UNIVERSITI PUTRA MALAYSIA

ESTABLISHMENT OF VEGETATION ON EXPOSED CARBONACEOUS SHALE FROM CUT SLOPE

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Agricultural Science
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Dedicated to

Allah S.W.T

My Parents,

Hj. Md. Isa Salleh & Hajjah Inshah Idris,

My Mother In-Law, Hajjah Zaiton Mansor

My Lovely Wife, Zura

And my beloved son, Muhammad Firdaus Haziq

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Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirement of the degree of Master Of Agricultural Science.

ESTABLISHMENT OF VEGETATION ON EXPOSED CARBONACEOUS SHALE FROM CUT SLOPE

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ISHARUDIN

February 2002

Chairman : Dr. Syed Omar Syed Rastan

Faculty : Agriculture

Shale is a common rock type in Malaysia. Some of the shales are carbonaceous in nature. Carbonaceous shale is exposed during construction of major highways. The instability on cut slopes contributes to soil erosion and in extreme cases slope failure may occur. The susceptibility of cut slopes to landsliding can be reduced in certain circumstances by establishment of a vegetation cover. The objective of this study were to determine the chemical properties of carbonaceous shale, suitable plants mix species and appropriate amendment for carbonaceous shale, and shear strength analysis upon establishment of the vegetation.

Initial carbonaceous shale chemical properties were identified before conducting a glasshouse experiment to determine the effect of plant species and

soil treatments on dry matter yield in pot experiments consisting of 4 plants species, 5 treatments and 4 replications. Completely randomized design was adopted in this experiment. The plants species (*Brachiaria ruziziensis, Colopogonium mucunoides, Axonopus affinis* and *Veteveria zizanioides*) were planted and treated with ground magnesium limestone (GML), chemical fertilizer (NPK), organic compost (Com), NPK+GML+compost (NGC) and control (Ctrl). Infiltration rate was determined using modified Double Ring Infiltrometer which was driven into the pot. The plant species that gave a relatively high dry matter yield from the glasshouse experiment *Brachiaria ruziziensis* and *Colopogonium mucunoides* were selected for the mix plant species study. The plants were grown in the wooden boxes measuring 20 cm (length) X 20 cm (width) X 100 cm (height). They were treated with compound fertilizer (NPK), NPK + GML (NGL), NPK + GML + foliar fertilizer (Vita-Grow^{TM})(NGF) and control (Ctrl). Complete randomized experimental design was adopted with five replications in this experiment. The shear strength analysis was conducted using the direct shear test method where the angle of internal friction (ϕ) and cohesion (c) were determined from the plotted graph in order to get the shear strength result.

The result showed that the initial chemical properties of carbonaceous shale were lower in pH, extractable P, basic cations (Ca, Mg and K) and micronutrients (Fe, Cu and Zn) as compared to the optimum nutrient requirements. The low in both P and Ca/Mg in carbonaceous shale may result in poor root developments. Although infiltration rate (IR) was low or near zero, based on the cumulative water

infiltration, water could still penetrate through the carbonaceous shale profile and absorbed by the roots of the plant. The result had indicated that *Brachiaria ruziziensis* and *Colopogonium mucunoides* gave a relatively high water infiltration rate compared to other plant species. The result showed that the dry matter yield, root length and root weight of *Brachiaria ruziziensis* and *Colopogonium mucunoides* responded toward the soil treatments. Soil treated with NGF treatment increased the plant dry matter yield and root weight significantly. The increased of plant top and root dry weight treated with NGF were 26% and 38%, respectively, compared with the NGL treatment. The positive effect of the foliar fertilizer was probably due to better absorption of the chelated micronutrients. Plant mix species which were treated with NGF would be the best option to be adopted on the carbonaceous shale. This is probably due to better root anchorage and increased in the shear strength along the 100 cm depth.

The roots of plant mix species increased the shear strength through the binding action on the carbonaceous shale mass and may contribute to the resistance from sliding. This study indicated that carbonaceous shale could be stabilized by the plant mix species (*Brachiaria ruziziensis* + *Colopogonium mucunoides*) and proper fertilizer management. The advantage of using the legume is that, it is able to fix the atmospheric nitrogen into the soil.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat keprerluan untuk mendapatkan Ijazah Master Sains Pertanian

Mewujudkan Tumbuhan di atas Syel Berkarbon

Oleh

ISHARUDIN

Februari 2002

Pengerusi : Dr. Syed Omar Syed Rastan.

Fakulti : Pertanian.

Syel adalah merupakan sejenis batuan yang biasa terdapat di Malaysia. Kebanyakan batuan syel adalah semulajadinya berkarbon. Syel berkarbon didedahkan semasa pembinaan lebuhraya utama. Ketidakstabilan cerun yang dipotong menyumbangkan kepada hakisan tanah dan dalam kes yang serius kegagalan cerun akan berlaku. Keresistanan cerun yang dipotong terhadap tanah runtuh boleh dikurangkan pada sesuatu keadaan dengan menanam tumbuhan penutup bumi. Objektif kajian ini adalah untuk menentukan sifat kimia syel berkarbon, spesies tumbuhan campuran yang sesuai dan bahan pembaiktanah yang berkesan untuk syel berkarbon dan analisis kekuatan ricih selepas pertumbuhan tanaman penutup.

Sifat awal kimia syel berkarbon dikenalpasti sebelum dijalankan eksperimen di rumah kaca bagi menentukan kesan spesies tumbuhan dan rawatan ke atas hasil berat kering dengan menggunakan eksperimen di dalam pasu dengan 4 spesies tumbuhan, 5 rawatan dan 4 replikasi. Rekabentuk rawak lengkap digunakan dalam eksperimen ini. Spesies tumbuhan (*Brachiaria ruziziensis, Colopogonium mucunoides, Axonopus affinis* dan *Veteveria zizanioides*) ditanam dan dirawat dengan kapur (ground magnesium limestone, GML), NPK (baja kimia), kompos organik (Com), kombinasi NPK+GML+ kompos (NGC) dan kawalan (Ctrl). Penentuan kadar infiltrasi air dijalankan dengan kaedah pengubahsuaian daripada Infiltrometer Dua Lingkaran yang dimasukkan ke dalam pasu. Spesies tumbuhan yang secara perbandingan, telah memberi hasil berat kering yang tinggi daripada eksperimen rumah kaca telah dipilih untuk kajian campuran spesies tumbuhan. Tumbuhan yang dipilih ialah *Brachiaria ruziziensis* dan *Colopogonium mucunoides*. Tumbuhan tersebut ditanam di dalam kotak kayu berukuran 20 sm X 20 sm X 100 sm. Tumbuhan tersebut dirawat dengan baja NPK, NPK+GML (NGL), NPK+GML+ baja daun (Vita-Grow^{TM})(NGF) dan kawalan (Ctrl). Rekabentuk rawak lengkap digunakan dengan lima replikasi di dalam eksperimen ini. Analisis kekuatan ricih dijalankan dengan menggunakan kaedah Ujian Kotak Ricih di mana sudut geseran (ϕ) dan nilai kejeleketan tanah (c) ditentukan daripada graf yang diplot bagi mendapatkan kekuatan ricih.

Keputusan menunjukkan syel berkarbon adalah rendah bagi pH, kation bes (Ca, Mg dan K) dan mikronutrien (Fe, Cu dan Zn) berbanding keperluan optimum

nutrien. Fosforus dan Ca/Mg yang rendah pada syel berkarbon menyebabkan perkembangan akar yang lemah. Kadar infiltrasi air adalah sangat rendah atau menghampiri sifar, berdasarkan kepada kumulatif infiltrasi air, air masih boleh menembusi melalui profil syel berkarbon dan diserap oleh akar tumbuhan. Keputusan menunjukkan spesies *Brachiaria ruziziensis* dan *Colopogonium mucunoides* memberikan secara bandingan infiltrasi air yang tinggi berbanding dengan yang selainnya. Keputusan menunjukkan hasil berat kering, panjang akar, dan berat akar bagi *Brachiaria ruziziensis* dan *Colopogonium mucunoides* memberikan tindakbalas positif terhadap rawatan tanah. Rawatan tanah dengan NPK+GML+ baja daun (Vita-Grow^{TM}) meningkatkan hasil berat kering tumbuhan dan berat akar secara beerti. Peningkatan berat kering tumbuhan dan akar setelah dirawat dengan baja daun meningkat sebanyak 26% dan 38% berbanding baja NGL. Kesan positif daripada baja daun kemungkinan disebabkan oleh penyerapan yang baik mikronutrien yang dikelat. Campuran spesies tumbuhan yang dirawat dengan NGF akan menjadi alternatif terbaik yang boleh digunakan pada syel barkarbon. lni adalah kemungkinan disebabkan oleh kekuatan akar yang baik dan peningkatan kekuatan ricih sedalam 100 sm.

Akar daripada campuran spesies tumbuhan meningkatkan kekuatan melalui tindakan pengikatan dengan syel barkarbon dan menyumbangkan kepada rintangan menggelongsor. Kajian ini menunjukkan syel berkarbon dapat distabilkan dengan campuran spesies tumbuhan (rumput dan kekacang) dan pengurusan pembajaan

yang sesuai. Kelebihan menggunakan kekacang adalah kemampuan untuk mengikat nitrogen daripada atmosfera ke dalam tanah.

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Agricultural Science.

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LIST OF ABBREVIATIONS

mL	milliliter
kg	kilogram
g	gram
kN	kilo Newton
ppm	part per million
cm	centimeter
m	meter
mm	millimeter
ha	hectare
N	Nitrogen
P	Phosphorus
K	Potassium
Ca	Calcium
Mg	Magnesium
GML	Ground Magnesium Limestone
Al	Aluminium
O.M	Organic matter
C	Carbon
kN/m^2	kilo Newton per meter square

CHAPTER I

INTRODUCTION

Soil is defined as a dynamic body of the earth's surface composed of mineral (nutrients) and organic material that support plant growth (Brady, 1990). Soil, as a general term usually denotes the unconsolidated, thin, variable layer of mineral and organic material, usually biologically active, which covers most of the earth's land surface. Soil develops from some starting material such as consolidated rock or unconsolidated material called parent material. The process of dissolution and reformation of new minerals is part of the process of weathering (Singer and Munns, 1996). The engineers classified soils as regolith where the unconsolidated mantle of weathered rock and soil material on the earth's surface; loose earth materials above solid rock including horizon A, B and C from the soil profile (Brady, 1990), while the soil scientists consider soil as A and B horizons (solum), which can support plant growth.

The C and R horizons are not part of the solum and are unable to support plant growth due to their infertility. After a long period of weathering, C and R horizons will become a solum (soil). It has been shown that parent material (shale) often fails to support successful growth of vegetation. This is due to low pH and low exchangeable P, basic cations (Ca, Mg and K) and micronutrients (Fe, Cu and

Zn) as compared to the optimum nutrients requirements for plant growth (Plank, 1989).

The low in both P and Ca/Mg ratio in carbonaceous shale may result in poor root developments (Isharudin et al., 2000). In Malaysia, carbonaceous shale is exposed and normally found on the cut slopes along the highways. Poor growth of vegetation on this cut slopes may be the cause of major soil erosion and in extreme case a landslide may occur.

Malaysia is situated in a tropical climate with heavy rainfall ranging from 2000mm to 3000mm and temperatures ranging from 25.6 to 27.8 ^{O}C throughout the year (Shamshuddin et al., 1998). These conditions tend to accelerate erosion process. Water is the most important causative factor in the failure of the cut slopes in this country. Water, in fact has been implicated as either the controlling factor or a primary controlling factor in 95% of all slope failures (Chassie and Goughnour, 1976). The majority of slope failures in Malaysia occur during and after a period of heavy rainfall (IKRAM, 1993). Generally, steep land tends to be relatively low in chemical fertility, with strong accumulations of nutrients in the surface layer. The loss of this layer can cause a rapid decline in soil productivity.

Vegetation and cover crops are used to protect the slopes in areas which are prone to surface erosion. The root system of plant plays an important role in soil erosion controlled by binding soil particles physically into stable aggregates.

Establishment of cover crops to reduce erosion has been widely practiced (Maene and Sulaiman, 1980). Creeping leguminous cover has better residual effect than grasses or natural covers. These legumes improve soil physical characteristics (Soong and Yap, 1976). Grasses and legumes are commonly used because of its ability to enrich soil with nutrients. It also has the ability to fix atmospheric nitrogen. Vegetation can ameliorate many of the factors and conditions causing instability by erosion.

Grass turfing method is a very popular method due to its simple application and ease of supply. Turfing needs proper management with regular watering and fertilization to ensure successful growth. Poor growth by the turf grass may cause extreme erosion forming rill and gully between the turfs. Legumes also produce a lot of surface mulch, which reduces water erosion by reducing raindrop impact, increasing soil infiltration rate, decreasing crusting and surface sealing, increasing surface storage of water runoff, decreasing runoff velocity, improving soil structure and porosity and improving biological activity related to soil fertility.

An understanding of the soil fertility and the reasons of vegetation failure on carbonaceous shale need to be identified by introducing proper fertilizer application and vegetation species in sustaining their successful growth on this material.