Tropical and Subtropical Agroecosystems, 8 (2008): 165 - 170

Tropical and Subtropical Agroecosystems

PERFORMANCE OF WINTER VEGETABLES GROWN UNDER COCONUT-LEMON BASED MULTISTRATA AGROFORESTRY SYSTEM

[PRODUCTIVIDAD INVERNAL DE VEGETALES CULTIVADO EN SISTEMAS AGROFORESTALES MULTIESTRATO BASADOS EN COCOTERO-LIMÓN]

K.K. Islam[1*], M.J. Pervin[2], M.H.Rashid[3], M.A. Mondol[3]and M.A. Rahim[4]

[1]Assistant Professor, Department of Agroforestry,
[2]MS student, Department of Environmental Science,
[3]MS student, Department of Agroforestry,
[4]Professor, Department of Horticulture,
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
**Corresponding author*

SUMMARY

A field experiment was conducted to evaluate the performance of seven winter vegetables under coconut-lemon based multistrata system in Bangladesh Agricultural University from October 2005 to April 2006. Tomato, chilli, carrot, onion, garlic, turnip and french bean were the tested vegetables under two treatments namely multistrata system T1 (Lemon + Coconut based, 35-50% reduced Photosynthetic Active Radiation (PAR)) and full sunlight condition T0 (100% PAR). There were significant variations in respect of plant height of winter vegetables (except chilli and turnip) under shade condition. On the other hand, significantly highest yield per plot and yield per hectare were observed when plant grown under full sunlight condition. Moreover, the economic analysis showed that among the seven vegetables carrot gave the highest economic return (108,937 Tk./ha) followed by chilli (95295 Tk./ha) under multristrata (Lemon + Coconut) agroforestry system. Therefore, production of winter vegetables especially carrot and chilli under multistrata agroforestry systems are economically profitable than sole production systems.

Keywords: Winter vegetables, growth parameters, multilayered system, economic analysis.

RESUMEN

Se realizó un experimento en Bangladesh para evaluar la productividad invernal de siete vegetales en un sistema multiestrato de cocotero-limón de Octobre 2005 a Abril 2006. Tomate, chile, zanahoria, cebolla, ajo, nabo y frijol fueron los vegetales empleados en dos tratamiento multiestrato: T1- Limón + cocotero, 35-50 y reducción de la radiación fotosintéticamente activa (PAR), y T0 – Luz solar total (100% PAR). Se encontró variación en la el tamaño (except en chile y nabo) bajo condiciones de sombra. Una producción significativamente mayor se encontró en los vegetales creciendo en areas abiertas (T0). El análisis económico mostró que la zanahoria obtuvo el mayor retorno económico (108,937 Tk./ha) seguido del chile (95295 Tk./ha) en el sistema multiestrato (Limón + Cocotero). Se concluye que la producción invernal de vegetales, especialmente zanahoria y chile en sistemas agroforestales multiestrato es económicamente más rentable.

Palabras clave: vegetales de invierno, crecimiento, sistemas multiestrato, análisis económico.

INTRODUCTION

Vegetables are one of the essential nutrient suppliers for our daily diet. For this, to increase the production of vegetables is our prior need which can be easily attained through the cultivation of vegetables under different light levels permitted by the upper storey crops like tree or shrubs. Multistoried agroforestry system offers production of various vegetables under different shade conditions by maximum utilization of natural resources like Photosynthetic Active Radiation (PAR) levels (Taleb, 2003). In Bangladesh, the multistoried production system has wider implications and potentials. Multistoried production system combines several (two to five layers) vertical strata with high species diversity with carrot, chilli, brinjal, onion, garlic and turnip with some fruit tree such as guava, lemon, papaya, banana etc. with high yielding fruit and timber trees (Mustafa, 1997). The country

occupy about 15.4 million homesteads which comprises about 0.3 million hectare of land are under vegetable production and consumed in the country are coming from these homesteads and (Abedin and Quddus, 1990) farmers grow different type of vegetables in association with trees in their homesteads where productivity of vegetable is low due to lack of appropriate combinations (Mustafa *et al.*, 2002). Among the different vegetables, winter vegetable production is maximum in Bangladesh and Tomato, carrot, chilli, onion, garlic, turnip and french been are most important winter vegetables. Financial returns from vegetables showed that winter vegetable is more profitable than the production of most field crop (Sharfuddin and Siddique, 1998). From the winter vegetables, carrot is an important one which contain high amount of carotene and vitamin C (10.52 mg/100 g) and minerals. Tomato is very popular for its diversified use and nutritional value. It is used as salad which is rich in vitamin C (35 mg/100 g). Turnip and french bean are important for their quick growing nature but not widely used winter vegetables all over the country but very rich in mineral (Ann., 1980). Chilli is the important spices in our country, which contain high amount of vitamin. Onion is the well known bulb crop of the world and also popular in Bangladesh which is used as main spices. Garlic is the second most widely used cultivated spice crop with a characteristic pungent smell.

From the above statements, there have a great scope and essentialities of cultivation of winter vegetables under multistoried agroforestry production system. No study had been reported on the production ability and yield potential of winter vegetables as a component of multilayered system. Consequent on this, the study was conducted to evaluate the performance and economic return of growing winter vegetables under lemon-coconut based multistoried agroforestry system.

MATERIAL AND METHODS

The experiment was carried out on the existing Coconut + Lemon based multistoried garden at the Germplasm Centre of Fruit Tree Improvement Project (FTIP), Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from November 2005 to April 2006. Geographically it is located at 24°75´North latitude and 90°50´East longitude. Two treatments namely T_0 (under full sunlight/open condition) and T_1 (Coconut + Lemon based agroforestry system, severe shade condition) were used to evaluate the performance of seven winter vegetables. Treatment T_1 was a three layered canopy configuration consisted of coconut, lemon and winter vegetables. The winter vegetables were in ground layer, the second layer had lemon plants which were seven years old and were in fruiting condition and coconut occupied the third layer. The spacing between lemon and rows of coconut, 6m × 8 m which permitted 30-50 percent of light intensity and the spacing between coconut plantations were 8 m × 8 m. The tested vegetables were carrot (*Daucus carota L.*), turnip (*Brassica rapa*), tomato (*Lycopersicon esculentum*), onion (*Allium cepa*), garlic (*Allium sativum*), chilli (*Capsicum frutescens*) and french bean (*Phaseolus vulgaris*) which were laid out following the Randomized Complete Block Design with three replications, while the number of vegetables were same in control and other treatment plots . In total 42 plots were set up and individual plot size for vegetables were 4 m × 2.5 m. Adjacent plots and neighboring blocks were separated by 0.5 m and 2 m respectively. Control plots were situated out side the multilayered system. Irrigation, fertilizers and spacing were mentioned at the recommended (standard) way of the vegetables production in Bangladesh conditions. Light intensity was measured with the help of "Quantum Sensor". Three readings were taken from each plot as well as in control plot and the average values showed 35 to 50% PAR penetrated to the multilayered system. Vegetables were harvested in several times; turnip was harvested at 60 days; Onion at 90 days; Carrot at 80 days of planting and continued up to 105 days. Tomato was harvested in several picking when the fruits appeared at yellow to orange color. Garlic was harvested at 120 days after transplanting while Chilli harvesting started at 80 days after planting and continued up to 120 days. Finally total yield was converted into the hectare (10,000m^2) and calculate the total cost of production of individual vegetables under multistrata system.

RESULTS AND DISCUSSION

Growth and yield

Tomato: Tomato plants cultivated under shade grew more vigorously than those grew in the open field. Significantly the tallest plant (117.75 cm) and maximum number of leaves per plant (34.40) were observed under shade condition (T_1) (Table 1), whereas three parameters *viz.* number of branches per plant, number of clusters per plant and fresh weight of fruits per plant were non significant under different light levels. Ali (1999) found significant results with the tallest plant height under shaded condition in okra. On the other hand, rest of the selected parameters of tomato was statistically significant under different light levels. In which, maximum number of fruits per plant (30.50), diameter of fruits (6.10 cm), yield per plot (3.32 kg) and yield per hectare (32.68 t) were counted under full sunlight i.e. under open field condition. Durieux (1997) reported that under the full sunlight condition yield of tomato was the highest

while Gracie (2004) said that incase of edible vegetables flower buds formation was highest under full sunlight situation.

Chilli: Morphological characters except plant height and number of branches per plant of chilli were not found different under different PAR levels ($p<0.05$). Maximum number of leaves per plant (15.93) was observed under 35-50 % reduced PAR level (Table 2). Brainard *et al.* (2005) reported that morphological parameters of vegetables were varied significantly under shade level. On the other hand, maximum number of fruits per plant (19.30), length of fruit (4.80 cm) and highest fresh weight of fruits per plant (153.33 g), yield per plot (0.83 kg), yield per hectare (8.17 t) were higher under 100% PAR level, i.e. under full sunlight condition.

Carrot: In case of carrot, all the selected parameters in respect of growth and yield were found significant when cultivated under different sunlight levels (Table 3). Morphological behaviors such as plant height (57.00 cm), number of leaves per plant (5.90), and length of leaves (43.40 cm) were increase with the increase of shade level. Under reduced sunlight condition in carrot Miah (2000) was observed that plant height was increased. But diameter of root (3.10 cm), fresh weight of root (149.35 g) yield per plot (2.51 kg), and yield per hectare (24.70 t) were found increased under open field condition.

Onion: Significant difference on yield and yield contributing characters of onion (except number of leaves per plant) were also recorded in onion. However, highest plant height (53.12 cm), number of leaves per plant (6.73) and fresh weight of leaves (151.64 g) were observed under treatment T_1 (Table 4). Moreover, maximum diameter of bulb (2.95 cm), fresh weight of bulb (37.34 g), yield per plot (0.79 kg), and yield per hectare (7.78 t) were found under the treatment T_0 (open field condition). Wang and Zhang (1998) reported that there is a significant difference between the productions of Ginger in different shade level.

Garlic: The growth and yield characteristics of garlic were influenced significantly (except number of leaves per plant) by the different PAR levels. The tallest plant height (39.50 cm) and maximum fresh weight of leaves (143.25 g) were recorded under reduced PAR level (T_1) (Table 5). Whereas, maximum diameter of bulb (3.25 cm), fresh weight of bulb (29.80 g), yield per plot (0.60 kg) and yield per hectare (5.90 t/ha) were observed under full PAR level (T_0). Shahadat (2006) conducted an experiment on a leafy medicinal herb and found that under the reduced shade level there was a significant variation in respect of their yield.

Turnip: All the selected characteristics related to the performance of turnip were different under different light levels at 5% level of significance. The maximum length of leaves (39.63 cm), leaf breadth (23.32 cm), and fresh weight of leaves (199.76 g) were measured under shade condition (T_1) (Table 6), whereas minimum were counted under full sunlight condition (T_0). Moreover, under full light level, diameter of root, fresh weight of root, yield per plot and yield per hectare were recorded highest.

French bean: In french bean, all parameters were significant (except length of pod) when grown under two different treatments (Table 7). All the growth characters such as plant height, leaf breadth were vigorous under shade condition compared to full sunlight condition. Highest pods per plant (51.20), pod weight per plant (248.70 g), yield per plot (4.59 kg) and yield per hectare (13.15 t/ha) were counted when french bean grown under full sunlight condition, i.e. under open field condition. Wadud (1999) conducted an experiment on four vegetables in Bangladesh with different light level (Shade level) and found that plant of these vegetable were increased with the increase of shade level while total production was highest under full sunlight conditions.

Table 1. Growth and yield contributing characters of tomato under different light conditions.

System	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	No. of clusters/plant	No. of fruits/plant	Diameter of fruit (cm)	Fresh wt. fruits/plant (kg)	Yield/plot (kg)	Yield (t/ha)
T_0	97.50	26.75	6.30	4.95	30.50	6.10	0.58	3.32	32.68
T_1	117.75	34.40	6.80	5.44	22.30	5.50	0.43	2.43	23.92
$Lsd_{(0.05)}$	12.42	7.452	NS	NS	7.452	0.4968	NS	-	7.452

Table 2. Growth and yield contributing characters of chilli under different light conditions.

System	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Fruits/ plant	Length of fruit (cm)	Fresh wt. fruits/plant (g)	Yield/plot (kg)	Yield (t/ha)
T_0	57.40	13.00	5.00	19.30	4.80	153.33	0.83	8.17
T_1	55.80	15.93	4.40	12.80	4.30	98.00	0.57	5.61
$Lsd_{(0.05)}$	NS	2.484	NS	4.968	0.2484	52.66	-	-

Table 3. Growth and yield contributing characters of carrot under different light conditions.

System	Plant height (cm)	No. of leaves/ plant	Length of leaves (cm)	Length of root (cm)	Diameter of root (cm)	Fresh wt. root (g)	Yield/plot (kg)	Yield (t/ha)
T_0	52.70	5.60	37.60	12.00	3.10	149.35	2.51	24.70
T_1	57.00	5.90	43.40	15.80	2.66	134.75	2.10	20.67
$Lsd_{(0.05)}$	2.484	0.2484	4.968	2.484	0.2484	12.50	0.2484	2.484

Table 4. Growth and yield contributing characters of onion under different light conditions.

System	Plant height (cm)	No. of leaves/plant	Fresh wt. leaves (g)	Diameter of bulb (cm)	Fresh wt. bulb (g)	Yield/plot (kg)	Yield (t/ha)
T_0	42.00	4.87	142.46	2.95	37.34	0.79	7.78
T_1	53.12	6.73	151.64	1.92	29.57	0.55	5.41
$Lsd_{(0.05)}$	9.937	NS	7.452	-	7.452	0.1111	1.490

Table 5. Growth and yield contributing characters of garlic under different light conditions.

System	Plant height (cm)	No. of leaves/plant	Fresh wt. leaves (g)	No. of cloves	Diameter of bulb (cm)	Fresh wt. bulb (g)	Yield/plot (kg)	Yield (t/ha)
T_0	27.40	6.35	143.25	9.88	3.25	29.78	0.60	5.90
T_1	39.50	5.05	136.95	9.45	2.18	20.25	0.42	4.13
$Lsd_{(0.05)}$	-	NS	4.968	NS	-	4.968	0.1571	1.490

Table 6. Growth and yield contributing characters of turnip under different light conditions.

System	No. of leaves/ plant	Length of leaves (cm)	Leaf breadth (cm)	Fresh wt. leaves (g)	Diameter of root (cm)	Fresh wt. root (g)	Yield/plot (kg)	Yield (t/ha)
T_0	7.60	37.67	18.40	180.37	9.50	540.50	4.11	39.76
T_1	7.90	39.63	23.32	199.76	8.87	515.00	3.64	35.82
$Lsd_{(0.05)}$	NS	1.739	2.484	12.42	0.4968	12.42	0.2939	2.484

Table 7. Growth and yield contributing characters of french bean under different light conditions.

System	Plant height (cm)	Leaf breadth (cm)	Pod/plant	Length of pod (cm)	No. of seeds/ pod	Pod weight (g)	Yield/plot (kg)	Yield (t/ha)
T_0	50.65	23.14	51.20	16.80	8.00	248.70	4.59	13.15
T_1	55.81	26.10	36.29	10.10	5.00	193.72	3.45	9.91
$Lsd_{(0.05)}$	4.968	2.484	7.452	NS	2.484	24.84	0.7452	4.968

Economic analysis

The input and overhead costs were recorded for all the vegetables and calculated on per hectare basis. The total cost of production ranged between Tk. 16013 to Tk. 35735 per hectare (Table 8) (currently 1 Taka = 70 US$). The total production cost was the highest in case of carrot and the lowest was obtained from the french bean. The gross income from different treatment combinations ranged between Tk. 49550 to Tk. 144690 per hectare. Gross income was the total income through the sale of marketable products. The highest net return (Tk.108937) was obtained from carrot, while lowest net return (Tk. 31787/ha) was obtained from onion when cultivated under Lemon + Coconut based multistoried cropping system.

Though the 100% PAR level yield of vegetables were higher than multilayered yield but if we considered the total yield of multilayered production system is considered, it was economically profitable. Moreover, multilayered production system can properly utilize the land and nutrient of the production area (Ahmed *et al.*, 2007). Agroforestry system deals with multilayered production system in a sustainable ways and it will continue several years. Production of vegetables under different layered agroforestry system says that it is better to cultivate vegetables in early establishment of tree period i.e. initial stages of tree development.

Table 8. Cost and return analysis of different vegetables production under Lemon + Coconut based multistrata system.

Vegetables	Total yield (t/ha)	Gross income (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)
Tomato	23.92	107640	22575	85065
Chilli	5.61	112200	16905	95295
Carrot	20.67	144690	35717	108973
Onion	5.41	54100	22313	31787
Garlic	4.13	103250	18428	84822
Turnip	35.82	107460	20003	87457
French bean	9.91	49550	16013	33537

1 Taka (TK) = 70 US$ or 98 Euro,

CONCLUSION

In a limited resources country like Bangladesh, multilayered production system can play a significant contribution of the multiple component yield and economic condition of the farmers. From this experiment, carrot under Lemon + Coconut based multistoried system was gave highest economic return. So, vegetables carrot and chilli under this multistoried system might be encouraged.

REFERENCES

Durieux, A. 1997. Effect of (additional) lighting on the production of vegetables crops. III International symposium on artificial lighting in horticulture. ISHS Acta Horticulturae 418, Netherlands.

Gracie, A.J., Brown, P.H., and Clark, RJ. 2004. Study of some factors affecting the growth and development of myoga (*Zingiber misga* Roscoe). Scientia Horticulturae. 100: 267-278.

Abedin, M. Z. and M. A. Quddus, 1990. Homestead fuel situation, home garden and agroforestry practices at six-agroecologically different locations of Bangladesh.In: Abedin *et al.* (ed). Homestead plantation and agroforestry in Bangladesh. BARI, Winrock International and BARC. pp. 19-53.

Ahmed, F., M.A. Rahim, M.S. Alam, M.A. Hamid, and K.M.B. Haque. 2007. Performance of medicinal plants and species in coconut based agroforestry system. Journal of Agroforestry and Environment. 1: 51-53.

Ali, M. A. 1999. Growth and yield of mungbean genotype under sun and shade conditions. Unpublished MS Thesis, BSMRAU, Bangladesh.

Anonymous, 1980. Nutritious value of indigenous food. Institute of Nutrition and Food Sci.. Univ. of Dhaka. pp. 5-15.

Dan C. Brainard, Robin R. Bellinder and Antonio Di Tommaso. 2005. Effect of canopy shade on the morphology, phenology and seed characteristics of Powell amaranth. Weed Science. 53: 175-186.

Miah, M. G. 2000. Performance of five winter vegetables under different light conditions for agroforestry systems. M.S. Thesis, Dept. of Agroforestry, Bangabandhu Sheikh Mujibar Rahman Agricultural University, Salna, Gazipur.

Millat-e-Mustafa, M., 1997. Tropical Homegardens: An overview. In: Alam MK, Ahmed FU and Amin SM (eds) Agroforestry: Bangladesh

Perspective. APAN/NAWG/ BAEC, Dhaka, Bangladesh. Pp: 18-33.

Millat-e-Mustafa, M., Z. Teklehaimanot and A.K.O. Haruni, 2002. Traditional uses of perennial homestead garden plants in Bangladesh. Forest, Trees and Livelihoods 12: 235-256.

Shahadat, H. 2006. Performance of Thankuni (*Centella asiatica*) as a medicinal plant under various fertilizer doses and light levels for its suitability in Agroforestry system. MS thesis, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh. P56.

Shorfuddin, A. F. M. and Siddique, M. A. 1998. 'Sabji Bigyan' a Bengali book of horticulture.Published by the Department of Horticultue, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 10-12.

Taleb, M. A. 2003. Screening of some winter vegetables as lower layer crops under three layered agroforestry systems. M.S. Thesis. Bangladesh Agricultural University, Mymensing.

Wadud, M. A. 1999. Performance of four summer vegetables under reduced light conditions for agroforestry systems. An M. S. Thesis submitted to BSMRA University, Salna, Gazipur.

Wang, S, H. and Zhang, Z. X. 1998. Effect of shade on growth and yield of ginger. China Vegetables 5: 5-8.

Submitted November 24, 2007 – Accepted February 22, 2008
Revised received March 02, 2008