Growth and Yield of Dragon Fruit in Aonla based Multistoried Fruit Production Model

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ABSTRACT

The study was conducted at the aonla based agroforestry experimental field of the department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University from June, 2019 to July, 2020 to develop a multistoried food production model for the terrace ecosystem of Bangladesh. The experiment was carried out under twenty years old aonla orchard which was considered as upper storied component, while two minor fruits namely carambola and lemon were used as middle storied component. Dragon fruit was the test crop grown in the alley of tree lines. The experiment was laid out in a two-factor randomized complete block design with three replications. Three different production systems (T₁: aonla + carambola + lemon + dragon fruit, T₂: aonla + dragon fruit, and T₃: dragon fruit as sole) were considered as the three different levels of factor A. Two dragon fruit genotypes i.e. red fleshed dragon fruit (V₁), and white fleshed dragon fruit (V₂) were considered as the two levels of factor B. Red fleshed genotype produced the highest plant height, maximum number of branches and fruit yield compared to those of white fleshed genotype irrespective of treatment combinations. Total height increment, mean annual increment and current annual increment of plant height were found maximum in red fleshed genotype in multistoried conditions. A negative linear relationship was observed between plant height and Photosynthetically Active Radiation (PAR) but a positive linear relationship was noticed between the yield of dragon fruit and PAR. The highest Land Equivalent Ratio was observed in aonla + carambola + lemon + dragon fruit with white fleshed genotype. The result revealed that red fleshed dragon fruit genotype was found suitable for partial shade conditions like aonla tree and successfully grown without sacrificing the significant yield loss compared to that of the open field.

Keywords: Dragon fruit, Growth, LER, Multistoried Model, Yield.

I. INTRODUCTION

Bangladesh is the eighth most populated countries in the world. It has 170 million population spread over 1, 47,570 sq. km with 1.02% annual growth rate [1]. The per capita land area of the country has been gradually decreasing at an alarming rate which is 0.174 hectare in 1961 to 0.046 hectare in 2019 [2]. Again, the agricultural production is not increasing expectedly in the background of over growing population. The country has only 7.97 million hectares of arable land to feed more than 170 million people [1]. Agricultural land makes up 65 % of its geographical surface, forest lands account of almost 17.58% [1]. According to the world bank, collection of development indicators agricultural land and forest area in Bangladesh was reported at 70.63 and 10.98%, respectively in 2015 [2]. Bangladesh has been experiencing demographic pressure, which drive large number of people to get goods and services from a single unit of land, compared to any other country. Under this alarming condition, it is necessary to find out a suitable alternative farming system 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 being called agroforestry system.

The per capita consumption of fruits of Bangladesh is very low which is only 44.7 g/head/day against the standard requirements of 100 g/head/day [3]. On the other hand, agriculture is always vulnerable to unfavorable weather events and climate conditions. Impact of climate change on agriculture is one of the major deciding factors influencing the future food security of mankind on earth. Although advance agricultural research has been trying to earn the food security for the people but nutritional security is not yet addressed. Under the above conditions, climate smart integrated fruit gardening will be preferable cropping system for ecological balance and also for achieving nutritional security through diversified production at changing climate. According to [4] global temperature will increase 1.5 to 4 °C by the next 50 years. In this connection tropical fruit species like dragon fruit can be incorporated in different tree orchards which will easily be sustained at increasing temperature.

Multistoried fruit production model offers production of various fruits under different shade conditions by maximum utilization of different Photosynthetically Active Radiation (PAR) levels. In this system different components are
arranged in different layers. So the light limitation of lower storied crop is most important consideration. Hence, lower storied crops selection for multistoried system is important and difficult task. Therefore different initiative of screening of suitable crops for lower storied component is going on. In this consequence, dragon fruit genotypes are being tested for its suitability under aonla based multistoried agroforestry system.

Aonla is one of the most important deciduous plants for agroforestry practices and also naturally grown in the terrace eco-system in Bangladesh. The fruit is highly nutritious and the richest source of vitamin C.

The fruits of cactaceae family and genus *Hylocereus* are called as pitahaya or dragon fruit. Pitahaya producing cacti of the genus *Hylocereus* are originally native to Mexico. They were transplanted to Central America, probably by European [5]. These cacti are cultivated in Southeast Asia mainly Thailand and Vietnam, the United States, Israel, Australia, Cyprus and the Canary Islands. Various Pitahaya producing *Hylocereus* species include *Hylocereus undatus* (white fleshed dragon fruit), *Hylocereus costaricensis* (red fleshed dragon fruit) [6]. Being a high value fruit dragon fruit (*Hylocereus spp.*) is getting popularity among the farmers of Bangladesh day by day. Potentiality of this fruit as lower storied crop in the multistoried agroforestry system is good.

Considering the above facts, it was aimed to find out a high productive multistoried fruit production system, which can be a sustainable land use practice and high yielding multistoried model comprising medicinal plant (aonla), fruit trees (carambola, lemon) and dragon fruits through maximum utilization of natural resources for homestead and upland eco-system of Bangladesh. Therefore, the study was undertaken to study the morphological parameters and yield and yield contributing characters of dragon fruits in aonla based multistoried fruit production model.

II. MATERIALS AND METHODS

A. Location of Experimental Site

The experiment was conducted in the existing aonla, carambola and lemon based multistoried garden at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) research farm of the Department of Agroforestry and Environment, Gazipur from 1st July 2019 to 30th June 2020. This site was located between the latitude of 24.09°N and between the longitudes of 90.25°E and above 8.5 m above the sea level [7].

B. Climate, Weather and Soil

The experimental area has subtropical climate characterized by three distinct seasons, the monsoon or rainy season (May to October), the winter or dry season (November to February) and the pre monsoon or hot season (March to April). Heavy rainfall used to occur during the months from May to September and scanty rainfall during rest of the year. The soil of the experimental field was originally shallow red brown terrace [8], [9] of Madhupur Tract (AEZ 28) under Salna series [10]. Initial soil and status of different treatments was as follows:

| TABLE I: SOIL HEALTH STATUS OF THE EXPERIMENTAL FIELD |
|-----------------------------------------------|
| Soil characters | T1 | T2 | T3 |
| Soil Moisture (%) | 27 | 23 | 21 |
| Soil Bulk Density (g/cc) | 1.3 | 1.35 | 1.39 |
| Particle Density | 2.63 | 2.66 | 2.69 |
| Porosity (%) | 50 | 49 | 47 |
| Soil pH | 4.98 | 5.04 | 5.11 |
| Soil OM (%) | 2.33 | 2.23 | 2.48 |
| Nitrogen (%) | 0.12 | 0.13 | 0.08 |
| Phosphorus (ppm) | 6.20 | 11.65 | 9.07 |
| Potassium (meq/100 g soil) | 0.22 | 0.19 | 0.18 |
| Sulfur (ppm) | 32.08 | 27.18 | 26.44 |

C. Design and Layout of The Experiment

The experiment was conducted in 20 years old aonla orchard established in 2000 maintaining 8 m × 8 m distance, which was used for the experiment. Lemon and carambola were planted in 2008 in between the aonla tree line which formed middle story. Each carambola plant was planted just middle of two aonla trees and each lemon plant was planted just middle of aonla and carambola plant. For further maximization of land use, two modern dragon fruit genotypes were planted in the alley as test crop. So, in the experiment, aonla tree was treated as upper storied lemon and carambola were treated as middle storied, dragon fruit was treated as lower storied crops.

The experiment was laid out in a two factorial randomized complete block design (RCBD) with three replications. The plot size for each treatment was 4 m x 6 m. Adjacent plots were separated by 1 m distance and neighboring block was separated by Aonla trees and other tree stories by 2 m distance. Open field is adjacent to the south of Aonla orchard. The experiment consisted of two factors, which were Factor A: Agroforestry systems, i.e T1: Aonla + Carambola + Lemon + Dragon fruit T2: Aonla + Dragon fruit and T3: Dragon fruit (open field); factor B: Dragon fruit genotypes (two years old) i.e V1: Red fleshed dragon fruit and V2: White fleshed dragon fruit.

D. Fertilizer Application

The recommended doses of fertilizer for dragon fruit genotypes were cow dung 30-40 kg/plant, urea 50 g/plant, TSP and MoP 100 g/plant, gypsum, borax and zinc sulphate 10 g/plant. One third of the cow dung, urea, TSP, MoP, gypsum, borax and zinc sulphate were applied during the final land preparation and rest of the fertilizers were applied in two equal installments.

E. Intercultural Operations

Various intercultural operations such as weeding, irrigation, drainage, pest and disease control were done as per requirement. Bavistine and Redomil was applied @ 2 g/l in dragon fruit to prevent fungal diseases by inhibiting the development of fungal spores.

F. Data Collection

Above ground maximum and minimum temperature of each treatment was recorded by Six’s maximum and minimum thermometer.

Light was measured by sunflex ceptometer (LP-80 AccuPAR) on each replication. It was done to determine the extent of shading by the upper storied tree species and expressed as µ mol m⁻² s⁻¹.
The plant height (cm) and number of branches per plant were recorded at 30 days interval. The height was measured from the attachment of the ground level up to the tip of the growing point.

Fruits are collected from each plant three times and aggregated to kg/plant then expressed into t/ha.

G. Land Use Efficiency

Among different indices for determining land use efficiency LER is one of the best index for measuring land use efficiency in intercropping on Agroforestry. The term land equivalent ratio derived from its indication of relative land requirement for intercrops versus monocultures. LER helps finding the relative performance of a component of crop combination compared to sole stands of that species [12]. In simple agroforestry situations, LER can be expressed as:

\[ LER = \frac{Ci}{Cs} + \frac{Ti}{Ts} \]

where

Ci – Crop yield in agroforestry, 
Cs – Crop yield in sole cropping, 
Ti – Tree yield in agroforestry, 
Ts – Tree yield in sole cropping.

H. Data Analyses

All data were processed, calculated, and analyzed by using computer software MS-Excel and MSTAT- C. Necessary tests were performed to compare the treatment means. The mean differences were adjusted by Least Significant Difference (LSD) and Duncan’s Multiple Range Test (DMRT) at 5 % and 1 % level of significance.

III. RESULTS AND DISCUSSION

A. Temperature of the Study Location

Maximum and minimum temperature was found different in different treatment conditions. The average maximum temperature was found in T1 treatment 32.33 °C (dragon fruit sole) followed by T2 treatment 31.06 °C (aonla + dragon fruit) and T3 (30.56 °C) in the Fig. 1. The highest minimum temperature was recorded in T3 treatment 21.28 °C and the lowest minimum temperature was found in both T2 and T1 treatments. In T1 and T2 treatments temperature lowered by 1.77 °C and 1.27 °C, respectively. In multistoried condition (T3) temperature was low compared to the open field condition (T1) due to the presence of double storied tree species.

B. Photosynthetically Active Radiation (PAR) Distribution

Photosynthetically Active Radiation (PAR) was varied in different treatment due to various canopy structure of upper storied trees. The mean maximum light intensity was the highest in T3 treatment (dragon fruit sole) 1503.36 µmol m⁻²s⁻¹ followed by moderate in T2 (aonla + dragon fruit) 1181.70 µ mol m⁻²s⁻¹ and the lowest in in T1 (multistoried system) 1128.22 µmol m⁻²s⁻¹. In T1 and T2 treatments, the light intensity was lowered by 375.15 µ mol m⁻²s⁻¹ (75 %) and 321.66 µ mol m⁻²s⁻¹ (78.60 %), respectively. Due to deciduous nature of aonla trees under storied crops and trees received about 75 % to 80 % light intensity. Average light intensity was higher in T3 treatment (dragon fruit sole) 1503.36 µ mol m⁻²s⁻¹ than T2 treatment (aonla + dragon fruit) 1181.70 µ mol m⁻²s⁻¹ and lower light intensity was found in T1 treatment (multistoried system) 1128.22 µ mol m⁻²s⁻¹ (Fig 2). Similar results were observed by [10], [13] and [14] that was shading by upper storied species was responsible for reducing the photosynthetically active radiation which controls production of photosynthates, dry matter partitioning and fruit yield.

Fig. 2. Average Photosynthetically Active Radiation (PAR) distribution in different treatments.

C. Plant Height

1) Effect of production system

Plant height of dragon fruit is an important morphological characteristic that was significantly influenced by different agroforestry systems. Plant height of dragon fruit did not vary among agroforestry system from July to January but varied from February to June (Fig. 3). Plant height was noted the highest in treatment 1 (aonla + carambola + lemon + dragon fruit) followed by treatment 2 (aonla + dragon fruit), the lowest plant height was observed in the treatment 3 (dragon fruit sole). As the dragon fruit saplings took few months to start their root and shoot growth, that’s why up to six months no increment was observed of both genotypes of dragon fruit. In Fig.3(b) plant height of dragon fruit was significantly varied by treatments. Significantly the longest plant was found in T1 treatment (229.3 cm) followed by T2 treatment (212.4 cm) and the smallest plant height was observed in T3 treatment (205.4 cm). Among the three treatment the lowest amount of sunlight were available in T1 (multistoried system) then T2 treatment and full sunlight was available in T3 (open field condition) but plant became the longest in multistoried condition, because in shade condition plant releases auxin hormone and due to this auxin hormone plant show apical dominancy, which increases the plant height for harvesting of more light. [15] 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 was observed by [16] in mungbean, [17] in black gram and mungbean, [18] in cotton, [7] in okra and [19] in dragon fruit.

2) Response of genotypes

Plant height was significantly influenced by different genotypes of dragon fruit (Fig. 4). Results showed that the red fleshed dragon fruit genotype (V1) exhibited higher plant height at all the samples months and 276.47 cm at last month. The white fleshed dragon fruit genotype (V2) exhibited lower plant height round the year and 243.8 cm at last month. The plant height of different dragon fruit genotypes varied due to their genetical characteristics.

3) Interaction effect

Plant height of dragon fruit genotypes were significantly influenced by the interaction effect of agroforestry systems and genotypes (Table II). Red genotypes produced the longest plant in all the treatment combination than white genotype. In the first month (July 2019) plant height was significantly the highest in T1V1 treatment (red dragon fruit in open condition) which did not vary with the values recorded in T2V1, T1V2, T2V2 and T1V2 treatment conditions. However, the shortest plant height was recorded in T1V1 treatment condition. Up to October 2019 all most similar trend of variation was observed. From November 2019, gradually plant height increased over time in all the treatment combination and showed significant difference.

At the end of the year (June 2020) significantly the tallest plant 312 cm was found in T1V1 treatment combination (aonla + carambola + lemon + red flesh dragon fruit). Significantly the smallest plant height was observed in T1V2 combination 218.3 cm, which was statistically similar with T2V2 combination 237.6 cm. The combined effect showed that red flesh dragon fruit genotype performed the best in aonla based multistoried system over white fleshed dragon fruit. Aonla based multistoried system produced the tallest plant than open field condition. Higher plant height under reduced light levels was observed by [19] in dragon fruit, [11] in cabbages, [7] in okra, [18] in cotton, [20] in mungbean and [21] in chickpea. This might be attributed due to stimulation of cellular expansion and cell division under shade condition [22] as was observed in capsicum.

D. Branches of Dragon Fruit Genotypes in Aonla Based Multistoried System

1) Effect of production system

Number of branches is an important morphological character of dragon fruit for producing higher yield (Fig. 6). Significantly the highest number of branch (148) was found in open field (T1) round the year. Moderate number of branches were observed in T2 treatment which was statistically different from both T1 and T2 treatments. Significantly the lowest number of branch per plant (48) was recorded in aonla + carambola + lemon + dragon fruit (T1) based multistoried system. The maximum number of branches in T1 might be due to experiencing full sun light (1503 µ mol m⁻²s⁻¹ or 100 %) in open field condition. In multistoried condition there was the heaviest shade prevailed. This result is similar to the previous study by [23] in agroforestry systems.
by T₂V₁ (Red dragon under aonla). The lowest MAI was found in open field (62.76 cm/year) for white dragon fruit (V₂). The MAI of V₁ was always higher than V₂ irrespective of treatment combinations. Although the difference was gradually increased with the decreased of light level of multistoried treatments. The result proved that V₁ (white dragon fruit) was more sensitive to shade than V₂ genotype (Fig. 8).

1) Response of genotypes

Number of branches per plant did not vary between the genotypes.

2) Interaction Effect of Branch Number

Number of branches per plant was significantly influenced by the interaction effect of agroforestry system and dragon fruit genotypes (Table II). At the end of the year (at 3 years of age of plant) significantly the highest number of branches (150) were produced by red dragon fruit (V₁) in open field condition (T₁) followed by T₁V₂ condition (146) which was statistically similar to T₁V₁ and T₂V₂ combination. Significantly the lowest number of branches per plant was recorded in T₁V₂ combination (45.6) which was statistically similar to that of T₁V₁ (50.8). Open field condition produced the highest number of branches per plant than aonla based agroforestry system. Similar result was reported by [24] in mungbean based agroforestry system and [19] in dragon based agroforestry system.

E. Total Increment (TI) of Dragon Fruit Genotypes in Aonla based Multistoried System

Increment of height is one the most vital characters of perennial plants in growth process. There are three types of increments i.e., total increment (TI), mean annual increment (MAI) and current annual increment (CAI). Total increment calculated by subtracting initial plant height (30 cm) from the last plant height. Mean annual increment was calculated dividing total plant height by the age of the plant (years), current annual increment is the last year growth of the plants. The height increment of red dragon fruit genotype (V₁) was greater than that of white dragon genotype (V₂) in all the treatment combinations (Fig. 7). Although the difference varied by the treatments. Minimum difference (22.3 cm) was recorded in open field condition (T₁) whereas the maximum difference (36.9 cm) was found in multistoried condition. The result revealed that red dragon fruit (V₁) plant growth gradually increased with the decrease of available PAR of the system.

F. Mean Annual Increment (MAI) of Dragon Fruit Genotypes in Aonla Based Multistoried System

Mean annual increment (MAI) of dragon fruit genotypes in aonla based multistoried system was influenced by the treatments. The highest MAI (94.1 cm/year) was recorded for T₁V₁ combination (Red dragon fruit in multistoried) followed by T₂V₁ (Red dragon under aonla). The lowest MAI was found in open field (62.76 cm/year) for white dragon fruit (V₂). The MAI of V₁ was always higher than V₂ irrespective of treatment combinations. Although the difference was gradually increased with the decreased of light level of multistoried treatments. The result proved that V₁ (white dragon fruit) was more sensitive to shade than V₂ genotype (Fig. 8).
### TABLE II: INTERACTION EFFECT OF AGROFORESTRY SYSTEMS AND GENOTYPES ON PLANT HEIGHT OF DRAGON FRUIT AT AONLA BASED MULTISTORIED AGROFORESTRY

| Months | Treatments | July  | August | September | October | November | December | January | February | March | April | May | June |
|--------|------------|------|--------|-----------|---------|----------|----------|---------|----------|-------|-------|-----|------|
|        | TV_{1}     | 175.7a | 180.4ab| 187.6ab   | 206.2ab | 217.9a   | 230.8a   | 245.7a  | 261.2a   | 277.4a | 289.0a | 300.0a | 312.3a |
|        | TV_{2}     | 157.0ab| 163.9ab| 175.6ab   | 187.0abc| 199.0ab  | 210.6b   | 222.0bc | 234.3bc  | 246.0b | 257.6b | 269.6b | 275.4b |
|        | TV_{1}     | 184.3a | 192.7a | 201.3a    | 210.3a  | 218.3a   | 226.6ab  | 235.6ab | 244.6ab  | 253.3b | 262.6b | 271b  | 276.8b|
|        | TV_{2}     | 148.3b | 156.3b | 164.3b    | 171.6b  | 179.0b   | 187.6c   | 196.0d  | 204.0d   | 212.0cd| 220.3cd| 229.0c| 237.6c|
|        | TV_{1}     | 191.0a | 195.3a | 200.3a    | 204.3a  | 209.6a   | 213.0b   | 218.0c  | 222.3c   | 227.0c | 231.3c | 237.0c| 240.3c|
|        | TV_{2}     | 170.0ab| 174.6ab| 179.3ab   | 183.6bc | 187.0b   | 190.6c   | 196.0d  | 204.0d   | 209.0d | 214.0d | 218.3d|       |
| CV (%) |            | 11.46 | 10.13  | 7.90      | 6.45    | 5.48     | 4.54     | 3.82    | 3.63     | 3.82   | 3.27   | 2.31 | 0.89 |

In a column, means followed by same letter (s) are not statistically different at 5% level of significance by DMRT. TV_{1} = aonla + carambola + lemon + dragon fruit, TV_{2} = aonla + dragon fruit, TV_{3} = dragon fruit sole (open field). V_{1}: red fleshed dragon fruit, V_{2}: white fleshed dragon fruit. CV: coefficient of variance.

### TABLE III: INTERACTION EFFECT OF AGROFORESTRY SYSTEMS AND GENOTYPES ON NUMBER OF BRANCHES PER PLANT OF DRAGON FRUIT IN AONLA BASED MULTISTORIED AGROFORESTRY SYSTEM

| Months | Treatments | July  | August | September | October | November | December | January | February | March | April | May | June |
|--------|------------|------|--------|-----------|---------|----------|----------|---------|----------|-------|-------|-----|------|
|        | TV_{1}     | 9.3  | 11.6c  | 15.0c     | 19.6c   | 23.3c    | 27.0c    | 30.3c   | 34.3c    | 38.0c | 42.3b | 46.3c| 50.8c|
|        | TV_{2}     | 8.0  | 11.0c  | 14.6c     | 18.0c   | 21.6c    | 25.3c    | 29.0c   | 33.0c    | 35.0c | 38.3d | 41.6c| 45.6c|
|        | TV_{1}     | 9.8  | 21.8b  | 35.9b     | 50.0b   | 60.9b    | 72.5b    | 84.3b   | 97.8b    | 114.0b| 124.3b| 129.6b| 134.8b|
|        | TV_{2}     | 11.0 | 23.0b  | 37.3b     | 56.6b   | 62.3b    | 70.6b    | 83.3b   | 97.0b    | 110.0b| 120.3c| 128.3b| 134.0b|
|        | TV_{1}     | 13.0 | 32.3a  | 46.3a     | 61.3a   | 73.0a    | 85.0a    | 98.0a   | 116.0a   | 123.0a| 138.3a| 144.0a| 150.0a|
|        | TV_{2}     | 9.2  | 33.3a  | 47.1a     | 61.9a   | 72.5a    | 86.4a    | 98.3a   | 114.0a   | 124.0a| 134.0ab| 140.0ab| 146.0ab|
| CV (%) |            | 34.05| 10.34  | 6.15      | 5.61    | 5.26     | 6.95     | 5.91    | 4.87     | 4.56  | 6.20  | 7.27 | 6.32 |

In a column, means followed by same letter (s) are not statistically different at 5% level of significance by DMRT. TV_{1} = aonla + carambola + lemon + dragon fruit, TV_{2} = aonla + dragon fruit, TV_{3} = dragon fruit sole (open field). V_{1}: red fleshed dragon fruit, V_{2}: white fleshed dragon fruit. CV: coefficient of variance.

### TABLE IV: FRUIT YIELD AND LER OF DRAGON FRUIT IN AONLA BASED MULTISTORIED PRODUCTION MODEL

| Treatments | Number of fruit per plant | Fruit yield (t ha\(^{-1}\)) | LER |
|------------|---------------------------|----------------------------|-----|
| TV_{1}     | 13                        | 3.12                       | -   |
| TV_{2}     | 6                         | 1.63                       | -   |
| TV_{3}     | 10                        | 1.78                       | 2.52|
| TV_{2}     | 5                         | 0.90                       | 2.51|
| TV_{3}     | 6                         | 1.12                       | 3.36|
| TV_{2}     | 4                         | 0.76                       | 3.47|

TV_{1} = aonla + carambola + lemon + dragon fruit, TV_{2} = aonla + dragon fruit, TV_{3} = dragon fruit sole (open field). V_{1}: red fleshed dragon fruit, V_{2}: white fleshed dragon fruit.
H. Yield of Dragon Fruit in Different Treatments

The red fleshed dragon fruit genotype (V₁) always produced higher yield than that of white fleshed dragon fruit (V₂) irrespective of treatments. The highest yield (3.12 t ha⁻¹) was obtained from T₁V₁ (red genotype of dragon fruit in open field) followed by T₂V₂ (white fleshed dragon fruit in open field) and the lowest yield (0.769 t ha⁻¹) was recorded in T₁V₂. The result revealed that V₁ (red dragon genotype) was found suitable for partial shade condition like aonla tree and successfully grown without sacrificing the significant yield loss compared to that of open field (Table IV).

I. Evaluation of Production System by Land Equivalent Ratio (LER)

There are several tools for measuring land use efficiency of mixed cropping or inter cropping or agroforestry. Such as HI, LER and TPF etc. For measuring land use efficiency of agroforestry LER is commonly used. In this experiment LER was also measured (Table IV) for knowing the profitable land use. The highest LER (3.47) was recorded in aonla + carambola + lemon + dragon fruit (white genotype) followed by aonla + carambola + lemon + dragon fruit (red genotype). The lowest LER (2.51) was recorded in aonla + dragon fruit (white genotype). Moderate LER (2.52) was recorded in aonla + dragon fruit (red genotype). The result proved that multistoried production system (aonla + carambola + lemon + dragon fruit) was the most efficient land use system. The LER in multistoried system was more than three for both genotypes of dragon fruit. It means if we want to get the same component yield from the sole cultivation than it will take more than three times land. So, this model is as important for Bangladesh as it is one of the most densely populated countries in the world.

J. Relationship between Light Intensity (PAR) of Agroforestry System and Plant Height of Dragon Fruit Genotypes

Linear relationships between PAR (µ mol m⁻²s⁻¹) and plant height of dragon fruit genotypes were estimated as y = -0.164x + 484.45 (R² = 0.8544) for red fleshed dragon fruit (V₁) and y = -0.1256x + 403.64 (R²=0.7614) for white fleshed dragon fruit. The R² values of the equations for red fleshed and white fleshed dragon fruit were 0.8544 and 0.7614 respectively, which were high and significant (Fig. 9). The R² values indicated that 85.44 and 76.14 percent plant height of red and white fleshed dragon fruit were attributed to PAR (µ mol m⁻²s⁻¹).

The relationship also stated that the plant height of red and white fleshed dragon fruit was decreased at the rate of 0.164 cm and 0.125 cm for per unit of changing light intensity/PAR (µ mol m⁻²s⁻¹). Plant showed apical dominancy in shade condition to harvest more sunlight due to the presence of auxin hormone, that’s why plant height in shade condition (T₁: multistoried condition) is higher than open condition (T₃: dragon fruit in open field).

K. Relationship between Light Intensity (PAR) of Agroforestry System and Yield of Dragon Fruit Genotypes

Linear relationships between PAR (µmolm⁻²s⁻¹) and plant height of dragon fruit genotypes were estimated as y = 0.0049x - 4.2527 (R² = 0.9615) for red fleshed dragon fruit (V₁) and y = 0.0023x-1.8063 (R² = 0.9999) for white fleshed dragon fruit. The R² values of the equations for red fleshed and white fleshed dragon fruit were 0.9615 and 0.9999 respectively, which were high and significant (Fig. 10). The R² values indicated that 96.15 and 99.99 percent yield of red and white fleshed dragon fruit were attributed to light (PAR µ mol m⁻²s⁻¹). The relationship also stated that the yield of red and white fleshed dragon fruit was changed at the rate of 0.0049 t/ha and 0.0023 t/ha for per unit changing of light intensity (PAR µ mol m⁻²s⁻¹).

IV. Conclusion

The studied morphological parameters were found the highest in red fleshed genotype of dragon fruit. On the other hand except plant height others morphological parameters were found high in open field. The highest yield was recorded in open field condition in red fleshed genotype and moderate yield was recorded in aonla based system while the lowest yield was found in aonla + carambola + lemon based system with white fleshed genotype. Hence, the red dragon fruit was found better for yield then white one where as the maximum land use efficiency was recorded for white fleshed dragon fruit in aonla + carambola + lemon based multistoried production model.

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