

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING WITH *GLIRICIDIA SEPIUM* ON GROWTH AND YIELD OF MUNGBEAN (*VIGNA RADIATA* L. WILCZEK)

R.S.K.KEERTHISENA

Regional Agricultural Research Centre
Maha Illuppallama

ABSTRACT

An experiment was carried out to study the effect of different tree management practices in alley cropping on the growth of mungbean. Two alley widths (2 and 4 m), two lopping heights (75 and 150 cm) and three pruning frequencies (2, 4 and 5 prunings/year) were tested in a strip-split plot design with four replicates using *Gliricidia sepium* as the tree species. The shoot dry matter yield of *Gliricidia* hedgerows increased with decreasing alley width and pruning frequency. Increasing lopping height also enhanced shoot dry weights of *Gliricidia*. With decreasing alley width and pruning frequency, and increasing lopping height, weed dry matter yield as well as the proportion of grass to broadleaf weeds decreased. Growth parameters and seed yield of mungbean decreased with increasing lopping height in the 2 m wide alleys. The reverse was observed in the 4 m wide alleys. Increasing pruning frequency had a negative effect on crop growth irrespective of alley width or lopping height. Seed yield increased with increasing pruning frequency in the 2 m wide alleys but decreased in the 4 m wide alleys. It was concluded that 4 m wide alleys with 150 cm lopping height combined with 2 prunings/year frequency could be an advantageous tree management practice in alley cropping for the dry zone.

KEY WORDS: Alley cropping, Alley width, Lopping height, Pruning frequency, *Gliricidia*

INTRODUCTION

Alley cropping is an agroforestry system where crops are grown in alleys formed by planted hedgerows of woody species. These hedgerows are pruned regularly to reduce the adverse effects on the crop due to competition for light, water and nutrients, and thereby to provide a source of pruning. The usefulness of alley cropping in the humid tropics has been demonstrated at the International Institute of Tropical Agriculture (Kang *et al.*, 1984).

The effectiveness of this system to increase and sustain upland crop production in humid tropics depends upon the amount of prunings that is produced by the system. It has been shown that tree management practice affects biomass production. Karim *et al.* (1991) showed that, three years after establishment, shoot dry matter

yield of *Leucaena leucocephala* was highest at 75 and 150 cm cutting heights with longer cutting intervals during a six-month period. An experiment conducted with *Gliricidia* showed that the shoot dry matter yield decreased with increasing alley width (Karim and Savill, 1991).

Attempts to increase the quantity of prunings by tree management practices affect crop growth due to competition for light, nutrients and moisture. Singh *et al.* (1986) showed that crops grown in close-spaced alleys yield less than in wide-spaced alleys. This was attributed to competition for moisture. Hence, there is a need to investigate crop performances under alternative tree management practices to find out suitable practices for alley cropping.

Investigations with *Gliricidia sepium* on the effects of tree management on hedgerow performance and crop yields in alley cropping are still limited. Duguma *et al.* (1988) found that yield of hedgerow prunings increased with decreasing pruning frequency and increasing lopping height. They also observed greater maize and cowpea yields with increasing pruning frequency and decreasing lopping height. However, this information is difficult to interpret because pruning times are defined in terms of calendar periods, but not on actual weather patterns and cropping seasons.

The present study was therefore undertaken to investigate the effects of various tree management practices on shoot dry matter yield of hedgerows, weed growth, and growth and yield of mungbean.

MATERIALS AND METHODS

A field trial was carried out on alley cropping with *Gliricidia sepium* five years after tree establishment at the Regional Agricultural Research Centre, Maha Illuppallama during minor (yala) and major (maha) seasons in 1992. The experimental area has a bimodal rainfall distribution with an annual mean of 1400 mm. The minor cropping season starts in late March and ends in June and is followed by the major cropping season from October to January. Rainfall is 350 mm and 900 mm during yala and maha seasons respectively.

The soil in the experimental site was a Rhodustalf and is the most leached member of the catena in the region (Panabokke, 1956). The surface soil (0 - 10 cm) had a pH of 5.5, organic matter content of 1.9%, available P of 30 ppm and exchangeable K of 1.3 me/100 g. Weed occurrence in the experimental site was high.

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING

In 1987, *Gliricidia* hedgerows were established using 3 month-old seedlings raised in polythene bags. Two alley widths (2 and 4 m) were established at a 50 cm within row space in 4 replicates to be considered as the horizontal factor in a strip-split plot design. After one year, trees were lopped at 75 and 150 cm height assigning the treatments in strips vertical to alley width. Sub-sub plots consisted of three pruning frequencies (two prunings/year each at the beginning of the cropping season; four prunings/year, two in each season having a 40-day pruning interval; and five prunings/year, two in yala season and three in maha season having a 40-day pruning interval). The sub-subplot size was 6 x 12 m.

During the first two years, sesame (var. MI 1) and maize (var. Bhadra 1) were grown in yala and maha seasons at 15 x 30 cm and 40 x 60 cm spacing respectively. During next three years cowpea (var. MI 35) was grown in yala season instead of sesame at a spacing of 20 x 30 cm with 2 plants/hill. Maize was planted in maha as in previous years. In each season, plots were weeded before the rains and seeds were planted one day after pruning of trees with the first rains. The prunings were applied as a mulch after removing the stems. Basal fertilizer was added at planting and a top dressing was applied at four weeks after seeding. Sesame, maize and cowpea received a basal dressing of 12 N - 55 P₂O₅ - 35 K₂O, 12 N - 45 P₂O₅ - 30 K₂O and 8 N - 65 P₂O₅ - 45 K₂O kg/ha respectively applied as a mixture of urea, triple superphosphate and muriate of potash. Top dressing for each crop was 15, 23 and 7 kg N/ha applied as urea. Tree prunings during the season were also spread as a mulch between crop rows. Only the cobs/pods were harvested and crop residues were left in the field.

Mungbean, variety MI 5, was seeded at 20 x 30 cm spacing with 2 plants/hill after initial weeding in each season during the study period. Seeding was done one day after pruning. A basal dressing of 8 N - 65 P₂O₅ - 45 K₂O kg/ha was applied as a mixture of urea, triple superphosphate and muriate of potash at seeding. A top dressing of 7 kg N/ha was applied as urea at the flowering stage. Plots were weeded with a hoe one day before application of top dressing.

Shoot (leaves + green branches) dry matter yield of pruning was determined by oven drying for 24 hours at 80°C. Weed dry matter yield was obtained by removing the above ground parts of weeds from 0.5 m strip across the alley. The weeds were separated into grasses (including a small amount of purple nutsedge) and broadleaves and oven dried at 80°C for 24 hours. Plant height, leaf area index and dry matter yield of the crop were determined from a sample removed from a 0.6 m strip across the alley. Mungbean was harvested at the end of each season and seed yields were determined at 12% moisture content.

RESULTS

Shoot dry matter yield (SDMY) of *Gliricidia*

The cumulative shoot dry matter yield of the four years prior to the experimental period and five years (including the experimental period) showed that SDMY in 2 m wide alleys was higher when compared to that in 4 m wide alleys (Fig. 1). It was also higher when lopped at 150 cm. Lower pruning frequency gave higher SDMY irrespective of the alley width or lopping height (Fig. 1a and b). Thus the highest SDMY was recorded in 2 m wide alleys when pruned twice a year at 150 cm lopping height. A similar trend was observed during the study period (Fig 1c and d).

Weed dry matter yield (WDMY) and composition of weeds

There were significant differences in WDMY in the different alley widths, lopping heights and pruning frequencies (Table 1) with no interaction between these parameters. WDMY in 2 m wide alleys was lower when compared to that in the 4 m wide alleys. It was also lower when these were lopped at 150 cm. Pruning *Gliricidia* twice a year controlled weeds to a greater extent.

Dry weight of grass weeds was lower in 2 m wide alleys when compared to the 4 m wide alleys and at the 150 cm lopping height. With decreasing lopping frequency dry weight of grass weeds decreased. The reverse was observed in dry weight of broadleaf weeds for different alley widths, lopping heights and pruning frequencies.

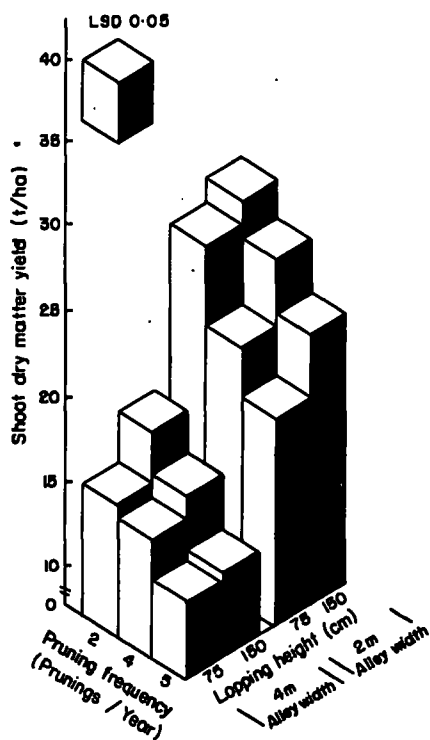
Growth of mungbean

Plant height at flowering

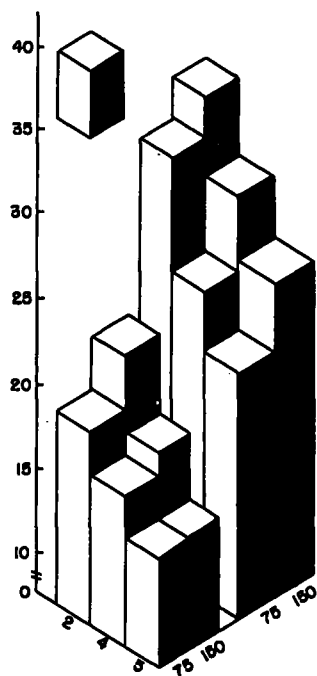
An interaction between alley width and lopping height was observed (Table 2). Plant height at 75 cm lopping height was higher compared to that at the 150 cm lopping height in the 2 m wide alleys. Reverse was observed in the 4 m wide alleys. Increasing trend in plant height was observed with decreasing pruning frequency irrespective of alley width or lopping height.

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING

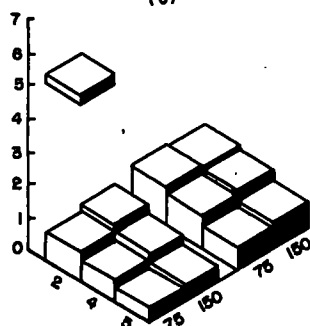
(a)



(b)



(c)



(d)

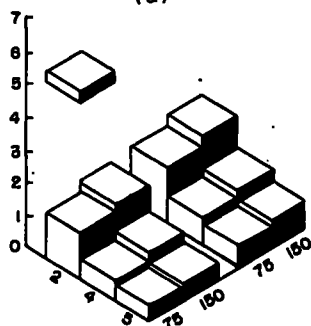


Fig. 1. Effect of pruning regimes on total shoot dry matter yield of *Gliricidia* hedgerows during previous four years (a), five years (b), yala season (c) and maha season (d).

Table 1. Effect of alley width, lopping height and pruning frequency on weed dry matter yield at flowering of mungbean

Treatment	Dry weight of weeds (g/m ²)		
	Grasses	Broadleaves	Total
Alley width (m)			
2	14.0 (61%)*	9.1 (39%)	23.1 (100%)
4	29.7 (84%)	5.6 (16%)	35.3 (100%)
LSD (0.05)	5.6	1.8	4.0
Lopping height (cm)			
75	24.9 (79%)	6.7 (21%)	31.7 (100%)
150	18.8 (70%)	7.9 (30%)	26.7 (100%)
LSD (0.05)	5.9	1.9	5.6
Pruning frequency (Prunings/year)			
2	7.2 (41%)	10.3 (59%)	17.5 (100%)
4	26.0 (77%)	7.7 (23%)	33.7 (100%)
5	32.4 (89%)	4.1 (11%)	36.5 (100%)
LSD (0.05)	3.9	2.1	4.5
CV (%)	24.5	38.6	21.2

* Weed dry weight as a percentage of total is given in parenthesis

Leaf area index (LAI) at flowering

A significant interaction was observed between alley width and lopping height (Table 3). LAI at 75 cm lopping height was higher when compared to that at the 150 cm lopping height in the 2 m wide alleys. The reverse was observed in the 4 m wide alleys. LAI increased with decreasing pruning frequency irrespective of alley width or lopping height.

Dry matter yield at flowering

Although there were no significant differences in dry matter yield for different alley widths and lopping heights, an interaction was recorded between alley width and lopping height. Dry matter yield at 75 cm lopping height was higher compared to that at the 150 cm lopping height in the 2 m wide alleys (Table 4). The reverse was observed in the 4 m wide alleys. Dry yield decreased with increasing pruning frequency irrespective of alley width or lopping height.

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING

Table 2. Effect of alley width, lopping height and pruning frequency on plant height at flowering of mungbean

Pruning frequency (prunings/year)	Plant height (cm)				Mean
	Alley width (m)				
	2		4		
	Lopping height (cm)				
	75	150	75	150	
2	30.0	29.5	26.0	26.6	28.0
4	27.8	26.1	22.4	23.1	24.8
5	27.1	24.3	21.8	22.6	23.9
Mean	28.3	26.6	23.4	24.1	
LSD (0.05) Between pruning frequency mean 1.2					
Between lopping height mean at same or different alley width 1.4					
CV (%)	6.2				

Table 3. Effect of alley width, lopping height and pruning frequency on LAI at flowering of mungbean

Pruning frequency (prunings/year)	Leaf area index (LAI)				Mean
	Alley width (m)				
	2		4		
	Lopping height (cm)				
	75	150	75	150	
2	1.18	1.09	1.03	1.09	1.10
4	1.09	0.97	0.82	0.97	0.96
5	1.03	0.89	0.73	0.86	0.88
Mean	1.10	0.98	0.86	0.97	
LSD (0.05) Between pruning frequency mean 0.08					
Between lopping height mean at same or different alley width 0.12					
CV (%)	11.8				

Table 4. Effect of alley width, lopping height and pruning frequency on dry matter yield at flowering of mungbean

Pruning frequency (prunings/year)	Dry matter yield (g/10 m ²)				Mean
	Alley width (m)				
	2		4		
	Lopping height (cm)				
	75	150	75	150	
2	83	73	63	67	71
4	64	61	52	58	59
5	68	54	41	52	54
Mean	72	63	52	59	
LSD (0.05)	Between pruning frequency mean 5.0				
	Between lopping height mean at same or different alley width 7.3				
CV (%)	11.2				

Table 5. Effect of alley width, lopping height and pruning frequency on seed yield of mungbean

Pruning frequency (prunings/year)	Seed yield (kg/ha)					
	Alley width (m)					
	2			4		
	Lopping height (cm)					
	75	150	Mean	75	150	Mean
2	449	402	425	533	694	614
4	501	494	498	490	586	539
5	679	540	610	356	399	378
Mean	543	479		460	560	
LSD (0.05)	Between pruning frequency mean at same alley width 135 Between lopping height mean at same or different alley width 88					
CV (%)	25.6					

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING

Seed yield

Interactions were observed between alley width and lopping height, and alley width and pruning frequency (Table 5). In the 2 m wide alleys, seed yield was higher at 75 cm lopping height while reverse was observed in the 4 m wide alleys. Effect of pruning frequency also was different in the two alley widths. In the 2 m wide alleys, seed yield increased with increasing pruning frequency while it decreased with increasing pruning frequency in the 4 m wide alleys.

DISCUSSION

The results show that the different tree management practices had a marked effect on SDMY. In *Gliricidia* hedgerows, SDMY was higher for lower alley width, taller lopping height and lower pruning frequency (Fig.1). Similar results were reported by Duguma *et al.* (1988). Higher SDMY with lower alley width is mainly due to the increased number of trees per unit area. Taller tree stems have more food reserves available in the stem so that they produce higher SDMY than shorter trees. The low SDMY with frequent pruning of hedgerows may be due to trees becoming weak as a result of frequent removal of dry matter which retards subsequent regrowth.

Alley width and pruning frequency on reducing WDMY was more effective than lopping height. There was a 35% reduction in total weed dry matter in 2 m wide alleys compared to 4 m wide alleys and a 52% reduction in 2 prunings/year compared to 5 prunings/year frequency. Difference in WDMY between two lopping heights was marginal. Fast growth of *Gliricidia* covers the 2 m wide alleys quicker than 4 m wide alleys. Fast and undisturbed regrowth for 6 months in 2 prunings/year covers the alley more than 4 and 5 prunings/year. Resultant shading effect, specially, during the off-season is a possible explanation for lower weed growth. The effect of physical suppression by different levels of mulching cannot be neglected. However, Budelman (1988) concluded that *Gliricidia* mulch is not suitable to control weeds since it decomposes too fast to have a significant lasting effect. Generally, higher application rates show a longer effective mulch due to the larger amount of material present. During the 5-year period, 2 m wide alleys received 29 t/ha, 65% more shoot dry matter than 4 m wide alleys. Two and 4 prunings/year received 42% and 18% more shoot dry matter respectively than 5 prunings/year. Allelopathic effect, the third potential factor, of this vastly different additions of shoot dry matter could have a significant contribution to the differences in WDMY. However, data presented here do not warrant any quantification and in literature emphasis has been placed mostly on shading effect (Budelma, 1988; Jama *et al.*, 1991). Marginal differences in WDMY with increasing

lopping height has been due to the marginal differences in shoot dry matter additions as well as shading effect.

Shift in weed composition towards broadleaf weeds with decreasing alley width, increasing lopping height and decreasing pruning frequency is also attributed to the shading effect. Most of grass weeds having high light compensation point are susceptible to shade so that they are replaced by broadleaf weeds which have low light compensation point. Both these factors ensure better weed control at a low cost in narrow alleys, at taller heights and lower frequencies.

Crop growth is low when narrow alley width combines with taller lopping height, even if it produces more shoot dry matter and less weeds than with shorter lopping height. This can be due to the underground competition for water and nutrients by the dense tree stand during its fast regrowth. Taller trees create more shade and the situation becomes aggravated when trees are closely spaced (Jackson and Palmer, 1987). Crop growth may also be affected due to the inhibitive effect that builds up with the addition of *Gliricidia* shoots especially in previous seasons. In the 4 m wide alleys, these three factors (competition, shading and inhibitors) are not that severe due to lesser tree density and therefore the crop growth is not affected adversely resulting in an increasing crop growth with increasing lopping height. Reduction of crop growth with increasing pruning frequency can be mainly due to differences in the amount of nutrients added to the soil through prunings and weed populations associated with different pruning frequencies. Shading effect due to various pruning frequencies at early stages of crop growth cannot have a considerable effect as trees were pruned at crop establishment.

Although a similar trend is expected in seed yield as with the crop growth parameters, seed yield behaved differently. In the 2 m wide alleys, seed yield was higher at 75 cm than 150 cm lopping height while reverse was observed in the 4 m wide alleys. But, in the 2 m alleys, seed yield increased with increasing pruning frequency while it decreased with increasing pruning frequency in the 4 m wide alleys. The latter mentioned deviation is presumably due to shading offered by hedgerows during grain filling which is not so effective during early crop growth. In the 2 m wide alleys, two prunings/year (at the beginning of the season) led to a complete covering of the alley at the time of grain filling resulting in the seed yield being the lowest. But the shading effect is not that severe in the 4 m wide alleys to have a similar effect as hedgerows are spaced far apart and enough solar radiation is allowed to penetrate through the tree canopy. The trends in seed yield obtained for 2 m alley are comparable to the results recorded by Duguma *et al.* (1988).

EFFECT OF TREE MANAGEMENT PRACTICES IN ALLEY CROPPING

CONCLUSIONS

The study indicates an increase in SDMY, as well as a reduction in weed dry matter and a shift in weed composition towards broadleaf weeds, with decreasing alley width and pruning frequency, and increasing lopping height. This can result in increased soil fertility levels as well as energy savings for weed control. However competition, shading and inhibitors may modify these favourable effects on crop growth and yield.

This study also shows that two tree management combinations give higher yields when compared to others. They are narrow alley width and shorter lopping height associated with frequent pruning, and wider alley width and higher lopping height associated with lower pruning frequency. The latter combination has an advantage over the former due to the lower labour involvement because of fewer trees in the system and fewer prunings and the lower physical damage to the associated food crop during pruning. Therefore, 4 m wide alleys with 150 cm lopping height associated with 2 prunings/year frequency can be an advantageous tree management practice in alley cropping for the dry zone.

ACKNOWLEDGEMENT

I thank Mr.G.Gunawardana for his support given in carrying out the field work and data collection.

REFERENCES

- Budelman, A. 1988. The performance of the leaf mulches of *Leucaena leucocephala*, *Flemingia macrophylla* and *Gliricidia sepium* in weed control. *Agroforestry Systems* 6: 137 -145.
- Duguma, B., B.T. Kang and D.U.U. Okali. 1988. Effect of pruning intensities of three woody leguminous species grown in alley cropping with maize and cowpea on an alfisol. *Agroforestry Systems* 6: 19-35.
- Jackson, J.E. and J.W. Palmer. 1987. Light availability at the tree/crop interface. In *Meteorology and agroforestry*. Eds. W.S. Reifsnnyder and T.O. Darnhofer. pp. 391-400. International Council for Research in Agroforestry (ICRAF), Nairobi, Kenya.

TROPICAL AGRICULTURIST, VOL. 148, 1992

- Jama, B., A. Getahun and D.N. Ngugi. 1991. Shading effect of *Leucaena leucocephala* on weed biomass and maize yield at Mtwapa, Coast Province, Kenya. *Agroforestry Systems* 13: 1-11.
- Kang, B.T., G.F. Wilson and T.L. Lawson. 1984. Alley cropping: a stable alternative to shifting cultivation. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 22 p.
- Karim, A.B., E.R. Rhodes and P.S. Savill. 1991. Effect of cutting height and cutting interval on dry matter yield of *Leucaena leucocephala* (Lam) De Wit. *Agroforestry Systems* 19: 129-137.
- Karim, A.B. and P.S. Savill. 1991. Effect of spacing on growth and biomass production of *Gliricidia sepium* (Jacq) Walp in an alley cropping system in Sierra Leone. *Agroforestry Systems* 16: 213-222.
- Panabokke, C.R. 1956. A pedologic study of dry zone soils. *Tropical Agriculturist* 114: 151-174.
- Singh, R. P., R.J. van Den Beldt, D. Hocking and G.R. Korwar. 1986. Alley cropping in the semi-arid regions of India. Paper presented at the alley cropping workshop, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, 10-14 March 1986.