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EFFECT OF LIGHT INTENSITY ON DIFFERENT BETELVINE GERMPLASM UNDER TERAI REGION OF WEST BENGAL

NISON BHUTIA[1], PARTHA SARATHI MEDDA[1], P. CHOUDHURI,*[2] A. GHOSH[3] AND G. PANDIT[4]
[1]Department of Plantation Crops and Processing, Faculty of Horticulture,
[2]Department of Vegetable and Spice Crops, Faculty of Horticulture,
[3]Department of Agricultural Staistics, Faculty of Agriculture,
[4]Department of Biochemistry, Faculty of Agriculture,
Uttar Banga Krishi Viswavidyalaya , Pundibari, Cooch Behar, West Bengal - 736 165
e-mail: partha2909@rediffmail.com

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***Corresponding author**

ABSTRACT

The present field trial was conducted in Himalayan Tract of West Bengal with three different light intensities (25%, 50% and 65%) and nine cultivars to standardize the optimum light requirement of different bangla cultivars and its effect on their growth, leaf yield and essential oil yield. The experiment was laid out in Split Plot Design. Lower light intensity (25%) recorded higher statistically significant linear growth during both active and dormant growth phase with increased leaf area(212.70 cm^2), maximum vine elongation (26.15 cm), inter nodal distance(10.28 cm) and highest chlorophyll content (49.32). Cultivars like Simurali Gole Bhabna and Local recorded highest monthly yield (2.81no) under 25% light intensity over all cultivars. Interaction effect showed that for all the above characters the Bangla varieties under study gave maximum values in lowest light intensity. On the contrary due to more production of photosynthates higher light intensity gave significantly higher essential oil content (58.47 mg/100 g) of the leaves. Growing of betel vine under 25% light intensity may be considered optimum for better growth and higher leaf yield under closed type system of cultivation for all the cultivars under trial except Utkal Sudam and Bagerhat Local.

INTRODUCTION

Betel vine (*Piper betle* Linn) commonly known as Paan is a perennial dioecious evergreen creeper, grown in shady condition with high humidity (Das and Mallick, 2010).On an average about 66% of total production of betel leaf our country is contributed by the West Bengal. The crop provides a National income to the tune of 6000-7000 million every year providing livelihood to 25 million farm families of the country and at the same time it also provides an income of Rs 800-1000 million to the state of West Bengal. Betel leaves worth about Rs 30-40 million are exported to the Middle East and European countries (Guha, 2006) indicating the foreign exchange earning potentiality of the crop. Since the study area is closer to Assam chewing betel leaf and offering the leaf in different ceremonies and rituals is a mandatory practice for the people (Jane *et al.*, 2014 and Guha, 2006). Like other areas in terai zone of West Bengal the crop is cultivated in conservatory structure called as 'boroj.'It provides shade and high humid environment to the crop needed for a good harvest (Khatua, 2013). But if the light intensity is not properly governed pungency of leaf sometimes become beyond consumption. The growers of terai zone use bamboo, straw or locally available thatching materials for raising this structure. But due to unscientific management of light and humidity sometimes these conservatories become source of disease and pests and causes havoc to this crop (Maiti and Shivashankara 1998).Weather changes promoted by protected environments can be adverse, due to excessive internal warming and/or photosynthetically active radiation decrease (Ferreira, 2014). Since the solar radiation has decisive importance in all plant vital processes such as photosynthesis, respiration, photoperiod, tissue growth and flowering, among others, a correct choice for protected environment cover material is a crucial issue for plant development (Sapounas *et al.*, 2010).On the other shade netting is frequently used to protect agricultural crops from excessive solar radiation, improving the thermal climate (Kittas *et al.*, 2009), sheltering from wind and hail and exclusion of bird and insect transmitted virus diseases (Teitel *et al.*, 2008). For better vegetative growth and quality parameters like essential content environmental factors like light plays an important role in betel vine. The importance of genotypes x environment interaction (G x E) has been recognised from very beginning especially in the crops like betel vine where environmental fluctuation play a vital role in its seasonal production and productivity (Rahaman *et al.*, 1997) The potential growth and developmental rates for a particular genotype may be decreased by stress factors (Shukla *et al.*, 2013). The performance of plant growth and economic yield of plant can be suitably modified by fluctuating external influences. There is strong correlation between the environmental factors and the life form of plants. In plants the major biological events are seedling, vegetative, flowering, fruiting, growth, leaf fall, maturing and all these stages are governed by the environmental factors. Light is one of the most limiting factors for growth and biomass of the plant (Yuanlong *et al.*, 2012). Being a natural habitat of tropical humid forest ecosystem, the crop requires diffused light intensity, high available soil moisture and high relative humidity for its successful cultivation. However the optimum light requirement for better growth and yield has not been studied successfully. Betel vine may require around 25% sunlight for successful growth and development (Balasubramanyam *et al.*, 1994).Keeping the importance of light intensity for better growth and yield of the crop, the present study was carried out to standardize the optimum light requirement on different bangla cultivars of betel vine by using agro shed nets of different densities and their subsequent effect on growth, yield and quality parameters in Terai region of West Bengal.

MATERIALS AND METHODS

The present experiment was conducted at the Horticultural Instructional Farm of Uttar Banga Krishi Viswavidyalaya, under Terai region of West Bengal at 26º19'86"N latitude and 89º23'53"E longitude. This zone is characterized by subtropical humid climate with prolonged rainy season. The annual rainfall of the zone varies from 2300 to 3400 mm. and 80% of the total rainfall is distributed between June to October. The temperature range varies from minimum of 7-8ºC to maximum of 30-34ºC with high relative humidity. The soil of the experimental site is acidic sandy loam in texture having moderate to poor fertility status having micro nutrient deficiency. The performances of nine different Bangla cultivars were studied under varied light intensities. The experiment was laid out in split-plot design keeping three light intensities(35%, 50%, 75%) as main plot treatment and nine different cultivars(Simurali Chamurdali, Kotki, Simurali Deshi, Simurali Gole Bhabna, Bagerhat Local, Simurali Bhabna, Utkal Sudam, Kali Bangla, Local) as sub-plot treatment with three replications. Three closed conservatories were constructed using bamboo made structure covered with agro-shade nets of varying mesh for achieving three desired level of light intensities within these conservatories Single leaf single node cuttings of nine different cultivars were planted in the month of July during the years 2013 and 2014 following paired row system of planting with a spacing of 10 cm X 10 cm X 50 cm, accommodating forty plants per plot of 2m X 1m size. The vines were watered regularly and fertilized with 10 tonnes of FYM and N, P_2O_5 and K_2O @ 200, 100, 100 kg per ha. Of which 50% of the nitrogen requirement were fulfilled through organic in the form of mustard cake and rest of the 50% were applied in the form of Urea. The observations on growth, yield and quality parameters of the betel vine were recorded by tagging five randomly selected plants leaving the border rows from each treatment and their average values were worked out. The observations recorded in boroj and laboratory from different treatments were subjected to statistical analysis by using Statistical Analysis System (9.2). Treatment variations were tested for significance by adopting F test (Cochran and Cox, 1957). For determination of critical difference at 5% level of significance Fisher and Yates table was consulted. Pooled analysis over two years was also done as per method suggested by Gomez and Gomez (1983).

Leaf chlorophyll content (SPAD value)

Chlorophyll content of the randomly selected nine leaves per plot was measured after harvesting of leaves at an interval of six months by using portable leaf chlorophyll meter (SPAD 502, Minolta) and following the method of Arnon (1949).

Essential oil content of leaf (mg/100g leaves)

For essential content, 100 g fresh betel leaves from each cultivar were taken for extraction and estimation of essential oil content. The essential oil was extracted using Clevenger's method (1928). The volume of the essential oil was collected in 10 ml conical flask and calculated on weight basis.

RESULTS AND DISCUSSION

Monthly vine elongation

Data on mean monthly vine elongation of the different betel vine germplasm (Table1) under study showed significant variations. The lower light intensity (L_3) had a profound effect on monthly average growth rate of betel vine. The lowest light intensity (25%) recorded significantly maximum vine elongation (26.15 cm) over other main plot treatments, which was in conformity with the findings of *Shivasankara et al., (2000)*.The cultivar Simurali Gole Bhabna recorded maximum vine elongation (29.68 cm) under lowest light intensities which was statistically significant over all the cultivars under varied light intensities. Irrespective of the light intensities, the different cultivars also showed significant results with respect to their average monthly vine elongation and similar trend was followed by the cultivar Simurali Gole Bhabna. It recorded

Table 1: Effect of light intensity on mean monthly vine elongation of different cultivars of betel vine

Cultivar	Mean monthly vine elongation (cm)			Sub-plot
	L_1	L_2	L_3	mean (cm)
Kali Bangla	23.30	24.57	26.18	24.68
Simurali Chamurdali	23.25	24.20	25.58	24.18
Utkal Sudam	23.53	25.18	23.53	24.08
Kotki	23.50	23.99	25.07	24.34
Simurali Deshi	23.53	23.83	25.80	24.38
Simurali GoleBhabna	23.50	24.93	29.68	26.03
Bagherhat Local	23.05	25.45	27.28	24.26
SimuraliBhabna	23.70	25.45	26.70	25.28
Local	24.01	26.51	25.58	25.37
Main plot mean	23.48	24.90	26.15	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	0.32	0.48	0.83	0.84

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

Table 2: Effect of light intensity on Inter nodal length different cultivars of Betel vine

Cultivar	Inter-nodal length (cm)			Sub-plot
	L_1	L_2	L_3	mean (cm)
Kali Bangla	9.89	10.28	11.12	10.43
Simurali Chamurdali	9.39	9.72	10.21	9.77
Utkal Sudam	9.10	9.42	9.52	9.35
Kotki	10.09	10.16	10.26	10.17
Simurali Deshi	9.01	9.62	10.64	9.76
Simurali Gole Bhabna	8.86	11.22	10.55	10.21
Bagherhat Local	9.66	10.53	10.06	10.08
Simurali Bhabna	9.44	9.70	10.15	9.77
Local	9.86	11.63	9.97	10.49
Main plot mean	9.48	10.25	10.28	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	0.33	0.27	0.47	0.55

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

Table 3: Effect of light intensity on leaf area of different cultivars of betel vine

Cultivar	Leaf area (cm^2)			Sub-plot
	L_1	L_2	L_3	mean (cm)
Kali Bangla	176.50	230.82	234.80	214.04
SimuraliChamurdali	141.25	225.60	248.16	205.00
UtkalSudam	170.90	193.75	233.61	199.42
Kotki	138.85	170.70	198.71	169.42
SimuraliDeshi	165.05	176.37	165.60	169.00
SimuraliGoleBhabna	146.85	171.40	232.55	183.60
Bagherhat Local	178.10	235.30	130.65	181.35
SimuraliBhabna	183.20	232.55	242.36	219.37
Local	188.50	232.87	227.91	216.43
Main plot mean	165.46	207.70	212.70	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	6.46	13.09	22.56	22.16

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

Table 4: Effect of light intensity on fresh weight of 10 leaves of different cultivars of betel vine

Cultivar	Fresh weight of 10 leaves (g)			Sub-Plot
	L_1	L_2	L_3	mean(cm)
Kali Bangla	28.61	39.71	29.71	32.68
Simurali Chamurdali	35.39	28.52	35.55	33.15
Utkal Sudam	36.56	39.36	41.54	39.15
Kotki	34.56	35.24	37.08	35.62
Simurali Deshi	26.55	23.01	28.53	26.03
Simurali Gole Bhabna	32.82	34.44	34.75	34.00
Bagherhat Local	35.42	40.83	36.95	37.73
Simurali Bhabna	17.84	33.82	34.17	28.61
Local	29.96	40.97	38.10	36.34
Main plot mean	31.41	35.10	34.60	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	2.08	3.79	6.56	6.50

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

maximum vine elongation (26.03 cm) which was statistically superior over all the cultivars, whereas the cultivar Utkal Sudam showed minimum vine elongation (24.08) and statistically *at par* with Simurali Chamurdali (24.18 cm), Bagerhat Local (24.26 cm), Kotki (24.34 cm) and Simurali Deshi (24.38 cm). Depending upon the rate of vine increment of different cultivars in different months of the year the growth phase of the betel vine may be grouped into – (a) Active phase of growth (Apr-Oct) and (b) Dormant phase of growth (Dec-Mar).This variation is mainly due to change in temperature and relative humidity. Early onset of monsoon coupled with rising temperature from April onwards triggered off moderate to vigorous growth till the ceases on of rainy season in October (Medda, 2012).

Inter nodal length

Data presented in Table 2 clearly showed that variation in light intensity had significant effect on inter nodal distance of betel vine. Shivasankara *et al.* (2000) also reported that there is positive correlation between leaf size and intermodal length with light intensity in betel vine .The lowest light intensity L_3 recorded longer inter nodal distance(10.28 cm.) which was statistically significant over L_1 and *at par* with L_2.Local cultivar showed longest inter nodal distance (10.49 cm) which was statistically *at par* with Kali Bangla (10.43 cm), Simurali Gole

Table 5: Effect of light intensity on leaf yield of different cultivars of betel vine (no. of leaves/month)

Cultivar	No. of leaves/ month			Sub-PlotMean(cm)
	L_1	L_2	L_3	
Kali Bangla	2.35	2.39	2.35	2.36
SimuraliChamurdali	2.50	2.46	2.45	2.47
UtkalSudam	2.55	2.57	2.68	2.60
Kotki	2.33	2.48	2.29	2.36
SimuraliDeshi	2.61	2.48	2.42	2.50
SimuraliGoleBhabna	2.66	2.22	2.81	2.56
Bagherhat Local	2.38	2.41	2.71	2.50
SimuraliBhabna	2.51	2.62	2.63	2.59
Local	2.43	2.28	2.57	2.42
Main plot mean	2.48	2.43	2.54	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	0.08	0.09	0.15	0.17

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

Table 6: Effect of light intensity on total chlorophyll content of leaf of different cultivars of betel vine

Cultivar	Chlorophyll content of leaf (SPAD value)			Sub-Plot Mean(cm)
	L_1	L_2	L_3	
Kali Bangla	47.70	49.70	50.85	49.41
Simurali Chamurdali	49.60	48.30	52.80	50.23
Utkal Sudam	45.05	49.60	47.35	47.33
Kotki	35.75	47.65	42.95	42.11
Simurali Deshi	44.65	49.55	51.15	48.45
Simurali Gole Bhabna	48.15	46.55	50.80	48.50
Bagherhat Local	41.75	46.15	47.80	45.23
Simurali Bhabna	46.10	49.80	50.85	48.91
Local	45.90	47.90	52.60	48.80
Main plot mean	45.31	48.35	49.32	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	3.39	3.80	6.57	7.01

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

Bhabna (10.21 cm)). The shortest inter nodal distance was recorded from cultivar Utkal Sudam (9.35cm) irrespective of the different main plot treatment. Shorter vine with very short internodes is desirable when cost of cultivation is considered, because, it saves the cost of most important and labour intensive operation 'lowering'.

Leaf area

The leaf area of different cultivars varied significantly under different light intensities. The low light intensity has a favourable effect on larger size leaf production of different cultivars of betel vine. It is evident from the data presented in Table 3 that 25% light intensity (L_3) produced maximum leaf area (212.70 cm^2) followed by 50% light intensity (L_2), which were statistically significant over 65% light intensity (L_1).Simurali Chamurdali recorded the largest leaf area (248.16 cm^2) under lowest light intensity and was statistically *at par* with Simurali Bhabna (242.36 cm^2), Kali Bangla (234.80 cm^2), Utkal Sudam (233.61 cm^2), Simurali Gole Bhabna (232.55 cm^2) and Local (227.91 cm^2). However, the cultivar Bagerhat Local, Simurali Deshi and Local exhibited reverse trend and they produced larger size leaves under 50% light intensity.Leaf size of any cultivar is generally governed by the genetically controlled factor. However, it is obvious that higher growth and size of leaves of betel vine influenced by favourable micro-climate and light intensity within the boroj as evidenced by Shivsankara *et al.* (2000). increased leaf area was obtained in *Alianthus tryphyta* under shade (Saju *et al.*, 2000).

Fresh weight of 50 leaves

Data presented in Table 4 clearly indicated significant variation with respect to fresh weight of ten leaves.50% light intensity recorded highest fresh weight (35.10 g.) which was statistically at par with 25% light intensity (30.60 g.). However, fresh weight of ten leaves under lower light intensity (L_3 & L_2) statistically differs from higher (L_1) light intensity.

Utkal Sudam recorded highest fresh weight (39.15 g.) and was *at par* with Bagherhat Local (37.73 g.), Local (36.34 g.), Kotki (35.62 g.). Simurali Deshi recorded lowest fresh weight (26.03 g.) might be due to its lower leaf area and thickness of leaf.The interaction effect of different light intensity with the cultivar was also gave the statistically significant results. Variation in fresh weight was observed among the cultivars may be due to their varied moisture content, dry matter accumulation rate and the size of petiole produced under varied light intensity. Kumar et al. (2014) observed the similar findings in case of geranium and he reported that curtailment of illumination favoured the increase of fresh wt of geranium plant.

Leaf yield

Data presented in Table 5 revealed that mean monthly leaf production of the cultivar varied significantly. The lowest light intensity L_3 recorded highest leaf yield (2.54) which was statistically significant over L_1 and statistically at par with L_2

Table 7: Effect of different light intensity on essential oil content of different cultivars of betel vine.

Cultivar	Essential oil content (mg/100g)			Sub-Plotmean
	L_1	L_2	L_3	
Kali Bangla	63.92	65.75	56.48	62.05
Simurali Chamurdali	57.51	56.43	52.68	55.54
Utkal Sudam	52.22	52.97	59.23	54.80
Kotki	62.58	65.92	61.42	63.30
Simurali Deshi	57.39	58.61	57.58	57.86
Simurali Gole Bhabna	65.48	53.58	58.48	59.18
Bagherhat Local	51.89	50.54	52.74	51.72
Simurali Bhabna	57.19	55.15	57.26	56.53
Local	58.06	56.52	58.28	57.62
Main plot mean	58.47	57.27	57.12	
	(M)	(S)	(S x M)	(M x S)
C.D. (p=0.05)	0.28	1.34	2.32	2.21

L_1-65% Light intensity; L_2-50% Light intensity; L_3-25% Light intensity

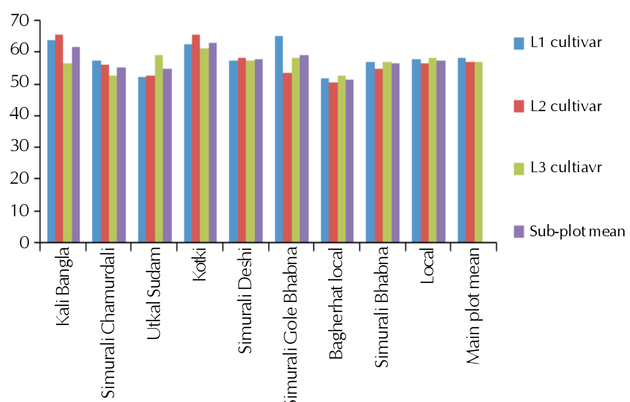

Figure 1: Essential oil content of different betel vine cultivars

(2.48). The cultivar Simurali Gole Bhabna and Local recorded highest monthly yield (2.81) under 25% light intensity over all cultivar followed by Bagherhat Local (2.71),Utkal Sudam (2.68) and Simurali Bhabna (2.63).In *Lawsonia inermis* decreasing light intensity favoured more shoot weight ,leaf yield and dry matter production (Vyas 2004).

Chlorophyll content of the leaves (SPAD value)

Data presented in Table 6 revealed that different Bangla cultivars also showed statistically significant variation under different light intensities with respect to chlorophyll content of leaf. The lowest light intensity recorded highest chlorophyll content (49.32) which was statistically at par with 50% light intensity (48.35) and significant over 65% light intensity.this result was in conformity with the findings of Paez *et al.*2000 who found that there was sequential reduction in chlorophyll content as the intensity of light increases. Among the different cultivars Simurali Chamurdali showed highest (50.80) chlorophyll content under 25% light intensity and statistically at par with the chlorophyll content of the leaves of all the cultivar except Kotki. However the cultivar Kotki and Utkal Sudam gave higher chlorophyll content under 50% light intensity.

Similar trend was observed by Shivashankara *et al.,* (2000). Higher chlorophyll content of the leaves may lead to increase the photosynthesis efficiency of betel vine under lower light intensity which paved way to higher yield.

Essential oil content

Data presented in Table 7 and Fig.1 showed that light intensity had a profound effect on essential oil content of betel vine. The highest light intensity gave the statistically significant result (58.47 mg/100g) over other main plots. Irrespective of the light intensities, the different cultivar also showed significant result with respect to their essential oil content. The cultivar Kotki showed maximum essential oil content (63.30mg/100g) which was statistically superior over all the cultivar, where as cultivar Bagherhat local showed minimum essential oil content (51.72 mg/100 g) irrespective of the different main plot treatment. Essential oil is a secondary plant metabolite synthesized from the product of photosynthesis. Essential oil is a secondary plant metabolite synthesized from the products of photosynthesis. Restricted availability of photosynthates adversely affects crop growth and essential oil synthesis and accumulation (Kumar *et al.*, 2014).Reduced light availability under 50% and 25% light intensity might be the reason for recoding significantly lower essential oil content of leaves.

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