Annals of the Sri Lanka Department of Agriculture 2001. 3: 27-36.

GROWTH PERFORMANCE OF MANGO AND LIME WITH *IN-SITU* RAINWATER HARVESTING

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ABSTRACT

Soil moisture is the major limiting factor for establishment of perennial crops in the dry zone uplands. The long dry period (July – September) could be tolerable to deep-rooted, well-established, mature trees, but many young plants die due to inadequate soil moisture. Farmers, who fail to save the crop during drought, are discouraged to develop their home gardens. A study was carried out at Field Crops Research and Development Institute, Maha Illuppallama (1998-2000) to assess the performance of mango and lime under an *in-situ* rainwater harvesting system (RHS) named as 'Eyebrow bund and pitcher system'. Runoff is collected by means of an eyebrow shaped bund into a buried pitcher, which provides water to the plant when soil is dry. Plant height, girth and leaf count were monitored. Results showed that the plant height increase in mango and lime with the RHS was 80 and 37 percent higher respectively than that without the RHS. Plant girth increase of mango and lime with the RHS was 138 and 45 percent higher respectively compared to the control. Results further showed that the rate of leaf formation in mango and lime supported with RHS was 267 and 168 percent higher respectively compared to that without the RHS.

KEYWORDS: Dry zone, Perennial crop establishment, Soil moisture deficit.

INTRODUCTION

Development of home gardens with a mixture of perennial fruit, food and timber trees in the dry zone confines to lower valleys and slope bottoms in the land catena, where soil profile is moist during many months of the year. In the upper slopes young perennial plants cannot withstand the long dry period without additional water source, due to low water holding capacity of soil and shallow soil depth. Therefore, most of the home gardens that could be found in the upper areas are under-developed and do not have a well-grown vegetation (Dharmasena, 1994). Any attempts made to improve this situation by various governmental and non governmental agencies who provided large number of planting materials have failed due to farmers not adopting adequate measures to address the problem of water shortage. Lack of an appropriate technology has been found to be the main reason behind the problem. However, in home gardens, the establishment of perennial trees was successful only when planted under shade of tree species, which are naturally grown in the area (Dharmasena, 1993).

Establishment of fruit crops in the dry zone environment in general, is mainly constrained by soil moisture deficit, which prevails in some parts of the year. This is due to the occurrence of dry spells, which some times extend even for more than two months. A rainfall analysis carried out by using records available at Maha Illuppallama from 1945 to 1995 shows that in months of June, July and August a dry spell longer than 20 days would occur in 3 out of 4 years. Further, with the same frequency there is a possibility of occurring a dry spell of 32 days during the period from June to September (Dharmasena and Fledermann, 1998). Such situation is tolerable to deep-rooted, well-established, mature trees but young plants of perennials cannot withstand this seasonal drought without a support of additional water source. In the absence of water source only alternative is to use rainwater for raising plants in upper land areas, where ability to use groundwater is also far remote. Therefore, a technology had to be innovated to collect and store rainwater during rainy season and provide adequate water to the perennials during dry periods. With the above background a micro-level rainwater harvesting system was designed as a measure to address the water shortage problem in establishment of mango and lime.

Rainwater harvesting for agriculture is not new to the dry zone of Sri Lanka. Due to uncertainty of seasonal rainfall even the early settlers had realized the importance of man made structures to store rainwater and use during water deficit periods (Dikshit, 1986). Adoption of micro-level rainwater harvesting systems has hardly been reported from Sri Lanka dry zone, but evidence from other countries has been well documented (Laryea, 1992 and Katyal and Das, 1994). Pitcher irrigation can successfully be practiced in areas where irrigation water quality is questionable, and it is a low cost technology for conserving water, particularly in areas with scarce water resources (Dubey et al, 1988). It is now well established that pitcher irrigation can be utilized for vegetable crops and in establishment of perennial crops with much less quantity of water compared to surface or sprinkler irrigation (Mondal *et al.*, 1987).

MATERIALS AND METHODS

The proposed *in-situ* rainwater harvesting system was named as 'Eyebrow bund and pitcher system'. In this method perennial trees are planted at recommended spacing. Large planting pits (75 cm x 75 cm x 75 cm) are prepared and filled with a mixture of topsoil and organic manure. Each plant receives runoff water gathered from upstream area and diverted into the planting point by an eyebrow shaped small earth ridge. The eyebrow shape was specifically meant to regulate the runoff flow without causing any soil erosion. These ridges are prepared by using the sub-soil removed from the planting pit. Water gathered flows freely into a clay pitcher buried near the plant and spills off when there is any excess water to the other eye-brow bund and so on. Pitcher is oval in shape and capable of storing 15 liters of water.

Gradient of the eyebrow bund gradually increases from zero to about one percent at planting point and decreases to zero back at the spill. The width of eyebrow is directly proportional to the varying gradient. A row of *Citronella* is planted at the downstream side to stabilize the ridge and to use subsequently as a mulch source.

Outer surface of pitcher is painted with black lacquer leaving about half the pitcher wall unpainted for releasing water to the soil-plant phase when the soil is dry. Pitcher is positioned on a brick placed at the bottom of the pit facing the exposed (unpainted) patch to the plant side. Burying the pitcher and planting are done simultaneously keeping a gap of about 25 cm between the pitcher and the soil pack of the plant. The pitcher is placed as to have its mouth just above the soil surface with a height difference of 1 - 2 cm. Then the mouth of the pot is covered with a sand filled clay lid or a coconut shell to act as a filter. Four *Gliricidia* plants are planted around the fruit plant to create a shady environment to the plant expecting to lower the soil temperature, by increasing the micro-atmospheric humidity and to cut-off the advection by wind. An illustrative diagram of the system is given in figure 1.

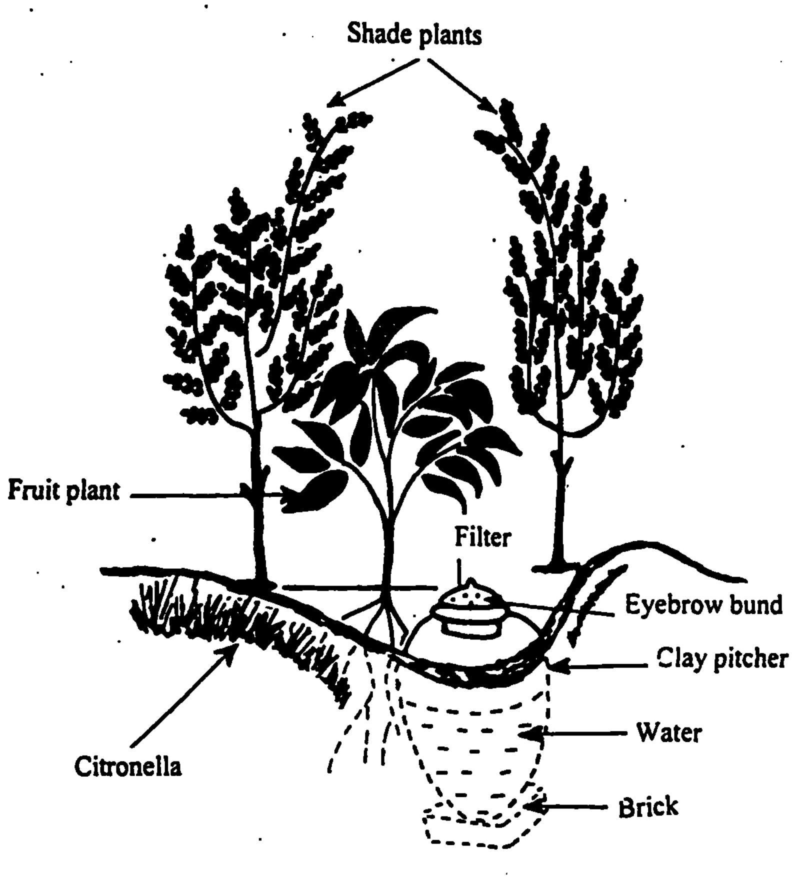


Figure 1. Eyebrow bund and pitcher rainwater harvesting system.

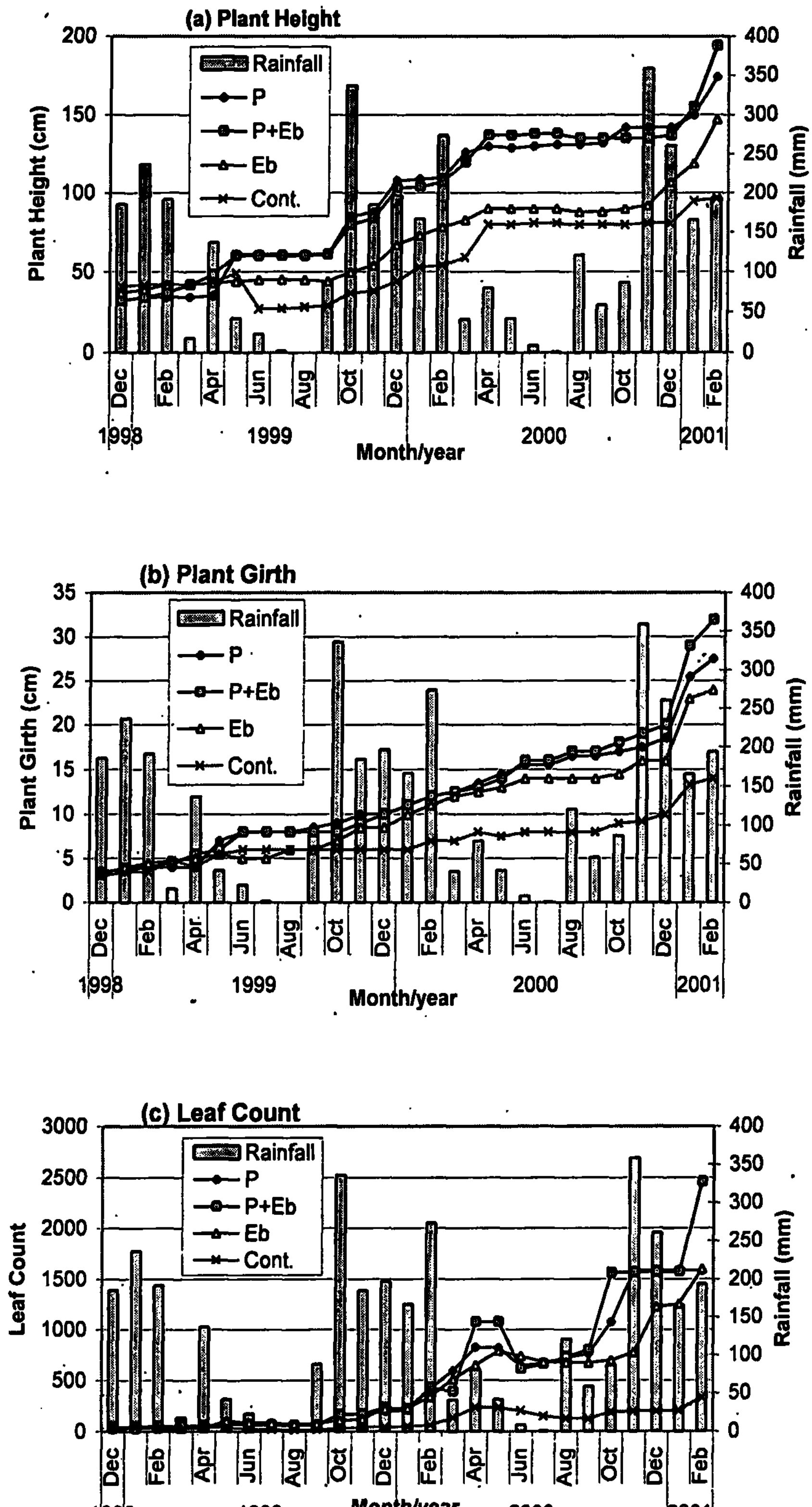
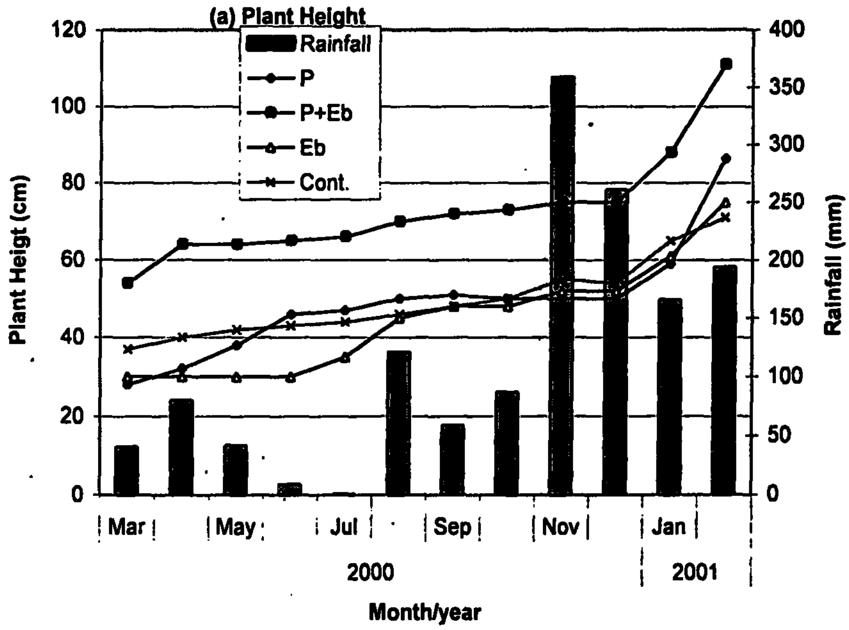


Figure 2. Growth performances of mango plant during Dec. 1998 to Feb. 2001.



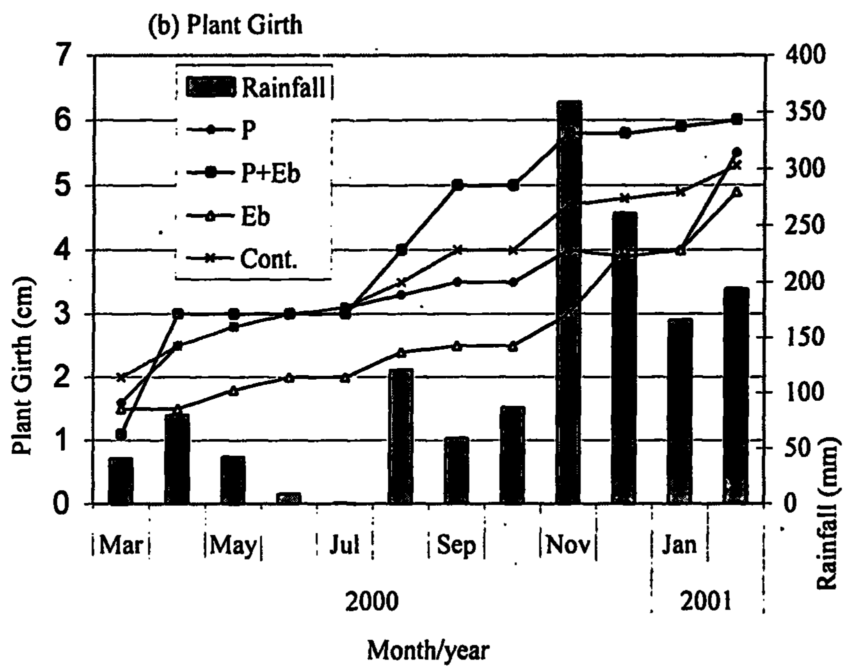


Figure 3. Growth performances Of lime plant during Mar. 2000 to Feb. 2001

A study was carried out at Field Crops Research and Development Institute, Maha Illuppallama (1998-2000) to assess the growth performance of mango and lime under 'eyebrow bund and pitcher' rainwater harvesting system (RHS). The field experiment was planned in RCBD with 6 replicates (plants).. Treatments were: a. eyebrow bund and pitcher; b. eyebrow bund; c. pitcher; and d. plant alone. Spacing for mango and lime was 6 m x 6 m and 3 m x 3 m respectively. Mango trial was established in 1998/1999 *maha* season and lime trial established one year later. Rainfall, pan evaporation and pitcher water levels were measured. Plant growth performance was monitored from December 1998 to February 2001 on monthly basis by measuring plant height, leaf count, and plant girth. Soil moisture status was observed by using the gravimetric method (Hillel, 1980), and sampling was done at 20 cm depth from each planting point during dry periods. Root distribution was measured by sampling roots at 3 locations; i.e. between i. plant and pitcher; ii. plant and *Gliricidia*; and iii. two *Gliricidia* plants. *Gliricidia* and fruit plant roots were separated and measured.

RESULTS AND DISCUSSION

Water releasing rate of pitcher was in the range 0.22 – 0.31 liters/day, therefore, a pitcher can supply water to plant for a period of 50 – 70 days. Figure 2 illustrates the variation of these growth parameters with time. Rainfall was also included in the illustration to understand the response of growth to the amount of rainfall. Presence of a pitcher, which provides water to the plants, causes a clear increase of plant height. Leaf count records show very low number of leaves in the plants, which were not supported by pitcher or eyebrow bund. Mango plants supported with the combination of pitcher and eyebrow bund have shown the highest growth performance while recording highest number of leaves and largest plant girth. Similar trend was shown by lime plants responding to the eyebrow bund and pitcher system to gain highest plant height and girth (figure 3).

During the first dry period (*yala* 1999 season) since the establishment of mango, data collected on growth parameters were analyzed to study the effect of different components in the system. Results are summarized in table 1. A significant improvement was observed in all growth parameters measured in mango plants supported with the complete rainwater harvesting system (RHS). Increasing rate of plant height with RHS was 3 times the value of that without the system. Relatively high rate of leaf formation was observed in plants supported with the RHS showing steady growth even during the dry period. No stem growth was observed in plants without the RHS and with the eyebrow bund alone. A considerable girth increase was shown in plants supported with the pitcher water and further increase could be gained in the presence of the bund along with the pitcher. However, a high variability was observed in growth parameters due to the variation of growth from plant to plant irrespective of treatments.

Table 1. Growth performance of mango plants with rainwater harvesting practices (*yala* 1999).

Practice	*Plant girth (cm/month)*	*Leaf count (No./month)*	*plant height (cm/month)*
Eyebrow bund and pitcher (RHS)	5.02a	16.1a	0.32a
Pitcher	4.12 ab	9.3ab	0.17b
Eyebrow	2.50ab	16.2a	0.00c
Plant only	1.67b	16.2a	0.00
Significance level	0.05	0.10	0.10

Mean values followed by a common letter in a column are not significantly different.

Data on growth performance observed during yala 2000 season in mango and lime plants are summarized in table 2 and 3 respectively. Results show that the RHS could increase the plant height by 77 percent in mango. Rate of leaf formation was very poor in mango plants, which were not supported from any of the component. Plant girth of mango has increased by 160 percent due to adoption of the RHS. Response of lime crop to RHS was not much distinct compared to that of mango. Results show that plant girth of lime has increased by 45 percent, and average values of other parameters also at higher levels with the RHS.

Table 2. Growth performance of mango plants with rainwater harvesting practices (*Yala* 2000).

Practice	*Plant girth (cm/month)*	*Leaf count (No./month)*	*plant height (cm/month)*
Eyebrow bund and pitcher (RHS)	5.83a	52a	0.57a
Pitcher	4.80a	37ab	0.43ab
Eyebrow	24.70a	32ab	0.41ab
Plant only	3.04b	12b	0.22b
Significance level	0.10	0.05	0.10

Mean values followed by a common letter in a column are not significantly different.

Table 3. Growth performance of lime plants with rainwater harvesting practices (*yala* 2000).

Practice	*Plant girth (cm/month)*	*Leaf count (No./month)*	*plant height (cm/month)*
Eyebrow bund and pitcher (RHS)	3.60	71a	0.41a
Pitcher	4.19	67ab	0.31b
Eyebrow	3.00b	30b	0.26b
Plant only	2.70	38ab	0.29b
Significance level	Ns	0.10	0.05

Mean values followed by a common letter in a column are not significantly different.

Mid-day wilt was observed during dry period in mango and lime plants. In mango plants it was difficult to judge wilting, but lime plants showed very clear wilting due to soil moisture stress. Results showed that during July 2000, lime plants, which indicated wilting were 17 % with RHS, 33 % with pitcher support and 67 % either with eyebrow bund or without any support. This confirms that the proposed RHS had a distinct influence in providing soil moisture to the perennial plants during dry periods.

Results of the soil moisture study are summarized in table 4. Observed soil moisture values were closure to permanent wilting point. Soil moisture content at mango plants supported with the RHS was 27 percent higher than that of the control (without eyebrow bund and pitcher). In case of lime soil moisture content was 18 percent higher with RHS compared to the control.

Table 4. Soil moisture at 20 cm depth (% on wt. basis) under rainwater harvesting practices.

Practice	*Mango*	*Lime*
Eyebrow bund and pitcher (RHS)	10.90a	10.51a
Pitcher	9.71b	8.82b
Eyebrow	8.70b	8.18b
Plant only	8.58b	8.94b
Significance level	0.05	0.10
CV	8%	9%

Mean values followed by a common letter in a column are not significantly different.

One of the implications anticipated in pitcher irrigation and mulching in perennial crop establishment in arid areas is the concentration of roots towards the water source or high soil moisture phase. This has been the concern of many who discussed on the feasibility of the proposed RHS system. Therefore, a root distribution study was planned to observe the root behavior of fruit plant and the shade plant (*Gliricidia*) under different practices. Results of the root distribution study are summarized in table 5.

Table 5. Plant root length density (cm/cm^3) with rainwater harvesting systems Crop: Mango.

Location	*Root type*	*Pitcher + Eyebrow*	*Pitcher*	*Eyebrow*	*Control*
Between					
Fruit plant - Pitcher	Fruit plant	0.09	0.11	0.15	0.20
Fruit plant - Gliricidia	Fruit plant	0.41	0.09	0.10	0.16
Gliricidia - Gliricidia	Fruit plant	0.16	0.17	0.21	0.39
Fruit plant - pitcher	Gliricidia	1.01	0.56	1.08	0.75

One of the important observations from table 5 is that in the presence of eyebrow bund, *Gliricidia* roots move towards the bund. In the presence of RHS roots of fruit plant are more concentrated in between fruit plant and *Gliricidia*, and have not moved towards the pitcher. There was no clear interaction found between two types of roots in soil irrespective of the treatment. Therefore, it could be concluded that there is no competition for pitcher water made by both fruit and *Gliricidia* roots. In arid areas soil is dry for longer period in the year, therefore roots move more towards a water source. However, this behaviour is not distinct in the dry zone of Sri Lanka, where soil profile becomes dry during a shorter period of time, so that plants could be adjusted by itself to minimize evapo-transpiration by reducing leaves rather than expanding the root system in search of water.

CONCLUSIONS

Use of a pitcher with the capacity of 15 liters is adequate to keep fruit plants survive for more than 50 days. Relatively high growth performance (plant height, leaf formation, stem girth) of mango and lime plants can be obtained with the proposed 'eyebrow bund and pitcher rainwater harvesting system'. The proposed rainwater harvesting system acts as a soil moisture reserve to support perennial plants during dry periods. There is no concentration of plant roots towards the pitcher in the rainwater harvesting system. *Gliricidia* roots do not compete with plant roots for water.

ACKNOWLEDGEMENT

Authors acknowledge with appreciation the financial support given by the CARP under the project CARP/12/387/281 and administrative facilities provided by the Department of Agriculture for a period of 4 years from 1998 to 2001 to conduct the research program at FCRDI, Maha Illuppallama.

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