Performance of spinach under ipil-ipil based alley cropping system

T.R. Saha, M.M. Rahman[1], R. Rahman, M.A. Wadud and G.M.M Rahman
Department of Agroforestry, Bangladesh Agricultural University, Mymensingh-2202, [1]Department of Agroforestry, Patuakhali Science and Technology University, Dumki, Patuakhali-8602

Abstract: An experiment was conducted at Agroforestry Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from October 2014 to November 2014 to observe the performance of Spinach (*Spinacia oleracea*) in Ipil-ipil based (pruned and unpruned) alley cropping system following Randomized Complete Block Design (RCBD) with three replications. Different treatments of the experiment were T_0 = Control (without fertilizer), T_1 = (Ipil-ipil Leaf Biomass) ILB+1/2 RFD (Recommended Fertilizer Dose), T_2 = ILB + 1/3 RFD , T_3 = ILB+1/4 RFD , T_4 = ILB and T_5 = RFD. Growth and yield of spinach was recorded in this alley cropping system at unpruned and pruned condition. It was found that growth parameters viz. plant height plant^{-1}, leaf length plant^{-1}, no. of leaves plant^{-1}, breadth of leaf plant^{-1}, leaf Size, weight per plant, fresh and dry yield of crops were almost similar in all manure/fertilizer treated plots. Performance of Spinach in terms of growth and yield parameters was remarkably lower in control (without fertilizer and manure) plot. Yield of spinach was statistically similar with all fertilizer and manure treated plots both in pruned & unpruned condition but it was drastically reduced in control plots. Though treatment T_1 gives highest value for different parameters, but it was statistically similar with T_2 and T_3 which was only 6-9 % and 4-5 % lower compare to T_4. Therefore it can be concluded that spinach crops are suitable in Ipil-ipil based alley cropping system and we can this alley cropping is a sustainable system by using only lpil-ipil leaf biomass.

Key words: Spinach, growth performance, Alley cropping system, pruned and unpruned condition

Introduction

Agroforestry systems plays an important role in the face of acute land shortage of our country and provide a range of products and services to rural and urban people. As natural vegetation is cut for agriculture and other types of development, the benefits that trees provide are best sustained by integrating trees into agricultural system a practice known as agroforestry. Agroforestry is a relatively new term for the practice of growing trees with agricultural crops and/or livestock on the same piece of land. Agroforestry is the intentional integration of trees and/or shrubs into crop and animal production.

Among the different agroforestry systems, alley cropping is the typical one as organic farming. In alley cropping, woody species are periodically pruned during the cropping season to prevent shading and to provide mulch and green manure for the companion crops (Wilson *et al*., 1986). Hedgerow trees in alley cropping increase the supply of nutrients mainly through input of nitrogen (N) by biological nitrogen fixation and retrieval of nutrients from below the rooting zone of crops (Buresh and Tian, 1998).

In Bangladesh, different crops are cultivated in different season. Among the different vegetables, spinach is one of them. These are well known and very popular vegetable grown successfully during winter season in Bangladesh. Spinach has a high nutritional value and is extremely rich in antioxidants, especially when fresh, steamed, or quickly boiled. It is a rich source of vitamin A (and especially high in lutein), vitamin C, vitamin E, vitamin K, magnesium, manganese, folate, betaine, iron, vitamin B2, calcium, potassium, vitamin B6, folic acid, copper, protein, phosphorus, zinc, niacin, selenium and omega-3 fatty acids. Recently, opioid peptides called rubiscolins have also been found in spinach. Polyglutamyl folate (vitamin B9 or folic acid) is a vital constituent of cells, and spinach is a good source of folic acid.

Considering the aforementioned facts and potentiality, a study was undertaken with the objective to examine the competitive performance of Spinach grown in alleys of Ipil ipil tree (*Leucaena leucocephala*) hedges at pruned and unpruned condition.

Materials and Methods

Experimental site and season: The experiment was carried out at the experimental farm, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh, during the period from 27 October 2014 to 27 November 2014. Geographically the place is located at about 24°75" North latitude and 90°50' East longitudes (FAO, 1988).

Plant materials and hedge establishment: In this study, one year old previously established four hedges of Ipil-ipil in pruned and unpruned condition (*Leucaena leucocephala*) were used as tree component. The seeds of Spinach were collected from Natunbazar, Mymensingh and in October. The Spinach vegetables were used as plant materials in this study. Ipil-ipil hedge was established during the year 2012 in a plot of 1200 sq. feet area. Total four hedgerows were established and length of each hedgerow was 40ft. Two hedgerows was pruned at 1m height above the ground level and rest two hedgerows were not pruned.

Experimental design, layout and treatment combination: Plot size of this study was 30ft × 40ft. In this plot total three alleis were created and inside the each alley a total of 12 plots (3ft × 8ft) were made. Total number of plots was 36 (3×12). Layout of this study is shown in Fig. 1. Among the 36 plots, 18 were pruned condition and 18 were unpruned condition. This study was laid out in two factorial Randomized Complete Block Design (RCBD) with three replications. Factor A: pruned status i.e. pruned and unpruned condition and factor B: fertilizer status i.e. T0 = Control (without fertilizer and manure), T_1 = Ipil-ipil Leaf Biomass (ILB) + 1/2RFD (Recommended Fertilizer Dose) , T_2 = ILB + 1/3 RFD, T_3 = ILB + 1/4 RFD, T_4 = ILB, T5 = RFD. In case of treatment T0 (control plots), no fertilizer and manure was applied and in case of treatment T_1, Ipil-ipil Leaf Biomass (ILB) and 1/2RFD was applied. In case of treatment T_2, Ipil-ipil Leaf Biomass (ILB) and 1/3 RFD, T_3 = ILB + 1/4 RFD, T_4 = Only ILB and T5 = RFD, respectively (BADC, 2011). Recommended dose of fertilizers were used for the respective crop species. Ipil-ipil leaf biomass was added in

the respective plot @ 10 kg/plot. Additional leaf biomass collected from other ipil-ipil tree etc.

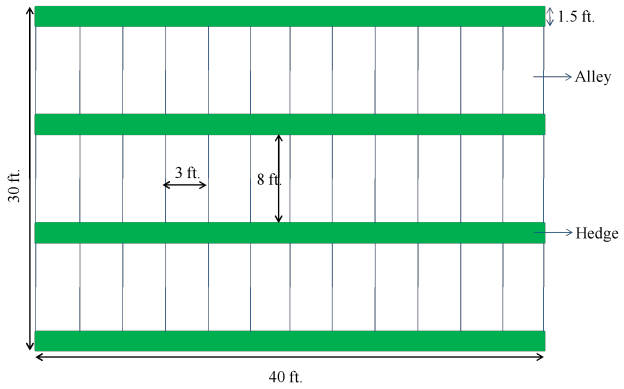

Fig. 1. Layout of the study

Spinach Seed sowing, establishment and harvesting: Seeds of spinach were sown in broadcasting method in the experimental plot on 27 October, 2014. After emergence finally spinach plants were thinned out.Emergence of spinach seedling was started after 7 days from the date of sowing. Seedlings of spinach was thinned out for maintaining proper plant density as for vegetable production, 25% plants were thinned out for seed production.To keep the plots free from weeds, weeding was done six times for experimental plots and control plots. All the plots were irrigated whenever needed by using watering cane to supply sufficient soil moisture for the vegetables.

Sampling procedure and data collection: Plant samples of spinach were collected randomly from the respective plots. Ten plants of spinach were selected from each plot for data collection. Data were collected at 7 days after emergence, at pre-harsvesting stage and during harvesting time for measuring plant height (cm), no. of leaves per plant, Leaf length (cm), Leaf breadth (cm), leaf size (cm^2).

Statistical analysis: The data were collected from the experiment at different stages of various growths and then analyzed statistically by using WASP-2 software package to find out the statistical significance of the experimental results. The mean differences were evaluated by Duncan's New Multiple Range Test (DMRT) and also by Least Significant Difference (LSD) test.

Results and Discussion

The results of this study for each vegetable was observed as morphological characters and yield separately. Morphological characteristics and yield of spinach obtained from this study are presented below:

Morphological characteristics

Morphological parameters viz. plant height (cm), no. of leaves per plant, Leaf length (cm), Leaf breadth (cm) and weight per plant (g) were recorded in different fertilizer treatment under pruned and unpruned condition at harvesting period. All of these recorded data were significantly influenced by different treatments which are presented as:

Table 1. Morphological characteristics of spinach in alley cropping system under unprune condition during

Treatment	Morphological Characteristics of Spinach				
	Plant height (cm)	No.of leaf	Leaf length (cm)	Leaf breadth (cm)	Weight per plant (g)
T_0	11.500 d	3.126 e	5.143 e	2.093 e	3.346 e
T_1	15.740 a	4.706 a	7.846 a	3.190 a	8.160 a
T_2	14.800 b	4.526 b	7.666 b	3.116 b	7.716 b
T_3	14.720 b	4.463 c	7.500 c	3.050 c	7.590 b
T_4	13.610 c	4.343 d	7.160 d	2.913 d	7.090 d
T_5	13.883 c	4.420 c	7.163 d	2.916 d	7.233 c
CV(%)	1.979	0.731	0.812	0.836	1.098
LSD (0.01)	0.714	0.086	0.141	0.064	0.197
Level of significance	**	**	**	**	**

Means in column followed by the different letter are significantly different by DMRT at $P \leq 0.05$, T_0= Control (without fertilizer), T_1= ILB + 1/2RFD, T_2= ILB + 1/3RFD, T_3 = ILB + 1/4RFD, T_4 = ILB and T_5 = RFD, ILB = Ipil-ipil Leaf Biomass, RFD = Recommended Fertilizer Dose, DAG= Days after germination

Plant height (cm): During harvesting period at unpruned condition, the highest plant height (15.740cm) was found (Table 1) in treatment T_1 (ILB+1/2 RFD) and lowest plant height (11.500 cm) was found (Table 7) in treatment T_0(without fertilizer). Like harvesting period at pruned condition the highest plant height (23.136cm) was found (Table 8) in treatment T_1 (ILB+1/2RFD) and lowest plant height (16.896 cm) was found (Table 2) in treatment T_0 (without fertilizer). From this study it was observed that plant height of spinach was higher under unpruned condition compare to pruned condition may be due to shade effect. Shade effect influence the apical dominance of any plant and consume more moisture (Nair,1980). Leafy vegetable like spinach need more moisture which are relatively more in shade condition which generally occurred in unpruned condition compare to pruned condition. These results are in agreement with the results of Rahman *et al.* (2013) in different winter vegetables under alley cropping system.

No. of leaves plant^{-1}: During harvesting period at unpruned condition, the highest number of leaves plant^{-1} (4.706) was found (Table 1) in treatment T_1 (Ipil-Ipil + 1/2 RFD) which is statistically dissimilar to the other treatment. The lowest number of leaves plant^{-1} (3.126) was found in treatment T_0 (without Fertilizer). The number of leaves plant^{-1} in treatment T_3 (4.463) which is statistically

similar to the treatment T_4 and T_5 was found 4.343 & 4.420 respectively. Like harvesting period at pruned condition, the highest number of leaves plant^{-1} (6.813) was found (Table 2) in treatment T_1 (Ipil-ipil + 1/2 RFD) which is statistically dissimilar to the other treatment. The lowest number of leaves plant^{-1} (4.530) was found in treatment T_0 (without Fertilizer).). The number of leaves plant^{-1} in treatment T_3 (6.466) which is statistically similar to the treatment T_5 and T_4 was found 6.283 respectively.

Leaf size (Length x Breadth, cm^2): During harvesting period, at unpruned condition, the largest leaf size (25.029 cm^2) was found (Table 1) in treatment T_1 (Ipil-Ipil + 1/2 RFD) and the smallest leaf size (10.764 cm^2) was found in treatment T_0 (without Fertilizer) respectively. Like harvesting period at pruned condition, largest leaf size (53.361 cm^2) was found (Table 2) in treatment T_1 (Ipil-Ipil + 1/2 RFD) and Smaller leaf size (22.946 cm^2) was found in treatment T_0 (without fertilizer). Highest leaf size was found in T_1 (ILB + 1/2 RFD) because for applying RFD plus leaf biomass. This result is supported by Hasan *et. al.* (2014) in kankong and Indian Spinach under alley cropping system.

Table 2. Morphological characteristics of spinach in alley cropping system under prune condition

Treatment	Morphological Characteristics of Spinach				
	Plant height (cm)	No.of leaf	Leaf length (cm)	Leaf breadth (cm)	Weight per plant (g)
T_0	16.896 d	4.530 e	7.573 e	3.030 e	4.820 e
T_1	23.136 a	6.813 a	11.550 a	4.620 a	11.763 a
T_2	21.750 b	6.553 b	11.286 b	4.516 b	11.123 b
T_3	21.633 b	6.466 c	11.043 c	4.416 c	10.946 b
T_4	20.000 c	6.283 d	10.540 d	4.216 d	10.226 d
T_5	20.400 c	6.400 c	10.546 d	4.216 d	10.430 c
CV(%)	1.986	0.745	0.821	0.821	1.096
LSD (0.01)	1.057	0.116	0.227	0.083	0.287
Level of significance	**	**	**	**	**

Means in column followed by the different letter are significantly different by DMRT at P ≤ 0.05, T_0= Control (without fertilizer), T_1= ILB + 1/2RFD, T_2= ILB + 1/3RFD, T_3 = ILB + 1/4RFD, T_4 = ILB and T_5 = RFD, ILB = Ipil-ipil Leaf Biomass, RFD = Recommended Fertilizer Dose, DAG= Days after germination

Weight per plant (gm): During harvesting period at unpruned condition, the highest plant weight (8.160gm) of spinach was found (Table 1) in T_1 (ILB + 1/2 RFD), the second highest plant weight (7.716gm) in T_2 (ILB + 1/3 RFD) which is statistically similar to the treatment T_3 and the lowest weight (3.346gm) was found in treatment T_0 (control). Like harvesting period at pruned condition, the highest plant weight (11.763gm) of spinach was found (Table 2) in T_1 (ILB + 1/2 RFD), second highest plant weight (11.123gm) in T_2 (ILB + 1/3 RFD) which is statistically similar to the treatment T_3 and the lowest weight (4.820gm) was found in treatment T_0 (control). Low nutrient content of control plot may be responsible for this. Such type of results also recorded by basak *et al.* (2014) in soybean and wheat under hedgerow intercropping system and Bithi *et al.* (2014) in soybean and mustard under alley cropping system with *Leucaena* tree.

Yield: It was found that fresh yield of spinach was higher under unpruned condition than pruned condition. Both pruned and unpruned condition it was found that highest fresh yield was in treatment T_1 (ILB + 1/2 RFD) followed by treatment T_2 (ILB + 1/3 RFD), treatment T_3 (ILB + 1/4 RFD), treatment T_4 (ILB), treatment T_5 (RFD) and lowest spinach plant was recorded in treatment T_0 (without fertilizer). Under unpruned condition fresh yield of spinach were highest per plot and per hectare in the treatment T_1 (6.86 kg and 11.77 ton respectively),T_2 (6.49 kg and 10.95 ton respectively), T_3(6.40 kg & 10.93 ton respectively), T_4 (5.99 kg & 10.24 ton respectively) and T_5 (6.06 kg & 10.40 ton respectively) and lowest yield in control condition i.e. without fertilizer condition. Under pruned condition fresh yield of spinach were highest per plot and per hectare in the treatment T_1 (6.53 kg and 11.20 ton respectively), T_2 (6.18 kg and 10.42 ton respectively), T_3 (6.11 kg & 10.42 ton respectively), T_4 (5.73 kg & 9.49 ton respectively) and T_5 (5.77 kg & 9.94 ton respectively) and lowest yield in control condition i.e. without fertilizer condition. From this study it was found that fresh yield if spinach as higher in pruned condition compare to unpruned condition may be due to shade effect .

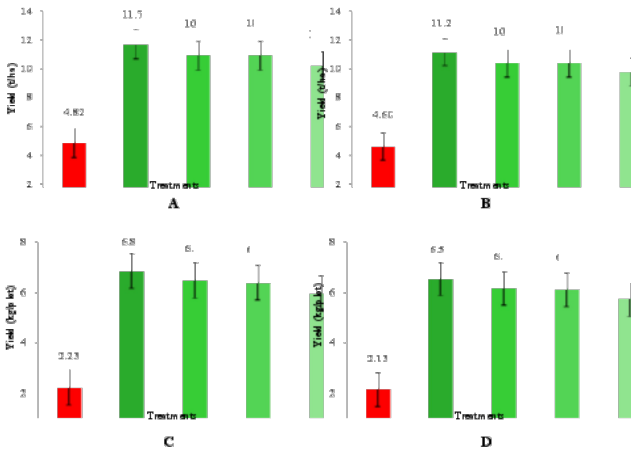

Fig. 2. Fresh yield of Spinach (A) Unpruned (t/ha), (B) Pruned (t/ha), (C) Unpruned (kg/plot) and (D) Pruned (kg/plot) in under Ipil-ipil based alley cropping system.

Shade condition ensure more moisture then open field condition (Nair,1980) through mulcing effect barrier, and cover effect of tree. Leafy vegetables like spinach need more moisture which relatively available in shade

condition than open field condition. Due to above reason may be more fresh yield was found in spinach under unpruned condition of this study. Emon *et al.* (2014) and Islam *et al.* (2014) also observed more fresh yield in Radish and Amaranth under shade condition in alley cropping system. Relatively more yield was found in ILB and inorganic fertilizer mixed treatmented plot may be due to addition of organic manure (ILB). Sharma and Mitra (1990), also reported that addition of organic manure increased plant length significantly.

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