Sustainability of Farming Systems on Sloping Uplands

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Introduction

A farming system is considered sustainable if it continues to satisfy the needs of the farmers and conserves the natural resources. Farmer satisfaction includes issues such as productivity, profitability, stability, and social acceptability. Resource conservation is concerned with maintaining or improving the natural resource, which includes soil, water and biological diversity. Kelly and Gomez (1996) have revealed that yield, net income, frequency of crop failure, soil depth, organic carbon and percent ground cover are suitable field indicators for sustainability. Simulation modeling is a powerful approach for studying complex intercropping system in entirety and a complementary tool to conventional field experiments especially in the evaluation of the biological productivity and sustainability of a farming system. Sloping uplands are relatively less sustainable. Loss of surface layer through erosion can cause a rapid decline in soil productivity mainly due to loss of nutrients and organic matter. Several cropping systems on sloping upland involving rubber, oil palm, annual and cash crops are known to have beneficial effects on soil sustainability and crop growth. The study aims to evaluate different cropping systems on sloping uplands and determine suitable indicators of sustainability of these systems. Soil erosion problems in Malaysia have been recognized for a long time. However, management of upland area which is more exposed to soil erosion and soil degradation risk through introduction of different cropping systems and role of root is still largely unknown. Consequently, the current knowledge of rates of soil loss on upland slopes is very limited. Therefore, the objectives of this study were to evaluate the effect of root biomass on soil structure attributes and soil erosion, and to evaluate effects of slope position on structure attributes and soil erosion.

Materials and Methods

A suitable procedure for evaluating sustainability of farming systems that uses a combination of resource conservation indicators including soil erosion, surface runoff, soil organic matter content and soil structure attributes was adopted. A FORTRAN computer model, SURHIS (Sharing and Utilization of Radiation intercepted in a Hedgerow-Intercropping System) was developed for simulating daily light interception and growth of Rubber-banana-pineapple intercropping system. Crop growth was modeled based on net biomass resulting from the difference between crop photosynthesis and respiration. An intercropping systems of perennials and annuals of immature rubber, pineapple and banana which have been carried out for few years were selected. Historical data on the crops planted, crop yield and management practices were obtained from the farmers and managers of the systems. The slope of the area ranged from 9 to 15%. Soil samples were collected from the farms and analyzed for its changes in depth, organic carbon content and other relevant soil properties such as particle size distribution, aggregate stability and bulk density. Root biomass was also measured. UPM erosion plots in Puchong Farm where an intercrop of banana and pineapple were planted on standard erosion plots were used to generate soil erosion and surface runoff data.

Results and Discussion

Soil sustainability was greatly affected by the cropping systems. Results indicated that banana when intercropped with pineapple showed optimum performance in improving soil structure attributes particularly in increasing soil organic matter and aggregate stability. Due to better and thicker canopy coverage and as well as the role of their root network in building good soil structure, the combination of banana and pineapple is more effective in reducing runoff since this system provided a better protection for soil surface against impact of raindrops and improved soil infiltrability. The least soil erosion occurred under pineapple, suggesting a good conservation crop, and the most under immature rubber. Stepwise multiple linear regressions demonstrated that soil loss was closely related to root biomass, soil organic matter, and aggregate stability of the soil. In terms of slope position, results showed that at depth 0-15cm middle slope had lowest bulk density and highest soil organic matter content and percent soil aggregation indicating the convex nature of the landscape. Due to higher deterioration of soil properties on the upper slope compared to other slope positions the

most soil erosion appeared to be on upper slope position. Several future studies is needed especially on crop suitability in relation to its physiological, morphological and economic values in an intercropping system. Simulation results showed that increments in leaf area index (LAI) had a greater effect on radiation interception by component crops compared to height increments. The crop growth modules were sufficiently accurate in estimating LAI and dry matter yield (DMY) but less precise for crop height. The intercropping system showed a DMY productivity advantage of 81% over the component monocrops grown at optimum population densities. The water budget analysis for the field in Taiping, showed that soil moisture storage resulting from normal rainfall was sufficient to supply the water requirements of the intercropping of immature rubber, banana and pineapple. With appropriate modifications, the model, SURHIS can be readily adopted for productivity analysis of similar cropping systems involving other crops.

Conclusions

Immature rubber intercropped with pineapple and banana is a sustainable farming system in areas of slope ranging from 8 to 15%. The model SURHIS can be used to predict leaf area index and dry matter yield of an intercropping system. Involving immature rubber, banana and pineapple.

Benefits from the study

Direct recommendations on the possible choice of cropping systems and their management implications to rubber smallholders in the upland areas. Farmers continue getting income from pineapple and banana while waiting for the rubber to be tapped. Meanwhile the system would decrease soil degradation and downstream pollution. The model SURHIS can be used by researchers, planners and policy makers in agricultural and landuse planning for both economic and environmental impact.

Patent(s), if applicable:

Nil

Stage of Commercialization, if applicable:

Nil

Project Publications in Refereed Journals

1. Adrinal, **T. Jamal**, W.H. Wan Sulaiman and M.F. Ramlan. 2001 Soil structure attributes and soil erodibility under intercropping of immature rubber with banana and pineapple planted on sloping land. Jurnal Stigma (An Agricultural Science Journal), IX(2):123-130

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Project Publications in Conference Proceedings

1. Jalloh, M.B., T. Jamal, M.F. Ramlan, W.H. Wan Sulaiman, C.B.S. Teh and A. Rajan. 2002. RADINTA model for light partitioning in immature-rubber, banana and pineapple hedgerow-intercropping system. Abstract. 13th. Malaysian Society of Plant Physiology Conference. Melaka, Malaysia, 13:17-18.

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Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Mohamadu Boyie Jalloh	Modelling and simulation of radiation interception and biomass production in an immature-rubber, banana and pineapple intercropping system	Biophysics and modelling	PhD	2003
Adrinal	The effect of intercropping on soil structure attributes and soil erosion on sloping land	Soil Physics and Conservation	PhD	2002

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