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Bio-economic evaluation of aloe vera in coconut based multistoried agroforestry systems

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Abstract: The experiment was conducted at the existing multistoried coconut orchard of the Horticulture Farm, Bangladesh Agricultural University, Mymensingh, to investigate the performance of aloe vera in coconut based multistoried Agroforestry system (MAF) during the period of March 2005 to March 2007. The experiment was laid out in randomized complete block design with five replications. Treatments were **:**T_1- comprises the combination of coconut + guava + aloe vera based Agroforestry system, T_2- comprises the combination of coconut + lemon + aloe vera based Agroforestry system, T_3- aloe vera in open condition. . In the open condition T_3 received 100% sunlight; while coconut + guava based multistoried Agroforestry system (T_1) and coconut + lemon based multistoried Agroforestry system (T_2) allowed, respectively 42 to 46% and 53 to 58% sunlight for the growth of aloe vera. The coconut tree was planted thirty years before and the spacing of plantation was 8m x 8m. As the middle or second layer plant, guava and lemon both were five years old and were in full bearing condition. Spacing between guava and / or lemon and between rows was 3m × 3m. Multistoried Agroforestry systems under this study had showed significant influence on yield and yield attributing parameters of aloe vera. The result revealed that the highest yield (31.10 t/ha) was recorded under sole cropping of aloe vera which was followed to that of coconut+lemon based MAF. Significantly, the lowest yield (18.53 t/ha) was recorded in sisoo+guava based MAF. This yield reduction was 37.20 per cent over the sole cropping. But, among the treatments, it was found that the highest benefit-cost ratio of 3.54 was recorded from coconut+guava based MAF followed by coconut+lemon based MAF. The lowest benefit-cost ratio of 1.65 was observed in sole cropping.
Key words: Multistoried, coconut, lemon, guava, aloe vera, agroforestry system

Introduction

Medicinal plants play an important role in the healthcare of people around the world, especially those living in the developing countries (Rao *et al*., 2004). Bangladesh has a significant herbal medicine sector including 65 processing factories and about 200000 herbal medical practitioners-consuming a wide variety of medicinal plants (Raju *et al.,* 2003). The aloe plant (*Aloe indica)* in the family liliaceae is one of the most important medicinal plants in Bangladesh. Aloe vera mostly used as traditional medicine by the rural villagers. It is the raw material for Aurvedic, Unani and Harbal medicine and an important element for cosmetic industries. Aloe vera is used for traditional remedies from cough, cold, fever, headache, dysentery and digestive disorder/gastric ulcer (Ghani, 2003). It is also used as Sarbat which keeps the stomach cool and also helps in mitigating constipation. Aloe vera is also used to remove weakness to control burning of hand and feet and treating body and teeth pain (Majumdar, 2006). The pulp of the Aloe vera is used to erase spots and to brighten the skin by the rural young pupil. Total demand of Aloe vera for self-treatment is about 1000 tones per year and worth about 1 million taka per year. But the cultivation of Aloe vera is not extended at the commercial scale in all over Bangladesh. Some farmers of natore district start its cultivation in commercially as sole cropping. Still, allocating land for medicinal plants as a sole crop is a critical decision for the farmer. Indeed they are not in a position to spare lands only for medicinal plant production. To increase the production of medicinal plants like Aloe vera, therefore, should be made to find alternate avenues for its cultivation. Using well-planned and well managed medicinal plant based agroforestry systems might be the way to minimize this problem. Some farmers already have started to cultivate Aloe vera as intercrops with forest and fruit trees. But the farmers of the area do not know how to utilize the silvi-medicinal systems (Manjare, 2005) and other agroforestry systems more efficiently to overcome their economic condition to some extent. So, now research should be carried out to examine appropriate agroforestry systems in which Aloe vera can be grown without displacing the traditional crops. Therefore, considering the above facts the present investigation is planned in order to evaluate the performance of Aloe vera as a medicinal plants under coconut based multistoried agroforestry systems for its sustainable production.

Materials and Methods

The experiment was conducted in the existing multistoried coconut garden of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh throughout the growing seasons of 2005-2007. The experimental area is under sub-tropical climate characterized by heavy rainfall during the months from April to September and scanty rainfall during the rest period of the year. The soil of the experimental area is silty loam in texture. It is a medium high land and fertile well drained. The experiment was laid out in randomized block design with five replications and three treatments viz. T_1: coconut+guava+aloe vera based multistoried Agrofortestry system; T_2: coconut+lemon+aloe vera based multistoried Agrofortestry system: T_3: Control (aloe vera as monocropping). The treatments T_1 and T_2 were three layered garden consisted of coconut at the top layer, guava and lemon at the middle layer; and aloe vera was at the ground layer and T_3 was in open condition. In the open condition T_3 received 100% sunlight; while coconut+guava based multistoried Agroforestry system (T_1) and coconut +lemon based multistoried Agroforestry system (T_2) allowed, respectively 42 to 46% and 53 to 58% sunlight for the growth of aloe vera. The coconut tree was planted thirty years before and the spacing of plantation was 8m x 8m. As the middle or second layer plant, guava and lemon both were five years old and were in full bearing condition. Spacing between guava and / or lemon and between rows was 3m × 3m. The seedlings of aloe vera were collected from Haybotpur village of Natore district. The experimental plots were kept weeds free by weeding frequently. The plots were irrigated whenever needed by using hose pipe and watering cane. Economics of various treatments was calculated taking into account the current costs of inputs and produce. The data on

various growth and yield performance characters of aloe vera were statistically analyzed to examine the significant variation of the results due to different shading condition. The analysis of variance for each of the studied character was done by F (Variance ratio) test following Randomized Complete Block Design (RCBD). The treatment means were compared at 1 and 5 per cent level of significance (using MSTAT computer programme and Excel Programme).

Results and Discussion

Growth and yield contributing characters of aloe vera as influenced by the coconut based multistoried agroforestry systems: The influence of coconut based multistoried agroforestry on the growth and yield contributing characters of aloe vera were significant except plant height. The perusal data (Table 1) shows that the plant height of aloe vera ranged from 41.92 cm to 46.98 cm. Numbers of leaves per plant of aloe vera were significantly influenced by the different production systems. The maximum number of leaves (10.66) was obtained in sole cropping (T_3) followed by coconut+lemon based MAF (T_2). Notably, the lowest number of leaves (7.90) was found in coconut+guava based MAF (T_1). Leaf length of aloe vera also varied markedly due to the practice of different multistoried agroforestry systems as well as sole cropping. The trend of leaf length under different production systems was nearly parallel to that of plant height. The maximum leaf length (37.31 cm) was observed in coconut+guava based MAF (T_1), which was followed by the treatment T_2. The minimum leaf length (34.12cm) of aloe vera was observed in plants grown under sole cropping system (T_3). Width of aloe vera leaves increased gradually with the decrease of shade level. The highest leaf width (5.34 cm) was recorded from the sole cropping of aloe (T_3), which was statistically similar to that produced from the treatments T_2. Significantly, the lowest leaf width (4.05 cm) was recorded from the coconut+guava based MAF (T_1). A significant variation in canopy volume of aloe vera plant was observed due to the practice of different production systems. It in clear from the Table 1 that the canopy volume of aloe vera was decreased with the severity of shading. The maximum canopy volume of aloe vera (12504.88 cm^3) was recorded in open condition (T_3). Between the two MAF, coconut+guava based MAF produced lower canopy volume than that of from coconut+lemon based MAF. Significantly, the minimum canopy volume of aloe vera (8963.00 cm^3) was produced in coconut+guava based MAF (T_1). Again, individual fresh weight of aloe vera leaf was also decreased as the light interception decreased. Significantly, the maximum fresh leaf weight (413.9 g) was observed in sole cropping (T_3), which was followed by the treatment T_2. On the other hand, the minimum fresh leaf weight (262.8 g) was produced under sisoo+guava based MAF (T_1). Data in Table 1 advocated that leaf dry weight of aloe vera was significantly influenced by the different production systems. The leaf dry weight of aloe vera in multistoried agroforestry systems was observed lower than sole cropping (T_3). The pattern of leaf dry weight observed was as $T_3 > T_2 > T_1$.

Table 1. Growth and yield of aloe vera as Influenced by the coconut based multistoried agroforestry system

Treatments	Plant height (cm)	No. of leaves per /plant	Leaf length (cm)	Leaves width (cm)	Canopy volume $(cm)^3$	Fresh wt of leaves/ plant (g)	Dry matter of leaves/ plant (g)	Yield (t/ha)		
								1st harvest	2 nd harvest	Total
T_1	46.98	7.90	37.31	4.05	8963.00	262.76	13.69	7.48	11.00	18.53
T_2	42.97	9.16	35.90	4.59	10527.97	290.49	17.01	9.73	12.75	22.48
Open (T_3)	41.92	10.66	34.12	5.34	12504.88	413.90	25.73	13.28	17.40	31.10
Lsd $_{0.01}$	-	2.29	3.40	1.10	1831.22	61.35	3.79	2.89	2.94	6.57
CV (%)	8.33	11.68	4.48	11.16	8.09	8.97	9.61	13.42	10.11	12.88

T_1 = C+G+Aloe vera, T_2 = C+L+Aloe vera, ** Significant at 0.01 level; NS = Not significant

Yield (t/ha) of aloe vera as influenced by the coconut based multistoried agroforestry systems: Leaf yield of aloe vera was significantly influenced by different production systems. In general, leaf yield of aloe vera was increased with the increase of light level (Table 1). The highest yield (31.10 t/ha) was recorded under sole cropping of aloe vera (T_3) which was followed to that of treatment T_2 (coconut+lemon based MAF). Significantly, the lowest yield (18.53 t/ha) was recorded in sisoo+guava based MAF (T_1). This yield reduction was 37.20 per cent over the sole cropping (T_3). The reason of maximum yield reduction in MAF might be that upper and middle layer trees canopy made shade on the entire ground layer plots consequently shading effect on aloe vera was prevailed. As a result, yield of aloe vera was low.

Economic analysis: The economics of cultivation of aloe vera solely as well as together with coconut, guava and lemon trees has been analyzed to ascertain economically profitable combinations as feasible for Bangladesh conditions. The cost of production of different production systems, the return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) have been presented in Table 2. The values in Table 2 indicate that the total cost of production was the highest (107428 Tk./ha) in sole cropping (T_3) followed by coconut+guava based MAF (80693 Tk./ha) (T_1). The lowest cost of production (78546 Tk./ha) was recorded from coconut+lemon based MAF (T_2). Higher cost of production was found in sole cropping of aloe vera due to higher area was cultivated (100%) for aloe vera production as compared to coconut based MAF (25%), as a result more input cost was required. Again,

The highest value of gross return (285922 Tk. /ha) was obtained from the coconut+guava based MAF (T_1), which was followed by the coconut+lemon based MAF (T_2). On the other hand, the lowest value of gross return (177330 Tk. /ha) was obtained from sole cropping of aloe vera (T_3). The highest gross return was obtained due to higher fruit yield of guava along with the value of nuts which were produced on the coconut trees. Among the treatments, it was found that the highest benefit-cost ratio of 3.54 was recorded from coconut+guava based MAF (T_1) followed by coconut+lemon based MAF (T_2). The lowest benefit-cost ratio of 1.65 was observed in sole cropping (T_3). The highest benefit-cost ratio were registered under coconut based multistoried agroforestry systems might be due to the substantial additional contribution by coconut tree and lemon or guava tree, while extra benefit was absent under sole cropping. Moreover, among the two MAF group, coconut+guava based MAF proved more remunerative than that of coconut+lemon based MAF. Because, yield and unit price of guava was more than lemon. So, aloe vera can advantageously be cultivated in multistoried agroforestry systems.

Table 2. Economics of aloe vera production under coconut based multistoried cropping system

Treatments	Return (Tk./ha)				Gross Return (Tk./ha)	Total cost of Production (Tk./ha)	Net Return (Tk./ha)	BCR
	Aloe vera	Guava	Lemon	Coconut				
C+G+Aloe vera (T_1)	18530	172080	----------	95312	285922	80693	205229	3.54
C+L+Aloe ver (T_2)	22480	---------	103837	95312	221629	78546	143083	2.82
Open (T_3)	124400	---------	--------	---------	177330	107428	69902	1.65

Note: Aloe vera 4 tk./kg, Guava 6 Tk./kg; Lemon 1 Tk./piece, Coconut 8Tk./nut

Considering the above mentioned results and discussion, it is, therefore, concluded that diversification of farming system and growing medicinal plant like aloe vera as ground layers crops in coconut orchard is a viable option for increasing income of farmers. The performance of aloe vera as ground layered crop under coconut based multistoried agroforestry production system was encouraging. Among the two fruits, lemon is more suitable than that of guava as middle layered crops. But in general the fruit plants like lemon and guava can be composed successfully as the middle layered crops in coconut based multistoried agroforestry production system. So, aloe vera, guava/lemon may be adopted as suitable tree-crop combinations in coconut based multistoried Agroforestry systems for diversification and boosting economy of farmers in land scare Bangladesh circumstances.

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