THE EFFECTIVENESS OF HEDGEROW CROPPING SYSTEM IN REDUCING MINERAL N-LEACHING IN ULTISOLS

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ABSTRACT

Arable land in the humid tropics is dominated by Ultisols. This arable land is characterized by acid soils with shallow crop root development, relatively coarse texture, low cation exchange capacities, low organic content, and having 2500 to 3000 mm of annual rainfall. Such conditions cause intensive leaching of soluble nutrients, especially NO_3^-, below the crop root zone. Therefore, hedgerow inter-cropping systems, with development of tree root systems under the main crop root zone, can hypothetically intercept the nutrients lost and recycle them by acting as a "safety net". To provide a better understanding of the effectiveness of hedgerow cropping in reducing mineral N leaching, we studied two contrasting tree species. In this paper we describe field measurements of the root distribution, mineral-N leaching and crop production from *Peltophorum dasyrrhachis* (a deep-rooted local tree and with low litter quality), *Gliricidia sepium* (extensive rooted and with high litter quality) and alternate *Peltophorum /Gliricidia* hedgerow cropping systems, and maize monoculture treatments. The hedgerow inter cropping systems have been established by the BMSF-Project since1986 (about 13 years ago) in N. Lampung. The result showed that all trees have a tap root into the subsoil. *Gliricidia* extended some thick roots horizontally into the top soil and *Peltophorum* had the lowest root length density on profile wall between 0-1 m. The deepest tap root growth was found in the alternate of *Peltophorum & Gliricidia* hedgerow inter-cropping systems. The hedgerow inter-cropping system with *Peltophorum dasyrrhachis* was the most effective in reducing mineral N-leaching. It showed that incorporation of *Peltophorum* and *Peltophorum & Gliricidia* in *Peltophorum* and alternate *Peltophorum /Gliricidia* hedgerow inter-cropping systems respectively into the soil produce maize grain yield equivalent to those resulting from application of 45 kg ha^{-1} or even 90 kg ha^{-1} inorganic N in maize monoculture systems within 4 years of cropping systems.

INTRODUCTION

Leaching of Nitrogen (N) is very intensive under arable rainfed-upland in the humid tropics (Van-Noordwijk, 1989; Seyfried and Rao 1991). Arable rainfed-upland in the humid tropics is dominated by acid soils of low inherent fertility known as Oxisols and Ultisols (Sanchez, 1976). In Indonesia, Ultisols which are classified as Red-yellow Podzolic Soils, are estimated to cover 47.5 million ha or 24.9 % of the total land area of Indonesia (Santoso, 1998). The major part of this arable rainfed-upland are characterized as acid soils with shallow crop root development, relatively coarse texture, low cation exchange capacities, low organic matter content, and having 2000 to 3000 mm of annual rainfall (Van Noordwijk, 1996). Such conditions cause intensive leaching of soluble nutrients, especially NO_3^-, below the crop root

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zone. In the humid tropics, greater net leaching gives the potential for much larger losses of nitrate than in temperate regions. Measurements suggest that 150 to 250 kg N ha^{-1} of soil and fertilizer nitrogen may be lost each year from freshly cultivated soil (Mueller-Harvey *et al.*, 1985; Van Der kruijs *et al.*, 1988). Therefore, alley-cropping or hedgerow inter-cropping system, with the development of root system under the main crop root zone, can (hypothetically) intercept the nutrients lost and recycle them by acting as a "safety-net".
The role of deep-rooted trees to act as 'safety net' is very important on soil in which fertilizer or organic material easily leach to the subsoil from and in areas with abundant rainfall. Uptake activity from deeper layers may be expected especially where nutrient stocks and root development in deeper layers are larger than in more superficial layers of the soil and total plant demand can not be met from the top- soil. Our study was conducted to provide a better understanding of the effectiveness of hedgerow inter-cropping in reducing mineral N leaching under humid tropics. Specific objectives were to (1) evaluate the root distribution on different cropping systems, (2) monitor leaching of mineral N under hedgerow inter-cropping in comparison with mono-culture crop of maize, and (3) compare crop performance in hedgerow inter-cropping and mono-culture cropping systems.

MATERIALS AND METHODS

Site Description

This study is carried out in the Biological Management of Soil Fertility Project (BMSF Project), Karta (4° 31' S. 104° 55' E), about 50 km N of Kotabumi, Lampung, Indonesia. This project is located in a patch of secondary forest surrounded by sugar cane field, 15 km from the village Negara Tulang Bawang on the banks of the Way Kiri branch of the Tulang Bawang river.

In the recent 1: 250.000 land unit and soil map (Hikmatullah *et al.*, 1990) the site is mapped as landscape unit Idq 4.2. and characterized as moderately dissected undulating to rolling plain, containing acid tuffs and coarse felsic sedimentary rock, with sloped 3 - 15%. Accelerated erosion is common and the drainage pattern is dendritic. The soils are classified as a Plinthic Kandiudults (Soil-Survey-Staff, 1992). As Al-toxicity probably is a major constrain, apart from deficiencies of the major nutrients. The percentage Al-saturation of the exchange complex is 20 % for the topsoil and almost 60% for the subsoil, which represent high, but not extreme values (BMSF-Project, 1996). On the climatic map of (Oldeman *et al.*, 1979) the project site is on the climate zone C2. This zone is characterized by 5 consecutive wet months (at least 200 mm precipitation) and three dry months (less than 100 mm precipitation). The wet season usually occurs on November- March, and the dry season occurs on May - July. Further descriptions of site and climate were given in (Van Der Heide *et al.*, 1992).

Hedgerow inter-cropping system establishment and pruning

Stems cutting of the hedgerow trees were planted in single rows during the rainy season of 1986. The hedgerow system used two plant species with two planted systems, those were *Peltophorum dasyrrhachis* (a deep-rooted local tree and with low litter quality), *Gliricidia sepium* (extensive rooted and with high litter quality) and alternate *Peltophorum* and *Gliricidia* hedgerow inter-cropping systems. The experiment was laid out in a Randomized Block Design with two replicates of each hedgerow system. The stems cutting were established along 16 m of the contour line with 0.5 m spacing between plants. Each experimental plot was 16 m long with four of 4-m-wide alleyway, giving a plot area of 256 m^2.

Starting in the rain season of 1986/7, a maize (*Zea mays L.*) – maize crop sequence was established in the alleys, and the hedgerow species was pruned. The hedgerow was pruned to = 0.75 m above the ground surface and 0.5 m from the trunk from two to four times per year. The leaves + twig from pruned trees were kept separately from woody branch. Stems with diameter > 2 cm was removed from the plot. The pruning from the tree hedgerows was applied to the alley crops as green manure in the respective plots. The pruning biomass was presented in this paper that was selected from 1993/1994 to 1997/1998 of crop growing periods. The cropping pattern maize-maize with 45 kg N ha^{-1} and 90 kg ha^{-1} respectively was also planted for comparison. Therefore, the combinations of plant species were:

1. *Peltophorum dasyrrhachis* +maize-maize (PP),
2. *Gliricidia sepium* + maize - maize (GG),
3. alternate *Peltophorum* and *Gliricidia* +maize - maize (PG.),
4. Control-1 or maize-maize + 45-45 kg N ha^{-1} (C45).
5. Control-2 or maize-maize + 90-90 kg N ha^{-1} (C90).

In all control plots, urea was applied twice, half dosage each, at a day and 30 days after planting the maize. Other fertilizers applied were TSP at the rate of 133 kg ha^{-1} (60 kg P_2O_5 ha^{-1}) and KCl at the rate of 100 kg ha^{-1} (60 kg K_20 ha^{-1}). Those fertilizer were applied at a day of planting the maize. The biomass residue and grain yield of maize presented in this paper were obtained from 1993/1994 to 1996/1997 of crop growing periods. In crop growing period of 1997/1998, all plots were applied with urea at the rate of 90 kg N ha^{-1}.

Root measurement

In January 1998 root distribution in the vertical plane was observed in Experiment 17, in *Peltophorum* + maize (PP), *Gliricidia* + maize (GG) and *Gliricidia/Peltophorum* + maize hedgerow inter-cropping systems (PG), and maize monocropping systems (C). Soil trenches were prepared just out-sided of a plot of each cropping system which soil was dug to 1 m soil depth. Trenches bordering a 4 m, 8 m, and 2 m section were dug for PP and GG, PG, and C respectively. This width of trenches gives two replications of root distribution (two side positions). To quantify root distribution (root length density, L_{rv}, cm/cm^3), the block soil of root samples were taken in 0 – 0.5 m, 0.05 – 0.2 m, 0.2 – 0.4 m, 0.4 – 0.6 m, 0.6 – 0.8 m and 0.8 – 1 m soil depths, 0 2 m (between rows of maize) and 0.3 m (inter row of maize) width and 0.2 m thick of samples in each block samples every profile wall of all trenches.

The collected soil samples were soaked overnight in water and wet-sieved in the following day on a 2 mm sieve and retained in a 0.5 mm sieve to separate roots from the soil. The root mass, together with organic debris retained on the sieve, was transferred to a plastic bag and then added with thymol. Within 24 to 36 h, the tree and crop roots were sorted manually from other organic debris, and the root length was measured. The sorted root was stained with methyl violet, and spread out on the "millimeter board" to determine root length density. Root length density of each sample was measured by a line intercept method (Tennant, 1975).

Leaching of mineral N

Vacuum lysimeters developed by (Dorrance *et al.* (1990) were used to sample mineral-N percolated into deep soil horizons. A vacuum lysismeter is defined as a device for collecting percolating water for analysis. Vacuum lysimeters generally consist of a porous cup mounted on the end of a tube, similar to a tensiometer. A rubber stopper is inserted tightly into the upper end of the body tube.

Solute samples were taken from different cropping systems, at 0.8 m soil depths and, at varied distance from the tree rows. Under artificial fertilizer treatment in maize monoculture crop, the vacuum lysimeters were placed in the 0.125 m from rows of maize and, in *Peltophorum dasyrrhachis* and *Gliricidea sepium* hedgerows, they were installed in 2 zones that is 0.7 m and 2 m from the row of trees (row distance 4 m). In the alternated *Gliricidia /Peltophorum* hedgerow, they were placed at 0.7 m, 2 m and 3.5 m from hedgerows (row distance 4 m). Each placement had vacuum lysimeters installed at 0.8 m. The vacuum lysimeters were installed in four replication.

The solute samples were taken after intense rainfall events during the crop-growing season. The solute samples were sucked from the vacuum lysimeters under 75 kPa within two days after rain stop. The solute sample was takèn from the field immediately added with toluene (to suppress microbial growth) and kept in freezer before mineral N determination.

The amount of NH_4^+ and NO_3^- in percolated solute samples were determined using flow injection analysis developed by Alves *et al.* (1993). To calculate the amount of leaching, ammonium and nitrate contents were than converted from ppm to kg ha^{-1} unit using the equation:

$$CN_{leached} = 10 \times C_n \times W_{drain} \quad (1)$$

Where $CN_{leached}$ is amount of mineral N leached (kg ha^{-1}), C_n is mineral N contents in units mg l^{-1}. W_{drain} was simulated using WaNuLCAS models version 1.2. (Van Noordwijk and Lusiana, 1999) and the existing rainfall, soil characteristics and cropping system data from this site experiments were used as input simulation.

RESULTS

Root distribution

The performance of crop and trees root distribution, in terms of root length density (Lrv) and expressed as weighted average Lrv from 0- 1 m soil depths, top soil (0-0.2 m soil depth) and sub soil (>0.2 – 1.0 m soil depth) respectively, was presented in Figure 1. Figure 1.b.2 and 1.c.2. showed that the weighted average Lrv of maize on top soil was ranged from 0.62 cm cm^{-3} in GG to 2.04 cm cm^{-3} in C and in sub soil was ranged from 0.04 cm cm^{-3} in GG to 0.24 cm cm^{-3} in PG. The maize in C was the highest Lrv in the top soil. Among the hedgerow cropping systems, maize in PG was the highest and in GG was the lowest of Lrv. In sub soil, the Lrv of maize was the lowest in GG and the highest in PG. On weighted average Lrv from 0-1 m soil depths (Figure 1.b.2), the maize in C had better Lrv (0.54 cm cm^{-3}) than in hedgerow cropping systems. Among the hedgerow cropping systems, the Lrv of maize was highest in the PG (0.44 cm cm^{-3}) and the lowest in GG (0.16 cm cm^{-3}).

With introducing hedgerow cropping systems, in 0-1 m soil depths, the weighted average Lrv of *Pletophorum* in PP (0.13 cm cm^{-3}) was the lowest and *Gliricidia* in GG (0.29 cm cm^{-3}) was the highest. However, the weighted average Lrv of *Gliricidia* (0.75 cm cm^{-3}) in GG mainly developed on top soil, compared with *Peltophorum* (0.36 cm cm^{-3}) in PP and *Peltophorum* + *Gliricidia* (0.42 cm cm^{-3}) in PG respectively. In sub soil, the weighted

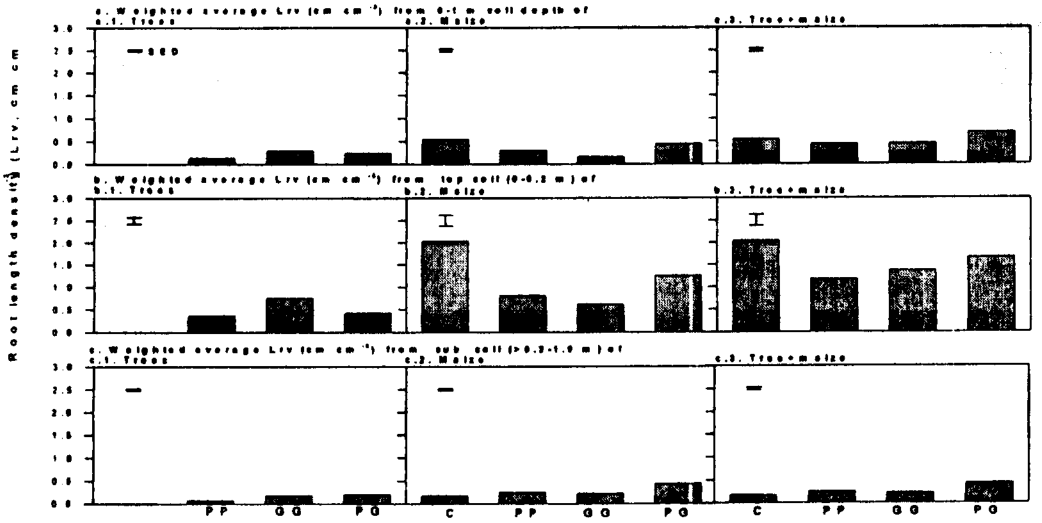

Figure 1.: Weighted average fine root length density (>0.5 mm - < 2 mm of diameter) at (a) 0-1.0 m, (b) 0-0.2 m, and (c) 0.2-1.0 m soil depths using root trenching methods where cropping systems were maize + *Peltophorum* (PP), maize + *Gliricidia* (GG), maize + alterante *Peltophorum* and *Gliricidia* hedgerows cropping systems, and maize monoculture (C)

average Lrv of *Peltophorum* + *Gliricidia* (0.20 cm cm^{-3}) in PG was the highest and *Peltophorum* (0.08 cm cm^{-3}) in PP was the lowest.

Overall, in 0-1 m soil depths, the weighted average Lrv of *Peltophorum* + *Gliricidia* +maize (0.68 cm cm^{-3}) in PG was the highest and other cropping systems were 0.54 cm cm^{-3}, 0.43 cm cm^{-3}, 0.45 cm cm^{-3} of maize in C, *Pletophorum* + maize in PP, and *Gliricidia* + maize in GG respectively. In top soil, the maize in C still had better Lrv (2.04 cm cm^{-3}) compared with Lrv of maize + trees in PP (1.17 cm cm^{-3}), GG (1.37 cm cm^{-3}) and in PG (1.67 cm cm^{-3}) respectively. In sub soil, however, the Lrv of maize (0.17 cm cm^{-3}) in C was the lowest compared with Lrv of maize + trees in PP (0.25 cm cm^{-3}), GG (0.22 cm cm^{-3}) and in PG (0.43 cm cm^{-3}) respectively.

Leaching of mineral N

Figure 2. shows the effectiveness of different cropping systems on reducing water drainage, concentration and amount of mineral N leached below 0.8 m soil depths. Accumulative water drainage within 70 days with 1162 mm of total rainfall was 39 %, 37 %, 38% and 46 % of total rainfall in PP, GG, PG and C respectively. The mineral N contents in the solutions extracted from ceramic cups over the whole season (Figure 2.b.) indicate that, there were greater accumulation in the initial growth of maize or after N fertilizer application in each soil among the other sampling period for mineral N remaining in all of the cropping

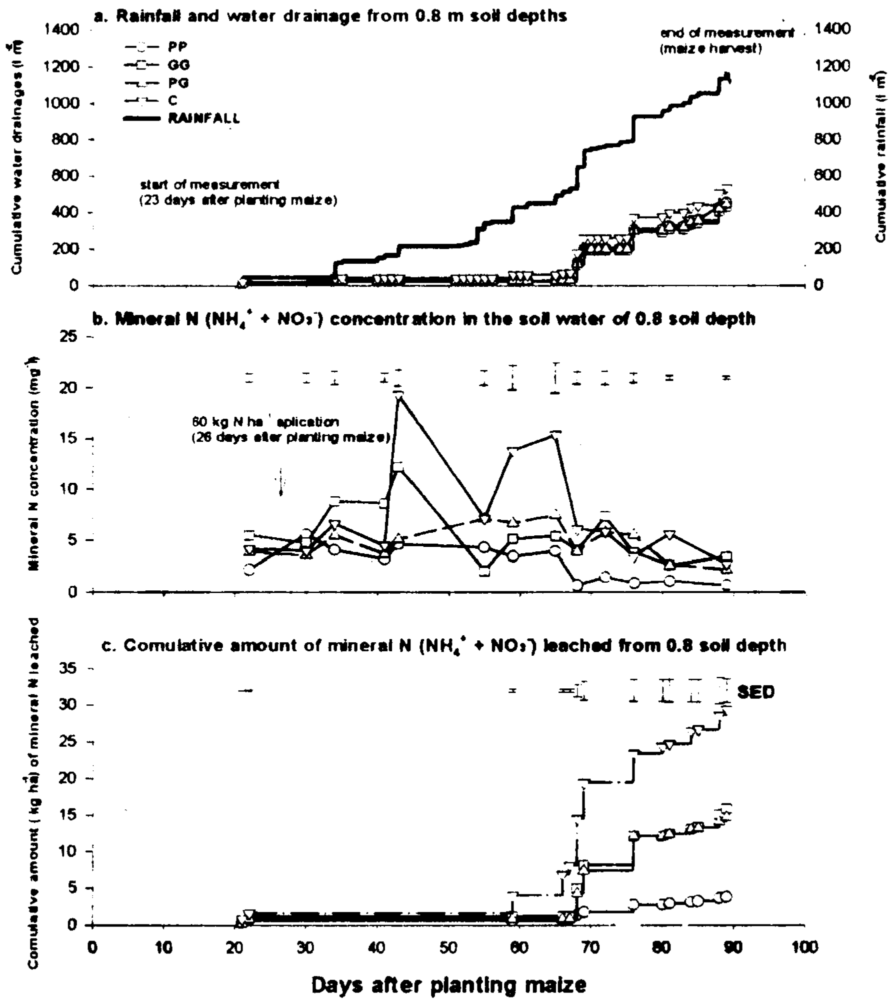

Figure 2: Rainfall, water drainage, mineral N concentration, and comulative amount of mineral N leached from 0.8 m soil depth where cropping systems, were: ***Peltophorum*** (PP), ***Gliricidia*** (GG), alternate ***Peltophorum*** and *Gliricida* (PG) hedgerow cropping systems and maize monoculture (C).

systems. Pattern of mineral N content between treatments at each soil depths declined in the following order in C > GG> PG> PP. The average of mineral N ($NH_4^+ + NO_3^-$) concentration in the soil water in 0.8 m soil depth during measurement period was 2.75 ppm (range from 0.65 ppm to 5.59 ppm), 5.66 ppm (range from 2.00 ppm to 12.20 ppm), 4.83 ppm (range from 2.15 ppm to 6.68 ppm) and 7.58 ppm (range from 2.7 ppm to 19.3 ppm) in PP, GG, PG and C respectively. The accumulative amount of mineral N leached under maize growing period was 3.8 kg ha^{-1}, 15.9 kg ha^{-1}, 14.8 kg ha^{-1}, and 29.4 kg ha^{-1} in PP, GG, PG and C respectively. This give reducing the N leached 87 %, 46 %, 50 % in PP, GG and PG respectively compared with C.

Performance of trees

The performance of tree species, in terms of total biomass (dry weight basis) incorporated into the soil in the form of pruning is presented in Table 1 for 5 consecutive seasons (1993/1994 to 1997/1998). During dry season in 1994, the plot was burnt, therefore the biomass of pruning trees after fallow period was less than other seasons. In 1996/1997 cropping season, the plot was only planted with maize one time, which a , give longer fallow period in than other season when maize grown twice. Within maize growing period, excluded pruning data from 1996/1997 cropping period, the pruning biomass of *Peltophorum* in PP was the lowest (2.03 Mg ha^{-1} on averages and ranges from 1.75 Mg ha^{-1} to 2.63 Mg ha^{-1}) compared with *Gliricidia* in GG (5.15 Mg ha^{-1} on averages and ranges from 4.11 Mg ha^{-1} to 6.81 Mg ha^{-1}) and *Peltophorum* + *Gliricidia* in PG (4.38 Mg ha^{-1} on averages and ranges from 2.86 Mg ha^{-1} to 5.90 Mg ha^{-1}). Under fallow period (dry season), excluded pruning data from 1994 and 1997 , the pruning biomass of *Gliricidia* in GG was the lowest (3.30 Mg ha^{-1} on averages and ranges from 2.77 Mg ha^{-1} to 4.25 Mg ha^{-1}) compared with *Peltophorum* in PP (7.57 Mg ha^{-1} on averages and ranges from 6.25 Mg ha^{-1} to 9.85 Mg ha^{-1}) and *Peltophorum* + *Gliricidia* in PG (6.08 Mg ha^{-1} on averages and ranges from 5.34 Mg ha^{-1} to 7.22 Mg ha^{-1}). Within 1993/1994 to 1997/1998 cropping season, total pruning biomass among trees species had similar result, those are 40.3 Mg ha^{-1}, 39.7 Mg $ha^{-1}$and 47.5 Mg ha^{-1} from *Peltophorum* in PP, *Gliricidia* in GG and *Peltophorum* + *Gliricidia* in PG respectively.

Table 1. Prunning biomass of hedgerow trees from 5 seasons (1993/94 – 1997/98)

Cropping season	Phase	Pruned biomass (Mg ha^{-1}) from tree species or hedgerow systems of			
		Peltophorum	*Gliricidia*	*Peltophorum* + *Gliricida*	SED
1993/1194	Fallow	6.62	4.25	5.34	1.44
	CGP*	1.86	6.81	5.90	1.18
1994/1995	Fallow**	1.85	1.14	1.93	0.12
	CGP	1.89	4.11	2.86	1.22
1995/1996	Fallow	6.25	2.89	5.69	0.76
	CGP	2.63	5.16	4.83	1.22
1996/1997	Fallow	9.85	2.77	7.22	1.95
	CGP	1.48	1.44	1.64	0.64
1997/1998	Fallow***	6.11	6.66	8.16	1.91
	CGP	1.75	4.50	3.91	0.71
		40.29	39.73	47.48	9.81

* Crop growing period . ** the plot was burnt, *** the plot has longer fallow period in comparison with other season; SED; = Standard error of different mean

Table 2. Effect of hedgerow intercropping systems on yield of maize for 4 seasons (1993/94 to 1996/1997)

Crop systems	Average of biomass		Average of grain yield		Total of	
	1st crop	2nd crop	1st crop	2nd crop	Biomass residue	Grain yield
	Kg ha-1 (%*)					
Peltophorum dasyrrhachis	1,882 (+10)	865 (+15)	1,583 (+2)	479 (-5)	10,121 (+11)	7,769 (+1)
Gliricidia sepium	1,447 (-16)	611 (-19)	1,095 (-29)	242 (-52)	7,624 (-16)	5,107 (-34)
Alternated *Peltophorum and Gliricida*	1,504 (-12)	957 (+27)	1,482 (-4)	395 (-21)	8,888 (-3)	7,109 (-8)
Maize monocroped + *45 kg N ha*$^{-1}$	1,715 (0)	754 (0)	1,550 (0)	502 (0)	9,123 (0)	7,704 (0)
Maize monocroped + *90 kg N ha*$^{-1}$	1,883 (+10)	635 (-16)	1,745 (+13)	368 (-27)	9,437 (+3)	8,082 (+5)
Standard error of different mean (SED)	330	73	379	58	570	525

*) Percentage of - decreased or + increased of biomass residue and grain yield in comparison with maize monocroped + 45 kg N ha^{-1}

Influence on crop yield

The yield of maize during the1993/1994 to 1996/1997 cropping season are presented in Table 2. Data were not available for the second crop season of 1996/1997, because the plot was planted with the *Mucuna utilitis* as cover crop to improve the soil fertility and preparing the "safety-net" experiment in 1997/1998 cropping season period.

During four seasons from 1993/1994 to 1997/1997, the average biomass and grain yield of maize at second cropping season were lower than the first one (Table 2). Within first and second cropping season the overall trend in both biomass and grain yield of maize in among treatments were quite consistently affected by the amount of rainfall during the growing season. The effect of hedgerow trees and increasing fertilizer N application in C decreased the biomass and grain yield in comparison with maize in monoculture + 45 kg N ha^{-1} for the second crop. The effect of hedgerow trees and increasing fertilizer N application in C increased or had equivalent the biomass and grain yield in comparison with maize in monoculture + 45 kg N ha^{-1}, except in GG decreased significantly.

DISCUSSION

Specific hypotheses to be tested were:

In rainfed arable land, crop has shallow root systems due to subsoil acidity.
Introducing the hedgerow intercropping systems can increase rooting depth.

As in many cases of food crop grown on the acid soil under high-rainfall conditions, its root was only grown on the top soil (Figure 1). However, introducing the hedgerow trees, the root of maize was suppressed. The *Gliricidia* trees was the higher Lrv on top soil and caused higher effect on suppressing the root of maize than the *Peltophorum* trees. Those indicated that the root of *Glricidia* trees competed better for moisture and nutrients (except a nutrient of N) in the rooting zone of companion crops than the *Peltophorum* trees. The result of ^{15}N experiment showed that *Gliricida* took up less ^{15}N from 5 cm, 35 cm and 55 cm applications compared with *Peltophorum* and the crop (Rowe *et al.*, 1999). Hairiah *et al.* (1992) observed that *Peltophorum* trees made no nodule while *Gliricidia* trees were had few nodule and could obtain an estimated 44-58% of its N from atmospheric N2-fixation (Rowe *et al.*, 1999). Alternating *Peltophorum* and *Gliricidia* had no effect on the root of maize. Those positive combination may have synergistic effect on nodulation, and synchronize between low and high quality of pruning material decomposition (Handayanto *et al.*, 1995).

A deep root system acdtung as a "safety net" under the crops might help intercepting leached or leaching nutrients so as to improve nutrient use efficiency of the cropping systems

The effectiveness of hedgerow cropping system in reducing mineral N-leaching was in the following order 87 %, 50 %, and 46 %, in PP, PG and GG respectively compared with mineral N leached in C (Figure 2.). Data of *Gliricidia* had a higher root length density than *Peltophorum* , in contrast to the measured difference of the effectiveness of hedgerow cropping system in reducing mineral N-leaching. As also found by Cadisch *et al.* (1997) there was not a direct relationship between root length density and activity when comparing the two species. (Rowe *et al.*, 1999) showed that *Pelthoporum* obtained twice as much of N from the subsoil than *Gliricidia.* High N leached in GG and PG may also caused by high mineral N content and a faster decomposition of *Gliricida* pruning material than *Peltophorum* (Handayanto *et al.*, 1994) and caused less synchronization of nitrogen supply and demand during the crop growing season (Van-Noordwijk , 1989).

Long term productivity of upland soils for food crops may be improved by using hedgerow intercropping systems.

The result in Table 1 showed that P+G in PG performed best among the three hedgerow intercropping systems, followed by P in PP and then G in GG within 5 years measurement. This was also supported by the total biomass and grain yield of maize, where there were not significantly different in PP, PG , C45 and C90, but significantly reduced GG. It seemed that incorporation of P in PP and PG in PG into the soil produce maize grain yield equivalent to those resulting from application of 45 kg ha^{-1} or even 90 kg ha^{-1} inorganic N in maize monoculture systems. Overall, the PP and PG showed beneficial effect in later years and would give the best results and the best prospects in the long term. Especially, alternating P and G was successful; good nodulation of *Gliricidia* is combined with favorable below-and aboveground characteristics of *Peltophorum.*

CONCLUSIONS

It can be concluded that: (1) hedgerow trees were suppressing the root development of maize. *Peltophorum* had the lowest root length density (L_{rv}), *Gliricidia* roots hardly penetrated into the sub soil and extended its roots horizontally into top soil, However, alternated *Peltophorum* and *Gliricidia* covered the whole space on profile wall between 0-1 m.

(2) There was a pronounced concentration of maize root in the top 0.2 m of soil. In the top 0.2 m of soil, the maize root in monoculture system give the best root length density, but in the sub soil (0.2-1.0 m) and weighted averages of 0-1 m soil depth, the alternated *Peltophorum* and *Gliricida* give the highest L_{rv} of maize root. (3) The effectiveness of hedgerow cropping system in reducing mineral N-leaching was in the following order in *Peltophorum*, > alternated *Peltophorum* and *Gliricida* >*Gliricida* hedgerow inter-cropping systems respectively compared with mineral N leached in maize monoculture system. (4) There was appear that incorporation of *Peltophorum* and *Peltophorum & Gliricidia* in *Peltophorum* and alternate *Peltophorum /Gliricidia* hedgerow inter-cropping systems respectively into the soil produce maize grain yield equivalent to those resulting from application of 45 kg ha^{-1} or even 90 kg ha^{-1} inorganic N in maize monoculture systems within 4 years cropping systems.

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