YIELD PERFORMANCE OF MUNGBEAN IN DIFERRENT LIGHT LEVEL

A Thesis

By

Md. Hafizur Rahman

Student No. 1405044

MASTER OF SCIENCE

IN

CROP PHYSIOLOGY AND ECOLOGY

DEPARTMENT OF CROP PHYSIOLOGY AND ECOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY DINAJPUR

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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

A field experiment was carried out at the Research Field of Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from April 20, 2015 to June 30, 2015 to evaluate the three mungbean varieties in regard to morpho-physiological parameters, yield and yield contributing characteristics under different light levels. The experiment was laid out in a split plot design with three replications. Three light levels i.e. 100, 75 and 50 percent of full sunlight were assigned in the main plot while three mungbean varieties (BINA mung 5, BINA mung 8 and BARI mung 6) were assigned in the sub-plot. Light levels were adjust using mosquito nets of different mesh sizes and color. Different light levels had a significant effect on morpho-physiological characteristics like plant height, number of leaves, leaf area, chlorophyll content, dry weight of leaf, stem and root of different days after sowing (DAS) of different mungbean varieties. In case of yield and yield contributing characteristics like number of pods per plant, number of seeds per pod, thousand grain weight and yield of different mungbean varieties found higher at 100 percent of full sunlight compare to 75 and 50 percent of full sunlight. Among the three varieties, BARI Mung 6 showed lesser reduction in pods per plant, number of seed per pod, thousand grain weight and yield both at 75 and 50 percent of full sunlight and this variety may be used as tolerant variety under partial shade condition.

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CHAPTER I

INTRODUCTION

The demand of grain legumes is increasing day by day as they are the second largest crops next to cereals as a source of food for human. Grain legumes are potential intercrops because of their relatively short duration crop, high protein value and nitrogen fixing ability. They are commonly grown with comparatively long duration crops crops such as maize, sugarcane etc. 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 reduction in light reaching the legume canopy when intercropped with maize was about 30% - 50% of the total incoming radiation and began around 30 - 35 days after maize seeding (Polthanee and Changsri 1999, Polthanee and Treloges 2002 and Polthanee and Treloges 2003). 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 (Catedral and Lantican 1977). In contrast, under 40% artificial shade the yield of mungbean was decreased by 70% (Lantican and Catedral 1977).

Shade leaves generally lacking in well-organized palisade layer (one or two) and the mesophyll mainly consists primarily of spongy parenchyma and intercellular air space (Allard *et al*. 1991 and Hart 1990). As a consequence, the shade leaves are thinner with lower Specific Leaf Weight (Weaver and Clements, 1978). Shading leads to phenotypic change in their photosynthetic apparatus (Sundari 2009). Shading reduced photosynthesis due to increase in stomatal and mesophyll resistance, transpiration, portioning of biomass from vegetative parts to economic parts (Nygren and Killomaki 1993). General adaptive responses of crop plant to low irradiance are increase in leaf area ratio, chlorophyll content, leaf to stem mass and stem length and decrease in leaf thickness, chl a to b ratio and relative root to shoot growth (Fujita *et al*. 1993 and Singh 1994).

Mungbean (*Vigna radiata* L.) is one of the most important grain legumes in Bangladesh which has the potential to be used as profitable intercrop. However, the responses of mungbean to change in light intensity may vary in different genotypes. Hence, developing variety adapted to low light condition is important and a need has arisen for selecting shade tolerant mungbean genotypes. 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 (Wahua and Miller 1978). Therefore, the study was conducted to find out potential shade tolerant mungbean genotypes with following objectives-

1. To assess the effect of reduced light levels on leaf characteristics of mungbean varieties
2. To identify low light tolerance suitable mungbean variety
3. To evaluate on dry matter partitioning, yield attributes and yield of mungbean under reduced light levels

CHAPTER II

REVIEW OF LITERATURE

A good number of research works have been carried out on various aspects of management practices for higher productivity of mungbean. Still intensive research on improving its yield and quality is in progress. Yield and quality of maize are complex characters and these are contributed by many morphological and physiological events. The present study is related to yield of mungbean as influenced by light levels. The information available in this area generated from different studies has been reviewed in this chapter.

Polthanee *et al.* (2011) conducted an experiment to determine the influence of light regimes (30 % of normal light, 50 % of normal light and normal light) on the growth and yield of four soybean cultivars (early, medium and late maturity) under artificial shading at 35 days after seeding until harvest in the wet and dry seasons. The results showed that grain yield was significantly ($p < 0.05$) decreased under the low light intensity at 30 % of natural light both in wet and dry season. This was mainly due to low light intensity at 30 % of natural light decreasing the number of pods per plant in the dry season. The cultivar KKU 74 (medium maturity) gave maximum grain yield both in wet and dry season under the low light at 30 % of natural light. The KKU 74 cultivar is better adapted to shading environment than other cultivars. This was due to the KKU 74 cultivar produced higher chlorophyll b concentration in leaves after the plant experienced to shading.

Akhter *et al.* (2009a) investigated low light responses of eight garden pea genotypes in terms of dry matter accumulation and partitioning in the plant. The light treatments consisted of (i) 100 % photo-synthetically active radiation (PAR) measured in the open field and (ii) 25 %, (iii) 50 %, (iv) 75 % reduction of natural PAR obtained by using mosquito nets of variable color and mesh number. Most of the genotypes (e.g. IPSA3, P30, P51, P52 and local white) showed increased total dry matter production (TDM) under 75 % PAR level compared to 100% but reduced with further reduction of PAR in all the genotypes tested. . Among the genotype tested in the experiment Per cent of dry matter allocation to leaf and stem was increased in P30, P51, P52, J1 and local white due 25 % reduction of PAR, whereas it was decreased in rest of the genotypes. Further reduction in light intensity decreased the percent dry matter investment to leaf and stem. Per cent dry matter allocation to seed was increased in IPSA1, IPSA2, IPSA3, J1 and local white due to reduction in light intensity, whereas the investment to seed was reduced in other genotypes by reducing light treatment.

Akhter *et al.* (2009c) investigated low light responses of eight garden pea genotypes in terms of morphological and yield attributes. The light treatments consisted of (i) 100 % photo-synthetically active radiation (PAR) measured in the open field and (ii) 25 %, (iii) 50 %,

(iv) 75 % reduction of natural PAR obtained by using mosquito nets of variable color and mesh number. Plant height, internode length and node number were increased under reducing light intensity up to 25 % PAR compared to 100 % PAR in garden pea genotypes P51, P52, P30 and J1. In other genotypes these parameters were increased up to 50 % PAR thereafter decreased in 25 % PAR. Reducing the light intensity from 100 % to 25 % exerted variable quantity of reduction of dry seed yield plant^{-1} in different genotypes. The minimum extent of reduction in seed yield plant^{-1} was range between 54 % and 59 % and was observed in P30 (54 %), Local White (55 %) and in P52 (59 %). The largest reduction was observed in IPSA3 (80 %). Reduction of seed yield plant^{-1}was attributed to poor pod plant^{-1}, fewer seed pod^{-1} and smaller weight seed. The results lead to suggest that among the eight garden pea genotypes tested in the present experiment P30 and local white performed better under low light environment whereas IPSA3 was found as sensitive to reducing light intensity.

Akhter *et al.* (2009b) investigated low light responses of eight garden pea genotypes in terms of physiological attributes. The light treatments consisted of (i) 100 % photo-synthetically active radiation (PAR) measured in the open field and (ii) 25 %, (iii) 50 %, (iv) 75 % reduction of natural PAR obtained by using nets of variable color and mesh number. 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. Reduction of specific leaf weight (SLW) was recorded in all the genotypes as light level was reduced.

At 25 % PAR genotypes IPSA 1, P 30, P 52 and Local white maintained maximum leaf weight ratio (LWR) and the increasing pattern with reducing light intensities was higher in P 30, P 52 and Local white compare to IPSA 2 and IPSA 3. The rate of photosynthesis decreased more of less with equal magnitude with the decreasing light level from 100 % to 25 % of PAR as measured only in IPSA3 and P30.

Chipungahelo *et al*. (2007) studied the effect of light regimes on three different crops namely sweet potato, cowpea and pineapple between 1995 and 1996. Four light intensities with nominal values of light transmission namely LO= 100 %, L1= 75 %, L2= 50 %, L3= 25 % were provided by nylon netting materials which filtered sunlight to varying light percentages. They found that light intensity strongly influenced growth and development of sweet potato. Specific leaf area values in full light were smaller than those in under heavy shade. The light intensity increased the cowpea seed yield significantly ($p<0.01$) and the interaction between seasons (year) x light regimes was significant ($p<0.01$). In low intensity, pineapple flowered earlier and yielded more than in high intensity.

Miranda-Abilay and Lantican (1982) evaluated some parameters associated with yield performance of selected mungbean varieties grown under 40 per cent shading in 1980. Higher harvest index, greater pod number per plant, higher specific leaf weight, higher area ratio and lower leaf duration, determinate growth habit, and greater resistance to diseases were the characters associated with shade tolerance. Correlation and path coefficient analyses indicated that pod number per plant, specific leaf weight, leaf area ratio and leaf area duration at six weeks after emergence contributed greatly to yield variation under partial shaded condition. In addition total chlorophyll and carotenoid content were increased but nitrate reductase activity decreased due partial shade condition.

Kubota and Hamid (1992) compared the light-responses of growth, dry matter production, photosynthesis and leaf or mesophyll conductance between mungbean cultivar Chinese and black gram cultivar MAK-1 grown in different light intensities. Dry matter production and leaf area of black gram decreased with shade, while those of mungbean became the highest under the moderate shade condition (55% in relative light intensity). The light-photosynthetic response of shade-grown mungbean presented a typical shade-leaf pattern characterized by photosynthetic reduction and low light-saturation point. While in black gram photosynthetic difference was not apparent between control and shade-grown plants, both of which had no light saturation within a light intensity range up to 1,800 µmol $m^{-2}s^{-1}$. Mesophyll conductance in shade-grown black gram was considerably higher than that of control plant at a light intensity below 1,000 µmol $m^{-2}s^{-1}$ which may suggest the enzymatic activity in CO_2 fixation system was enhanced under the shade conditions.

Karim *et al.* (2003) evaluated the photosynthetic performance of mungbean (*Vigna radiata* L.) leaves developed at (1) 30/25°C +700 PFD (LT+HI), (2) 40/25°C+700 PFD (HT+HI), and (3) 40/25°C+200 PFD (HT+LI). They found that Photosynthesis (Pn) of the LT+HI-developed leaves continued to increase till 2000 PFD while the Pn was lower in the leaves developed at high temperature. HT+/HI-developed leaves showed higher Pn than that developed at the same temperature but with low light (HT+LI). Rapid light curves revealed that leaves developed at high light had better photosynthetic efficiency at fast changing light environment than those developed at low light irrespective of their growth temperatures.

Nine tolerant genotypes (MMC 87 D-KP-2, MLG 369, MLG 310, MLG 424, MLG 336, MLG 428, MLG 237, MLG 429, and VC2768B) and three sensitive genotypes to shading (Nuri, MLG 460, and MLG 330) were tested by Sundari (2009) in two shading levels, which were without shading and shading of 52 %. The results showed that the shading tolerant mungbean genotypes had good response to light stress so that the growth and development of the leaves were better than that of sensitive genotypes. The shading tolerant mungbean genotypes had bigger and thicker leaves than that of sensitive genotypes. The shading treatments caused reducing rate of PAR absorption, transpiration, photosynthesis, and CO_2 stomata conductance. The reduction of all parameters in tolerant genotype was smaller than that of sensitive genotype. The specific leaf area at four weeks after planting could be used as shading tolerant indicator of mungbeans.

Hidoto and Loha (2013) conducted a field experiment using cassava (cultivar Kelo) and 4 legume varieties including haricot bean (omo 95), mung bean (boroda-1), soybean (Awassa-95), and cow pea (Maze). Intercropping cassava with haricot bean, cowpea, soybean and mung bean, reduces cassava yield by 27, 37, 52 and 50% respectively. However, intercropping cassava with haricot bean, cowpea, soybean and mung bean resulted in 82, 49, 48, and 62% greater land use efficiency than for either crop grown alone. Overall land equivalent ratio (LER) was greater than one when cassava intercropped with legumes.

The influence of different intercropping treatments on yield and yield components of mungbean was investigated by Khan *et al.* (2012) at the New Developmental Farm of Khyber Pakhtunkhwa Agricultural University Peshawar. The experiment comprised of five treatments viz, sole mungbean, maize + 1 row of mungbean simultaneously seeded, intercrop maize + 2 rows of mungbean simultaneously seeded, intercrop maize + 1 row of mungbean delay seeded by 3 weeks, intercrop maize + 2 rows of mungbean delay seeded by 3 weeks. The treatments significantly affected nodules plant^{-1}, nodule dry weight, pods plant^{-1}, number of grains pod^{-1}, thousand grain weight, grain yield and biological yield though the impact was non-significant on weeds fresh and dry biomass parameters. Highest number of nodules plant^{-1} (9.87), nodules dry weight (2.10 g), number of pods plant^{-1} (17.32), number of grains pod^{-1} (4.23), thousand grain weight (39.33 g), biological yield (1654 kg ha^{-1}) and grain yield (525 kg ha^{-1}) of mungbean was recorded in plots where sole mungbean was cultivated as compared to intercropping with maize in all combinations.

Ialam *et al*. (1993) evaluated growth and yield response of mungbean to different shading conditions imposed at the onset of pod formation stage. Shading nets were used to cut down the incident photosynthetic active radiation by 15 %, 45 % and 75 %. They found almost no difference between the control and 15 % shaded plants for all the parameters studied. Total dry weight was found to decrease with increase in shading intensity and this phenomenon continued till the maturity of the crop. The crop growth rate, relative growth rate and net assimilation rate decreased due to shading. Lower specific leaf weight and higher chlorophyll content were due to increased shading. Decreased photosynthetic active radiation caused significant reduction in pods per plant and thus there was a significant decrease in seed yield per plant.

Mungbean (*Vigna radiata* L.) Wilczek) is one of the important pulse crops in our country. The agro ecological condition of Bangladesh is quite favorable for growing the crop. The crop is usually grown with residual soil moisture in Bangladesh under rain fed condition with little or no inputs but it adds a lot to improve the soil health. Its yield in Bangladesh is very low compared to other countries (Bose 1982). A brief review relating morpho -physiological characteristic in yield improvement of mungbean genotypes under the sun and shaded conditions are discussed below:

Generally dry matter and yield of mungbean are higher under sun but it is necessary to grow some crops under reduced light condition when intercopping systems is practiced. In the context Islam et al. (1993) conducted an experiment with mungbean under three levels of shading and reported that there are almost on differences between full sun (control) and 15 precent shading for all the plant parameters. However, the growth attributes and yield of mungbean were decreased with further increase level.

Shade has pronounced effect on morphological characters of many crops. It influences plant height, number of branch per plant, pod length, pod number etc. which ultimately affect final yield. Generally plants grown under shade are elongated because of enhancement of auxin synthesis. Islam (1995) working with mungbean and Murshed (1996) with chickpea found taller plants under shaded condition in both the crops. Miah *et al*. (1999) found that the tallest onion plants under 25 percent PAR level and shortest ones under 100 percent PAR level. Similar results were also reported in mungbean and chickpea (Ali 1998). Shading produced taller tomato plant with longer internodes (Thomas and Teoh 1983) and thinner stem (Bscetinceli *et al.* 1994). Plant grow in low light levels was found to be apically dominant than those grown in high light environment resulting taller plant under shade (Hillman 1984).

Different levels of PAR also influence the number of leaves per plants and varietal different is also found in this regard. In mungbean leaf number usually decreases under shade condition (Islam 1995) and most of the crops such as red amaranth, Indian spinach (Ali 1999, wadud 1999). But in tomato and okra highest number of leaves produced at 75 percent PAR lealve (Miah 2001). Physiological and morphological differences between *plantago major* (l) growing in full sunlight and shaded condition were (Niklas and Owens 1989). Morphometric comparisons indicate shaded plants bear fewer leaves have and less leaf overlap, lower total leaf area and longer petioles than full sun-plants. Leaf elongation rates are lower and the duration between the emergence of successive leaves is longer in shaded plants.

Plants grown at high intensity have different leaf morphology from those grown at low light intensities. (Crookston *et at*. 1975).They also reported that shading reduced leaf number, leaf area and thickness of dry bean. Rao and Mitra (1988) reported that leaf thickness was correlated with light intensity during the growth and indicated light photosynthetic activity in leaves with higher specific leaf weight. Allard *et al.* (1991 b) and singh *et al*. (1985) observed a lower leaf area per plant in low irradiance compared with high irradiance. Genotypic variation in leaf area development of mungbean was documented by Bushby and Lawn (1992). Among the different genotypes of mungbeans, they found CPI 106032 showed the highest leaf area development and satin the lowest. Under shade condition leaf senescence is delayed which might prolong the reproductive phase life ripen of shade grown plants and root growth reduced (Andersen *et al.* 1993). It was observed that the seed yield of plant and leaf dry weight was decreased and flowering delayed at 50 percent light intensity (Laosuwan *et al*. 1992). When PAR was reduced by 50 percent senescence was delayed (Sheldrake and Saxena 1980).

Effect of light on growth parameters of crops was also reported by Sinoquet and Caldwell (1995). Growth parameters of crops depend upon the amount of photo synthetically active radiation intercepted by the crop canopy and there is functional relationship between crop growth and leaf area (Wilson 1990). Leaf area of mungbean might be increase due to heavy shading (Kubota and Hamid 1992) but shade plants receive lower amount of photosynthetic active radiation which reduce photosynthetic rate (Crookston *et al.* 1975) and lower the growth attributes. Shading also may reduce leaf thickness, increase intracellular resistance and impair biological reaction of the leaf. Further with the advancement of time, mutual shading is obvious (Imai *et al*. 1993) which declines the effective leaf area and reduce net assimilation rate of shaded plants (Adelana and Milbourn 1972). This is reflected in growth components of plants and, Rao and Mittra (1988) observed lower relative growth rate and net assimilation rate in peanut under 25 and 50 percent shading, respectively. Pandey *et al.* (1978) also reported similar observation in black gram.

Leaf area is made up of the total green lamina area of emerged leaves (Keating and Carberry 1993). It is one of the important determinants of dry matter production and yield of crops. Dry matter produced by plant in an interval of time is more dependent on the size of its total assimilating system than on the photosynthetic rate of a single leaf. Photosynthetic rate of mungbean leaf also varies with the variation of light regimes as well as with the variation of season. Rao and Ghildyal (1985) found lower photosynthetic rate of mungbean under 40 percent reduced light than the normal light.

It has been shown that the rate of dry matter production is proportional to the amount of radiation intercepted by the plants (Williams *et al.* 1965, Murty and Venkateswaralu 1978). Islam *et al*. (1993) and Ghandoram *et al*. (1988) reported that total dry weight decreased with the increase of shading intensity and this continued until the crop maturity. They found that the crop growth rate, relative growth rate, Net Assimilation Rate decreased due to shading. Therefore decreased photosynthetically Active Radiation caused a significant reduction in number of pod per plants and thus there was a significant decrease in seed yield per plant. Shading that decreased light intensity by 15 percent; seed yield reduced significantly when other factors were not limiting (Pandey and Torrie 1980).

The production of dry matter and its conversion into economic yield is the cumulative result in various physiological and biological events occurring in the life cycle of the plant system. Leaf photosynthesis is one of the basic physiological attributes that determines plant biomass production and harvestable yield of crops (Chandrababu *et al.* 1985). Mungbean cultivars grown in summer with high solar radiation showed better photosynthesis and crop growth rate, NAR, SLW and higher LAI than mungbean grown during the rainy season with cloudy weather (Singh *et al.* 1985). Effect of seasonal variation on leaf area index of mungbean in also reported by Matsunaga *et al.* (1989).

It is well documented that the photosynthetic characteristics of many species of plants are influenced by the light intensity under which the plant is grown (Singh *et al.* 1974, Woledge 1971).With the decrease in light intensity reduce the photosynthetic rate and decrease the assimilate translocation to the pod of groundnut (Sengupta and Jadhav 1988). Maximum reduction of photosynthesis of mungbean occurred when plants were exposed to low light intensity during pod development stage and resulted in low pod yield. A decrease trend of photosynthetic rate was also observed in shaded condition compared to sun in mungbean and black gram by Kubota and Hamid (1992).

Photosynthetically active radiation is the major regulating factor in photosynthesis and other physiological process in plants (Rao and Mitra 1988). High Dry matter production is one of the pre-requisites for greater productivity in crop plants. Developmental factors affecting the accumulation of dry mater and subsequent partitioning of assimilates are of great importance in determining the final yield in crops (Watson 1971).

Differences in photosynthetic rate among crop varieties are of major differences in crop improvement program as photosynthesis is considered the basis for economic yield in crop plants. Ojima *et al*. (1969) conducted their researches for the selection of photosynthetically efficient crop varieties as the character is found to be genetically controlled and quantitatively inherited. Cultivator differences had been observes in leaf photosynthetic rate and other gas exchange characteristics in various crops. The large genotypic differences in photosynthetic rates and its related factors were observed by Islam *et al*. (1994) in mungbean plants. Several workers (Orgen and Rinne 1973, Asay *et al.* 1974, Shibles *et al*. 1975) have suggested that high photosynthetic rates are essential in selecting cultivars for higher yield, but in many cases differences in leaf photosynthesis are not related to productivity of crops (Osada 1966, Rahodes 1972, Nelson *et al.,* 1975, Evans 1975). Manipulation of photosynthetic potentialities has been practiced to increase their productivity for a long time. In order to improve the production potential, selection of genotypes based on their leaf photosynthetic rates has been practices in other crops (Mahon *et al.* 1981).

Dry matter production of mungbean is influenced by imposition of shading. Mungbean has some tolerance to shade but high level of shade drastically reduces the dry matter production (Islam *et al.* 1993, Lawn and Williams 1987). Effect of shade on the dry matter production of other legumes was also pointed by Farnham *et al*. (1985). They conducted an experiment with two cultivars of peanut in controlled environment and found three times more dry matter under higher irradiance. Dry matter production of legumes is also affected by duration of shading. Imposition of 50 percent shading throughout the growing period of peanut reduced more than 50 percent dry matter as compared to sun peanut (Rao and Mirttra 1988). Sometimes accumulation of dry matter of some plants under shade might be enhanced. Wilson (1990) explained increased growth under shade environment as modified soil conditions that enable better nitrogen mineralization and improve photosynthetic efficiency of plants.

Both genotypic and environmental variation in dry matter partitioning over time is useful in explaining the growth characteristics of mungbean genotypes. In general, dry matter partitioning to structural organ is higher under shade condition. Thus under shaded condition, partitioning of dry matter to vegetative organ was higher in chickpea (Murshed 1996) which might prolong the reproductive period of shade grown mungbean genotypes. Expense of energy to to structural development of shade plants may be the strategy of their survivability. But it may be reproductive organ and the efficiency of remobilization was governed by the genetic characteristics and the environment of crop (Patrick 1988). Reduction of dry weight of reproductive organ under shade condition was associated with shedding of flowers of pods and the reduction in photosynthetic rate during reproductive growth of legumes (Schou *et al.* 1978).

Shading had a significant effect on chlorophyll content of leaves. Partial shading increased the quantity of chlorophyll in leaf (George and Nair 1990, Islam *et al*. 1994). Zhao and Oosterhuis (1998) also found that total chlorophyll concentration was higher in shade leaf than those of no shaded control leaf. Haque (2001) worked on the effect of different light levels on the morphology, physiology and yield our selected vine crops and found that leaf chlorophyll increased but specific leaf weight (SLW) was decreased remarkable with the reduction of the amount of lights. Ahamed (2003) recorded fewer than 100 percent PAR level and gradually increased with the reduction of PAR levels.

Seed legumes occupy an important place as source of dietary proteins. On an average about 80 percent proteins and 90 percent of calories consumed by the people in developing countries are supplied by plants (Singh and Jambunathan 1991). Protein in seeds of mungbean average around 24 percent (Poehlman 1991). Percent protein content of mungbean seeds were found to range from 25.2 to 20.3 % with an average value of 26.6 % (Shobhane *et al*. 1976) and from 19.1 to 20.3 percent with a mean of 24 percent (Yohe and

Poehlman 1972). The high protein strains of mungbean tended to have smaller seeds (Yohe and Poehlman 1972).Protein quality may be evaluated with references to its digestibility and biological value. Mungbean is highly regarded among Indian village people as being more easily digested than other pulses. Another measure of protein quality is biological value (amount of absorbed nitrogen retained in the body). Generally the protein content in mungbean is greater than in chickpea, cowpeas and lentil (Poehlman 1991). Hamid (1992) found no significant difference in the protein content in the seeds of mungbean genotypes. The protein content of the genotypes ranged between 24.52 to 26.67 percent.

Seed yield of mungbean is attributed by number of pods, number of seeds per pod and seed size. The yield of mungbean being the product of these components (Poehlman, 1991). Parida and Singh 1984, Khan 1985 also reported that there was a significant relationship between all the yield contributing characters and yield. Chowdury *et al.* (1988) observed high correlation between final seed yield and number of pods per plant. These yield attributes were severely affected by degree of shading. Lantican and Catedral (1977) and Laosuwan *et al.* (1992) observed lower seed yield for shaded grown mungbean plant. Length of pod indicated the seed size and number of seeds within each pod and it may be assumed that longer pods were capable of holding more number of seeds and seed size may be larger length of pod is shorter under shade condition and genotypic variation in pod of mungbean was found distinck by

Khanum *et at*. (1982) Islam (1995) found pods per plant decreased with the increase of shading. Seeds per pod differed significantly among different levels of irradiance treatments in mungbean and there was no significant difference in seed weight between different shaded mungbean but the size of shaded and control plots different significantly.

CHAPTER III

MATERIALS AND METHODS

Details of the methodology of the study followed during the research period are presented in this chapter.

3.1. Location and duration

The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from April 20, 2015 to June 30, 2015.

3.2. Experimental design and treatments

The experiment was laid out in a split plot with three replications. Three light levels were assigned in main plots and three varieties were arranged in sub plots. Individual plot size was 2 m X 1.50 m.

Main plot treatment:

Three light levels were assigned as follows:

L_{100} - 100 % of full sunlight (open field control)

L_{75}- 75 % of full sunlight

L_{50} - 50% of full sunlight

In L_{100} treatment, full sunlight was allowed to fall over the three varieties of mungbean without any barrier, which was considered as 100 percent of full sunlight. In L_{75} and L_{50} treatments, the light level was reduced to 75 and 50 percent of full sunlight using mosquito net comparing open field light at 100 percent of full sunlight. For this purpose, sample nets having different mesh sizes were previously tested.

Sub plot: Mungbean variety

Three mungbean varieties i.e., BINA 5, BINA 8 and BARl mung 6 were assigned in the sub plots.

3.3. Land preparation

The selected experimental field was first opened at l0 days before laying out the experimental plots. The land was prepared well with the tractor drawn disk plough followed by harrowing and laddering up to a good tilth. The clods were broken and weeds and stubbles of the previous crops were collected and removed from the field during the land preparation.

3.4. Fertilizer application

Recommended doses of fertilizer for mungbean were used in this experiment, for all varieties of mungbean 30 kg N, 30 kg P and 60 kg K per hectare were applied. All fertilizers were applied during the final land preparation.

3.5. Seed sowing

Seeds of mungbean varieties were sown on April 28, 2015. Seeds were sown in the lines at 30 cm X l0 cm spacing.

3.6. Net setting

Mosquito nets of different pore size were hung about 2.5 meter above the ground level over the L_{75} and L_{50} treatments for maintaining 75 and 50 percent of full sunlight respectively with bamboo support. Control plots will not be covered with mosquito net. Light treatment was given at 22 days after sowing.

3.7. Crop management

Weeding and mulching were done at 15 and 30 days after sowing respectively, to keep the crop weed free and to pulverize the soil. Irrigation was not given because the experiment was conducted during rainy season. For crop protection, Diazinon 60 EC @ 35 ml per l0 litre water was applied at l0 days after emergence and Cymbush l0 EC @ l0 ml per l0 litre water was applied at 15, 25, 35 and 40 days after emergence to control hairy caterpillar, bean aphid, cut worm and pod borer. Some plants were affected by virus. The infested plants were uprooted immediately.

3.8. Sampling procedure and data collection

Three plants from each plot were randomly selected at l0 days interval for collecting data on plant height, root length, number of leaves, leaf area, stem dry weight, leaf dry weight and root dry weight at 40, 50 and 60 days after sowing. Plant height was measured from base to the tip of the plant. Leaf area of all the green leaves was measured by manual scale. At each sampling, plants were uprooted and separated into leaf, stem and root. After separating the different parts of the plants, individual component were oven (Model- E28# 03-54639, Binder, Germany) dried at 70ºC for at least 72 hours and weight were recorded with an electrical balance (Model- AND EK- 300 i).

3.9. Leaf chlorophyll

Chlorophyll content of the flag leaf at 29 days after shading was estimated according to Witham *et al.* (1986). 0.25g of leaf was taken from middle position of the flag leaf in a brown bottle containing 25ml of 80% aqueous acetone. The bottles were kept in dark for 48 hours. The optical density of this green colored solution was determined against 80% acetone as blank using spectrophotometer (SPECTRO UV-VIS RS Spectrophotometer, Labo Med, Inc.) at 645 and 663 nm. Chlorophyll-a, chlorophyll-b and total chlorophyll of fresh leaf was determined using Witham formula.

3.10. Yield and yield component

For yield components of mungbean, five plants of each of variety were selected randomly frorn each replication at early stage of crop. At maturity, pods were harvested in different pickings. The harvesting of mungbean pods was started at 23 days after shading and ended at 37 days after shading. Yields of mungbean varieties was determined from the summation of all picking period and then converted to ton per hectare. Length of individual pod, pod per plant, seeds per pod and 1000 seed weight were also recorded from the five randomly selected plants from each plot.

3.11. Statistical analysis

The data were analyzed by partitioning the total variance with the help of computer using MSTATC program. The treatment means were compared using Duncan’s Multiple Range Test.

CHAPTER IV

RESULTS AND DISCUSSION

The influence of different light levels on the growth and yield of mungbean varieties are presented and discussed in this chapter.

4.1. Plant height at 40 DAS

The interaction of light levels and mungbean variety significantly influenced the plant height at 40 days after shading (Fig.1). Different varieties responded differently under different light levels. Among the varieties, the tallest plant (47.32 cm) was observed in BINA Mung 8 under 50 percent of full sunlight which was followed by BARI Mung 6 under 50 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 75 of full sunlight, BINA Mung 5 under 100 percent sunlight and the lowest plant height (37.85) was observed in BINA Mung 5 under 50 percent of full sunlight level.

4.2. Plant height at 50 DAS

The interaction of light levels and mungbean varieties significantly influenced the plant height at 50 days after shading (Fig. 2). The present study revealed that plant height increased with the decrease of light levels in all the Mungbean variety. Among the varieties, the tallest plant (75.94 cm) was observed in BARI Mung 6 under 50 percent of full sunlight which was followed by BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight, BARI Mung under 100 percent sunlight and the lowest plant height was observed in BINA Mung 8 under 100 percent sunlight level.

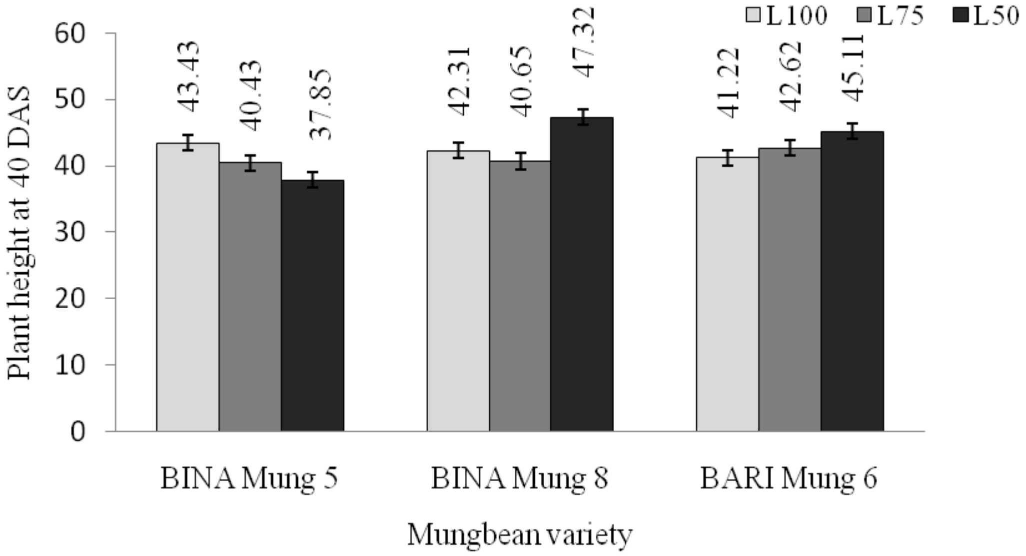

Fig. 1. Effect of different light levels on plant height at 40 days after sowing of different of different mungbean varieties.

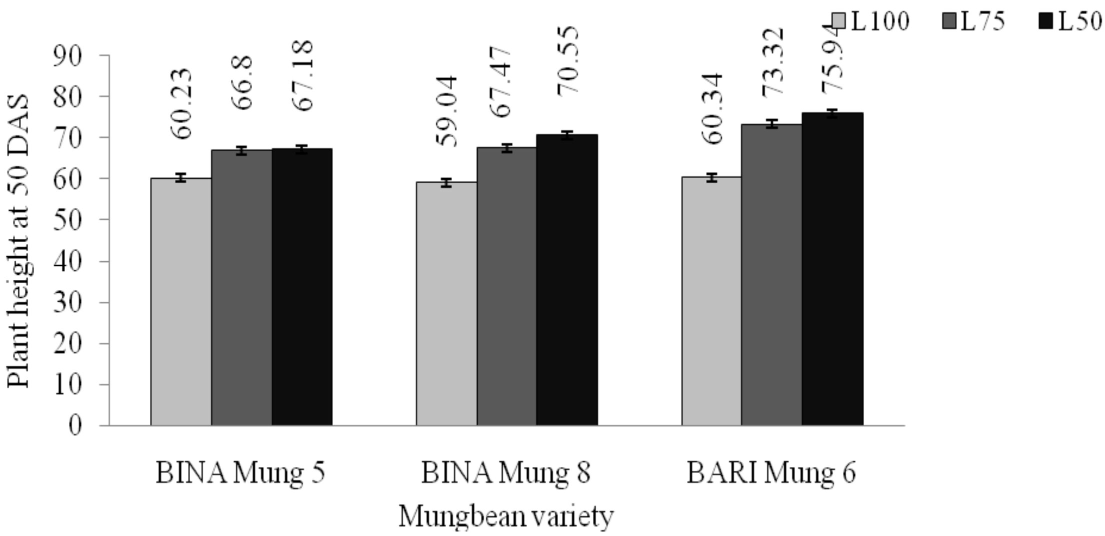

Fig.2. Effect of different light levels on plant height at 50 days after sowing of different of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

4.3. Plant height at 60 DAS

The interaction of light levels and mungbean varieties significantly influenced the plant height at 60 days after shading (Fig. 3). The present study revealed that plant height increased with the decrease of light levels in all the Mungbean varieties. Among the varieties, the tallest plant (98.82 cm) was observed in BARI Mung 6 under 50 percent of full sunlight which was followed by BARI Mung 6 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BINA Mung 5 under 50 percent of full sunlight, BINA Mung 5 under 75 percent of full sunlight and the lowest plant height was observed in BINA Mung 5 under 100 percent sunlight level.

Plant height depends on a number of factors such as availability of required quantity of water, mineral nutrients, quantity, quality and duration of light, temperature area of growing space (aerial and edaphic), and genetic set-up of, the plants. Plant grown in low light levels was found to be exhibited apical dominance than those grown in high light environment resulting in taller plants under shade (Hillman, 1984), Miah (2001) observed taller tomato plant under reduced PAR levels. Similarly higher plant height under reduced light levels was also observed in mungbean (Ali, 1998, lslam, 1996) and chickpea (Murshed, 1996). This may be attributed to the stimulation of cellular expansion and cell division undcr shaded condition (Schoch, 1972).

4.4. Number of leaves per plant at 40 DAS

The interaction of light levels and mungbean varieties significantly influenced the number of leaves per plant at 40 days after shading (Fig.4). The figure study showed that numbers of leaves were increased with the increase of light levels in all the mungbean

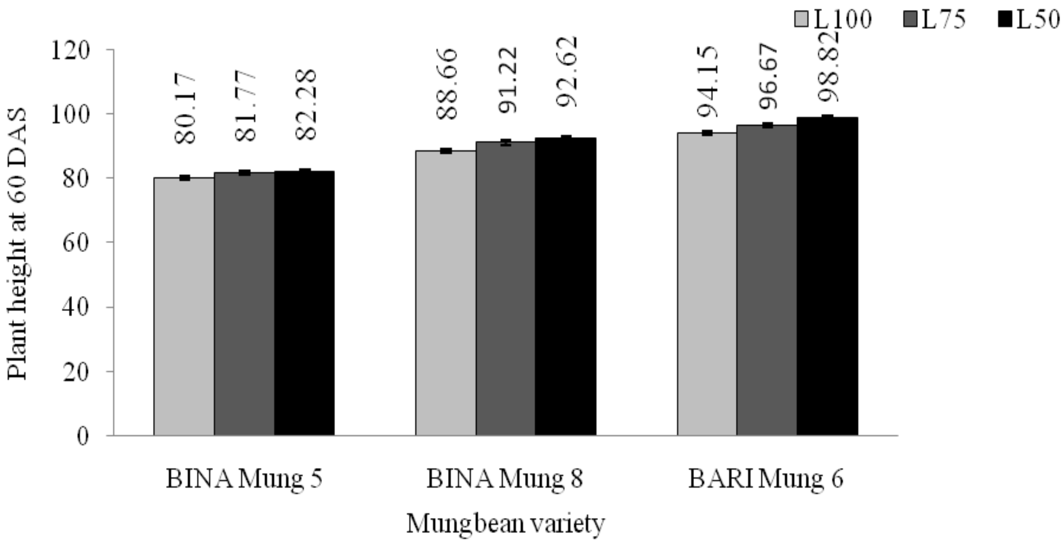

Fig.3. Effect of different light levels on plant height at 60 days after sowing of different mungbean varieties.

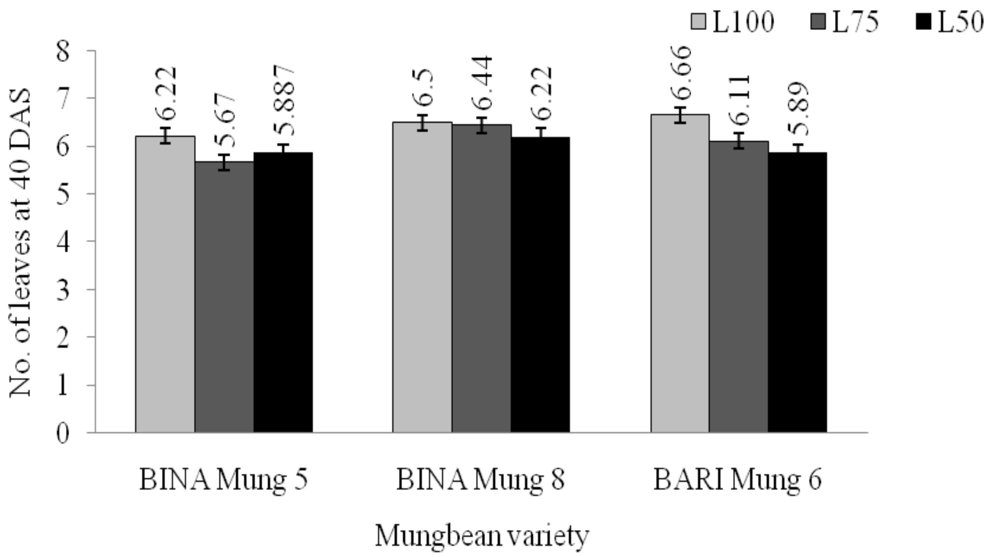

Fig. 4. Effect of different light levels on number of leaves per plant at 40 days after owing of different of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

varieties. Among the varieties, the highest number of leaves (6.66) were observed in BARI Mung 6 under 100 percent sunlight which was followed by BINA Mung 8 under 100 percent full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight and the lowest number of leaves (5.88) were observed in BINA Mung 5 under 50 percent of full sunlight level.

4.5. Number of leaves per plant at 50 DAS

The interaction of light levels and mungbean varieties significantly influenced the number of leaves per plant at 50 days after shading (Fig.5). The present study revealed that number of leaves was increased with the increase of light levels in all the mungbean varieties. Among the varieties, the highest number of leaves (10.89) were observed in BINA Mung 5 under 100 percent full sunlight level which was followed by BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung 5 under 75 percent of full sunlight and the lowest number of leaves (7.22) were observed in BINA Mung 5 under 50 percent of full sunlight level.

4.6. Number of leaves per plant at 60 DAS

The interaction of light levels and mungbean varieties significantly influenced the number of leaves per plant at 60 days after shading

(Fig. 6). The figure showed that numbers of leaves were increased with the increase of light levels in all the mungbean varieties except BINA Mung 8 under 50 percent of full sunlight level where number of leaves increased compare to 100 percent

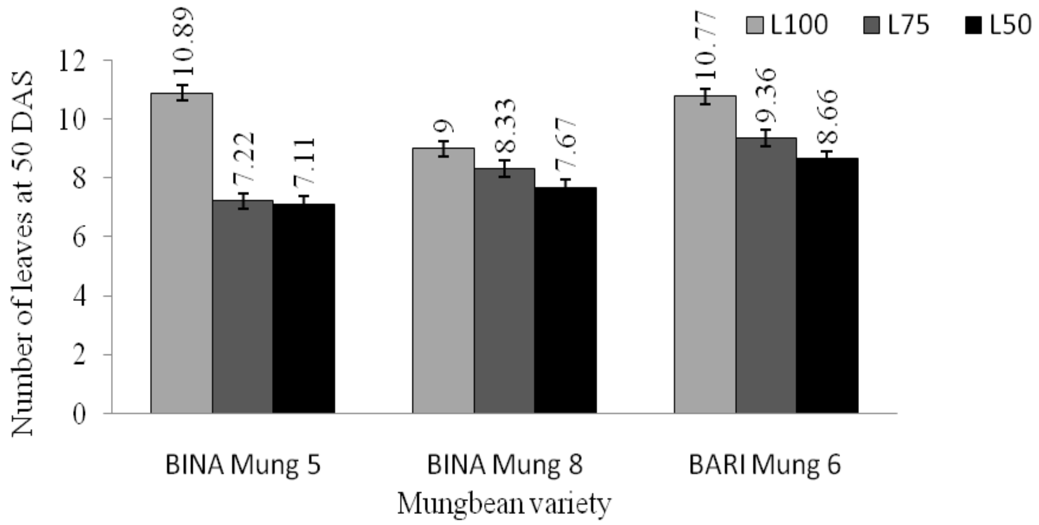

Fig. 5. Effect of different light levels on number of leaves per plant at 50 days after sowing of different mungbean varieties.

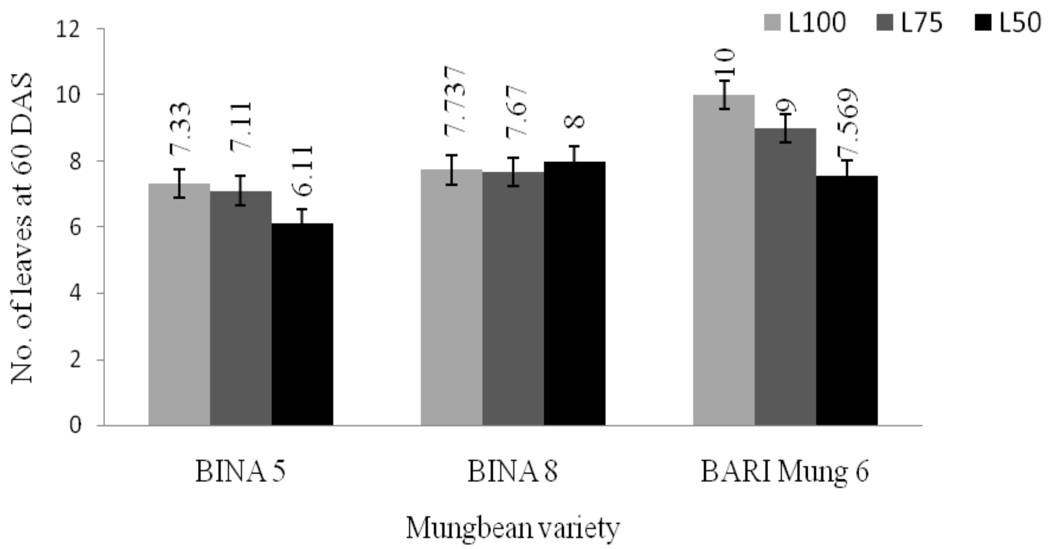

Fig.6. Effect of different light levels on number of leaves per plant at 60 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight

L_{50} - 50% of full sunlight

sunlight. Among the varieties, the highest numbers of leaves (10) were observed in BARI Mung 6 under 100 percent sunlight level which was followed by BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BINA Mung 8 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 5 under 75 percent of full sunlight and the lowest number of leaves (6.11) were observed in BINA Mung 5 under maximum shade (i.e. 50 percent of full sunlight level).

The present study revealed that full sunlight (i.e. 100 percent sunlight level) produced the higher nurnber of leaves per plant, whereas, the maximum shade (i.e. 50 percent of full sunlight level) produced the lowest nurnber of leaves per plant. The lower may be due to lower number of leaves per plant at the reduced light condition may be due to lower production of photosynthates under low light conditions for longer period (Miah *et al*. 1999). Similar results were reported by Wadud (l999) in okra under low light condition.

4.7. Leaf area per plant at 40 DAS

The interaction of light levels and mungbean varieties significantly influenced the leaf area per plant at 40 days after shading (Fig.7). The figure showed that the leaf area per plant was increased with the decreasing of light levels in all the mungbean varieties except BINA Mung 5 under 50 percent of full sunlight level where leaf area increased compare to 100 percent sunlight. Among the varieties, the highest leaf area (30.71) was observed in BARI Mung 6 under 75 percent of full sunlight level which was followed by BARI Mung 6 under 50 percent of full sunlight, BINA Mung 8 under 50 percent of sunlight, BARI Mung 6 under 100 percent sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA 8 under 100 percent sunlight, BINA Mung 5 under 75 percent of

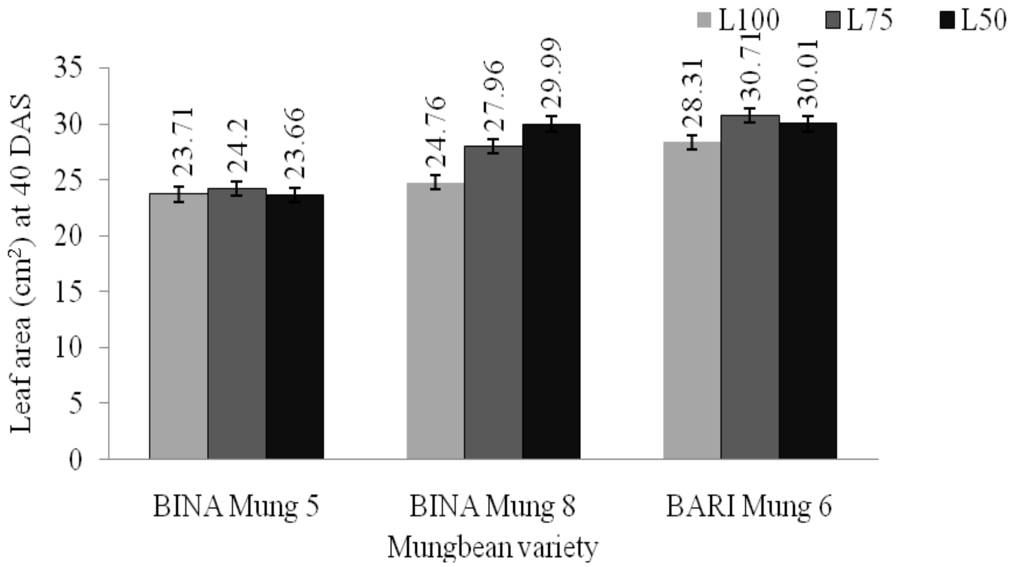

Fig. 7. Effect of different light levels on leaf area per plant at 40 days after sowing of different mungbean varieties.

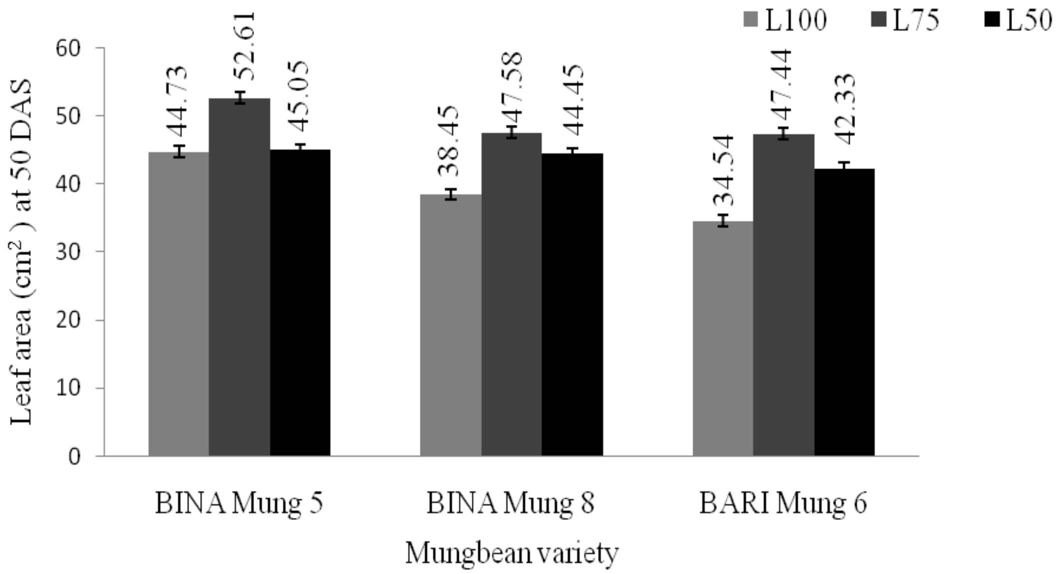

Fig. 8. Effect of different light levels on leaf area per plant at 50 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

full sunlight, BINA Mung 5 under 100 percent sunlight and the lowest leaf area per plant (23.66) was observed in BINA Mung 5 under 100 percent sunlight.

4.8. Leaf area per plant at 50 DAS

The interaction of light levels and mungbean varieties significantly influenced the leaf area per plant at 50 days after shading (Fig.8). The figure showed that the leaf area per plant was increased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight and all the varieties under 75 percent of full sunlight showed maximum leaf area. Among the varieties, the highest leaf area (52.61 cm^2) was observed in BINA Mung 5 under 75 percent of full sunlight which was followed by BINA Mung 8 under 75 percent of full sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 8 under 50 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight and the lowest leaf area per plant (38.45 cm^2) were observed in BINA Mung 8 under 100 percent sunlight.

4.9. Leaf area per plant at 60 DAS

The interaction of light levels and mungbean varieties significantly influenced the leaf area per plant at 60 days after shading (Fig.9). The figure showed that the leaf area per plant was increased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight and all the varieties under 75 percent of full sunlight showed maximum leaf area. Among the varieties, the highest leaf area (65.52 cm^2) was observed in BARI Mung 6 under 75 percent of full sunlight which was followed by BINA Mung 5 under 75 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BARI Mung 6 under 50

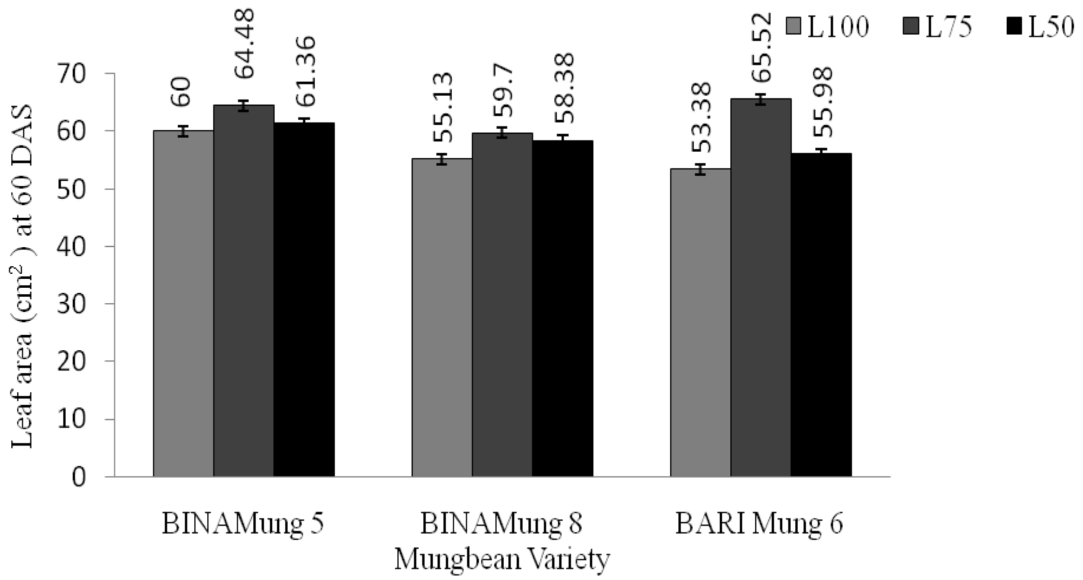

Fig.9. Effect of different light levels on leaf area per plant at 60 days after sowing of different mungbean varieties.

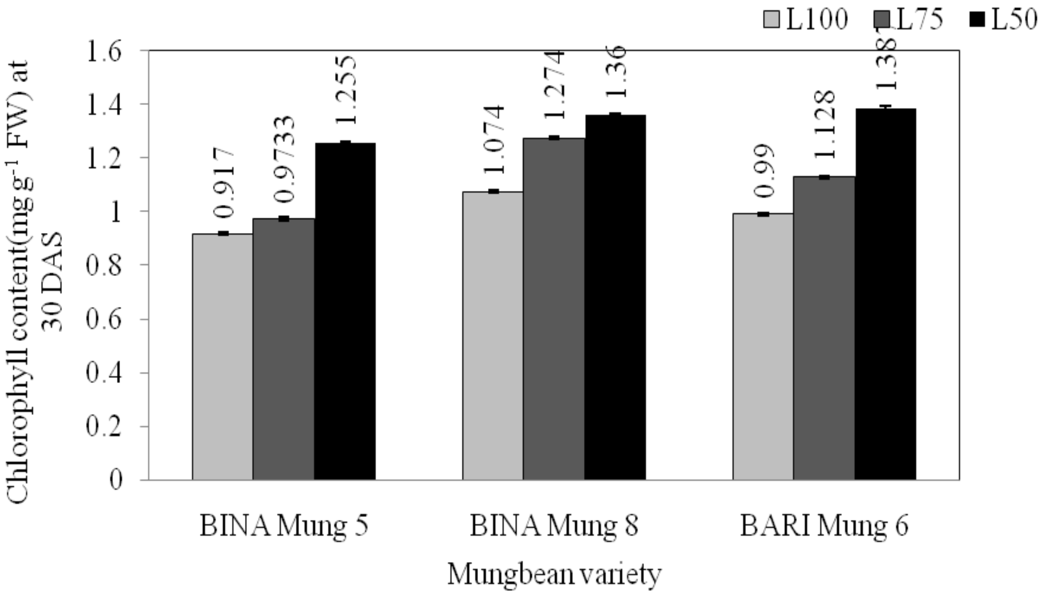

Fig. 10. Effect of different light levels on total chlorophyll content of leaf at 30 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

percent of full sunlight and the lowest leaf area per plant (53.38 cm^2) was observed in BARI Mung 6 under 50 percent of full sunlight.

4.10. Total leaf chlorophyll

The interaction of light levels and mungbean varieties significantly influenced the leaf chlorophyll content at 30 days after shading (Fig.10). The figure showed that the total leaf chlorophyll content was increased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight but the degree of increasing was not similar for all mungbean varieties. Among the varieties, the highest chlorophyll content (1.387 mg g^{-1} FW) was observed in BARI Mung 6 under 50 percent of full sunlight which was followed by BINA Mung 8 under 50 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 100 percent sunlight, BINA Mung 5 under 75 percent of full sunlight and the lowest chlorophyll content (0.917 mg g^{-1} FW) was observed in BINA Mung 5under 75 percent of full sunlight.

George and Nair (1990) found in groundnut that leaf chlorophyll content increased with the increasing shade intensities.

4.11. Leaf chlorophyll a and chlorophyll b ratio

The interaction of light levels and mungbean varieties significantly influenced the leaf chlorophyll a and chlorophyll b ratio at 30 days after shading (Fig.11). The figure showed that the ratio of leaf chlorophyll was decreased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight but the degree of decreasing was not similar for all mungbean varieties. Among the varieties, the highest chlorophyll ratio (0.307) was observed in BINA Mung 8 under 100 percent sunlight

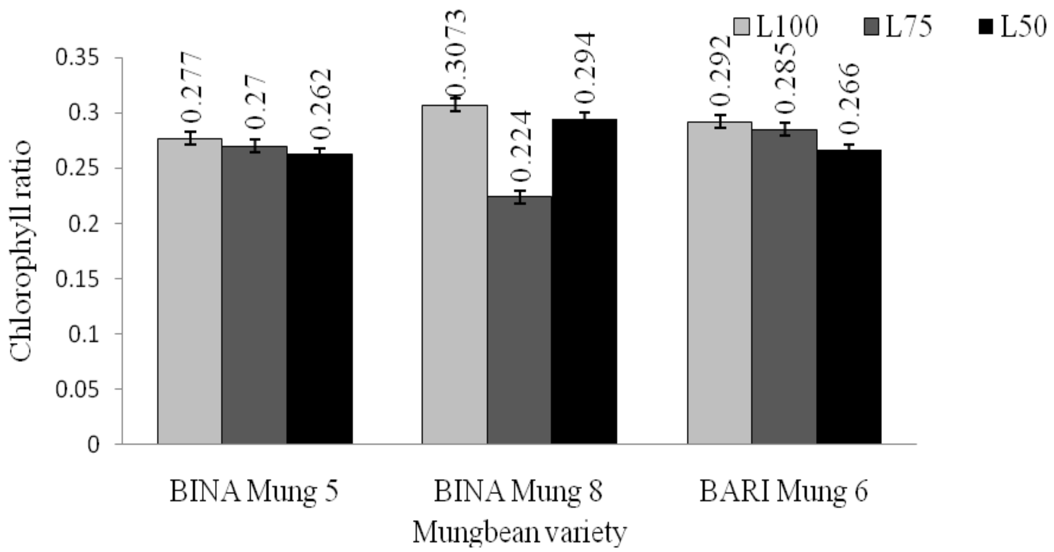

Fig. 11. Effect of different light levels on chlorophyll ratio of leaf at 30 days after sowing of different of different mungbean varieties.

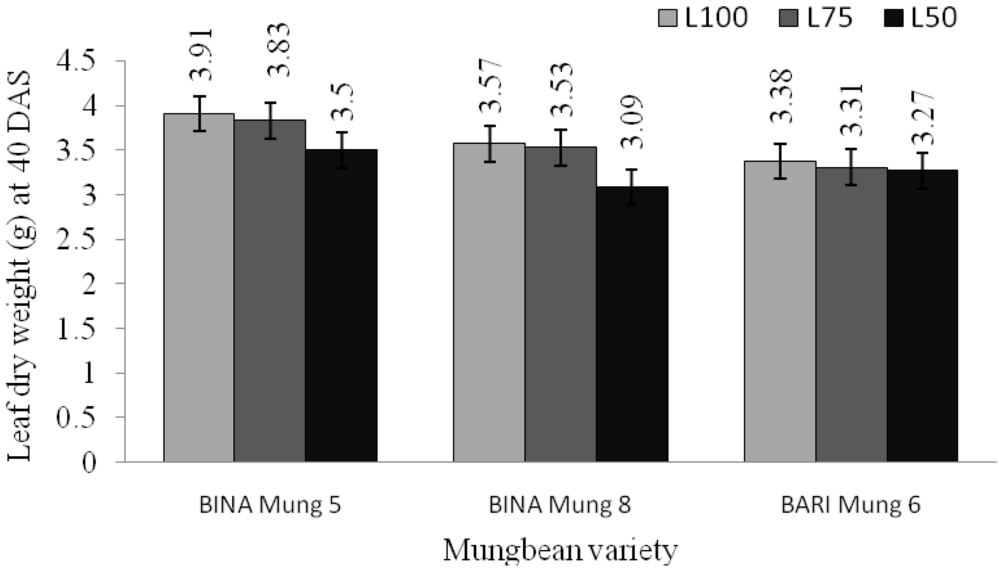

Fig.12. Effect of different light levels on leaf dry weight per plant at 40 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

which was followed by BINA Mung 8 under 50 percent of full sunlight, BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 5 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight and the lowest chlorophyll ratio (0.224) were observed in BINA Mung 8 under 75 percent of full sunlight.

4.12. Leaf dry weight per plant at 40 DAS

The combined effect of light levels and mungbean varieties on leaf dry weight per plant at 40 DAS was significant (Fig.12). The figure showed that the leaf dry weight per plant was increased with the increasing of light levels in all the mungbean varieties. Among the varieties, the highest leaf dry weight (3.91 g) was observed in BINA Mung 5 under 100 percent full sunlight which was followed by BINA Mung 5 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight, BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent sunlight, BARI Mung 6 under 50 percent sunlight and the lowest leaf dry weight per plant (3.09 g) was observed in BINA 8 under 50 percent of full sunlight.

4.13. Leaf dry weight per plant at 50 DAS

The combined effect of light levels and mungbean varieties on leaf dry weight per plant at 50 DAS was significant (Fig. 13). The figure showed that all the varieties obtained maximum dry weight under 75 percent of full sunlight. Among the varieties, the highest leaf dry weight (10.14 g) was observed in BINA 5 under 75 percent of full sunlight which was followed by BINA 8 under 75 percent of full sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA 5 under 100 percent sunlight, BINA 8 under 100 percent sunlight, BINA 8 under 50 percent of full sunlight, BINA 5 under 50 percent of

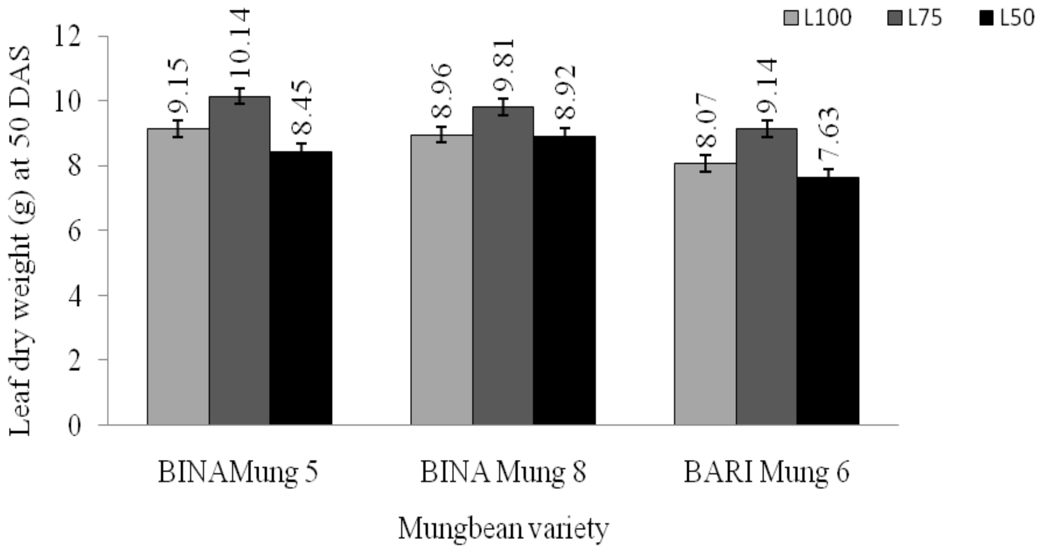

Fig.13. Effect of different light levels on leaf dry weight per plant at 50 days after sowing of different mungbean varieties.

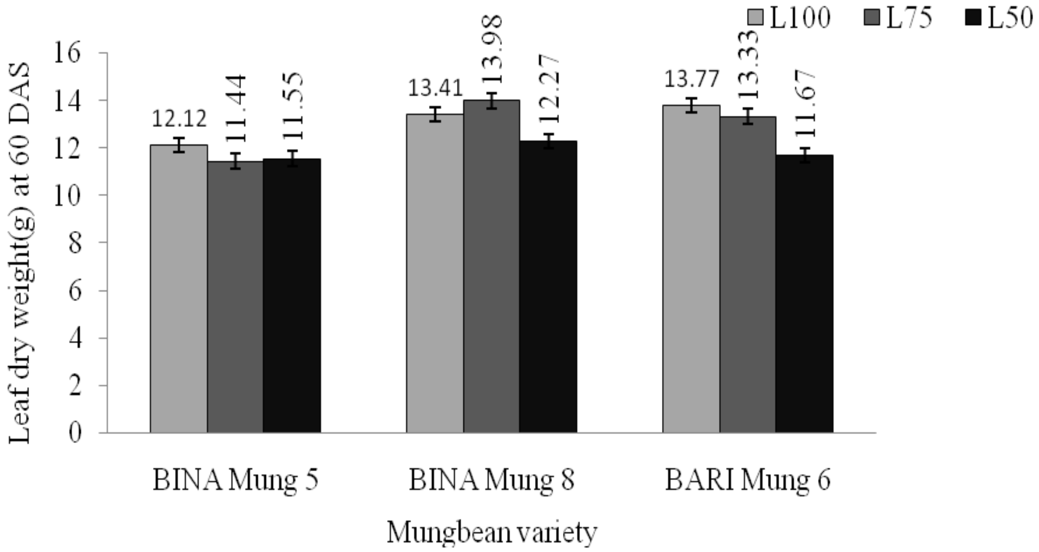

Fig.14. Effect of different light levels on leaf dry weight per plant at 60 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

full sunlight and the lowest leaf dry weight per plant (7.63 g) was observed in BARI Mung 6 under 75 percent of full sunlight.

4.14. Leaf dry weight per plant at 60 DAS

The combined effect of light levels and mungbean varieties on leaf dry weight per plant at 60 DAS were significant (Fig.14). The figure showed that maximum dry weight was obtained under full sunlight in BINA Mung 5 and BARI Mung 6 and BINA Mung 8 obtained under 75 percent of full sunlight. Among the varieties, the highest leaf dry weight (13.98 g) was obtained in BINA Mung 8 under 75 percent of full sunlight which was followed by BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 100 percent sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung under 100 percent sunlight, BARI Mung 6 under 50 percent of full sunlight ,BINA Mung 5 under 50 percent of full sunlight, the lowest leaf dry weight per plant (11.44 g) was observed in BINA Mung 8 under 50 percent of full sunlight.

4.15. Stem dry weight

Stem dry weight tended to increase with the advanced of time but the rate of increase was slower at latter part of growing season. Slow rate of dry matter accumulation into vegetative organs of mungbean genotypes was mainly associated with the remobilization of reserve assimilates to reproductive organs and the efficiency of remobilization is governed by genetically characteristics and the crop environment (Patrick l988).

4.16. Stem dry weight per plant at 40 DAS

The combined effect of light levels and mungbean varieties on stem dry weight per plant at 40 DAS was significant (Fig.15). The figure showed that different variety performs differently in obtaining root dry weight under different light levels at 40 days after sowing.

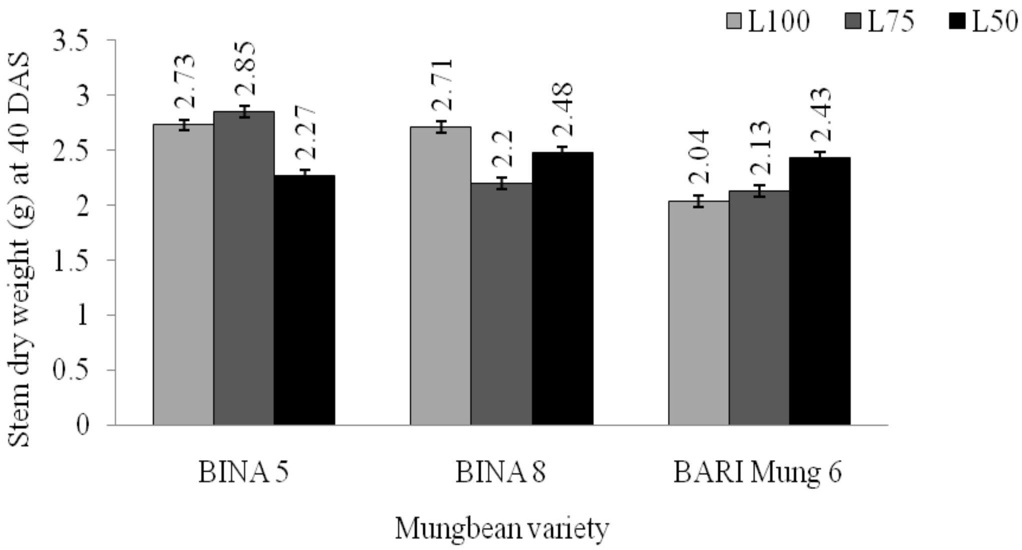

Fig.15. Effect of different light levels on stem dry weight per plant at 40 days after sowing of different mungbean varieties.

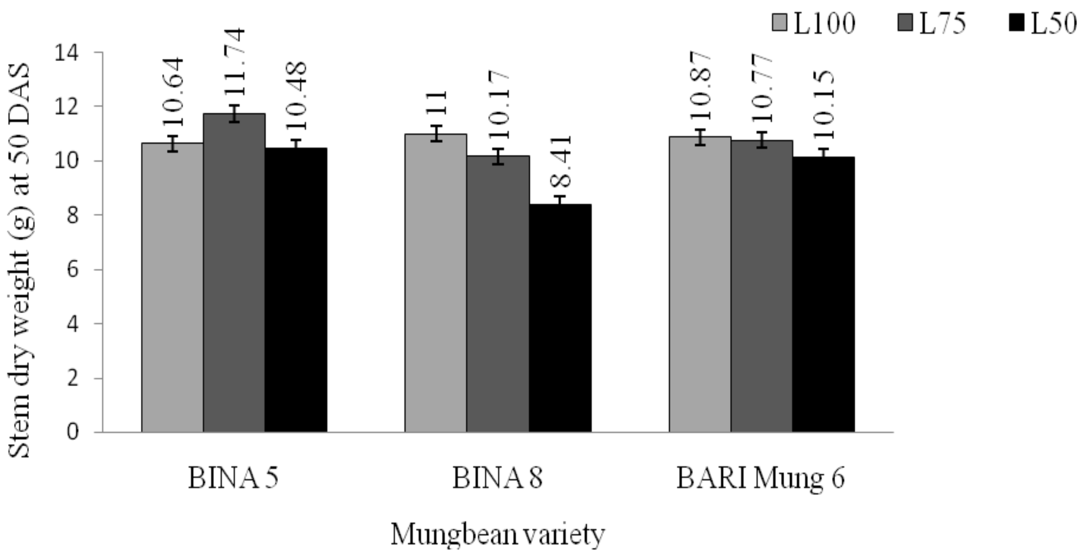

Fig.16. Effect of different light levels on stem dry weight per plant at 50 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

Among the varieties, the highest stem dry weight (2.85 g) was observed in BINA Mung 5 under 75 percent of full sunlight which was followed by BINA Mung 5 under 100 percent sunlight, BINA Mung 8 under 100 percent sunlight, BINA Mung 8 under 50 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BARI Mung 6 under 75 percent of full sunlight and the lowest stem dry weight per plant (2.04 g) was observed in BARI Mung 6 under 75 percent of full sunlight.

4.17. Stem dry weight per plant at 50 DAS

The combined effect of light levels and mungbean varieties on stem dry weight per plant at 50 DAS was significant (Fig.16). The figure showed that all the variety both under 100 and 75 percent of full sunlight produced more stem dry matter compare to 50 percent of full sunlight. Among the varieties, the highest stem dry weight (11.74 g) was observed in BINA Mung 5 under 75 percent of full sunlight which was followed by BINA Mung 8 under 100 percent sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 5 under 100 percent sunlight, BINA Mung 5 under 50 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight and the lowest stem dry weight per plant (8.41 g) was observed in BINA Mung 8 under 100 percent sunlight.

4.18. Stem dry weight per plant at 60 DAS

The combined effect of light levels and mungbean varieties on stem dry weight per plant at 60 DAS was significant (Fig.17). The figure showed that stem dry weight was increased with the increment of light levels in all varieties. Among the varieties, the highest stem dry weight (15.17 g) was observed in BINA 5 under 50 percent of full sunlight which was followed by BINA Mung 8 under 100 percent sunlight, BINA Mung

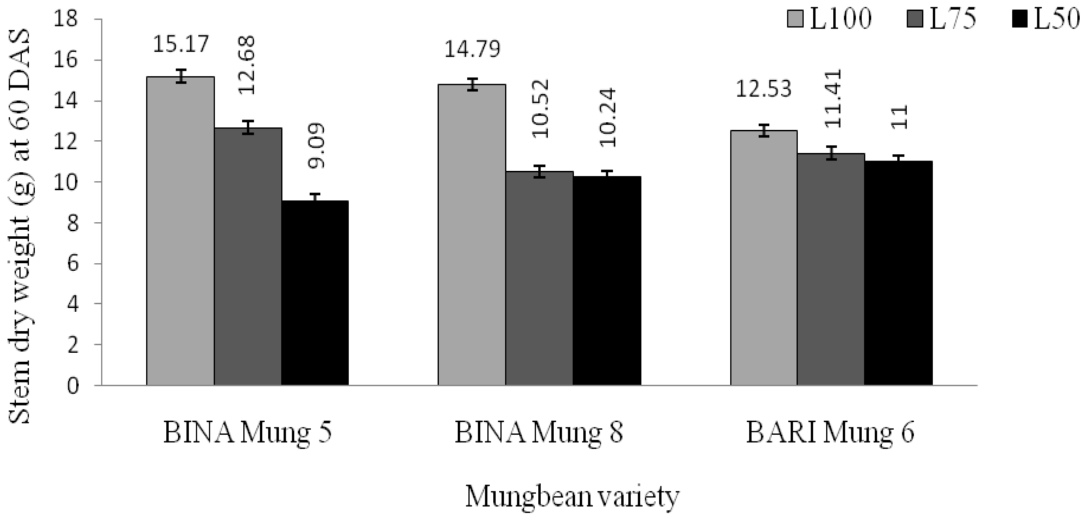

Fig.17. Effect of different light levels on stem dry weight per plant at 60 days after sowing of different of different mungbean varieties.

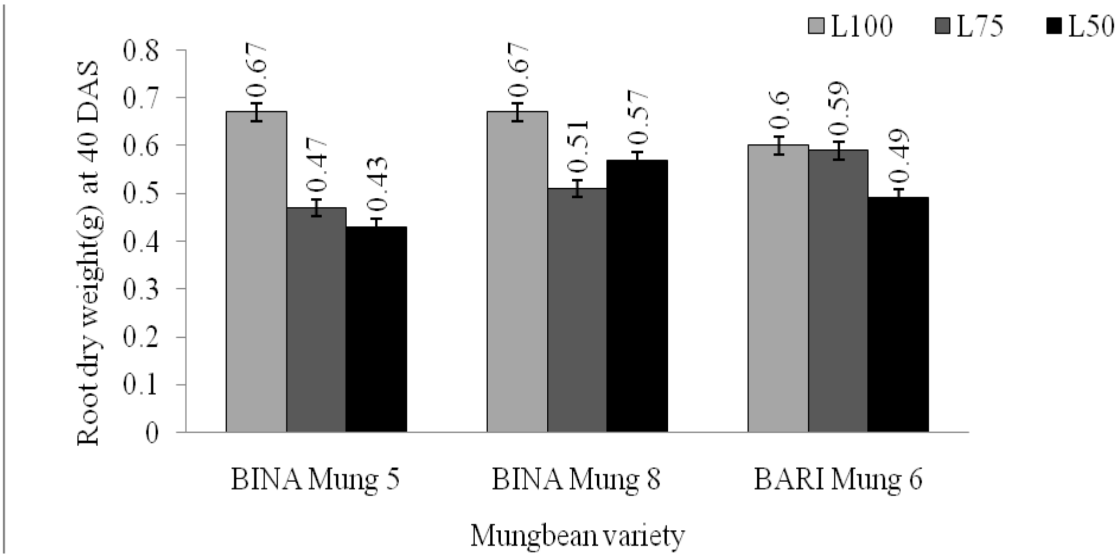

Fig. 18. Effect of different light levels on root dry weight per plant at 40 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

5 under 75 percent of full sunlight, BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight and the lowest stem dry weight per plant (9.09 g) was observed in BINA Mung 5 under 50 percent of full sunlight.

4.19. Root dry weight per plant at 40 DAS

The combined effect of light levels and mungbean varieties on root dry weight per palnt at 40 DAS was significant (Fig.18). The figure showed that root dry weight was increased with the increment if light levels of different varieties. Among the varieties, the highest root dry weight (0.67 g) was obtained in both BINA 5 under 100 percent sunlight and BINA 5 under 100 percent sunlight which was followed by BARI Mung 6 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA 8 under 50 percent of full sunlight, BINA 8 under 75 percent of full sunlight, BARI Mung 6 under 50 percent of full sunlight, BINA 5 under 75 percent of full sunlight and the lowest root dry weight per plant (0.43 g) was observed in BINA 5 under 75 percent of full sunlight

4.20. Root dry weight per plant at 50 DAS

The combined effect of light levels and mungbean varieties on root dry weight per palnt at 50 DAS was not significant (Fig.19). The figure showed that different variety performs differently in obtaining root dry weight under different light levels at 50 days after sowing.

The highest dry weight per plant (2.29 g) was found in BINA Mung 8 under 75 percent of full sunlight and the lowest dry weight (1.56 g) was found in BINA Mung 5 under 50 percent of full sunlight.

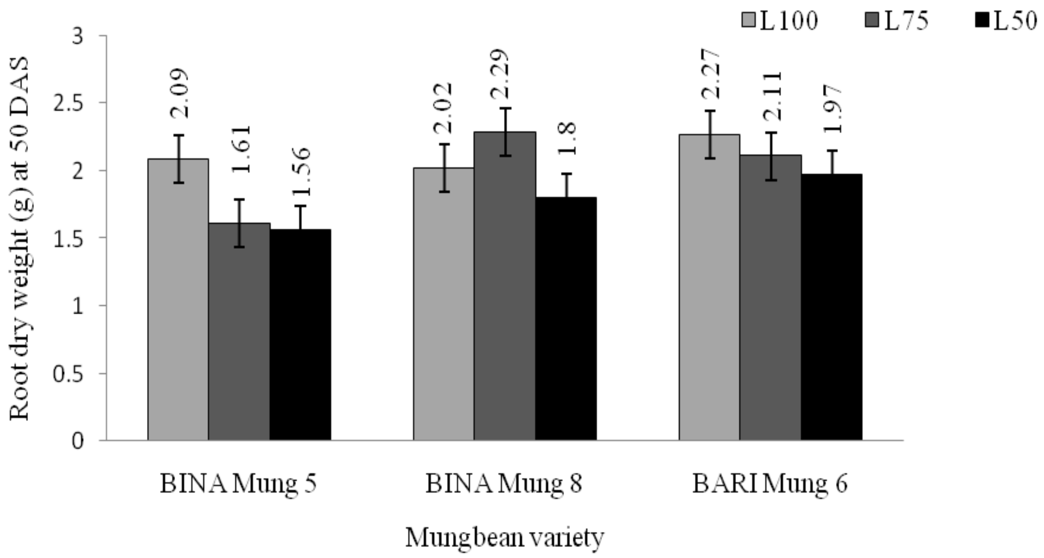

Fig.19. Effect of different light levels on root dry weight per plant at 50 days after sowing of different mungbean varieties.

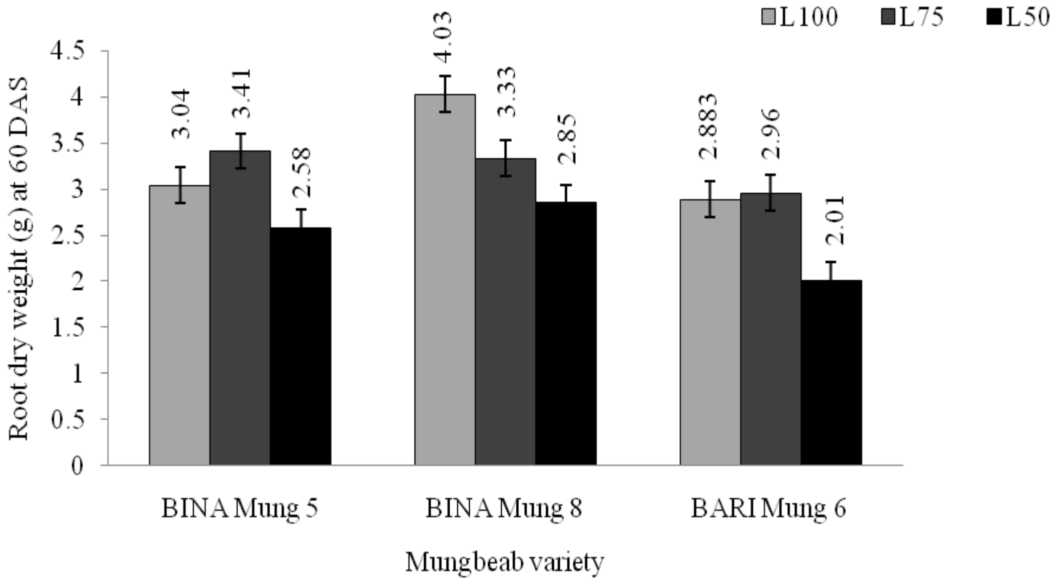

Fig. 20. Effect of different light levels on root dry weight per plant at 60 days after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

4.21. Root dry weight per plant at 60 DAS

The combined effect of light levels and mungbean varieties on root dry weight per palnt at 60 DAS was not significant (Fig.20). The figure showed that different variety performs differently in obtaining root dry weight under different light levels at 60 days after sowing. The highest dry weight (4.03 g) per plant was found in BINA 8 fewer than 100 percent sunlight and the lowest dry weight (2.01) was found in BARI mung under 50 percent of full sunlight.

4.22. Inflorescence dry weight per plant at 60 DAS

The combined effect of light levels and mungbean varieties on Inflorescence dry weight per plant at 60 DAS was not significant (Fig.21). The figure showed that all the mungbean varieties under 100 percent PAR produced maximum dry weight compared to 75 and 50 percent of full sunlight level and at 75 and 50 percent of full sunlight all the varieties produced almost similar inflorescence dry weight except BARI Mung 6 produced higher dry weight compare to 50 percent of sunlight level. Among the varieties, the highest Inflorescence dry weight (3.78 g) was obtained in BINA Mung 5 under 100 percent sunlight which was followed by BARI Mung 6 under 100 percent sunlight, BINA Mung 8 under 100 percent sunlight, BARI Mung 6 under 75 percent of full sunlight, BINA Mung 8 under 50 percent of full sunlight, BINA Mung 8 under 75 percent of full sunlight, BINA Mung 5 under 50 percent of full sunlight and the lowest Inflorescence dry weight per plant (1.98 g) was observed in BARI Mung 6 under 50 percent of full sunlight level.

4.23. Plant height at harvest

The combined effect of light levels and mungbean varieties on plant height at harvest was not significant (Fig.22). The figure showed that different variety performed

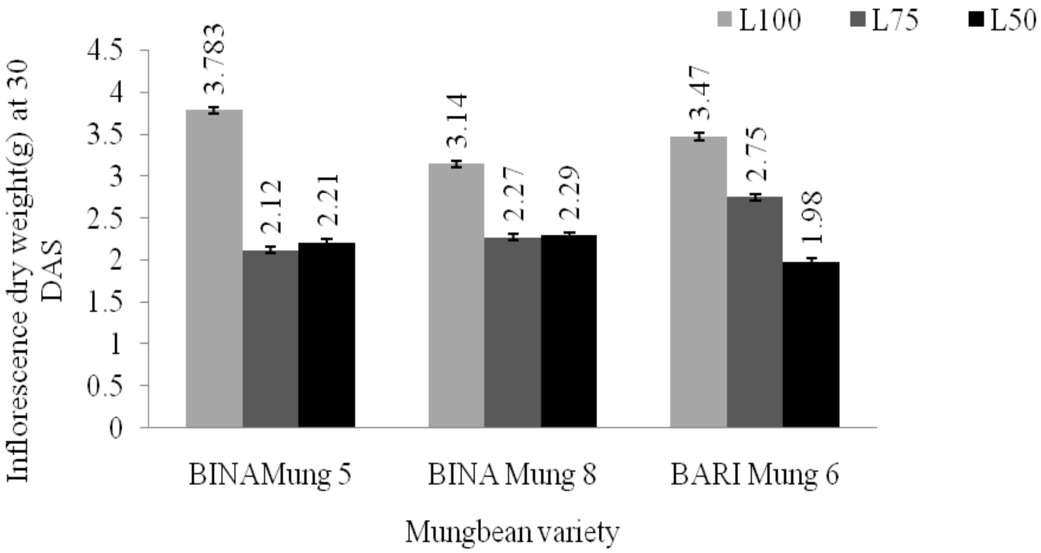

Fig.21. Effect of different light levels on inflorescence dry weight per plant at 30 days after sowing of different mungbean varieties.

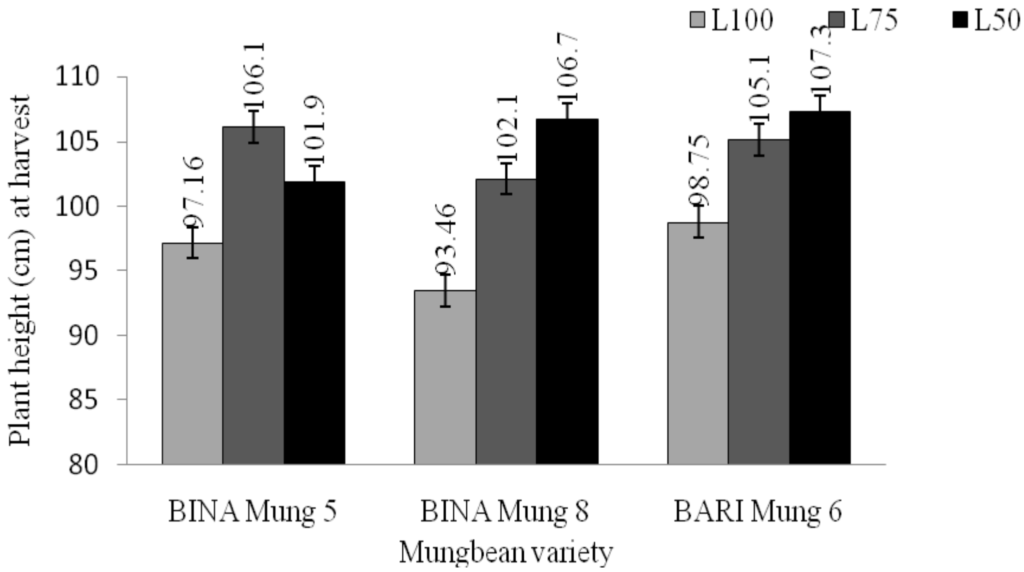

Fig.22. Effect of different light levels on plant height at harvest after sowing of different mungbean varieties.

L_{100} - 100 % sunlight (open field control)
L_{75}- 75 % of full sunlight
L_{50} - 50% of full sunlight

differently in obtaining plant height at harvest under different light levels. The highest plant height (107.3 cm) was found in BARI mung under 50 percent of full sunlight and the lowest plant height (93.46 cm) was found in BINA mung 8 fewer than 100 percent sunlight level.

4.24. Number of pods per plant

The combined effect of light levels and mungbean varieties on number of pod per plant was significant (Table 1). In all the varieties the number of pods was reduced with the reduction of light levels compare to control i.e. full sunlight. But the degree of reduction in number of pods was different for different mungbean varieties at different light levels. From the % reduction it was found that only BARI mung 6 under 75 percent of full sunlight and 50 percent of full sunlight reduced lesser percent of pods per plant compare to others two varieties under shade condition. Among the varieties, the highest number of pods (10.45) was attained in BINA mung 5 under 100 percent sunlight and the lowest number of pods (7.31) was found in BINA mung 5 under 50 percent of full sunlight level.

4.25. Pod length

The combined effect of light levels and mungbean varieties on pod length was not significant (Table 1). The figure showed that different variety performed differently in obtaining pod length under different light levels. The highest pod length (8.78 cm) was found in BINA mung 5 under 100 percent sunlight and the lowest pod length

(7.91cm) was found in BINA mung 8 under 50 percent of full sunlight level.

Table 1. Effect of different light levels on number of pods per plant and pod length of different mungbean variety

Variety	Treatment	Pods per plant	% change over full sunlight	Pod length (cm)
BINA Mung 5	L_{100}	11.60 a	-	8.78
	L_{75}	9.85 bc	-15.08	8.16
	L_{50}	8.46 ef	-27.06	8.22
BINA Mung 8	L_{100}	10.66 b	-	8.77
	L_{75}	9.00 de	-15.77	8.56
	L_{50}	7.73 fg	-27.48	7.91
BARI Mung 6	L_{100}	10.46 b	-	8.14
	L_{75}	9.56 cd	-8.60	8.08
	L_{50}	8.43 ef	-19.40	8.32
Level of significance		*		NS
CV (%)		4.75		5.85

Table 2. Effect of different light levels on seeds per pod and thousand seed weight of different mungbean variety

Variety	Treatment	Seeds per pod	% change over full sunlight	1000 seeds weight (g)	% change over full sunlight
BINA Mung 5	L_{100}	9.63 ab	-	32.81 b	-
	L_{75}	9.93 a	+3.00	29.85 cd	-9.00
	L_{50}	9.53 ab	-1.00	28.93 d	-11.00
BINA Mung 8	L_{100}	9.66 ab	-	32.42 b	-
	L_{75}	9.00 bc	-6.00	30.86 c	-4.00
	L_{50}	8.53 c	-11.00	29.46 cd	-9.00
BARI Mung 6	L_{100}	10.06 a	-	35.98 a	-
	L_{75}	9.51 ab	-5.00	34.85 a	-2.00
	L_{50}	9.00 bc	-10.00	32.84 b	-8.00
Level of significance		*	-	**	-
CV (%)		4.78	-	2.37	-

4.26. Number of seeds per pod

The combined effect of light levels and mungbean varieties on number of seed per pod was significant (Table 2). In all the varieties, the number of seeds per pods was reduced with the reduction of light levels except BINA mung 5 under 75 percent of full sunlight where number of seeds per pod was increased. But the degree of reduction in number of seeds per pod was different for different mungbean varieties at different light levels. Among the varieties, the highest number of seeds per pod (10.06) was attained in BARI mung 5 under 100 percent sunlight level the lowest number of seeds (8.53) was found in BINA mung 8 under 50 percent of full sunlight level.

4.27.Thousand seeds weight

The combined effect of light levels and mungbean varieties on thousand seeds weight was significant (Table 2). In all the varieties, thousand seeds weight was reduced with the reduction of light levels compare to control i.e. full sunlight. But the degree of reduction in thousand seeds weight was different for different mungbean varieties at different light levels. From the % reduction it was found that only BARI mung 6 under 75 percent of full sunlight level and 50 percent of full sunlight reduced lesser percent of thousand grain weight compare to others two varieties under shade condition. Among the varieties, the highest thousand seeds weight (35.98 g) was attained in BARI mung 6 under 100 percent sunlight and the lowest thousand seeds weight (28.93 g) was found in BINA mung 5 under 50 percent of full sunlight.

4.28. Yield

The combined effect of light levels and mungbean varieties on yield was significant (Table 3). In all the varieties, yield was reduced with the reduction of light levels compare to control i.e. full sunlight. But the degree of reduction in thousand seeds

Table 3. Effect of different light levels on yield of different mungbean variety

Variety	Treatment	yield (ton/ha)	% change over full sunlight
BINA Mung 5	L_{100}	1.31 a	-
	L_{75}	1.01 c	-22.00
	L_{50}	0.88 d	-32.00
BINA Mung 8	L_{100}	1.13 b	-
	L_{75}	0.96 cd	-15.00
	L_{50}	0.84 d	-25.67
BARI Mung 6	L_{100}	1.31 a	-
	L_{75}	1.14 b	-12.00
	L_{50}	1.00 cd	-23.66
Level of significance		*	
CV (%)		5.27	

weight was different for different mungbean varieties at different light levels. From the % reduction it was found that only BARI Gom 6 under 75 percent of full sunlight and 50 percent of full sunlight reduced lesser percent of yield compare to others two varieties under shade condition. Among the varieties, the highest yield (1.31 ton ha^{-1}) was produced both in BINA Mung 5 and BARI mung 6 under 100 percent sunlight and the lowest yield (0.84 ton ha^{-1}) was found in BINA mung 8 under 50 percent of full sunlight.

CHAPTER V

SUMMARY AND CONCLUSION

Performance of three different mungbean varieties (BINA Mung 5, BINA Mung 8 and BARI Mung 6) was evaluated under different light levels for the selection mungbean variety (ies) under reduced light levels based on their rnorpho-physiological, yield and yield contributing characteristics. The experiment was conducted at Crop Physiology and Ecology Research Field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from April 20, 2015 to June 30, 2015. The experiment was laid out in a split plot design with three replications where three light revels (100, 75 and 50 percent of full sunlight) were assigned in main plots and three mungbean varieties (BINA mung 5, BINA mung 8 and BARI mung 6) were assigned in the sub plots. Variation in plant height at different days (40, 50 and 60 DAS) after sowing of different mungbean varieties due to variation of light levels was significant. Plant height at 40 DAS different varieties responded differently under different light levels. In general, plant height at 50 and 60 DAS of mungbean varieties increased with the decrease of light levels, where the tallest and the shortest plants were recorded under 50 and I00 percent of full sunlight levels respectively. Variation in number of leaves per plant at different days (40, 50 and 60 DAS) after sowing of different mungbean varieties due to variation of light levels was significant. In general, number of leaves per plant at 40, 50 and 60 DAS of mungbean varieties decreased with the decrease of light levels except BINA Mung 8 where number of leaves increased under decreased sunlight and the highest and the lowest number of leaves per plant were recorded under 100 and 50 percent of full sunlight levels respectively. Leaf area per plant at 40 DAS was increased with the decreasing of light levels in all the mungbean varieties except BINA Mung 5 fewer than 50 percent of full sunlight level where leaf area increased compare to 100 percent sunlight. In general, leaf area at 50 and 60 DAS was increased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight and all the varieties under 75 percent of full sunlight showed maximum leaf area. At 50 DAS, the highest leaf area (52.61 cm^2) was observed in BINA Mung 5 under 75 percent of full sunlight and the lowest leaf area per plant (38.45 cm^2) was observed in BINA Mung 8 under 100 percent sunlight. At 60 DAS, the highest leaf area (65.52 cm^2) was observed in BARI Mung 6 under 75 percent sunlight and the lowest leaf area per plant (53.38 cm^2) was observed in BARI Mung 6 under 50 percent of full sunlight. Total leaf chlorophyll content was increased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight but the degree of increasing was not similar for all mungbean varieties. Among the varieties, the highest chlorophyll content (1.387 mg g^{-1} FW) was observed in BARI Mung 6 under 50 percent of sunlight and the lowest chlorophyll content (0.917 mg g^{-1} FW) was observed in BINA Mung 5 under 75 percent of full sunlight. Leaf chlorophyll ratio was decreased with the decreasing of light levels in all the mungbean varieties compare to 100 percent sunlight but the degree of decreasing was not similar for all mungbean varieties. Among the varieties, the highest chlorophyll ratio (0.307) was observed in BINA Mung 8 under 100 percent sunlight and the lowest chlorophyll ratio (0.224) were observed in BINA Mung 8 under 75 percent of full sunlight and the lowest chlorophyll ratio (0.224) were observed in BINA Mung 8 under 75 percent of full sunlight. Leaf dry weight per plant at 40 DAS was increased with the increasing of light levels in all the mungbean varieties. Among the varieties, the highest leaf dry weight (3.91 g) was observed in BINA Mung 5 under 100 percent sunlight and the lowest leaf dry weight per plant (3.09 g) was observed in BINA 8 under 50 percent sunlight. Leaf dry weight at 50 DAS all the varieties obtained maximum dry weight under 75 percent of full sunlight. Among the varieties, the highest leaf dry weight (10.14 g) was observed in BINA 5 under 75 percent of full sunlight and the lowest leaf dry weight per plant (7.63 g) was observed in BARI Mung 6 under 75 percent of full sunlight. Leaf dry weight per plant at 60 DAS was different for different varieties under different light levels. Stem dry weight per plant at 40 and 50 DAS was different for different varieties under different light levels. Stem dry weight at 60 DAS was increased with the increment of light levels in all varieties. Among the varieties, the highest stem dry weight (15.17 g) was observed in BINA 5 under 50 percent of full sunlight and the lowest stem dry weight per plant (9.09 g) was observed in BINA Mung 5 under 50 percent of full sunlight. Root dry weight at 40 DAS was increased with the increment if light levels of different varieties. Among the varieties, the highest root dry weight (0.67 g) was obtained in both BINA 5 under 100 percent sun light and BINA 5 under 100 percent sunlight and the lowest root dry weight per plant (0.43 g) was observed in BINA 5 under 75 percent of full sunlight. Root dry weight at 50 and 60 DAS was different for different varieties under different light levels. All the mungbean varieties fewer than 100 percent sunlight produced maximum dry weight compared to 75 and 50 percent of full sunlight level and at this level, all the varieties produced almost similar inflorescence dry weight except BARI Mung 6 produced higher dry weight compare to 50 percent of full sunlight level. Among the varieties, the highest Inflorescence dry weight (3.78 g) was obtained in BINA Mung 5 under 100 percent sunlight and the lowest inflorescence dry weight per plant (1.98 g) was observed in BARI Mung 6 under 50 percent of full sunlight. In all the varieties the number of pods was reduced with the reduction of light levels compare to control i.e. full sunlight. From the % reduction it was found that only BARI mung 6 under 75 and 50 percent of full sunlight reduced lesser percent of pods per plant compare to others two varieties under shade condition. The number of seeds per pods was reduced with the reduction of light levels except BINA mung 5 under 75 percent of full sunlight where number of seeds per pod was increased. But the degree of reduction in number of seeds per pod was different for different mungbean varieties at different light levels. Thousand seeds weight was reduced with the reduction of light levels compare to control i.e. full sunlight in all the varieties. From the % reduction it was found that only BARI mung 6 under 75 percent and 50 percent of full sunlight reduced lesser percent of thousand grain weight compare to others two varieties under shade condition. Yield was reduced with the reduction of light levels compare to control i.e. full sunlight in all the mungbean varieties. But the degree of reduction in thousand seeds weight was different for different mungbean varieties at different light levels. From the % reduction it was found that only BARI mung 6 under 75 percent and 50 percent of full sunlight reduced lesser percent of yield compare to others two varieties under shade condition.

From the overall results it may be concluded that-

- Plant height and leaf area were increased but number of leaves per plant was decreased under partial shade condition.
- Dry weight of leaf, stem and root were reduced due to partial shade condition at different days after sowing.
- Amount of total leaf chlorophyll was increased but chlorophyll a to b ratio was reduced under partial shade condition.
- Yield and yield attributes of different mungbean varieties were affected due to partial shading but BARI Mung 6 was affected least compared to rest.
- Among the mungbean varieties studied, BARI Mung 6 may be used as potential intercrop.

REFERENCES

Adelana B. O. and G. M. Milborn. 1992. The growth of maize. II. Dry matter partition maize hybrids. J. Agric. Sci. camb. 78: 73-78.

Ahamed T. 2003. Effect of different light levels on growth, yield and quality of tomato varieties. An MS thesis, BSMRAU, Gazipur, Bangladesh.

Akhter N., M. M. Rahman, M. Hasanuzzaman and K. Nahar. 2009a. Dry matter partitioning in garden pea (*Pisum sativum* L.) as influenced by different light levels. Academic Journal of Plant Sciences 2(4): 233-236.

Akhter N., M. M. Rahman, M. Hasanuzzaman and K. Nahar. 2009b. Plant Characters and Seed Yield of Garden Pea under Different Light Intensity. American-Eurasian Journal of Agronomy 2(3): 152-155.

Akhter N., M. M. Rahman, M. Hasanuzzaman and K. Nahar. 2009c. Physiological Response of Garden Pea (*Pisum sativum* L.) grown under different light environment. Botany Res. Int. 2(4): 304-309.

Ali M. A. 1998. Growth and yield of mungbean genotype under sun and shade conditions. An unpublished MS Thesis BSMRAU, Gazipur, Bangladesh.

Ali M. A. 1999. Performance of red amaranth and lady's Finger growth at different orientations and distances under guava and Drumstics trees. An MS thesis BSMRAU, Gazipur, Bangladesh.

Allard G., C. J. Nelson and S.G. Pallardy. 1991. Shade effects on growth of tall fescue: I. Leaf anatomy and dry matter partitioning. Crop Sci. 31: 163-167.

Allard G., O. C. J. Nelson and S. G. pallardy. 1991b. Shade effects on growth of tall Fescue: 11. Leaf gas exchange characteristics. crop- sci. 31: 167-172.

Andersen T. B. T., P. Hasson, K. sorolarz and K. Kamarlichi. 1993. Growth and development in black currants Ribes nigrum. Effect of light and leaf shoot removals on growth distribution and fruit drop. Sixth international symposium on Rubus and Ribes. Skierniewices Poland, 3-10 July 1993. Acta-Horticulture no. 352: 237-245.

Asay K. H., C. J. Nelson and G. L. Horst. 1974. Genetic variability for net photosynthesis in tall fescue {Festuca arundinacea Schreb), Crop Sci. 14: 571- 574.

Bates L. S. 1973. Rapid determination of free proline for water-stress studies. Plant Soil 39: 205-207.

Bose R. D. 1982. Studies in Indian pulses, No.4. Mung or Green gram. Indian J. Agril. Sci. 52 (2): 604-624.

Bscentinceli K. A., K. Abab, K. Bayforum and H. H. Ozturk. 1994. The effect of double covered root and thermal screens on internal solar radiation and tomato plant grown in plastic houses 2nd symposium on protected cultivation of solanaceae in mid winter climate Adana, Turkey 13-16 April. 1993. Acta. Horticulture No. 366: 141-148.

Bushby H. V. A. and R. I. Lawn. 1992. Accumulation and partitioning of nitrogen and dry matter by contrasting genotypes of mungbean (*Vigna radiata* L.). Aust. J. Agric. Res. 43: 1609-1628.

Chandrababu R., R. sadasivam, N. Natarajaratram and S. R. S. Rangaswamy. 1985. photosynthesis in relation to yield potential in Blackgram. Madras Agric. J. 72: 152-155.

Chipungahelo G. S., A. Ngereza, P. Kawamala and T. Kwileka. 2007. Effects of light regimes on different crops, sweet potato (*Ipomoea batatas*), cowpea (*Vigna unguiculata*) and pineapple (*Ananas comosus*). African Crop Science Conference Proceedings 8: 467-471.

Chowdhury M. A., M. A. Khaleque and M. M. Rahman. 1988. Variability and correlation among some yield contributing characters in mungbean. Bangladesh J. plant Breeding and Genetics 1(I & 2): 62-65.

Crookston R. K., K. J. Treharne P. Ludofrd and J. L. Ozbur. 1975. Response of beans to shading. Crop Sci. 15: 4 12-416.

Evans L. T. 1975. Thc physiotogical basis of crop yield. in: crop physiology. Some case hostories. London. Cambridge University press.

Farnham M. W., H. D. Gross and J. J. cappy. 1985. Effect of light level on nitrogen fixation and carbohydrate distribution in Virginia peanuts. North Carolina Agric. Res. Serv. Releigh, K, NC: 27601-27695.

Fujita K., K. Matsamoto, G.K.O. Buda and S. Ogata, 1993. Effect of shading on growth and Di-nitrogen fixation of Kudzce and tropical pasture legumes. Soil Sci. Plant nutrition. 39(1): 43-54.

Gandoram M. O., M. M. El-Rouby, F. A. Al-saad and A. A. Al-Derfasi. 1988. Effects of shading densities of the Agronomic and physiological characters of two sugarbeat cultivars. J. Agron. Crop. Sci. 161: 114-122.

George S. and R. V. Nair. 1990. Effect of shading on leaf development and chlorophyll content in groundnut (*Arachis. hypogea* L.) legume Res. 13(3): 130-132.

Hamid A. 1992. Seed Development. Quality and yield of five selected Mungbean Genotypes. An MS Thesis, IPSA, Gazipur, Bangladesh.

Haque M. M. 2001. Effect of different light levels on the morphology, physiology and yield of four selected vine crops. An MS Thesis, BSMRAU, Gazipur, Bangladesh.

Hart J.W. 1990. Growth and development: Photomorphogenesis. In: Light and plant growth. Unwin Hyman Ltd. London pp. 102-137.

Hidoto L. and G. Loha. 2013. Identification of suitable legumes in cassava (*Manihot esculenta* Crantz)-Legumes intercropping. Afr. J. Agric. Res. 8(21): 2559-2562.

Hillman J. R. 1984. Apical dominance in willing, M.b. (ed). Advanced plant physiology. Pitman, London pp. 127-147.

Imai K., T, Kawan, K. shimabe, K. lntabon and K. Tanaka. 1993. Studies on dry Matter production edible canna (Canna edulis ler.) II. Changes of dry matter production with growth. Japan. J. Crop. Sci. 62: 601-608.

Islam M. S. 1996. Effect of shading on gas exchange characteristics and productivity of mungbean and blackgram. An MS thesis, Dept. of Agron. IPSA, Gazipur, Bangladesh,

Islam M. T., F. Kubota, M. F. H. Mollah and W. Agata. 1993. Effect of Shading on the Growth and Yield of Mungbean. J. Agron. Crop Sci. 171(4): 274–278.

Islam M. T., W. Agata, F. Kubota and A. Hamid. 1994. Evaluation of characteristics related to photosynthetic rate and leaf area production in mungbean Genotypes. J. Crop Sci. 63: 502-509.

Islam S. M. 1995. Effect of shading on gas exchange characteristics and productivity of mungbean and blackgram. An Unpublishsd MS thesis, IPSA, Gazipur, Bangladesh.

Karim A., H. Fukamachi and T. Hidaka. 2003. Photosynthetic performance of *Vigna radiata* L. leaves developed at different temperature and irradiance levels. Plant Science 164: 451-458.

Keatin B. A. and P. S. Carberry. 1993. Resource capture and use in Intercropping: solar radiation. Field Crops Res. 34: 273-301.

Khan M. A., K. Naveed, K. Ali, B. Ahmed and S. Jan. 2012. Impact of mungbean-maize intercropping on growth and yield of mungbean. Pak. J. Weed Sci. Res. 18(2): 191-200.

Khanum M.. M. Q. Islam, M. A. K. Mia and M. A. Islam. 1982. Estimation of genotypic and phenotypic variation, habitability and genetic advance of some important quantitative characters in mungbean (*Vigna radiata* L). In proc. Nat 1 Workshop on pulses, (Aug. I8-19-1981) BARI, Joydebpur, Gazipur, Bangladesh pp. 26-31.

Kubota F. and A. Hamid. 1992. Comparative analysis of dry matter production and photosynthesis between mungbean (*Vigna radiuta* (L.) Wilczek) and black gram *(V. mungo* (L.) Hepper) grown in different light intensities. J. Fat. Agr., Kyushu Univ. 37(1): 71-80.

Lantican R. M. and I. G. Catedral. 1977. Evaluation of legumes for adaptation to intensive cropping systems. I. Mungbean, *Vigna radiata* (L.) wikzel. Philippine J. crop sci. 2: 62-66.

Laosuwan P., S. S. Saengpratoom, S. Kaloowong and A. Thongsomsni. 1992. Breeding mungbean for shade tolerance. Proceedings of mungbean meeting, chiang Mai. Thailand pp. 95-100.

Lawn R., Jond J. H. Willams. 1987. Limits imposed by climatological factors. In Food legume improvement for Asian farming systems willis, E. S. and D. E. Byth (eds). Proceedings of an international workshop held in Khan Kaew, Thailand. 1-5 September 1986. ACIAR proceedings no. l8 ACIAR, Canberra pp. 83-98.

Islam. M. S. 1996. Effect of shading on gass exchange characteristics and productivity of mungbean and blackgram. An M.S, Thesis, Dept. of Agron. IPSA, Gazipur, Bangladesh.

Mahon J. D. and J. A. Hobbs, 1981. selection of peas for photosynthetic CO_2 exchange rate under field conditions. Crop Sci. 21: 616-621.

Miah M. M. 2001. Performance of five winter vegetables under different light conditions for Agroforestry Intercropping system. An M.S. Thesis, BSMRAU, Gazipur, Bangladesh.

Miah M. G., M. A. Rahman and M.M. Haque. 1999. Performance of onion under different reduced light levels for Agroforestry and Intercropping systems. Bulletin of Tropical Agriculture, 22.

Miranda-Abilay R. and R. M. Lantican. 1982. Characters associated with yield performance of grain legume crops under partial shaded condition I. Mungbean (*Vigna radiata*). Philipp. J. Crop Sci. 7(2): 88-93.

Murshed A. N. M. M. 1996. Influence of management conditions on growth flowering and pod set, seed development and yield of chickpea. An M.S. thesis, IPSA, Gazipur, Bangladesh.

Murty K. S. and Venkateswaralu. 1978. Physiological constraints on growth and productivity in rice during kharif season. Nati. symp. on increasing rice yield in kharif. IRRI. Cuttack. pp. 45-65.

Mutsunaga R. A. A. Hamid and A. Hashem. 1989. Dry matter production and yield performance of summer and winter pulses in Bangladesh. J. Fac. Kyushu Univ. 38: 221-228.

Nelson C. J., K. H. Asay and G. L. Hort. 1975. Relationship of leaf photosynthesis to forage yield of tail fescue. Crop. Sci. 15: 476-478.

Niklas K. J. and T. C. Owens. 1989. Physiological and morphological modifications of plant ago major (ptontaginacee) in response to light conditions. Amer. J. Bot. 76(3): 370-382.

Nygren M. and S. Killomaki. 1993. Effect of shading on leaf structure and photosynthesis in young birches. Forest Ecol. Manag. 7(2): 119-132.

Ojima M., R. Kawashima and K. Mikoshiba. 1969. Studies on the seed production of soybean. VII. The ability of photosynthesis in F1 and F2 generations. crop. Sci. Soc. Japan Proc. 38-93.

Orgen W. L. and R.W. Rinne. 1973. Photosynthesis and seed metabolism in: (ED caldwell, B. E.) Soybean: Improvement, Production and user Madison, American Society of Agronomy.

Osada A. 1966. Relationship between photosynthetic activity and dry matter production in rice varieties, especially as influenced by nitrogen supply. bull. Natl. Inst. Agro Sci. scr. 14: 117-188.

Panday C. K., M. C. Saxena and V. B. Singh. 1978. Growth analysis of blackgram genotypes Indian J. Agric. Sci. 45: 466-473.

Pandey J. P. and J. H. Torrie. 1980. Path coefficient analysis of seed yield components in soybeans (*Glycine max* (L.) marr). Crop Sci. 13: 505-507.

Patrick J. W. 1988. Assimilate partitioning in relation to crop Productivity. Hort. Sci. 23:33-40.

Phoclman J. M. 1991. Genetics of quantitative characters in: The mungbean west view press, Bouldar, Colorado, USA. pp. 195-222.

Polthanee A. and R. Changsri. 1999. Effect of planting dates of mungbean on growth and yield in corn mungbean relay cropping under rainfed conditions in an up-land area of Northeastern Thailand. Thai J. Agric. Sci. 32: 187-196.

Polthanee A. and V. Treloges. 2002. Growth and yield of mungbean cultivars in mungbean corn relay inter-cropping systems. J. of Int. Society for Southeast Asian Agric. Sci. 8: 1-14.

Polthanee A. and V. Treloges. 2003. Growth, yield and land use efficiency of corn and legumes grown under intercropping systems. Plant Production Sci. 6: 139-146.

Polthanee A., K. Promsaena and A. Laoken. 2011. Influence of low light intensity on growth and yield of four soybean cultivars during wet and dry seasons of Northeast Thailand. Agricultural Sciences 2(2): 61-67.

Rahodcs L. 1972. Yield, leaf area index and photosynthetic rate in some perennial ryegrass (*Lolium perenne* L.) selections. J. Agric. Sci. 78: 509-511.

Rao L. J. and B.N. Mittara. 1988. Growth and yield of peanut as influenced degree and duration of shading. J. Agronomy and Crop. Sci. 160: 260-265.

Rao T. R. K. and M. C. Ghildyal. 1985. Analysis of photosynthetic source and sink relationship in mungbean (*Vigna radiata* (L.). Indian J. Plant physiol. 28: 115-144.

Schoch P. C. 1972. Effect of shading a structural characteristics of leaf and yield of fruit in *Capsicum annum* L. J. Amer. Soc. Hort. Sci. 97(4): 461-464.

Schou J. B., D. L. Jeffer and J. C. Streeter. 1978. Effects of reflectors, black boards or shades applied at different stages of plant development on yield of soybeans. Crop Sci. 18: 29-34.

Sengupta, V. K. and B. B. Jadhav. 1988. Effect of low light intensity on photosynthesis and translocation of photosynthetes in groundnut. Indian J. Plant physiolo. Vol. XXXI. pp. 270-275.

Sheldrakc A. R. and N. P. Saxena. 1980. Physiology of growth, development and yield Of cheakpeas in India pp. 89-96. In proceedings of the international workshop on chickpea improvement. 28 Feb. 2 Mar 1979. Hydrabad. A. P. ICRISAT, India.

Shibles R. M., I. C. Anderson and A. H. Gibson. 1975. Soybean, In: (Ed. Evans, L. T.) Crop physiology, London, Cambridge University Press.

Shobhana S. P., H. S. Nainawatee and B. M. Lal. 1976. Chemical composition of some improved varieties of pulses. J. Food Sci. Technol. 13: 49-51.

Singh M., W. L. Organ and J. M. Widholm. 1974. Photosynthetic characteristics of several C_3 and C_4 plant species grown under different light intensities' Corp Sci. 14: 563-566.

Singh B. G., V. J. M. Rao, C. A. Suguna and L. M. Rao. 1985. Varietal differences in growth and yield of rnungbean (*Vigna radiate* (L.) wlezek) during summer and kharif seasons. Indian Journal of plant physiology 28: 207-214.

Singh S. 1994. Physiological response of different crop species to low light stress. Indian J. Plant Physiol. 37(3): 147-151.

Singh, U. and R. Jambunathan. 1991. Pulses as substitute for animal protein. Pages 1971-1977, *In* Advances in pulse research in Bangladesh, Proceedings of second national workshop on pulses 6-9 Jun. 1989. BARI. Joydebpur, Bangladesh.

Sinoquet H and R. M. Caldwell. 1995. Estimation of light capture and partitioning in intercropping systems. pp. 79-89. In. Ecophysislogy of Tropied intercropping system. H. Sinoquet and P. Cruz. (eds.). INRA, Grace.

Sundari T. 2009. Morphological and physiological characteristics of shading tolerant and sensitive mungbean genotypes. HAYATI J. Biosci. 16(4): 127-134.

Thomas B. M. and S. L. Teoh. 1983. Culture of container grown Focus macrophylla. II. Influence of shading and N fertilization. Royal New Zealand Ins. Hort. Ann. J. 11: 77-82.

Wadud M. A. 1999. Performance of four summer vegetables under reduced light conditions for Agroforestry Systems. An MS. Thesis, BSMRAU, Gazipur, Bangladesh.

Wahua T. A. T. and D. A. Miller. 1978a. Effects of intercropping on soybean NL-fixation and plant composition on associated sorghum and soybeans. Agron. J. 70: 292-295.

Watson D. J. 1971. Size, structure and activity of the productive system of crops, In: (Eds. Wearing, P. E. and J. P. Cooper) potential crop production, London, Weiremann Education Books.

Weaver J. E. and F. E. Clements. 1978. Light. In: Plant Ecology. Tata McGraw Hill Publishing Co. Ltd. New Delhi pp. 380-417.

Williams W. A., W. C. Loomis and C. R. Lepley. 1965. Vegetative growth of corn as affected by population density. II. Components of growth net assimilation rate and real-area index. Crop Sci. 5: 215-219.

Wilson J. R. 1990. Agroforestry and soil fertility. The eleventh hypothesis Shade. Agroforestry Today 2: 14-15.

Witham H., D. F. Blades and R. H. Devin. 1986. Exercise in plant physiology (2nd edition), PWS Publishers, Boston, USA pp. 128-131.

Woledge, J. 1971. The effect of light intensity during growth on the subsequent rate of photosynthesis of leaves of tall fescue (*Festuca arundinacea* Schreb.). Ann. of Bot. 35: 311-322.

Yohe J. M. and J. M. Poehlman. 1972. Genetic variability in mungbean (*Vigna radiata* L.) Crop Sci. 12: 461.

Zhao D. and D. Oosterhuis. 1998. Cotton responses to shade at different growth stages: Nonstructural Carbohydrate Composition. Crop Sci. 38: 1196-1203.

APPENDICES

Appendix I: Morphological and Physical characteristics of soil

Morphology	Characteristics
Location	Crop Physiology and Ecology, HSTU, Dinajpur
AEZ	Old Himalayan Piedmont Plain (AEZ-1)
General Soil type	Non-Calcareous Brown Floodplain Soil
Parent material	Piedmont alluvium
Soil series	Ranishankail
Drainage	Moderately well drained
Flood level	Above flood level
Topography	High land
Physical Characteristics	Value
sand (2-0.02mm)	60.0
silt (0.02-0.002mm)	27.0
clay (< 0.002mm)	13.0
Textural class	Sandy loam

Source: The Morphological and physical characteristics of soil samples were done by SRDI, Dinajpur, Bangladesh.

Appendix II: Chemical characteristics of initial soil samples

Characteristics	Content	Interpretation
pH	5.40-5.50	Moderately acidic
Organic carbon (%)	0.69	Low
Organic matter (%)	1.19	Low
Bulk density (g cm-3)	1.30-1.57	Medium
CEC (meq/100g soil)	5.60	Low
Total N (%)	0.07	Very low
Available P (ppm)	16.75	Medium
Exchangeable K (meq/100g soil)	0.17	Medium low

Source: The chemical analysis of initial soil samples were done in SRDI, Dinajpur, Bangladesh.

Appendix III: Calculated mean sum square of different sources of variance for the following parameters

Source of variance (SV)	df	Mean Sum square					
		Plant height at 40 DAS	Plant height at 50 DAS	Plant height at 60 DAS	Shoot dry weight	Root dry weight	Seedling dry weight of
Light levels (A)	2	10.846*	337.622*	6.592**	0.030**	0.023**	43.195*
Mungbean varieties (B)	2	21.283*	61.291*	425.090**	0.400*	0.008**	23.748*
Interaction (AB)	4	30.187**	15.621**	6.211*	0.286*	0.029*	4.571**
Error	12	4.062	2.509	1.308	0.008	0.001	0.565
Total	26	352.101	921.313	911.893	2.405	0.266	165.711