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Leaf Characteristics and Yield Performance of Mungbean (*Vigna radiata* L.) Varieties under Different Levels of Shading

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Abstract

An experiment was carried out to evaluate the leaf characteristics and yield performances of mungbean (*Vigna radiata* L.) under different light levels at the Crop Physiology and Ecology Research Field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during March to June 2016. The experiment was laid out in a split plot design with three replications. Three light levels (L_{100} - 100 % light intensity, L_{75}- 75 % light intensity and L_{50}- 50% light intensity) were assigned in the main plots and four varieties (BARl Mung-6, BINA Mung-8, BINA Mung-5 and BU Mug-4) were assigned in subplots. Mosquito nets of different pore size were used for maintaining 75 and 50 percent light intensity. Leaf area was increased due to reduced light levels in all mugbean varieties but the increment was significant in BINA Mung-5 and BINA Mung-8 only at 75% light intensity at 40 days after sowing and only in BARI Mung-6 with L_{50} and BU Mug-4 with L_{75} and L_{50}at 50 days after sowing. Due to reduced light levels, leaf dry weight was affected more in BINA Mung-5 and BU Mug-4 than BARI Mung-6 and BINA Mung-8. Leaf thickness was reduced under shade in all the mungbean varieties, except in BU Mug-4 at 75% light intensity, and the reduction in leaf thickness was mainly due to the reduction in thickness of spongy layer. The palisade layer thickness was influenced insignificantly but spongy layer thickness was increased in BINA Mung-5 at 100% light intensity. The grain yields (t ha^{-1}) of BARI Mung-6 and BINA Mung-8 remained stable under partial shade condition but the grain yield of BINA Mung-5 and BU Mug-4 was reduced drastically under partial shade condition. Higher leaf dry weight, number of pods $plant^{-}1$, seeds pod^{-1}, and heavier grains in BARI Mung-6 and BINA Mung-8 contributed to the higher grain yield $plant^{-1}$ under partial shade condition than in BINA Mung-5 and BU Mug-4.

Keywords: Mungbean, Light level, Spongy and palisade parenchyma and Yield.

1. Introduction

Mungbean (*Vigna radiata* L.) is one of the important pulse crops in our country. The agro ecological condition of Bangladesh is quite favorable for growing the crop. The demand of grain legumes is increasing day by day in Bangladesh due to increase in consciousness of the nutrition of leguminous food among the common people (BBS, 2012). High population pressure and increased demand for food and other agricultural commodities have already started disruption of the natural resource base and environment in Bangladesh. The production capacity of our land is decreasing progressively due to intensive cropping with high yielding crop varieties and high input technologies. However, legume crops are considered as the contributor to improve the soil health worldwide.

Cereal-legume intercropping is a very common practice all over Bangladesh. However, most of the grain legumes are sensitive to partial shading and often suffer from low light stress caused by associated tall crops (Miranda-Abilay and Lantican, 1982). The legume canopy when intercropped with maize received about 30- 50% of the total incoming radiation at around 30-35 days of age of maize seedling (Polthanee and Changsri, 1999, Polthanee and Treloges, 2002). Light is the basic element that provides energy for photosynthesis, which is the basis of crop production. Shading causes decreasing of quantity and quality of the sun light intercept to the crop and it affects the productivity of the intercrops. Yield reduction by shading depends upon crop species as well as the degree of shading. The degree of shading is generally controlled by the nature, age and characteristics of upper storied crops. The yield of soybean was decreased by 25% under 47% shade cover in the field (Wahua and Miller, 1978) and it was decreased by 30% under 40% artificial shade (Lantican and Catedral, 1977). In contrast under 40% artificial shade the yield of mungbean was decreased by 70% (Lantican and Catedral, 1977). Shading leads to phenotypic change in their photosynthetic apparatus (Sundari, 2009). Shading reduced photosynthesis due to increase in stomatal and mesophyll resistance, transpiration, partitioning of biomass from vegetative parts to economic parts (Nygren and Killomaki, 1993). General adaptive responses of crop plant to low irradiance are the increase in leaf area ratio, chlorophyll content, leaf to stem mass and stem length and decrease in leaf thickness (Fujita *et al*., 1993; Singh, 1994).

However, responses of mungbean to change in light intensity may vary in different genotypes. Hence, developing mungbean variety adapted to low light condition is important in the context of intercropping between legume and non-legume crops in Bangladesh. The mungbean genotypes which have the least decrease in grain yield, number of pods per plant, per cent leaf N and total stem N could be the most tolerant mungbean genotypes to low light situation (Wahua and Miller, 1978). Therefore, the present investigation was conducted to find out potential shade tolerant mungbean genotypes with following objectives-

1. To estimate the effect of reduced light levels on vegetative growth and leaf characteristics of different mungbean varieties, and
2. To estimate the effect of reduced light levels on yield performances of different mungbean varieties.

2. Materials and Methods

The experiment was conducted at the Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from March to June 2016.

2.1 Design and treatments

The experiment was laid out in a split plot design with three replications. Three light treatments were assigned in the main plots and four varieties were arranged in the subplots. Three light levels were $L_{100=}$100 % light intensity (open field control), $L_{75=}$ 75 % light intensity and $L_{50=}$50% light intensity), and the four mungbean varieties used in the sub-plots were BARI Mung-6, BINA Mung-8, BINA Mung-5 and BU Mug-4. L_{75} and L_{50} sunlight were maintained by using Mosquito nets.

2.2 Data collection and analysis

Three plants from each plot were randomly selected at 30, 40 and 50 days after sowing for collecting data on plant height, number of leaves, leaf area, leaf dry weight. Plant height was measured from base to the tip of the plant. Leaf area of all the green leaves was measured by leaf area meter (CI-202 AREA METER). At each sampling, plants were uprooted and separated into leaf, stem and root. After separating the different parts of the plants, individual component of the plants was oven dried at 70°C for at least 72 hours and weighed.

Leaf thickness was measured at 50 days after sowing. Firstly leaves were collected from the field and kept in ice-bag. Then crossed section was done and the thickness (mm) of leaf with palisade and spongy layer in microscope was measured with used stage and ocular meter scale. For yield components of mungbean, ten plants of each of variety on each subplot were selected randomly from each replication at maturity stage of crop. At maturity, pods were harvested in different pickings. The harvesting of mungbean pods was started at 61 days after sowing and ended at 80 days after sowing. Yield of mungbean varieties was determined from the summation of all picking period and then converted to t ha^{-1}. Length of individual pod, pod number per plant, seeds per pod and 1000 seed weight were also recorded from the ten randomly selected plants of each plot.

The data were analyzed by partitioning the total variance with the help of computer using STATA program. The treatment means were compared using Tukey's Test.

3. Results and Discussion

3.1 Plant height

The interaction of light levels and mungbean varieties influenced the height of plant significantly at 30, 40 and 50 days after sowing (Table 1). In general the height of the plant increased with the advanced of time after sowing. At 30 days after sowing, the tallest plant (30.33 cm) was observed in BARI Mung- 6 with 50% light intensity which was statistically similar to those observed in BINA Mung -8 with 50% light intensity, BARI Mung- 6 and BINA Mung- 8 with 75% light intensity, BU Mug-4 with 100% light intensity, BU Mug-4 with 50% and 75% light intensity. The shortest plant (25.50 cm) was observed in BINA Mung-8 with L_{100} which was statistically similar to those observed in BARI Mung- 6 and BINA Mung- 5 with $L_{100.}$ The results also showed that the plant height was increased with the reduction in light levels compared to the control (L_{100}) in all the mungbean varieties. The increment due to low light stress was significant for BARI Mung-6 and BINA Mung-8, and it was insignificant for BINA Mung-5 and BU mug-4.

At 40 days after sowing, the tallest plant (44.63 cm) was observed in BARI Mung-6 with 50% light intensity which was statistically similar to those observed in BINA Mung-5 with $L_{100,}$ BU Mug-4 with 50% and 75%. The shortest plant (30.43 cm) was observed in BU Mug-4 with L_{100} which was statistically similar to those observed in BARI Mung-6 with 100% and 75% light intensity, BINA Mung-8 with L_{100} and BINA Mung-5 with $L_{100.}$ The results also revealed that the plant height was increased with the reduction in light levels compare to control (L_{100}) in all the mungbean varieties. The increment was significant only at 50 percent light intensity (L_{50}) in BARI Mung-6 and BINA Mung-8, whereas the increment was significant both 75 percent light intensity (L_{75}) and 50 percent light intensity (L_{50}) in BINA Mung-5 and BU mug-4.

At 50 days after sowing, the tallest plant (53.36 cm) was observed in BU Mug-4 with 50% light intensity which was statistically similar to those observed in BARI Mung-6 with 50% light intensity, BINA Mung-8 with 50% light intensity, BU Mug-4 with 75% light intensity. The shortest plant (31.65 cm) was observed in BINA Mung-8 with L_{100} which was statistically similar to those observed in BINA Mung-5 with L_{100}. The results also showed that the plant height was increased with the reduction in light levels compare to control (L_{100}) in all mungbean varieties. The increment was significant both at 75 percent light intensity (L_{75}) and 50 percent light intensity (L_{50}). Similar results that shading effect increased plant height were also reported in mungbean by Islam (1995), Bashir (2002) and Islam (1996); in mungbean and chickpea by Ali (1998), in garden pea by Akhter *et al.* (2009c), in all legumes by Chiangmai *et al.* (2013) and in soybean by Bakhshy *et al*. (2013).

Table1. Plant height of mungbean as influenced by light levels and varieties at different days after sowing (DAS)

Variety	Light level	Plant height (cm)		
		30 DAS	40 DAS	50 DAS
BARI Mung- 6	L_{100}	26.03 d	31.69 e	33.73 cd
	L_{75}	29.26 ab	36.72 de	39.23 b
	L_{50}	30.33 a	44.63 a	45.96 ab
BINA Mung- 8	L_{100}	25.50 d	36.47 de	31.65 e
	L_{75}	29.64 ab	38.41 bd	42.09 b
	L_{50}	30.19 a	39.33 bc	44.78 ab
BINA Mung- 5	L_{100}	26.29 cd	37.18 de	33.33 de
	L_{75}	27.98 bc	39.30 bc	37.25 c
	L_{50}	28.13 bc	44.30 a	32.28 c
BU Mug- 4	L_{100}	29.03 ab	30.43 e	35.83 cd
	L_{75}	29.16 ab	43.57 ab	44.72 ab
	L_{50}	29.29 ab	43.60 ab	53.36 a
Level of significance		**	**	*
CV(%)		9.97	5.67	11.45

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control); L_{75}- 75 % light intensity; L_{50} - 50% light intensity

Table 2. Leaf number of mungbean as influenced by light levels and varieties at different days after sowing

Variety	Light level	Leaf number plant^{-1}		
		30 DAS	40 DAS	50 DAS
BARI Mung- 6	L_{100}	5.67	6.67	4.56
	L_{75}	5.67	6.56	4.11
	L_{50}	5.44	6.89	4.44
BINA Mung- 8	L_{100}	5.00	6.56	4.00
	L_{75}	5.22	6.44	3.89
	L_{50}	4.89	6.56	4.78
BINA Mung- 5	L_{100}	5.11	6.89	5.22
	L_{75}	5.44	6.89	4.45
	L_{50}	5.22	6.33	4.33
BU Mug- 4	L_{100}	5.89	7.00	4.33
	L_{75}	5.44	7.22	4.67
	L_{50}	5.33	7.00	5.22
Level of significance		NS	NS	NS
CV(%)		10.95	3.49	7.78

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control); L_{75}- 75 % light intensity; L_{50} - 50% light intensity.

3.2 Number of leaves per plant

The interaction of light levels and mungbean varieties showed that the leaf number was increased consecutively from 30 to 40 days after sowing thereafter decreased at 50 days after sowing (Table 2). At 30 days after sowing, the highest leaf number (5.89) was observed in BU Mug-4 with 100% light intensity and the lowest leaf number (4.89) was observed in BINA Mung-8 with 50% light intensity. At 40 days after sowing, the highest leaf number (7.22) was observed in BU Mug-4 with 75% light intensity and the lowest leaf number was observed in BINA Mung-5 with 50% light intensity (6.33). At 50 days after sowing, the highest leaf number was observed both in BU Mug-4 with 50% light intensity and BINA Mung-5 with 100% light intensity (5.22), the lowest leaf number was observed in BINA Mung-8 with 75% light intensity (3.89).

The lower number of leaves per plant at the reduced light conditions may be due to lower production of photosynthates under low light conditions (Miah *et al*. 1999). Islam (1995) in mungbean and Crookston *et al*. (1975) in dry bean also found decreased leaf number under shade condition. Similar result of decrease in leaf number due to shading was found in all legumes by Chiangmai *et al.* (2013).

3.3 Leaf area per plant

Leaf area per plant was not influenced significantly by the interaction of light levels and mungbean varieties at 30 days after sowing but it was influenced significantly at 40 and 50 days after sowing (Table 3).

At 30 days after sowing, the highest leaf area per plant (163.28 cm^2) was obtained in BARI Mung-6 with 75% light intensity and the lowest leaf area per plant was obtained in BU Mug-4 with 50% light intensity (96.29 cm^2).At 40 days after sowing, the highest leaf area per plant (482.44 cm^2) was obtained in BINA Mung- 8 with 75% light intensity. The lowest leaf area per plant (283.93 cm^2) was obtained in BU Mug-4 with 100% light intensity. The results revealed that the leaf area was increased due to reduced light levels in all mugbean varieties but the increment was significant in BINA Mung-5 and BINA Mung-8 only with 75% light intensity.

At 50 days after sowing, the highest leaf area per plant was obtained in BARI Mung-6 with 50% light intensity (430.20 cm^2) which was followed by all the treatment combinations. The lowest leaf area per plant was obtained in BU Mug-4 with 100% light intensity (173.38 cm^2) which was statistically similar in BARI Mung- 6 with 100% and 75% light intensity, BINA Mung-5 with 100%, 75% and 50% light intensity and BINA Mung-8 with 100% and 50%light intensity. The results revealed that the leaf area was increased due to reduced light levels in all mungbean varieties but the increment was significant only in BARI Mung-6 with L_{50} and BU Mug-4 with L_{75} and L_{50}.

Kubota and Hamid (1992) reported increased leaf area in mungbean and decreased leaf area in black gram under shade condition. Sundari (2009) found bigger leaves in tolerant genotypes than that of sensitive mungbean genotypes. Akhter *et al.* (2009b) investigated low light responses of eight garden pea genotypes. Among the genotype tested in the experiment leaf area (LA) increased with the reduction of PAR in P 30 and Local white but LA reduced in rest of the genotypes. Araki et al. (2014) also found a similar result that shading increased leaf area in greengram.

3.4 Leaf dry weight per plant

The interaction of light levels and mungbean varieties did not influence the leaf dry weight per plant significantly at 30 days after sowing but it was influenced significantly at 40 and 50 days after sowing (Table 4).

At 30 days after sowing, the highest leaf dry weight per plant (0.56 g) was obtained in BINA Mung-5 with 75% light intensity and the lowest leaf dry weight per plant (0.33 g) was obtained in BU Mug-4 with 50% light intensity.

Table 3. Leaf area of mungbean as influenced by light levels and varieties at different days after sowing

Variety	Light level	Leaf area plant^{-1} (cm^2)		
		30 DAS	40 DAS	50 DAS
BARI Mung- 6	L_{100}	133.82	307.69 c	186.10 e
	L_{75}	163.28	319.12 c	209.41 ce
	L_{50}	125.55	403.41 ac	430.20 a
BINA Mung- 8	L_{100}	124.29	289.91 c	218.53 be
	L_{75}	152.38	482.44 a	280.64 cd
	L_{50}	148.13	344.73 bc	232.01 be
BINA Mung- 5	L_{100}	116.92	312.52 c	194.04 e
	L_{75}	135.69	461.96 ab	205.39 de
	L_{50}	116.78	303.68 c	207.19 ce
BU Mug- 4	L_{100}	134.06	283.93 c	173.38 e
	L_{75}	133.67	409.60 ac	291.80 b
	L_{50}	96.29	377.68 ac	278.79 bd
Level of significance		NS	**	*
CV(%)		9.97	4.68	4.89

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control); L_{75}- 75 % light intensity; L_{50} - 50% light intensity.

Table 4. Leaf dry weight of mungbean as influenced by light levels and varieties at different days after sowing

Variety	Light level	Leaf dry weight (g)		
		30 DAS	40 DAS	50 DAS
BARI Mung- 6	L_{100}	0.45	1.61 ab	1.34 b
	L_{75}	0.53	1.29 ac	1.42 b
	L_{50}	0.44	1.71 a	1.72 a
BINA Mung- 8	L_{100}	0.42	1.46 ac	1.42 b
	L_{75}	0.46	1.56 ab	1.42 b
	L_{50}	0.45	1.54 ac	1.32 b
BINA Mung- 5	L_{100}	0.48	1.37 ac	1.85 a
	L_{75}	0.56	1.61 ab	1.79 a
	L_{50}	0.35	1.05 c	1.27 b
BU Mug- 4	L_{100}	0.55	1.46 ac	1.66 b
	L_{75}	0.52	1.66 a	1.34 b
	L_{50}	0.33	1.20 bc	1.27 b
Level of significance		NS	**	*
CV(%)		6.97	6.43	4.34

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control); L_{75}- 75 % light intensity; L_{50} - 50% light intensity.

At 40 days after sowing, the highest leaf dry weight per plant (1.71 g) was obtained in BARI Mung-6 with 50% light intensity which was statistically similar in all treatment combinations except BINA Mung-5 and BU Mug- 4 with 50% light intensity. The lowest leaf dry weight per plant (1.05 g) was obtained in BINA Mung-5 with 50% light intensity which was statistically similar in BU Mug- 4 with 100% and 50% light intensity, BARI Mung-6 with 75% light intensity, BINA Mung-5 with 100% light intensity, BINA Mung-8 with 100% and 50% light intensity.

At 50 days after sowing, the highest leaf dry weight per plant (1.85 g) was obtained in BINA Mung-5 with 100% light intensity which was statistically similar in BINA Mung-5 with 75% light intensity and BARI Mung-6 with 50% light intensity. The lowest leaf dry weight per plant (1.27 g) was obtained both in BINA Mung-5 and BU Mug- 4 with 50% light intensity which was statistically similar in all treatment combinations except BARI Mung-6 with 50% light intensity, BINA Mung-5 with 100% and 75% light intensity.

The overall results in leaf dry weight showed that BINA Mung-5 and BU Mug-4 affected more than BARI Mung-6 and BINA Mung-8. Islam *et al*. (1993) and Laosuwan *et al*. (1991) reported lower specific leaf weight in mungbean. Akhter *et al.* (2009b) reported lower specific leaf weight in garden pea under shade. Rao and Mittra (1988), Marler *et al*. (1994) and Singh (1994) found lower leaf dry weight in legume crops under shade. Similar result was found in all legumes by Chiangmai *et al*. (2013). Araki et al. (2014) also found similar result in greengram.

3.5 Thickness of palisade and spongy layer

Light levels and mungbean varieties interacted significantly to influence the thickness of spongy layer but the thickness of palisade layer was not influenced significantly by the interaction effect of light levels and mungbean varieties (Table 5).

Table 5. Thickness of spongy and palisade layer of mungbean as influenced by light levels and mungbean varieties

Variety	Light level	Thickness of spongy layer (mm)	Thickness of palisade layer (mm)
BARI Mung- 6	L_{100}	0.10 ab	0.13
	L_{75}	0.10 ab	0.13
	L_{50}	0.07 b	0.12
BINA Mung- 8	L_{100}	0.09 ab	0.11
	L_{75}	0.06 b	0.12
	L_{50}	0.10 ab	0.10
BINA Mung- 5	L_{100}	0.13 a	0.10
	L_{75}	0.11 ab	0.13
	L_{50}	0.09 ab	0.10
BU Mug- 4	L_{100}	0.09 ab	0.11
	L_{75}	0.10 ab	0.12
	L_{50}	0.08 ab	0.10
Level of significance		*	NS
CV(%)		9.97	3.43

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control), L_{75}- 75 % light intensity, L_{50} - 50% light intensity.

Table 6. Yield attributes of mungbean as influenced by light levels and varieties

Variety	Light level	No.of pod plant^{-1}	No. of seed pod^{-1}	1000 seed wt (g plot^{-1})
BARI Mung- 6	L_{100}	10.00 a	8.57 ef	45.20 b
	L_{75}	9.57 ab	9.15 bc	47.23 a
		(-4.30)	(6.77)	(2.03)
	L_{50}	9.27 ab	9.03 bd	44.00 b
		(-7.30)	(5.37)	(-2.65)
BINA Mung- 8	L_{100}	8.97 ab	8.08 g	45.28 b
	L_{75}	9.63 ab	8.62 ef	44.09 b
		(7.35)	(6.68)	(-2.63)
	L_{50}	9.07 ab	8.40 fg	45.11 b
		(1.11)	(3.96)	(0.38)
BINA Mung- 5	L_{100}	9.90 a	9.20 bc	38.26 d
	L_{75}	7.03 de	9.32 b	38.91 d
		(-28.99)	(1.30)	(1.70)
	L_{50}	7.70 cd	8.95 cd	40.49 c
		(-22.22)	(-2.72)	(5.83)
BU Mug- 4	L_{100}	8.93 ac	9.20 bc	45.40 b
	L_{75}	8.27 bd	9.73 a	41.87 c
		(-7.39)	(5.76)	(-9.85)
	L_{50}	6.07 e	8.78 de	41.65 c
		(-32.03)	(-4.56)	(-8.26)
Level of significance		**	**	**
CV (%)		5.97	1.25	1.26

In a column, means followed by different letter(s) differed significantly by Tukey'stest at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control), L_{75}- 75 % light intensity, L_{50} - 50% light intensity.

The highest spongy layer thickness (0.13 mm) was recorded in BINA Mung-5 with 100% light intensity which was statistically identical in all treatment combinations except BARI Mung-6 with 50% light intensity and BINA Mung-8 with 75% light intensity. The lowest spongy layer thickness (0.06 mm) was recorded in BINA Mung-8 with 75% light intensity which was statistically identical to those recorded in all other treatment combinations except BINA Mung-5 with 100% light intensity.

The results revealed that leaf thickness was reduced under shade in all varieties except in BU Mug-4 with 75% light intensity and this reduction in leaf thickness was due to reduced thickness of spongy layer. Crookston *et al*. (1975) reported that shading reduced leaf thickness of bean. Similar result of shading induced reduced thickness was found in all legumes by Chiangmai *et al.* (2013) and Araki *et al.* (2014).

3.6 Yield and yield contributing characters

The interaction effect of light levels and mungbean varieties on number of pod per plant was significant (Table 6). The highest number of pod per plant (10.00) was observed in BARI Mung-6 with 100% light intensity which was statistically similar to those recorded in BINA Mung-5 with 100% light intensity, BINA Mung-8 with 100%, 75% and 50% light intensity, BARI Mung-6 with 75% and 50% light intensity and BU Mug-4 with 100% light intensity. The lowest number of pod per plant (6.07) was observed in BU Mug-4 with 50% light intensity which was statistically similar to that recorded in BINA Mung-5 with 75% light intensity.

Percent change from L_{100} values indicated that the number of pod per plant was reduced with reduction in light levels in BARI Mung-6, BINA Mung-5 and BU Mug-4 but it was even increased in BINA Mung-8 under low light levels. The reduction in number of pod per plant with the reduction of light levels was more in BINA Mung-5 and BU Mug-4 than that in BARI Mung-6.

3.7 Number of seeds pod^{-1}

The interaction effect of light levels and mungbean varieties on number of seed per pod was significant (Table 6). The highest number of seed per pod (9.73) was recorded in BU Mug-4 with 75% light intensity which was followed by all others treatment combinations. The lowest number of seed per pod (8.08) was recorded in BINA Mung-8 with 100% light intensity which was statistically similar to that recorded in BINA Mung-8 with 50% light intensity (8.40).

Percent change from control (L_{100}) values indicated that the number of seed per pod was increased with reduction in light levels in BARI Mung-6 and BINA Mung-8. On the other hand, in BINA Mung-5and BU Mug-4 it was increased in 75% light intensity but decreased in 75% light intensity.

3.8 Thousand Seeds weight plot^{-1}

The interaction effect of light levels and mungbean varieties on 1000-seed weight was significant (Table 6). The heaviest 1000-seed weight (47.23 g) was observed in BARI Mung-6 at L_{75}which was followed by all others treatment combinations. The lowest 1000-seed weight (38.26 g) was observed in BINA Mung-5 at L_{100}which was statistically similar to that recorded in BINA Mung-5 at L_{75} (38.91 g). The results in thousand seeds weight also revealed that it was increased or remained more or less unchanged due to low light conditions in BARI Mung-6, BINA Mung-8 and BINA Mung-5 but it was reduced with the reduction in light levels in BU Mug-4.

3.9 Grain yield

The interaction effect of light levels and mungbean varieties on grain yield per plant was significant (Table 7). The highest grain yield per plant (3.07 g) was observed in BARI Mung-6 both at L_{100} and L_{75} which was statistically similar to those obtained from BINA Mung-8 at L_{100} (3.01 g), BU Mug-4 at L_{100} (3.00 g), BARI Mung-6 at L_{50} (2.89 g) and BINA Mung-5 at L_{100} (2.89 g). The lowest grain yield per plant (2.02 g) was observed in BU Mug-4 at L_{50}. The results in grain yield plant^{-1} also revealed that it was remained unchanged or decreased with the reduction in light levels but the reduction in grain yield plant^{-1} more in BINA Mung-5 and BU Mug-4 than in BARI Mung-6 and BINA Mung-8.

The interaction of light levels and mungbean varieties influenced the grain yield (t ha^{-1}) significantly (Table 7). The highest grain yield per hectare (0.94 t ha^{-1}) was recorded in BU Mug-4 with 100% light intensity which was statistically similar to those recorded in BINA Mung-5 with 100% light intensity (0.90 t ha^{-1}). The lowest grain yield per hectare (0.52 t ha^{-1}) was recorded in BU Mug-4 with 50% light intensity which was statistically similar to that observed in BINA Mung-5 with 50% light intensity (0.60 t ha^{-1}). Other treatment combinations provided moderate grain yield.

The results in grain yield per hectare also indicated that the yield was remained statistically unchanged due to lower light levels in BARI Mung-6 and BINA Mung-8 but in BINA Mung-5 and BU Mug-4, the grain yield was reduced with the reduction in light levels.

Lantican and Catedral (1977), Laosuwan *et al.* (1992) and Miranda-Abilay and Lantican (1982) observed lower seed yield for shaded grown mungbean plant.

Table 7. Grain yield of mungbean as influenced by light levels and varieties

Variety	Light level	Grain yield (g plant^{-1})	Grain yield (tha^{-1})
BARI Mung- 6	L_{100}	3.07 a	0.82 ce
	L_{75}	3.07 a (0.00)	0.79 de
	L_{50}	2.89 ad (-5.86)	0.82 ce
BINA Mung- 8	L_{100}	3.01 ac	0.85 bc
	L_{75}	2.86 bd (-4.98)	0.87 bc
	L_{50}	2.84 cd (-5.64)	0.86 bc
BINA Mung- 5	L_{100}	2.89 ad	0.90 ab
	L_{75}	2.47 e (-14.53)	0.76 e
	L_{50}	2.28 e (-21.11)	0.60 g
BU Mug- 4	L_{100}	3.00 ac	0.94 a
	L_{75}	2.75 d (-8.33)	0.61 f
	L_{50}	2.02 f (-32.67)	0.52 g
Level of significance		**	**
CV(%)		2.66	3.43

In a column, means followed by different letter(s) differed significantly by Tukey's test at $P \leq 5\%$ level of probability. L_{100} - 100 % light intensity (open field control), L_{75}- 75 % light intensity, L_{50} - 50% light intensity.

Polthanee *et al*. (2011) showed that grain yield of soybean was significantly ($p < 0.05$) decreased under the low light intensity at 30% of natural light both in wet and dry season. Akhter *et al.* (2009c) reported reducing the light intensity from 100% to 25% exerted variable quantity of reduction of dry seed yield plant^{-1} in different genotypes and the reduction of seed yield plant^{-1} was attributed to poor pod plant^{-1}, fewer seed pod^{-1} and smaller weight of seed. Islam (1995) found pods per plant decreased with the increase of shading. . Khan *et al.* (2012) also reported reduced number of pods plant^{-1}, number of grains pod^{-1}, 1000-grain weight, biological yield and grain yield of mungbean in plots intercropping with maize compared to sole mungbean.

4. Conclusions

Leaf area was increased due to reduced light levels in all mugbean varieties but the increment was significant in BINA Mung-5 and BINA Mung-8 only at 75% light intensity at 40 days after sowing and only in BARI Mung-6 with L_{50} and BU Mug-4 with L_{75} and L_{50}at 50 days after sowing. Due to reduced light levels, leaf dry weight was affected more in BINA Mung-5 and BU Mug- 4 than BARI Mung-6 and BINA Mung-8.Leaf thickness was reduced under shade in all the mungbean varieties except in BU Mug-4 at 75% light intensity, and the reduction in leaf thickness was mainly due to the reduction in thickness of spongy layer. The palisade layer thickness was insignificantly influenced but spongy layer thickness was increased in BINA Mung-5 at 100% light intensity. The grain yield (t ha^{-1}) of BARI Mung-6 and BINA Mung-8 remained stable under partial shade condition but the grain yield of BINA Mung-5 and BU Mug-4 was reduced drastically under partial shade condition. Higher leaf dry weight, number of pods $plant^{-1}$seeds pod^{-1}, and heavier grains in BARI Mung-6 and BINA Mung-8 contributed to the higher grain yield $plant^{-1}$ under partial shade condition than in BINA Mung-5 and BU Mug-4.

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