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MORPHO-PHYSIOLOGICAL CHANGES AND YIELD PERFORMANCE OF YARD LONG BEAN UNDER REDUCED LIGHT LEVELS

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ABSTRACT

An intensive investigation was conducted to study the morpho-physiological changes and yield performance of yard long bean under different light levels (100, 75, 50 and 25%). Main stem length, internode length and individual leaf area were increased but main stem diameter, leaves plant^{-1} and SLW decreased significantly under reduced light intensity. Leaf chlorophyll and leaf nitrogen content were increased but leaf β-carotene content decreased markedly under reduced light levels. Chlorophyll a : b ratio significantly decreased when light intensity was lower to 50% because of the less increase of chlorophyll a compared to chlorophyll b. The highest number of fruits plant^{-1} (255.2) and the maximum individual fruit weight (15.78 g) were recorded at 75% light level. Significantly the lower fruits plant^{-1} (138.7) and individual fruit weight (11.98 g) were achieved from 25% light level. The highest fruit yield was obtained at 75% light level (12.91 t ha^{-1}) was followed by 100% light level (12.16 t ha^{-1}), 50% light level (10.21 t ha^{-1}) and then by 25% light level (5.73 t ha^{-1}). Under reduced light level shade tolerant parameters viz. leaves plant^{-1}, individual leaf area and leaf chlorophyll content exerted positive effect on the yield of yard long bean. Consequently fruit yield did not decrease significantly up to 50% reduction of light intensities.

Key-words: light, total dry matter, leaf pigment, leaf nitrogen, yield and yard long bean

INTRODUCTION

Vegetables are one of the essential food items for human beings. The standard requirement of vegetables is 200g per head per day (FAO, 2004). But it is only 70 g per head per day in Bangladesh due to unconsciousness of the people and shortage of production (Anon., 1999). Hence, it is a prime need to increase the vegetables production. Summer vegetables are mostly cultivated in homestead and its surroundings beneath the fruit and timber trees. There are about 28.7 million homestead in Bangladesh which comprises about 0.45 million hectares of land (BBS, 2010). These areas are increasing due to construction of houses, factories and roads for ever growing population. In order to meet up the shortage of vegetables in Bangladesh, more attention should be given on vine type for utilizing homestead areas where shade is unavoidable due to standing trees.

However, Yard long bean (*Vigna unguiculata* ssp. *sesquipedalis*) is very popular, costly leguminous and vine type vegetables, and grow year round in Bangladesh. It also widely grows in the warmer parts of Southeastern Asia, Thailand and Southern China. Light is the major factor regulating photosynthesis, dry matter production and yield of crops (Rao and Mitra, 1998). Plants encounter shading, showed decreased photosynthesis which ultimately induced yield reduction and possibly impairs fruit quality (Morgan *et al*., 1985). Generally adaptive responses of plant to low radiance are increase of leaf area ratio, stem mass and stem length. On the other hand the adaptive responses also include decreased of leaf thickness and root growth, relative shoot growth (Fujita *et al*., 1993; Singh, 1994 and Miah, 2001). However, research work on reduced light or partial shade tolerance of yard long bean is scanty or little. The present investigation was therefore; under taken to study the morpho-physiological parameters and yield of yard long bean at different levels of reduced light intensities.

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MATERIALS AND METHODS

The study was conducted including yard long bean variety BARI-1 at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during February to June, 2010. The experiment was laid out following Randomized Complete Block Design with four replications including four treatments of different light intensities (100, 75, 50, 25 %). Mosquito net of different sieve sizes were hanged with the help of bamboo sticks at the height of 3.0 m to create low light treatments and net free plots were used as control treatment. Different light levels were adjusted by using Lux Meter (Model LX-102). The individual plot size was 3m x 2m (6 m^2). Adjacent plots and neighbouring plots were separated by 2.5 m and 1m, respectively. Two seedlings of 20 days old were transplanted in each pit (30 cm x 30 cm) maintaining a planting distance of 1.5 m. Manure (cowdung) was applied@ 10 tons ha^{-1}. Urea, TSP and MP were applied at the rate of 50, 150 and 150 kg ha^{-1} (Rashid, 1999). Half 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. Standard intercultural operation and plant protection measures were taken as and when required. Data on main stem length, internode length, individual leaf area, leaf number $plant^{-1}$, main stem diameter, fruit number $plant^{-1}$, fruit length and diameter, individual fruit weight and fruit yield $plant^{-1}$ were recorded. Stem and leaf dry matter at maturity, and fruit dry matter were also recorded. Total dry matter (TDM) was calculated by adding stem, leaf and fruit dry matter. Specific leaf weight (SLW) and leaf weight ratio (LWR) were calculated using following formula (Schoch, 1972).

SLW =Leaf dry weight (mg) ÷ area of leaf (cm^2)

LWR = Leaf weight ÷ above ground dry weight

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 (Russell, 1994).

RESULTS AND DISCUSSION

Morphology

Both main stem length and internode length of yard long bean was increased significantly when light levels were reduced to 50% or below. (Table 1). The longest internode length at 25% light level (21.66 cm) and the shortest (14.02 cm) was obtained under full sunlight. Under reduced sun light the increase in individual internode length results increased main stem length. This was probably due to higher apical dominance under shade condition. Diameter of main stem decreased significantly due to reduced light levels. The highest diameter of main stem was recorded from 100% (1.32 cm) whereas the lowest (0.71 cm) was obtained from 25% light level. Corre (1983) reported that stem length increased at the expense of root growth and stem girth. The highest leaves $plant^{-1}$ was obtained from 75% light level (419.2) which was statistically similar to that of full sunlight (405.9). The lowest leaves $plant^{-1}$ was recorded at 25% light level (232.9). Significant increase in individual leaf area was observed when the light levels were decreased from 100% (107.6 cm^2) to 25% (285.3 cm^2). 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. The highest SLW was recorded from full sunlight (2.63 $mgcm^{-2}$) which was statistically identical to that of 75% light level (2.15 $mgcm^{-2}$). Significantly lowest SLW was obtained from 25% light level (1.56 $mgcm^{-2}$). SLW was decreased under low light intensity due to reduction of leaf thickness (Corre, 1983 and Haque *et al.*, 2009).

Table 1. Stem and leaf characteristics of yard long bean at different light levels

Light levels (%)	Main stem length (m)	Internode length (cm)	Main stem Diameter (cm)	Leaves plant^{-1}	Individual leaf area (cm^2)	SLW ($mgcm^{-2}$)
100	4.13	14.02	1.32	405.9	107.6	2.63
75	4.72	16.71	1.21	419.2	136.1	2.15
50	5.52	17.05	0.97	321.5	189.5	1.74
25	5.91	21.66	0.71	232.9	285.3	1.56
LSD (0.05)	0.47	3.12	0.15	81.4	25.4	0.19
CV (%)	8.03	10.45	7.32	12.82	8.21	7.27

Dry matter accumulation and partitioning

Different light levels exerted significantly influence on the dry matter accumulation in leaf, stem and fruit (Table 2). At 75% light level, the maximum stem dry matter (97.4 g plant^{-1}) was harvested. Stem dry mater did not show any significant variation with the reduction in light levels up to 50%. Leaf dry matter gradually decreased with reduced light levels. The highest leaf dry matter (125.4 g plant^{-1}) was obtained from full sunlight. Significantly the lowest leaf dry matter (89.8 g plant^{-1}) was achieved from 25% light level. The maximum fruit dry matter (305.8 g plant^{-1}) was recorded at 75% light. Significantly the lowest fruit dry weight (110.1 g plant^{-1}) was obtained from 25% light level. The highest amount of total dry matter (528.3 g plant^{-1}) was achieved at 75% light level which was statistically similar to full sunlight (489.0 g plant^{-1}). The total dry matter (TDM) recorded under at 25% light level (258.0 g plant^{-1}) was the lowest. The result also suggested that mild shading stress (i.e. at 75% light) did not show any adverse effect on the total dry matter accumulation in long yard bean. The LWR was lowest at 100% light (0.25), which then increased significantly at 25% light level (0.35). Reduction of light levels from 100% to 50% did not affect the distribution of total dry matter to leaf. But at 25% light level considerable dry matter was utilized to foliage tissues. The highest total dry matter obtained at 75% light level (528.3g plant^{-1}) compared to any other light levels indicates that yard long bean plants have got some advantage at 75% light in dry matter yield. But high LWR at 25% light suggests that leaf dry weight was less adversely affected relative to other components. Actually yard long bean showed a tendency to maintain higher leaf area under low light stress for keeping total photosynthesis's constant. Almost similar result was found in cucumber by Haque *et al.* (2005).

Table 2. Dry matter accumulation in the above ground parts of yard long bean at different light levels

Light levels (%)	Dry matter (g plant^{-1})				LWR
	Stem	Leaf	Fruit	Total	
100	97.4	125.2	263.2	489.0	0.25
75	99.8	122.7	305.8	528.3	0.23
50	84.5	104.3	222.5	401.5	0.26
25	58.1	89.8	110.1	258.0	0.35
LSD (0.05)	16.2	11.1	51.8	51.3	0.06
CV (%)	11.49	6.12	12.52	14.15	6.64

Leaf pigment

The leaf pigment content viz. chlorophyll a, chlorophyll b, chlorophyll a : b ratio and β-carotene differed significantly under different light levels (Table 3). The lowest chlorophyll a content was recorded from full sunlight (9.01 mgg^{-1}) which was statistically similar to 75 % light level (9.95 mgg^{-1}) but different from the rest of the two treatments. The highest quantity of chlorophyll a in leaf was obtained from 25% light (14.27 mgg^{-1}). Chlorophyll b also showed similar increasing pattern with the decreasing PAR levels. Ratio of chlorophyll a : b was gradually decreased with the decrease of light levels. The ratio of chlorophyll a : b was the maximum in full sunlight (2.57) closely followed 75% light level (2.45). Chlorophyll a : b ratio was significantly lower under 50% (1.99) and 25% (1.82) light levels. Lower ratio of chlorophyll a : b at 50% light level or below suggested the extent of increase in chlorophyll b was higher than that of chlorophyll a under reduced sunlight. Under reduced light, chlorophyll b is considered to be a major light harvesting pigment in the chloroplasts (Hilton, 1983). So, increased chlorophyll b could be desirable adjustment to maintain the photosynthetic process under light limiting condition. 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 lowered the amount of β-carotene in then leaves. The highest amount of β-carotene in leaf was recorded under 75% light level (4.04 mgg^{-1}). Significantly the lowest amount of β-carotene (1.74 mgg^{-1}) was found in 25% light level. The result was in agreement with Haque (2001) who found a reduction of β-carotene under shaded condition in cucumber and yard long bean.

Table 3. Photosynthetic pigment (mgg^{-1}) and nitrogen ($g\ 100g^{-1}$)) content in the leaf of yard long bean under different light levels

Light levels (%)	Chlorophyll a	Chlorophyll b	Chlorophyll a : b	β-carotene	Leaf nitrogen
100	9.01	3.51	2.57	3.90	3.27
75	9.95	4.06	2.45	4.04	3.39
50	13.93	7.01	1.99	3.19	3.51
25	14.27	7.84	1.82	1.74	3.71
LSD (0.05)	1.25	0.76	0.21	0.54	0.39
CV (%)	6.12	8.02	5.69	9.81	6.70

Leaf nitrogen

The highest amount of leaf nitrogen was recorded from 25% light treatment (3.71 g $100g^{-1}$) followed by 50% light levels (3.51 g $100g^{-1}$) which were significantly higher compared to that of 75 % and full sunlight (Table 3). 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

Yield component were significantly influenced by different reduced light level (Table 4). The maximum number of fruit was found under 75% light level (255.1 $plant^{-1}$) which was statistically similar to full sunlight (223.5 $plant^{-1}$) or 50% light level (210.0 $plant^{-1}$). A drastic reduction in the number of fruits $plant^{-1}$ was recorded under 25% light (138.7 $plant^{-1}$). Reduction of light levels up to 75% induced non-significant variation in fruit length. Reduced light levels did not significantly affect fruit diameter. The heaviest individual fruit was recorded under 75% light level (15.78 g) and was statistically similar to those under 100% (15.05 g) and 50% light (13.93 g).

Table 4. Effect of different light levels on yield and yield components of yard long bean

Light levels (%)	Fruits $plant^{-1}$	Fruit length (cm)	Fruit diameter (mm)	Individual fruit weight (g)	Fruit yield $plant^{-1}$ (g)	Fruit yield ($t\ ha^{-1}$)
100	223.5	56.87	4.62	15.05	3.55	12.16
75	255.2	57.18	4.45	15.78	3.92	12.91
50	216.0	50.95	4.40	13.93	2.77	10.21
25	138.7	42.32	4.87	11.98	1.70	5.73
LSD(0.05)	35.6	0.49	Ns	1.92	0.67	2.45
CV (%)	10.84	4.79	13.78	7.05	13.22	11.32

However, it reduced markedly when the light availability was further reduced to 25% light level (11.98 g). Among the light levels, the highest yield $plant^{-1}$ was recorded at 75% light level (3.92 kg). The lowest yield $plant^{-1}$ was found under 25% light level (1.70 kg). The yield reduction at 25% light was contributed by the significant reduction of fruits $plant^{-1}$ and individual fruit weight. Almost similar result was found by Haque (2001) and Haque *et al.*(2009) in cucumber and yard long bean. The yield ha^{-1} exhibited the similar reduction pattern of yield $plant^{-1}$ with the decreasing light levels. However, yard long bean plant gave only 44% fruit yield under 25% light level compared to full sunlight. It means that shading with 25% sunlight exerted an adverse effect on the yield of yard long bean. There was significant polygonal (quadratic) relationship between fruit yield of yard long bean and light levels (Figure 1). This relation explained that the fruit yield of yard long bean was the maximum (12.95 t ha^{-1}) at 81.46% light level and beyond this light level fruit yield decreased at the rate of 0.0021 t ha^{-1}.

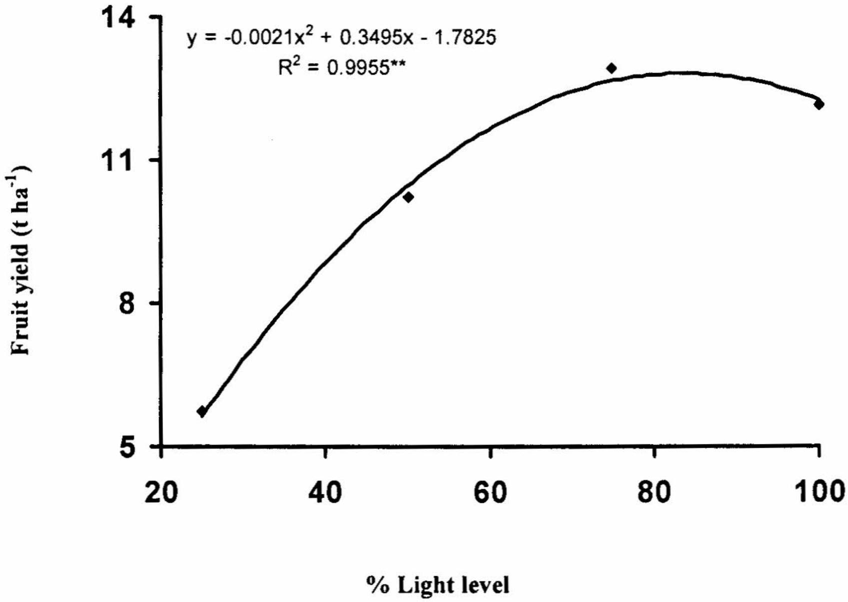

Fig. 1. Relationship between light levels and fruit yield of yard long bean

The overall results indicate that leaf $plant^{-1}$, LWR and leaf dry matter did not deduce significantly with the reduction of sunlight up to 50%. Because of these factors, plant gave higher number of fruit $plant^{-1}$ and bigger individual fruit between full sunlight to 50% light Consequently yard long bean did not show significant difference in fruit yield between 100% to 50% light.

CONCLUSION

The overall results suggested that yard long bean is suitable for growing as understorey crop where only half of the natural light is available. For more confirmation further thorough studies are suggested with large number of yard long bean genotypes under different tree species.

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