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Research Article

Growth and yield of Cabbage in Aonla based Multistoried Agroforestry

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Abstract

Globally conventional agroforestry systems (CAS) underpin the basic needs and accelerate the livelihood of billions of rural people. Nevertheless, the outcomes of multistoried agroforesty systems are yet to be addressed. Therefore, the present study emphasis on evaluation of yield, yield attributes and economic performance of cabbage in aonla based multistoried agroforestry system (MAS). The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Four systems combinations are T1: aonla + carambola+ lemon + dragon fruit+ cabbage, T2: aonla + dragon fruit + cabbage, T3: dragon fruit + cabbage, T4: cabbage in the open field (Control). Results showed that mean photosythetically active radiation (PAR) of a day was relatively higher (1027.19 µmol m^{-2} s^{-1}) (100%) in open field condition (T4) followed by dragon fruit based system (T3) (1004.74 µmol m^{-2} s^{-1}) (98 %), aonla+dragon fruit-based system (T2) (808.92 µmol m^{-2} s^{-1}) (78%) and aonla + carambola+lemon+dragon fruit-based system (T1) (507.87 µmol m^{-2} s^{-1}) (50%). The superior performance of cabbage in terms of plant height, number of leaves $plant^{-1}$, leaf length, leaf breadth, and land equivalent ratio (LER) was found in aonla + carambola + lemon + dragon fruit-based system (T1) while SPAD value was found highest in open field condition (T4). Fresh leaf weight, leaf dry weight, head dry weight, head length, head breadth, individual head weight, marketable head weight, and yield was the highest in dragon fruit-based system (T3). Gross income (1261384 BDT ha^{-1}) and BCR (2.95) were the highest in aonla + dragon fruit-based system (T2).

Keywords: *Aonla, Cabbage, Economic return, Multistoried agroforestry, Yield.*

Introduction

The population is growing rapidly, but the land is decreasing day by day due to the construction of new houses, factories, roads and highways, brickyards, hospitals, educational facilities, religious institutions and other infrastructure. It is reported that land is shrinking at an alarming rate of 0.005 ha $head^{-1}$ $year^{-1}$ (Ahmed, *et al*., 2019). People should consume at least 400 g of fruits and vegetables daily (FAO/WHO 2003), but the people usually consume 36 and 167 g of each, respectively (BBS, 2018). In this case, it is essential to investigate a system that can aid in overcoming the drawbacks of significant investment in conventional agriculture. Increasing agricultural productions urgently requires the use of modern or appropriate methods (Alam, *et al*., 2012).

In many countries across the world, including Bangladesh, agroforestry has played a significant role in rural people livelihood improvement. By ensuring family food and energy security, increasing profitability and jobs, opening up investment possibilities, and protecting the environment (Miah, *et al*., 2002;

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Batish, *et al*., 2007; Mondal, *et al*., 2013). Low consumption of vegetables puts enormous pressure on cereals and also causes malnutrition leading to several types of health risks. The demand for vegetables is increasing, but unfortunately the area for vegetable production is decreasing due to the increasing area under rice and wheat cultivation. Diversification into vegetable and increasing commercialization can support the development of the agricultural sector in several ways (Mondal, *et al*., 2012; Rahman, *et al*., 2021).

Aonla (*Emblica officinalis*) is a deciduous tree that bears fruit profusely, is resilient and profitable for farmers with poor land. For its nutritional value, aonla is highly regarded. In comparison to an apple, the edible aonla fruit tissue contains 160 times as much ascorbic acid and 3 times as much protein. It is abundant in ascorbic acid, which is second only to Barbados cherry (*Malpighia glabra* L.), and is also high in polyphenols, tannins, and minerals (Maheshwari, *et al*., 2022). Carambola is a dwarf plant that may be seen growing under certain huge trees in rural homesteads. Additionally, it is a good source of ascorbic acid, reducing sugars, and minerals including K, Ca, Mg, and P (Haick, 1952). Lemon, a member of the Rutaceae family, is regarded as the third-most significant citrus species, behind orange and mandarin (Hossain, 2018). It is a fruit that is abundant in vitamin C and tolerant of a variety of soils and environments (Gosh, *et al*., 2001). These two species therefore have the capacity to develop as a middle-storied component of multistory agroforestry systems (Ferdous, *et al*., 2022). The most significant fresh and processed vegetable throughout the world is cabbage (*Brassica oleracea* var. capatata L.),. Both tropical and temperate nations grow it extensively. It is said to have come from Western Europe and was the first cole crop ever grown (Islam, *et al*., 2017). It also has a small amount of protein and a high caloric content in addition to a variety of vital vitamins and minerals (Haque, *et al*., 2006).

Bangladeshi farmers currently practice several modern agroforestry production systems based on both fruit and timber species (Miah and Hussain 2005; Haque, *et al*., 2016; Miah, *et al*., 2018). Agroforestry systems based on fruit trees are able to provide higher yield and economic return and are grown under different biotic and abiotic stress conditions compared to many annual crops (Miah, *et al*., 2018,). Nonetheless, multistoried agroforestry system offers production of various fruits and vegetables under different level of shade (Reza, 2021) by maximum utilization of altered Photosynthetically Active Radiation (PAR). In this system, different components are arranged in different layers. So the light limitation of the lower storied crop is the most important consideration. Hence, lower storied crop selection for this system is a pivotal task. Considering the aforesaid issues, cabbage was selected for lower storey crop to find the productivity of this system. Moreover, this study also explore the yield contributing characters and yield of cabbage and evaluate the economic performance of cabbage in aonla based multistoried agroforestry system.

Materials and Methods

Plant Materials and Experimental Set Up

The study was conducted from December 2020 to April 2021 in a 21years old aonla orchard established in 2000 at the research farm of the department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, Bangladesh. The experimental field is located at 24.09° N latitude and 90.26° E longitude with an altitude of 8.5 meters above sea level in the agro-ecological zone (AEZ)-28 (Madhupur Tract). The experimental field's soil was terrace soil from the Madhupur Tract's Salna series of Shallow Red-Brown Terrace Soil (Table 1). The soil texture at the experimental site was silty clay loam, and acidic in nature (Ratul, *et al*., 2021).

Table 1: Initial soil status of different treatments (Ferdous, *et al*., 2022)

Soil characters	T_1	T_2	T_3	T_4
Soil pH	5.50	5.06	5.26	5.20
Soil OM (%)	2.31	2.21	2.44	2.31
Nitrogen (%)	0.12	0.11	.065	0.061
Phosphorus(ppm)	6.18	11.62	9.05	4.56
Potassium (meq/100g soil)	0.18	0.17	0.17	0.16
Sulfur (ppm)	27.24	15.49	19.23	13.62

The existing twenty-one-year-old Aonla orchard was established in 2000 with a spacing of 8m × 8m and converted into an agroforestry system where cabbage was grown in the winter. There were six rows of aonla trees and each row had eleven trees. One-year-old seedlings of lemon (seedless BARI lebu) and carambola (var. BARI Kamranga-1) were planted in 2008 in between aonla tree (local race) to test their performance. Each carambola plant was planted exactly in the middle of two aonla trees, and each lemon tree was planted exactly in the middle of the aonla and carambola trees. The dragon was planted in September 2018. Two genotypes of dragon fruit (red fleshed dragon and white fleshed dragon) were planted in the alley. Cabbage was planted between the dragon fruit plant with spacing of 60 cm × 50. The experiment was designed in a Randomized Complete Block Design (RCBD) with four replications. The system combinations were T1: aonla + carambola + lemon + dragon fruit + cabbage, T2: aonla + dragon fruit + cabbage, T3: dragon fruit + cabbage, T4: field cabbage (control)

Crop Establishment and Management Practices

Cabbage seeds were sown on 9th November 2020. After preparation of land properly 30 days old seedlings were transplanted in the main field. In Vegetables cow dung was applied at the rate of 15 t ha^{-1}, Nitrogen, phosphorus and potassium were applied at the rate of $N:P_2O_5:K_2O$ of 135:90:125 kg ha^{-1} Cow dung, all non-urea fertilizer and 50% urea was applied as a basal dose during the final land preparation. The remaining urea was added before sowing and at fruiting in two equal doses (25% in each case). Intercultural operations such as weeding, irrigation, gap filling, pest and disease control, etc. were accomplished for better growth and development of the cabbage whenever necessary.

Harvesting and Data Collection

Harvesting of cabbage was done during 14th February 2021 to 1st March 2021. Data were recorded on the following parameters from the sample plants during the experiment. The plants in the outer rows and the end of the middle rows were excluded from the random selection to avoid the border effect. Five cabbage plants were randomly selected per replication for data collection. Leaf length, leaf breadth, leaf weight, leaf number $plant^{-1}$, SPAD (Soil Plant Analysis Development) value of leaves, plant height, head length, head breadth, individual head weight, marketable head weight, dry weight of leaf and head and yield were measured. The chlorophyll content of the leaf was measured from the selected plant by SPAD 502 plus Chlorophyll meter (Konica Minolta Sensing, Inc., Japan). Photosynthetically active radiation (PAR) was measured on each crop row at 9.30 am., 12.30 pm and 3.30 pm each day at a one-week interval as functions of multistrata and distances from the tree base using LP-80 Accu PAR Ceptometer to determine the extent of shading by the tree species during 14 DAT to 67 DAT.

Benefit–cost ratio (BCR) and land equivalent ratio (LER) were determined according to the equations followed by Miah, *et al*., (2018) in aonla-based agroforestry system.

Benefit-cost ratio (BCR) = Gross return/Total cost of production.

Land equivalent ratio=Ci/Cs +Ti/Ts, where, Ci is crop yield under agroforestry, Cs is crop yield under sole cropping, Ti is fruit yield under agroforestry, and Ts is fruit yield under sole cropping (Miah, *et al*., 2018)

Statistical Analysis

Using computer programs MS Excel and STATISTIX 10, all data were processed, computed, and analyzed. To identify the significant variations in the results caused by various agroforestry systems, the data on the various growth and yield-contributing features of the vegetables were statistically evaluated. The F (variance ratio) test was used to analyze the variance for each of the features that were the subject of the study. The LSD test was used to separate the mean variance at a 5% level of significance. Analyzed data were used to create tables and graphs.

Results and Discussion

Photosynthetically Active Radiation (PAR) in Multistoried Agroforestry Systems

Among different aonla-based multistoried agroforestry systems, the highest photosynthetically active radiation (PAR) was recorded in open filed condition (T4) (961.15 µmol m^{-2} s^{-1} at 9.30 am, 1345.93 µmol m^{-2} s^{-1} at 12.30 pm, 460.61 µmol m^{-2} s^{-1} at 3.30 pm). The lowest PAR (Fig.1) was recorded in aonla + carambola+lemon+dragon fruit-based system (T1) (398.33 µmol m^{-2} s^{-1} at 9.30 am, 808.50 µmol m^{-2} s^{-1} at 12.30 pm and 167.97 µmol m^{-2} s^{-1} at 3.30 pm). The recorded PAR in aonla + dragon fruit-based system (T2) and dragon fruit-based system (T3) was varied between PAR in aonla + carambola + lemon + dragon fruit fruit-based system (T1) and open filed condition (T4). Thus, ultimately mean PAR of a day was also the highest (922.56 µmol m^{-2} s^{-1}) in open field condition (T4) followed by dragon fruit based system (T3) (901.63 µmol m^{-2} s^{-1}) (97 %), aonla+dragon fruit-based system (T2) (665.36 µmol m^{-2} s^{-1}) (72%) and aonla + carambola+lemon+dragon fruit-based system (T1) (458.26 µmol m^{-2} s^{-1}) (50%). Upper storied plant aonla received 100 % PAR, but incident light was gradually decreased on carambola, lemon, dragon fruit, and vegetables in multistoried conditions. Vegetable (cabbage) growing in open fields and aonla (upper storied component) received 100% PAR. As the canopy covering increases, light intensity diminishes. Due to its extensive canopy cover, the multistory agroforestry system built on an aonla was less light-available than an open field. Similar result also reported Amin, *et al*., 2022 in okra. In any multistory agroforestry system, the lack of light is the main limiting factor for the understoried crop.

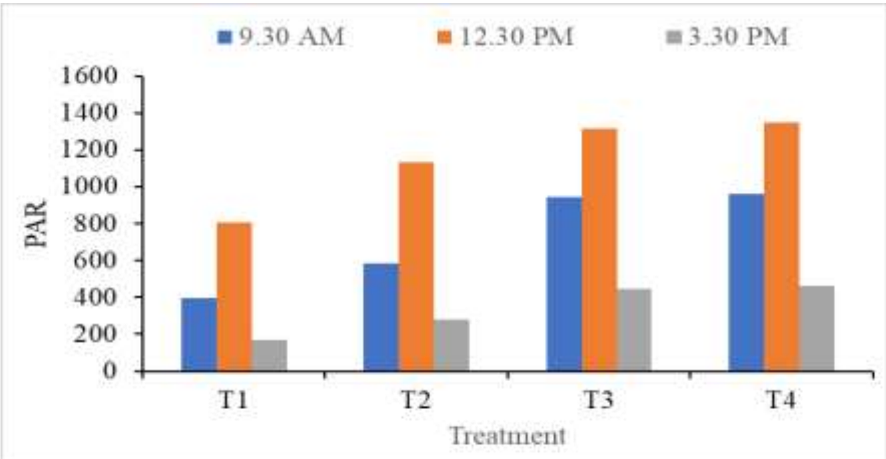

Fig.1: Mean availability of PAR measured three times a day within the cabbage growing season in different Aonla based multistoried agroforestry system.

Plant Height

At 30 DAT, significantlythe tallest plant (23.58 cm) was observed in aonla + carambola + lemon + dragon fruit (T1) based agroforestry system where light availability was only 50% followed by aonla + dragon fruit-based system (T2) (21.33 cm) and dragon fruit-based system (T3) (17.83 cm). Significantly the shortest plant (15.99 cm) was observed in an open field (T4) where light availability was 100%. At 60 DAT, though the tallest plant (39.21 cm) was recorded in aonla + carambola

+ lemon + dragon fruit (T1) based agroforestry system but it did not vary significantly from aonla+dragon fruit-based system (T2) (38.20 cm). On the other hand, T1 and T2 were significantly different from T3 and T4. Significantly the shortest plant (35.40 cm) was observed in an open field (T4). The plant height of cabbage is an important morphological character that was significantly influenced by different aonla based agroforestry systems (Fig. 2). Usually, plant grown in low light levels was found to be exhibited apical dominance than those grown in the high light environment resulting in taller plants under shade (Hillman, 1984). Hillman (1984) observed that, plant grown in low light levels was found to have more apical dominance than those grown in high light environment resulting in taller plants under partial shade. Similar result also reported in Rahman, *et al.*, 2015 in tomato, Ferdous, *et al.*, 2022 in radish.

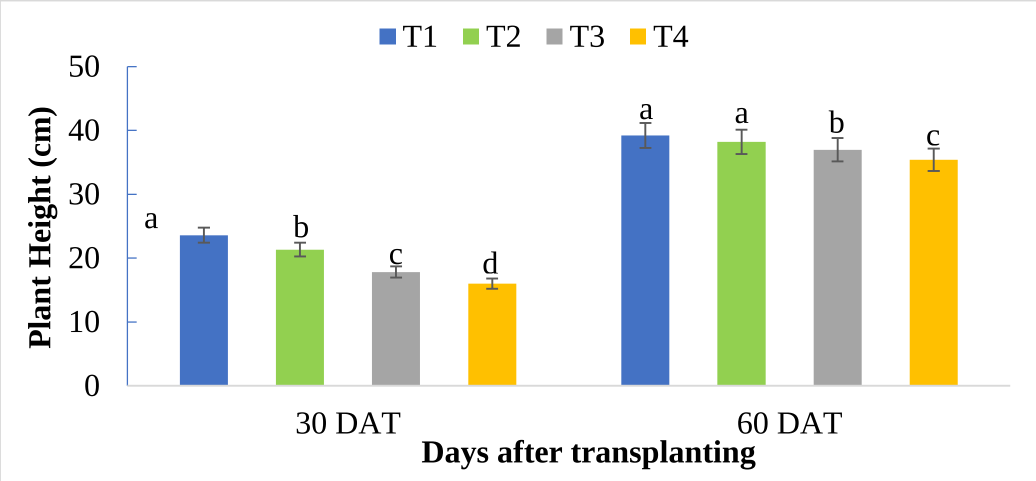

Fig. 2: Plant height of cabbage at 30 DAT and 60 DAT in different aonla-based multistoried agroforestry systems

Number of Outer Leaves

The number of outer leaves is an important morphological character of cabbage that was significantly influenced by different aonla-based agroforestry systems (Fig. 3) at 30 DAT and 60 DAT. At 30 DAT, the maximum number of outer leaves plant^{-1} (8.66) was recorded in aonla + carambola + lemon + dragon fruit (T1) based agroforestry system which was statistically similar to that of the aonla + dragon fruit-based system (T2) (8.24). A moderate number of leaves plant^{-1} was found in the dragon fruit-based system (T3) (7.83) which was statistically similar to the T2 treatment. Significantly the minimum number of leaves plant^{-1} (7.19) was observed in an open field condition (T4) that was statistically different from T1, T2, and T3 systems. At 60 DAT, the maximum number of leaves plant^{-1} (13.72) was recorded in aonla + carambola + lemon + dragon fruit (T1) based agroforestry system. A moderate number of leaves plant^{-1} was found in the aonla+dragon fruit-based system (T2) (12.80) and dragon fruit-based system (T3) (12.49). Both T2 and T3 statistically did not vary from each other. Significantly the minimum number of leaves plant^{-1} (11.86) was observed in an open field condition (T4). The maximum numbers of leaves in T1 because leaves grow more quickly where light levels are low. This may be occurred due to modification of maximum inner leaf in head formation (Miah, *et al.*, 2010).

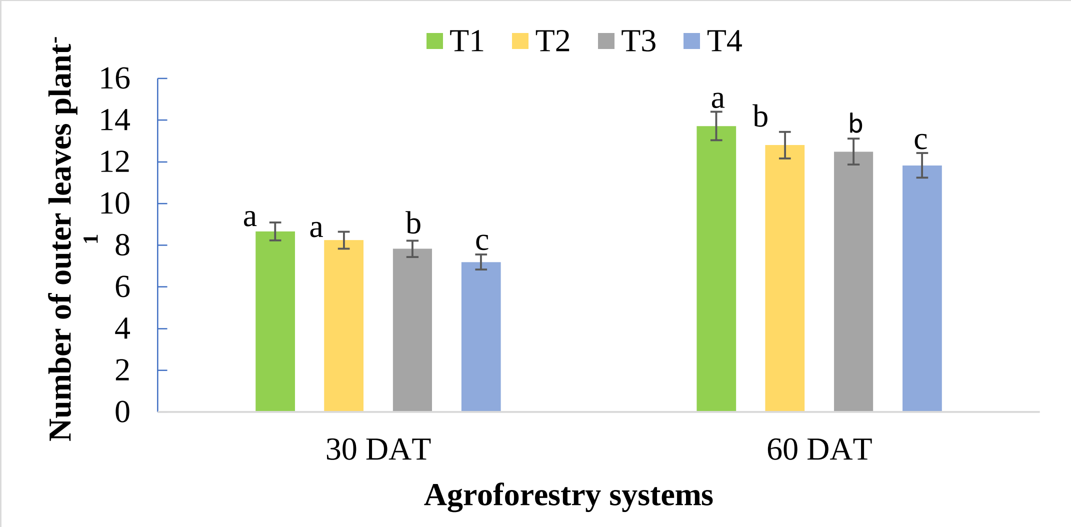

Fig.3: The number of outer leaves of cabbage at 30 DAT and 60 DAT in aonla-based multistoried agroforestry systems.

Outer Leaf Length and Outer Leaf Breadth

Leaf length and leaf breadth are an important morphological characteristic of cabbage. Significant variation was observed for leaf length and leaf breadth plant^{-1} at different days after transplanting in different aonla-based agroforestry systems (Table 2.). Significantly the highest outer leaf length (39.10 cm) was observed in aonla + carambola + lemon + dragon fruit (T1) based agroforestry system where light availability was lowest. Significantly the lowest outer leaf length (30.60 cm) was recorded in an open field condition (T4) and that was statistically similar with the dragon fruit-based system (T3) (32.90 cm).

Outer leaf breadth was also significantly varied due to different aonla-based agroforestry systems. The highest leaf breadth plant^{-1} (36.10 cm) was observed in aonla + carambola + lemon + dragon fruit (T1) based agroforestry system. The lowest outer leaf breadth (27.07 cm) was observed in an open field condition (T4). The moderate leaf breadth was recorded in T2 and T3 systems. Outer leaf length and outer leaf breadth are highest in T1 system because in shade conditions, leaves harvest more light for photosynthesis, so length and breadth are also higher. And also due to the stimulation of cellular expansion and cell division of outer leaf under shaded conditions (Miah, *et al.*, 2010).

Table 2: Leaf length and breadth of cabbage in different aonla based agroforestry system

Treatments	Leaf length (cm)	Leaf breadth (cm)
T1: Aonla + Carambola+ Lemon + Dragon fruit + Cabbage	39.10a	36.10a
T2: Aonla + Dragon fruit + Cabbage	35.72b	33.80b
T3: Dragon fruit + Cabbage	32.90c	29.72c
T4: Cabbage in open field (sole)	30.60c	27.07d
CV (%)	4.74	1.95

In a column, means followed by the same letter (s) are not statistically different at a 5% level of significance by LSD. CV = coefficient of variance.

Yield Attributes of Cabbage

Leaf Fresh Weight, Leaf Dry Weight and Head Dry Weight

Fresh leaf weight, leaf dry weight and head dry weight are important yield contributing characteristics and it was found significant due to different aonla-based agroforestry systems (Fig. 4). The highest leaf fresh weight (845.10 g) was recorded in open field conditions (T4). Significantly the lowest leaf weight (500.09 g) was recorded in Aonla + Carambola + Lemon + Dragon fruit-based agroforestry system (T1). The moderate leaf weight was found in aonla+dragon fruit-based system (T2) (752.97 g) and dragon fruit-based system (T3) (810.35 g). In high light condition, the thickness of leaves, palisade parenchyma and spongy parenchyma are the bigger, and the stomatal frequency and stomatal area per unit leaf area were also higher. So leaf weight also higher (Fan, *et al.*, 2013). At harvest, the highest leaf dry weight was observed in open field conditions (T4) (47.35 g) and Dragon fruit-based agroforestry system (T3) (45.66 g). The lowest leaf dry weight (39.33 g) was observed in Aonla + Carambola + Lemon + Dragon fruit fruit-based agroforestry system (T1). This might be due to heavy shade associated with the lower mobilization of reserve assimilation to the reproductive organs (Hanif, *et al.*, 2010). At harvest, the highest head dry weight (53.50 g) was observed in open field conditions (T4) and the lowest head dry weight (45.32 g) was found in Aonla + Carambola + Lemon + Dragon fruit fruit-based agroforestry system (T1). The moderate head weight was observed in T2 (48.44 g) and T3 (51.12 g).

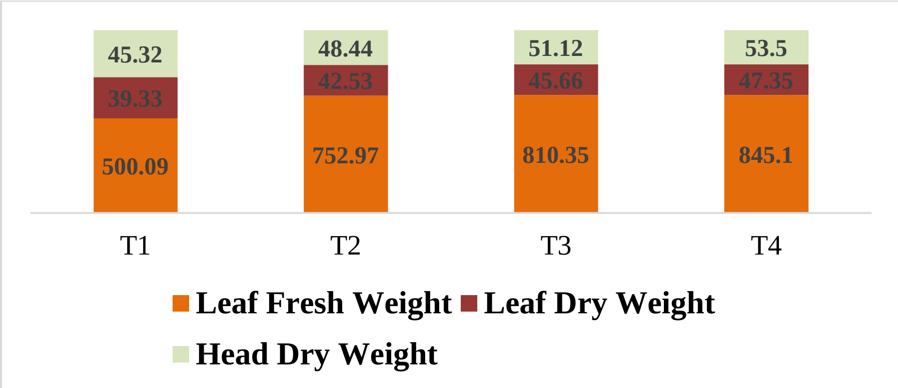

Fig. 4: Leaf fresh weight, leaf dry weight and head dry weight of cabbage in different aonla-based multistoried agroforestry system.

Head Related Attributes

Head Length, Head Breadth, Weight of the Individual Head and Marketable Head

Head length, head breadth, weight of the individual head and marketable head are an important attribute for contributing yield performance which was significantly influenced by different aonla-based agroforestry systems (Table 3.). The highest head length (17.82 cm) was found in dragon fruit-based system (T3) and the lowest head length (13.42 cm) was found in Aonla + Carambola + Lemon + Dragon fruit fruit-based agroforestry system (T1) which was statistically similar to aonla+dragon fruit-based system (T2) (13.55 cm). Head length was the highest in dragon fruit-based system (T3) because it might be accumulated more nutrients compared to other agroforestry systems. The highest head breadth (20.45 cm) of cabbage was found in dragon fruit-based system (T3) and the lowest head breadth (16.60 cm) was observed in Aonla + Carambola + Lemon + Dragon fruit fruit-based agroforestry system (T1). The moderate head breadth of cabbage was observed in T2 (18.00 cm) and T4 (19.80 cm) systems. Head breadth was highest in dragon fruit-based system (T3) because the light intensity was higher in T4 (98%) and competition of water and nutrients was less in T3.

The highest individual head weight of cabbage (3.20 kg) was observed in dragon fruit-based system (T3) and the lowest individual head weight of cabbage (1.67 kg) in Aonla + Carambola + Lemon + Dragon fruit-based agroforestry system (T1). The moderate individual head weight was found in aonla+dragon fruit-based system (T2) (2.22 kg) and open field condition (T4) (3.00 kg). In case of marketable head weight, the highest head weight (2.20 kg) was observed in dragon fruit-based system (T3) and the lowest marketable head weight (1.16 kg) was recorded in Aonla + Carambola + Lemon + Dragon fruit-based agroforestry system (T1). The moderate marketable head weight was observed in aonla+dragon fruit-based system (T2) (1.67 kg) and open field condition (T4) (2.09 kg). The lowest head weight plant^{-1} may be due to lower production of photosynthates under low light conditions for a longer period (Miah, *et al*., 1999).

Table 3: Length, breadth, weight of head and Marketable head weight of cabbage in the systems during harvest

Treatments	Head length (cm)	Head breadth (cm)	Individual head weight (kg)	Marketable head weight (kg)
T1: Aonla + Carambola+ Lemon + Dragon fruit + Cabbage	13.42c	16.60d	1.67d	1.16d
T2: Aonla + Dragon fruit + Cabbage	13.55c	18.00c	2.22c	1.67c
T3: Dragon fruit + Cabbage	17.82a	20.45a	3.20a	2.20a
T4: Cabbage in open field (sole)	16.00b	19.80b	3.00b	2.09b
CV (%)	4.24	2.46	6.41	8.01

In a column, means followed by the same letter (s) are not statistically different at a 5% level of significance by LSD. CV = coefficient of variance.

Head Yield (t ha^{-1})

The yield was significantly influenced by different aonla-based agroforestry systems and open field conditions (Table 4). The highest marketable head yield of cabbage (73.33 t ha^{-1}) was recorded in dragon fruit-based system (T3) and the lowest marketable head yield of cabbage (38.66 t ha^{-1}) was recorded in Aonla + Carambola + Lemon + Dragon fruit-based agroforestry system (T1). The moderate head yield was recorded in aonla+dragon fruit-based system (T2) (55.66 t ha^{-1}) and open field conditions (T4) (69.66 t ha^{-1}). The results showed that cabbage can be grown in shade and partial shade conditions without causing considerable yield loss.

Table 4: The marketable head yield of cabbage in different aonla based agroforestry systems

Treatments	Marketable head yield (t ha^{-1})
T1: Aonla + Carambola+ Lemon + Dragon fruit + Cabbage	38.66
T2: Aonla + Dragon fruit + Cabbage	55.66
T3: Dragon fruit + Cabbage	73.33
T4: Cabbage in an open field (sole)	69.66

Relationship between Light Intensity (PAR μmolm^{-2}s^{-1}) and Yield of Cabbage

There was a positive linear relationship between PAR (%) and yield of cabbage (Fig. 5) in agroforestry system. The R^2 value (0.98) was positive and strongly significant, which indicated that the contribution of 98.00% of cabbage yield could be attributed to PAR (%) of agroforestry system. The relationship also stated that yield of cabbage was increased at the rate of 0.6708 t ha^{-1} per unit changing of light intensity (PAR μ mol m^{-2} s^{-1}).

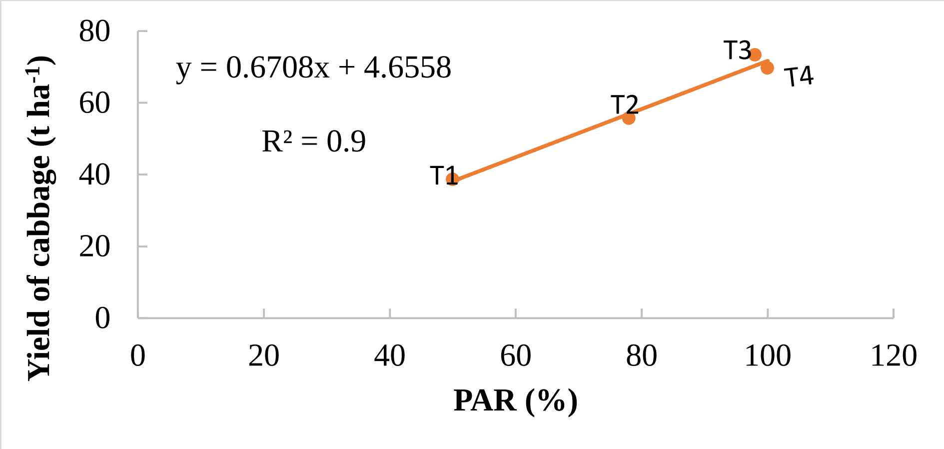

Fig.5: Relationship between PAR (%) and yield of cabbage in aonla-based multistoried agroforestry systems.

Economic and Land Productivity of Multistoried Production Systems

For measuring the land-use efficiency of agroforestry, LER is commonly used. In this experiment, LER was also measured to know the profitable land use (Table 5). The highest LER (3.78) was recorded in the Aonla + Carambola + Lemon + Dragon fruit-based agroforestry system (T1) and the lowest LER (2.06) was recorded in the Dragon fruit-based agroforestry system (T3). The LER in the multistoried system (T1 and T2) was more than three times than cabbage (sole crop). It means if we want to get the same component yield from the sole cultivation then it will take more than three times land. So, this model is as important for the most densely populated countries in the world as Bangladesh.

Profitability of growing cabbage as inter-crop in different production systems was calculated based on local market rate that prevailed during the experiment. The return of products and the profit i.e. benefit-cost ratio (BCR), gross income, and total cost of production have been presented in Table 5. Considering gross income, the highest income (1261384 Tk ha^{-1}) was recorded in the aonla+dragon fruit-based system (T2) and the lowest income (444315 Tk ha^{-1}) was recorded in open field conditions (T4). So the highest BCR (2.95) was recorded in the aonla+dragon fruit-based system (T2) and the lowest BCR (1.13) was recorded in open field condition (T4). The results revealed that T2 system was superior to all other production systems in terms of yield and income.

Table 5: Determination of land use efficiency by LER and economic evaluation by total income and BCR of cabbage for the different production system

Treatments	Gross income (Tk ha^{-1})	Rank	The total cost of production (Tk ha^{-1})	BCR	LER
Cabbage sole (T4)	504680	4th	444315	1.13	---
Aonla + Carambola + Lemon + Dragon fruit + Cabbage (T1)	1130420	2nd	526568	2.15	3.78
Aonla + Dragon fruit + Cabbage (T2)	1261384	1st	426298	2.95	3.63
Dragon fruit + Cabbage (T3)	1116420	3rd	384237	2.90	2.06

Conclusions

Cabbage grown in different aonla based agroforestry systems respond differently but the yield contributing characters and yield of studied vegetables performed best in dragon fruit-based system (T3). Benefit-cost ratio was found highest in aonla + dragon fruit-based system (T2) while the highest land equivalent ratio was found in aonla + carambola + lemon + dragon fruit -based system (T1). And the highest gross income was found in aonla + dragon fruit-based system (T2). In a resourcelimited country like Bangladesh, aonla based multistoried agroforestry system can play a vital role in the supply of multiple products throughout the year. The findings indicated that aonla based multistoried agroforestry system could be a model approach for smallholder farmers to enhance profitability and land use efficiency.

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