Academic Journal of Plant Sciences 2 (3): 158-161, 2009
ISSN 1995-8986

Effect of Light Intensity on the Morpho-physiology and Yield of Bottle Gourd (*Lagenaria vulgaris*)

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Abstract: This study was carried at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Bottle gourd cv. High-green (hybrid) was grown to investigate the morpho-physiological changes and yield performance under four different levels of light (100, 75, 50 and 25% PAR). It was observed that some of the morphological characters like main stem length, internode length and individual leaf area increased, whereas main stem diameter and numbers of leaves per plant decreased due to the reduced light levels. At 50% PAR number of leaves per plant did not decrease significantly in bottle gourd. Leaf weight ratio (LWR) remained more or less similar up to 50% reduction of PAR. SPAD value increased with the reduction of PAR level i.e. partial shading stimulated chlorophyll synthesis in leaves. Compared to 100% PAR the total dry matter (TDM) did not reduce. Bottle gourd produced the highest yield (41.53 t ha^{-1}) at 75% PAR level and it did not show significant fruit yield reduction at 25% PAR level compared to full sunlight. However, considering TDM and fruit yield bottle gourd and cucumber were found suitable for reduced light condition (up to 50% PAR).

Key words: Cucurbits · TDM · Photosynthesis · PAR · Shading

INTRODUCTION

Vegetables are one of the essential food items of daily requirement. Improvement of daily dietary value depends largely on the vegetables consumption. The per capita consumption of vegetables in Bangladesh is only 53 g, which is far behind the daily requirement of 200 g per head [1]. So, vegetable production and consumption need to be increased in Bangladesh. Secondly, Bangladesh is an over populated and agro-based country. Demographic consumption and declining per capita land availability make it clear that Bangladesh will have to produce more farm products from less land plus other resources in the future or next century. It is now a prime need to improve system-based productivity and emphasis should be given on homestead vegetables production. The development or identification of low light tolerant vegetables could be one of the achievable attempts to solve such problems.

Bottle gourd (*Lagenaria vulgaris*) is one of the important vegetables of Cucurbitaceae family grown all over the Bangladesh. But the available recommended cultural practices of these crops do not provide their optimum growth and yield performance under low light environment in homestead areas. Under low light condition, plant expense more energy to structural development compare to the plant grown under full sunlight [2]. Adaptive responses of plant to low irradiance include an increase of leaf area ratio, leaf to stem mass ratio and stem length, decreased leaf thickness and root growth relative to shoot growth [3]. Increased LAR occurring with reduced SLW of plant grown under low irradiance has been associated with reduced leaf thickness [3]. Most of the families of Bangladesh depend on the vegetables which are growing in the homestead areas where shade is unavoidable due to standing trees. So, there is a tremendous need to screen these vine type vegetables under low light environment for evaluating their adaptability and yield potential. To serve this purpose, higher yielding and partial shade tolerant vegetables should be introduced. Considering the above mentioned facts bottle gourd were grown to evaluate the yield and yield contributing characters of the three vegetables (cucumber, ash gourd and bottle gourd) under reduced light condition and to characterize the morphological and physiological changes of under reduced light levels.

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MATERIALS AND METHODS

The research work was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from February 2009 to June, 2009. The experimental field is located at 90°22'E longitude and 23°41'N latitude at an altitude of 8.6 meter above sea level. The soil was clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63.

Four treatments were evaluated in this study viz. T_1=100% Photosynthetically Active Radiation (PAR) or Full sunlight, T_2 =75% PAR, T_3 =50% PAR and T_4 = 25% PAR. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The individual (unit) plot size for vegetables was be 3 m × 2 m. Adjacent plots and neighboring blocks were be separated by 1.5 m and 1.0 m space.

The bottle gourd variety High-green (hybrid) was used in this experiment. The seedlings was raised first on separate seed beds or polybags followed by planting on the experimental plots and then these were supported by trellis framed in combination with bamboo and rope. After crop establishment, nylon nets of different sieve size were hanged with the help of bamboo sticks at a height of 2.3 meters to create low light treatments. Low light treatments consisted of 75% photosynthetically active radiation (PAR), 50% PAR and 25% PAR. The control treatment consisted of full sunlight or 100% PAR. Manure and fertilizer was applied at following rate according to the recommendation. Urea, TSP and MP was applied as 90, 75 and 60 kg ha^{-1}. Beside these, cowdung @ 10 t ha^{-1} was also applied. At the time of land preparation, half of the cowdung were applied. Rest of the cowdung and the whole quantity of TSP were applied 15 days prior to transplanting in the pit. The urea and muriate of potash was applied in two installments consisting of ½ at each installment. The first installment was applied 10 days after transplanting the seedlings. The second installment was applied at 20 days after the first installment.

Data on individual leaf area, leaf numbers $plant^{-1}$, internode length, main stem length, main stem diameter, days to first flowering, crop duration, length of reproductive period, days to fruit maturity, leaf dry weight and stem dry weight were recorded. Data on yield and yield contributing characters like fruit numbers per plant fruit length, fruit diameter individual fruit weight, fruit yield and fruit dry weight per plant were recorded. With the help of above recorded data specific leaf weight (SLW), leaf weight ratio (LWR) and relative yield were calculated using formula given by Schoch [4]. SPAD reading was determined on fresh weight basis extracting with 80% acetone and used double beam spectrophotometer according to Witham *et al.* [5]. Finally chlorophyll content was converted to dry weight basis using leaf dry matter percentage. SPAD (Soil Plant Analyses Development) reading was recorded with a chlorophyll meter (Model SPAD-502, Minolta Co. Ltd. Japan). Data obtained from the experiments for each parameter was analyzed following MSTAT-C [6] software to obtain the level of significance. The mean differences among the treatments were compared by Least Significant Difference Test at 5% level of significance.

RESULTS AND DISCUSSION

Morphology: The highest main stem length was observed at 50% PAR level (9.04 m) which was significantly different from other light levels. Bottle gourd plant exhibited the longest internode at 50% PAR level (20.86 cm) and the shortest length (17.17 cm) was obtained under full sunlight (Table 1). Up to 50% reduced sunlight, the concomitant increase in main stem length and internode length clearly explained the contribution of internode length to main stem length. This was probably due to higher apical dominance under shade condition [7]. Diameter of main stem was also adversely affected by reduced PAR levels. Highest diameter of main stem was recorded from 100% (2.32 cm) as well as 75% PAR level (2.24 cm). The lowest diameter was obtained from 25% PAR (1.85 cm). Corre [3] reported that stem length increased at the expense of root growth and stem girth.

The highest number of leaves per plant was obtained from full sunlight (334.8), which was statistically similar with 75% (305.8) and 50% (293.3) PAR levels. The lowest number of leaf was produced under 25% PAR levels (245.0). Significant increase in individual leaf area was observed when the PAR level was decreased up from 100% (256.6 cm^2) to 25% (372.3 cm^2) PAR level. Under partial shade condition stimulation of cellular expansion and cell division in leaf could be one of the possible factors that contribute to the individual leaf area increase [4]. The specific leaf weight (SLW) was also significantly reduced by reducing PAR levels (Table 1). Decrease SLW at low light levels apparently indicates that the low PAR levels resulted in reduction in leaf thickness. The SPAD value increased with the reduction of PAR level. The highest SPAD value (62.4) was obtained at 25% PAR level which is statistically different from other PAR levels. This means that reduced light stimulated higher amount of chlorophyll content in leaves.

Table 1: Stem and leaf characteristics of sponge gourd in the different light conditions

Light levels (% PAR)	Main stem length(m)	Internode length (cm)	Main stem diameter(cm)	Leaves plant^{-1}	Leaf area (cm^{-2} leaf^{-1})	SLW (mg cm^{-2})	SPAD Value
100	7.55b	17.17b	2.32a	334.8a	256.6c	2.91a	54.0c
75	8.24b	19.90a	2.24a	305.8a	316.5bc	2.80a	57.8b
50	9.04a	20.86a	2.25a	293.3a	352.0ab	2.46b	58.2b
25	6.54c	19.58a	1.82b	245.0b	372.3a	2.20c	62.4a
$LSD_{0.05}$	0.71	2.70	0.13	45.6	50.3	0.25	2.7
CV (%)	15.84	9.48	5.41	10.28	16.21	12.91	9.9

Table 2: Dry matter accumulation in the above ground parts of bottle gourd at different light levels

	Dry matter (g plant^{-1})				
Light level (% PAR)	Stem	Leaf	Fruit	Total	LWR
100	293.0a	354.2a	275.1b	923.2a	0.38
75	277.9b	340.1a	392.4a	1009.5a	0.34
50	245.0c	335.5a	342.7a	925.2a	0.36
25	226.6d	275.1b	211.6b	713.3b	0.39
$LSD_{0.05}$	13.27	32.47	65.62	125.8	NS
CV (%)	6.48	8.06	25.49	12.48	13.06

Table 3: Effect of different light levels on yield and yield components of bottle gourd

Light levels (% PAR)	Fruit numbers plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield Plant^{-1} (kg)	Fruit yield (t ha^{-1})
100	7.38b	43.65b	19.76b	1451b	10.71b	28.00b
75	9.15a	48.21a	23.13a	1894a	17.20a	41.53a
50	9.00a	48.57a	23.70a	1835a	16.51a	39.44a
25	6.60b	44.89b	20.57b	1357b	8.96b	21.95b
$LSD_{0.05}$	1.59	2.94	2.26	96.86	3.59	8.63
CV (%)	18.31	10.15	15.36	15.24	16.87	13.57

The values in the column sharing common letter(s) do not differ significantly at P=0.05

Dry Matter Accumulation and Partitioning: At 100% PAR level, the maximum stem dry matter (293.0 g plant^{-1}) was harvested which was statistically different to other light levels (Table 2). The lowest stem dry matter was produced under 25% PAR level (226.6 g plant^{-1}). Leaf dry matter reduced gradually with decreasing PAR levels. The lowest leaf dry matter was produced by 25% PAR level (275.1 g plant^{-1}). The highest leaf dry matter of 254.2 g plant^{-1} was produced under full sunlight. The reduction of leaf dry matter was significant only at 25% PAR level. However, fruit dry matter under 75% (392.4 g plant^{-1}) and 50% (342.7 g plant^{-1}) sunlight were higher and statistically identical. The lowest fruit dry matter was produced by 25% PAR level (211.6 g plant^{-1}). Under 75% and 50% PAR levels, stem and leaf dry matter decreased compared to that of full sunlight whereas fruit dry matter increased. It revealed that dry matter partitioned to the fruit under 75% and 50% PAR levels were higher compare to other treatments. Total dry matter (TDM) production in sponge gourd plant was significantly affected by varying PAR levels (Table 2). The highest amount of TDM (1009.5 g plant^{-1}) was obtained under 75% PAR level which was statistically similar to that of 100% (923.2 g plant^{-1}) and 50% PAR (925.2 g plant^{-1}) levels. The TDM recorded under at 25% PAR level was the lowest (713.3 g plant^{-1}). The result suggested that shading up to 50% exerted favourable influence on the total dry matter accumulation in bottle gourd. Reduced PAR levels had no significant influence on leaf weight ratio. Under 25% light bottle gourd plant showed considerable reduction in total dry matter compared to full sunlight which in turn was attributed to poor leaf, stem and fruit dry weight. But high LWR at 25% light suggests that leaves was less adversely affected relative to other components. However the effect was statistically insignificant (Table 2). Rao and Mittra [8]

reported that photosynthetically active radiation is the major factor regulating photosynthesis, dry matter production and yield of crops.

Yield and Yield Components: The different light levels had significant effects on the fruiting behavior of bottle gourd (Table 3). Number of fruits per plant recorded at 75% (9.15) and 50% (9.00) PAR levels was statistically similar but significantly higher than that of other two light levels (100% and 25%). The number of fruits per plant recorded at 25% PAR was the least (6.60) but was statistically similar to the number of fruits obtained at 100% PAR level (7.38).The lower number of fruits per plant recorded at 25% and 100% PAR levels might have happened due to the lower number of female flowers and fruit setting. Fruit length, fruit diameter, individual fruit weight and fruit yield per plant also showed similar trend like fruit number at different PAR levels. The fruit yield of bottle gourd obtained at 75% PAR (41.53 t ha^{-1}) and 50% PAR (39.44 t ha^{-1}) levels did not vary much, though numerically higher yield was obtained under 75% PAR level. The fruit yield of bottle gourd, however, decreased drastically at 25% reduced light level (21.95 t ha^{-1}) which was statistically similar to the fruit yield (28.0 t ha^{-1}) at full sunlight. It means that shading below 25% light exerted an adverse effect on the yield of bottle gourd. Morgan *et al.* [9] also reported that plants encounter shading, showed decreased photosynthesis which ultimately induced yield reduction and possibly impairs fruit quality.

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