**UNIVERSITI PUTRA MALAYSIA**

# MARLING A REGOSOL OF CENTRAL JAVA AND ITS EFFECT ON MAIZE CROP PERFORMANCE

**BAMBANG DJADMO KERTONEGORO**

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# MARLING A REGOSOL OF CENTRAL JAVA AND ITS EFFECT ON MAIZE CROP PERFORMANCE

By

**BAMBANG DJADMO KERTONEGORO**

**Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of Philosophy in the Faculty of Agriculture Universiti Putra Malaysia**

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# DEDICATION

The author would like to dedicate this thesis entitled, "Marling A Regosol of Central Java and Its Effect on Maize Crop Performance", to his alma mater, Gadjah Mada University, in Yogyakarta. He regards his alma mater as a prestigious community in which he and his family have been nurtured and guided towards a scientific and society oriented family.

Through this university too, the author has received opportunities to broaden his knowledge in Agricultural Science in general, and Soil Science in particular.

In this dedication, the author would like to express his sincere appreciation to his alma mater for her guidance and encouragement.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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**Chairman : Professor Wan Sulaiman Wan Harun, Ph.D.**

**Faculty : Agriculture**

In this study, a sandy soil (Regosol) derived from volcanic debris is amended with clay soils (Latosol and Grumusol) taken from different localities, with the objective of increasing the productivity of the Regosol as a marginal land.

Soil samples taken from the top 30 cm of the soil surface are dried, ground, and passed through a sieve with 2.0 mm openings. The Regosol is then thoroughly mixed with the Latosol or Grumusol based on oven weight percentage of 0%, 10%, 20%, 30%, 40% ,50%, and 100% of the Latosol or Grumusol.

Mineralogical analyses indicate that the sandy soil (Regosol) is mainly dominated by feldspars and cristobalite while the clay Latosol contains mainly 1:1 type clay minerals of the kaolinite type and most probably layers of halloysite, metahalloysite or kaolinite, with some cristobalite in it. The Grumusol, on the other hand, is dominated by open 2:1 clay minerals (swelling clay, smectite) mixed with 1:1 type such as halloysite, metahalloysite or kaolinite.

The addition of clay soils to the sandy soil changes the textural class towards clay. The particle density and the bulk density of the soil mixture decrease. The total porosity increases. The oxygen diffusion rate (ODR) in the soil mixture is influenced by the water content. Most of the ODR curves are lifted sharply when the matric potential decreases below – 2 kPa. The saturated hydraulic conductivity declines significantly after the addition of 10% to 20% of clay soils. Mixtures containing more than 40% clay soil show similar patterns as those of the original clay soils, while those containing less than 40% clay soil show intermediate behaviour between the sandy soil and the clay soils. The addition of 30% of clay soil causes a substantial reduction in the rate and maximum height of capillary rise during a ten-hour period of observation.

With increasing amounts of clay soils added, the Atterberg limits, namely the liquid limit (LL), sticky point (SP), and plastic limit (PL), generally increase with increasing amounts of clay soils added. The mechanical resistance declines when the condition is moist. When dry, Grumusol increases mechanical resistance substantially. The aggregate stability tends to decrease, even though there is a tendency for the number of aggregates each with a diameter bigger than 2.0 mm to increase. The response of the soil mixture to the Proctor standard compaction shows that 10% to 40% mixture of Latosol or 10% to 50% of Grumusol brings about an increase in dry soil bulk density. The maximum dry bulk density values of the mixtures are achieved at different critical moisture contents.

The pH of the mixture tends to shift towards those of the clay soils. The pH in the Latosol mixture decreases gradually from 6.33 to 5.97 due to the lower pH of Latosol than Regosol. In the Grumusol mixture, a 10% addition of Grumusol causes a substantial increase in the pH from 6.33 to 7.05 which is followed by a more gradual increase from 7.12 to 7.36. This may be the result of a dilution effect. The organic carbon and cation exchange capacity (CEC) increase linearly. The electrical conductivity (EC) shows a gradual increase, but in the Grumusol mixture the increase is more linear.

The results of the field experiment with maize reveal that an addition of 20% Latosol or 30% Grumusol are promising mixtures for increasing maize yields. These mixture percentages seem to have an optimum physical and chemical properties combination which is suitable for the growth of maize.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMARELAN TANAH REGOSOL DI JAWA -TENGAH DAN KEBERKESANANNYA ATAS TUMBESARAN TANAMAN JAGUNG**

**Oleh**

**BAMBANG DJADMO KERTONEGORO**

**December 2000**

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Dalam kajian ini, tanah Regosol bertekstur pasir kasar hasil aktiviti gunung berapi, dicampur dengan tanah-tanah berkandungan lempung tinggi, iaitu Latosol ataupun Grumusol, dengan tujuan untuk meningkatkan produktivitinya. Sampel tanah diambil daripada tanah sedalam 30 cm. Tanah-tanah ini kemudiannya dikeringudara, ditumbuk, dan ditapis dengan tapisan 2.0 mm. Tanah pasir dicampur dengan tanah lempung samada Latosol atau Grumusol pada aras : 0%, 10%, 20%, 30%, 40%, 50%, dan 100% tanah lempung berdasarkan peratusan berat kering ketuhar. Percubaan menggunakan tanaman jagung juga dilakukan di ladang pada tanah-tanah campuran serupa.

Hasil-hasil kajian menunjukkan bahawa penambahan tanah lempung kepada tanah gunung berpasir kasar telah mengubah tekstur sehingga menjadi lempung. Ketumpatan zarah dan ketumpatan pukal menurun. Porositi keseluruhannya meningkat akibat penambahan tanah lempung. Laju difusi oksigen meningkat sedikit

sejajar dengan jumlah penambahan tanah lempung dan dengan berkurangnya kandungan air. Konduktiviti dalam keadaan tepu air menurun sejajar dengan jumlah penambahan tanah lempung yang diberikan. Penambahan 10% hingga 20% tanah lempung menurunkan secara nyata konduktiviti tepu air.

Nilai had Atterberg, iaitu, had cecair (LL), titik lekat (SP) dan had plastik (PL), pada amnya, selalu meningkat. Rintangan mekanik meningkat sejajar dengan berkurangnya kandungan air dan meningkatnya paras kandungan lempung. Dalam keadaan basah ataupun lembab, rintangan mekanik tertinggi pada tanah pasir tulin, kemudiannya diikuti pada campuran 20% dan 30%. Campuran tanah Grumusol menunjukkan rintangan mekanik (pada keadaan kering) yang lebih tinggi daripada campuran dengan Latosol.

Tindakbalas tanah campuran terhadap tenaga penumpatan meningkat apabila 10% hingga 40% tanah lempung Latosol diberikan, tetapi pada penambahan dengan Grumusol berkesan apabila 10% hingga 50% tanah diberikan. Penambahan tanah lempung melebihi 50% menunjukkan penumpatan tidak bertindakbalas. Penumpatan maksimum dicapai pada kandungan air yang berbeza-beza.

Nilai pH tanah meningkat dengan nyata daripada 6.33 ke 7.36 setelah dicampur dengan Grumusol dan menurun sedikit daripada 6.33 ke 5.97 setelah dicampur Latosol. Keupayaan pertukaran kation (KPK) meningkat secara linear, kandungan kapur meningkat secara kwadratik, bahan organik meningkat secara linear, dan begitu pula kandungan bes tertukarkan meningkat secara linear.

Paras campuran 20% bagi Latosol dan 30% bagi Grumusol memberikan pengaruh yang nyata bagi tumbesaran dan hasil tanaman jagung. Paras campuran ini paling berkesan, kerana ianya memberikan keadaan fizikal dan kemikal yang optimum bagi tanaman.

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| | |
|---|---|
| $\rho_s$ | soil particle density, Mg $m^{-3}$ |
| $\rho_b$ | soil dry bulk density, Mg $m^{-3}$ |
| n | total porosity, % |
| $K_s$ | saturated hydraulic conductivity, cm $h^{-1}$ |
| K(h) | hydraulic conductivity as a function of matric potential |
| K(θ) | hydraulic conductivity as a function of moisture content |
| D(θ) | diffusifity as function of soil moisture |
| A | cross section area of a soil sample perpendicular to the direction of water flow, $cm^2$ |
| L | length of soil sample, cm |
| ΔH | hydraulic head difference, cm |
| Q | volume of water passing through the cross sectional area of the soil sample perpendicular to the direction of water flow, $cm^3$ |
| Ψm | matric potential, - cm $H_2O$ or kPa |
| Ψ(θ) | matric potential as a function of moisture content |
| h | matric head, - cm $H_2O$ or kPa |
| i | observed microelectrode current, μA |
| pH | unit of acidity |