume *et. al.,* 2011).Using an Inductive Electromagnetic Soil Conductivity Meter[1] for EC (Rhoades 1981).

The soil pH was determined in distilled water and an electrolyte solution of 0.01 N KCL (1:2.5 soils to solution) with a glass electrode. Total N and organic C were by the micro Kjeldahl- method and Walkley-Black (1934) procedures respectively. The Bouyoucos hydrometer method (Bouyoucos, 1962) was used for determining the soil particle size distribution. CEC was determined after leaching with 1.0 M ammonium acetate pH 7.0 and exchangeable K, Ca, Na and Mg were determined by ammonium acetate solution and measured by flame photometer for K and AAS (Atomic Absorption Spectrometer) for Ca, Na and Mg. Na is reported because very low contend in the soils and Fe was also determined. The extraction of the available P was done by the Bray 2 (acid fluoride) solution and measured by a spectrometer (Bray, *et. al.,*1945). Base saturation was calculated as the sum of exchangeable cations (Sparks *et. al.,* 1996):

$$Base\ saturation:\ = \frac{K + Mg + Ca}{CEC} \boldsymbol{x100}$$

3. RESULTS AND DISCUSSIONS

Physical condition of the study area

The soil in the study area of Setiu - Terengganu plains of Malaysia which is dominated by herbs and shrubs provides the soils with their debris that metamorphosed to form humus (acid humus), the soil is depleted of it physical capabilities with soil temperature ranging from 21 to 43^0 C, while the setback of water deficit around the months of February to June is a constrain to considered. The Eustatic effects that creates the undulating characteristics on the coastal plain, brings about the ridges and swales, whereby, ridges bring about the elevated section of the landscape while swales dominates the depression area.

Base on the Soil Taxonomy, the soil in the study area dominantly Entisols and Spodosols orders. Entisols at the location of study are still young and they are situated by the saturated water environment. They lack the presence of diagnostic horizons within a specific depth in their profile. Spodosols soil is commonly found in cool, moist, humid, or perhumid environments (Usman, Armanto, and Adzemi 2013). They can also be found in hot humid tropical regions etc. Surface litter composed of debris, breaks down in the presence of water to form a weak organic acid. Acidic soil water removes base ions in solution to create an acidic soil. Easily dissolved materials are leached from surface layers leaving behind the most resistant material like quartz creating an ashy-grey, near-surface layer. Layers at depth are stained with iron and aluminum oxides.

Determination and Analyses of Limiting Factors

The data obtained around March to December (2013) as stated earlier were evaluated for the suitability on a selected crops namely maize. The FAO, (1976 and 1981) manual land suitability was adopted to evaluate 4 soil series namely Baging, Rhu tapai, Rudua and Jambu. This research was able to identify which area is suitable for what crops. The reference crop table for the evaluation of land suitability for maize (Table 1), is explain in tabular form respectively.

Table 1: Land characteristics suitability for maize

			Range in Degree of Limitatoins				
Land Characteristics			0 98	1 85	2 60	3 45	4
Topography (t)	Slope %		0-2	2-4	4-8	8-16	>16
	Flooding		No	No	No	Slight	Mod. Severe
Wetness(w)	Drainage		Good	Moderate	Imperfect	Poor	Very poor
			Imperfect	Moderate	Good	Poor	Very poor
	Texture		Co Cs SC	SCL	SL	LS	S
	Depth(cm)		>90	50-90	20-50	10-20	<10
Physical soil condition (s)	Subsurface stoniness		0-15%at any depth	15-40%within 50cm	40-75%within 50cm	>75 b/w10-20cm	75%within 10cm
		CEC	16-24	<16 (--ve)			
		O.M.	>2	1.5-2.0	0.7-1.5	<0.7	
Soil fertility characteristc(f)	Typic	BS(A)	>80	50-80	35-50	<35	
		BS(B)	>50	>50	<50	<50	
	Arenic	BS(A)	>35	20-35	<20		
		BS(B)	50	Any	any		

Note: Co =Granular or weak subangular blocky spodosol, Cs = Angular or subangular blocky structure of argillic and cambic horizon, BS = Base saturation, OM= Organic matter, (A) and (B) = A and B horizons, ve = negative and positive charge SC= Sandy clay, SCL=Sandy clay loam, SL=Sandy loam, LS=Loamy sand, S=Sandy. (Source FAO 1979, 1980)

Table 2: Characterize land units according to land characteristics

Land unit	Topography	Wetness (w)		Physical soil characteristic (s)		Natural fertility (f)		
(soil series)	(t) %	Drainage	Flooding	Texture	Depth(cm)	CEC	B.S (%)	O.M (%)
Baging	0-2	w.d.		S	0-15	1.27	52	0.37
	0-1	w.d		S	15-30	0.59	93	0.19
	0-2	w.d		S	>40	0.80	63	0.09
Rhu tapai	0-1	w.d		S	0-15	2.12	86	1.8
	0-1	w.d		S	15-30	0.32	28	0.52
	0-2	w.d		S	>40	0.16	69	0.08
Rudua	0-2	w.d		SL	0-15	1.81	83	2.12
	0-2	w.d		S	15-30	0.02	36	0.87
	0-2	w.d		S	>40	0.92	123	0.91
Jambu	0-1	w.d		S	0-15	4.52	81	2.58
	0-2	w.d		SC	15-30	2.51	39	0.43
	0-1	w.d		SC	>40	0.56	52	0.21

Note: SC – Sandy clay, S—Sand, SL—Sandy loam, w.d – well-draine

Land suitability evaluation for maize on BRIS soil

Maize is a tropical or temperate crop as it grown under extreme divergence weather condition, thus it is a warm weather loving crop. Hence maize crop cannot succeed or withstand the frost at any stage during the growing period.

Soil that is normally sandy in nature can equally do well in the production of maize, as they require deep fertile and well-drained soil which are rich in organic content, thus maize can be grown in any kind of soil measuring from a deep heavy to light Coastal/BRIS soil. However, soil should maintain the range of texture with good water holding capacity and with the pH that does not exceed the range of 7.5. During the period of seedling stages, maize crop is highly susceptible to water logged area, as such care need to be taken into consideration in order to control water not to stagnate at the surface area of the planted crop for a longer time of 4 to 5 hours. Hence, BRIS soil with one of the threshold of water holding capacity will make an impact in the production of maize crop, as it has the quality of proper drainage essential when it comes to the successful cultivation of maize crop. Thus, it is observed from the local farmers that the most ideal soil for maize crops is silt loam or loam topsoil and also fair brown silt clay loam with a fairly sandy which has the pH of 6 to 7.5.

The previous work of Adzemi (2014) and Usman, Armanto, and Adzemi (2013) which stated that at the lower elevation sedimentary aggregation is mostly predominant. Thus, a recent activity in the riverine and marine alluvium occurs on coastal plains and the inland low hills. The evaluation of land (Table 3) for maize cultivation with the use of land characteristics and landscape criteria as adopted from Sys *et. al*. (1991). With the utilization of land evaluation in beach ridge soil classification system i.e., soil crop suitability classification of (FAO 1976; Sys C. 1985), the ability to use the available data collected during the field study and the prospect to use it in the production of maize crop is a way out and has frequently been used to evaluate the fertility status of soil in Peninsular Malaysia. However, the classification system is used mainly for the purposes of crop yield and growth which is basically on physical limitations and in some cases chemical limitation properties as well.

Table 3: Evaluation of the Land suitability for Maize according to Land Characteristics

Soil	Topography (t)	Drainage (w)	Physical soil characteristics(s)			Fertility characteristics 0-5 cm (f)			Land indices	Suitability subclass
	Slope		Texture	Depth	Subsurface stoniness	CEC	BS	O.C.		
Udicpsamment	0(100)	2(80)	1(98)	0(100)	0(100)	2(75)	2(80)	3(55)	26	S3;w,f
arenic,siliceous, QP	0 (100)	2(80)	2(75)	0(100)	0(100)	1(98)	3(60)	4(40)	14	N1;w,s,f
sandy,IT, alorthod	0(100)	2(80)	1(90)	0(100)	0(100)	2(75)	2(80)	3(55)	24	N1;w,f
sandy,IT, alorthod	0(100)	2(80)	2(75)	0(100)	0(100)	1(98)	3(60)	4(40)	14	N1;s,f
typic, psammaquents ,IT	0(100)	2(80)	2(75)	0(100)	0(100)	1(98)	3(60)	4(40)	14	N1;s,f
Sandy,siliceous typic QP	0(100)	2(80)	2(75)	0(100)	0(100)	1(98)	3(60)	4(40)	14	N1;s,f
Sandy,siliceous typic QP	0(100)	0(100)	1(90)	0(100)	0(100)	1(90)	3(60)	2(80)	39	S3;f
sandy,Siliceous, QP	0(100)	2(75)	1(90)	0(100)	0(100)	1(90)	3(60)	2(80)	29	S3;w,f
typic, psammaquents ,IT	0(100)	0(100)	0(100)	1(90)	0(100)	2(75)	2(80)	2(80)	43	S3;f
arenic,siliceous, QP	0(100)	2(75)	1(90)	0(100)	0(100)	1(90)	2-3(60)	2(80)	29	S3;w,f

Source: FAO 1976, Note: QP = Quartzipsamment, IT = isohyperthermic

From the data in table 3, the most limiting factor is nutrient retention follow by soil texture and fertility; it is likely that some available management can upgrade the suitability class from actual to the potential suitability class, thus the texture is weakly structure, in such a way that the water impedes nutrients through the soil horizon. From the top soil to lower or adjacent ground level as quickly as the root can take up water and also the adverse effects of evapotranspiration. Furthermore, this reduces the nutrients state as most of it are quickly or excessively moved laterally during the flow of water through the soil horizon as a result of the large pore spaces which shift and disperse the nutrients to the lower elevation in the substrate, through water movement

Suitability

Base on the limiting factors, the following limitation could be express as the identifier of suitability class, such as nutrient retention/low fertility (nr), slope/erosion hazard (eh), oxygen availability/poor drainage (oa), rooting condition (rc), flood hazard/water inundation (fh), and peaty soil (ps). Hence, the physical and chemical properties of BRIS soil in the study area also contribute greatly in the suitability criteria. However, the value of CEC is less than <5 $cmo1_c$ kg^1 and the pH value around 4 to 5 shows that crops can be a threat as result of the acidity.

However, the spodic horizons of the soil contain some appreciable amounts of organic carbon with respect to the soil profile. This implies that spodic zone is more fertile in soil organic content and has the ability and potential to grow maize and other shallow rooted plants, the facts is supported in MARDI (2010). With the fine to very fine soil particles that dominate the horizon, indicating cemented horizon (hardpan). It is believe to enhance soil management practices, like land leveling, mulching and irrigation.

Table 4: Actual Suitability classification of the land suitability for maize cultivation by using land characteristics

Soil	Topo graphy	Wetness (w)		Physical soil characteristics (s)		Fertility characteristics 0-5 cm (f)			Land index	Suitability class
	Slope (t)	flooding	Drainage	Texture	Depth	CEC	BS	O.C.		
Baging	0(100)	0(100)	0(100)	1(98)	2(80)	2(75)	2(80)	3(55)	26	N1;w,f
Rhu Tapai	0(100)	0(100)	0(100)	2(85)	1(90)	1(90)	2(80)	2(80)	44	S3;f,s
Rudua	0(100)	0(100)	2(80)	2(80)	1(90)	2(85)	1(95)	2(70)	32	S3;w,f
Jambu	0(100)	0(100)	0(100)	1(90)	1(90)	2(85)	2(80)	2(85)	47	S3; f

However, when the potential class are managed by improving on the actual class with the ameliorants, then the following potential classes will be as; Baging, marginally suitable soil (S3;f) this indicates that this class cannot be easily improve due to the economic constrain surrounding the soil, whereas the potential class for Rhu Tapai, (S3;f), Rudua (S3; f) and Jambu are marginally suitable soil (S3; f) as shown in table 5.

Table 5: Potential suitability classification of the land suitability for maize cultivation by using land characteristics

Soil	Topo Graphy	Wetness (w)		Physical soil characteristics (s)		Fertility characteristics 0-5 cm (f)			Land index	Suitability class
	Slope (t)	flooding	Drainage	Texture	Depth	CEC	BS	O.C.		
Baging	0(100)	0(100)	0(100)	1(98)	0(100)	2(85)	2(90)	2(85)	64	S3;f
Rhu Tapai	0(100)	0(100)	0(100)	1(90)	1(90)	1(95)	0(100)	2(85)	65	S3;f
Rudua	0(100)	0(100)	0(100)	1(90)	0(100)	2(80)	1(90)	1(90)	58	S3; f
Jambu	0(100)	0(100)	1(90)	1(90)	1(90)	2(85)	2(85)	2(85)	45	S3; f

Limiting factors

In order to manage the limitations of maize production, the suitability characteristic can only be achieve through the matching procedure of land characteristics data available at hand. In every land mapping unit against the crop requirement manually as the area is not very vast area to evaluate and on a single crop at a time which can also be very time consuming when dealing with it physically. As it requires more concentration in carry out the procedure, which is based on the most serious limiting factors of soil classifications. Most of the areas are classified as marginally suitable for maize due to some threshold like wetness, physical soil properties and fertility characteristics constraints. This can be evaluated from the actual suitability classification of the land units for maize cultivation by using land characteristics and the crop requirement as the Baging with actual class suitability of (N1;w,f), is not suitable for growth due to above mention constrains as in table

4 and Rhu Tapai marginally suitable soil (S3;f,s), Rudua (S3;w,f) and Jambu (S3; f) are marginally suitable class as well.

4. CONCLUSION

This study was done to evaluate the limiting factors for growth and production of maize crops in Coastal soils of Baging, Rhu Tapai, Rudua and Jambu soil series with efforts to examine the soil suitability of the study location.

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

2) According to soil taxonomy, Baging series are classified as Sandy, siliceous, isohyperthermic, typic, quartzipsamments, RhuTapai 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.

The results of Baging (N1;w,f) is not suitable for growth and Rhu Tapai (S3; f), Rudua (S3;w,f) and Jambu (S3;f) are marginally suitable class . However, the potential classes of these soil, if improved with soil ameliorants, the following potential classes emerge; Baging marginally suitable soil (S3;f), this indicates that this class Rhu Tapai: marginally suitable soil (S3;f), cannot be easily improve due to the fertility and soil physical characteristic surrounding it,as well as Rudua (S3; f) and Jambu are (S3; f) marginally suitable soil.

It is generally concluded that increase in organic matter and leaching control can revive the soil, with regard to the potential results. These finding can act as best practice for the rural dwellers.

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