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EFFECT OF DIFFERENT REDUCING LIGHT INTENSITIES ON THE MORPHO-PHYSIOLOGY AND YIELD OF CUCUMBER

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ABSTRACT

An investigation was made to study the morpho-physiological changes and yield performance of cucumber (variety Baromashi) under different light intensities (100, 75, 50 and 25% PAR). Main stem length, internode length and individual leaf area were increased, but main stem diameter, leaf number per plant and specific leaf weight were decreased significantly under reduced light intensities. Leaf chlorophyll and leaf nitrogen content increased but leaf β-carotene content decreased markedly with the reduction of light. Chlorophyll a/b ratio started to decrease when light was lowered to 50% PAR (photosynthetically active radiation) because of the less increase of chlorophyll "a" compare to chlorophyll "b". The highest fruit number per plant (21.83) and the heaviest individual fruit (267.3 g) were recorded at 75% PAR level. Compare to full sunlight, reduction of PAR at 25% resulted in significantly lower fruit number per plant (6.67) and the individual fruit weight (199.3 g). The highest fruit yield was obtained at 75% PAR level (16.09 t/ha), followed by 50% PAR level (11.73 t/ha), 100% PAR level (11.28 t/ha) and 25% level (4.57 t/ha). Under reduced light intensities shade tolerant parameters, namely leaf number per plant, individual leaf area and leaf chlorophyll content exerted positive effect on the yield of cucumber. Consequently fruit yield did not decrease significantly up to 50% reduction of PAR level. Beyond 73.08% PAR level, fruit yield decreased at the rate of 0.0048 t/ha.

Key words: Light intensity, morphology, leaf pigment, yield, cucumber

INTRODUCTION

Vegetables are one of the essential items of human dietary requirement. Per capita consumption of vegetables in Bangladesh is very low (30 g/head/day) compared to neighbouring countries like Nepal (42 g) Pakistan (69 g) India (135 g) and Srilanka (120 g) (Rampal and Gill., 1990). Therefore, it is needed to increase the production and consumption of vegetables for feeding the increasing population of Bangladesh. About 35% of the vegetables in Bangladesh are produced in summer season and the rest in winter (Rashid, 1999). Summer vegetables are traditionally grown in homestead and its surroundings beneath the fruit and timber trees. Among the potential summer vegetables, cucumber (*Cucumis sativa* L.) is a very popular and costly vegetable in Bangladesh for its food value and medicinal quality. It contain higher amount of minerals and vitamins compared to that in any other vegetables under Cucurbitaceae family. But the available recommended cultural practices of this crop do not indicate their optimum growth and yield performance under partial or full shaded environment in homestead (Anon.,1995). Plants encountering shading show decreased photosynthesis which ultimately induced yield reduction and possibly impairs fruit quality (Morgan *et al.*, 1985). However, reduced light or partial shade tolerance of cucumber has not being studied. The present investigation was, therefore, undertaken to study the morpho-physiological changes contributing to yield performance of cucumber under four different levels of light intensity.

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MATERIALS AND METHODS

This experiment was conducted using cucumber variety 'Baromashi' at the research farm of Bangabundhu Sheikh Mujibur Rahman Agricultural University, Gazipur during April to September, 2003. The experiment was laid out in Randomized Complete Block Design with four replications including four treatments of different light intensities (100, 75, 50 and 25% PAR). Mosquito net of different sieve sizes were hanged with the help of bamboo sticks at a height of 3 m to create low light treatments and a net free plot was used as the control treatment. Different light (PAR) levels were adjusted by using Light Meter (Model LX-102). The individual plot size was 3 m x 2 m. Adjacent plots and neighbouring plots were separated by 2.5 m and 1 m. Seeds were sown at 12 April in polybag and one seedling of 20 days old was transplanted in each pit (30 cm x 30 cm) maintaining a planting distance of 1.5 m. Manure was applied @ 10 tons cowdung and fertilizers were urea 150 kg, triple super phosphate (TSP) 125 kg, and muriate of potash (MP) 100 kg per hectare as per recommendation (Rashid, 1999). Half of the cowdung was applied during land preparation. Rest of the cowdung and the whole quantity of TSP were applied 15 days prior to transplanting in the pits. Urea and MP were applied in two equal instalments at 10 and 35 days after transplanting. Intercultural operation and plant protection measures were taken as and when required. Data on main stem length, internode length, individual leaf area, leaf number per plant, main stem diameter, fruit number per plant, fruit length and diameter, individual fruit weight and fruit yield per plant were recorded. Specific leaf weight (SLW) was calculated using following formula (Schoch, 1972).

$$SLW = \text{Leaf dry weight (mg)} \div \text{Area of leaf (cm}^2\text{)}$$

Chlorophyll content in leaf was estimated using standard method developed by Witham *et al.* (1986) and Shiraishi (1972), respectively. Leaf nitrogen content was determined by micro-kjeldal method as described by Black (1965). The collected data were statistically analyzed and analysis of variance was carried out using F-test. The treatment means were compared by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Morphology

Effect of different light intensities on the morphological parameters is shown in Table 1. The main stem length increased significantly at all levels of reduced PAR compared to full sunlight. The highest main stem length (6.30 m) was observed at 50% PAR level.

Table 1. Stem and leaf characteristics of cucumber in different light intensities

Light intensity (% normal PAR)	Main stem length (m)	Internode length (cm)	Main stem diameter (cm)	Leaves plant^{-1} (no.)	Individua leaf area (cm^2)	SLW (mg cm^{-2})
100	4.59b	8.11c	3.04a	309.00a	222.2c	3.08a
75	5.56a	8.77bc	3.09a	305.80a	266.0c	2.83ab
50	6.30a	9.85ab	2.56b	238.30ab	398.1b	2.42bc
25	5.80a	10.39a	2.08c	214.00b	529.1a	2.15c
LSD (0.05)	0.92	1.45	0.13	72.87	68.41	0.42
CV (%)	8.17	7.81	6.50	13.80	9.68	8.15

In a column, means followed by same letter(s) do not differ significantly at 5 level of probability

Higher length of main stem was also observed under reduced sunlight in bottle gourd (Anon., 2000). Cucumber plant exhibited the longest internode at 25% PAR level (10.39 cm) and the shortest length was obtained under full sunlight (8.11 cm). Diameter of main stem was also significantly affected by reduced PAR levels. The highest diameter of main stem was recorded from 75% PAR (3.09 cm) as well as 100% PAR level (3.04 cm). The lowest diameter was obtained from 25% PAR (2.08 cm). Corre (1983) reported that stem length increased under reduced light at the expense of root growth and stem girth. The leaf numbers per plant was significantly reduced by shade treatments. The highest number of leaves per plant was obtained from full sunlight (309), which was statistically similar with 75% (305.8) and 50% (238.3) PAR levels. The lowest number of leaf was produced under 25% PAR levels (214.0) and no significant variation was observed between 25% and 50% PAR. Significant increase in individual leaf area was observed when the PAR level was decreased from 100% (222.2 cm^2) to 25% (529.1 cm^2) PAR levels. 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 (Schoch, 1972). Similar to leaf number, the specific leaf weight (SLW) was also significantly reduced by reducing PAR levels. Among the four PAR levels, the highest SLW was recorded from full sunlight (3.08 mg cm^{-2}), which was statistically identical to that of 75% PAR level (2.83 mg cm^{-2}). The significantly lowest SLW was obtained from 25% PAR level (2.15 mg cm^{-2}). Corre (1983) reported that reduced SLW of plant grown under low irradiance has been associated with reduced leaf thickness i.e., reduced palisade layers.

Leaf pigment and nitrogen content

The pigment contents viz. chlorophyll a, chlorophyll b, chlorophyll a/b ratio and β- carotene differed under different PAR levels (Table 2).

Table 2. Pigment and nitrogen content in the leaf of cucumber at different light intensities

Light intensity (% normal PAR)	Chlorophyll a (mg g^{-1})	Chlorophyll b (mg g^{-1})	Chlorophyll a/b	β-carotene (mg g^{-1})	Nitrogen g $100g^{-1}$
100	8.72c	3.60d	2.41a	4.21a	2.88c
75	11.03b	4.72c	2.28a	3.28b	3.04bc
50	12.17b	5.82b	2.08b	3.33b	3.30ab
25	15.23a	9.08a	1.68c	2.36c	3.53a
LSD (0.05)	2.03	0.73	0.14	0.68	0.31
CV (%)	7.97	6.30	3.04	10.38	5.27

In a column, means followed by same letter(s) do not differ significantly at 5 level of probability

The lowest chlorophyll a content was recorded under 100% light (8.72 mg g^{-1}) which was statistically different from other treatments. The chlorophyll a content gradually increased with the reduction of PAR level. The highest quantity of chlorophyll a in leaf was obtained from 25% light (15.23 mg g^{-1}). Chlorophyll b also showed similar increasing pattern with the decreasing PAR levels. The highest amount of chlorophyll b was observed under 25% PAR level (9.08 mg g^{-1}) while the lowest chlorophyll b content was under full sunlight (3.60 mg g^{-1}). The ratio of chlorophyll a/b gradually decreased with the decrease in PAR levels. The ratio of chlorophyll a/b was higher in full sunlight (2.41) as well as in 75% light (2.28). Chlorophyll a/b ratio was significantly lower under 50% PAR level, which was further lowered to 1.68 at 25% PAR level. Lower ratio of chlorophyll a/b under 50% or 25% sunlight compared to either 75% or 100% sunlight indicates the less increase of chlorophyll a than that of chlorophyll b. Under shading condition the efficiency of the photosynthesis was maintained through absorption of more light by the accessory pigments and by increasing chlorophyll b (Hilton, 1983). Total chlorophyll (a + b) content also maintained by a pattern of increasing value

similar to chlorophyll a under reduced light condition. The highest amount of total chlorophyll was produced at 25% PAR level (24.06 mg g^{-1}). Then it gradually decreased with the increase in PAR level up to full sunlight. The lowest amount of total chlorophyll was observed under full sunlight. The lower light intensity due to shading caused an increase in synthesis and accumulation of chlorophyll (Chen *et. al.*, 1994). Plant grown under reduced light condition had significantly lower amount of β-carotene in the leaves. The highest amount of β-carotene in leaf was recorded under full sunlight (4.21 mg g^{-1}) followed by 75% (3.28 mg g^{-1}), 50% (3.33 mg g^{-1}) and 25% (2.36 mg g^{-1}) PAR levels. But there was no statistical difference between 75% and 50% PAR levels in respect of β-carotene not given at ref. section content. The result was in agreement with that of Adams and Adams (1992) as they also found a reduction of β-carotene under shaded condition in cucumber although α-carotene content was increased.

The amount of leaf nitrogen was the lowest under full sunlight (2.88 g $100g^{-1}$) and it then increased slightly at 75% PAR level (3.04 g $100g^{-1}$) but the difference was not significant (Table 2). The highest amount of leaf nitrogen was recorded from 25% PAR treatment (3.53 g$100g^{-1}$) which was statistically similar to that of 50% PAR level (3.30 g $100g^{-1}$) but significantly higher compared to leaf nitrogen content under any other higher levels of light in this experiment. This result indicates that the increased chlorophyll content under reduced sunlight induced deep green colour to the leaf which, in turn, resulted in higher foliar nitrogen content.

Yield and yield components

Number of fruits per plant is the most dominant yield contributing character, which was significantly influenced by variable PAR levels (Table 3). The maximum number of fruit was found at 75% PAR level (21.83$plant^{-1}$) which was about 24% higher than that of 100% PAR level (18 $plant^{-1}$). A drastic reduction of fruits per plant was recorded under 25% PAR level (6.67 $plant^{-1}$). Similar influencing pattern in number of fruits was found in bottle gourd under reduced PAR levels (Anon., 2000). Reduction of PAR levels up to 50% did not induce any significant variation in fruit length. Fruit diameter showed decreasing trend under reduced PAR levels but the variation was not significant. Individual fruit weight was significantly affected at different PAR levels. The heaviest individual fruit was recorded at 75% PAR level (267.30 g) which was statistically similar to those under 100% (255.5 g) as well as 50% PAR level (262.7g).

Table 3. Effect of different light intensities on yield and yield components of cucumber

Light intensity (% normal PAR)	Fruit number $plant^{-1}$	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield $plant^{-1}$ (kg)	Fruit yield (t ha^{-1})
100	18.0ab	18.70a	5.18	255.5a	3.39b	11.28b
75	21.83a	17.58a	5.23	267.3a	4.82a	16.09a
50	16.67b	15.80ab	5.33	262.7a	3.52b	11.73b
25	6.67c	12.60b	4.86	199.3b	1.38c	4.57c
LSD (0.05)	3.19	3.81	NS	38.31	1.19	3.96
CV (%)	10.58	11.81	8.32	11.35	18.14	18.13

In a column, means followed by same letter(s) do not differ significantly at 5 level of probability

However, individual fruit weight reduced markedly when the light availability was further reduced to 25% PAR level (199.3 g). Eventually, there was a significant influence of different light levels on the yield of cucumber. Among the PAR levels, the highest yield per plant was recorded at 75% PAR level (4.82 kg) and it was followed by 50% (3.52 kg) and full sunlight (3.39 kg). The lowest yield per plant

was found under 25% PAR (1.38 kg). Almost similar result was found by Miah (2000) in bottle gourd. The yield per hectare consequently showed similar pattern of variation among the four PAR levels as yield per plant. The highest yield was recorded under 75% PAR level (16.09 t ha^{-1}) and the lowest yield was obtained from 25% PAR level (4.57 t ha^{-1}). The 50% PAR level produced the second highest yield (11.73 t ha^{-1}) which was statistically similar with full sunlight (11.28 t ha^{-1}). These results reveal that 75% PAR level was exerted favourable effects in cucumber production compared to that of full sunlight. Reduction of PAR to 25% exerted adverse changes in plants to reduce the yield of cucumber. The results indicate that the highest yield of cucumber at 75% PAR level was attributed due to the highest number of fruit and the heaviest individual fruit. Majority of total variation in the yield of cucumber can be explained by the quadratic regression equation (Figure 1). The equation also stated that fruit yield of cucumber was maximum (16.37 t ha^{-1}) at 73.08% PAR level and beyond this PAR level, fruit yield decreased at the rate of 0.0048 t ha^{-1}.

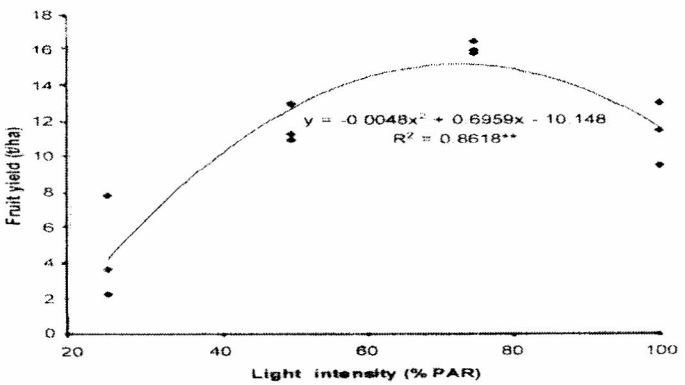

Fig 9 : Relationship between light intensity and fruit yield of cucumber.

Therefore, cucumber is suitable for growing as an under storey crop where only about half of the natural light is available. However more investigation should be needed with large number of genotypes for confirmation of this observation.

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