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Variation in water regimes of padi soils in the Kelantan plain

(Perubahan rejim air tanah padi di dataran Kelantan)

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Key words: watertable, water regime, padi soils, Kelantan plain

Abstrak

Aras air tanah bagi enam jenis tanah padi di 18 lokasi di dataran Kelantan telah diukur pada setiap bulan selama lebih daripada 2 tahun. Keputusan kajian menunjukkan terdapat rejim air tanah yang berbeza dalam berbagai-bagai siri tanah, dan rejim air ini boleh dikaitkan dengan kelas saliran tanah yang sedia ada. Memandangkan kedudukan air tanah mempengaruhi pergerakan jentera, maka bolehlah dirumuskan bahawa kelas saliran tanah, justru siri tanah, boleh digunakan untuk meramalkan pergerakan jentera di kawasan tanah padi di Kelantan.

Abstract

Watertable levels of six padi soil series at 18 locations in the Kelantan plain were continuously monitored at monthly intervals for more than 2 years. The results indicate that there are different ground water regimes in the various soil series, and that they can be related to the existing soil drainage classes. In view of the fact that the ground water position influences the soil mobility by machines, it is concluded that soil drainage class and therefore soil series can be used to predict machine mobility in the padi areas of the Kelantan plain.

Introduction

The padi soils of the Kelantan plain are mostly developed from recent riverine alluvium, colluvial granitic outwash and brackish deposits. The various soil series identified in the area are primarily based on their parent material and hydrological conditions while other soil properties such as texture and pedological features are used to differentiate soils of similar drainage class. Semi-detailed soil map of the area was prepared by Soo (1972, 1975) and the relationship between soils of the topo-hydrosequence were described by Aminuddin (1984) and Gopinathan and Aminuddin (1975). In the topo-hydrosequence studies, it was found that the following soil series occur from the upslope downwards viz. Tok Yong – Kg. Cempaka – Kg. Lating – Sg. Jabil – Sendong.

The various soil series of riverine and brackish origin have characteristic profile morphology reflecting their drainage conditions. The Tok Yong series is well-drained and has a uniform yellow brown matrix; the Kg. Cempaka series is moderately well-drained having yellow

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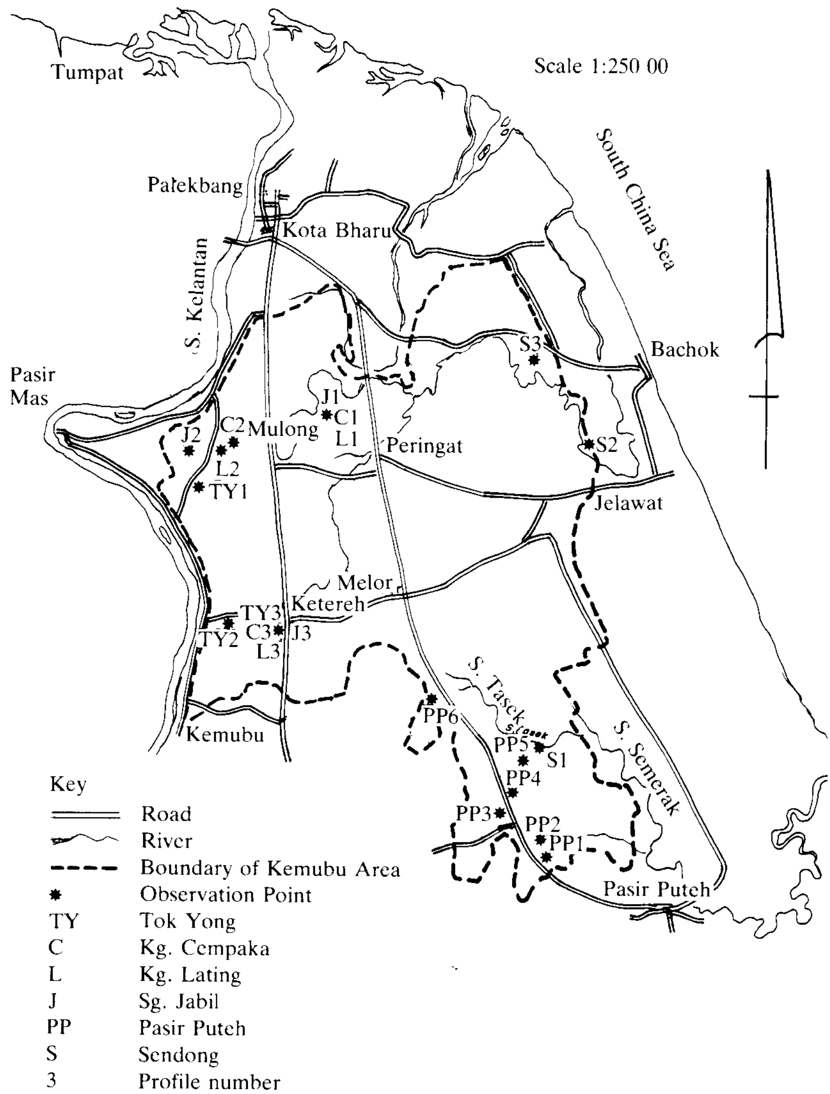

Figure 1. Location map showing experimental sites

brown matrix and bright mottles; the Kg. Lating series is imperfectly drained with greyish brown matrix and has both bright and low chroma mottles; the Sg. Jabil series is poorly drained and has low chroma matrix (50–80%) and bright mottles; and the Sendong series is very poorly drained and is characterized by an almost totally reduced matrix (>80%) in its profile (this soil includes the Lubok Itek series as described by Soo 1972, 1975). The soils originating from the granitic outwash have textures ranging from clay to sandy clay and display variable drainage classes. Detailed pedological characteristics of the soils have been described elsewhere (Aminuddin 1981; Soo 1972, 1975).

Previous studies carried out in the area showed that both the ground watertable and irrigated water had greatly influenced the morphology of these soils (Aminuddin 1981). However, studies on the watertable characteristics of these

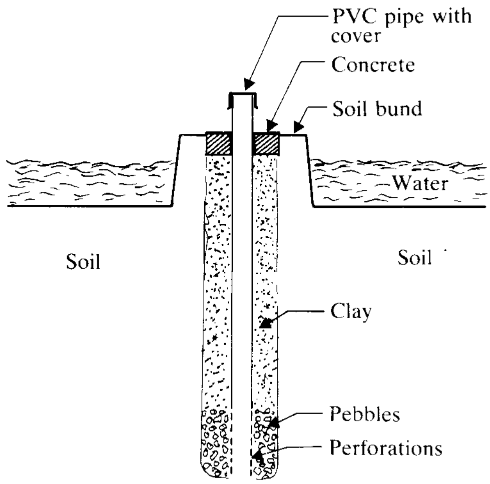

Figure 2. Piezometer installation. PVC pipes [diameter = 3" (7.6 cm)] were installed on the rice plot bund to a depth of 1 m below the plot surface

soils are lacking. The present study was conducted to monitor the watertable conditions in several soil series of the area, and to relate it to the soil mobility by machine.

Method

Six soil series were selected for this study viz. Tok Yong, Kg. Cempaka, Kg. Lating, Sg. Jabil, Sendong and Pasir Puteh. For each soil series, three profiles at different locations were selected for the study *(Figure 1)*. To monitor the ground water, piezometers were installed as shown in *Figure 2*. Ground watertable at each site was measured from the water level within the piezometer at monthly interval for more than 2 years.

Each piezometer was located on the bund to prevent the inflow of the surface water. Water level in wells wherever available was also observed. In addition, the presence or absence of water in the surrounding padi field was also recorded.

Moisture content at saturation (0 bar) and field capacity (1/3 bar) for the selected profiles were determined in the laboratory using pressure plates.

Results and discussion

Records of the surface water and watertable levels within 1-m depth in the piezometer for each soil series are shown in *Figure 3* to *Figure 8*. Field observation shows that, in high elevation areas, two ground water levels are present i.e. one within 100-cm depth in the piezometer and another at up to 760-cm depth in the nearby wells. The shallower ground water observed in the piezometer is that of the perched watertable, whereas the deeper one reflects the true ground watertable. Similar observation made in the low elevation areas shows that water levels in piezometer and wells are at the same depth and they reflect the true ground watertable.

The presence of the surface water of about 4-month duration in *Figure 3* to *Figure 8* indicates the growing season. This is followed by a short harvesting period which usually have no surface water. In some areas, where there is single cropping or the land is left idle *(Figure 7)*, the surface water is present for a longer period. This is also true for areas where harvesting is done in wet condition.

Watertable variation in the various soils

In the Tok Yong series *(Figure 3)*, the ground water fluctuates between the surface to a depth of greater than 1 m. The irrigated surface water occurs as a distinct layer, separated from the ground water by an unsaturated soil layer. Both water levels merge during monsoon. The fluctuation of ground water level are greatly influenced by the presence or absence of irrigated surface water and rainfall *(Figure 3)*. During irrigation, the perched ground water occurs at shallow depth while at harvest the surface water is removed and the ground water drops to a depth greater than 1 m. The perched ground water levels also show minor fluctuations during irrigation period. However, the cause of its variation is uncertain.

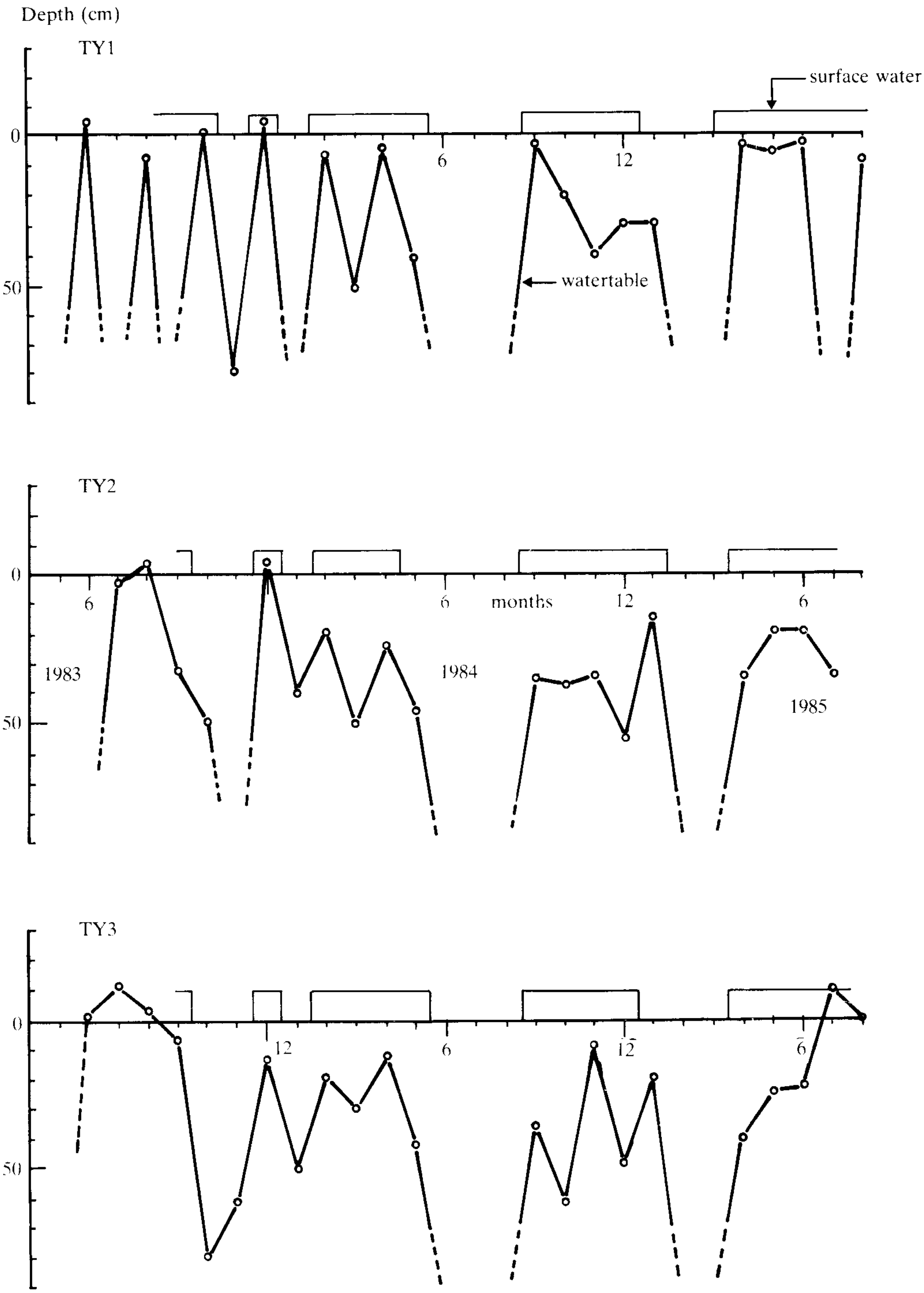

Figure 3. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Tok Yong series

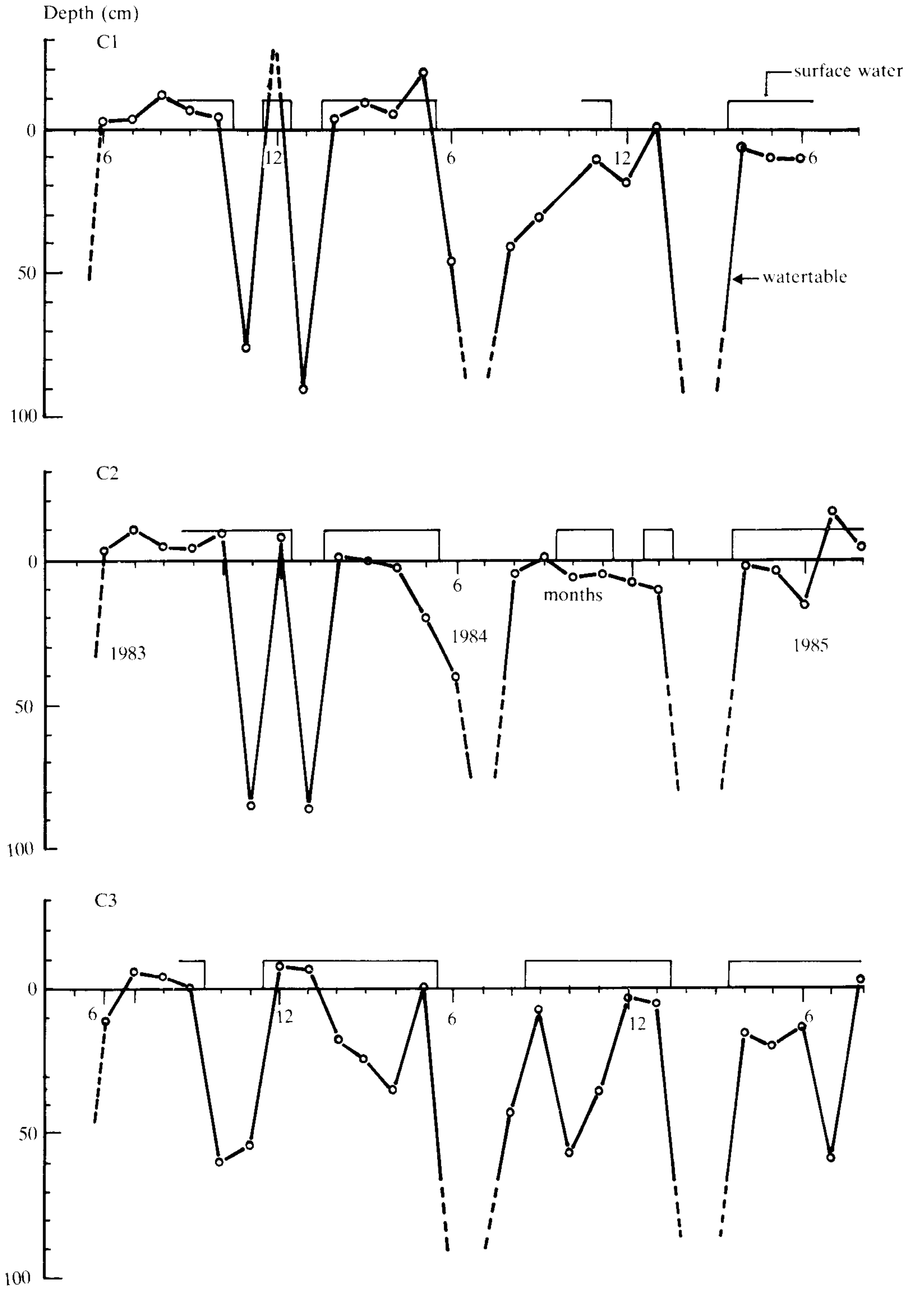

Figure 4. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Kg. Cempaka series

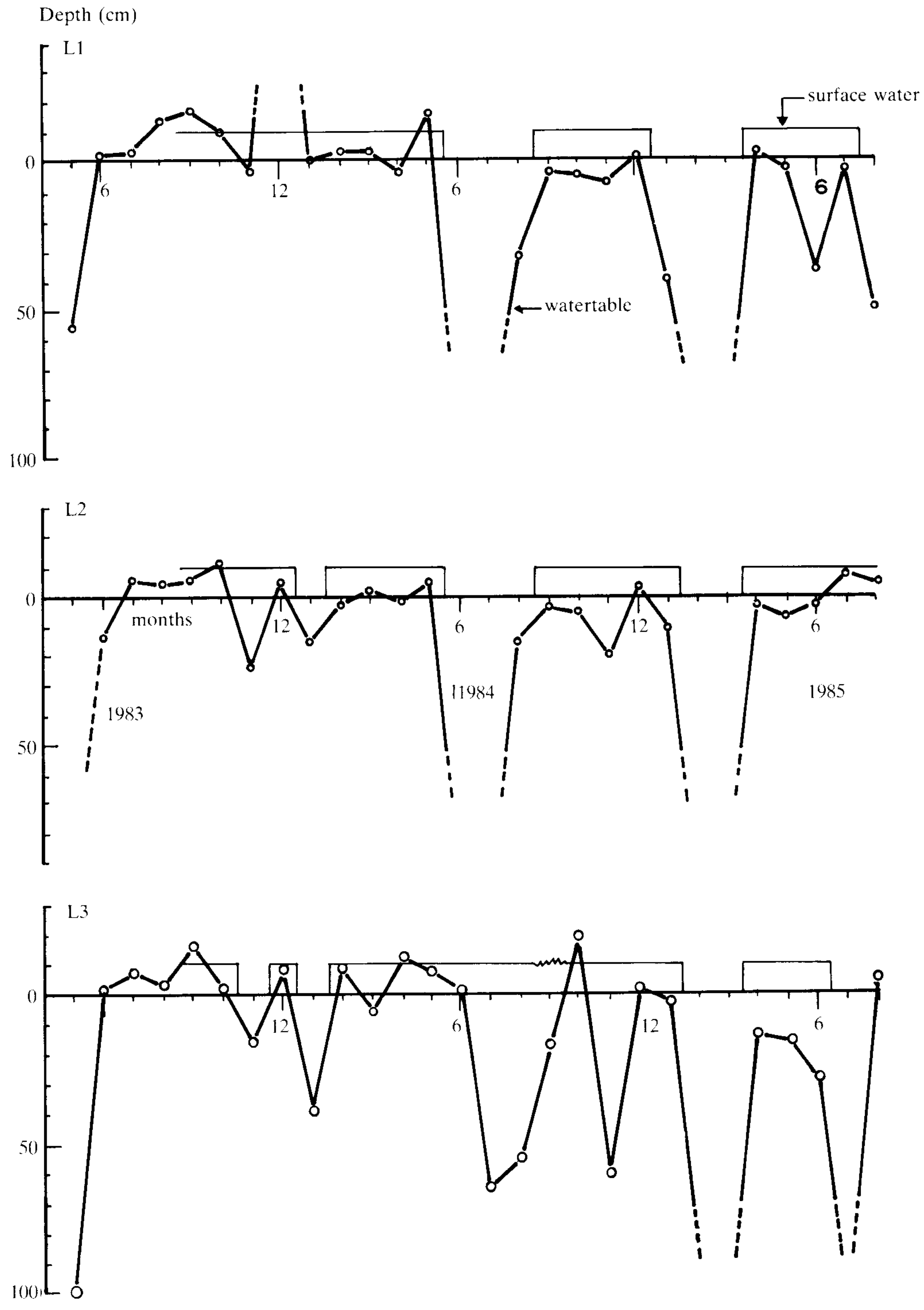

Figure 5. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Kg. Lating series

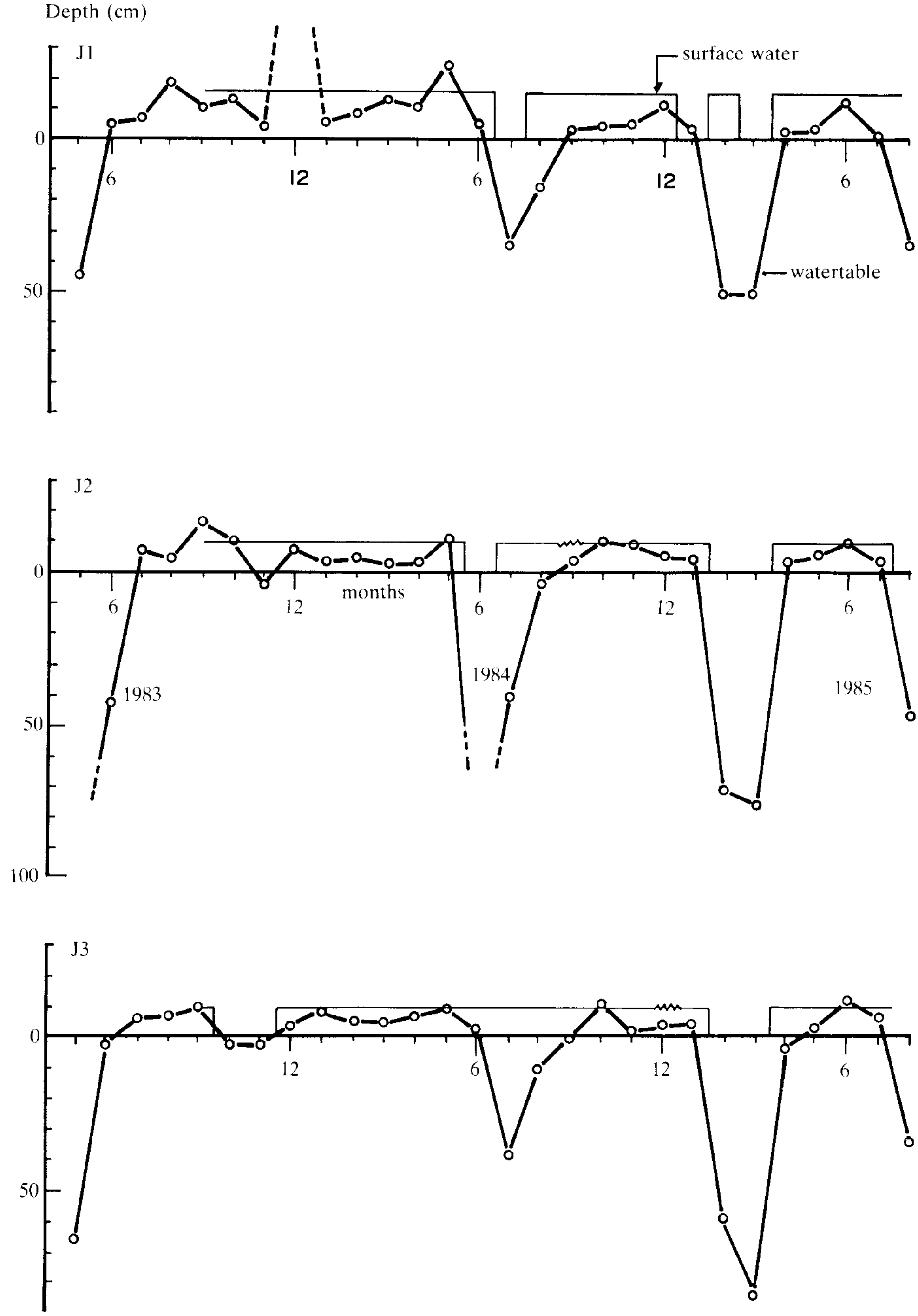

Figure 6. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Sg. Jabil series

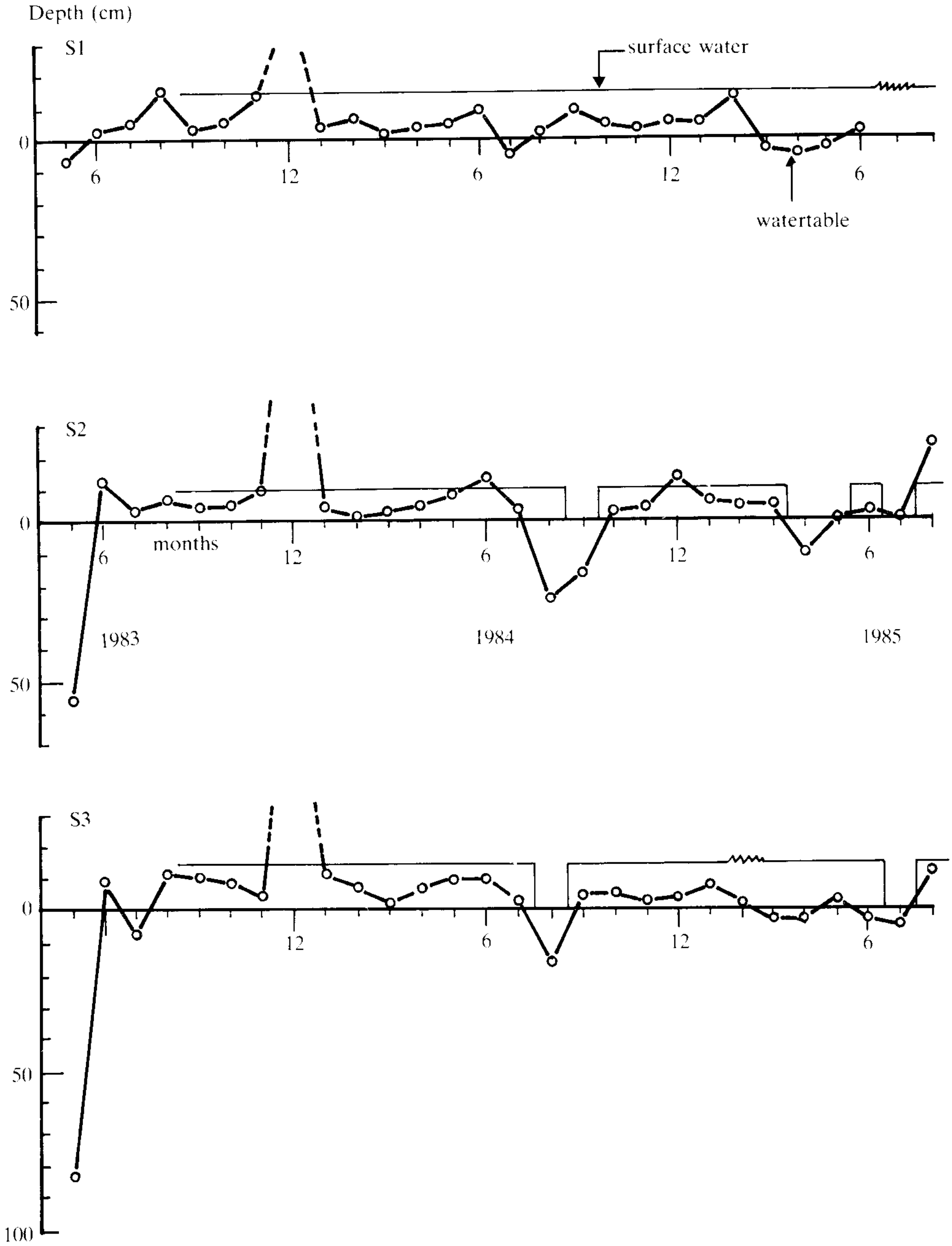

Figure 7. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Sendong series

The ground water in Kg. Cempaka series generally fluctuates in the same manner as that in Tok Yong series. It is also separated from the surface water. A deep dry soil layer occurs during the harvesting season reaching a depth of more than 1 m. When irrigated, this dry layer reduces in thickness or is absent. Similar trend is observed in the Kg. Lating series.

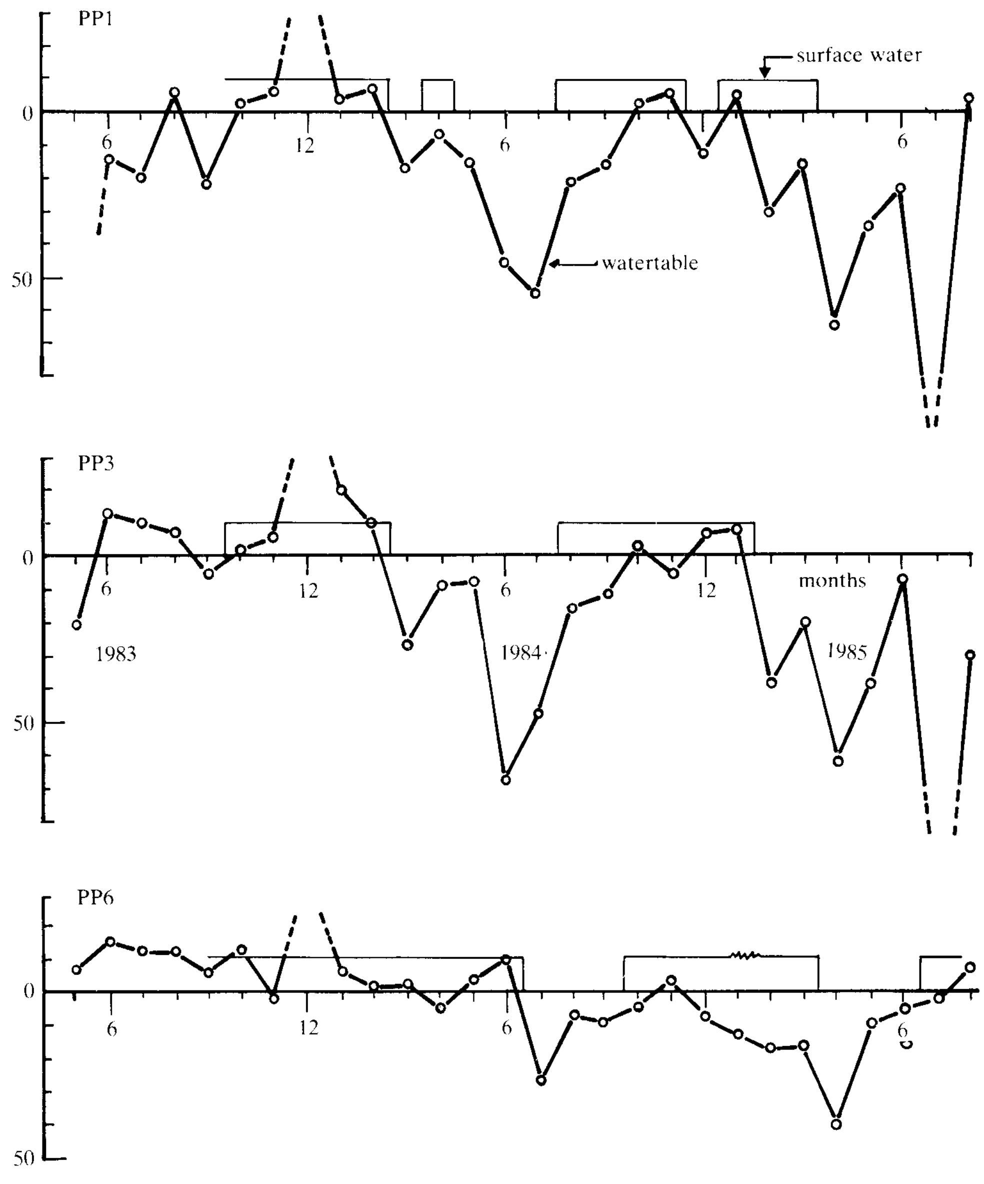

Figure 8. The fluctuation of watertable and the surface water with time (in months) in 3 profiles of the Pasir Puteh series

In the Sg. Jabil series, both the ground water and surface water merge during irrigation. During harvesting, the ground water level drops, but rarely exceed 1-m depth. In the Sendong series the surface water and ground water merge, and remain at or near the surface for most of the time. During the few occasions when surface water is absent, the ground water still stays within 25-cm depth. The high watertable level in the Sendong series is due to the fact that the soil occurs in the depressional areas, the majority of which below 15 feet (4.6 m)

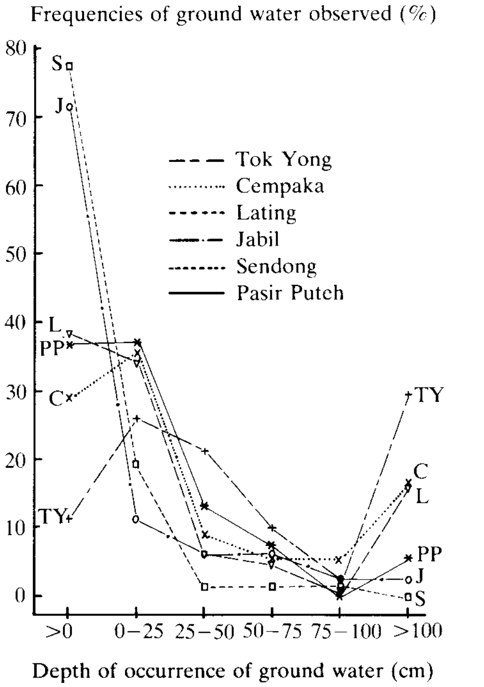

Figure 9. Average frequency of occurrence of ground water at various depths in the various soil series

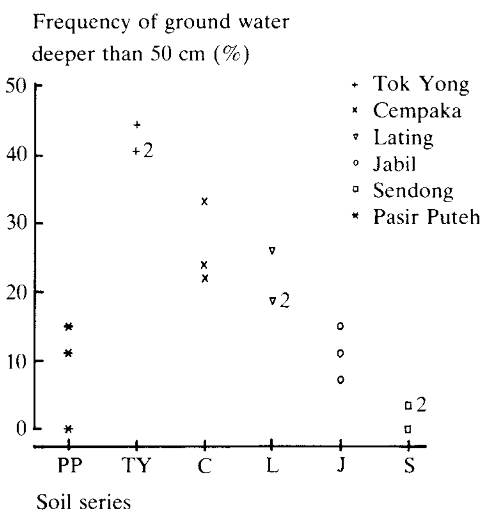

Figure 10. Frequency of ground water deeper than 50 cm (%) in the various soil series

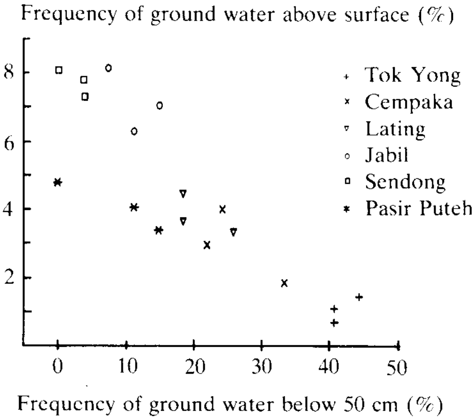

Figure 11. Frequency of ground water (%) above the surface and below 50 cm depth in the various soil series

above sea level.

There is some variation in the drainage condition in the Pasir Puteh series. In PP1 and PP3, there is separation between the surface water and the ground water. At harvesting, the ground water level drops, to a depth which depends on the season of the year. On the other hand PP6 is poorly drained compared to the other two profiles, and its ground water at harvest occurs at shallower depth than in PP1 and PP3.

A summary of the position of ground water levels in the various series is given in *Figure 9.* The frequency of occurrence of ground water at the surface (>0) and at a depth greater than 100 cm differentiates the various soil series. The frequency of occurrence of ground water at the surface increases in the order of Tok Yong, Kg. Cempaka, Kg. Lating, Sg. Jabil and Sendong series, while the frequency of occurrence of the ground water at depth is in the reverse order.

Relationship between soil types and ground water levels

The frequency of occurrence of ground watertable below the 50-cm depth in the various soil series is given in *Figure 10.* In *Figure 11* it is plotted against the frequency of ground water above the surface. It is evident from *Figure 10* that in padi soils, the frequency of occurrence of ground water below the 50-cm depth is closely related to soil drainage condition. Soils of the same series have similar variation in ground water position. However, it is also apparent from *Figure 10* and *Figure 11* that there is no distinct separation of ground water regime between the adjacent soils within the topo-hydrosequence. This is expected as the soil variation is continuous in nature, whereas the limits set in the classification of the soil series is artificial.

Despite the above, the water regime of the non-adjacent soil series in the topo-hydrosequence is well separated e.g. that of the well-drained Tok Yong series differs from the imperfectly drained Kg. Lating series, and the Kg. Lating series from the Sendong series.

The frequency of occurrence of ground water at the surface for the irrigated padi soils ranges from less than 15% for well-drained Tok Yong series to more than 70% for the very poorly drained Sendong series. The reverse trend is observed for the frequency of ground water below 50 cm. Apart from the effect of irrigation, the observed ground water regime is also influenced by the rainfall pattern during the study period. It must also be emphasized that under non-padi and non-irrigated conditions, the ground water regime of the various soil series may be different.

Implication of the soil watertable variation on mobility

In padi soils, mobility is determined by the occurrence of the dry layer between the surface water and the ground water. Mobility improves with increasing thickness of the dry layer. Yeoh (1981) indicates that penetrometer resistance of the soil is highest when a dry layer is present.

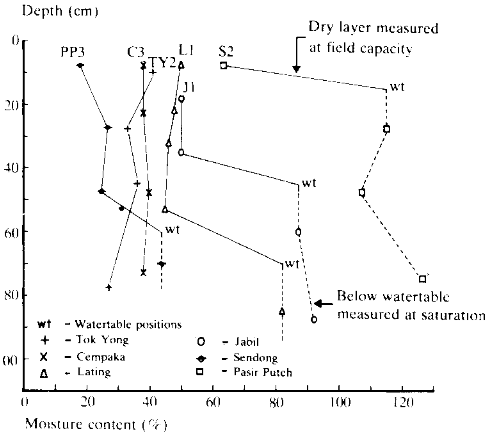

Figure 12. Approximate variation of moisture content in the various soils at harvest

Observation of the occurrences of the dry layer showed that at harvest, all soils except Sendong series had dry layer. The thickness of the dry layer at harvesting increased in the following order: Sendong, Sg. Jabil, Kg. Lating, Kg. Cempaka, Pasir Puteh and Tok Yong series. The occurrence of a reasonably thick dry layer implies that in all soils except Sendong series the ground water level will not pose any problem towards soil drying for machinery mobility at harvesting. This observation was confirmed by Fadzlil Ilahi, A. W. MARDI, Serdang, pers. comm. (1987) who carried out soil bearing pressure measurements in the same soil.

An approximate variation of moisture content in the various soils at harvest is given in *Figure 12*. It is evident that below the watertable, the clayey soils have moisture content greater than 60% which contributed to its softness. The Pasir Puteh series, being coarser textured has lower moisture content and may not be as soft as the other soils.

At the beginning of irrigation, the thickness of the dry layer reduces markedly. In Tok Yong series, it reduces to a thickness of greater than 20 cm, suggesting no mobility problems.

However, in Kg. Cempaka and Kg. Lating series, it reduces to a very thin layer. In these soils machinery mobility problems may occur during land preparation and its probability of occurrence is greatly dependent on the lag between land preparation and the beginning of irrigation itself. The mobility problems are expected to be more severe in the poorly drained soils such as Sg. Jabil series. In the Sendong series the dry layer rarely occurs, indicating that this soil will pose mobility problems during land preparation.

The mobility problems in the Sg. Jabil series could be overcome by draining the soils thus improving its soil bearing capacity. However, the Sendong series could not be easily drained as it mostly occurs below the elevation of 15 feet (4.6 m). Therefore, the mobility problems in this soil are more serious in nature.

Conclusion

The results of the study indicate that there are different regimes of ground water in the various soil series of the topo-hydrosequence, and they reflect the soil drainage class. Considering that the ground water regimes influence the machinery mobility, it can be concluded that soil drainage class could be used to predict soil mobility. Based on this drainage-mobility relationship, the semi-detailed soil maps (preferably those having soil series as the mapping units) could be used to produce an approximate soil mobility map.

In this study, all the soils, except Sendong series, have sufficiently thick unsaturated (dry) soil layer during harvesting period, indicating that at this time they pose no machinery mobility problems. However, upon irrigation at land preparation, as the thicknesses of the dry layer reduce markedly, machine mobility will be a problem on the poorly drained soils in the topo-hydrosequence such as the Sg. Jabil and Sendong series.

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