Performance of kangkong and indian spinach in ipil-ipil based alley cropping system

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Abstract: An experiment was conducted at Agroforestry Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from 20 March 2013 to 25 July 2013 to observe the performance of two summer vegetables viz. Kangkong and indian spinach in alley cropping system with Ipil-ipil tree (*Leucaena leucocephala*) following Randomized Complete Block Design (RCBD) with three replications. Different treatments of the experiment were T_0 = Control (without fertilizer and manure), T_1 = Ipil-ipil leaf biomass (ILB) as manure, T_2 = ILB + 1/4 RFD (Recommended Fertilizer Dose), T_3 = ILB + 1/2 RFD (Recommended Fertilizer Dose). Growth and yield of these two vegetables was recorded in this alley cropping system. It was found that growth parameters viz. plant height (cm), number of branches per plants, number of leaves per plants, leaf size (length × breadth, cm^2), stem girth (cm) and weight per plant (g) of both kangkong and indian spinach were almost similar in all manure/fertilizer treated plots. Performance of these two summer vegetables in terms of growth and yield parameters remarkably lower in control plot i.e., without manure/fertilizer treated plot. Yield of both kangkong and indian spinach was statistically similar with all fertilizer treated plots but it was drastic reduced in without fertilizer treated plots. The highest yield of kangkong and indian spinach was 42.68 and 53.71 t/ha respectively in ILB and ½ RFD treated plot and lowest was 17.11 and 22.10 t/ha respectively in control plot. Yield of all kangkong and indian spinach was 5-7 % and 10-12 % lower in ILB+1/4RFD treated condition and only ILB treated condition respectively. Therefore it can be concluded that all of these tested vegetable can be cultivated in alley cropping system by using only Ipil-ipil leaf biomass as manure without significant yield loss as organic or sustainable way.
Key words: Alley cropping, Kangkong and Indian spinach.

Introduction

Agroforestry, the integration of tree and crop or vegetable on the same area of land is a promising production system for maximizing yield and maintaining friendly environment (Nair, 1990). It combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems. Agroforestry can provide a sound ecological basis for increased crop and animal productivity, more dependable economic returns, and greater diversity in social benefits on a sustained basis. Among the different agroforestry systems alley cropping is the typical one as organic farming. In alley cropping, fallow 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). Organic matter acts as a reservoir of plant nutrients especially N, P, K and S and prevents leaching of the nutrients (Konboon *et al*. 1993). Organic matter of Bangladesh soils is decreasing day by day and presently organic matter in the soil of Bangladesh is around 0.5-1.15%. Different tree leaf biomasses such as Ipil-ipil is a good source of organic matter and can play a vital role in soil fertility improvement as well as supplying nutrients specially N, P, K and S. Thus, leaf biomass is a very important organic source of soil fertility improvement. The decomposition of leaf litters influence the amount of N availability for plant uptake (Samsuzzaman and Karim 2002). Leaf litter supplies the carbon, nitrogen, phosphorus, potassium and other nutrients in soil that are further considered as important indicators of soil productivity and the ecosystem health. Moreover, this leaf lifter has been waste by several ways. So, if we can utilize these materials as a source of organic matter for vegetable production, then we can reduce the considerable amount of chemical fertilizer.

Population of Bangladesh is increasing rapidly, therefore, demand for vegetable is increasing simultaneously but the areas under vegetable production are decreasing day by day. The capacity of our land is decreasing day by day due to intensive cropping and use of high input technologies. To meet up the demand of our increasing population, farmers are now encouraged in practicing agroforestry system, which is environmentally sound and ecologically balanced.

In Bangladesh, different vegetables are cultivated in summer season. Among the different summer vegetables, indian spinach and kangkong are the important summer vegetables in Bangladesh. These are well known and very popular vegetables grown successfully during summer season in Bangladesh. Kangkong (*Ipomoea reptans*) is very important cultivated crop in all South East Asian countries, where it has superior, bushy varieties that are grown with much care either as upland or a lowland crop (Edie and Ho, 1969). Kangkong is rich in carotene, vitamins and minerals that is excellent for human health. Kangkong is usually used as an ingredient in sinigang (sour stew). Spinach has a high nutritional value and 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 B_2, calcium, potassium, vitamin B_6, folic acid, copper, protein, phosphorus, zinc, niacin, selenium and omega-3 fatty acids

In alley Cropping, farmers plant annual crops (vegetables) in alleys of the hedges of trees. Thus, cultivation of vegetables by this way can ensure maximum optimization of our land resources and ultimately may increases our total yield. For the reclamation of partially degraded unfertile land alley cropping as organic farming can be suitable in Bangladesh. So it is necessary to examine the efficiency as organic farming of this promising agroforestry system in Bangladesh. In view of the current national and international interest on organic farming for safe environment it is needed to assess suitability of alley cropping as organic farming.

Materials and Methods

The experiment was carried out at the experimental farm, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh, during the period from 20 March 2013 to 25 July 2013 (Fig.1). The place is geographically

located at about 24°75" North latitude and 90°50' East longitudes (FAO, 1988). In this study one tree species was used for hedge establishment viz. Ipil-ipil (*Leucaena leucocephala*). Two crops were used as study species and these were: Kangkong and indian spinach. Each crop was laid out using the Randomized Complete Block Design (RCBD) with single factorial arrangement with three replications as separate experiment. Individual plot size was 4ft x 7ft = 2.52m^2. Different treatments of the experiment were T_0 = Control (without fertilizer and manure), T_1 = Ipil-ipil leaf biomass (ILB) as manure, T_2 = ILB + 1/4 RFD (Recommended Fertilizer Dose), T_3 = ILB + 1/2 RFD. For alley cropping hedge establishment is the first requirement. The distance between hedgerows was 9 feet and Total 4 rows were prepared for planting seeds of Ipil-ipil. The land was prepared for the first time by power tiller (in order to make the beds of ipil-ipil hedge). Then the land was prepared for the second time by spading for seed sowing and kept fallow for few days. All crop residues, weeds and stubbles were removed from the field, finally the land was properly leveled and twenty four beds were made in three alleys.

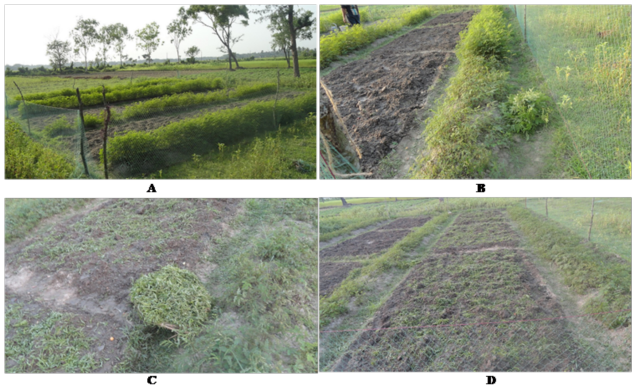

Fig. 1. Study field before sowing, (A) Over all view of experimental plot (B) Ipil-ipil hedge pruning (C & D) Prunings are added to the soil.

Seeds of kangkong and indian spinach were directly sown in the experimental plot on 07 april 2013. The spacing maintained was 15 cm x 15cm for these vegetables. kangkong and indian spinach was harvested five times with 20 days intervals. First harvest was done after 30 days from planting, accordingly 2nd, 3rd ,4th and 5th harvest were done at 50, 70, 90 and 110 DAP. Plant samples of two crops were collected randomly from all of the respective plots. Ten plants per plot for each crop were selected for data collection. The collected data (morphological characteristics and yield) were analyzed statistically by using PC M-STAT and wasp2 software package to find out the statistical significance of the experimental results. The means for all the treatments and analysis of variance of all the characters were calculated by Duncan's Multiple Range 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 Kangkong and indian spinach obtained from this study are presented as:

Kangkong:

Morphological characteristics:

Morphological parameters viz. plant height (cm), number of branches per plants; number of leaves per plants, leaf size (length × breadth, cm^2), stem girth (cm) and weight per plant (g) from kangkong were recorded during five times with 20 days intervals. The average morphological characters of Kangkong is shown in Table 1.

Plant length (cm): The result of the experiment showed that the plant length of kangkong was affected significantly by different treatments. It was observed that the highest plant length (28.63cm) was found in treatment T_3 (ILB + 1/2 RFD). The second highest plant length (28cm) was found in treatment T_2 (ILB + 1/4 RFD) which is statistically similar to the treatment T_3 (ILB + 1/2 RFD. The third highest plant length (26.55cm) was found in treatment T_1 (ILB) which is almost similar to the treatment T_3 (ILB + 1/2 RFD and T_1 (ILB + 1/4 RFD). The lowest value of plant length (24.43cm) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. These results are in agreement with the results of Rahman *et al.* (2013) in different winter vegetables under alley cropping system. Sharma and Mitra (1990), they reported that addition of organic manure increased plant length significantly.

Table 1. Morphological characteristics of kangkong in ipil-ipil based alley cropping system

Treatment	Plant length (cm)	Number of branches/plant	Number of leaves/plant	Leaf Size		Stem girth (cm)	Weight per plant (g)
				length (cm)	breadth (cm)		
T_0	23.15	3.00	34.81	11.48	2.36	2.16	34.95
T_1	26.55	5.76	53.10	14.40	2.78	2.54	59.07
T_2	28.00	6.64	57.59	16.81	3.26	2.74	67.82
T_3	28.63	7.00	60.90	17.45	3.34	2.82	72.64
Lsd $_{(0.01)}$	1.05	1.29	5.82	0.47	0.23	0.19	13.94
cv	2.04	11.94	5.84	1.64	4.08	4.02	12.3
Level of significance	**	**	**	**	**	**	**

T_0 = Control (without fertilizer and manure), T_1= Ipil-ipil leaf biomass (ILB) as manure, T_2 =ILB + 1/4 RFD (Recommended Fertilizer Dose) and T3 = ILB + 1/2 RFD (Recommended Fertilizer Dose).

No. of branches plant $^{-1}$: It was observed that the highest number of branches plant-1 (7) was found in treatment T_3 (ILB + 1/2 RFD which is statistically similar to T_2 (ILB + 1/4 RFD) and T_1 (ILB). The lowest number of branches plant-1 (3) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Fertility

status of the plots is the main factor for this result. Similar result was also found by Arefin *et al.* (2012) in rice under alley cropping system.

No. of leaves plant $^{-1}$: The result of the experiment showed that the highest number of leaves plant-1 (60.9) was found in treatment T_3 (ILB + 1/2 RFD) which is statistically similar to the treatment T_2 (ILB + 1/4RFD). The third highest number of leaves plant-1(53.1) was found in treatment T_1 (ILB) which is statistically similar to T_2 (ILB + 1/4 RFD). The lowest number of leaves plant-1 (34.81) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Treatment T_3 and T_2 gave highest value due to the application of leaf biomass and fertilizer. Similar explanation also reported by Tanzi *et al.* (2012) in rice based agroforestry practices under hedge row intercropping system.

Leaf size: Both leaf length and breadth of Kangkong were significantly affected by different treatment. It was observed that the largest leaf size (17.45 x 3.34cm^2) was found in treatment T_3 (ILB + 1/2 RFD). The Smaller leaf size (11.48 x 2.36cm^2) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Highest leaf size was found in T_3 (ILB + 1/2 RFD) because for applying RFD plus leaf biomass. This result is supported by Rahman *et al.* (2013) in different winter vegetables under alley cropping system.

Stem girth: Stem girth of Kangkong was affected significantly by different treatments. The highest stem girth (2.82cm) was noted in T_3 (ILB + 1/2 RFD) which is statistically similar to the treatment T_2 (ILB + 1/4 RFD). The lowest stem girth (2.16cm) was noted in T_0 (control) which is statistically dissimilar to the other treatment. Similar result was also observed by Habib *et al.* (2012) in amaranth along with Lohakat tree.

Weight per plant (gm): Plant weight was also influenced by different treatments. It was observed that the highest plant weight (72.64gm) of Kangkong was found in T_3 (ILB + 1/2 RFD and second highest (67.82gm) was found in T_2 (ILB + 1/2 RFD which is statistically similar to the treatment T_3 (ILB + 1/2 RFD). The third highest plant weight (59.07gm) was found in treatment T_1 (ILB) which is statistically similar to the treatment T_2 (ILB + 1/4RFD). The lowest weight (34.95gm) 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.* (2011) in soybean and wheat under hedgerow intercropping system with Leucaena tree.

Yield: Like morphological characteristics, yield of kangkong was also recorded during five times with 20 days intervals. It was observed that the yield of kangkong was affected significantly by different treatments. Yield of kangkong(t/ha) in different harvesting period is shown in Table 2 and Fig. 2.

Table 2. Yield of Kangkong (t/ha) in different harvesting period

Treatment	First harvest	Second harvest	Third harvest	Fourth harvest	Fifth harvest
T_0	1.32	3.03	6.10	4.53	2.13
T_1	3.08	6.10	12.50	8.95	5.05
T_3	3.57	6.51	13.35	10.52	5.54
T_2	4.02	7.50	14.04	11.02	6.10
Lsd $_{(0.01)}$	0.57	1.05	0.96	1.59	0.89
cv	9.62	6.17	5.29	8.50	9.54
Level of significance	**	**	**	**	**

T_0 = Control (without fertilizer and manure), T_1= Ipil-ipil leaf biomass (ILB) as manure, T_2 =ILB + 1/4 RFD (Recommended Fertilizer Dose) and T_3 = ILB + 1/2 RFD (Recommended Fertilizer Dose).

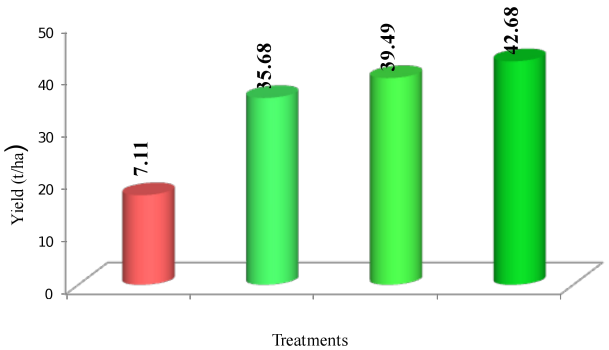

Fig. 2. Yield of kangkong in different treatments under alley cropping system

From first harvest to fifth harvest, it was observed that the highest yield (4.02, 7.50, 14.04, 11.02, 6.10 t/ha) was obtained under treatment T_3 (ILB + 1/2 RFD) and the second highest yield of kangkong (3.57, 6.51, 13.35, 10.52, 5.54 t/ha) was recorded at T_2 (ILB + 1/4 RFD) which is statistically similar to the treatment T3 (ILB + 1/2 RFD). The third highest yield of kangkong (3.08, 6.10, 12.50, 8.95, 5.05 t/ha) was recorded at T_1 (ILB) which is statistically similar to the treatment T_2 (ILB + 1/4RFD). The lowest yield of kangkong (1.32, 3.03, 6.10, 4.53, 2.13 t/ha) was produced under treatment T_0 (control). Total highest yield (42.68 t/ha) of Kangkong was obtained under treatment T_3 (ILB + 1/2 RFD). Second (39.49 t/ha) and third (35.68 t/ha) highest yield was recorded at T_2 (ILB + 1/4 RFD) and T_1 (ILB) respectively which are statistically similar to the treatment T_3 (ILB + 1/2 RFD). The lowest yield (17.11 t/ha) was produced under treatment T_0 (control) which is statistically dissimilar to the other treatment. Increased yield was found in treatment T_3 and T_2 due to their good fertility status produced by ILB and RFD. Similar results were also observed by Rahman et al. (2013) in different winter vegetables, Zoysa et al. (1990), Arefin *et al.* (2012) and Tanzi *et al.* (2012) in rice, Basak *et al.* (2011) in soybean and wheat under alley cropping system.

Indian spinach:

Morphological characteristics:

Morphological parameters viz. plant height (cm), number of branches per plants; number of leaves per plants, leaf size (length × breadth, cm^2), stem girth (cm) and weight per plant (g) from indian spinach were recorded during

five times with 20 days intervals. The average morphological characters of indian spinach is shown in Table 3.

Plant length: The result of the experiment showed that the plant length of indian spinach was affected significantly by different treatments. It was observed that the highest plant length (35.38cm) was found in treatment T_3 (ILB + 1/2 RFD). The second highest plant length (34.27cm) was found in treatment T_2 (ILB + 1/4 RFD) which is statistically similar to the treatment T_3 (ILB + 1/2 RFD. The third highest plant length (32.18cm) was found in treatment T_1 (ILB) which is almost similar to the treatment T_3 (ILB + 1/2 RFD and T_2 (ILB + 1/4 RFD). The lowest value of plant length (24.79cm) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. These results are in agreement with the results of Rahman *et al.* (2013) in different winter vegetables under alley cropping system. Sharma and Mitra (1990), they reported that addition of organic manure increased plant length significantly.

Table 3. Morphological characteristics of indian spinach in ipil-ipil based alley cropping system

Treatment	Plant length (cm)	Number of branches/plant	Number of leaves/plant	Leaf Size		Stem girth (cm)	Weight per plant (g)
				length (cm)	breadth (cm)		
T_0	24.79	2.51	29.43	6.84	3.21	3.22	78.62
T_1	32.18	3.83	48.75	9.39	4.28	3.51	138.09
T_2	34.27	4.95	53.66	11.45	5.05	3.64	150.67
T_3	35.38	5.21	56.85	12.36	5.32	3.69	157.33
$Lsd_{(0.01)}$	1.15	1.23	6.14	0.49	0.27	0.07	23.07
cv	2.22	15.48	6.73	2.54	3.2	1.06	9.1
Level of significance	**	**	**	**	**	**	**

T_0 = Control (without fertilizer and manure), T_1= Ipil-ipil leaf biomass (ILB) as manure, T_2 =ILB + 1/4 RFD (Recommended Fertilizer Dose) and T3 = ILB + 1/2 RFD (Recommended Fertilizer Dose).

No. of branches plant $^{-1}$: It was observed that the highest number of branches plant-1 (5.21) was found in treatment T_3 (ILB + 1/2 RFD which is statistically similar to T_2 (ILB + 1/4 RFD). The lowest number of branches plant-1 (2.51) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Fertility status of the plots is the main factor for this result. Similar result was also found by Arefin *et al.* (2012) in rice under alley cropping system.

No. of leaves plant^{-1}: The result of the experiment showed that the highest number of leaves plant-1 (56.85) was found in treatment T_3 (ILB + 1/2 RFD) which is statistically similar to the treatment T_2 (ILB + 1/4RFD). The third highest number of leaves plant-1(48.75) was found in treatment T_1 (ILB) which is statistically similar to T_2 (ILB + 1/4 RFD). The lowest number of leaves plant-1 (29.43) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Treatment T_3 and T_2 gave highest value due to the application of leaf biomass and fertilizer. Similar explanation also reported by Tanzi *et al.* (2012) in rice based agroforestry practices under hedge row intercropping system.

Leaf size: Both leaf length and breadth of indian spinach were significantly affected by different treatment. It was observed that the largest leaf size (12.36 x 5.32cm^2) was found in treatment T_3 (ILB + 1/2 RFD). The Smaller leaf size (6.84 x 3.21cm^2) was found in treatment T_0 (control) which is statistically dissimilar to the other treatments. Highest leaf size was found in T_3 (ILB + 1/2 RFD) because for applying RFD plus leaf biomass. This result is supported by Rahman *et al.* (2013) in different winter vegetables under alley cropping system.

Stem girth: Stem girth of indian spinach was affected significantly by different treatments. The highest stem girth (3.69cm) was noted in T_3 (ILB + 1/2 RFD) which is statistically similar to the treatment T_2 (ILB + 1/4 RFD). The lowest stem girth (3.22cm) was noted in T_0 (control) which is statistically dissimilar to the other treatment. Similar result was also observed by Habib *et al.* (2012) in amaranth along with Lohakat tree.

Weight per plant: Plant weight was also influenced by different treatments. It was observed that the highest plant weight (157.33gm) of indian spinach was found in T_3 (ILB + 1/2 RFD. Second (150.67gm) and third (138.09gm) highest plant weight was found in T_2 (ILB + 1/2 RFD and T_1 (ILB) which are statistically similar to the treatment T_3 (ILB + 1/2 RFD). The lowest weight (78.62gm) was found in treatment T_0 (control) which is statistically dissimilar to the other treatment. Low nutrient content of control plot may be responsible for this. Such type of results also recorded by basak *et al.* (2011) in soybean and wheat under hedgerow intercropping system with Leucaena tree.

Yield: Like morphological characteristics, yield of indian spinach was also recorded during five times with 20 days intervals. It was observed that the yield of indian spinach was affected significantly by different treatments. Yield of indian spinach (t/ha) in different harvesting period is shown in Table 4 Fig. 3.

From first harvest to fifth harvest, it was observrd that the highest yield (5.04, 10.52, 16.58, 13.50, 8.07 t/ha) was obtained under treatment T_3 (ILB + 1/2 RFD) and the second highest yield of indian spinach (4.55, 9.94, 15.53, 12.79, 7.85 t/ha) was recorded at T_2 (ILB + 1/4 RFD which is statistically similar to the treatment T_3 (ILB + 1/2 RFD). The third highest yield of indian spinach (4.029.15, 14.32, 11.83, 6.82 t/ha) was recorded at T_1 (ILB) which is statistically similar to the treatment T_2 (ILB + 1/4RFD). The lowest yield of indian spinach (2.07, 4.5, 7.23, 5.20, 3.10 t/ha) was produced under treatment T_0 (control). Total highest yield (53.71 t/ha) of indian spinach was obtained under treatment T_3 (ILB + 1/2 RFD). Second (50.66 t/ha) and third (46.14 t/ha) highest yield was recorded at T_2 (ILB + 1/4 RFD) and T_1 (ILB) respectively which are statistically similar to the treatment T_3 (ILB + 1/2 RFD).The lowest yield (22.1 t/ha) was produced under

Table 4. Yield of indian spinach (t/ha) in different harvesting period

Treatment	First harvest	Second harvest	Third harvest	Fourth harvest	Five harvest
T_0	2.07	4.50	7.23	5.20	3.10
T_1	4.02	9.15	14.32	11.83	6.82
T_2	4.55	9.94	15.53	12.79	7.85
T_3	5.04	10.52	16.58	13.50	8.07
Lsd $_{(0.01)}$	0.62	0.85	1.65	0.99	1.07
cv	7.87	2.95	6.10	4.08	7.54
Level of significance	**	**	**	**	**

T_0 = Control (without fertilizer and manure), T_1= Ipil-ipil leaf biomass (ILB) as manure, T_2 =ILB + 1/4 RFD (Recommended Fertilizer Dose) and T_3 = ILB + 1/2 RFD (Recommended Fertilizer Dose).

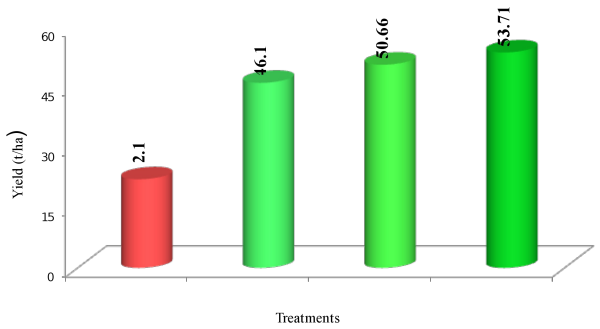

Fig. 3. Yield of indian spinach in different treatments under alley cropping system

treatment T_0 (control) Which is statistically dissimilar to the other treatment. Increased yield was found in treatment T_3 and T_2 due to their good fertility status produced by ILB and RFD. Similar results were also observed by Rahman et al. (2013) in different winter vegetables, Zoysa *et al.* (1990), Arefin *et al.* (2012) and Tanzi et al. (2012) in rice, Basak *et al.* (2011) in soybean and wheat under alley cropping system.

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