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Performance of medicinal plants grown under multilayered agroforestry system

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Abstract: The experiment was conducted at the Germplasm Center (GPC), Bangladesh Agricultural University, Mymensingh during December 2008 to November 2009 to investigate the growth and development of some medicinal plants (Aloevera, Asparagus and Misridana) under multistoried agroforestry systems having three light levels i.e. open condition (received 100% of light), guava + lemon based agroforestry system (received 55-60% light) and sissoo + lemon based agroforestry system (received 45-55% light). The experiment was laid out in a randomized complete block design with three replications. Results revealed that the performance of three medicinal plants, Aloevera, Asparagus and Misridana in terms of growth, yield contributing characters and yield was significantly influenced by the multilayered agroforestry systems. Growth and development, yield contributing characters and yield of Aloevera, Asparagus and Misridana were greater in all the agroforestry systems than open condition. However, between two agroforestry systems (guava + lemon and sissoo + lemon based systems), Aloevera and Misridana performed better under guava with lemon agroforestry system than sissoo with lemon agroforestry system in terms of growth, yield contributing characters and yield except leaf dry matter percentage for Aloevera and corms dry matter percentage for Misridana. On the other hand, Asparagus performed better in respect of growth, yield contributing characters and yield under sissoo + lemon based agroforestry system than guava + lemon based agroforestry system.

Key words: Medicinal plants, agroforestry systems, growth and yield.

Introduction

In Bangladesh, the demand of food crops increasing rapidly due to ever increasing population. Bangladesh has been carrying one of the highest population densities in the world about 977 persons per square kilometers (BBS, 2009). The population has been doubled in the last 30 years. As a result per capita land availability had declined from 0.19 hectare in 1961 to 0.08 hectare in 2009 (BBS, 2009)), which put heavy pressure on land for human habitation and crop production. The present forest cover is only 5.40% (BBS, 2009) which is below the critical level (25%) due to rapid growth of population. There is a tremendous pressure on the forest land. About 7300 hectares of forest are cleared for agricultural lands, aquaculture, homestead and other purpose. The annual deforestation rate is estimated to be 8000 hectares (FAO, 2007). Village forest mainly is covered by homestead account only 0.27 million hectares. Out of 64 districts, 28 districts have no public land farm. But to maintain the equilibrium and rate of socio-economic development at least 25% area of any country should be covered with forest. However, the fertility of the land is decreasing rapidly due to intensive cropping and use of high input technologies. Under this alarming condition, it is necessary to find out a suitable alternative to overcome this situation. Since there is neither scope for expanding forest area nor sole crop areas, the country has to develop combined production system integrating trees and crop which is now being called multilayer agro-forestry system. It is combination of several vertical strata. There are about 20.0 million homesteads in the country which comprise about 0.3 million hectare of land. So, there is great opportunity to undertake every homestead to multilayered system. Introducing of medicinal plants into multistoried cropping system is very important because medicinal plants are used in herbal treatments but their marketing facilities are not yet developed. So these plants are not widely cultivated but also important to maintain their biodiversity. Studies of medicinal plants help to identify them and also help to know their therapeutic effects and other uses. Aloevera (*Aloe indica*), Asparagus (*Asparagus racemosus*) and Misridana (*Scoparia dulcis*) are three important medicinal plants in the country. The leaf juice of Aloevera is used for remedy of inlargement of liver, skin diseases, gonorrhoea, piles, jaundice and rheumatic affection. Very recently, the Aloevera juice is widely used in skin beatification. The medicinally important part of Asparagus is its tuberous root. It is useful in dysentery, tumour, tuberculosis and inflammations. The useful parts of Misridana is its corm. It is widely used for haemorrhage, diabetes and eye disease (Kirtikar *et al*. 1987).

Although some sporadic studies for some medicinal and spices plants were done (Deng *et al.*, 1999; Nasir, 2004), but no systematic information is available on its performance under agroforestry system. So, it is necessary to evaluate the growth and development of different medicinal plants grown under agroforestry system.

Materials and Methods

The experiment was carried out at the existing multilayered garden of Germplasm Centre, Bangladesh Agricultural University, Mymensingh. Geographically the experimental area is located at $24^0 75''$ N latitude and $90^0 50''$ E longitudes at the elevation of 18 m above the sea level. The experimental field was medium high land belonging to the Sonatola Soil Series of Grey Floodplain soil under the agro-ecological zone of Old Bahmaputra Floodplain (AEZ-9). The soil was silty loam. The growth and development of three medicinal plants viz. Aloevera, Asparagus and Misridana were investigated under multistoried agroforestry systems having three light levels i.e. open condition (received 100% of light), guava + lemon based agroforestry system (received 55-60% light) and sissoo + lemon based agroforestry system (received 45-55% light). For this purpose, nine treatments were included in the experiment. The treatments were- i) Guava + lemon + Aloevera, ii) Sissoo + lemon + Aloevera, iii) Guava + lemon + Asparagus, iv) Sissoo + lemon + Asparagus, v) Guava + lemon + Misridana, vi) Sissoo + lemon + Misridana, vii) Aloevera (open condition), viii) Asparagus (open condition) and ix) Misridana (open condition).The experiment was single factor and conducted in randomized complete block design with three replications. The plot size of each treatment was 40 m × 2.0 m. Adjacent plots and neighbouring blocks were by 0.5 m and 2.0 m, respectively.The land was opened in the

month of December 2008 and then clear out of small bushes by scissors and prepared the land thoroughly by ploughing and cross ploughing with power tiller followed by laddering to obtain good tilth. The weeds and stubbles were removed from the field and bigger clods were broken into small pieces. Finally, the soil particles were pulverized and the land was leveled uniformly.Seedling of Aloevera, tuberous root of Asparagus and mother rhizome of Misridana were planted in the experimental plot on 10th January 2009. The spacing of planting was maintained by 60 cm × 40 cm for all the plants.

Data collection

Aloevera: Five plants of Aloevera were collected randomly from each plot. These sample plants were used for data collection. The collected data from the sample plants were plant height, canopy volume, leaf number, leaf length, leaf width, leaf fresh weight, leaf dry matter and yield.

Canopy volume: The canopy volume was calculated by using the following formula given by Westwood *et al*. (1963). i.e. Canopy volume = 4/3 a^2b; where, a = ½ of the plant height, b = average of E-W and N-S space covered by the plant.

Dry matter: The leaves were cleaned immediately after harvest. Then 100 g of leaves were taken from each selected plants and cut into small pieces. Then the leaves were oven dried at 70 ^{0}C for 48 hours. After drying it was weighted by an electrical balance and then the average value was calculated in g.

Asparagus: The collected data from asparagus plants were plant height, number of leaves/plant, plant canopy volume, number of tuberous roots plant^{-1}, tuberous root length, fresh weight of tuberous roots plant^{-1} and yield. All these parameters were recorded using the same procedure like Aloevera.

Misridana: The collected data from misridana plants were plant height, number of primary fingers plant^{-1}, number of secondary fingers plant^{-1}, weight of primary and secondary fingers plant^{-1}, canopy volume plant^{-1}, Total fresh weight of corms plant^{-1} and yield. All these parameters were recorded using the same procedure like Aloevera.

Statistical Analysis: The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and Discussion

Effect of multilayered tree system on plant characters of Aloe vera

Plant height: The highest plant height of Aloe vera was recorded in guava and lemon based agroforestry system (36.2 cm) followed by sissoo and lemon based agroforestry system (32.4 cm) (Table 1). In contrast, the shortest plant height was recorded in open condition (23.6 cm). This result indicated that shade enhance the growth and development of Aloe vera plant.

Table 1. Growth and yield contributing characters of Aloevera grown under different agroforestry system

Agroforestry systems	Plant height (cm)	Number of leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)	Leaf fresh weight plant^{-1} (g)
Guava + lemon	36.2 a	11.2 a	28.3 a	2.55 a	359 a
Sissoo + lemon	32.4 b	9.90 b	25.6 b	2.50 a	318 b
Open condition	23.6 c	8.10 c	17.9 c	2.01 b	128 c
Level of significance	**	*	**	*	**
CV (%)	8.61	6.84	6.39	7.85	8.98

Same letter in a column do not differ significantly at P ≤ 0.05 by DMRT; * and ** indicate significant at 5% and 1% level of probability, respectively.

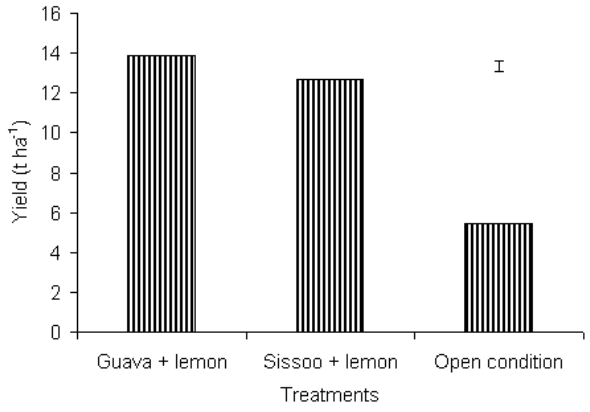

Fig.1. Effect of different agroforestry systems on yield in Aloevera, Vertical bar represent LSD (0.05).

Canopy volume plant^{-1}: The highest canopy volume was observed in guava and lemon based agroforestry system (10212 cm^3 plant^{-1}) followed by sissoo and lemon based agroforestry system (8050 cm^3 plant^{-1}). The canopy volume was higher in guava and lemon based agroforestry system might be due taller plants and better growth and development than the other treatment. The lowest plant volume (4841 cm^3 plant^{-1}) was recorded in open condition due to inferior growth and development of the plants.

Number of leaves plant^{-1}: The highest leaves plant^{-1} (11.2) was recorded in guava and lemon based agroforestry system and the lowest leaves plant^{-1} observed in open condition (8.10) (Table 1). Nasir (2004) reported that under multilayered agroforestry system increased plant growth and development of Aloe vera than open condition which resulted higher production of leaves plant^{-1} in multilayered agroforestry system than open condition.

Leaf length: The treatment, guava + lemon agroforestry system showed the highest leaf length (28.3 cm) followed by sissoo + lemon based agroforestry system (25.6 cm)

(Table 1). On the other hand, open condition produced the lowest leaf size (17.9 cm). Variation in leaf length due to different multilayered agroforestry system in Aloe vera was also observed by Rahim *et al.* (2007) which supported the present experimental result.

Yield of Aloevera: This result indicates that cultivation of Aloevera under agroforestry system is suitable than open condition. Nasir (2004) reported that under multilayered agroforestry system increased plant growth and development of Aloevera than open condition which resulted higher production of leaves plant^{-1} in multilayered agroforestry systems that in turn increased yield than open condition.

Yield varied significantly due to different agroforestry systems. Result revealed that yield was greater in agroforestry system than open condition. The yield was higher in agroforestry system due to production of higher number of leaves plant^{-1} and taller plant (Table 1 and Fig. 1). The highest yield (13.85 t ha^{-1}) was recorded in guava and lemon based agroforestry system followed by sissoo and lemon based agroforestry system (12.66 t ha^{-1}) and the lowest was observed in open condition (5.46 t ha^{-1}) (Fig. 1).

Effect of multilayered tree system on plant characters of Asparagus

Plant height: The highest plant height of Asparagus was recorded in sissoo and lemon based agroforestry system (118.6 cm) followed by guava and lemon based agroforestry system (114.4 cm) (Table 2). In contrast, the shortest plant height was recorded in open condition (67.3 cm). This result indicates that shade enhance the growth and development of asparagus plant.

Table 2. Growth and yield contributing characters of Asparagus grown under different agroforestry systems

Agroforestry systems	Plant height (cm)	Number of leaves plant^{-1}	Number of tuberous root plant^{-1}	Length of tuberous root (cm)	Fresh weight of tuberous root plant^{-1} (g)
Guava + lemon	114.4 b	566 b	58.7 a	14.53 b	142.9 b
Sissoo + lemon	118.6 a	604 a	61.7 a	16.9 a	160.4 a
Open condition	67.3 c	251 c	25.7 b	13.77 b	92.6 c
Level of significance	**	**	**	*	**
CV (%)	5.68	8.53	4.56	5.80	9.58

Same letter in a column do not differ significantly at P ≤ 0.05 by DMRT; * and ** indicate significant at 5% and 1% level of probability, respectively.

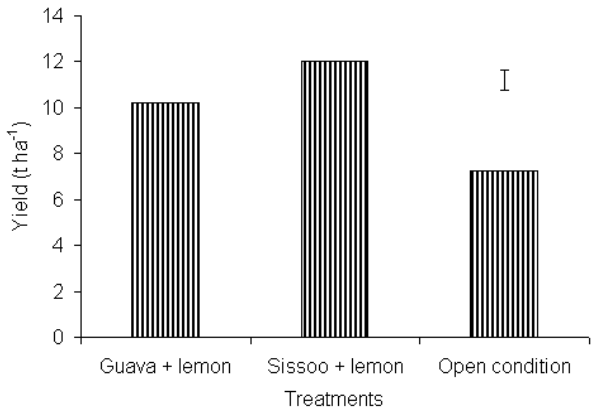

Fig. 2. Effect of different agroforestry systems on yield in Asparagus, Vertical bar represent LSD (0.05).

Number of tuberous plant^{-1} : The treatment, sissoo + lemon agroforestry system showed the highest number of tuberous roots plant^{-1} (61.7) followed by guava + lemon based agroforestry system (58.7) with same statistical rank (Table 2). On the other hand, open condition produced the lowest number of tuberous roots (25.7).

Dry matter percentage of tuberous root: Result revealed that root dry matter percentage of Asparagus was greater in sissoo and lemon based agroforestry system and the lowest was recorded in open condition (Fig. 2). The root dry matter percentage was higher in multilayered agroforestry system than open condition as reported by Islam (2005) which supported the present experimental result.

Yield of Asparagus: Yield varied significantly due to different agroforestry systems. Result revealed that yield was greater in agroforestry systems than open condition. The yield was higher in agroforestry system due to production of higher number of roots plant^{-1}. The highest yield (12.0 t ha^{-1}) was recorded in sissoo and lemon based agroforestry system followed by guava and lemon based agroforestry system (10.21 t ha^{-1}) and the lowest was observed in open condition (7.27 t ha^{-1}) (Fig. 2). This result indicates that cultivation of Asparagus under agroforestry system is suitable than open condition. Nasir (2004) reported that under multilayered agroforestry system increased plant growth and development of Asparagus than open condition which resulted higher production of leaves plant^{-1} in multilayered agroforestry systems that in turn increased yield than in open condition.

Effect of multilayered tree system on plant characters of Misridana

Plant height: The highest plant height of Misridana was recorded in guava and lemon based agroforestry system (65.7 cm) which was statistical similar to sissoo and lemon based agroforestry system (62.6 cm) (Table 3). In contrast, the shortest plant height was recorded in open condition (33.2 cm). This result indicate that shade enhance the growth and development of Misridana plant.

Num**ber of primary fingers plant^{-1}:** The highest number of primary fingers plant^{-1} (42.3) was recorded in guava and lemon based agroforestry system followed by sissoo and lemon based agroforestry system (40.2) with same statistical rank. The lowest primary fingers plant^{-1} observed in open condition (25.2) (Table 3).

Table 3. Growth and yield contributing characters of Misridana grown under different agroforestry systems

Treatment	Plant height (cm)	No. of primary finger plant^{-1}	No. of secondary finger plant^{-1}	Wt of primary fingers plant^{-1} (g)	Wt of secondary fingers plant^{-1} (g)	Total fresh weight of corms plant^{-1} (g)
Guava + lemon	65.7 a	42.3 a	13.3 a	150.5 a	15.0 a	165.5 a
Sissoo + lemon	62.6 a	40.2 a	13.0 a	137.2 a	13.1 b	150.1 a
Open condition	33.2 b	25.2 c	5.00 b	81.65 c	3.1 c	84.7 b
Level of significance	**	**	**	**	**	**
CV (%)	4.91	7.36	6.28	10.18	7.42	11.89

Same letter in a column do not differ significantly at P ≤ 0.05 by DMRT; * and ** indicate significant at 5% and 1% level of probability, respectivel

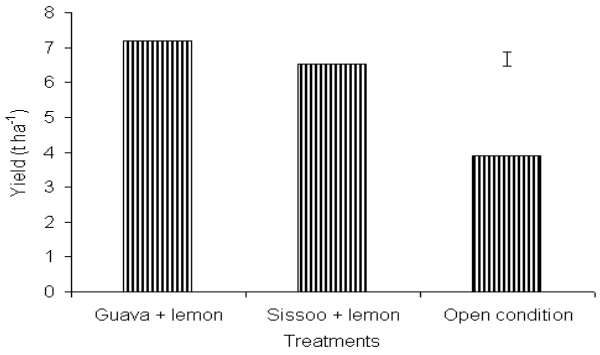

Fig. 3. Effect of different agroforestry systems on yield in Misridana, Vertical bar represent LSD (0.05).

Corms dry matter percentage: Result revealed that corms dry matter percentage of Misridana was greater in open condition than agroforestry system. This result indicates that under agroforestry system, corms of Misridana were more fleshy than open condition. The highest corms dry matter percentage was recorded in open condition (19.48%) and the lowest was recorded in sissoo + lemon based agroforestry system (17.1%). The corm dry matter percentage was higher in open condition than multilayered agroforestry systems as reported by Nasir (2004) which supported the present experimental result.

Yield of Misridana: Result revealed that yield was greater in agroforestry system than open condition. The yield was higher in agroforestry system due production of higher number of leaves plant^{-1} and greater canopy volume (Fig. 3). The highest yield (7.19 t ha^{-1}) was recorded in guava and lemon based agroforestry system followed by sissoo and lemon based agroforestry system (6.52 t ha^{-1}) and the lowest was observed in open condition (3.89 t ha^{-1}) (Fig. 3). This result indicates that cultivation of Misridana under agroforestry system is suitable than open condition. Nasir (2004) reported that under multilayered agroforestry systems increased plant growth and development of Misridana than open condition which resulted higher production of leaves plant^{-1} in multilayered agroforestry system that in turn increased yield than open condition.

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