

NOTE ON THE WATER CHARACTERISTICS AND MINERALOGY OF A SOIL CONTAINING DIAGNOSTIC PUMICE

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ABSTRACT

Soil samples from Hoskins, New Britain, containing diagnostic pumice were analysed. While allophane was found in the samples, its high silicon content suggests it would not adsorb phosphate strongly. The amount of water held by the soil that would be readily available to plants is unusually large. It is suggested this will buffer the effect of uneven rainfall distribution throughout the year.

INTRODUCTION

SIGNIFICANT amounts of particulate pumice are found in some volcanic ash soils. In the Hoskins area of New Britain such soils occur, and in some instances are being used to grow oil palm. The effect of this pumice on the basic physical and chemical properties of the soil is not well understood and is a matter of some interest. While pumice soils are thought to hold large amounts of water, how much is held and whether this water is readily available to plants appears not to be known. Furthermore, soils developed on pumice or volcanic ash often contain the amorphous clay mineral allophane. This mineral has a large specific surface and is very reactive; it stabilizes soil organic matter and can strongly adsorb phosphate. The water characteristics and mineralogy of pumice soil from Mosa, Hoskins (New Britain) are reported here.

MATERIALS AND METHODS

Soil samples were collected at the Mosa block from depths of 0 to 5 cm and 50 to 55 cm and stored in sealed polythene bags. The soil profile is described in the *Table*. The rainfall at the site is 400 cm per annum.

For the mineralogical analysis the clay fraction (less than 2μ) was separated by centrifugation after ultrasonic dispersion at pH 10 with sodium hydroxide. The clay was treated to remove free iron with dithionite-citrate, then with 2 per cent Na_2CO_3 and 0.5M NaOH according to Wada and Greenland (1970).

Table 1.—Profile description of the Mosa soil

Depth (cm)	Description
0—7	Moist very dark brown (5 YR 2/2) friable loam with fine sub-angular blocky structure, pH 7
7—35	Moist yellowish brown (10 YR 5/4) structureless sandy loam, pH 6.5
35—50	Intermediate ash and pumice layers relatively unweathered
50—55	Moist brown (7 YR 4/4) structureless gravelly loam, pH 6

The amount of clay dissolved at each extraction was determined. The clay minerals were determined with a Perkin Elmer 257 infrared spectrometer and by X-ray powder photography using a Phillips PW1120 generator.

The relation between matric potential and gravimetric water content for the two samples was determined for potentials ranging from -0.1 bar to -27.3 bar. To cover this wide potential range a hanging column and fritted glass funnel were used from -0.1 to -0.2 bar; pressure plate and pressure membrane apparatus were used from -0.5 bar to -15 bar; and a vacuum desiccator containing a saturated copper sulphate solution was used at -27.3 bar. All determinations were made in duplicate. Unsieved material was used for the analyses, the lack of structure in the samples precluding the use of natural aggregates. The amount of pumice in the soil was estimated by hand-picking and floating off the pumice particles in water or dibromoethane. The two fractions were then oven-dried and weighed.

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RESULTS AND DISCUSSION

The 0.5 cm sample contained 15 per cent clay and the 50-55 cm depth subsoil yielded 9 per cent by repeated extraction. Both clay fractions contained the clay minerals allophane and hydrated hollloysite with minor amounts of cristobalite. Selective dissolution analysis caused large amounts of clay to be removed. Dithionite-citrate and Na_2CO_3 treatment dissolved 70 per cent of the clay from the topsoil and 40 per cent of the clay from the subsoil. Examination of the clay by infrared spectroscopy before and after treatment showed that silicon-rich, amorphous, aluminium silicate gel (an allophane) was removed by the treatment. Amorphous compounds usually adsorb phosphate strongly and cause it to be unavailable to plants. However, allophanes with a high silicon content fix phosphate less strongly (Cloos *et al.* 1968). The Mosa soil is unlikely to adsorb phosphate strongly and this prediction has been confirmed (J. Brigatti 1970, personal communication).

The 0.5 cm horizon was found to contain 13 per cent pumice by weight, and the 50-55

cm horizon 30 per cent. The pumice particles ranged in size from a fraction of a millimetre to approximately a centimetre in diameter.

The soil water characteristic release curves are shown in the *Figure*. The gravimetric water contents at -0.1 bar water potential, the value often assumed to approximate field capacity in well-drained soil profiles, were 1.20 and 1.05 for the surface and subsoil horizons respectively. Both these values are unusually large, even when compared with values for heavy clay or humus soils (see Stace 1968). The samples lost much of their water at quite low suctions. At a matric potential of -1 bar (equivalent to a suction of 1 bar) the water contents of the samples were 0.8 and 0.55, which indicates that a large fraction of the water held in the profile would be readily available for plant use. The gravimetric water contents at -15 bars potential, which can be taken as approximating the wilting point or lower level of available water, were 0.36 and 0.33 for the 0.5 cm and 50-55 cm depth samples respectively. These values are not unusual (Stace *op. cit.*).

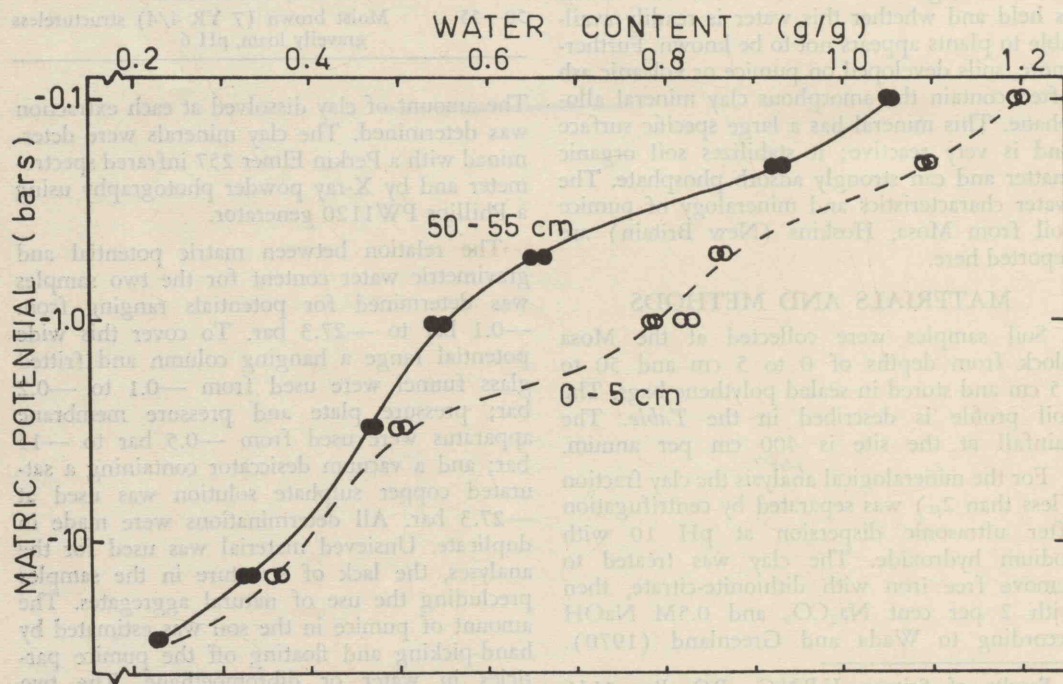


Figure.—Water release curves for 0.5 cm and 50-55 cm soil samples

The differences between the water contents at -0.1 and -15 bars show the available water held by the soil to be unusually large, and approximately two thirds of this water is available at suctions of less than 1 bar. Qualitative observation of outflow rates from soil samples coming to potential equilibrium indicated the saturated and unsaturated hydraulic conductivity of the soil to be high, which would suggest it has excellent infiltration and drainage characteristics. The net result of these factors would be that during rainfall the profile would wet up readily and retain in it a very large amount of water which would effectively tide the oil palm over even quite extended rainless periods without the plants experiencing any deleterious water stress. Tensiometer readings under oil palms at Mosa (Mendham 1971, personal communication) have confirmed this. Mendham found that even during a two-month dry period with less than 10 cm of rainfall the water potential in the root zone did not fall below -0.56 bars.

CONCLUSION

The physical characteristics of the Mosa soil are such that plant water stress caused by uneven distribution of the high rainfall is unlikely, due to the unusually large amount of water held by the soil. The high hydraulic conductivity should preclude waterlogging, even after heavy rain. The mineralogy of the soil suggests phosphate fixation will not be a serious problem, as the allophane present has a high silicon content.

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(Accepted for publication November, 1971.)