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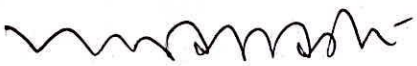
DECLARATION

The work described in this thesis was carried out by me under the supervision of Prof. P.A.J. Yapa and Prof. R.B. Mapa, and a report on this has not been submitted to any University for another degree



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We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation

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Evaluation of alley cropping systems on resource utilization in the Dry Zone of Sri Lanka

by

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Evaluation of alley cropping systems on resource utilization in the Dry Zone of Sri Lanka

R. S. K. Keerthisena

ABSTRACT

Continuous cultivation of annual crops in uplands, under rainfed conditions in the Dry Zone of Sri Lanka has led to productivity decline as a result of loss of fertility and soil erosion. Alley cropping, which incorporates tree hedgerows into annual cropping, has been recommended as a sustainable land management system for the rainfed uplands. However, the effect of hedgerows on the use of limited resource base could result in various consequences, and therefore this investigation was conducted in order to study the effect of hedgerow component on the food crop component and the utilization of agricultural resources under alley cropping. Two alley cropping systems, namely 2 m wide alleys and 6 m wide alleys were compared with similar sole gliricidia alley systems, and sole crop systems. Hedgerows were established using 3 - months old gliricidia seedlings with 0.5 m within row spacing in *yala* 1997 in alley cropping and sole gliricidia systems. Cowpea in the two *yala* seasons (1998 and 1999) and blackgram in the two *maha* seasons (1998/1999 and 1999/2000) were grown as associated food crops in alley cropping systems. The food crops were also grown as sole crops with no-mulch, mulch equal to the hedgerow biomass yield of 2 m wide, and 6 m wide alley systems. The hedgerows were pruned at the beginning and end of each season.

High hedgerow biomass production (13.5 t ha^{-1} over a two year period) was observed irrespective of alley width and cropping. However, the increase of alley width from 2 m to 6 m reduced the hedgerow biomass by $^2/_3$ from 20.0 t ha^{-1} to 7.05 t ha^{-1} over the study period. The total biomass yields (hedgerow and crop) of alley cropping systems were higher than sole gliricidia or sole crop systems.

Growth parameters of the crop were measured in order to study the effect of hedgerows in alley cropping. Both 2 m wide and 6 m wide alley cropping recorded lower crop dry matter production, leaf area index, free proline content and crop yield than all sole crops. Specific leaf area in both alley cropping systems was higher than that of sole crop systems. However, relative leaf water content of the crop in 2 m wide and 6 m wide alley cropping was lower than that in respective sole crops. Between two alley cropping systems, crop dry matter production, leaf area index and crop yield were lower in 2 m wide alley than that of 6 m wide alley system. Specific leaf area in 2 m wide alley system was higher than that in 6 m wide alley system. Relative leaf water content in *yala*, and the leaf proline content in *yala* and *maha* in 2 m wide alley cropping system were lower than that in 6 m wide alley cropping system. While increasing mulch rate increased the dry matter production, leaf area index, relative leaf water content and crop yield, it reduced the specific leaf area and free proline content in sole crop systems.

The crop rows closer to the hedgerow recorded lower crop dry matter production, free proline content and crop yield, and higher specific leaf area and relative leaf water content than the crop rows at the centre in both alley cropping systems. Between two crop rows to the north and south of a hedgerow, difference in

above parameters varied with season. The crop row immediate to the north of hedgerow recorded a higher crop dry matter production, leaf area index, free proline content and crop yield than the one to the south in *yala*. An opposite trend was observed in *maha*. But, specific leaf area behaved *vice versa*.

The analysis of soil chemical properties revealed that electrical conductivity, available P and exchangeable K increased considerably in 0-30 cm soil layer while pH and exchangeable Na, Ca and Mg did not change significantly in all systems during the study period. In addition, both 2 m wide alley cropping and sole crop with mulch equal to 2 m wide alley system recorded higher electrical conductivity in 0-5 cm layer and higher exchangeable K in 0-30 cm soil layer respectively than 6 m wide alley cropping and sole crop with mulch equal to 6 m wide alley cropping system. Sole crop without mulch always recorded lowest values.

The water contents in 0-15 cm soil layer of all the systems were highly variable with frequent recharging after every rain. Recharge of deeper layers occurred frequently in *maha* while it happened only once in *yala*. Soil water contents in other layers fluctuated in relation to rainfall with less variability. Soil water content did not differ among three sole crop systems and so the soil water consumption. Higher soil water consumption was observed in 2 m wide alley cropping followed respectively by 2 m sole gliricidia, 6 m wide alley cropping and sole crops. The lowest soil water consumption was recorded in 6 m wide sole gliricidia alleys. The sole crops extracted most of the water from shallow depth up to 150 cm, while gliricidia hedgerows extracted water from deeper soil layers also. Soil water content across the alley was uniform in all the soil layers of the 200 cm

deep soil profile in 2 m wide alleys. However, soil water contents of all the soil layers increased towards the centre of alley in 6 m wide sole gliricidia system and of layers below 105 cm depth in alley cropping system. The soil water extraction patterns showed that the hedgerows did not extract soil water at the centre of 6 m wide alleys.

The higher interception of light by hedgerows reduced the seasonal mean available light on the associated food crop by 34.8% and 39.1% in *yala* and *maha* respectively with a within seasonal variation of 0 - 77%. The shading by hedgerows was higher to the north of the hedgerow in *maha* season and to the south of the hedgerow in *yala* season. Two meter wide alley cropping system achieved 0.73, 0.46, 0.59 and 0.56 of mean fractional light interceptions respectively in *yala* 1998, *yala* 1999, *maha* 1998/1999 and *maha* 1999/2000 with mean light conversion coefficients of 1.1, 1.08, 1.08 and 0.98 g MJ^{-1} respectively. The mean fractional light interceptions of 2 m wide sole gliricidia system in respective seasons were 0.4, 0.3, 0.38 and 0.41, where mean seasonal conversion coefficients were 1.65, 1.46, 0.95 and 0.91 g MJ^{-1}. The sole crop treatments recorded mean fractional light interceptions higher than that of 2 m wide sole gliricidia except in *yala* 1999 and lower than 2 m wide alley cropping in all the seasons. Seasonal mean conversion coefficients of all the sole crop systems in all seasons were lower than that of 2 m wide sole gliricidia and 2 m wide alley cropping. However, the fractional light interception and conversion coefficient in sole crop systems increased with increasing mulch rate.

The results prove that effect of mulch and hedgerows are important in determining the performance of the crop that results through the change of resource use in alley cropping. While mulching affects largely on soil nutrients and light use. hedgerow effect is more prominent on use of soil water and light. Nevertheless. the crop performance in alley cropping is mainly determined by the availability of light as affected by the hedgerows. The effect of hedgerows is extended to a distance of 150 cm and 50 cm on either side of the hedgerow where incident light is changed. The results suggest that alley cropping can successfully be used to increase soil water and light resource use and efficiency for the Dry Zone of Sri Lanka. Thus. alley cropping increases the overall productivity and higher crop yields can be achieved by adopting proper pruning to minimize the competition for these resources.