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INITIAL GROWTH PERFORMANCE AND ESTABLISHMENT PROBLEM OF DRAGON FRUIT UNDER AONLA BASED MULTISTORIED PRODUCTION SYSTEM

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ABSTRACT

A field experiment was conducted at the aonla based multistoried agroforestry research field of Bangabandhu Sheikh Mujibur Rahman Agricultural University from June, 2018 to July, 2019 to know the growth performance of dragon fruit and its establishment problems under multistoried tree orchard. The upper storied component of multistoried was aonla tree, carambola and lemon were used as middle storied components, while dragon fruit was the test crop grown as lower storied component. The experiment was laid out in a two-factor randomized complete block design with three replications. Factor A: Production systems (T_1: aonla + carambola + lemon + dragon fruit, T_2: aonla + dragon fruit, and T_3: dragon fruit as sole). Factor B: Two dragon fruit genotypes i.e. red fleshed dragon fruit (V_1), and white fleshed dragon fruit (V_2). The result indicated that the higher plant height and the maximum number of branches were produced by the red-fleshed dragon fruit than white-fleshed dragon fruit irrespective of production systems. Upper storied plant aonla received 100% PAR but the average amount of light availability for lower storied dragon fruit in the whole growing season was 70.71% (807.51 $\mu mm^{-2}s^{-1}$), middle storied carambola and lemon received 77.11% (880.60 $\mu mm^{-2}s^{-1}$) and 65.19% (744.47 $\mu mm^{-2}s^{-1}$) PAR, respectively. The study found a negative linear relationship between the plant height of dragon fruit and PAR. Only basal rot disease was observed as establishment problem. The maximum disease infestation occurred (37.50%) in multistoried system compared to the sole cropping system (6.94%) and *Fusarium oxysporum* was identified as causal organism.

Keywords: Dragon fruit genotypes; Growth; PAR; Multistoried production system

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INTRODUCTION

Bangladesh is a deltaic small country of 1, 47,570 km^2 with a large population (168,770,968) having 8.77 million hectares of cultivable land (BBS, 2022). It has the lowest per capita arable land due to its high population density. Predominantly Bangladesh is an agro-based country and this sector employs 40.6% of the total labor force and contributes 11.50 % of the country's GDP (BBS, 2022). The prediction indicates that the built-up area will increase by 15.06%, whereas 9.77% of agricultural land will be converted to other land uses through urban expansion by 2029 (Kafy, 2021). Moreover, about 80% of arable land is used for cereal crop production, which consequently reduces the area of other cash crops. Under these scenarios, the existing land-use systems with separate allocation to agriculture and forest are insufficient to meet the demands for food, fuel, fodder, timber, and other minor products in the 21st century. One should follow effective and compatible cultivation approaches where medicinal plants, fruits, fiber crops can be grown combined on the limited land. Hence multilayer fruit production will be a sustainable land use system which can provide diversified products. Moreover, such cropping systems are high income generating and render opportunity for year-round labor utilization.

Multistoried cropping system is a perspective modern approach for sustainable production at changing climate (Ahmed, 2019). In a multistoried system, the trees in different layers harvest sunlight at different canopy strata and they also harvest soil nutrients, from different soil layers by different root strata (Bari and Rahim, 2009). Most of the households of the country are acting as multistoried agroforestry units (Miah and Hussain, 2010).

In the terrace ecosystem of Bangladesh, medicinal plant like aonla (*Phyllanthus emblica*) is grown naturally. Its fruit is highly nutritious and it is the richest source of Vitamin C. Carambola is a dwarf species it is found to grow under some large trees in the homesteads of the country. The farmers usually cultivate lemon in their homestead in association with others tree species in Bangladesh. So, these two species have enough potentiality to grow as a middle-storied component of a multistoried agroforestry system.

Dragon fruit *(Hylocereus* spp.*)* is a climbing vine cactus species that has received worldwide recognition first as an ornamental plant and then a high-value fruit crop. It produces fruit from second year after planting and attains full production within five years (Perween, 2018). So, it will be a better option if we can grow this fruit species successfully under different tree species.

Thus, there is a scope of cultivating dragon fruit in aonla orchards to increase the system productivity and economic benefits. The cultivation of dragon fruit is impaired by the infection of some fungal pathogens. In this context, the present experiment was undertaken to evaluate the initial growth performance of dragon fruit and to identify the problems associated its establishment under aonla based multistoried system.

MATERIALS AND METHODS

Study Area

The experiment was conducted in the aonla based multistoried research field of the Department of Agroforestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) from June, 2018 to July, 2019. The study area was under the Madhupur tract (AEZ 28) which lies between 24.09° N latitude and 90.26° E longitude with a mean elevation of 8.5 m above sea level (Roxy, 2017).

Experimental Design

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 and adjacent plots were separated by 1 m distance and neighboring blocks were separated by aonla trees and other tree stories. The open field was adjacent to the south of aonla orchard. There were three treatment combinations i,e T_1 = Aonla + Carambola + Lemon + Dragon fruit , T_2 = Aonla + Dragon fruit, T_3 = Dragon fruit (sole) and two dragon fruit genotypes were examined as the lower story component i,e V_1 = Red-fleshed dragon fruit and V_2 = White-fleshed dragon fruit.

The aonla orchard was established in the year 2000 maintaining 8m x 8m spacing which was used for the experiment. One-year-old seedlings of lemon and carambola were planted in the year 2008. The variety of aonla was local, carambola was BARI Kamranga-1 and lemon was seedless BARI lebu-1.

Field preparation and establishment of dragon fruit

The experimental fields were prepared by June 2018. The land of the alley was prepared thoroughly by ploughing with a power tiller followed by laddering to obtain a good tilth. Cemented pillars were set on the middle of the pit before the planting of suckers. Two suckers are planted at June 2018 in each pit at opposite side of cemented pillar. Plant to plant and line to line spacing of dragon fruit was maintain 2.5 m X 2.5 m. Each plot contained six plants. Tires were provided in the pillars above 5feets height at 210 days after planting of the suckers.

Fertilizer Application

Manures and fertilizers were applied as per recommendation made by Rahim et al., (2009) @ 40kg cow dung/pit and 50-100-100-10-10-10 g/pit of Urea, TSP, MoP, gypsum, borax and zinc-sulphate, respectively. All cow dung and fertilizers were applied at the time of pit preparation.

Intercultural Operations

Weeding was done regularly to keep the crop weed-free and excess rainwater was drained out through the side canal of the plot. Drasban 20 EC was applied at the rate of 400 ml/acre for preventing insect attack after transplanting and Bavistin DF were applied at the rate of 1gm/l during the basal rot disease outbreak

Data Collection

All plants of dragon fruit of each plots were used for data collection. Plant height and number of branches per plant data were recorded at 0, 60, 120, 180, 240, 300, and 360 days after planting. Photosynthetically active radiation (PAR) above aonla, carambola, lemon, and dragon fruit in agroforestry and open field were measured by sunflex ceptometer (LP-80 AccuPAR) on each replication and expressed as µ mol $m^{-2}s^{-1}$.

The disease sample was isolated and a pure culture was prepared for identifying the causal organism. The PDA was prepared by using potato, agar, and clean tap water. The prevalence of disease was calculated based on the following formula: Disease prevalence= (Number of infected plants/Total number of plants) ×100. The disease cycle was studied based on the initial symptom showed in the seedling which later on progressed with the development of disease symptoms at the maturity stage of the plant. The recorded data were statistically analyzed to find out the significance of the results with the help of statistics-10 software.

RESULTS AND DISCUSSIONS

Response of Dragon fruit

Availability of Photosynthetically Active Radiation (PAR)

The photosynthetically active radiation (PAR) significantly varied in aonla based agroforestry as compared to open field (Figure 1). The average amount of light availability for lower storied crops (dragon fruit) in the whole growing season was 70.71% (807.51 $\mu mm^{-2}s^{-1}$). Middle storied carambola and lemon received 77.11 % (880.60 $\mu mm^{-2}s^{-1}$) and 65.19% (744.47 $\mu mm^{-2}s^{-1}$) PAR, respectively in average. In the case of aonla + dragon fruit-based agroforestry system, upper storied plant aonla received 100% (1142 $\mu mm^{-2}s^{-1}$) PAR and the average amount of light availability for the lower storied crop (dragon fruit) in the whole growing season was 82.39%. (940.89 $\mu mm^{-2}s^{-1}$). Though light transmission was greatly influenced by canopy volume and ordination, PAR availability significantly decreased with reducing distance towards the tree base.

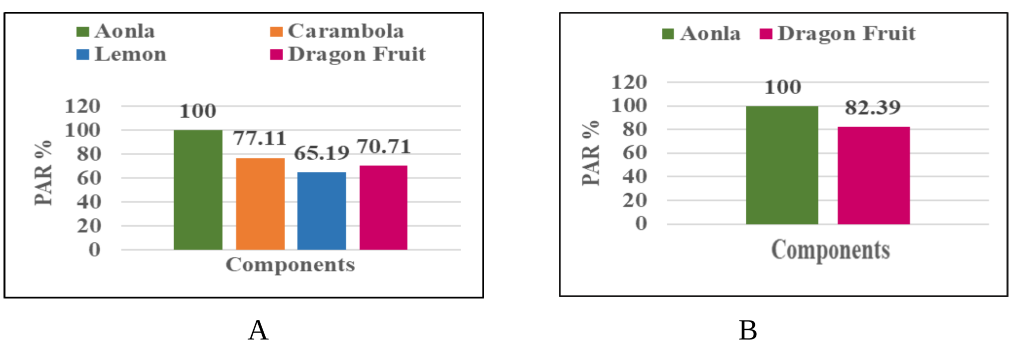


Figure 1. Availability of Photosynthetically Active Radiation (PAR) at different strata of dragon fruit growing season (A) Aonla + Carambola -Lemon + Dragon fruit-based agroforestry system (B) Aonla + Dragon fruit-based agroforestry system.

Plant height

Effect of the system: The plant height of dragon fruit was significantly influenced by different agroforestry systems and open fields (Figure 2). At planting date (0 DAP) the sapling height was almost similar but the numerically tallest plant (50.92 cm) was in an open condition. Up to 60 DAP the plants did not take part in growth process. This might be due to undeveloped root system. From 120 DAP and on ward plants showed significantly different growth. From 120 DAP to 240 DAP plant height of different treatment was irregularly varied. At 300 DAP and 360 DAP, similar trend of variation of plant height was found, the tallest plant height (99.88 cm and 106.89 cm in 300 DAP and 360 DAP, respectively) was observed in the Aonla + Carambola-Lemon + dragon fruit-based agroforestry system. Moderate plant height was found in aonla + dragon fruit (T_2) and significantly the lowest plant height (99.88 cm and 106.89 cm in 300 DAP and 360 DAP, respectively) was observed in open field. This variation might be due to the shade of multistoried system. Crops grown in low light levels usually exhibit apical dominancy due to high auxin production in shaded conditions. Similar results have also been reported for turmeric and ginger in agroforestry systems under reduced light levels (Bhuiyan et al., 2013).

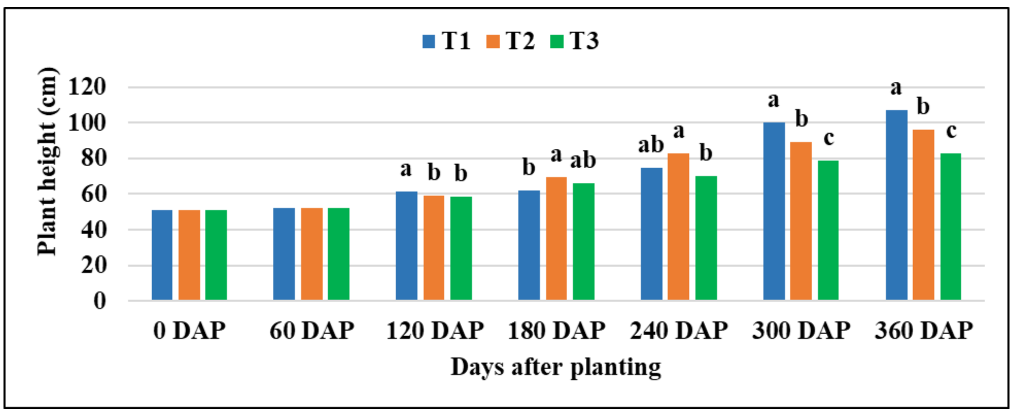


Figure 2. Plant height of dragon fruit at different stages as an influence by aonla based agroforestry system (T_1= Aonla + Carambola -Lemon + dragon fruit, T_2= Aonla + Dragon fruit, T_3= only dragon fruit in open field).

Response of genotypes: The plant height of two dragon fruit genotypes was significantly varied. At planting date (0 DAP) the sapling height was almost similar for both the varieties but the numerically tallest plant was (50.68 cm) found for the red fleshed dragon fruit (Figure 3). Up to 60 DAP no plant height increment was occurred this might be due to inadequate root system. From 120 DAP and on ward plants showed significantly different growth and the height difference gradually increased with the increase of plant age. The red-fleshed dragon fruit always produced significantly higher plant height than white-fleshed dragon fruit. At 120 DAP, the highest plant height (67.87cm) was found for red fleshed dragon fruit. Similarly, the plant height of red flashed dragon fruit at 180, 240, 300 and 360 DAP was 76.7, 90.71, 102.05 and 107.23 cm, respectively which is higher than the white fleshed dragon fruit at the sampling days. The plant height of white dragon fruit was 51.09, 54.94, 61.1, 76.36, and 83.5 cm at 120, 180, 240, 300, and 360 DAP, respectively. Faster growth of red fleshed dragon fruit was noted which might be due to the genetic makeup. Similar results were also found by Patwary et al. (2013) for the red and white-fleshed dragon fruit genotypes in the Chittagong region of Bangladesh.

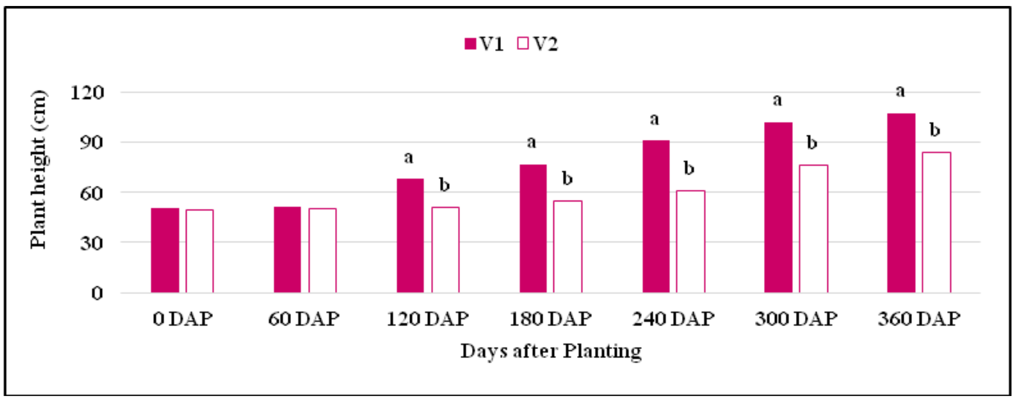


Figure 3. Response of different dragon fruit genotypes about plant height at different growth stages under aonla based agroforestry systems.

Interaction effect of the system and genotype: The plant height of dragon fruit was significantly influenced by the combined effect of agroforestry systems and dragon fruit (values) genotypes (Table 1). At planting date (0 DAP) and 60 DAP no plant growth was occurred and variation was insignificant. From 120 DAP to 360 DAP plant height of different combination was irregularly varied. From 120 DAP to 360 DAP the tallest plant was found in red fleshed dragon fruit in Aonla + Carambola-Lemon + dragon fruit (T_1V_1) based agroforestry system and smallest plant was found in white fleshed dragon fruit in open condition (T_3V_2). Similarly, higher plant height under reduced light levels was also observed in pulse crops like mungbean (Imran, 2014; Miah, 2010) and okra (Roxy, 2017).

Table 1: Interaction effect of agroforestry systems and genotypes on plant height (cm) of dragon fruit at different days after planting (DAP)

Treatment combinations	Plant height (cm)				
	120 DAP	180 DAP	240 DAP	300 DAP	360 DAP
T_1V_1	75.65 a	84.65 a	98.57 a	111.46 a	117.82 a
T_1V_2	56.56 c	65.67 c	72.44 b	90.78 b	99.51 bc
T_2V_1	61.35 bc	73.63 b	93.58 a	108.99 a	114.27 ab
T_2V_2	49.97 d	52.09 d	59.70 c	71.91 c	76.46 de
T_3V_1	66.62 b	71.46 bc	79.96 b	85.71 b	89.61 cd
T_3V_2	46.76 d	47.10 d	51.17 c	66.40 c	74.52 e
CV (%)	4.89	5.99	8.39	8.22	8.61

Here, V_1= Red Flashed Dragon Fruit, V_2= White Fleshed Dragon Fruit, T_1= Aonla + Carambola -Lemon + dragon fruit, T_2= Aonla + Dragon Fruit and T_3= Only Dragon Fruit in open field

Number of branches per plant

Effect of the system: The number of branches per plant is one of the important yields contributing characters of dragon fruit which was significantly influenced by the aonla based multistoried agroforestry systems and open field condition (Figure 4). Up to 60 DAP plant produced no branches. This period was the establishment phase of dragon fruit in the main field. From 120 DAP to 360 DAP, the maximum number of branches per plant was recorded in open field condition and a minimum number of branches per plant was recorded in Aonla + Carambola-Lemon + Dragon fruit-based agroforestry system. At 120, 180, 240, 300 and 360 DAP the number of branches for open condition was 2.37, 3.01, 3.65, 8.29, 9.22 respectively. Maximum light levels might be insisted to produce higher number branches per plant.

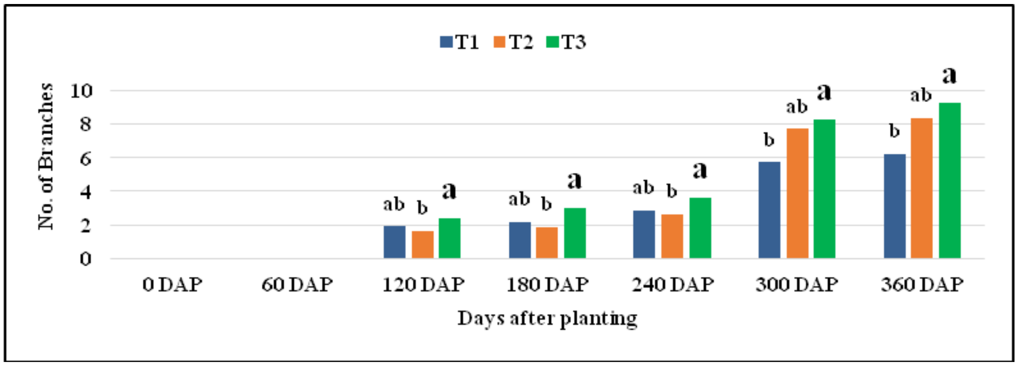


Figure 4. Number of branches per plant of dragon fruit at different stages as an influenced by aonla based agroforestry system (T_1= Aonla + Carambola-Lemon + Dragon fruit, T_2= Aonla + Dragon fruit, T_3= Open field).

Response of genotypes: The number of branches per plant varied with the genotypic characteristics (Figure 5). From planting to 60 days, there was no countable branches was found for both the genotypes. After 60 DAP, the maximum number of branches per plant was recorded in red-fleshed dragon fruit and the minimum number of branches per plant was found in white-fleshed dragon fruit at all sampling dates. The number of branches per plant of red-fleshed dragon fruit at 120 DAP, 180 DAP, 240 DAP, 300 DAP, and 360 DAP were 3.06, 3.55, 4.05 8.42, and 9.3, respectively. While significantly the minimum number of branches per plant of genotype white-fleshed dragon fruit was recorded and the values were 0.88, 1.17, 2.07, 6.06, and 6.56 at 120 DAP, 180 DAP, 240 DAP, 300 DAP, and 360 DAP, respectively.

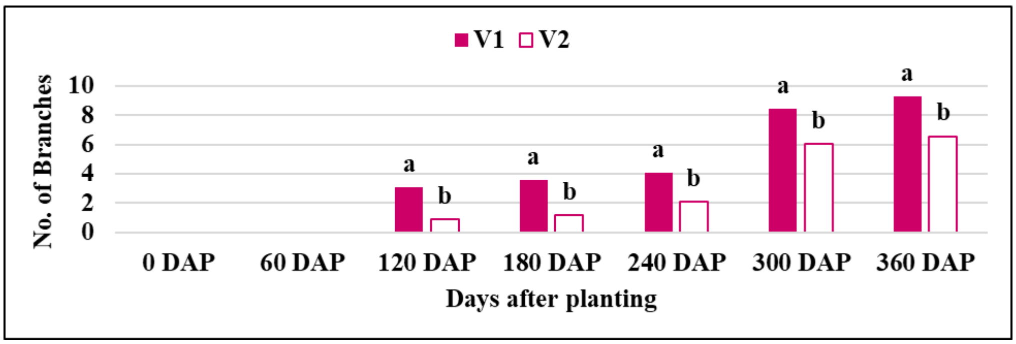


Figure 5. Number of branches per plant of different dragon fruit varieties at different growth stages under aonla based agroforestry systems.

Interaction effect of the system and genotype: The number of branches per plant of dragon fruit was significantly influenced by the combined effect of agroforestry systems and dragon fruit genotypes (Table 2). Up to 60 DAP there was no countable branches was found. The significant variation of number of branches were observed in different treatment combinations. The maximum number of branches per plant was recorded in red-fleshed dragon fruit in open field condition (T_3V_1 combination) and the minimum number of branches per plant was found in T_1V_2 combination at 120, 180, 240, 300 and 360 DAP (Table 2). The combined effect showed that red-fleshed dragon fruit performed better in aonla based agroforestry systems. The lower number of leaves per plant at the reduced light conditions for a longer period and tree crop competition for food, space, light, and water, etc. (Bithi et al., 2014).

Table 2. Interaction effect of agroforestry systems and genotypes on number of branches per plant of dragon fruit at different growth stages

Treatment combinations	No. of Branches				
	120 DAP	180 DAP	240 DAP	300 DAP	360 DAP
T_1V_1	3.20 ab	3.61 ab	4.16 a	6.24 ab	6.77 ab
T_1V_2	0.62 c	0.74 b	1.61 b	5.22 b	5.66 b
T_2V_1	2.32abc	2.61 ab	2.94 ab	8.39 ab	9.27 ab
T_2V_2	0.94 bc	1.14 b	2.36 ab	7.02 ab	7.44 ab
T_3V_1	3.66 a	4.41 a	5.05 a	10.64 a	11.86 a
T_3V_2	1.07 bc	1.61 ab	2.24 ab	5.94 ab	6.58 ab
CV (%)	2.48	2.86	3.79	4.95	5.47

Here, V_1= Red fleshed dragon fruit, V_2= white fleshed dragon fruit, T_1= Aonla + Carambola + Lemon + dragon fruit, T_2= Aonla + dragon fruit and T_3= Open field

Relationship of light level and plant height of Dragon fruit:

To find out the relationship between PAR and plant height, regression analysis was carried out. A negative linear relationship between light level (percent PAR) and plant height of dragon fruit was found for both the dragon fruit genotypes (Figure 6). The estimated equation was as $y = -1.1324x + 204.94$ ($R^2 = 0.9138$) for red fleshed dragon fruit and $y = -0.9059x + 161.67$ ($R^2 = 0.7145$) for white-fleshed dragon fruit. The R^2 values of red and white-fleshed dragon fruit were 0.9138 and 0.7145, respectively which were high and significant. The R^2 value indicated that 91.38 and 71.45 percent height contributions were attributed due to % PAR. The relationship also stated that the height of red-fleshed and white-fleshed dragon fruit genotypes were changed at the rate of 1.13 cm and 0.91 cm, respectively for per unit of changing the percent PAR.

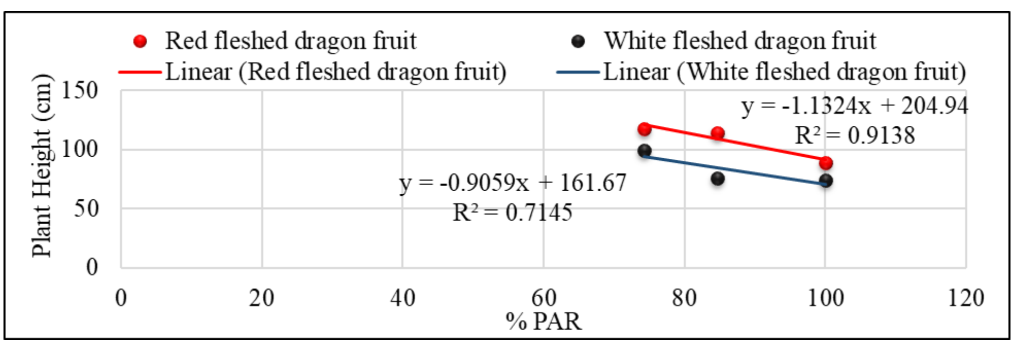


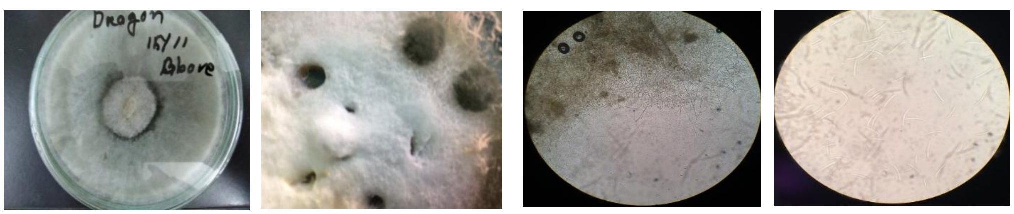
Figure 6. Relationship between light level and plant height of dragon fruit.

Pest and disease infestation

After plantation of dragon fruit in multistoried aonla field, no serious insect was recorded but only basal rot disease was out broken.

Identification of the causal organism: The causal organism of basal rot of dragon fruit disease was identified by the following characteristics suggested by (Wright, 2007; Mahmud, 2020).

The white colony appeared on PDA (Figure 7A) and the growth rate of 1cm /day on PDA. Colonies produced single-celled microconidia from unbranched, short monophyletic conidiophores and separate macroconidia as well as chlamydospores in PDA which was consist of *Fusarium oxysporum*. *F. oxysporum* produced three types of asexual spores: microconidia, macroconidia, and chlamydospores. Microconidia were one or two-celled, and are the type of spore most abundantly and frequently produced by the fungus under all conditions. It is also the type of spore most frequently produced within the vessels of infected plants. Macroconidia were three to five celled, gradually pointed, and curved toward the ends (Figure 7B). These spores were commonly found on the surface of plants killed by this pathogen as well as in sporodochialike groups. The symptoms, colony color, macroconidia, and microconidia proved that the pathogen was *Fusarium oxysporum*.



A B

Figure 7. (A) Pure culture of *Fusarium oxysporum* on PDA media (B) Microscopic view of the causal pathogen

Prevalence of basal rot disease in different treatments: The result presented in Figure 8 revealed the prevalence of the basal rot on dragon fruit plants in different treatments under natural conditions. In Aonla + Carambola-Lemon + Dragon fruit-based agroforestry system, it was recorded that, 37.5% of plants were infested which was the highest prevalence of the basal rot disease of dragon fruit. The prevalence of the disease was found lower in the open field condition where only 6.94% of plants were infested by the basal rot disease of dragon fruit. In the Aonla + Dragon fruit-based condition, it was recorded that, 20.83% of plants were infested by the pathogen. The highest infestation of basal rot disease of dragon fruit in Aonla + Carambola-Lemon + Dragon fruit-based agroforestry system might be due to low light level and high population density of tree species.

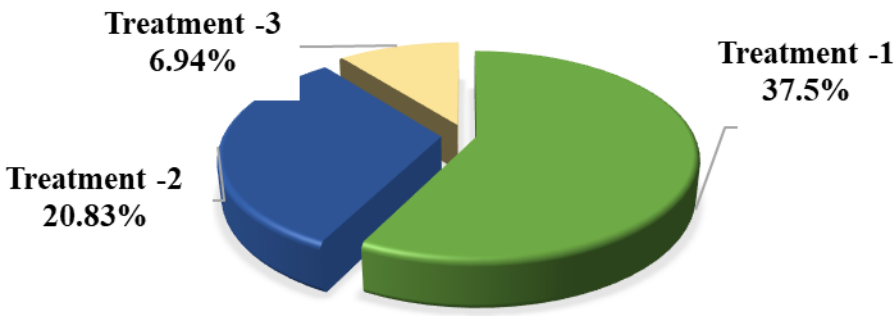


Figure 8. Incidence of basal rot (*Fusarium oxysporum*) in dragon fruit in different treatments under natural condition.

Disease cycle: Initial symptom appeared at 8 weeks after planting (WAP). The disease symptom was found at the basal part near the soil as a greenish lesion and then gradually extended to the upper stem at 12 WAP (Figure 9A) and became soft and watery and occurred yellowish at 15 WAP (Figure 9B). Then at 17 WAP, the yellowish color became brownish which then became dry (Figure 9C). At the final stages the whole affected stem became dried and at this stage, the tissues were separated from the affected stem (Figure 9D).

A **B** **C** **D**

Figure 9. Disease cycle found in the research field for basal rot disease of dragon fruit, (A) initially affected plants at 8 WAP (B) yellowish color occur in the affected portion at 12 WAP (C) Yellowish symptom turned to brownish at 15 WAP (D) At 17 WAP the infected stem dried and disintegrated the tissues.

CONCLUSION

Considering the present findings, it may be concluded that the initial height of both dragon fruit genotypes was found the highest in Aonla + Carambola-Lemon + Dragon fruit-based multistoried system and the lowest in open field. On the other hand, number of branches are found maximum in open field compared to multistoried system. Disease infestation was found maximum in multistoried system compared to double storied and open field system. Although the basal rot disease of dragon fruit in multistoried system was fully controlled by spraying fungicides.

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