Compacted sub-surface soil of upland cropping systems in Tropical savanna region and root distribution patterns of grass and legume pasture

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In tropical savanna regions, continuously high temperatures along with intense rains which concentrate in the monsoon have caused extreme weathering and leaching of soils. Inappropriate land management and over-exploitation have resulted in the significant soil degradation; namely, soil acidification, decline in soil organic matter, and decreases in nutrient and water holding capacities. Further, in recent years, soils of upland cropping systems in the region are prone to sub-surface compaction resulting in a high resistance to penetration that inhibits the development of crop root systems. In the current study, physical properties of upland soils with compacted sub-surface soil in Northeast Thailand were investigated. In addition, two different deep root pasture species (*Stylosanthes guianensis*; Stylo and *Andropogen gayanus*; Gamba grass) were established in order to ameliorate the compacted sub-surface soil, and root distribution patterns of those pasture were assessed.

The study site was located at the Animal Nutrition Development Station, Department of Livestock, Chiang Yuen, Mahasarakham province, northeast Thailand (16° 26' N, 103° 4' E). Texture of top soil (0-0.18 m), sub-surface soil (0.18-0.35 m), and lower subsoil (0.35 m -) are classified as Sandy Loam, Sandy Clay Loam, and Sandy Clay, respectively. Remarkable differences in penetrometer resistance were observed between crop land and adjacent remnant *Dipterocarp* forest in an upland landscape position (**Figure 1**). A layer of extreme resistance (>2.0 MPa) was present for the crop land over the 0.15-0.35 m depth interval indicating that the sub-surface soil compaction was caused by the changed land use. The consequences of these areas of high soil strength would impede root proliferation of crops, reduce the crops ability to accesses stored water, and hence enhance a risk of drought stress.

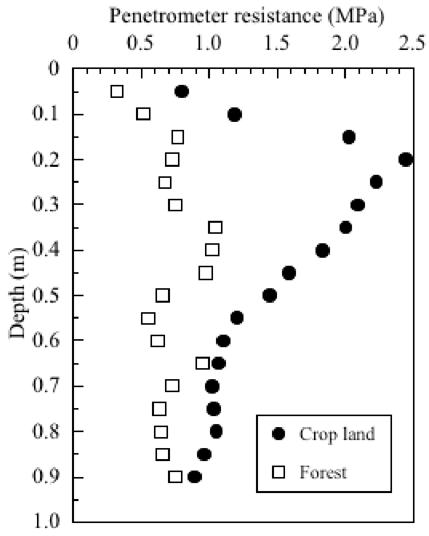

Figure 1. Effect of changed land use on penetrometer resistance in Northeast Thailand.

Root distribution patterns of Gamba grass and Stylo were assessed as follows. 1) root mapping; root systems were described on a soil profile along with the planting line with 0.60 m in width and 1.00 m in depth having a 20 × 20 mm grid. The absence or presence of at least one root in each cell was counted. The results were expressed as a root frequency impact (percentage of cells occupied with at least a root) for each depth interval. 2) root length; on the soil profile along with the planting line, soils were collected at 0.10 m intervals from soil surface down to 1.00 m. Pasture roots were

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separated from the soil samples at each interval. Root lengths were measured by the intercept method and expressed as the root length density (a length per unit volume of the soil). The root frequency impact and root length density analyses revealed that the root of both Gamba and Stylo penetrated the sub-surface soil and existed down to 1.00 m in depth although the root proliferation of those species was impeded by the compacted sub-surface soil (**Figure 2**). Further, the root frequency impact and root length density of Gamba grass were significantly greater than those of Stylo through whole soil profile.

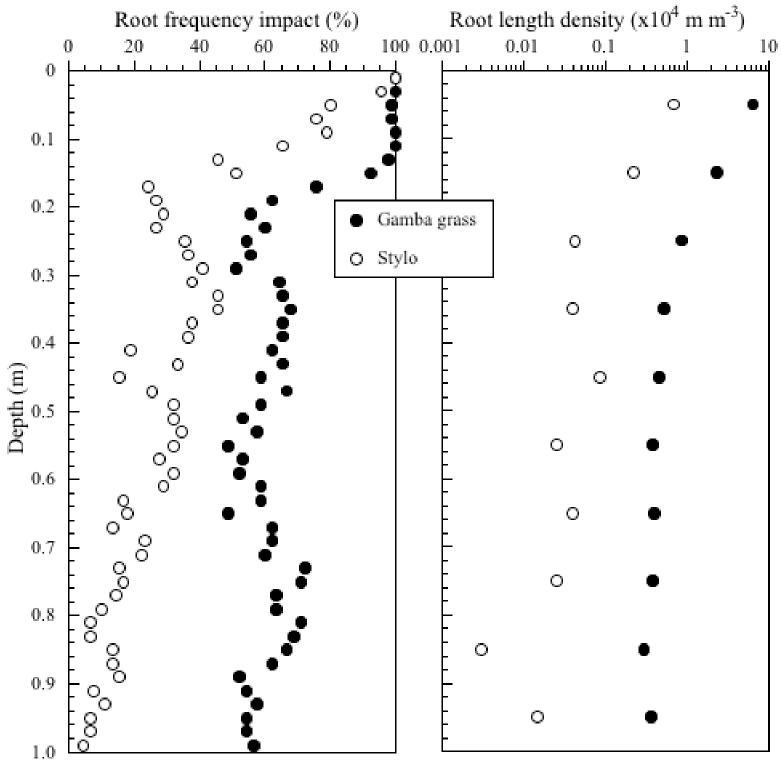

Figure 2. Root distribution patterns for Gamba grass and Stylo established at upland sandy soil with a compacted sub-surface soil.

In general, the saturated hydraulic conductivity was in proportion to the macro-porosity (i. e. air-filled pore volume at the matric potential of -6 kPa) (**Figure 3**). Top soil (0.05 m in depth) had greater macro-porosity resulting in higher saturated hydraulic conductivity. The lower subsoil collected from 0.50 m in depth had smaller macro-porosity and lower saturated hydraulic conductivity than those of the top soil due to the lower subsoil having more clay fraction. Contrasting this, sub-surface soil collected from 0.20 m in depth had a significantly smaller macro-porosity and hence saturated hydraulic conductivity decreased as a consequence of the soil compaction. However, it is of note that the compacted sub-surface soil for Gamba grass plot also showed the highest saturated hydraulic conductivity despite smaller macro-porosity. In addition, a divergence from the proportional decrease in the saturated hydraulic conductivity with decreases in the macro-porosity was observed for the lower subsoil of Stylo plot. The results demonstrate that the root systems of Gamba and Stylo improved tortuosity of macropore through which subsequent crop roots can elongate to explore nutrients and water in the deeper regions of soil profile.

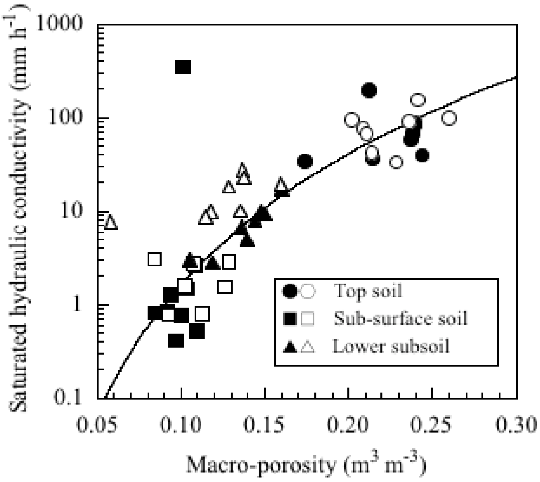

Figure 3. Saturated hydraulic conductivity as a function of macro-porosity. Closed and open symbols represent Gamba grass and Stylo, respectively.