Original Research Article

Influence of different growing conditions on growth parameters of banana varieties

ABSTRACT

Banana is one of the most widely consumed and economically important fruit crop in the world. It is the second most important fruit crop in India after the mango with respect to area.The present experiment investigates the growth and physiological parameters like pseudostem height, pseudostem girth, leaf length, leaf width, leaf area,number of functional leaves, total number of leaves per plant, days taken for phyllochron, chlorophyll content and stomatal conductance in different banana varieties under different growing conditions over a two year research period (2021 – 2022 and 2022 – 2023) at MHREC, UHS, Bagalkot. The experiment consisted of six treatments (T_1- G_1V_1 – Ney Poovan under net house condition, T_2 – G_1V_2 – Grand Naine under net house condition, T_3 – G_1V_3 – Rajapuri under net house condition, T_4 – G_2V_1 – Ney Poovan under open field condition, T_5 – G_2V_2 – Grand Naine under open field condition, T_6 – G_2V_3 – Rajapuri under open field condition) laid out in FRCBD with 4 replications. The results obtained had the highest pseudostem girth, leaf length, leaf width, leaf area, number of functional leaves, total number of leaves per plant and chlorophyll content was found in banana variety Grand Naine grown under net house condition. The minimum days taken for phyllochronand stomatal conductance was recorded in Grand Naine under net house conditions.

Keywords:*Net house, physiological parameters, Ney Poovan, phyllochron, chlorophyll, open field*

1. INTRODUCTION

Banana is one of the most widely consumed and economically important fruit crop in the world. Today, banana is cultivated in tropical and subtropical regions across the globe, making them a staple food for millions of people. It is the second most important fruit crop in India after the mango with respect to area. In addition to Indonesia, Philippines, Malaysia, and other South-Eastern Asian countries, India is thought to be one of the centres of origin for banana. Banana is grown in more than 130 countries across the world in an area of 23.41 million ha, producing 533 thousand million tonnes of banana and plantain (Anon, 2023). India is the largest producer of banana in the world with production of 30.5 million tonnes that accounts 26.02% to the global share. The major banana growing areas are Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Kerala, Odisha Assam, Bihar, and West Bengal. The production is highest in Andhra Pradesh (5,684.47 thousand tonnes) followed by Maharashtra (4,966.33 thousand tonnes). Whereas, Gujarat has the highest productivity of 66.09 tonnes/ha (Anon, 2023).

Cultivation of Banana under open field conditions is affected by various anomalies like wind damage, sun burn, pests, diseases, frost injury and adverse climatic conditions during the growth season, the yield is adversely affected and most of the time whole crop remain damaged. So, to overcome this problem banana cultivation under net house conditions is needed and so far, there no proper work has been done on protected cultivation of banana. As the world population is growing day by day and urbanization is happening all over, it has resulted into decrease in land holding capacity for growing different crops and due to environmental changes, this is the need of the hour to adopt new cultivation techniques to protect the crops from some biotic and abiotic factors. Protected cultivation provides favourable environment or growing conditions to the plants by providing optimum light, temperature, humidity, carbon di-oxide and circulated air which are suitable for better plant growth, heavy yield and good quality fruits. It also ensures plant protection from various biotic and abiotic factors and reduced gestation period of the crops. The research aims to study the influence of net house and open field growing conditionson growth and physiological parameters of banana varieties.

UNDER PEER REVIEW

2. MATERIAL AND METHODS

The present investigation was carried out during 2021 – 2023 in Main Horticultural Research Station, UHS, Bagalkot. The research centre comes under northern dry zone of Karnataka. It is located at 16º 11´ North latitude, 75 º 42´ East longitudes with an altitude of 537 m above the mean sea level.Soils are medium black colour and shallow depth. The pH of the soil range between 7.5 to 8.5.

1. Design: Factorial RCBD

Factor 1	**Factor 2**
G-Growing conditions	**V- Varieties**
G_1-Net house conditions	V_1-Ney Poovan
G_2-Open conditions	V_2-Grand Naine
	V_3- Rajapuri

2. Treatment combinations: 06

3. Replications: 04

4. Spacing: 1.80 m (plant-plant) x 2.10 m (row-row)

5. Plot size: 34.02 m^2

6. Observation of plants per treatment: 05

List 1. Treatment details

Treatments	Code	Treatment details
T_1	G_1V_1	Ney Poovan (AB) under net house condition
T_2	G_1V_2	Grand Naine(AAA) under net house condition
T_3	G_1V_3	Rajapuri(AAB) under net house condition
T_4	G_2V_1	Ney Poovan (AB) under open field condition
T_5	G_2V_2	Grand Naine(AAA)under open field condition
T_6	G_2V_3	Rajapuri(AAB) under open field condition

UNDER PEER REVIEW

2.1 Pseudostem height (cm)

The pseudostem height of the plant was measured in the randomly selected 5 plants in each replication at monthly intervals upto shooting stage. The measurement was recorded using measuring scale from the ground level from the marked point (15 cm above the ground level) up to the angle between youngest first and second leaf axils on the pseudostem, and finally 15 cm was added to the total height of the pseudostemand the average values were expressed in centimeters.

2.2 Pseudostem girth (cm)

The circumference of pseudostem of the plant was measured in the randomly selected plants in each replication. The measurement was taken at 30 cm above the ground level by using measuring tape at monthly intervals up to shooting stage and the average values were expressed in centimeters.

2.3 Leaf length (cm)

The length of the third leaf from the top was considered to be the index leaf was measured in the randomly selected plants at monthly intervals up to shooting stage. The measurement was done using measuring scale from the base of the leaf lamina on the midrib to the apex of the leaf lamina. The average leaf length was calculated and given in centimetres.

2.4 Leaf breadth (cm)

Leaf breadth of the third leaf from the top of the randomly selected plant was measured using measuring tape at maximum leaf blade portion including midrib at monthly intervals up to shooting stage. The average values are expressed in centimetres.

2.5 Leaf area (m^2)

Third fully opened banana leaf was selected to calculate leaf area. Leaf area was calculated by multiplying leaf length and breadth with a constant factor 0.8 to arrive the actual leaf area of the plants and the average was worked out and expressed in m^2 (Hewitt, 1955). The total leaf area was calculated by adding the leaf area of the functional leaves.

$$\text{Leaf area} = l \times b \times n \times \text{'K'}$$

Where, l = length of the leaf; b = breadth of the leaf; n = number of leaves per plant; 'K' = constant factor (0.80).

2.6 Number of functional leaves per plant

Actual number of fully opened green leaves on the randomly selected plants was counted at monthly intervals up to at shooting stage and expressed as average number of functional leaves per plant.

2.7 Total number of leaves per plant

The total number of leaves per plant present at monthly intervals up to shooting stage of crop growth was counted and expressed in number.

2.8 Days taken for phyllochron

The date of emergence of two successive leaves was recorded at monthly intervals up to shooting stagefrom which the rate of emergence by counting the days taken for two successive leaf productions and expressed in days (Summerville, 1944).

2.9 Chlorophyll content (SCMR units)

The chlorophyll content (SCMR) of fully opened and physiologically matured leaves as replicated from all treatments was measured using a SPAD-502 (Konica-Monolta) meter at monthly intervals up to shooting stage.

2.10 Stomatal conductance (m mol/m^2/s)

The fully opened and physiologically matured leaves in all five observational plants were selected to estimate the stomatal conductance by using porometer (Decagon devices, USA) at monthly intervals up to shooting stageand mean value of these were recorded and expressed in m

UNDER PEER REVIEW

mol/m²/s

3. RESULTS AND DISCUSSION

Growth and physiological parameters was significantly influenced the varieties under the net house growing conditions. Three key morphological parameters associated with growth and development of banana varieties are pseudostem height, girth, and leaf count. The pooled data of growing conditions revealed significant results with respect to pseudostem height is depicted in Table 1.

Among the growing conditions, G_1 (net house condition) recorded significantly highestpseudostem height (26.92, 58.73, 107.70, 148.18, 195.13, 210.41 and 252.47 cm at 30, 60, 90, 120, 180 days after planting (DAP) and at shooting stage, respectively).However, the lowest pseudostem height was 22.52, 50.64, 96.41, 136.91, 181.66, 194.54 and 229.73 cm at 30, 60, 90, 120, 180 days after planting (DAP) and at shooting stage was observed in G_2 (open field condition), respectively. Under net house conditions, the temperature, humidity and other environmental factors such as light intensity, sunshine are regulated which lead to growth of the plant to its maximum potential. During the different growth stages of plant, the maximum average temperature and relative humidity of 27.73 ^{o}C and 95.92 % as compared to open field conditions which was 31.29 ^{o}C and 86.23 %, respectively).

Among the varieties, V_1 (Ney Poovan) obtained the highest pseudostem height (27.73 cm - 213.02 cm)initial stage of growth to shooting stage, respectively. The lowest pseudostem height (21.88 cm - 211.31 cm) from initial stage of growth to shooting stage, respectively was recorded in V_3 (Rajapuri). Since Ney Poovan is tall variety having highest pseudostem, as the height of the plant is inversely proportional to girth of the pseudostem (Galan Sauco*et al.,* 1995).This may be due to the genotypic variation in the varieties which in turn might have contributed for variation in pseudostemheight. Evaluation of Ney Poovan (AB) by Jalawadi*et al.* (2021) also recorded highest pseudostem height.However, the interaction effects of different growing conditions and varieties on pseudostem height did not vary significantly at 30 DAP up to 90 DAP. Later on, it was significantly influenced at120 DAP to shooting stage in main and ratoon crop. Among the treatment combinations, the pooled data of Ney Poovan (V_1) under net house registered maximum pseudostem height of 166.92 cm to 292.38 cm at 120 DAP to shooting stage. It might be due to positive interaction among the treatments with respect to growth parameters. Galan Sauco*et al.* (1992) have also recorded maximum pseudostem height of banana under protected conditions due to influence of temperature on plant growth.

The pseudostem girth was significantly highest under G_1 (net house condition) (7.98, 13.90, 17.83, 27.30, 36.43, 43.91 and 59.32 cm at 30, 60, 90, 120, 180 DAP and at shooting stage, respectively).However, the minimum pseudostem girth of 6.28, 10.69, 15.82, 23.16, 30.67, 38.18 and 54.11 cm registered in G_2 (open field conditions) at 30, 60, 90, 120, 180 DAP and at shooting stage, respectively presented in Table 2.This might be due to good canopy architecture due to maximum number of leaves leading to maximum photosynthetic assimilation, which led to increase in girth of pseudostem.Chlorophyll is one of the major contributingfactors for increasing the pseudostem girth because increased chlorophyll content was recorded under net house condition which in turn increased the photosynthetic activity and also lower stomatal conductancerecorded under net house condition increases the CO_2 concentration which consecutively increases the carbohydrate assimilation contributing an increase in pseudostem girth (Yelle *et al.,*1990).

UNDER PEER REVIEW

Table 1: Pseudostem height (cm) of banana varieties at different growth stages as influenced by net house and open field growing conditions

Pseudostem height (cm)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	32.30	23.72	26.92	60.94	56.51	58.73	110.72	104.69	107.70	150.05	146.30	148.18
G_2	30.10	20.38	22.52	53.13	48.15	50.64	99.43	93.38	96.41	139.37	134.45	136.91
S.Em±	**0.88**	**0.61**	**0.49**	**1.61**	**1.04**	**1.09**	**2.08**	**1.97**	**2.02**	**2.88**	**2.78**	**2.83**
C.D at 5%	**2.65**	**1.84**	**1.47**	**4.85**	**3.14**	**3.28**	**6.26**	**5.95**	**6.10**	**8.68**	**8.39**	**8.53**
Factor- 02	**Varieties**											
V_1	34.10	25.34	27.73	67.50	63.09	65.30	128.80	123.44	126.12	164.05	158.84	161.44
V_2	31.90	21.90	24.55	60.80	54.54	57.67	97.05	90.04	93.54	147.95	145.11	146.53
V_3	27.61	18.91	21.88	42.81	39.36	41.08	89.37	83.63	86.50	122.13	117.18	119.66
S.Em±	**0.88**	**0.61**	**0.49**	**1.61**	**1.04**	**1.09**	**2.08**	**1.97**	**2.02**	**2.88**	**2.78**	**2.83**
C.D at 5%	**2.65**	**1.84**	**1.47**	**4.85**	**3.14**	**3.28**	**6.26**	**5.95**	**6.10**	**8.68**	**8.39**	**8.53**
	Interaction effect (GxV)											
G_1V_1	34.70	27.45	29.60	71.20	67.53	69.37	138.40	130.45	134.43	168.50	165.34	166.92
G_1V_2	32.60	23.40	26.40	65.60	59.86	62.73	101.40	95.68	98.54	152.30	150.77	151.54
G_1V_3	29.61	20.31	24.76	46.02	42.14	44.08	92.35	87.93	90.14	129.36	122.80	126.08
G_2V_1	33.50	23.23	25.85	63.80	58.65	61.23	119.20	116.43	117.82	159.60	152.33	155.97
G_2V_2	31.20	20.40	22.70	56.00	49.22	52.61	92.70	84.39	88.55	143.60	139.45	141.53
G_2V_3	25.60	17.50	19.00	39.60	36.57	38.09	86.40	79.33	82.87	114.90	111.56	113.23
S.Em±	**1.08**	**0.75**	**0.84**	**1.97**	**1.80**	**1.89**	**3.59**	**3.42**	**3.51**	**4.99**	**4.82**	**4.90**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**15.04**	**14.53**	**14.78**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS-Non Significant

UNDER PEER REVIEW

Contd…

Pseudostem height (cm)									
	150DAP			180DAP			Shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	184.16	178.83	195.13	212.33	208.46	210.41	255.32	249.63	252.47
G_2	170.17	164.93	181.66	197.97	191.12	194.54	232.90	226.56	229.73
S.Em±	**3.51**	**3.40**	**3.73**	**4.06**	**3.96**	**4.05**	**4.84**	**4.73**	**4.79**
C.D at 5%	**10.57**	**10.25**	**11.27**	**12.24**	**11.93**	**12.22**	**14.59**	**14.26**	**14.43**
Factor- 02	**Varieties**								
V_1	193.90	188.31	213.03	234.15	229.10	231.63	283.97	278.84	281.40
V_2	182.40	177.34	184.37	195.10	189.89	192.49	234.60	226.59	230.60
V_3	155.19	150.00	167.79	186.20	180.39	183.32	213.77	208.85	211.31
S.Em±	**3.51**	**3.40**	**3.73**	**4.06**	**3.96**	**4.05**	**4.84**	**4.73**	**4.79**
C.D at 5%	**10.57**	**10.25**	**11.27**	**12.24**	**11.93**	**12.22**	**14.59**	**14.26**	**14.43**
	Interaction effect (GxV)								
G_1V_1	200.40	195.40	219.40	243.60	238.40	241.00	295.43	289.33	292.38
G_1V_2	189.50	182.34	189.92	200.90	197.44	199.17	249.56	241.23	245.40
G_1V_3	162.58	158.75	176.06	192.50	189.54	191.07	220.97	218.33	219.65
G_2V_1	187.40	181.22	206.65	224.70	219.80	222.25	272.50	268.34	270.42
G_2V_2	175.30	172.33	178.82	189.30	182.33	185.82	219.64	211.95	215.80
G_2V_3	147.80	141.25	159.52	179.90	171.23	175.57	206.57	199.38	202.98
S.Em±	**6.07**	**5.89**	**6.47**	**7.03**	**6.86**	**7.02**	**8.38**	**8.19**	**8.29**
C.D at 5%	**18.31**	**17.75**	**19.52**	**21.20**	**20.66**	**21.16**	**25.27**	**24.70**	**24.99**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS-Non Significant

UNDER PEER REVIEW

Table 2. Pseudostem girth (cm) of banana varieties at different growth stages as influenced by open field and net house growing conditions

Pseudostem girth (cm)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	8.20	7.76	7.98	14.62	13.17	13.90	18.37	17.29	17.83	28.18	26.42	27.30
G_2	6.64	5.91	6.28	11.17	10.21	10.69	16.44	15.20	15.82	23.89	22.43	23.16
S.Em±	**0.15**	**0.14**	**0.14**	**0.26**	**0.24**	**0.25**	**0.35**	**0.33**	**0.34**	**0.52**	**0.49**	**0.50**
C.D at 5%	**0.44**	**0.41**	**0.43**	**0.78**	**0.72**	**0.75**	**1.07**	**1.00**	**1.03**	**1.57**	**1.47**	**1.52**
Factor- 02	**Varieties**											
V_1	6.90	6.57	6.74	13.26	11.86	12.56	17.07	15.73	16.40	25.49	24.13	24.81
V_2	8.80	7.87	8.33	16.33	15.22	15.77	22.60	21.34	21.97	31.72	29.18	30.45
V_3	6.56	6.07	6.32	9.09	8.00	8.55	12.56	11.67	12.11	20.90	19.97	20.43
S.Em±	**0.15**	**0.14**	**0.14**	**0.26**	**0.24**	**0.25**	**0.35**	**0.33**	**0.34**	**0.52**	**0.49**	**0.50**
C.D at 5%	**0.44**	**0.41**	**0.43**	**0.78**	**0.72**	**0.75**	**1.07**	**1.00**	**1.03**	**1.57**	**1.47**	**1.52**
	Interaction effect (GxV)											
G_1V_1	7.65	7.23	7.44	15.32	13.39	14.36	18.15	17.22	17.69	27.22	26.12	26.67
G_1V_2	9.72	9.12	9.42	18.33	17.22	17.78	23.85	22.54	23.20	34.98	32.13	33.56
G_1V_3	7.22	6.93	7.08	10.21	8.90	9.56	13.12	12.12	12.62	22.35	21.01	21.68
G_2V_1	6.15	5.91	6.03	11.20	10.32	10.76	15.98	14.23	15.11	23.76	22.14	22.95
G_2V_2	7.88	6.61	7.25	14.33	13.21	13.77	21.34	20.14	20.74	28.45	26.22	27.34
G_2V_3	5.90	5.20	5.55	7.97	7.10	7.54	12.00	11.22	11.61	19.45	18.92	19.19
S.Em±	**0.26**	**0.24**	**0.25**	**0.45**	**0.41**	**0.43**	**0.61**	**0.57**	**0.59**	**0.90**	**0.84**	**0.87**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**2.73**	**2.54**	**2.63**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS-Non Significant

UNDER PEER REVIEW

Contd…

Pseudostem girth (cm)									
	150 DAP			180 DAP			At shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01									
G_1	37.26	35.60	36.43	45.31	42.50	43.91	60.22	58.42	59.32
G_2	31.60	29.75	30.67	39.16	37.20	38.18	54.39	53.83	54.11
S.Em±	**0.71**	**0.67**	**0.71**	**0.86**	**0.81**	**0.84**	**1.14**	**1.11**	**1.13**
C.D at 5%	**2.14**	**2.02**	**2.13**	**2.59**	**2.44**	**2.52**	**3.43**	**3.36**	**3.39**
Factor- 02									
V_1	30.85	29.18	30.01	35.82	34.79	35.30	53.66	52.14	52.90
V_2	45.43	43.21	44.32	55.34	52.70	54.02	64.94	63.78	64.36
V_3	27.01	25.63	26.32	35.56	32.06	33.81	53.33	52.46	52.90
S.Em±	**0.71**	**0.67**	**0.71**	**0.86**	**0.81**	**0.84**	**1.14**	**1.11**	**1.13**
C.D at 5%	**2.14**	**2.02**	**2.13**	**2.59**	**2.44**	**2.52**	**3.43**	**3.36**	**3.39**
G_1V_1	33.24	32.13	32.69	40.14	39.12	39.63	56.33	54.33	55.33
G_1V_2	46.56	44.52	45.54	57.55	55.23	56.39	67.54	66.23	66.89
G_1V_3	31.98	30.14	31.06	38.25	33.15	35.70	56.80	54.70	55.75
G_2V_1	28.45	26.22	27.34	31.50	30.45	30.98	50.98	49.94	50.46
G_2V_2	44.30	41.90	43.10	53.12	50.16	51.64	62.33	61.33	61.83
G_2V_3	22.04	21.13	21.59	32.87	30.98	31.93	49.87	50.22	50.05
S.Em±	**1.23**	**1.16**	**1.22**	**1.49**	**1.40**	**1.45**	**1.97**	**1.93**	**1.95**
C.D at 5%	**3.70**	**3.51**	**3.68**	**4.49**	**4.23**	**4.36**	**5.94**	**5.82**	**5.88**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS-Non Significant

UNDER PEER REVIEW

With respect to varieties, the maximum pseudostem girth was recorded in Grand Naine from initial stage of growth to shooting stage (8.33 cm -64.36 cm).The minimum pseudostem girth was recorded in Rajapuri from initial stage of growth to shooting stage (6.5 cm – 52.90 cm).The increase in pseudostem girth among banana varieties might be attributed to the differences among genotype and the response of the varieties for the environmental conditions (Wassu*et al.,*2014). This might be due to larger leaf photosynthetic area in Grand Naine since it had significantly more number of leaves (Patel *et al.,* 2018).Similar results were obtained by Lamessa (2021) where Grand Naine possessed highest girth of pseudostem. This result are in line with the findings of Njuguna *et al.*(2008) that reported stem girth ranging from 43 to 76.6 cm, 77 to 90 cm (Kamira *et al.,* 2016) and 81.4 to 88.3 cm.Further, interaction effects of different growing conditions and varieties on pseudostem girth did not vary significantly at 30 DAP up to 90 DAP. Later on, it was significantlyinfluenced at 120 DAP to shooting stage (33.56 cm – 66.89 cm) in Grand Naine under net house conditions.The lowest pseudostem girth (19.19, 21.59, 31.93 and 50.05 cm) was recorded in G_2V_3 at 120, 150, 180 DAP and at shooting stage, respectively.It might be due to favourable micro-climatic conditions which advocated the enhanced plant metabolic activities like photosynthesis and respiration due to that prevailed in the constant growth inside the net house. The plant's enhanced pseudostem girth in the net house environment may be the result of better nutrient uptake and reduced evaporation.These results are in conformity with reports of Guvens and Gubbuk (2014) in Williams banana, Altinkaya*et al.* (2016) in Dwarf Cavendish.

Leaf length and breadth was also significantly influenced by the growing conditions, which is presented in Table 3 and 4. The maximum leaf length (34.33 cm - 156.50 cm) and leaf breadth (15.34 cm -15.34 cm) from initial growth stage to shooting stage was recorded under the net house conditions whereas, the minimum leaf length (24.98 cm -145.22 cm) and leaf breadth (15.34 cm - 62.34 cm)from initial growth stage to shooting stage was recorded under the open field conditions. Itcan be attributed to a combination of factors related to congenial microclimate, environmental control and plant physiological responses and response of plants to existing environmental conditions under net house conditions. The higher relative humidity, lower maximum temperature and light irradiance, higher minimum temperature, reduced evapotranspiration, higher photosynthetic activity and lower wind speed in comparison to open field conditions may be to blame for the improved leaf parameters (Khapte*et al.,* 2021). With respect to varieties, the leaf length (32.25 cm -159.03 cm) and breadth (16.41 cm -65.28 cm) was found to be highest in Grand Naine from initial growth stage to shooting stage, respectively. The minimum the leaf length (26.91 cm - 145.22 cm) and breadth (11.24 cm – 56.53 cm) was found in Rajapuri from initial growth stage to shooting stage.Similar results were also obtained by Tak *et al.* (2015) where Grand Naine obtained leaf length (39.42-157.52 cm), leaf width (19.17-41.09 cm).

Further, the interaction effects of different growing conditions and varieties on leaf length and breadth did not vary significantly at 30, 60, and 90 DAP.However, variety Grand Naine under net house conditions (G_1V_2) was registered highest leaf length (91.35 cm -163.83 cm) and breadth (44.34 cm - 68.29 cm) at 120 DAP to shooting stage. It was on par with G_2V_2(84.13 cm154.98 cm at 120 DAP to shooting stage) in case of leaf length and G_1V_1 in case of leaf breadth (41.25 cm – 66.04 cm).Further, the lowest leaf length (67.48, 91.90, 109.60 and 139.758 cm) and breadth (30.83 cm p-54.49 cm) was recorded in Rajapuri under open field conditions at 120, 150, 180 DAP and at shooting stage respectively.The increase in leaf length and breadth might be due to increase in cell division and cell number under optimum temperature and high humidity conditions which are prevailed under net house conditions (Poojashree *et al.,* 2022). The results were also in line with Retamales*et al.* (2008) who reported that there was a reduction of partially active radiation (PAR) by 47 %to 54 % under white shade net. Such a reduction was associated with an increase in leaf size *i.e.,* length and width.

Leaf area was significantly influenced by net house growing conditions from initial growth stage of banana to shooting stage (0.32 m^2- 12.51 m^2).It is presented in Table 5. Whereas the minimum leaf area was recorded in open field conditions from initial growth stage of banana to shooting stage (0.17m^2-10.00 m^2), respectively.The increased leaf area undernet house might be due to the favourable weather conditions. *i.e.,* changes in the temperature, relative humidity, light intensity and wind speed prevailed inside the net house condition as reported by Medany*et al.* (2009). Similar observations were also made by Eckstein *et al.*(1998) reported that greenhouse cultivation of banana cv. Grand Naine plants had higher leaf area of 17.4 m^2, compared with 11.7 m^2 outside at shooting stage.Leaf area significantly differed among the varieties at all the stages of crop growth. The

UNDER PEER REVIEW

maximum leafarea (0.35 m^2- 13.70 m^2) was recorded in Grand Naine from initial growth stage to shooting stage and minimum leaf area (0.18m^2- 9.65 m^2) was recorded in Rajapuri from initial growth stage to shooting stage.It might due to genetical character of the variety as it is vigorous in nature. Similar findings were also recorded by Abo-el-ez*et al.* (2007) in Grand Naine which had highest leaf area of 23.95 m^2 at flowering stage. Chalise *et al.* (2023) also recorded highest leaf area and leaf area index in Grand Naine. Hazarika and Raghavan (2018) also reported highest leaf area (12.76 m^2) and leaf area index (5.34) in Grand Naine banana.

Further, interaction effects of different growing conditions and varieties on leaf area did not vary significantly at 30 DAP up to 90 DAP. Later on at 120 DAP to shooting stage (4.03 m^2 -15.15 m^2) it was significantly influenced in Grand Naine variety under the net house conditions.The lowest leaf area (1.69, 3.30, 5.51 and 8.51 m^2) was recorded in Rajapuri under open field conditions (G_2V_3), respectively.The increase in leaf area might be due to optimum light intensities under net house. This was most likely the result of cell expansion to compensate for lower light under shading environment to receive more light for photosynthesis. These results were in agreement with the findings of Eckstein *et al.*(1998) in banana, Ceccoli *et al.* (2013), Kaur and Kaur (2017) in papaya, Vukovic *et al.*(2017) in peach plants grown under net house conditions.

The greatest accumulation of dry matter is around 20°C in banana, whereas the rate at which new leaves emerge peaks at 30°C. The accumulation of dry matter stops below 16°C, and the plant stops growing entirely below 14°C.Number of functional and total number of leaves was also significantlydiffered among the growing conditions. The maximum number of functional leaves (7.32 – 15.74) and total number of leaves (10.74 - 25.63)was recorded in G_1 (net house condition) at initial growth stage to shooting stage. However, the minimum number of functional leaves (6.75 – 14.61) and total number of functional leaves (9.71 - 22.60) was registered in G_2 (open field conditions) at initial growth stage of banana to shooting stage, respectively.As the nethouse provides favourable conditions such as adequate relative humidity, lower maximum temperature, lower light irradiance and low evapotranspiration which are suitable for mitotic activity, there is formation of more new cells which in turn increases the production of maximum number of functional and total number of leaves. Likewise, Gubbuk*et al.* (2016) and Ali *et al.* (2018) in banana, Choudhury *et al.* (2022) also obtained highest number of leaves in papaya under net house conditions.

With respect to varieties, the highest number of functional leaves (7.79 -16.17) and total number of leaves (11.58 – 25.91) was found in Grand Naine at initial growth stage to shooting stage is presented in Table 6 and 7. However, the minimum number of functional leaves (9.71- 22.60) andtotal number of leaves (9.04 – 22.67) was found in Rajapuri at initial growth stage to shooting stage.This might be due to varietal character and response of the plants to the environmental conditions. These findings are in agreement with Cabrera and Sauco (2012) who have recorded in Grand Naine with highest total number of leaves (40.1). Chalise *et al.* (2023) also recorded highest number of effective leaves in Grand Naine at shooting stage (17.00).Further, interaction effects of different growing conditions and varieties on number of functional leaves and total number of leaves did not vary significantly at 30 DAP up to 150 DAP. Later on at 180 DAP (14.98) and shooting stage (16.63) the number of functional leave was significantly influenced in Grand Naine in both main and ratoon crop.At 180 DAP, G_1V_2 was at par with G_2V_2 (13.61) but at shooting it was on par with G_2V_2 (15.70) followed by G_1V_1 (5.44) and G_1V_3 (15.15). Whereas, the total number of leaves was significantly influencedat 180 DAP (24.62) and shooting stage (28.19).The lowest number of functional leaves (12.56 and 13.71) and total number of leaves(20.37 and 22.55) was recorded in Rajapuri (V_3) under open field conditions (G_2) at 180 DAP and shooing stage, respectively.

Phyllochron is defined as the period between the appearance of two successive leaves. The pooled data regarding phyllochron days differed significantly among the growing conditions at all stages of crop growth. The minimum days for successive leaf production (phyllochron) was recorded in G_1 (net house condition) at initial stage of growth (7.53) to shooting stage (8.41) presented in Table 8.However, the maximum phyllochron days was registered in G_2 (open field conditions).Different varieties of banana had differed significantly on successive leaf emergence (phyllochron) at all the stages of crop growth.The pooled data on lowest phyllochron days was noticed in Grand Naine at initial stage of growth to shooting stage (7.69 – 8.60).However the maximum days (8.52 - 9.32)were registered in Rajapuri at 30 DAP to shooting, respectively.The interaction effect between growing conditions and varieties on days taken for phyllochron did not vary significantly at all the stages of crop growth.

UNDER PEER REVIEW

Table 3: Leaf length (cm) of banana varieties at different growth stages as influenced by net house and open field growing conditions

Leaf length (cm)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	36.02	32.63	34.33	46.49	44.93	45.71	69.32	66.52	67.92	85.62	83.73	84.67
G_2	26.22	23.74	24.98	39.28	38.65	38.97	61.12	59.20	60.16	76.83	75.45	76.14
S.Em±	**0.61**	**0.55**	**0.58**	**0.84**	**0.82**	**0.83**	**1.29**	**1.24**	**1.26**	**1.60**	**1.57**	**1.59**
C.D at 5%	**1.84**	**1.67**	**1.75**	**2.53**	**2.47**	**2.50**	**3.88**	**3.73**	**3.80**	**4.83**	**4.74**	**4.78**
Factor- 02	**Varieties**											
V_1	31.34	28.28	29.81	42.77	41.38	42.07	64.05	61.83	62.94	80.20	78.83	79.51
V_2	34.17	30.33	32.25	45.54	44.21	44.88	72.86	69.56	71.21	89.47	87.93	88.70
V_3	27.87	25.96	26.91	40.35	39.79	40.07	58.76	57.18	57.97	74.01	72.00	73.01
S.Em±	**0.61**	**0.55**	**0.58**	**0.84**	**0.82**	**0.83**	**1.29**	**1.24**	**1.26**	**1.60**	**1.57**	**1.59**
C.D at 5%	**1.84**	**1.67**	**1.75**	**2.53**	**2.47**	**2.50**	**3.88**	**3.73**	**3.80**	**4.83**	**4.74**	**4.78**
	Interaction effect (GxV)											
G_1V_1	35.87	32.23	34.05	46.33	44.53	45.43	68.44	66.33	67.39	84.93	83.33	84.13
G_1V_2	39.88	34.97	37.43	49.86	47.22	48.54	77.39	72.33	74.86	92.34	90.36	91.35
G_1V_3	32.32	30.70	31.51	43.27	43.04	43.16	62.14	60.89	61.52	79.59	77.49	78.54
G_2V_1	26.80	24.33	25.57	39.20	38.22	38.71	59.66	57.33	58.50	75.46	74.33	74.90
G_2V_2	28.45	25.68	27.07	41.22	41.20	41.21	68.32	66.79	67.56	86.59	85.49	86.04
G_2V_3	23.42	21.22	22.32	37.43	36.54	36.99	55.38	53.47	54.43	68.43	66.52	67.48
S.Em±	**1.06**	**0.96**	**1.01**	**1.46**	**1.42**	**1.44**	**2.23**	**2.14**	**2.19**	**2.78**	**2.72**	**2.75**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**8.37**	**8.21**	**8.29**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS-Non Significant

UNDER PEER REVIEW

Contd…

Leaf length (cm)									
	150 DAP			180 DAP			At shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	107.00	105.38	106.19	124.25	122.36	123.31	156.66	156.31	156.50
G_2	100.48	98.70	99.59	115.99	114.40	115.19	145.79	144.38	145.09
S.Em+	**2.06**	**2.02**	**2.04**	**2.38**	**2.34**	**2.36**	**2.98**	**2.96**	**2.97**
C.D at 5%	**6.19**	**6.09**	**6.14**	**7.17**	**7.06**	**7.12**	**8.99**	**8.93**	**8.96**
Factor- 02	**Varieties**								
V_1	102.83	101.43	102.13	119.39	117.66	118.52	148.78	147.48	148.13
V_2	111.47	109.39	110.43	127.10	125.29	126.19	159.13	158.93	159.03
V_3	96.91	95.31	96.11	113.86	112.19	113.04	145.77	144.62	145.22
S.Em+	**2.06**	**2.02**	**2.04**	**2.38**	**2.34**	**2.36**	**2.98**	**2.96**	**2.97**
C.D at 5%	**6.19**	**6.09**	**6.14**	**7.17**	**7.06**	**7.12**	**8.99**	**8.93**	**8.96**
	Interaction effect (GxV)								
G_1V_1	105.44	104.32	104.88	119.35	120.36	120.29	154.50	153.96	154. 23
G_1V_2	114.30	112.44	113.37	132.96	131.22	132.09	163.76	163.90	163.83
G_1V_3	101.25	99.39	100.32	117.40	115.52	116.49	151.00	150.30	150.69
G_2V_1	100.22	98.54	99.38	116.40	114.98	115.69	142.33	140.23	141.28
G_2V_2	108.64	106.33	107.49	122.38	120.33	121.36	155.23	154.73	154. 98
G_2V_3	92.57	91.23	91.90	110.33	108.87	109.60	140.54	138.95	139.75
S.Em+	**3.56**	**3.50**	**3.53**	**4.12**	**4.06**	**4.09**	**5.17**	**5.13**	**5.15**
C.D at 5%	**10.73**	**10.54**	**10.64**	**12.41**	**12.24**	**12.32**	**15.57**	**15.47**	**15.52**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting

UNDER PEER REVIEW

Table 4: Leaf breadth (cm) of banana varieties at different growth stages as influenced by net house and open field growing conditions

Leaf breadth (cm)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	15.88	14.80	15.34	22.09	20.84	21.46	32.19	30.38	31.28	41.25	40.00	40.63
G_2	12.49	11.53	12.01	17.67	16.95	17.31	27.12	25.46	26.29	36.90	36.20	36.55
S.Em±	**0.28**	**0.26**	**0.27**	**0.40**	**0.38**	**0.39**	**0.59**	**0.55**	**0.57**	**0.78**	**0.76**	**0.77**
C.D at 5%	**0.86**	**0.79**	**0.82**	**1.20**	**1.14**	**1.17**	**1.77**	**1.67**	**1.72**	**2.34**	**2.28**	**2.31**
Factor- 02	**Varieties**											
V_1	13.94	12.82	13.38	19.83	18.73	19.28	30.40	28.93	29.66	40.29	39.89	40.09
V_2	17.05	15.77	16.41	23.49	22.53	23.01	33.39	31.51	32.45	42.83	41.40	42.11
V_3	11.57	10.90	11.24	16.31	15.42	15.86	25.18	23.32	24.25	34.11	33.01	33.56
S.Em±	**0.28**	**0.26**	**0.27**	**0.40**	**0.38**	**0.39**	**0.59**	**0.55**	**0.57**	**0.78**	**0.76**	**0.77**
C.D at 5%	**0.86**	**0.79**	**0.82**	**1.20**	**1.14**	**1.17**	**1.77**	**1.67**	**1.72**	**2.34**	**2.28**	**2.31**
	Interaction effect (GxV)											
G_1V_1	15.50	14.34	14.92	21.34	20.12	20.73	32.45	30.89	31.67	41.65	40.84	41.25
G_1V_2	18.20	17.30	17.75	25.59	24.02	24.81	36.13	34.56	35.35	45.20	43.47	44.34
G_1V_3	13.95	12.75	13.35	19.33	18.37	18.85	27.98	25.69	26.84	36.91	35.69	36.30
G_2V_1	12.37	11.30	11.84	18.32	17.34	17.83	28.34	26.97	27.66	38.93	38.93	38.93
G_2V_2	15.89	14.23	15.06	21.39	21.04	21.22	30.65	28.45	29.55	40.45	39.33	39.89
G_2V_3	9.20	9.06	9.13	13.29	12.47	12.88	22.37	20.95	21.66	31.32	30.34	30.83
S.Em±	**0.49**	**0.45**	**0.47**	**0.69**	**0.66**	**0.67**	**1.02**	**0.96**	**0.99**	**1.34**	**1.31**	**1.33**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**4.05**	**3.96**	**4.00**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Leaf breadth (cm)									
	150 DAP			180 DAP			Shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	49.51	47.76	48.64	59.00	57.46	58.23	66.26	65.57	62.34
G_2	44.24	42.55	43.40	52.84	51.51	52.18	60.74	59.81	57.29
S.Em±	**0.92**	**0.89**	**0.90**	**1.10**	**1.07**	**1.09**	**1.25**	**1.23**	**1.18**
C.D at 5%	**2.78**	**2.68**	**2.73**	**3.32**	**3.24**	**3.28**	**3.77**	**3.72**	**3.56**
Factor- 02	**Varieties**								
V_1	47.33	45.33	46.33	55.57	53.16	54.36	63.14	62.76	57.64
V_2	50.60	49.46	50.03	59.67	58.41	59.04	66.79	66.02	65.28
V_3	42.71	40.68	41.69	52.54	51.88	52.21	60.58	59.30	56.53
S.Em±	**0.92**	**0.89**	**0.90**	**1.10**	**1.07**	**1.09**	**1.25**	**1.23**	**1.18**
C.D at 5%	**2.78**	**2.68**	**2.73**	**3.32**	**3.24**	**3.28**	**3.77**	**3.72**	**3.56**
	Interaction effect (GxV)								
G_1V_1	50.43	48.34	49.39	58.76	55.98	57.37	66.04	65.76	60.19
G_1V_2	53.23	52.34	52.79	62.79	61.34	62.07	70.34	69.70	68.29
G_1V_3	44.88	42.59	43.74	55.46	55.06	55.26	62.40	61.26	58.56
G_2V_1	44.23	42.32	43.28	52.37	50.34	51.36	60.23	59.75	55.09
G_2V_2	47.96	46.57	47.27	56.54	55.47	56.01	63.23	62.34	62.28
G_2V_3	40.54	38.76	39.65	49.62	48.71	49.17	58.76	57.34	54.49
S.Em±	**1.60**	**1.54**	**1.57**	**1.91**	**1.86**	**1.88**	**2.17**	**2.14**	**2.05**
C.D at 5%	**4.81**	**4.64**	**4.72**	**5.75**	**5.61**	**5.68**	**6.53**	**6.45**	**6.17**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting

UNDER PEER REVIEW

Table 5: Leaf area (m^2) of banana varieties at different growth stages as influenced by net house and open field growing conditions

Leaf area (m^2)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	0.36	0.28	0.32	0.77	0.65	0.71	1.86	1.63	1.74	3.36	3.12	3.24
G_2	0.19	0.15	0.17	0.47	0.43	0.45	1.26	1.10	1.18	2.47	2.35	2.41
S.Em±	**0.02**	**0.01**	**0.02**	**0.04**	**0.03**	**0.04**	**0.10**	**0.09**	**0.09**	**0.18**	**0.16**	**0.17**
C.D at 5%	**0.05**	**0.04**	**0.05**	**0.12**	**0.10**	**0.11**	**0.29**	**0.26**	**0.27**	**0.53**	**0.49**	**0.51**
Factor- 02	**Varieties**											
V_1	0.24	0.18	0.21	0.54	0.48	0.51	1.47	1.27	1.37	2.80	2.68	2.74
V_2	0.39	0.31	0.35	0.87	0.75	0.81	2.13	1.88	2.00	3.69	3.45	3.57
V_3	0.20	0.16	0.18	0.44	0.39	0.41	1.07	0.95	1.01	2.26	2.07	2.17
S.Em±	**0.02**	**0.01**	**0.02**	**0.04**	**0.03**	**0.04**	**0.10**	**0.09**	**0.09**	**0.18**	**0.16**	**0.17**
C.D at 5%	**0.05**	**0.04**	**0.05**	**0.12**	**0.10**	**0.11**	**0.29**	**0.26**	**0.27**	**0.53**	**0.49**	**0.51**
	Interaction effect (GxV)											
G_1V_1	0.30	0.22	0.26	0.65	0.57	0.61	1.71	1.50	1.60	3.12	2.98	3.05
G_1V_2	0.50	0.39	0.45	1.07	0.87	0.97	2.55	2.24	2.40	4.19	3.87	4.03
G_1V_3	0.28	0.22	0.25	0.58	0.51	0.54	1.31	1.16	1.24	2.77	2.50	2.64
G_2V_1	0.17	0.14	0.15	0.43	0.38	0.41	1.24	1.04	1.14	2.47	2.38	2.43
G_2V_2	0.27	0.22	0.24	0.67	0.63	0.65	1.70	1.52	1.61	3.20	3.04	3.12
G_2V_3	0.12	0.10	0.11	0.30	0.27	0.28	0.84	0.74	0.79	1.75	1.64	1.69
S.Em±	**0.03**	**0.02**	**0.03**	**0.07**	**0.06**	**0.06**	**0.17**	**0.15**	**0.16**	**0.31**	**0.28**	**0.29**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.92**	**0.86**	**0.89**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Leaf area (m^2)									
	150 DAP			180 DAP			Shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	5.41	5.07	5.24	8.55	7.83	8.19	13.47	11.54	12.51
G_2	4.33	3.95	4.14	6.68	6.12	6.40	10.71	9.29	10.00
S.Em±	**0.29**	**0.27**	**0.28**	**0.45**	**0.41**	**0.43**	**0.71**	**0.62**	**0.66**
C.D at 5%	**0.88**	**0.80**	**0.84**	**1.35**	**1.24**	**1.30**	**2.13**	**1.88**	**2.00**
Factor- 02	**Varieties**								
V_1	4.67	4.34	4.50	7.30	6.54	6.92	11.58	9.25	10.41
V_2	6.02	5.56	5.79	9.05	8.39	8.72	14.18	13.22	13.70
V_3	3.94	3.62	3.78	6.49	6.00	6.24	10.51	8.78	9.65
S.Em±	**0.29**	**0.27**	**0.28**	**0.45**	**0.41**	**0.43**	**0.71**	**0.62**	**0.66**
C.D at 5%	**0.88**	**0.80**	**0.84**	**1.35**	**1.24**	**1.30**	**2.13**	**1.88**	**2.00**
	Interaction effect (GxV)								
G_1V_1	5.16	4.91	5.03	8.04	7.15	7.59	12.92	10.27	11.59
G_1V_2	6.63	6.22	6.42	10.33	9.67	10.00	15.86	14.43	15.15
G_1V_3	4.45	4.08	4.26	7.28	6.67	6.97	11.63	9.93	10.78
G_2V_1	4.17	3.78	3.97	6.56	5.92	6.24	10.24	8.23	9.23
G_2V_2	5.40	4.91	5.16	7.78	7.12	7.45	12.49	12.01	12.25
G_2V_3	3.43	3.17	3.30	5.69	5.32	5.51	9.39	7.63	8.51
S.Em±	**0.50**	**0.46**	**0.48**	**0.78**	**0.71**	**0.75**	**1.22**	**1.08**	**1.15**
C.D at 5%	**1.52**	**1.39**	**1.45**	**2.34**	**2.15**	**2.25**	**3.69**	**3.26**	**3.47**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

The filtering or reduction of ultraviolet (UV) radiation in net houses, along with enhanced and diffused light distribution, contributes to more uniform light exposure, positively influencing leaf emergence. Apart from this, temperature also plays an important role in leaf emergence rate (LER) as it is directly dependant (Robinson and Galan Sauco, 2010).

The growth and developmental activity of reproductive structures, which significantly impact crop output, are dependent on the photosynthetic efficiency and photosynthate transports that physiologically active leaves. The highestchlorophyll content was registered in G_1 (net house condition) at initial stage of growth to shooting stage (39.28 SCMR - 62.08 SCMR).While, G_2 (open field conditions) recorded the lowest chlorophyll content (29.78 – 56.65 SCMR) at initial growth stage to shooting, respectively is presented in Table 9.Net house modify the light concentration which affect the chlorophyll concentration. Shaded leaves typically contain more total chlorophyll than control leaves (open field). Although shade-grown leaves do not receive direct sunlight, they produce more chlorophyll to capture diffuse radiation and produce the carbohydrates required for plant growth (Ilic *et al.,* 2015). Also, white shade net reduces the quantity of light but not the quality of light spectrum. Thus, it had increased levels of chlorophyll content. Higher yield corresponding to better nutrients as well as chlorophyll contents.

With respect to varieties the chlorophyll content found significantly influenced at all stages of banana crop growth. The highest chlorophyll content was found in Grand Naine at initial growth stage to shooting stage (36.70 SCMR - 62.71 SCMR),which was found to be at par with Ney Poovan at 30 DAP (34.95 SCMR), 90 DAP (45.67 SCMR), 120 DAP (47.77 SCMR) and at shooting stage (59.34 SCMR). However the lowest chlorophyll content (31.93, 39.51, 42.52, 42.64, 48.63, 52.18 and 56.04 SCMR) at 30 DAP up to shooting stage, respectively was registered in Rajapuri.Further, interaction effects of different growing conditions and varieties on chlorophyll content did not vary significantly at 30 DAP up to 90 DAP. Later on at 120 DAP to shooting stage (50.10 SCMR – 66.10 SCMR) it was significantly influenced in main and ratoon crop.This might be due to the varietal character and also Grand Naine recorded highest number of leaves, leaf length, breadth and leaf area which could have contributed to increase in the chlorophyll content. These results were in line with the research findings with Altinkaya and Gubbuk (2018), Chalise *et al.* (2023) Choudhury *et al.* (2023) in banana.

The data on stomatal conductance was significantly influenced among the growing conditions at all the growth stages of crop.The pooled data showed that the highest stomatal conductance (242.49 - 309.73 56 m mol/m²/s) was registered in G_2 (open field house condition)at initial growth stage to shooting stage is presented in Table 10. Whereas, net house condition recorded lowest stomatal conductance (226.18 - 302.56 m mol/m²/s) atinitial growth stage to shooting stage, respectively.With respect to varieties, the highest stomatal conductance was found Grand Naine at initial growth stage of banana upto shooting stage (251.60 – 329.25 m mol/m²/s), which was found to be at par with V_1 (Ney Poovan) at 60 DAP (283.05 m mol/m²/s), 150 DAP (287.92 m mol/m²/s), 180 DAP (295.16 m mol/m²/s) and at shooting stage (317.29 m mol/m²/s). However the lowest stomatal conductance (221.41, 266.17, 230.69, 244.17, 273.97, 286.56 and 271.90 m mol/m²/s) was registered in Rajapuri at different growth stages studied during the research.Further, interaction effects of different growing conditions and varieties on stomatal conductance did not vary significantly at 30 DAP up to 90 DAP.Among the treatment combinations, pooled data for Grand Naine under open field conditions (G_2V_2) registered the maximum stomatal conductance (310.87 m mol/m²/s, 316.22 m mol/m²/s, 320.98 m mol/m²/s, 346.99 m mol/m²/s from 120 DAP to shooting stage and it was on par with G_2V_1 (Ney poovan under open field) which was 285.44 m mol/m²/s, 296. m mol/m²/s, 303.40 m mol/m²/s and 325.60 m mol/m²/s at 120,150, 180 DAP and at shooting, respectively. Further, at 150 DAP and 180 DAP, G_2V_1 was on par with G_1V_2 (290.93 and 297.91 m mol/m²/s). The lowest stomatal conductance (238.04, 265.11, 274.58 and 287.19 m mol/m²/s) was recorded in Rajapuri under net house conditions (G_1V_3) at 120, 150, 180 DAP and at shooting, respectively. Whereas, the stomatal conductance was often lower in the net house conditions due to increased humidity within the enclosed environment. The elevated humidity reduces the water vapour pressure gradient between the leaf's internal spaces and the surrounding air, leading to decreased transpiration and stomatal opening (Aliniaeifard and Van Meeteren, 2016).

These results were in line with the research findings with Altinkaya and Gubbuk (2018), Choudhury *et al.*(2023) in banana, Amarante *et al.* (2011) in apple; Choudhury *et al.*(2022) in papaya.

UNDER PEER REVIEW

Table 6: Number of functional leaves of banana varieties at different growth stages as influenced by net house and open field growing conditions

Number of functional leaves												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	7.64	7.01	7.32	9.03	8.45	8.74	10.04	9.77	9.91	11.68	11.41	11.55
G_2	6.89	6.61	6.75	8.03	7.71	7.87	9.07	8.72	8.90	10.52	10.36	10.44
S.Em±	**0.14**	**0.14**	**0.14**	**0.17**	**0.16**	**0.16**	**0.19**	**0.18**	**0.19**	**0.22**	**0.22**	**0.22**
C.D at 5%	**0.44**	**0.41**	**0.42**	**0.51**	**0.48**	**0.50**	**0.57**	**0.55**	**0.56**	**0.66**	**0.65**	**0.66**
Factor- 02	**Varieties**											
V_1	6.51	5.94	6.23	7.76	7.45	7.61	9.23	8.66	8.94	10.63	10.45	10.54
V_2	7.93	7.65	7.79	9.83	9.18	9.50	10.61	10.43	10.52	11.79	11.61	11.70
V_3	7.37	6.83	7.10	8.00	7.61	7.81	8.83	8.66	8.74	10.89	10.60	10.75
S.Em±	**0.14**	**0.14**	**0.14**	**0.17**	**0.16**	**0.16**	**0.19**	**0.18**	**0.19**	**0.22**	**0.22**	**0.22**
C.D at 5%	**0.44**	**0.41**	**0.42**	**0.51**	**0.48**	**0.50**	**0.57**	**0.55**	**0.56**	**0.66**	**0.65**	**0.66**
	Interaction effect (GxV)											
G_1V_1	6.70	5.90	6.30	8.22	7.90	8.06	9.56	9.11	9.34	11.01	10.90	10.96
G_1V_2	8.45	8.00	8.23	10.32	9.44	9.88	11.22	11.00	11.11	12.33	12.10	12.22
G_1V_3	7.77	7.12	7.45	8.55	8.00	8.28	9.34	9.21	9.28	11.71	11.23	11.47
G_2V_1	6.32	5.98	6.15	7.30	7.00	7.15	8.90	8.20	8.55	10.24	10.00	10.12
G_2V_2	7.40	7.30	7.35	9.33	8.92	9.13	10.00	9.85	9.93	11.24	11.11	11.18
G_2V_3	6.96	6.54	6.75	7.45	7.22	7.34	8.32	8.10	8.21	10.07	9.97	10.02
S.Em±	**0.25**	**0.24**	**0.24**	**0.29**	**0.28**	**0.29**	**0.33**	**0.32**	**0.32**	**0.38**	**0.37**	**0.38**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Number of functional leaves									
	150 DAP			180 DAP			At shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	12.56	12.35	12.45	14.33	13.66	13.99	15.97	15.51	15.74
G_2	11.82	11.41	11.62	13.28	12.67	12.98	14.75	14.47	14.61
S.Em±	**0.24**	**0.23**	**0.24**	**0.27**	**0.26**	**0.27**	**0.30**	**0.30**	**0.30**
C.D at 5%	**0.73**	**0.71**	**0.72**	**0.82**	**0.79**	**0.80**	**0.91**	**0.89**	**0.90**
Factor- 02	**Varieties**								
V_1	11.79	11.56	11.67	13.50	12.83	13.16	15.10	14.75	14.93
V_2	13.08	12.59	12.84	14.59	14.00	14.29	16.33	16.00	16.17
V_3	11.70	11.48	11.59	13.33	12.67	13.00	14.65	14.21	14.43
S.Em±	**0.24**	**0.23**	**0.24**	**0.27**	**0.26**	**0.27**	**0.30**	**0.30**	**0.30**
C.D at 5%	**0.73**	**0.71**	**0.72**	**0.82**	**0.79**	**0.80**	**0.91**	**0.89**	**0.90**
	Interaction effect (GxV)								
G_1V_1	12.12	12.10	12.11	13.90	13.20	13.55	15.67	15.20	15.44
G_1V_2	13.40	12.98	13.19	15.20	14.76	14.98	16.92	16.34	16.63
G_1V_3	12.15	11.96	12.06	13.88	13.01	13.44	15.33	14.98	15.15
G_2V_1	11.45	11.02	11.24	13.10	12.45	12.78	14.53	14.30	14.42
G_2V_2	12.76	12.20	12.48	13.97	13.24	13.61	15.74	15.66	15.70
G_2V_3	11.26	11.00	11.13	12.78	12.33	12.56	13.97	13.44	13.71
S.Em±	**0.42**	**0.41**	**0.42**	**0.47**	**0.45**	**0.46**	**0.53**	**0.51**	**0.52**
C.D at 5%	**NS**	**NS**	**NS**	**1.43**	**1.36**	**1.39**	**1.58**	**1.55**	**1.57**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Table 7. Total number of leaves of banana varieties at different growth stages as influenced by net house and open field growing conditions

Total number of leaves												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	11.57	9.91	10.74	12.90	11.08	11.99	13.80	13.10	13.45	16.38	15.55	15.96
G_2	10.40	9.02	9.71	10.51	10.10	10.31	11.28	11.03	11.16	14.49	13.61	14.05
S.Em±	**0.23**	**0.20**	**0.21**	**0.24**	**0.22**	**0.23**	**0.26**	**0.25**	**0.26**	**0.32**	**0.31**	**0.31**
C.D at 5%	**0.69**	**0.60**	**0.65**	**0.74**	**0.68**	**0.71**	**0.79**	**0.76**	**0.78**	**0.98**	**0.92**	**0.95**
Factor- 02	**Varieties**											
V_1	9.84	8.25	9.04	10.87	9.23	10.05	11.71	11.34	11.52	14.89	13.65	14.27
V_2	12.06	11.11	11.58	12.67	12.25	12.46	13.52	12.92	13.22	16.33	15.90	16.12
V_3	11.06	9.05	10.06	11.57	10.29	10.93	12.38	11.93	12.16	15.08	14.20	14.64
S.Em±	**0.23**	**0.20**	**0.21**	**0.24**	**0.22**	**0.23**	**0.26**	**0.25**	**0.26**	**0.32**	**0.31**	**0.31**
C.D at 5%	**0.69**	**0.60**	**0.65**	**0.74**	**0.68**	**0.71**	**0.79**	**0.76**	**0.78**	**0.98**	**0.92**	**0.95**
	Interaction effect (GxV)											
G_1V_1	10.32	8.93	9.63	12.45	9.43	10.94	13.04	12.34	12.69	15.83	14.95	15.39
G_1V_2	12.74	11.47	12.11	13.32	12.95	13.14	14.56	13.95	14.26	17.27	16.46	16.87
G_1V_3	11.64	9.34	10.49	12.92	10.85	11.88	13.79	13.00	13.39	16.03	15.24	15.63
G_2V_1	9.35	7.56	8.46	9.29	9.02	9.16	10.37	10.34	10.36	13.94	12.34	13.14
G_2V_2	11.37	10.74	11.06	12.02	11.54	11.78	12.48	11.89	12.19	15.39	15.34	15.37
G_2V_3	10.49	8.76	9.63	10.23	9.74	9.99	10.98	10.87	10.93	14.13	13.16	13.65
S.Em±	**0.40**	**0.35**	**0.37**	**0.42**	**0.39**	**0.41**	**0.46**	**0.44**	**0.45**	**0.56**	**0.53**	**0.54**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Total number of leaves									
	150 DAP			180 DAP			At shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	19.33	18.70	19.01	23.04	22.38	22.71	26.37	24.89	25.63
G_2	16.39	15.62	16.01	20.77	19.96	20.36	23.15	22.04	22.60
S.Em±	**0.38**	**0.36**	**0.37**	**0.46**	**0.44**	**0.45**	**0.52**	**0.49**	**0.51**
C.D at 5%	**1.13**	**1.08**	**1.1**	**1.39**	**1.34**	**1.36**	**1.57**	**1.49**	**1.53**
Factor- 02	**Varieties**								
V_1	16.72	16.05	16.38	21.06	20.07	20.56	23.28	22.05	22.67
V_2	19.39	18.39	18.89	23.27	22.45	22.86	26.56	25.27	25.91
V_3	17.48	17.05	17.26	21.40	20.98	21.19	24.45	23.08	23.76
S.Em±	**0.38**	**0.36**	**0.37**	**0.46**	**0.44**	**0.45**	**0.52**	**0.49**	**0.51**
C.D at 5%	**1.13**	**1.08**	**1.1**	**1.39**	**1.34**	**1.36**	**1.57**	**1.49**	**1.53**
	Interaction effect (GxV)								
G_1V_1	18.11	17.98	18.05	21.98	21.02	21.50	24.33	23.12	23.73
G_1V_2	20.93	20.01	20.47	25.12	24.12	24.62	28.95	27.43	28.19
G_1V_3	18.94	18.12	18.53	22.03	21.99	22.01	25.83	24.12	24.98
G_2V_1	15.32	14.12	14.72	20.13	19.12	19.63	22.23	20.98	21.61
G_2V_2	17.84	16.76	17.30	21.42	20.78	21.10	24.17	23.10	23.64
G_2V_3	16.02	15.98	16.00	20.76	19.97	20.37	23.06	22.04	22.55
S.Em±	**0.65**	**0.62**	**0.63**	**0.80**	**0.77**	**0.78**	**0.90**	**0.85**	**0.88**
C.D at 5%	**NS**	**NS**	**NS**	**2.40**	**2.32**	**2.36**	**2.72**	**2.57**	**2.65**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Table 8. Number of days taken for phyllochron of banana varieties at different growth stages as influenced by net house and open field growing conditions

Days taken for phyllochron												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	7.45	7.60	7.53	7.00	7.41	7.21	6.90	7.03	6.97	7.16	7.43	7.30
G_2	8.59	8.76	8.67	7.88	8.26	8.07	7.71	7.88	7.80	8.15	8.69	8.42
S.Em±	**0.16**	**0.17**	**0.17**	**0.15**	**0.16**	**0.16**	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**
C.D at 5%	**0.50**	**0.50**	**0.50**	**0.46**	**0.48**	**0.47**	**0.45**	**0.46**	**0.45**	**0.47**	**0.50**	**0.48**
Factor- 02	**Varieties**											
V_1	8.06	8.14	8.10	7.67	7.96	7.81	7.28	7.45	7.36	7.67	8.16	7.91
V_2	7.57	7.80	7.69	6.82	7.27	7.04	7.10	7.22	7.16	7.47	7.74	7.60
V_3	8.43	8.61	8.52	7.84	8.29	8.07	7.54	7.71	7.63	7.84	8.30	8.07
S.Em±	**0.16**	**0.17**	**0.17**	**0.15**	**0.16**	**0.16**	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**
C.D at 5%	**0.50**	**0.50**	**0.50**	**0.46**	**0.48**	**0.47**	**0.45**	**0.46**	**0.45**	**0.47**	**0.50**	**0.48**
	Interaction effect (GxV)											
G_1V_1	7.38	7.42	7.40	7.23	7.42	7.33	6.91	7.07	6.99	7.21	7.54	7.38
G_1V_2	7.02	7.28	7.15	6.43	6.98	6.71	6.68	6.71	6.70	6.97	7.12	7.05
G_1V_3	7.94	8.11	8.03	7.34	7.84	7.60	7.10	7.32	7.21	7.30	7.64	7.48
G_2V_1	8.73	8.85	8.79	8.10	8.50	8.30	7.64	7.83	7.74	8.12	8.77	8.45
G_2V_2	8.12	8.32	8.22	7.20	7.55	7.38	7.52	7.72	7.62	7.96	8.35	8.16
G_2V_3	8.92	9.10	9.01	8.33	8.74	8.54	7.98	8.10	8.04	8.38	8.96	8.67
S.Em±	**0.28**	**0.29**	**0.29**	**0.26**	**0.28**	**0.27**	**0.26**	**0.26**	**0.26**	**0.27**	**0.29**	**0.28**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Days taken for phyllochron									
	150 DAP			180DAP			At shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	7.05	7.18	7.12	7.45	7.56	7.50	8.19	8.64	8.41
G_2	7.79	8.06	7.93	8.46	8.56	8.51	9.37	9.60	9.48
S.Em±	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**	**0.18**	**0.18**	**0.18**
C.D at 5%	**0.45**	**0.47**	**0.46**	**0.49**	**0.49**	**0.49**	**0.54**	**0.56**	**0.55**
Factor- 02	**Varieties**								
V_1	7.35	7.54	7.45	7.82	7.95	7.88	8.70	9.16	8.93
V_2	7.00	7.21	7.11	7.73	7.84	7.78	8.41	8.79	8.60
V_3	7.92	8.10	8.01	8.32	8.38	8.35	9.23	9.41	9.32
S.Em±	**0.15**	**0.15**	**0.15**	**0.16**	**0.16**	**0.16**	**0.18**	**0.18**	**0.18**
C.D at 5%	**0.45**	**0.47**	**0.46**	**0.49**	**0.49**	**0.49**	**0.54**	**0.56**	**0.55**
	Interaction effect (GxV)								
G_1V_1	7.03	7.12	7.08	7.21	7.34	7.28	8.11	8.75	8.43
G_1V_2	6.62	6.75	6.69	7.18	7.29	7.24	7.69	8.24	7.97
G_1V_3	7.50	7.66	7.59	7.96	8.04	8.00	8.76	8.92	8.84
G_2V_1	7.67	7.96	7.82	8.42	8.56	8.49	9.29	9.57	9.43
G_2V_2	7.38	7.67	7.53	8.27	8.39	8.33	9.12	9.33	9.23
G_2V_3	8.33	8.54	8.44	8.68	8.72	8.70	9.69	9.89	9.79
S.Em±	**0.26**	**0.27**	**0.26**	**0.28**	**0.28**	**0.28**	**0.31**	**0.32**	**0.31**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

G_1- Net house condition
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Table 9. Chlorophyll content (SCMR units) of banana varieties at different growth stages as influenced by net house and open field growing conditions

Chlorophyll content (SCMR units)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	39.33	39.23	39.28	44.22	43.29	43.75	46.41	45.31	46.74	48.19	47.60	47.90
G_2	29.59	29.96	29.78	41.45	40.71	41.08	42.81	41.99	43.32	44.65	43.82	44.23
S.Em±	**0.67**	**0.68**	**0.68**	**0.85**	**0.83**	**0.84**	**0.88**	**0.86**	**0.89**	**0.92**	**0.91**	**0.91**
C.D at 5%	**2.03**	**2.04**	**2.04**	**2.55**	**2.50**	**2.52**	**2.65**	**2.59**	**2.68**	**2.78**	**2.73**	**2.75**
Factor- 02	**Varieties**											
V_1	34.93	34.97	34.95	42.70	41.80	42.25	44.22	43.11	45.67	48.22	47.32	47.77
V_2	36.15	37.25	36.70	45.59	45.41	45.50	46.92	45.92	46.91	47.90	47.68	47.79
V_3	32.30	31.55	31.93	40.21	38.79	39.51	42.69	41.91	42.52	43.13	42.14	42.64
S.Em±	**0.67**	**0.68**	**0.68**	**0.85**	**0.83**	**0.84**	**0.88**	**0.86**	**0.89**	**0.92**	**0.91**	**0.91**
C.D at 5%	**2.03**	**2.04**	**2.04**	**2.55**	**2.50**	**2.52**	**2.65**	**2.59**	**2.68**	**2.78**	**2.73**	**2.75**
	Interaction effect (GxV)											
G_1V_1	39.54	39.21	39.38	44.35	43.25	43.80	46.32	44.96	46.98	49.00	48.32	48.66
G_1V_2	40.28	41.23	40.76	47.33	47.14	47.23	48.76	47.38	48.73	50.07	50.13	50.10
G_1V_3	38.16	37.24	37.70	40.97	39.47	40.23	44.14	43.58	44.52	45.48	44.36	44.93
G_2V_1	30.32	30.73	30.53	41.04	40.34	40.69	42.11	41.26	44.35	47.44	46.31	46.88
G_2V_2	32.02	33.27	32.65	43.86	43.67	43.77	45.08	44.46	45.09	45.72	45.23	45.47
G_2V_3	26.44	25.87	26.16	39.45	38.12	38.79	41.23	40.24	40.51	40.79	39.92	40.35
S.Em±	**1.17**	**1.17**	**1.17**	**1.46**	**1.44**	**1.45**	**1.52**	**1.49**	**1.54**	**1.59**	**1.57**	**1.58**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**4.81**	**4.73**	**4.77**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Chlorophyll content (SCMR units)									
	150 DAP			180 DAP			Shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	53.26	52.71	52.99	58.54	57.74	58.14	62.36	61.80	62.08
G_2	48.72	47.80	48.26	53.38	52.63	53.01	56.90	56.40	56.65
S.Em+	**1.00**	**0.99**	**1.00**	**1.10**	**1.09**	**1.09**	**1.18**	**1.16**	**1.17**
C.D at 5%	**3.03**	**2.98**	**3.00**	**3.32**	**3.27**	**3.30**	**3.55**	**3.51**	**3.53**
Factor- 02	**Varieties**								
V_1	49.91	49.58	49.74	55.85	54.23	55.04	59.01	59.68	59.34
V_2	53.79	53.22	53.50	60.18	58.81	59.50	63.35	62.08	62.71
V_3	49.28	47.97	48.63	51.84	52.51	52.18	56.54	55.54	56.04
S.Em+	**1.00**	**0.99**	**1.00**	**1.10**	**1.09**	**1.09**	**1.18**	**1.16**	**1.17**
C.D at 5%	**3.03**	**2.98**	**3.00**	**3.32**	**3.27**	**3.30**	**3.55**	**3.51**	**3.53**
	Interaction effect (GxV)								
G_1V_1	52.49	52.34	52.42	58.73	57.23	57.98	61.56	62.34	61.95
G_1V_2	55.65	55.09	55.37	62.53	61.28	61.91	66.76	65.43	66.10
G_1V_3	51.65	50.70	51.18	54.35	54.70	54.54	58.76	57.62	58.19
G_2V_1	47.32	46.82	47.07	52.97	51.23	52.10	56.45	57.02	56.74
G_2V_2	51.93	51.34	51.64	57.83	56.34	57.09	59.93	58.73	59.33
G_2V_3	46.92	45.25	46.09	49.34	50.32	49.83	54.32	53.46	53.89
S.Em+	**1.74**	**1.71**	**1.73**	**1.91**	**1.88**	**1.90**	**2.04**	**2.02**	**2.03**
C.D at 5%	**5.24**	**5.16**	**5.20**	**5.76**	**5.67**	**5.71**	**6.14**	**6.08**	**6.11**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Table 10. Stomatal conductance (m mol/m²/s) of banana varieties at different growth stages as influenced by net house and open field growing conditions at various intervals

Stomatal conductance (m mol/m²/s)												
	30 DAP			60 DAP			90 DAP			120 DAP		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**											
G_1	225.95	226.38	226.18	270.51	270.54	270.52	241.38	241.21	241.32	262.59	261.22	261.92
G_2	241.46	243.52	242.49	293.66	293.67	293.66	260.71	261.53	261.12	282.72	281.68	282.20
S.Em±	**4.69**	**4.72**	**4.70**	**5.68**	**5.68**	**5.68**	**5.04**	**5.05**	**5.09**	**5.47**	**5.46**	**5.53**
C.D at 5%	**14.13**	**14.23**	**14.18**	**17.12**	**17.13**	**17.12**	**15.18**	**15.23**	**15.35**	**16.50**	**16.46**	**16.67**
Factor- 02	**Varieties**											
V_1	230.44	229.55	229.99	281.82	284.29	283.05	249.89	251.07	250.48	277.69	277.09	277.39
V_2	250.31	252.90	251.60	297.83	296.31	297.07	272.36	272.62	272.49	295.90	293.36	294.63
V_3	220.38	222.39	221.41	266.61	265.72	266.17	230.90	230.43	230.69	244.37	243.90	244.17
S.Em±	**4.69**	**4.72**	**4.70**	**5.68**	**5.68**	**5.68**	**5.04**	**5.05**	**5.09**	**5.47**	**5.46**	**5.53**
C.D at 5%	**14.13**	**14.23**	**14.18**	**17.12**	**17.13**	**17.12**	**15.18**	**15.23**	**15.35**	**16.50**	**16.46**	**16.67**
	Interaction effect (GxV)											
G_1V_1	222.13	220.37	221.25	268.39	270.23	269.31	243.32	243.31	243.32	270.84	267.83	269.34
G_1V_2	246.29	247.43	246.86	289.73	288.34	289.04	258.37	256.93	257.65	279.43	277.35	278.39
G_1V_3	209.44	211.34	210.44	253.41	253.05	253.23	222.45	223.40	222.98	237.50	238.47	238.04
G_2V_1	238.74	238.73	238.74	295.24	298.34	296.79	256.46	258.83	257.65	284.53	286.35	285.44
G_2V_2	254.32	258.37	256.35	305.92	304.27	305.10	286.34	288.30	287.32	312.37	309.37	310.87
G_2V_3	231.32	233.45	232.39	279.82	278.39	279.11	239.34	237.45	238.40	251.25	249.33	250.29
S.Em±	**8.12**	**8.17**	**8.15**	**9.83**	**9.84**	**9.84**	**8.72**	**8.75**	**8.82**	**9.48**	**9.46**	**9.58**
C.D at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**28.58**	**28.52**	**28.87**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

Contd…

Stomatal conductance (m mol/m²/s)									
	150 DAP			180 DAP			Shooting		
	PC	RC	Pooled	PC	RC	Pooled	PC	RC	Pooled
Factor -01	**Growing conditions**								
G_1	278.39	278.24	278.34	287.38	285.47	286.47	303.58	301.44	302.56
G_2	298.85	298.42	298.63	307.64	307.65	307.64	326.27	293.20	309.73
S.Em±	**5.79**	**5.79**	**5.83**	**5.95**	**5.95**	**6.29**	**6.31**	**6.07**	**6.65**
C.D at 5%	**17.45**	**17.44**	**17.56**	**17.95**	**17.94**	**18.96**	**19.01**	**18.30**	**20.03**
Factor- 02	**Varieties**								
V_1	288.45	287.39	287.92	295.72	294.60	295.16	317.28	317.30	317.29
V_2	303.14	304.00	303.57	309.40	309.49	309.44	329.82	328.68	329.25
V_3	274.28	273.59	273.97	287.41	285.58	286.56	297.68	245.99	271.90
S.Em±	**5.79**	**5.79**	**5.83**	**5.95**	**5.95**	**6.29**	**6.31**	**6.07**	**6.65**
C.D at 5%	**17.45**	**17.44**	**17.56**	**17.95**	**17.94**	**18.96**	**19.01**	**18.30**	**20.03**
	Interaction effect (GxV)								
G_1V_1	279.64	278.32	278.98	289.32	284.53	286.93	310.73	307.21	308.97
G_1V_2	290.52	291.33	290.93	297.36	298.45	297.91	312.39	310.64	311.52
G_1V_3	265.02	265.06	265.11	275.46	273.42	274.58	287.61	286.48	287.19
G_2V_1	297.26	296.46	296.86	302.12	304.67	303.40	323.82	327.38	325.60
G_2V_2	315.76	316.67	316.22	321.43	320.53	320.98	347.25	346.72	346.99
G_2V_3	283.53	282.12	282.83	299.36	297.74	298.55	307.74	205.49	256.62
S.Em±	**10.03**	**10.02**	**10.09**	**10.31**	**10.31**	**10.89**	**10.92**	**10.52**	**11.51**
C.D at 5%	**30.23**	**30.20**	**30.42**	**31.09**	**31.07**	**32.83**	**32.93**	**31.70**	**34.69**

G_1- Net house conditions
G_2- Open field conditions

V_1- Ney Poovan
V_2- Grand Naine
V_3- Rajapuri

PC-Plant crop
RC-Ratoon crop

DAP-Days after planting
NS – Non-significant

UNDER PEER REVIEW

4. CONCLUSION

Based on the research findings, variety Grand Naine under net house conditions recorded the highest growth and physiological parameters especially pseudostem girth, leaf length, leaf length, leaf breadth, number of functional leaves, total number of leaves and chlorophyll content. Whereas, minimum days taken for phyllochron and stomatal conductance which are further going to influence on the yield and yield attributing characters by managing the source to sink ratio.

REFERENCES

1. Abo-el-ez A., Abdalla B., Gad-elkareem M. R. and Essa A., Evaluation of some banana cultivars under south Egypt conditions. J. Sohag Agrisci. 2017;2(2): 1-13.
2. Ali A. A., Mohsen F. S. and Desoky E. M., Comparative study on growth and productivity of some banana cultivars under the Egyptian conditions. Zagazig J. Agric. Res., 2018;45(6): 2319-2330.
3. Aliniaeifard S. and Van Meeteren U., Stomatal characteristics and desiccation response of leaves of cut chrysanthemum (*Chrysanthemum morifolium*) flowers grown at high air humidity. Scientia Hortic., 2016; 205: 84-89.
4. Altinkaya L. O. K. M. A. N., Balkic R. E. C. E. P. and Gubbuk H., September. Greenhouse cultivation of banana: very favorable crop in Turkey. In III Balkan Symposium on Fruit Growing, 2016; pp. 487-490.
5. Altinkaya L., and Gubbuk H., "Comparison of open-field and net-covered banana production in subtropical conditions." In XXX International Horticultural Congress IHC2018: XI International Symposium on Banana: ISHS-ProMusa Symposium on Growing, 2018; pp. 39-44.
6. Anonymous, 2023, FAO statistics 2022.*https://www.fao.org*
7. Anonymous., 2023, Area, production and productivity of banana in India during 2022-2023.*www.indiastat.com.*
8. Cabrera Cabrera J. and Galan Sauco V., Evaluation of different covers used in greenhouse cultivation of Cavendish bananas (*Musa acuminate* Colla AAA) in the Canary Islands. Acta Hortic., 2012;928: 31-39.
9. Ceccoli G., Panigo E. S., Gariglio N., Favaro J. C. and Bouzo C. A., Fruit yield and growth parameters of several Carica papaya L. genotypes in a temperate climate. Revista de la Facultad de CienciasAgrarias. Universidad Nacional de Cuyo. Mendoza. Argentina, 2013;45(2): 299-310.
10. Chalise B., Shrestha A. K., Srivastava A. and Tripathi K. M., Effect of plant nutrients on vegetative growth of Cavendish banana cv. 'Grand Naine' under mid-western terai condition of Nepal, Int. J Hortic., 2023;13(11): 1-11.
11. Choudhury S., Islam N., Mustaki S., Uddain J., Azad M. O. K., Choi K. Y. and Naznin M. T., Evaluation of the different low-tech protective cultivation approaches to improve yield and phytochemical accumulation of papaya (Carica papaya L.) in Bangladesh. Horticulturae, 2022;8(3): 210.
12. Choudhury S., Islam N., Shaon A. R. and Hossain J., Evaluation of different high tunnel protection methods for quality banana production in Bangladesh. J. Plant Sci. Crop Protec., 2023;6(1): 102.
13. Eckstein K., Fraser C. and Joubert W, Greenhouse cultivation of bananas in South Africa. In II International Symposium on Banana: I International Symposium on Banana in the Subtropics, 1998;490: 135-146.
14. Galan Sauco V., Cabrera J., Hernandez Delgado P. M, Phenological and production differences between greenhouse and open-air bananas in Canary Island. Acta hortic., 1992; 296: 97-112.
15. Galan Sauco, V., Cabrera Cabrera, J. and Hernandez Delgado, P.M., A comparison of banana cultivars' Dwarf Cavendish','GrandeNaine' and 'Williams', for the Canary Islands. Fruits, 1995; 50(4): 255-266.
16. Gubbuk H. and Pekmezci M., Comparison of open field and protected cultivation of banana (Musa spp. AAA) in the coastal area of Turkey. New Zealand J. Crop Hort., 2004;32(4): 375-378.
17. Gubbuk H., Gunes E. and Guven D., Comparison of open-field and protected banana cultivation for some morphological and yield features under subtropical conditions. In X

UNDER PEER REVIEW

International Symposium on Banana: ISHS-ProMusa Symposium on Agroecological Approaches to Promote Innovative Banana. 2016;1196: 173-178.
18. Guvens D. and Gubbuk H., Agronomic performance of several cavendish cultivars (*Musa spp.* AAA) under plastic greenhouse. LucrăriȘtiințifice, Universitatea de Științe Agricole ȘiMedicinăVeterinară" Ion Ionescu de la Brad" Iași, Seria Horticultură, 2014;57(1): 111-116.
19. Hazarika B. N. and Raghavan M., Effect of micronutrients on growth and yield of banana cv. Grand Naine (AAA) under foothills of Arunachal Pradesh. Crop Res., 2018;53(5&6): 242-246.
20. Hewitt C W. Leaf analysis as a guide to the nutrition of bananas.1995; 11-16.
21. Ilic Z. S., Milenkovic L., Sunic L. and Fallik E., Effect of coloured shade-nets on plant leaf parameters and tomato fruit quality. J. Sci. Food Agric., 2015;95(13): 2660-2667.
22. Jalawadi S., Jagadeesh R. C., Kantharaju V., Basavaraj N. and Mulla N. N. D. S. W., Evaluation of diploid banana genotypes under Northern dry zone of Karnataka. *IJCS*, 2021;9(1): 778-781.
23. Kamira M., Ntamwira J., Sivirihauma C., Ocimat W., van Asten P., Vutseme L. and Blomme G., Agronomic performance of local and introduced plantains, dessert, cooking and beer bananas (Musa spp.) across different altitude and soil conditions in eastern democratic Republic of Congo. Afr. J. Agric. Res., 2016;11(43): 4313-4332.
24. Kaur K. and Kaur A., A study on the performance of vegetative characters and yield of papaya cv. Red Lady 786 under open and protected conditions. Intl. J. Devel. Res., 2017; 7(9): 1150-1153.
25. Khapte P. S., Meena H. M., Kumar P., Burman, U., Saxena A. and Kumar P., Influence of different protected cultivation structures on performance of cucumber (*Cucumis sativus* L.) in Indian hot arid region. J. Agromet., 2021;23(3): 265-271.
26. Lamessa K., Performance evaluation of banana varieties, through farmer's participatory selection. Int. J. Fruit Sci., 2021; 21(1): 768-778.
27. Medany M. A., Abdrabbo M. A. A., Awny A. A., Hassanien M. K. and Abou-Hadid A. F., Growth and productivity of mango grown under greenhouse conditions. Egypt. J. Hort, 2009; 36(2): 373-382.
28. Njuguna J., Nguthi F., Wepukhulu S., Wambugu F., Gitau D., Karuoya M. and Karamura D., Introduction and evaluation of improved banana cultivars for agronomic and yield characteristics in Kenya. Afr. Crop Sci. J., 2008;16(1): 35-40.
29. Patel M. J., Sitapara H. H., Shah N. I. and Patel H. R., Effect of different levels of planting distance and fertilizers on growth, yield and quality of banana cv. Grand Naine. J. Pharmacog. Phytochem., 2018;7(2): .649-653.
30. Poojashree N. R., Suseela T., Rao, A. V. D. D., Subbaramamma P. and Sujatha, R. V., Studies on effect of coloured shade nets on growth of Peace lily (Spathiphyllumwallisii). Pharm Innov J, 2022;11(8): 1213-1219.
31. Retamales J. B., Montecino J. M., Lobos G. A. and Rojas L. A., Colored shading nets increase yields and profitability of highbush blueberries. In XXVII International Horticultural Congress-IHC2006: International Symposium on Cultivation and Utilization of Asian, 2008; pp. 193-197.
32. Robinson J. C. and Galan Sauco V., Bananas and Plantains. 2nd Edition. CABI. Wallingford. Oxfordshire. 2010;311p.
33. Summerville W. A. T., Studies on nutrition as quantified by development in *Musa cavendishii* (L). Qd. J. Agric. Sci., 1944; 1: 1-27.
34. Tak M. K., Sanjay A. and Tak P. K., Studies of banana cv. Grand Naine in the respect of correlation with growth and yield parameters. Int. J. Tropic. Agric., 2015;32(3/4): 633-640.
35. Vukovic M., Brkljaca M., Rumora J., Fruk M., Jatoi M. A. and Jemric T., Vegetative and Reproductive Traits of Young Peaches and Nectarines Grown under Red Photoselective Net. Agriculturae Conspectus Scientificus, 2017;81(3): 181-185.
36. Wassu M., Kebede W., Tekalign T. and Kiflemariam Y., Evaluation of genetic variation in local and introduced dessert banana (*Musa sp*.) genotypes for morpho-physicochemical traits. Sci. Technol. Arts Res. J. 2014;3(4): 19-28.
37. Yelle S., Beeson R.C., Trudel M. J. and Gosselin A., Duration of CO2 enrichment influences growth, yield, and gas exchange of two tomato species. J. American Soc. Hortic. Sci., 1990; 115(1): 52 -57.

UNDER PEER REVIEW