WEED MANAGEMENT FOR MUNGBEAN UNDER DIFFERENT LEVEL OF PLANT SPACING

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WEED MANAGEMENT FOR MUNGBEAN UNDER DIFFERENT LEVEL OF PLANT SPACING

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CERTIFICATE

This is to certify that the thesis entitled "**WEED MANAGEMENT FOR MUNGBEAN UNDER DIFFERENT LEVEL OF PLANT SPACING** " submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **Master of Science in Agronomy**, embodies the results of a piece of bona fide research work carried out by **ESRATUNNESA EASHA**, Registration. No. **08-2816**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been available of during the course of this investigation has been duly acknowledged by him and style of this thesis have been approved and recommended for submission.

Dated:

Dhaka, Bangladesh

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The author

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ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during August to October 2013 to study the effect of row spacing and weed management on the performance of mungbean (cv. BARI Mung-6). The experiment comprised of two factors viz. (i) plant spacing and (ii) weed management with three plant spacing (S_1 = 20 cm × 10 cm, S_2 = 30 cm × 10 cm, S_3 = 40 cm × 10 cm) and five levels of weeding treatments (W_1= No weeding, W_2= Hand weeding at 20 DAS, W_3 = Hand weeding at 20 and 40 DAS, W_4 = Pre emergence herbicide, Sunup 480 SL spraying after land preparation, W_5 = Post emergence herbicide, Release 9 EC spraying at 15-20 DAG . Results revealed that plant spacing with 30 cm x 10 cm stand superior than other in respect of branches plant^{-1} (1.04), above ground dry matter weight plant^{-1} (12.26 g), pod length (9.02 cm), seeds pod^{-1} (10.71), seed yield (1.08 t ha^{-1}), respectively while maximum number of pods plant^{-1} (10.39), 1000-seeds weight (47.16 g) and harvest index (37.90 %) were found in 40 cm x 10 cm spacing. Among weed management practices, the highest plant height (65.60 cm), dry matter content plant^{-1} (13.37 g), pod length (9.16 cm), seeds pod^{-1} (10.98) and straw yield (2.18 t ha^{-1}) were obtained by the application of post emergence herbicide at 15-20 DAG (W_5) while maximum number of pods plant^{-1} (9.89), grain yield (1.34 t ha^{-1}), biological yield (3.51 t ha^{-1}) and harvest index (38.71 %) was obtained from two hand weeding treatment. In interaction, the maximum dry matter weight plant^{-1} (15.48 g), pod length (10.75 cm), seeds pod^{-1} (12.71), grain yield (1.51 t ha^{-1}) and biological yield (3.973 t ha^{-1}) were gained by 30 × 10 cm row spacing with application of post emergence herbicide for weed management. However, the highest number of pods plant^{-1} (12.67) and harvest index (45.19%) were achieved by 40 × 10 cm row spacing with two times of hand weeding. But maximum 1000-grains weight (50.89) was found in 40 × 10 cm row spacing with single weeding. Economic analysis revealed that 30 cm x 10 cm plant spacing followed by application of post emergence herbicide (Release 9 EC @ 650 ml ha^{-1}) for weed control recorded maximum gross margin (111735 TK ha-1) and benefit cost ratio (3.50) which indicated that mungbean was used to cultivate giving spacing as 30 cm x 10 cm along with Release spraying at 15 days after germination.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
DAG	=	Days after germination
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram $hectare^{-1}$
g	=	gram (s)
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
m	=	Meter
P^{H}	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
t ha^{-1}	=	ton $hectare^{-1}$
%	=	Percent

INTRODUCTION

Ecological degradation from synthetic chemicals, population pressure and poverty coupled with malnutrition are the priorities for the present day agricultural researchers. So the plant scientists are facing the challenge that how to meet the food requirement of this unchecked population (Thirtle *et al*., 2003). Hence, nutrition oriented sustainable agricultural production system is of utmost priority in the present context. In this acute context, pulses are inseparable ingredients of vegetarian diet and one of the cheapest weapons for combating the malnutritional problem by supplying dietary protein to the people of our country. Pulses are used with meal as delicious food in the poor countries and in the modern world, they are utilized to maintain a good health. Being leguminous, they maintain soil fertility by fixing atmospheric nitrogen in available form through symbiosis with rhizobial strains. Pulses are also important component of animal feed and their dried straw is used as hay. In pulses, mungbean (*Vigna radiata* L.) is a vital crop (Khattak *et al*., 2004).This commonly grown pulse crop belongs to the family Fabaceae. Its edible grain is characterized by good digestibility, flavour, high protein content and absence of any flatulence effects (Ahmad *et al*., 2008). It also contains amino acid, lysine which is generally deficit in food grains (Elias *et al*., 1986). It holds the 3rd in protein content and 5th in acreage and production and first in market price (BBS, 2008). It is grown three times in a year covering 27530 ha with an average yield of 0.69 t ha^{-1} (BBS, 2011). It is produced for both human consumption and as fodder. Its seed contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamin (Afzal *et al*., 2008). The by-product of mung bean vermicelli processing contains 11-23% crude protein, 0.4-1.8% ether extract, 13-36% crude fibre, 0.30- 0.68 % calcium and 0.17-0.39 % phosphorus depending on the mungbean material (Sitthigripong *et al.*, 1998). Mungbean is usually grown at low to medium elevations in the tropics as a rainfed crop. It ranks second to drought resistance after soybean (Ali *et al*., 2001; Ghafoor *et al*., 2003). Mungbean can be grown as manure, hay, cover crop and forage or intercropped in cereals, sugarcane, sunflower or jute. On an average, it fixes atmospheric nitrogen @ 300 kg ha^{-1} annually (Sharar *et al*., 2001).The agro ecological condition of Bangladesh is favourable for growing this crop.

In spite of its importance as food and feed, very little attention has been paid to its quantitative and qualitative improvement in the country. In Bangladesh, total production of pulse is only 0.65

million ton against 2.7 million ton requirement which accounted for lower yield capacity of the crop (MoA, 2005). As resources are squeezing and population is hiking therefore crop scientists are focusing on improved management practices and advanced crop husbandry techniques (Lipton, 2001). Research on all pulse crops remained neglected until 1980, due to which work on mungbean improvement has not been systematized. Its per hectare yield obtained at farmers field is low, because no systematic efforts have been made in the past to develop a package of technology, which may ensure high seed yield of this crop. Important reasons for low average yield of mungbean on farmer's field are the continuous cultivation of traditional low potential cultivars, use of low seed rate and improper agronomic practices (Ansari *et al.*, 2000). Among many other crop production constraints, poor plant spacing and weed management are the most important areas which contribute substantially lower seed yield of mungbean (Ismail and Hall, 2000; Khan *et al.*, 2001). Various works on spacing of mungbean cultivition showed that optimum plant spacing gave maximum yield (Mondal, 2007; Mansoor *et al*., 2010). Improper spacing reduced the yield of mungbean up to 20-40% (AVRDC, 1974). It is due to crop suffers for light, space, water and nutrition under unfavourable spacing. The optimum spacing favours the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients and thus grain yield is increased (Miah *et al*.,1990).

Weed is one of the most important factors responsible for lower yield of crop (Islam *et al*.,1989; Rahman and Ullah, 2009). All crops have a vulnerable stage during their life cycle when they are particularly sensitive to weed competition. In general, it ranges up to first 25-50% of the life time of crops. Critical period of weed competition is the range within which a crop must be weeded to save the crop from yield loss (Islam *et al*.,1989). Mungbean is not very competitive against weed and therefore weed control is essential for mungbean production . Seed yield of mungbean was maximum (2108 kg ha^{-1}) in the weed free treatment (Punia *et al*., 2004) whereas about 69% reduction in mungbean grain yield due to weeds was estimated by Yadav and Singh (2005). According to Pandey and Mishra (2003) the decrease in mungbean productivity due to weed competition was 45.6%. Weeds compete with main crop for space, nutrients, water and light, thus crop becomes week and subsequently yield is lose. It is also recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Bueren *et al.*, 2002). Weed crop competition commences with germination of the crop and continues till its maturity. Several Growth stages of mungbean such as emergence, flowering and pod setting are greatly hampered by weed. Weed infestation of these stages causes low pod setting and ultimately yield reduces. Weeds above critical population thresholds can significantly reduce crop yield and quality. However, the aim of weed management should be to maintain weed population at a manageable level. Timely control of weeds either manually or using herbicide is essential for higher harvest yield in mungbean. Significantly more seed yields by weeding have been reported in mungbean (Hossain *et al*., 1990; Kumar and Kiron, 1990; Musa *et al*., 1996). Herbicides are one of the crucial factors in a worldwide increase in agricultural production. Herbicides contribute effectively and profitably to weed control, environmental protection, and in the same time, saving labour necessary for weed control practices, reduced soil erosion, saved energy, increased crop production, reduced the cost of farming. Therefore, herbicides benefit society as a whole. But, use of herbicides has created considerable concern for human health and environment. Fortunately, the health and environmental risks associated with herbicide use are largely a manageable problem. The increasing production and use of the new "low-rate" and "environment-friendly" herbicides has reduced the risks for non-target organisms and the environment as a whole.

Therefore, the optimum plant spacing along with proper weed management could be the most important management for better mungbean production.The present study was therefore, undertaken with the following objectives.

1. To study the effect of different levels of plant spacing on the growth, yield attributes and yield of mungbean.
2. To find out the suitable method of weeding for maximum yield of mungbean.
3. To study the combined effect of plant spacing and weeding method on the growth and yield of mungbean.

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abraod regarding the effect of different level of plant spacing and weed management on the growth and yield of mungbean and other crops to gather knowledge helpful in conducting the present research work and subsequently writing up the result and discussion.

2.1 Effect of different level of plant spacing

2.1.1 Effect on growth characters

2.1.1.1 Plant height

Rasul *et al*. (2012) conducted an experiment to study the influence of various Inter-row spacing on different varieties of mungbean in Faisalabad,Pakistan. He observed that plant height was significantly affected by inter-row spacing and maximum plant height was observed at a plant spacing of 45 cm (50.83 cm) while the average plant height at maturity of 30 and 60 cm inter-row spacing were 49.36cm and 47.72 cm, respectively.

An experiment was conducted at Agricultural Research Institute, Dera Ismail Khan, Pakistan to study the effect of different row spacings and seed rates on some physiological parameters of mungbean by Mansoor *et al*. (2010). He observed that 20 cm row spacing produced the tallest plants (72.20 cm), while the shortest plants (67.50 cm) were recorded in 40 cm row spacing.

Kabir and Sarkar (2008) conducted an experiment in the Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh and the tallest plant was observed at a planting density of 40 cm × 30 cm mainly due to more space for growing up the individual plant. The shortest plant was observed at a planting density of 20 cm × 20 cm.

Malik *et al.* (2006) noticed that maximum plant height (76.62 cm) of mungbean was attained by P1 (30 cm apart flat sowing) while he carried out an experiment in Department of Agronomy, University of Agriculture, Faisalabad-Pakistan.

Different field trials in different time were conducted to establish the proper inter-row spacing on sesame and found that narrow spacing increased plant height and reduced the number of branches plant^{-1} in crops (Narayanan and Narayanan, 1987; Chimanshette and Dhoble, 1992; Hossain and Salahuddin, 1994).

2.1.1.2 Branches plant^{-1}

A field experiment was carried out in Pakistan by Rasul *et al*.(2012) to observe the influence of various Inter-row spacing on different varieties of mungbean. He observed that the inter-row spacing of 30 cm affected the plant to produce more number of fruit bearing branches (6.24) and was statistically at par with that of inter-row spacing of 45 cm which produced 6.20 numbers of fruit bearing branches.

An experiment was conducted by Mansoor *et al*.(2010) at Agricultural Research Institute, Dera Ismail Khan,Pakistan during 2003 and 2004 to study the effect of different row spacings and seed rates on some physiological parameters of mungbean. The highest number of branches (5.23) was recorded with 20 cm row spacing and the lowest number of branches (4.35) was, however, recorded in wider row spacing but with increased seed rate.

The highest number of branches plant^{-1} at 30 cm × 10 cm spacing followed in order by 40 cm × 30 cm and 20 cm × 20 cm was observed by Kabir and Sarkar (2008) while conducting an experiment on mungbean with row spacing.

Khan (2000), Waheed (1996) and Zaidi (1998) who stated significant differences for branches plant^{-1} among various cultivars and inter-row spacing while they were conducting experiment on mungbean in different places.

2.1.1.3 Total dry matter production

A field experiment was undertaken in Mymensingh-2202, Bangladesh by Kabir and Sarkar (2008) on mungbean and they said that the highest dry matter plant^{-1} was produced at spacing of 30 cm × 10 cm, which was identical to that of 40 cm × 30 cm. The lowest dry matter plant^{-1} was produced in 20 cm × 20 cm spacing.

Ahmed (2001) carried out a field trial and stated that total dry matter of mungbean were significantly influenced by both Phosphorus level and row spacing. He found that the row spacing of 30 cm proved the best spacing.

Muchow and Edwards (1982) reported significantly positive linear trends of dry matter production in three varieties of mungbean to increasing density. Madhavan *et al*., 1986 also noticed that narrow spacing significantly increased dry matter production in pigeon pea.

2.1.2 Effect on yield contributing characters

2.1.2.1 Pods plant^{-1}

Rasul *et al*.(2012) said that the effect of inter-row spacing was non-significant on the number of pods plant^{-1}. He noticed that the number of pods per plant^{-1} was significantly affected on mungbean while set an experiment in Pakistan with the interaction of varieties and inter-row spacing .

The highest number of pods plant^{-1} was found at 30 cm × 10 cm spacing and the lowest one was found at 40 cm × 30 cm. However, 20 cm × 20 cm spacing produced similar pods plant^{-1} as that of 40 cm × 30 cm spacing. It was stated by Kabir and Sarker (2008).

Nadeem *et al*. (2004) carried out a field experiment to study the effect of two planting patterns on different legumes in Faisalabad-Pakistan and found that the number of pods per plant was affected significantly by different planting patterns. The 60cm apart double row produced more number of pods per plant than 40 cm apart single row strips in all legume crops. A significant effect of planting geometry on number of pods per plant has been reported by Ali *et al*. (2001).

2.1.2.2 Seeds pod^{-1}

Rasul *et al*.(2012) carried out a field trial on mungbean in Pakistan and mentioned that the inter-row spacing S_3 (60 cm) and S_2 (45 cm)were statistically similar and produced significantly more number of seeds per pod (10.55 and 10.37, respectively) than produced by S_1 (30 cm) inter-row spacing treatment.

Nadeem *et al.* (2004) said that the planting pattern showed non-significant effect on the number of seeds per pod. Effect of plant population and mulches was significant on grains cob^{-1} and lowest number of grains cob^{-1} (224) was recorded in the highest plant population of 90000 plants ha^{-1} compared to medium plant populations of 60000 plants ha^{-1} (254) and lower plant population of 30000 plants ha^{-1} (280) while Gul *et al.* (2011) conducted an experiment on maize in Peshawar.

The non-significant effect of row spacing on the number of seeds per plant has also been reported by Ali *et al*. (2001) and Sharar *et al*. (2001). But the results are contradictory to those of Aslam *et al*. (1993), who stated that 30 cm spacing gave higher number of seeds per pod in soybean.

2.1.2.3 Pod length (cm)

The pod length of mungbean ranged from 5.76 to 7.09 cm and the lengthiest pods (7.09 cm) were recorded in 20 cm row spacing by Mansoor *et al*.(2010) in his experiment which was done in Pakistan. This can be attributed to greater space within rows that resulted in efficient light interception and photosynthetic activity. The smallest sized pods (5.76 cm) were recorded in treatments having wider row spacing but with decreased plant to plant distance.

Kabir and Sarker (2008) conducted an experiment on mungbean in Bangladesh and mentioned that the highest pod length was obtained at 30 cm × 10 cm spacing. The lowest pod length was observed at 20 cm × 20 cm spacing, which was statistically identical to 40 cm × 30 cm spacing.

2.1.2.4 1000-Seeds weight (g)

Rasul *et al*.(2012) stated that among the inter-row spacing treatments, the maximum 1000-seeds weight (49.30 g) was obtained at 60 cm inter-row spacing while establishing an research work in Pakistan on mungbean with row spacing.

The highest 1000-seeds weight was observed at 40 cm × 30 cm spacing followed in order by 30 cm × 10 cm and 20 cm × 20 cm spacing by Kabir and Sarker (2008) while conducting an experiment on mungbean in Bangladesh.

Nadeem *et al.* (2004) said that 1000-seeds weight was affected significantly by different planting patterns. Crops sown in 40 cm apart rows produced significantly higher 1000-seeds weight than 60 cm apart double row strips. Significant effect of row spacing on 1000-seeds weight has also been reported by Ali *et al*. (2001).

2.1.2.5 Effect on grain yield

Rasul *et al*.(2012) conducted an exprriment to study the influence of various Inter-row spacing on different varieties of mungbean. He observed that the inter-row spacing of 30 cm and 45 cm produced 4131 & 4003.5 kg ha^{-1} of biological yield, respectively and these were statistically at par. The inter-row spacing of 60 cm gave minimum biological yield (3328.9 kg ha^{-1}).

It was reported by Mansoor *et al*. (2010) that the maximum grain yield of mungbean was recorded in treatments having 30 cm of row spacing by having maximum grain yield of 1111 kg ha^{-1} in the experiment which is conducted in Pakistan.

Ahmed (2001) and Tayyab (2000) reported increased grain yield with 30 cm row spacing. The lowest yield 1041 kg ha^{-1} was recorded in 40 cm row spacing treatment, in which plant spacing was less.

The highest seed yield (1046.0 kg ha^{-1}) was obtained at 30 cm × 10 cm spacing followed in order by 20 cm × 20 cm and 40 cm × 30 cm spacing. This highest seed yield resulted mainly due to higher number of branches $plant^{-1}$ and number of pods $plant^{-1}$ was observed by Kabir and Sarker (2008).

Achakzai and Panizai (2007) conducted a field experiment at Agricultural Research Institute, Quetta in year 2003 to study the influence of six different row spacing i.e., 20, 25, 30, 35, 40 and 45 cm on the growth, yield and yield attributes of mashbean grown under semi-arid climate. Results revealed that except of harvest index all the parameters including growth, yield and yield components were non-significantly ($P>0.05$) influenced by various levels of row spacing. Maximum harvest index (61.44%) was obtained in row spacing of 40 cm.

Mungbean cultivars Pusa 105 and Pusa Vishal were sown at 22.5 and 30 cm spacing and supplied with 36 - 46 and 58 - 46 kg N-P ha^{-1} in a field experiment which was conducted in Delhi, India during the kharif season of 2000. Cultivar *Pusa Vishal* recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Row spacing at 22.5 cm resulted in higher grain yields in both crops (Tickoo *et al*., 2006).

Ahmed *et al*. (2005) conducted an experiment in Faisalabad, Pakistan, during 2000 to study the effect of P fertilizer (0, 30, 60 and 90 kg ha^{-1}) and row spacing (30 and 45 cm) on the yield and yield components (pods $plant^{-1}$, seeds pod^{-1} and 1000-seeds weight) of mungbean cv. NM-92. Seed yield was the highest with 30 cm row spacing while pods per plant, seeds per pod and 1000-seeds weight were highest with 45 cm row spacing.

Bhatti *et al*. (2005) conducted a field experiment on a sandy-clay loam soil in Faisalabad, Pakistan for two consecutive years (2001 and 2002) to evaluate the effect of intercrops and planting patterns on the agronomic traits of sesame. The planting patterns comprised 40 cm spaced single rows, 60 cm spaced 2- row strips and 100 cm spaced 4-row strips, while the cropping systems were sesame + mungbean, sesame + mashbean (*Vigna aconitifolia*), sesame + soyabean, sesame + cowpea and sesame alone. Among the intercropping patterns, sesame intercropped with mungbean, mashbean, soyabean and cowpea in the pattern of 100 cm spaced 4-row strips (mungbean 25 cm apart) proved to be feasible, easily workable and more productive than sesame monocropping.

Sarkar *et al*. (2004) studied the effect of plant density on the yield and yield attributing characters of mungbean. Three planting densities viz., 20 cm × 20 cm, 30 cm × 10 cm and 40 cm × 30 cm were studied and it was observed that 30 cm × 10 cm spacing always showed highest yield performance with best quality.

Ihsanullah *et al.* (2002) concluded that row spacing of 20 cm (with plant to plant distance was 15 cm) is the best. The results are supported by Ali-khan and Kiehn (1989), Kler *et al*. (1991), Singh *et al*. (1991) and Board *et al*. (1992), who reported that narrow spacings resulted in higher grain yields in food legumes.

Ahmed (2001) evaluated the performance of plant spacing and stated that seed yield, straw yield, harvest index and seed protein content of mungbean were significantly influenced by both Phosphorus level and row spacing. He found that the row spacing of 30 cm proved the best spacing.

Important reasons for low average yield of mungbean on farmer's field are the continuous cultivation of traditional low potential cultivars, use of low seed rate and improper agronomic practices e.g. Inter-row spacing (Ansari *et al.*, 2000).

Among many other crop production constraints, appropriate varieties and inter-row spacing are the most important, which contribute substantially to the seed yield of mungbean (Ismail and Hall, 2000; Khan *et al.,* 2001). Research studies also revealed that most of the growth and yield contributing attributes are significantly and positively correlated with the grain yield of many crop plants viz., mash bean (Mahmoodul-Hassan *et al.,* 2003; Khan *et al.,* 2004), chickpea (Arshad *et al.,* 2004), Mungbean (Siddique *et al.,* 2006), soybean (Malik *et al.,* 2006, 2007) and sunflower (Vahedi *et al.,* 2010).

Based on climatic conditions, researchers obtained differential response of mash bean in relation to row spacing. Singh *et al.* (1994) got seed yields of 1.13, 1.37 and 1.36 t ha^{-1} of blackgram with 15, 22.5 and 30 cm row spacing.

2.2 Effect of weed management

2.2.1 Effect on growth characters

2.2.1.1. Plant height

Akter *et al*.(2013) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to assess the effect of weeding on growth, yield and yield contributing characters of mungbean *cv.* BINA mung- 4 during October 2011 to February 2012. Three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) ensured the highest plant height (58.62 cm).

Various rates of herbicide (2, 3 and 4 l/ha) including hand weeding were tried for weed control, of mungbean at Arid Zone Research Institute, D.I. Khan, Pakistan by Khan *et al.* (2011) and maximum plant height (67.30 and 59.73 cm) of mungbean was recorded in the treatment of hand weeding. It showed non-significant difference with the lowest rate of pendimethalin (2 l/ha, 62.8 and 57.63 cm).

Khaliq *et al*. (2002) investigated the efficacy of different weed management strategies in mungbean and stated that hoeing treatments resulted in reduced weed dry weight by 79% compared to control and maximum plant height while conducting a field trial.

The highest plant height was recorded in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was similar with treatments receiving quizalofop-pethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE and quizalofop-p-ethyl @ 50 g a.i. ha-1 at 7 DAE + HW at 14 DAE (Kundu *et al.*,2009).

Chattha *et al*.(2007) conducted a field study at National Agricultural Research Centre (NARC), Islamabad and observed that all the weed control methods significantly affected plant height of mungbean. Among different weed control methods, WC_6 (chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS) that was similar to that of WC_5 caused a pronounced affect on plant height of mungbean that showed about 5% and 3%, respectively higher plant height as compared to WC_1 (weedy check) treatment.

2.2.1.2 Dry matter weight plant^{-1}

Akter *et al*.(2013) mentioned that dry weight plant^{-1} (12.38 g) was highest from three stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) and the lowest from no weeding treatment while conducting an experiment on mungbean with weed management.

Chattha *et al*. (2007) conducted an experiment in Pakistan and concluded that maximum plant biomass (4.519 t ha^{-1}) was produced by WC_6 (chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS). On an average, treatment WC_6 caused about 31% increase in plant biomass of mungbean as compared to weedy check treatment.

Kumar *et al*. (2005) conducted a study to evaluate the benefits of the resource conservation technologies in mungbean during kharif 2004 in Haryana, India. Among the weed control treatments, the maximum reduction in dry weight of weeds was recorded in treatment with hand weeding at 20 and 40 DAS.

Anwar *et al.* (2004) investigated the feasiability of sorghum extract as natural weed control in comparison with hand weeding and herbicide. Sorghum extract reduced the weed number and weed weight. It also increased fresh and dry weight of crops.

2.2.1.3 Branches plant^{-1}

Akter *et al*.(2013) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to assess the effect of weeding on growth, yield and yield contributing characters of mungbean *(Vigna radiata* L.) *cv.* BINA mung- 4 during October 2011 to February 2012. Three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) ensured the highest plant height (58.62 cm) as well as the highest number of branches (4.45) and leaves (10.34) plant^{-1}.

2.2.2 Effect on yield contributing characters

2.2.2.1 Pods plant^{-1}

A field trial was carried out an experiment in Bangladesh by Akter *et al*.(2013) and observed that three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) ensured the highest number of pods (22.03) plant^{-1}.

Khan *et al.* (2011) conducted an experiment in Pakistan on mungbean and stated that among the treatments, hand weeding excelled in number of pods plant^{-1} (16.27 and 12.73) but appeared at par with the lowest rate of pendimathalin (16.00 and 12.20/plant) during the year 2006 and 2007, respectively.

The number of pods plant^{-1}, seeds pod^{-1} as well as seed yield (1327 kg ha^{-1}) were highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE. Similar result was also reported by Singh *et al.* (2001). The lowest number of pods plant^{-1}, seeds pod^{-1} as well as seed yield were recorded in weedy check treatment (T_{10}). It was stated by Kundu *et al.(*2009).

2.2.2.2 Pod length (cm)

Awan *et al*.(2009) conducted an experiment on mungbean in Pakistan and pod length was recorded maximum in plots where treatments were *terphali* (9.9 cm) and hand weeding (9.7 cm); while in plots with 45cm row spacing + tractor and 60cm + tractor, pod length was 9.2 cm and 9.6 cm, respectively compared to control (9.0 cm).

2.2.2.3 Seeds pod^{-1}

Akter *et al*.(2013) evaluated the performance weed management and noticed that the longest pod (5.95 cm), the highest number of seeds (17.07) pod^{-1} were obtained from three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) in mungbean.

Khan *et al.* (2011**)** studied an experiment in Pakistan and stated that the highest number of grains (12.30) were recorded in hand weeding which was statistically at par with minimum herbicide rate (2 l/ha) (11.63) during 2006. The said treatment increased the grains per pod (10.97) during the year 2007 over control and hand weeding.

Kundu *et al.*(2009) said that seeds pod^{-1} was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE. Similar result was also reported by Singh *et al.* (2001). The lowest number of pods plant^{-1}, seeds pod^{-1} as well as seed yield were recorded in weedy check treatment (T_{10}).

Chattha *et al*.(2007) concluded that maximum number of seeds pod^{-1} of mungbean was obtained with weed control method WC_6 (chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS), while rest of the treatments caused similar and significantly better effect than WC_1 (weedy check). Weed control method, WC_6 caused approximately 43% increase in number of grains pod^{-1} as compared to WC_1 (weedy check) treatment while an experiment was established in Pakistan.

2.2.2.4 1000-Seeds weight (g)

The highest values (40.39 and 38.95 g) of 1000-seeds weight of mungbean were recorded in hand weeding plots with 17 and 5 percent increase over control during 2006 and 2007 respectively while conducting an field trial in Pakistan by Khan *et al*. (2011).

Awan *et al*.(2009) stated that thousand grain weight of mungbean was increased with reduction in weeds dry biomass and found to be maximum (55.0 g) in plots with row spacing 60 cm + tractor followed by 54.67 g in plots with row spacing of 45 cm + tractor.

2.2.2.5. Effect on grain yield

Akter *et al*. (2013) conducted an experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh to assess the effect of weeding on growth, yield and yield contributing characters of mungbean *(Vigna radiata* L.) *cv.* BINA mung- 4 during October 2011 to February 2012. The highest seed yield (1.38 t ha^{-1}) was obtained from three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) in mungbean. On the other hand, the lowest seed yield was obtained under no weeding condition. The highest seed yield resulted in higher biological yield (4.70 t ha^{-1}) and the highest harvest index (37.15%) in three-stage weeding and the lowest from no weeding.

Mirjha *et al.*(2013) reported that yield attributes and yield of mungbean were significantly increased in weed control treatment over weedy check while a field trial was carried out in India with weed management.

Field experiments were carried out by Ibrahim Usman (2013**)** in 2010 and 2011 cropping seasons at the Institute for Agricultural Research, Ahmadu Bello University, Zaria- Nigeria to evaluate the effect of pre emergence herbicides on growth and yield parameters of cowpea. There was significant yield increase due to Application of pendimenthaline at 3.5 L ha^{-1} + Hand weeding of cowpea at 6 WAS (weeks after sowing).

The experiment was conducted by Madukwe *et al*. (2012) during the cropping season of 2011 at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University to evaluate the most common weed control methods in cowpea. The results showed that chemical weeding at 2-3 leaf stage of the weeds + hand weeding at 50 DAP was more effective in reducing weed biomass than other weed control methods. This superior treatment recorded the highest values of leaf area, plant height, number of branches and number of leaves compared to the other treatments. In addition, number of pods per/plant, 100 seed weight and the seed yield were significantly higher.

Khan *et al*. (2011) investigated that hand weeding produced higher yield (1092 and 743.3 kg ha^{-1}) of mungbean comparaed to control (631 and 518.8 kg ha^{-1}). Herbicide application @ 2 l ha^{-1} also had the highest value/cost ratio (19.3) among the treatments, ranging from 9.6 to 19.3 and might be profitable approach for achieving maximum production of mungbean under rainfed conditions.

Kundu *et al.*(2009) studied an experiment in India and concluded that the seed yield (1327 kg ha^{-1}) of mungbean was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @

50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE. Similar result was also reported by Singh *et al.* (2001).

The highest weed control efficiency was found in T_8 (quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE) followed by T_5 (quizalofopp- ethyl @ 50 g a.i. ha-1 at 14 DAE + HW at 21 DAE). On the other hand the sole chemical treatments like T_1 Quizalofop-p-ethyl @ 37.5 g a.i. ha^{-1} at 7 days after emergence (DAE); T_4 Quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE and T_7 Quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE had lower weed control efficiency in summer mungbean.This result was reported by Kundu *et.al*. (2009).

A field experiment was undertaken by Awan *et al*.(2009) in Pakistan and stated that increase in grain yield was 100% where weeds were controlled through tractor using 60 cm row spacing and increase in grain yield was about 85% in case of hand weeding and 45 cm row spacing + tractor compared to control.

Chattha *et al*. (2007) conducted that maximum reduction in density and biomass of the weeds was observed by chemical weeding at 2 - 3 leaf stage of weeds + hand weeding at 50 DAS. There was a significant increase (50%) in grain yield of mungbean due to chemical weeding at 2 - 3 leaf stage of weeds + hand weeding at 50 DAS.

Riaz *et al*. (2006) investigated that there was a significant increase (about 58% & 54%) in grain yield of wheat due to chemical weeding at 2 - 3 leaf stage of weeds + hand weeding at 50 DAS (WC_6) and two hand weedings after 20 and 40 DAS (WC_2), respectively. Raman (2006) and Chand *et al*. (2004) also observed similar findings of significant reduction in weed count, weed biomass and highest value of weed control efficiency under two hand weeding at 20 and 40 DAS over herbicides.

Mansoor *et al*. (2004) conducted an experiment in Pakistan during 2003 to investigate the efficacy of various weed management strategies in mungbean (cv. NIAB MUNG 98). Water extracts of sorghum, eucalyptus (*Eucalyptus camaldulensis*) and acacia (*Acacia nilotica*) were used in comparison with hand weeding and a pre-emergence herbicide (Pendimethalin, Stomp

330 EC). The water extract of acacia recorded the highest yield and almost all the yield components followed by the two hand weedings + pre-emergence herbicide treatment.

Among herbicides, tank mixture of fenoxaprop-p-ethyl @ 50 g/ha + chlorimuron-ethyl @ 4.0 g/ha (PoE) consistenly increased all the yield attributes *viz*. pods/plant, pod length and grains/pod and was statistically at par to 2-HW. The results are in conformity with the findings of Dungarwal *et al*. (2003).

Khajanji *et al*. (2002) obtained higher grain yield with twice hand weeding.Similar result was found by Saikia and Jitendra (1999) and Elliot and Moody (1990).

Weeds compete with main crop for space, nutrients, water and light. It is also recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms said by Bueren *et al.* (2002).

Batish *et al.* (2002) studied to explor the effect of parthenin a sesquiterpene lactone from *Parthenium hysterophorus* on two weed species viz. *Amaranthus viridis* and *Chenopodium murale*. The study concluded that phytotoxicity of Parthenin could be useful as a natural herbicide for future weed management programmes.

After a long review of literatures it may be concluded that plant spacing and weed management had significant influence on mungbean and other crops to produce increased plant growth and yield characters. Plant spacing as 30 cm and weeding method as hand weeding, herbicide use or combined effect of both produced maximum growth and yield value of mungbean.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to study the effect of different levels of plant spacing and weed management on the performance of mungbean (cv. BARI mung-6). Materials used and methodologies followed in the present investigation have been described in this chapter.

3. Description of the experimental site

3.1 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from August to October, 2013.

3.2 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone - Modhupur Tract (AEZ-28). The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix I.

3.3 Climate and weather

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The mean maximum air temperature and minimum air temperature range were (30.18-31.46^{0}c) and (14.85-15.27^{0}c) respectively.The mean relative humidity range from (67.82-74.41%), rainfall varies from (4.2-6.3 mm day^{-1}),wind speed (1-3 km hr^{-1}), sunshine hour (4.15-7.48) and evaporation rate range from (2.04-2.07 mm day^{-1}) were recorded from the SAU meteorological yard, Dhaka .However the prevailing weather conditions during the study period (August-October) have been presented in Appendix II.

3.4 Plant materials

BARI mung-6 was used as planting material. BARI Mung-6 was developed by BARI in 2003. Plant height of the cultivar ranges from 40 to 45 cm. It is resistant to *Cercospora* leaf spot and tolerant to yellow mosaic virus. Its life cycle is about 55 to 60 days after emergence. It is highly photoinsensetive.One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1.6-2.0 ton ha^{-1}. It contains about 21.2% protein and 46.6% carbohydrate.The seeds of BARI mung-6 for the experiment were collected from BARI, Joydepur Gazipur. The seeds were drum-shaped, dull and greenish and free from mixture of other seeds, weed seeds and extraneous materials.

3.5 Treatments under investigation

There were two factors in the experiment namely spacing (i.e. line to line and plant to plant distance) and weeding as mentioned below:

A. Factor-1 (Plant spacing: 3)

i. S_1 = 20 cm ×10 cm
ii. S_2 = 30 cm ×10 cm
iii. S_3 = 40 cm ×10 cm

B. Factor-2 (Weed management : 5)

i. W_1 = No weeding (control),
ii. W_2 = One hand weeding at 20 days after sowing (DAS),
iii. W_3 = Two hand weeding at 20 DAS and 40 DAS,
iv. W_4 = Pre emergence herbicide, **Sunup 480 SL** spraying before land preparation,
v. W_5 = Post emergence herbicide, **Release 9 EC** spraying at 15 days after germination (DAG).

Treatment combination: Fifteen treatment combinations are as follows

S_1W_1	S_2W_1	S_3W_1
S_1W_2	S_2W_2	S_3W_2
S_1W_3	S_2W_3	S_3W_3
S_1W_4	S_2W_4	S_3W_4
S_1W_5	S_2W_5	S_3W_5

3.6 Description of herbicides

A short description of the herbicides used in the experiment is given in Table 1.

Table 1. Short description of the herbicides used in the experiment

Trade name	Common name	Mode of action	Selectivity	Dose	Time of application
Sunup 480 SL	Glyphoset	Systemic	Non selective	3.7 l ha^{-1}	Pre-emergence
Release 9 EC	Phenoxprop -p-ethayel	Systemic	Bermudagrass, Jungle rice, Nutgrass, Scrab grass	650 ml ha^{-1}	Post-emergence

3.7 Experimental design and layout

The experiment was laid out in a Split Plot design having 3 replications. There were 15 treatment combinations and 45 unit plots. The unit plot size was 7.2 m^2 (4 m × 1.8 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively.

3.8 Land preparation

The experimental land was opened with a power tiller on 10th August, 2013. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 15th August, 2013 and was ready for sowing seeds.

3.9 Fertilizer application

The fertilizers were applied as basal dose @ N, P and K as 20, 17.20 and 17.60 kg ha^{-1} at final land preparation respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil .

3.10 Sowing of seeds

Seeds were sown at the rate of 40 kg ha^{-1} in the furrow on 20th August, 2013 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained as per treatment arrangements with continuous sowing of seeds in the line.

3.11 Germination of seeds

Seed germination occurred from 3rd day of sowing. On the 4th day the percentage of germination was more than 85% and on the 5th day nearly all baby plants (seedlings) came out of the soil.

3.12 Intercultural operations

3.12.1 Thinning

Thinning was done to maintain 10 cm plant to plant distance after 10 days of germination.

3.12.2 Weed control

Weed control was done as per experimental treatments.

3.12.3 Irrigation and drainage

Pre-sowing irrigation was given to ensure the maximum germination percentage. During experimental period, there was heavy rainfall for several times. So it was essential to remove the excess water from the field.

3.13 Harvesting and sampling

The crop was harvested at 60 DAS. The crop was harvested plot wise when about 80% of the pods became matured. Samples were collected from different places of each plot leaving undisturbed plant in the center. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated, cleaned and dried in the sun for 3 to 5 consecutive days for achieving safe moisture of seed.

3.14 Threshing

The crop was sun dried for three days by placing them on the open threshing floor. Seeds were separated from the plants by beating the bundles with bamboo sticks.

3.15 Drying, cleaning and weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.16 Recording of data

The data were recorded on the following parameters

i. Weed parameters

a. Weed density (no.)

b. Weed biomass (g)

c. Weed control efficiency

d. Relative weed density

ii. Crop Growth parameters

a. Plant height (cm) at 10 days interval upto harvest

b. Leaves plant $^{-1}$ (no.)

c. Branch plant^{-1} (no.)

d. Above ground dry matter weight plant^{-1} at 10 days interval upto harvest (g)

e. Days to podding (50%)

f. Days to maturity

g. Crop growth rate (CGR) plant^{-1} at 10 days interval upto harvest (g m^{-2} day^{-1})

h. Relative growth rate (RGR) plant^{-1} at 10 days interval upto harvest (g g^{-1} day^{-1})

iii. Yield contributing parameter

a. Pods plant^{-1} (no.)

b. Seeds pod^{-1} (no.)

c. Pod length (cm)

d. 1000 seeds weight (g)

iv. Yield parameter

a. Grain yield (t ha^{-1})

b. Straw yield (t ha^{-1})

c. Biological yield (t ha^{-1})

d. Harvest index (%)

v. Quality parameter

a. Protein % of seeds

3.17 Procedure of recording data

3.17.1 Weed parameters

i. Weed density

The data on weed infestation as well as density were collected from each treated plot at 20 days interval up to harvest. A plant quadrate of 1.0 m^2 was placed at three different spots of 7.2 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

ii. Weed biomass

The weeds inside each quadrate for density count were uprooted, cleaned and separated species wise. The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 70^0 C. After drying, weight of each species was taken and expressed to g m^{-2}.

iii. Weed control efficiency

Weed control efficiency was calculated with the following formula developed by Sawant and Jadav (1985):

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

iv. Relative weed density (%)

Relative weed density was calculated by using the following formula:

$$RWD = \frac{\text{Density of individual weed species in the community}}{\text{Total density of all weed species in the community}} \times 100$$

3.17.2 Crop growth parameter

i. Plant height (cm)

Ten plants were collected randomly from each plot .The height of the plants were measured from the ground level to the tip of the plant at 10, 20, 30, 40, 50 days after sowing (DAS) and at harvest time (60 DAS).

ii. Leaves plant^{-1} (no.)

Ten plants were collected randomly from each plot. Number of leaves per plant was counted from each plant sample and then averaged at 10, 20, 30, 40, 50 days after sowing (DAS) and at harvest time (60 DAS).

iii. Branch plant^{-1} (no.)

Ten plants were collected randomly from each plot. Number of fruit bearing branch per plant was counted from each plant sample and then averaged at 10, 20, 30, 40, 50 days after sowing (DAS) and at harvest time (60 DAS).

iv. Above ground dry matter weight plant^{-1} (g)

Ten plants were collected randomly from each plot at 10, 20, 30, 40, 50 days after sowing (DAS) and at harvest time (60 DAS).The sample plants were oven dried for 72 hours at 70°C and then dry weight plant^{-1} was determined.

v. Pods plant^{-1} (no.)

Number of pods plants^{-1} was counted from the 10 plant sample and then the average pod number was calculated.

vi. Seeds pod^{-1} (no.)

Number of seeds pod^{-1} was counted from 20 pods of plants and then the average seed number was calculated.

vii. Weight of 1000 - seeds (g)

1000-seeds were counted which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were recorded.

viii. Seed yield (t ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} (2 m^2) and was expressed in terms of yield (t ha^{-1}). Seed yield was adjusted to 12% moisture content.

ix. Stover yield (t ha^{-1})

After separation of seeds from plant, the straw and shell of harvested area was sun dried and the weight was recorded and then converted to t ha^{-1}.

x. Biological yield (t ha^{-1})

The summation of seed yield and above ground stover yield was the biological yield. Biological yield = Grain yield + Stover yield.

xi. Harvest index (%)

Harvest index was calculated on dry basis with the help of following formula.

$$HI\ (\%) = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

Here, Biological yield = Grain yield + stover yield

xiii. Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula developed by Radford (1967):

$$CGR = \frac{1}{GA} \times \frac{W_2 - W_1}{T_2 - T_1}\ g\ m^{-2}\ day^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

xiv. Relative growth rate (RGR)

Relative growth rate (RGR) is the growth rate relative to the size of the population.

Relative growth rate was calculated using the following formula developed by Radford (1967):

$$RGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \text{ g g}^{-1} \text{ day}^{-1}$$

Where,

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

ln = Natural logarithm

3.18 Economic analysis

From beginning to ending of the experiment, individual cost data on all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production.

i. Input cost

Input costs were divided into two parts. These were as follows:

A. Non-material cost (labor)

The human labor was obtained from adult male laborers. Eight working hours of a laborer was considered as a man day. The mechanical labor came from the tractor. A period of eight working hours of a tractor was taken to be tractor day.

B. Material cost

The seed of mungbean (BARI Mung-6) was purchased from BARI Headquarter @ Tk.90 per kg.Chemical fertilizers eg. Urea, TSP, and MP were bought from the authorized dealer at local market. Irrigation was done from the existing facilities of irrigation system of the Sher-e-Bangla Agricultural University field. Herbicides were bought from the respective dealers at local market.

ii. Overhead cost

The interest on input cost was calculated for 6 months @ Tk. 12.5% per year based on the interest rate of the Bangladesh Krishi Bank. The value of land varies from place to place and also from year to year. In this study, the value of land was taken Tk. 200000 per hectare. The interest on the value of land was calculated @ 12.5% per year for 2 months for nursery and 4 months for main field.

iii. Miscellaneous overhead cost (common cost)

It was arbitrarily taken to be 5% of the total running capital.

iv. Gross Return

Gross return from mungbean (Tk ha^{-1}) = Value of grain (Tk ha^{-1}) + Value of Stover (Tk ha^{-1})

v. Net return

Net return was calculated by using the following formula:

Net return (Tk. ha^{-1}) = Gross return (Tk. ha^{-1}) – Total cost of production (Tk. ha^{-1}) .

vi. Benefit cost ratio (BCR)

Benefit cost ratio indicated whether the cultivation is profitable or not which was calculated as follows:

BCR = Gross return (Tk ha^{-1}) \ Cost of production (Tk ha^{-1})

3.19 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT- C and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of signeficance.

RESULTS AND DISCUSSION

The results of the weed parameters, crop characters and economic evaluation of the production of BARI mung-6 as influenced by different plant spacing and weed control treatments have been presented and discussed in this chapter.

4. 1 Weed parameter

4.1.1 Weed density

It is a general observation that conditions favorable for growing mungbean is also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Table 1 showed that 17 weed species were found during the experiment. It was observed that the species, Durba (*Cynodon dactylon*) accounted the highest in number and thereafter were Mutha, Malancha, Carpet grass and so on. The lowest weed in number was Anguli.

Table 1. Name of weeds found in the experimental field

SL. No.	Local name	Common name	Scientific name	Family
1.	Durba	Bermuda grass	*Cynodon dactylon*	Poaceae
2.	Anguli ghash	Scrab grass	*Digitaria sanguinalis*	Poaceae
3.	Chapra	Goose grass	*Eleusine indica*	Poaceae
4.	Helencha	Harkuch	*Enhydra fructuans*	Compositae
5.	Malancha	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae
6.	Mutha	Nutsedge	*Cyperus rotundus*	Cyperaceae
7.	Joyna	Joyna	*Fimbristylis miliacea*	Cyperaceae
8.	Ban sharisha	Wild mustard	*Brassica kaber*	Cruciferae
9.	Shak notae	Pig weed	*Amaranthus viridis*	Amaranthaceae
10.	Chanchi	Chanchi	*Alternanthera philoxeroides*	Amaranthaceae
11.	Chota dudhia	Prostate spurge	*Euphorbia parviflora*	Euphorbiaceae
12.	Kanduli	Kanduli	*Murdania nudiflora*	Commelinaceae
13.	Hati shur	Hati shur	*Heliotropium indicum*	Boraginaceae
14.	Ban tamak	Wild tobacco	*Nicotiana plumbaginifolia*	Solanaceae
15.	Shama	Bernyard grass	*Eichinochloa crussgali*	Poaceae
16.	Bonpat	Wild jute	*Corchorus acutangulus*	Tiliaceae
17.	Khet papri	Khet papri	*Lindernia procumbens*	Scrophulariaceae

Number of weed species and total number of weeds in 1 m^2 were affected significantly by the different treatment combinations (Table 2). It was observed that the lowest number of weed species and total weeds m^{-2} was observed in S_1W_5 (8.23 and 75.25, respectively). On the other hand, the highest number of weed species and total number of weeds m^{-2} (13.23 and 266.12, respectively) was obtained from S_3W_1 .

Table 2. Weed density as per treatment combinations

Treatments	Number of weed species	No. of weeds m^{-2} at different days after sowing				Total weeds m^{-2} during crop growing period
		10 DAS	20 DAS	40 DAS	At harvest	
S_1W_1	12.21	--	--	--	231.03	231.03
S_1W_2	10.54	--	85.66	--	19.46	105.12
S_1W_3	12.42	--	125.30	19.74	20.00	165.04
S_1W_4	9.77	--	--	--	90.13	90.13
S_1W_5	8.23	34.40	--	--	40.85	75.25
S_2W_1	12.67	--	--	--	251.22	251.22
S_2W_2	9.09	--	115.58	--	30.56	146.14
S_2W_3	10.89	--	98.87	18.78	16.58	134.23
S_2W_4	11.21	--	--	--	97.28	97.28
S_2W_5	9.56	37.23	--	--	43.05	80.28
S_3W_1	13.23	--	--	--	266.12	266.12
S_3W_2	10.23	--	121.32	--	34.03	155.35
S_3W_3	7.44	--	114.43	35.39	28.44	178.26
S_3W_4	10.34	--	--	--	98.24	98.24
S_3W_5	9.77	43.09	--	--	49.17	92.26

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

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4.1.2 Weed biomass

Weed population had considerable effect on crop production. Data on table 3 showed that the highest dry weight of weed (401.21 g m^{-2}) was observed in S_3W_1 where no weeding was done with higher row spacing when maximum spacing invited weeds to grow profusely. The lowest dry weed biomass (100.18 g m^{-2}) was observed in S_2W_5 where post emergence herbicide was applied.

Table 3. Effect of plant spacing and weed management on dry weed biomass

Treatments	Dry weight of weeds at different DAS (g m^{-2})				Total dry weight of weed (g m^{-2}) during crop growing period
	10 DAS	20 DAS	40 DAS	At harvest (g m^{-2})	
S_1W_1	--	--	--	378.92	378.92
S_1W_2	--	149.05	--	34.44	183.49
S_1W_3	--	196.19	26.23	16.76	239.18
S_1W_4	--	--	--	135.32	135.32
S_1W_5	8.64	--	--	96.65	105.29
S_2W_1	--	--	--	389.34	389.34
S_2W_2	--	157.19	--	42.12	199.31
S_2W_3	--	150.57	26.43	20.03	197.03
S_2W_4	--	--	--	124.98	124.98
S_2W_5	10.41	--	--	89.77	100.18
S_3W_1	--	--	--	401.21	401.21
S_3W_2	--	149.70	--	39.21	188.91
S_3W_3	--	139.56	45.14	16.54	198.24
S_3W_4	--	--	--	123.11	123.11
S_3W_5	10.63	--	--	105.42	116.05

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

.

4.2 Growth parameters

4.2.1 Plants m^{-2}

The experimental treatment comprised of three different spacings viz; 20 cm x 10 cm, 30 cm x 10 cm and 40cm x 10 cm consequently, which gave 50, 33 and 25 plants m^{-2}, respectively.

4.2.2 Plant height (cm)

4.2.2.1 Effect of plant spacing

Environmental factors and genetic characteristics of plants play an important role in determining the plant height. Data on plant height at different days of mungbean was influenced by varying row spacing have been presented in Fig. 1. Results showed that at 10- 30 DAS the tallest plants

(19.76, 34.79, 48.97 for S_1 and 19.47, 34.93, 49.71 cm for S_2) were found similar than afterwards S_1 produced significantly higher plant heights (58.44, 63.37 and 64.08 cm 40, 50 and 60 DAS) when other two spacing gave plant heights which was difference at later stage of growth. Malik *et al.* (2006) noticed that maximum plant height (76.62 cm) of mungbean was attained by P_1 (30 cm apart flat sowing).

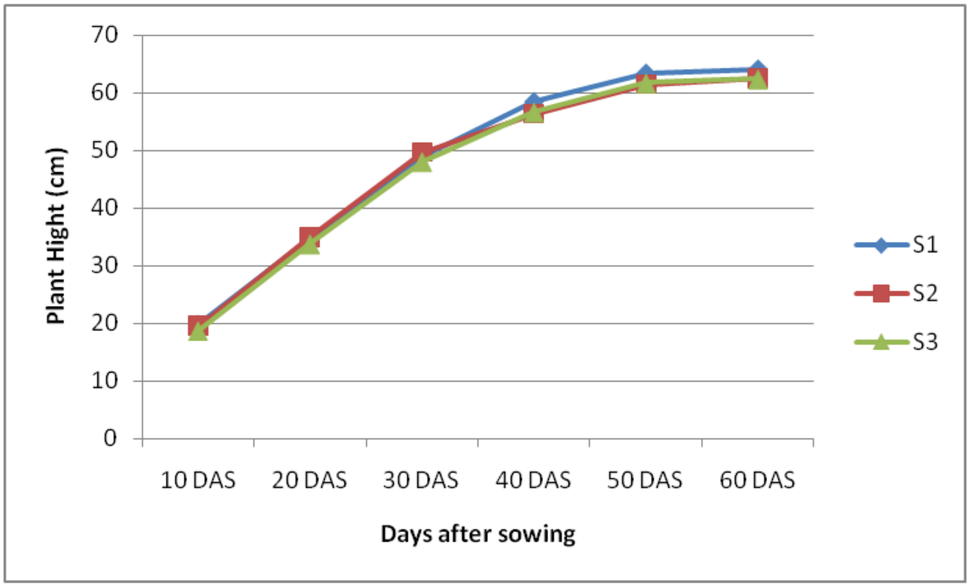

Fig. 1: Effect of plant spacing on plant height of mungbean at different days ($LSD_{0.05}$ = 1.03, 0.60, 0.76, 1.36, 0.76 and 0.50 at 10, 20, 30, 40, 50 DAS and harvest, respectively)

Here,
S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

4.2.2.2 Effect of weed management

The plant height was significantly influenced by weed management at all growth stages of mungbean (Fig. 2). At 10 and 20 DAS, the highest plant height (22.42 and 37.18 cm respectively) was recorded in W_4 where the lowest was achieved with W_2 (18.05 and 31.26 cm, respectively). At 30, 40, 50 DAS and harvest, the highest plant height (51.26, 60.37, 65.16 and 65.60 cm) was recorded in W_5 where the lowest was measured at W_2. Intermediate plant height was obtained from W_1 and W_3. The result under the present study was in agreement with the findings of Kundu *et al.*,(2009) and Chattha *et al.* (2007). The highest plant height was recorded in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE by Kundu *et al.*,(2009). Chattha *et al.*(2007) found that among different weed control methods, chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS gave maximum plant height compared to weedy check treatment.

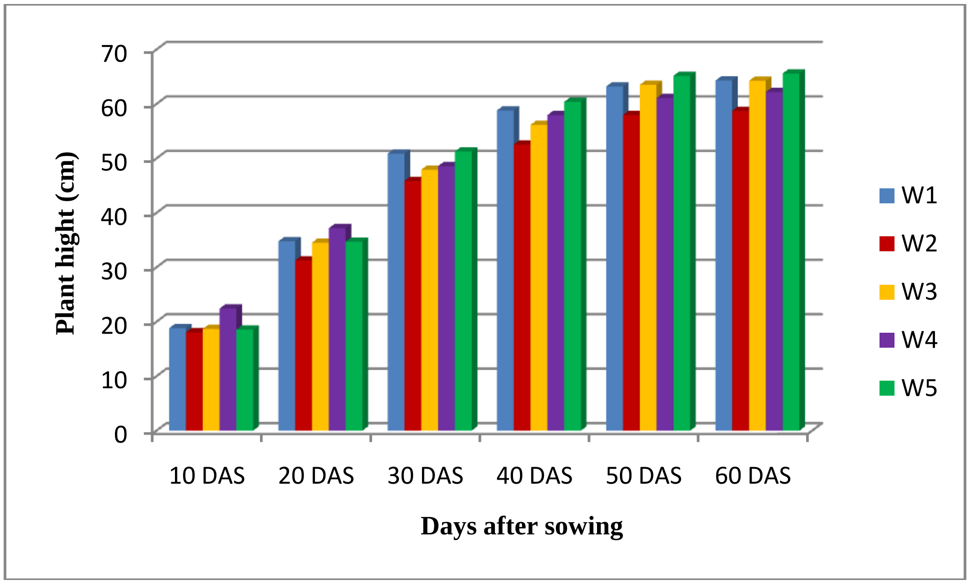

Fig. 2: Effect of weed control methods on plant height of mungbean at different days ($LSD_{0.05}$ = 0.84, 0.80, 0.81, 0.86, 2.09 and 2.03 at 10, 20, 30, 40, 50 DAS and harvest, respectively)

Here,

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

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4.2.2.3 Combined effect of row spacing and weed management

Combination between row spacing and weeding exerted significant effect on plant height (Table 4). The highest plant height (53.62,63.91,68.18 and 68.57 cm at 30, 40, 50 DAS and harvest, respectively) was observed in the 20 cm ×10 cm spacing with post emergence herbicide for weed management (S_1W_5) which was statistically similar with S_1W_4 and S_2W_1 at 50 DAS and at harvest. But at 10 and 20 DAS, the tallest plant (23.00 cm and 38.58 cm) was observed with S_1W_4 which was statistically similar with S_2W_4 and S_3W_4 at 10 DAS. The shortest plant height was obtained with S_1W_2 (28.99, 43.52 and 57.61 cm at 20, 30 DAS and harvest, respectively). But at 40 DAS, the shortest plant height was obtained with S_2W_2 (51.60 cm) which was statistically similar with S_1W_2 (52.02 cm) and at 50 DAS S_2W_4 produced shortest plant (56.68

cm) which was statistically similar with S_1W_2 (56.97 cm), S_2W_2 (58.35 cm), S_3W_2 (58.55 cm) and S_3W_4 (60.16 cm). The results obtained from all other treatment combinations were significantly different from each other.

Table 4: Combined effect of row spacing and weed management on plant height of mungbean at different days

Treatments	Plant height (cm) at different days after sowing					
	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	At harvest
S_1W_1	19.34 bc	33.97 ef	51.71 b	57.14 de	62.29 c-e	63.55 c-e
S_1W_2	17.65 ef	28.99 h	43.52 g	52.02 h	56.97 g	57.61 g
S_1W_3	19.09 b-e	35.64 cd	47.24 f	56.83 e	62.99 b-e	63.05 c-f
S_1W_4	23.00 a	38.58 a	48.74 de	62.31 b	66.40 ab	67.61 ab
S_1W_5	19.70 b	36.74 bc	53.62 a	63.91 a	68.18 a	68.57 a
S_2W_1	19.13 b-d	37.22 ab	51.71 b	61.68 b	65.77 a-c	66.54 a-c
S_2W_2	18.64 b-e	32.58 fg	47.24 f	51.60 h	58.35 fg	59.54 fg
S_2W_3	18.63 b-e	34.65 de	48.75 de	56.40 ef	62.95 b-e	64.66 b-d
S_2W_4	21.96 a	36.21 bc	50.55 bc	53.78 g	56.68 g	58.05 g
S_2W_5	19.00 b-e	33.97 ef	50.27 c	58.55 cd	63.63 b-e	63.99 c-e
S_3W_1	17.96 c-f	33.13 fg	49.22 cd	57.59 c-e	61.55 d-f	62.78 d-f
S_3W_2	17.86 d-f	32.20 g	46.79 f	54.03 g	58.55 fg	59.03 g
S_3W_3	18.30 b-f	33.29 e-g	47.78 ef	55.22 fg	64.56 a-d	65.04 b-d
S_3W_4	22.30 a	36.76 bc	46.46 f	57.74 c-e	60.16 e-g	60.93 e-g
S_3W_5	16.91 f	33.36 e-g	49.89 cd	58.65 c	63.66 b-e	64.23 b-e
$LSD_{(.05)}$	1.44	1.39	1.39	1.49	3.62	3.51
CV %	4.43	2.39	1.7	1.35	3.46	3.3

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

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4.2.3 Branches plant^{-1}(no.)

4.2.3.1 Effect of plant spacing

Branches plant^{-1} was not varied due to different row spacing at all growth stages except 30 DAS (Fig.3). At 30 DAS, the maximum (1.04) branches was recorded from S_2 while the minimum (0.53) in S_1.

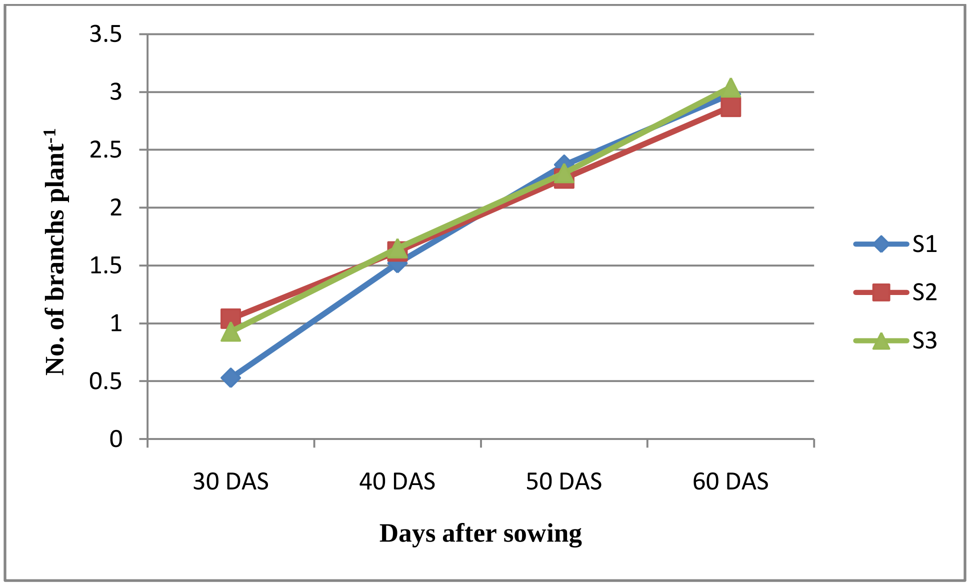

Fig.3: Effect of row spacing on the no.of branches plant^{-1} of mungbean at different days ($LSD_{0.05}$ = 0.43, 0.49, 0.71 and 0.75 at 30, 40, 50 DAS and harvest, respectively)

Here,
S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

4.2.3.2 Effect of weed management

Branches plant^{-1} was significantly influenced by different weed management at all growth stages of mungbean (Fig. 4). At 30, 40 , 50 DAS and harvest, the highest no. of branches plant^{-1} (1.00, 2.01, 2.82 and 3.45 respectively) was recorded in W_5 which was statically similar with W_3 except 30 DAS where the lowest was achieved with W_4 (0.54, 1.31, 1.82 and 2.60 respectively). Intermediate no.of branches plant^{-1} was obtained from W_1 and W_2. Muhammad *et al*. (2004) reported that weeding were applied twice, i.e. at 10 and 35 days after sowing significantly affected number of branches plant^{-1}.

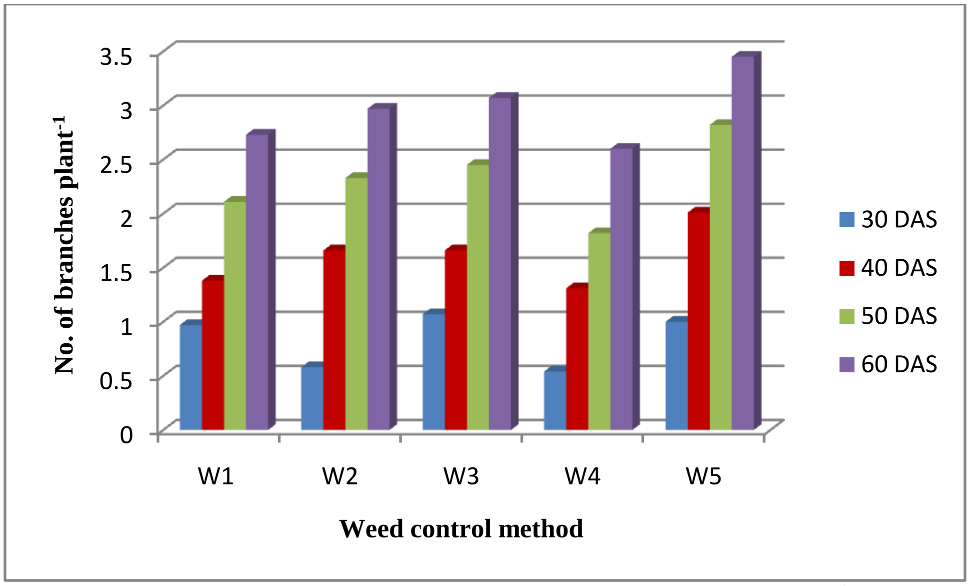

Fig. 4: Effect of weed control methods on no. of branches plant^{-1} of mungbean at different days ($LSD_{0.05}$ = 0.29, 0.34, 0.45 and 0.45 at 30, 40, 50 DAS and harvest, respectively)

Here,

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.2.3.3 Combined effect of plant spacing and weed management

Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant and play an important role in enhancing seed yield. Data given in Table 5 revealed that the number of branches plant^{-1} was affected significantly by combination of varying plant spacing and weed control methods. At 30 DAS,the highest no.of branches plant^{-1} (1.47) was observed in S_2W_3 which was statistically similar with S_2W_1, S_2W_5, S_3W_1, S_3W_3 and S_3W_5. At 40 DAS, maximum no. of branches plant^{-1} (2.38) was observed with S_1W_5 which was statistically similar with S_1W_2, S_2W_4, S_2W_5, S_3W_1 and S_3W_3. But at 50 DAS and harvest, the highest no. of branches plant^{-1} (2.98 and 3.53) were found in S_2W_5 which was statically similar with S_1W_1, S_1W_2, S_1W_3, S_1S_5, S_2W_4, S_3W_1, S_3W_2, S_3W_3 and S_3W_5. The minimum no. of branches plant^{-1} was obtained with S_1W_3 (0.30) at 30 DAS which was statistically similar with S_1W_1, S_1W_2, S_1W_3, S_1W_4, S_1W_5, S_2W_4, S_3W_2 and S_3W_4. At 40 DAS, the lowest no. of branches plant^{-1} was obtained with S_1W_1(0.87) which was statistically similar with S_1W_4, S_2W_1, S_2W_3 and

S_3W_4 . At 50 DAS, the lowest no. of branches plant^{-1} was obtained with S_3W_4 (1.42) which was statistically similar with S_1W_4,S_2W_1, S_2W_2 and S_2W_3. At harvest, S_1W_4 gave the minimum no. of branches plant^{-1}(2.23) which was statically similar with S_1W_1,S_2W_1, S_2W_2, S_2W_3, S_3W_1, S_3W_2 and S_3W_4.

Table 5 : Combined effect of plant spacing and weed management on the no. of branches plant^{-1} of mungbean at different days

Treatments	Number of branches plant^{-1}			
	30 DAS	40 DAS	50 DAS	At harvest
S_1W_1	0.53 ef	0.87 g	2.38 a-c	2.95 a-d
S_1W_2	0.50 ef	1.83 a-d	2.53 ab	3.18 a-c
S_1W_3	0.30 f	1.60 b-e	2.57 ab	3.10 a-c
S_1W_4	0.60 d-f	0.91 fg	1.58 de	2.23 d
S_1W_5	0.70 c-f	2.38 a	2.80 ab	3.44 a
S_2W_1	1.20 ab	1.10 e-g	1.62 c-e	2.24 d
S_2W_2	0.80 b-e	1.67 b-e	2.12 b-e	2.80 a-d
S_2W_3	1.47 a	1.33 d-g	2.07 b-e	2.66 b-d
S_2W_4	0.47 ef	2.08 ab	2.47 ab	3.13 a-c
S_2W_5	1.27 ab	1.94 a-c	2.98 a	3.53 a
S_3W_1	1.17 a-c	2.13 ab	2.34 a-d	3.00 a-d
S_3W_2	0.43 ef	1.47 c-f	2.34 a-d	2.93 a-d
S_3W_3	1.43 a	2.03 a-c	2.71 ab	3.46 a
S_3W_4	0.57 d-f	0.93 fg	1.42 e	2.45 cd
S_3W_5	1.03 a-d	1.70 b-d	2.67 ab	3.37 ab
$LSD_{(0.05)}$	0.49	0.59	0.77	0.78
CV (%)	35.57	21.69	19.93	15.53

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

.

4.2.4 Above ground dry matter (AGDM) weight plant^{-1}(g)

4.2.4.1 Effect of plant spacing

Irrespective of spacing differences with above ground dry matter was produced in plant slowly at early stage of growth (10-20 DAS), then sharply from 30-60 DAS as picked at 60 DAS. Above ground dry matter weight plant^{-1} was significantly varied due to different treatment variations at all growth stages of mungbean (Fig. 5). Under the present study, the highest dry matter weight plant^{-1} (1.06, 3.11,7.99,10.48 and 12.26 g at 20, 30, 40, 50 DAS and harvest, respectively) was achieved by S_2 where the lowest was achieved by S_1 (0.94, 2.58, 5.95, 8.21 and 10.07 g at 20, 30, 40, 50 DAS and at harvest, respectively). The results obtained from S_3 showed intermediate results. Similar result was found by Kabir and Sarker (2008). They observed that the highest dry matter plant^{-1} was produced at spacing of 30 cm × 10 cm, which was identical to that of 40 cm × 30 cm.The variation between closer spacing and other wider was 21.75% in respect of AGDM weight.

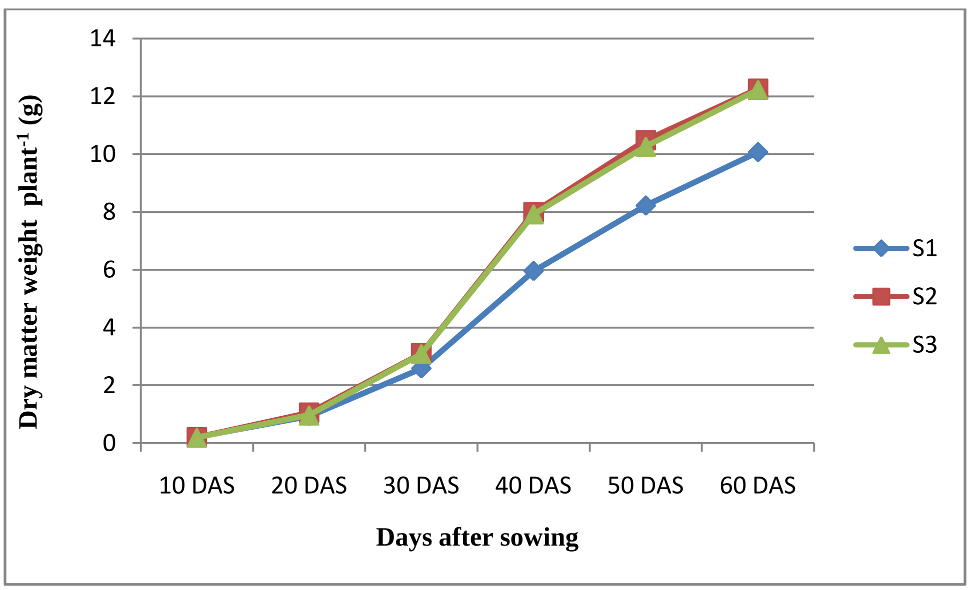

Fig.5 : Effect of plant spacing on above ground dry matter weight plant^{-1} of mungbean at different days ($LSD_{0.05}$ = 0.08, 0.21, 0.36, 0.87, 1.32 and 1.36 at 10, 20, 30, 40, 50 DAS and harvest, respectively)

Here,
S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

4.2.4.2 Effect of weed management

Above ground dry matter weight plant^{-1} was significantly influenced by number of weeding at all growth stages of mungbean except 10 DAS (Fig. 6). It is remarked from the present study that the increasing time of weeding significantly increased dry weight plant^{-1}. At 20, 30, 40, 50 DAS and harvest, the maximum of dry weight plant^{-1} (1.13, 3.31, 9.19, 11.69 and 13.37 g, respectively) was recorded in W_5. The lowest dry weight plant^{-1} was achieved with W_4 (5.67, 7.76 and 9.81 g at 40, 50 DAS and harvest, respectively) . At 20 and 30 DAS the lowest dry weight plant^{-1} was found in W_5,W_2 and W_1, respectively. The results under the present study was in agreement with the findings of Kumar and Kairon (1988) and Malik *et al*. (2005). Kumar and Kairon (1988) found that weed biomass increased and mungbean yield decreased with delay in weeding. They also reported that weed removal at 30 and 40 days after sowing showed high yield.

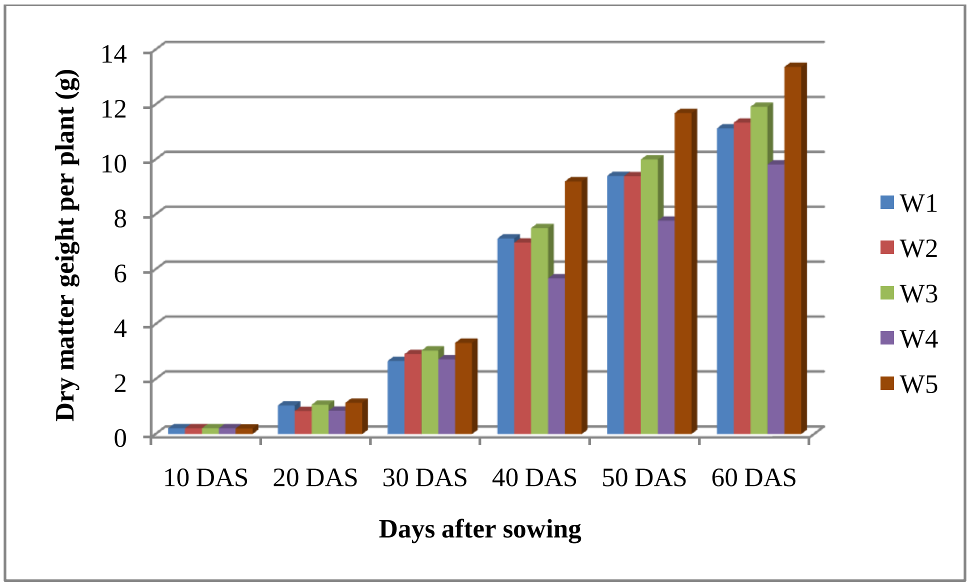

Fig. 6 : Effect of weed control methods on above ground dry matter weight plant^{-1} of mungbean at different days ($LSD_{0.05}$ = 0.04, 0.23, 0.57, 1.32, 1.20 and 1.11 at 10, 20, 30, 40, 50 DAS and harvest, respectively)

Here,

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.2.4.3 Combined effect of plant spacing and weed management

Significant influence was observed by combination of different spacings and weeding methods on above ground dry weight plant^{-1} (Table 6). Results indicated that the highest above ground dry weight plant^{-1} (0.25 g at 10 DAS) was observed in the treatment combination of S_1W_5 which was closely followed by $S_1W_{1,}$ S_1W_2, S_1W_3, S_1W_4, S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_2W_5, S_3W_1, S_3W_2, S_3W_3 and S_3W_4 whereas the lowest above ground dry weight plant^{-1} was obtained in S_3W_5 which was at per $S_1W_{1,}$ S_1W_2, S_1W_3, S_1W_4, S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_2W_5, S_3W_1, S_3W_2, S_3W_3 and $S_3W_{4.}$ At 20 DAS, S_2W_1 gave the highest above ground dry weight plant^{-1} (1.24 g) which was similar with $S_1W_{1,}$ S_1W_3, S_1W_4, S_1W_5, S_2W_2, S_2W_3, S_2W_5, S_3W_1, S_3W_2, S_3W_3, S_3W_4 and S_3W_5. But the lowest above ground dry weight plant^{-1} was obtained with S_1W_2 and S_2W_4 (0.69 g at 20 DAS). At 30 DAS, maximum AGDM weight plant^{-1} was obtained from S_3W_2 (3.67 g) which was statistically similar with $S_1W_{1,}$ S_1W_5, S_2W_1, S_2W_2, S_2W_3, S_2W_4, $S_2W_{5,}$ S_3W_3 and $S_3W_{5.}$ The lowest above ground dry weight plant^{-1}(2.20 g) was obtained in S_1W_2 and S_1W_3 which was at per S_1W_1, S_2W_1, S_2W_2, S_2W5 and S_3W_1. At 40, 50 DAS and harvest, S_2W_5 gave the maximum above ground dry matter weight plant^{-1} (10.93, 13.98 and 15.48 g, respectively). At 40 DAS lowest AGDM weight plant^{-1}(5.36 g) was found in S_1W_2 which was closed to S_1W_1, S_1W_3,S_1W_4, S_1W_5, S_2W_2, S_2W_4 and S_3W_4. At 50 DAS and harvest, S_1W_4 gave the lowest AGDM weight plant^{-1}(7.01 and 9.22 g) which was at per S_1W_1, S_1W_2, S_1W_3, S_2W_4 and S_3W_4. The results obtained from all other treatment combinations were significantly different compared to others.

Table 6: Combined effect of plant spacing and weed management on above ground dry matter weight plant^{-1} (g) of mungbean at different days

Treatments	Above ground dry matter weight plant^{-1} (g) at different days after sowing					
	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	At harvest
S_1W_1	0.22 ab	0.92 ab	2.71 a-c	5.40 d	8.12 de	9.85 de
S_1W_2	0.20 ab	0.69 b	2.20 c	5.36 d	7.97 de	9.88 de
S_1W_3	0.21 ab	0.98 ab	2.20 c	5.97 cd	8.43 c-e	10.15 de
S_1W_4	0.22 ab	1.01 ab	2.52 bc	5.57 d	7.01 e	9.22 e
S_1W_5	0.25 a	1.10 a	3.30 ab	7.48 b-d	9.54 b-d	11.22 cd
S_2W_1	0.21 ab	1.24 a	2.77 a-c	7.86 bc	9.76 b-d	11.26 cd
S_2W_2	0.23 ab	0.94 ab	2.85 a-c	7.06 b-d	9.48 b-d	11.47 cd
S_2W_3	0.22 ab	1.21 a	3.47 ab	8.16 bc	10.93 b	12.77 bc
S_2W_4	0.22 ab	0.69 b	3.37 ab	5.98 cd	8.25 c-e	10.30 de
S_2W_5	0.19 ab	1.20 a	3.08 a-c	10.93 a	13.98 a	15.48 a
S_3W_1	0.20 ab	0.95 ab	2.51 bc	8.09 bc	10.33 bc	12.28 bc
S_3W_2	0.21 ab	0.89 ab	3.67 a	8.50 b	10.73 b	12.66 bc
S_3W_3	0.20 ab	1.02 ab	3.46 ab	8.38 b	10.64 b	12.82 bc
S_3W_4	0.20 ab	0.86 ab	2.27 c	5.47 d	8.04 de	9.93 de
S_3W_5	0.17 b	1.11 a	3.57 a	9.18 ab	11.55 b	13.41 b
$LSD_{(0.05)}$	0.08	0.40	0.99	2.28	2.08	1.91
CV %	19.18	24.16	20	18.53	12.79	9.86

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

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4.2.5 Crop growth rate (CGR)

4.2.5.1 Effect of plant spacing

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. The increase can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to spacing shown in Fig.7 . There was trend to increase CGR with advancement of days up to 30-40 DAS and then declined . Under the present study, the highest CGR (3.61, 8.23, 16.84, 11.30 and 9.25 g m^{-2}day^{-1} at 10-20, 20-30, 30-40, 40-50 and 50-60 DAS, respectively) was achieved by S_1 where as the lowest was achieved by S_3 (1.93, 5.32, 12.08, 5.84

and 4.91 g $m^{-2}day^{-1}$). The results obtained from S_2 also showed promising result compared to others.

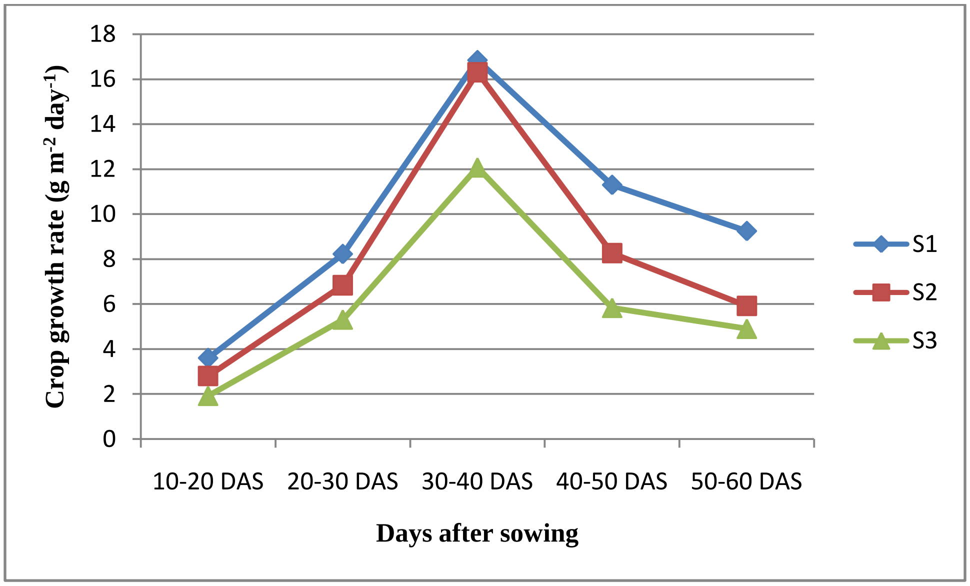

Fig.7: Effect of plant spacing on the crop growth rate of mungbean at different days ($LSD_{0.05}$ = 0.75, 1.35, 2.65, 2.82 and 1.58 at 10-20, 20-30, 30-40, 40-50 and 50-60 DAS, respectively)

Here,
S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

4.7.5.2 Effect of weed management

Significant variation was recorded for CGR due to weed management at all the stages except 20-30 and 50-60 DAS (Fig. 8). At 10-20 DAS, the maximum (3.33 g $m^{-2}day^{-1}$) CGR was recorded from W_5 which was statistically similar with W_1 and W_3, while the minimum (2.18 g $m^{-2}day^{-1}$) in W_2 which was at per W_1 and W_4. At 30-40 DAS,the highest value (20.36 g $m^{-2}day^{-1}$) was recorded from W_5 which was similar to W_1 and W_3. The lowest value of CGR was recorded from W_4 which was at per W_1, W_2 and W_3. At 40-50 DAS, W_3 gave the highest CGR (9.08 g $m^{-2}day^{-1}$) which was statistically similar with W_1, W_2 and W_5 while the lowest CGR (7.07 g $m^{-2}day^{-1}$) was recorded from W_4 which was similar to W_1, W_2 and W_5.

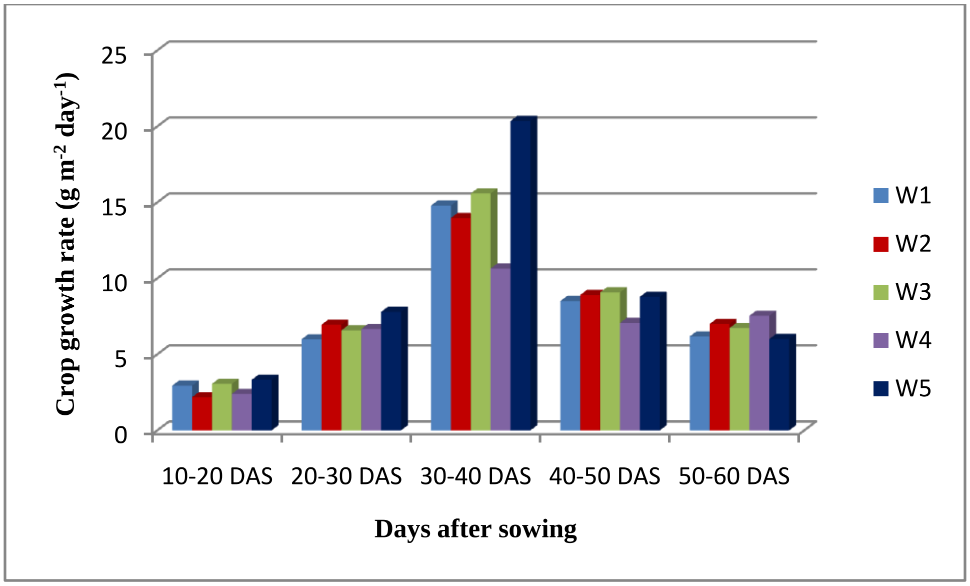

Fig. 8: Effect of weed control methods on crop growth rate of mungbean at different days ($LSD_{0.05}$ = 0.84, NS, 5.77, 1.92 and NS at 10-20, 20-30, 30-40, 40-50 and 50-60 DAS, respectively)

Here,

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.1.5.3 Combined effect of row spacing and weed control methods

The combination of weed control treatments and variety significantly influenced the CGR throughout the growing period (Table 7). In most of the treatment combinations, CGR increased gradually up to 30-40 DAS and then declined. At the beginning of the crop growth (10-20 DAS), S_1W_5 showed the highest CGR (4.27 g m^{-2} day^{-1}) which was ststistically similar with S_1W_1, S_1W_3, S_1W_4, S_2W_1, S_2W_3 and S_2W_5 whereas the lowest CGR (1.59 g m^{-2} day^{-1}) was found in S_2W_4 which was at per S_1W_2, S_2W_2, S_3W_1, S_3W_2, S_3W_4, S_3W_4 and S_3W_5. At 20-30 DAS, S_1W_5 showed the highest CGR (11.00 g m^{-2} day^{-1}) which was closed to S_1W_1, S_1W_2, S_1W_4, S_2W_3 and S_2W_4. At 30-40 DAS, the highest CGR (26.16 g m^{-2} day^{-1}) was found in S_2W_5 which was similar to S_1W_3, S_1W_5 and S_2W_1 whenever the lowest CGR was recorded from S_3W_4 which was closed to S_1W_1, S_1W_2, S_1W_4, S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_3W_1, S_3W_2, S_3W_3, S_3W_4 and S_3W_5. At 40-50 DAS, S_1W_1 gave the highest CGR value (13.60 g m^{-2} day^{-1}) which was statistically similar with S_1W_2, S_1W_3 and S_1W_5 and 50-60 S_1W_4 gave maximum CGR (11.08 g m^{-2} day^{-1}) which was closed to S_1W_1, S_1W_2, S_1W_3 and S_1W_5. The lowest CGR value (4.65 g m^{-2} day^{-1}) was found in S_3W_5 which was similar to S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_2W_5, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. The results obtained from all other treatment combinations were significantly different compared to others.

Table 7: Combined effect of plant spacing and weed management on crop growth rate at different days (g m^{-2} day^{-1}) of mungbean

Treatments	Crop growth rate at different days after sowing (g m^{-2} day^{-1})				
	CGR 10-20 DAS	CGR 20-30 DAS	CGR 30-40 DAS	CGR 40-50 DAS	CGR 50-60 DAS
S_1W_1	3.50 a-c	8.98 ab	13.43 bc	13.60 a	8.65 a-c
S_1W_2	2.47 b-f	7.52 a-c	15.80 bc	13.08 ab	9.55 ab
S_1W_3	3.85 ab	6.10 b-d	18.83 ab	12.33 a-c	8.58 a-c
S_1W_4	3.97 a	7.57 a-c	15.23 bc	7.18 d-f	11.08 a
S_1W_5	4.27 a	11.00 a	20.88 ab	10.30 a-d	8.40 a-d
S_2W_1	3.44 a-d	5.11 cd	16.97 a-c	6.31 ef	5.01 e
S_2W_2	2.37 c-f	6.38 b-d	14.05 bc	8.06 d-f	6.62 b-e
S_2W_3	3.30 a-e	7.53 a-c	15.63 bc	9.23 c-e	6.15 c-e
S_2W_4	1.59 f	8.91 ab	8.70 c	7.59 d-f	6.83 b-e
S_2W_5	3.37 a-d	6.27 b-d	26.16 a	10.16 b-d	4.99 e
S_3W_1	1.88 ef	3.89 d	13.97 bc	5.60 f	4.87 e
S_3W_2	1.72 f	6.94 b-d	12.06 bc	5.58 f	4.83 e
S_3W_3	2.03 d-f	6.10 b-d	12.30 bc	5.67 f	5.45 de
S_3W_4	1.65 f	3.52 d	8.00 c	6.44 ef	4.72 e
S_3W_5	2.36 c-f	6.14 b-d	14.04 bc	5.91 f	4.65 e
$LSD_{(0.05)}$	1.45	3.57	9.99	3.32	3.01
CV %	30.9	31.13	39.35	23.28	26.72

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.2.6 Relative growth rate (RGR)

4.2.6.1 Effect of plant spacing

Relative growth rate is the increase of materials per unit of plant materials per unit of time. RGR was higher at early stage of growth and declined with time. In case of BARI mung-6, non-significant differences was obtained for relative growth rate (RGR) for different row spacing (Fig. 9).

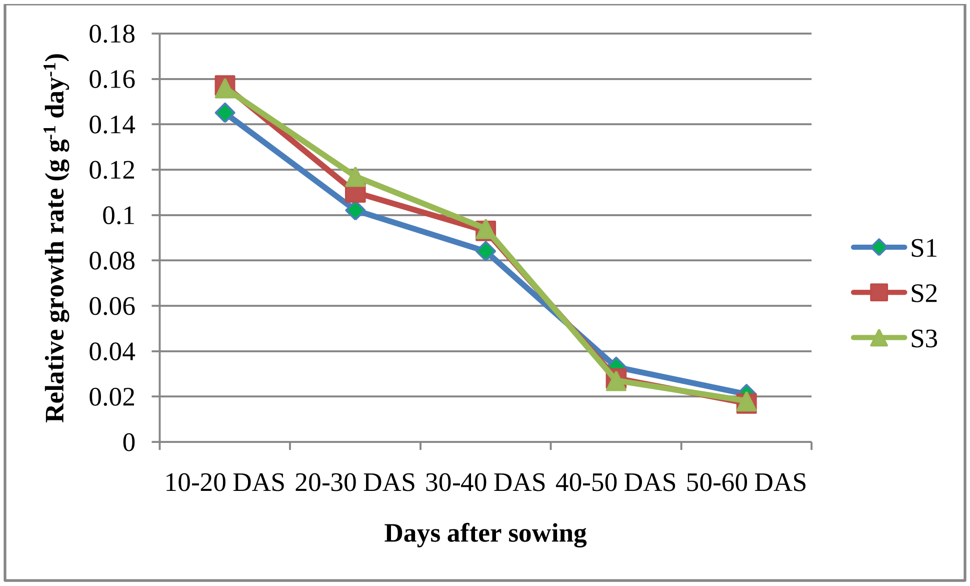

Fig.9: Effect of plant spacing on the RGR of mungbean at different days ($LSD_{0.05}$ = 0.32)

Here,

S_1 = 20 cm × 10 cm

S_2 = 30 cm × 10 cm

S_3 = 40 cm × 10 cm

4.2.6.2 Effect of weed control treatments

Relative growth rate was not significantly affected by different weed control treatments over time. Non significant result was found from experiment due to variation of weed control methods except 10-20 DAS (Fig. 10). At 10-20 DAS, the highest RGR(0.17 g g^{-1} day^{-1}) was found in W_5 which was similar to W_1 and W_3 while W_2 and W_4 gave the lowest RGR (0.14 g g^{-1} day^{-1}) which was similar to W_1 and W_3.

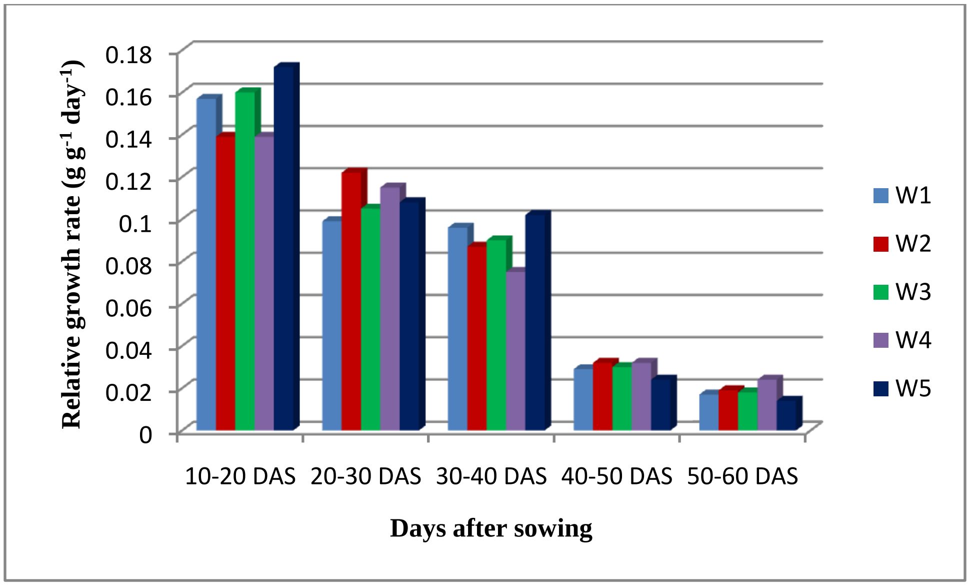

Fig. 10: Effect of weed control methods on RGR of mungbean at different days ($LSD_{0.05}$ = 0.03)

Here,

W_1	=	No weeding
W_2	=	1 hand weeding at 20 DAS
W_3	=	2 hand weeding at 20 and 40 DAS
W_4	=	Pre emergence herbicide, **Sunup** spraying after land preparation
W_5	=	Post emergence herbicide, **Release** spraying at 15 DAG

4.2.6.3 Combined effect of plant spacing and weed control treatments

RGR of BARI mung-6 was significantly influenced by the combined effect of the weed control treatments and plant spacing in all dates of observations except 40-50 and 50-60 DAS shown in Table 9. Results showed that at 10-20 DAS, S_2W_5 and S_3W_5 gave the highest RGR (0.18 g g^{-1} day^{-1}) which was statistically similar with S_1W_1, S_1W_3, S_1W_4, S_1W_5, S_2W_1, S_2W_2, S_2W_3, S_3W_1, S_3W_2, S_3W_3 and S_3W_4 while the lowest RGR (0.12 g g^{-1} day^{-1}) was found in S_2W_4 which was at per S_1W_1, S_1W_2, S_1W_3, S_1W_4, S_1W_5, S_2W_2, S_2W_3, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. At 20-30 DAS, the maximum RGR (0.16 g g^{-1} day^{-1}) was found in S_2W_4 which was closed to S_1W_1, S_1W_2, S_1W_5, S_2W_2, S_2W_3, S_3W_2, S_3W_3 and S_3W_5 and the lowest result was observed in S_1W_3 and S_2W_1 (0.08 g g^{-1} day^{-1}) which was at per S_1W_1, S_1W_2, S_1W_3, S_1W_4, S_1W_5, S_2W_2, S_2W_3, S_2W_5, S_3W_1, S_3W_3, S_3W_4 and S_3W_5. At 30-40 DAS, the highest RGR (0.13 g g^{-1} day^{-1}) was recorded from S_2W_5 which was statistically similar with S_1W_2, S_1W_3, S_1W_4, S_1W_5, S_2W_1, S_2W_2, S_2W_3, S_3W_1, S_3W_2, S_3W_3, S_3W_4 and S_3W_5 whereas the lowest result was obtained from S_2W_4 which was closed to S_1W_1, S_1W_2, S_1W_3, S_1W_4, S_1W_5, S_2W_1, S_2W_2, S_2W_3, S_3W_2, S_3W_3, S_3W_4 and S_3W_5.

Table 9. Combined effect of plant spacing and weed control methods on relative growth rate ($g\ g^{-1}\ day^{-1}$) of mungbean at different days after sowing

Treatments	Relative growth rate at different days after sowing				
	RGR 10-20 DAS	RGR 20-30 DAS	RGR 30-40 DAS	RGR 40-50 DAS	RGR 50-60 DAS
S_1W_1	0.14 a-c	0.11 a-c	0.07 bc	0.04	0.02
S_1W_2	0.13 bc	0.12 a-c	0.09 a-c	0.04	0.02
S_1W_3	0.15 a-c	0.08 c	0.10 a-c	0.04	0.02
S_1W_4	0.15 a-c	0.09 bc	0.08 a-c	0.02	0.03
S_1W_5	0.15 a-c	0.11 a-c	0.08 a-c	0.03	0.02
S_2W_1	0.18 ab	0.08 c	0.11 a-c	0.02	0.01
S_2W_2	0.14 a-c	0.11 a-c	0.09 a-c	0.03	0.02
S_2W_3	0.17 a-c	0.11 a-c	0.08 a-c	0.03	0.02
S_2W_4	0.12 c	0.16 a	0.06 c	0.03	0.02
S_2W_5	0.18 a	0.09 bc	0.13 a	0.02	0.01
S_3W_1	0.15 a-c	0.10 bc	0.12 ab	0.03	0.02
S_3W_2	0.15 a-c	0.14 ab	0.09 a-c	0.02	0.02
S_3W_3	0.16 a-c	0.12 a-c	0.09 a-c	0.02	0.02
S_3W_4	0.14 a-c	0.09 bc	0.09 a-c	0.04	0.02
S_3W_5	0.18 a	0.12 a-c	0.09 a-c	0.02	0.02
$LSD_{(0.05)}$	0.05	0.05	0.05	NS	NS
CV%	22.89	25.98	32.16	32.02	30.93

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.3 Yield contributing parameters

4.3.1 Pods plant^{-1} (no.)

4.3.1.1 Effect of plant spacing

Number of pods plant^{-1} is a key factor for determining the yield performance in leguminous plants. The productive capacity of mungbean plant is ultimately considered by the number of pods per plant. Table 10 showed that number of pods plant^{-1} was significantly varied due to different spacing under the present study. Results showed that pods plant^{-1} was increased gradually with increased spacing when closer (S_1) and intermediate (S_2) spacing gave similar value. Under the present study, S_3 produced the highest number of pods plant^{-1} (10.39) as significantly different from other and was about 68.18% higher yield than S_1 value. S_1 had minimum value i.e. 6.18 pods plant^{-1}. Intermediate value (6.78) was obtained from S_2. Nadeem *et al*. (2004) found the similar result and he observed that the 60cm apart double row produced more number of pods per plant than 40 cm apart single row strips in all legume crops. A significant effect of planting geometry on number of pods per plant has been reported by Ali *et al*. (2001).

4.3.1.2 Effect of weed management

Number of pods plant^{-1} was significantly influenced by weed management at all growth stages of mungbean (Table 10). It is remarked from the present study that the increasing number of weeding significantly increased number of pods plant^{-1}. W3 produced maximum number of pods plant^{-1} (9.89) which was similar with W_5. The lowest number of pods plant^{-1} was achieved with W_4 (5.43). Intermediate results on number of pods plant^{-1} were obtained from W_1 and W_2.The results under the present study was in agreement with the findings of Akter *et al*. (2013) and Khan *et al*. (2011). Akter *et al*.(2013) observed that three-stage weeding(Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) ensured the highest number of pods (22.03) plant^{-1}.

4.2.1.3 Combined effect of row spacing and weed management

Significant influence was observed by combined effect of spacing and weed management on number of pods plant^{-1} (Table 10). Results indicated that the highest number of pods plant^{-1} (12.67) was observed in the treatment combination of S_3W_3 which was significantly different from all other treatments. The lowest number of pods plant^{-1} was obtained with S_1W_4 (3.85) which was statistically similar with S_1W_2 and S_2W_4. The results obtained from all other treatment combinations were significantly different compared to other treatments.

4.2.2 Pod length (cm)

4.2.2.1 Effect of plant spacing

Pod length was not significantly influenced by different row spacing (Table 10). Under the present study, the highest pod length (9.02 cm) was achieved by S_2 where as the lowest was achieved by S_3 (8.04 cm).

4.2.2.2 Effect of weed management

Results presented in Table 10 on pod length influenced by number of weeding were statistically significant. The highest pod length (9.16 cm) was recorded in W_5 which was statistically similar with W_1 and W_2 and the lowest pod length(7.48 cm) was achieved by W_4.

4.2.2.3 Combined effect of plant spacing and weed management

Table 10 showed statistically significant results the combination of row spacing and weeding on pod length. Results indicated that the highest pod length (10.75 cm) was observed in the treatment combination of S_2W_5 which was significantly different from all other treatment combinations. On the other hand, the lowest pod length was obtained with S_3W_3 (6.93 cm) which was statically similar with S_1W_4, S_2W_4 and S_3W_4.

4.2.3 Seeds pod^{-1}(no.)

4.2.3.1 Effect of plant spacing

Number of seeds pod^{-1} is considered an important factor that directly imparts in exploiting potential yield recovery in leguminous crops. Data regarding number of seeds per pod given in Table 10 revealed that varying row spacing had a significant effect on the number of seeds per pod . Under the present study, the highest number of seeds pod^{-1} (10.71) was achieved by S_2 where as the lowest was in S_3 (9.94). The results obtained from S_1 showed intermediate results compared to highest and lowest number of seeds pod^{-1}. Similar findings were found by Rasul *et al*.(2012) and Saharia and Thakuria (1988). Rasul *et al*.(2012) observed that the inter-row spacing S_3 (60 cm) and S_2 (45 cm)were statistically similar and produced significantly more number of seeds per pod (10.55 and 10.37, respectively) than produced by S_1 (30 cm) inter-row spacing treatment.

4.2.3.2 Effect of weed management

Results presented in Table 10 on number of seeds pod^{-1} influenced by number of weeding were statistically significant. It is mentioned from the present study that the highest number of seeds pod^{-1} (10.98) was recorded in W_5 and the lowest number of seeds pod^{-1} was achieved by W_4 (9.16). The results from W_1 ,W_2 and W_3 on number of seeds pod^{-1} were intermediate compared to highest and lowest number of seeds pod^{-1}. Similar findings were found by Kundu *et al.*(2009).They said that seeds pod^{-1} was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE.

4.2.3.3 Combined effect of plant spacing and weed management

Table 10 showed statistically significant results from the combined effect of spacing and weeding methods on number of seeds pod^{-1}. Results indicated that the highest number of seeds pod^{-1} (12.71) was observed in the treatment combination of S_2W_5 which was significantly different from all other treatment combinations. On the other hand, the lowest number of seeds pod^{-1} was obtained with S_1W_4 (8.81) which was closely followed by W_2S_4,W_3S_3 and W_3S_4, but significantly different from all other treatment combinations.

4.2.4 Weight of 1000 seeds (g)

4.2.4.1 Effect of plant spacing

Among the various parameters contributing towards final yield of a crop, 1000-seeds weight is of prime importance. Data presented in Table 10 revealed that weight of 1000- seeds was not significantly influenced by different row spacing . Results showed that higher row spacing indicates higher 1000- seeds weight. Under the present study, the highest 1000- seeds weight (47.16 g) was achieved by S_3 where the lowest was achieved by S_1 (46.44 g). The results obtained from S_2 showed intermediate results compared to highest and lowest1000- seeds weight.

4.2.4.2 Effect of weed management

Results presented in Table 10 on 1000- seeds weight influenced by mumber of weeding were statistically significant. It is mentioned from the present study that the highest 1000- seeds weight (49.18 g) was recorded in W_2 which was statically similar with W_3 , whereas the lowest 1000- seeds weight was achieved by W_4 (43.25 g). The results from W_1 and W_5 on 1000- seeds weight were intermediate compared to highest and lowest 1000- seeds weight. Similar findings were found by Khan *et al*. (2011). The highest values (40.39 and 38.95 g) of 1000-seeds weight of mungbean in hand weeding plots with 17 and 5 percent increase over control were recorded by them.

4.2.4.3 Combined effect of row spacing and weed management

Table 10 showed statistically significant results influenced by combined effect of spacing and weeding methods on 1000- seeds weight. Results indicated that the maximum 1000 seeds weight (50.89 g) was observed in the treatment combination of S_3W_2 which was closely followed by S_2W_2 but significantly different from all other treatment combinations. On the other hand, the lowest 1000- seeds weight was obtained with S_2W_4 (42.42 g) which was at per with S_1W_4 and S_3W_4, but different from all other treatment combinations.

Table 10. Effect of plant spacing , weed management and their combination on yield contributing characters of mungbean

Treatments	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1}(no.)	1000-seeds weight (g)
Effect of row spacing				
S_1	6.18 b	8.22 a	9.99 b	46.44 a
S_2	6.78 b	9.02 a	10.71 a	46.84 a
S_3	10.39 a	8.04 a	9.94 b	47.16 a
LSD	0.95	NS	0.35	NS
CV %	11.98	11.91	6.78	2.48
Effect of weed management				
W_1	6.98 b	8.64 ab	10.55 ab	46.01 c
W_2	7.35 b	8.69 ab	10.27 b	49.18 a
W_3	9.89 a	8.18 b	10.11b	48.14 ab
W_4	5.43 c	7.48 c	9.17 c	43.25 d
W_5	9.27 a	9.16 a	10.98 a	47.49 b
LSD	0.88	0.59	0.56	1.32
CV %	11.69	7.21	5.62	2.9
Interaction effect of row spacing and weed management				
S_1W_1	5.83 e	8.49 b-d	10.23 bc	46.61 cd
S_1W_2	5.18 ef	8.49 b-d	10.24 bc	47.67 bc
S_1W_3	8.44 cd	8.53 b-d	10.58 bc	47.91 bc
S_1W_4	3.85 f	7.25 e	8.82 d	43.43 ef
S_1W_5	7.61 d	8.35 b-d	10.08 bc	46.58 cd
S_2W_1	6.04 e	8.81 b	10.92 b	46.34 cd
S_2W_2	5.98 e	8.93 b	10.28 bc	48.97 ab
S_2W_3	8.55 cd	9.08 b	10.72 b	48.38 bc
S_2W_4	3.87 f	7.55 de	8.95 d	42.42 f
S_2W_5	9.47 bc	10.75 a	12.71 a	48.09 bc
S_3W_1	9.07 cd	8.62 bc	10.52 bc	45.07 de
S_3W_2	10.90 b	8.63 bc	10.28 bc	50.89 a
S_3W_3	12.67 a	6.93 e	9.03 d	48.13 bc
S_3W_4	8.58 cd	7.64 c-e	9.73 cd	43.91 ef
S_3W_5	10.75 b	8.38 b-d	10.15 bc	47.81 bc
$LSD_{(0.05)}$	1.53	1.02	0.97	2.29
CV %	11.69	7.21	5.62	2.9

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding,
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation

W_5 =Post emergence herbicide, **Release** spraying at 15 DAG

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4.4 Yield parameters

4.4.1 Grain yield (t ha^{-1})

4.4.1.1 Effect of plant spacing

Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemicals, phenological and morphological events occurring in the plant system. Seed yield of a variety is the result of interplay of its genetic make up and environmental factors in which plant grow. Data pertaining to the seed yield (Table 11) elucidated that grain yield was significantly influenced by different row spacing. Under the present study, the highest grain yield (1.08 t ha^{-1}) was achieved by S_2 where as the lowest was achieved by S_1 (0.99 t ha^{-1}) which was 9.1% higher than S_1 value. The results obtained from S_3 was intermadiate regarding the value of grain yield. Similar findings were found by Mansoor *et al*. (2010) and Kabir and Sarker (2008). It was reported by Mansoor *et al*. (2010) that the maximum grain yield of mungbean was recorded in treatments having 30 cm of row spacing by having maximum grain yield of 1111 kg ha^{-1}. The highest seed yield (1046.0 kg ha^{-1}) was obtained at 30 cm × 10 cm spacing followed in order by 20 cm × 20 cm and 40 cm × 30 cm spacing was observed by Kabir and Sarker (2008).

4.4.1.2 Effect of weeding

Results presented in Table 11 on grain yield influenced by number of weeding were statistically significant. The highest grain yield (1.33 t ha^{-1}) was recorded in W_3 which was 86.11% hgher than lowest value while the lowest grain yield was achieved by W_4 (0.72 t ha^{-1}). The results from W_5 on grain yield also gave encouraging result where value from W_1 and W_2 were found similar. Khan *et al*. (2011) investigated that hand weeding produced higher yield (1092 and 743.3 kg ha^{-1}) of mungbean comparaed to control (631 and 518.8 kg/ha).

4.4.1.3 Combined effect of row spacing and weed management

Table 11 showed statistically significant results influenced by the combined effect of spacing and weeding methods on grain yield. Results indicated that the highest grain yield (1.51 t ha^{-1}) was observed in the treatment combination of S_2W_5 which was 147.54% higher than minimum value.

The lowest grain yield was obtained with S_1W_4 (0.61t ha^{-1}) which was also significantly similar with S_2W_4 and different from all other treatment combinations.It is noted here that two hand weeding along with close to sparse spacing (S_1W_3, S_2W_3 and S_3W_3) gave grain yield (1.30-1.36 t ha^{-1}) as next to higher production (S_2W_5) which could be the alternative choice of weed management.

4.4.2 Stover yield (t ha^{-1})

4.4.2.1 Effect of plant spacing

There was significant variation observed for straw yield due to plant spacing (Table 11). The higher stover yield (3.33 t ha^{-1}) was recorded from S_1 and the lower stover yield (2.77 t ha^{-1}) from S_3. Bhati *et al*. (2005) reported that mungbean cv. PDM-54 showed 13.7% higher fodder yield than the local cultivar.

4.4.2.2 Effect of weed management

Stover yield of mungbean varied significantly due to different weed managements (Table 11). The highest stover yield (2.18 t ha^{-1}) was observed from W_5 which was statistically similar with W_1 and W_3 while the lowest stover yield (1.62 t ha^{-1}) from W_4 .

4.4.2.3 Combined effect of row spacing and weed managements

The straw yield varied significantly due to different row spacing and weed managements combinations (Table 11). The highest stover yield (2.46 t ha^{-1}) was observed from S_2W_5 and it was statistically similar with S_1W_1, S_1W_2, S_1W_3, S_1W_5 and S_2W_3 whereas the lowest stover yield (1.47 t ha^{-1}) from S_2W_4 which was similar with S_1W_4, S_2W_2, S_3W_3, S_3W_4 and S_3W_5.

4.4.3 Biological yield (t ha^{-1})

4.4.3.1 Effect of plant spacing

The productivity of a crop is largely determined by the biological yield. Data regarding biological yield per hectare given in Table 11 revealed that there were significant differences among the row spacing that affected the biological yield. Under the present study, the highest biological yield (3.33 t ha^{-1}) was achieved by S_1 where as the lowest was recorded in S_3 (2.77 t ha^{-1}). The results obtained from S_2 showed intermediate results compared to highest and lowest biological yield. Similar findings were found by Ahmad *et al*. (2005) and Khan *et al*. (2001).

4.4.3.2 Effect of weeding

Biological yield was significantly influenced by number of weeding (Table 11). It is mentioned from the present study that the increasing number of weeding significantly increased biological yield. The maximum biological yield (3.51 t ha^{-1}) was recorded in W_3 and the munimum biological yield was achieved by W_4 (2.34 t ha^{-1}). The results from W_1, W_2 and W_5 on biological yield were intermediate compared to highest and lowest biological yield.

4.4.3.3 Combined effect of plant spacing and weed management

Table 11 showed statistically significant results influenced by interaction between spacing and weed management on biological yield. Results indicated that the highest biological yield (3.97 t ha^{-1}) was observed in the treatment combination of S_2W_5 which was statistically similar with S_1W_3 and S_2W_3, but significantly different from other treatment combinations. On the other hand, the lowest biological yield was obtained from S_2W_4 (2.09 t ha^{-1}) which was also significantly different from all other treatment combinations.

4.4.4 Harvest index (%)

4.4.4.1 Effect of plant spacing

Harvest index is a measure of physiological productivity potential of a crop variety. It is the ability of a crop plant to convert the dry matter into economic yield. The calculated values of Harvest index presented in Table 11 indicated that spacing differed significantly on account of conversion efficiency of assimilates. The maximum value of harvest index (38.03%) was achieved by S_3 whereas the lowest was achieved by S_1 (29.65%). The results obtained from S_2 showed intermediate results compared to highest and lowest harvest index.

4.4.3.2 Effect of weeding

Harvest index was significantly influenced by weeding (Table 12). It stated from the present study that the highest harvest index (38.13%) was recorded in W_3 and the lowest harvest index was achieved by W_4 (30.94%). The results from W_1 ,W_2 and W_5 on harvest index showed intermediate results compared to highest and lowest harvest index.

4.4.4.3 Combined effect of plant spacing and weed management

Table 11 showed statistically significant results influenced by interaction between spacing and weeding on harvest index. Results indicated that the highest harvest index (45.20%) was observed in the treatment combination of S_3W_3 which was significantly different from all other treatment combinations. On the other hand, the lowest harvest index was obtained from S_1W_2 (24.08%) which was significantly different from all other treatment combinations. The results obtained from all other treatment combinations were significantly different compared to highest and lowest harvest index.

Table 11. Effect of plant spacing , weed management and their combination on yields harvest index mungbean

Treatments	Grain Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
Effect of row spacing				
S_1	0.99 b	2.34 a	3.33 a	29.24 c
S_2	1.08 a	2.02 b	3.10 b	34.31 b
S_3	1.05 ab	1.72 c	2.77 c	37.90 a
LSD	0.08	0.09	0.08	1.98
CV %	7.44	4.42	2.7	5.7
Effect of weed management				
W_1	0.96 c	2.09 ab	3.05 c	31.88 c
W_2	0.98 c	2.07 b	3.05 c	32.55 c
W_3	1.34 a	2.17 ab	3.51 a	38.71 a
W_4	0.72 d	1.62 c	2.34 d	30.69 c
W_5	1.20 b	2.18 a	3.37 b	35.26 b
LSD	0.07	0.11	0.12	1.94
CV %	6.52	5.41	3.81	5.89
Interaction effect of row spacing and weed management				
S_1W_1	0.93 e-g	2.44 a	3.37 c	27.59 fg
S_1W_2	0.83 g	2.61 a	3.43 c	24.06 h
S_1W_3	1.35 b	2.48 a	3.83 ab	35.23 b-d
S_1W_4	0.61 h	1.74 cd	2.35 g	26.09 gh
S_1W_5	1.21 cd	2.44 a	3.65 b	33.23 cd
S_2W_1	0.96 ef	1.97 b	2.94 d	32.80 de
S_2W_2	0.95 ef	1.73 cd	2.68 ef	35.58 b-d
S_2W_3	1.36 b	2.44 a	3.82 ab	35.69 b-d
S_2W_4	0.62 h	1.47 e	2.09 h	29.47 ef
S_2W_5	1.51 a	2.46 a	3.97 a	38.03 b
S_3W_1	1.00 e	1.84 bc	2.84 de	35.25 b-d
S_3W_2	1.15 d	1.88 bc	3.04 d	38.02 b
S_3W_3	1.30 bc	1.58 de	2.88 d	45.20 a
S_3W_4	0.94 e-g	1.64 de	2.58 f	36.53 bc
S_3W_5	0.86 fg	1.64 de	2.50 fg	34.51 cd
LSD	0.12	0.18	0.19	3.36
CV %	6.52	5.41	3.81	5.89

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS

W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation

W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

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Quality parameter

1. Protein % of seed

Seeds of five important combined treatments were taken for determination of protein content. Results indicated that the protein varied from 24.45% to 26.04%. Plants were given 30 cm x 10 cm along with two hand weeding at 20 and 40 DAS produced seeds with maximum protein content (26.04%) that reduced small (25.51%) when plant was grown sparsly.Release herbicide facilited plants to have 24.63% to 25.78% protein in its seeds when grown at 20 cm x10 cm and 30 cm x 10 cm spacing.Close spacing with no weeding gave seeds of minimum (24.45%) protein content.

Table 12. Protein % (DM basis) of seeds of some selected treatments

Sample features	**Sample**				
	S_1W_1	**S_1W_5**	**S_2W_3**	**S_2W_5**	**S_3W_3**
Moisture	13.98	12.70	13.76	12.67	13.45
Dry Matter (DM)	86.02	87.30	86.24	86.30	86.48
Crude Protein (CP)	24.45	25.78	26.04	24.63	25.51

4.5 Economic performance of different combination of spacing and weeding methods

This economic analysis revealed the performance of weed control methods. Cost of production mainly varied due to weed management. As number of labours varied differently with weed management treatments.The cost involved in seed quantity due to different spacing is equal as different spacing had continuous sowing in line with equal seed rate. No weeding, one hand weeding, two hand weeding required 0, 45 and 90 respectively number of labour(s) for one hectore of land when herbicide spraying with Release 9 EC and Sunup 480 SL required only three labours in each case. The highest cost of production was (Tk. 70295.00 ha^{-1}) for the treatment S_1W_3 (two hand weeding) and the lowest cost of production was (Tk. 42260.00) for the treatment S_3W_1 (Table 13).

4.5.1 Gross return

The highest gross return (Tk. 156420 ha^{-1}) was obtained from the treatment S_2W_5 (application of Release 9 EC maintaining 30 cm x 10 cm spacing) and the lowest gross return (Tk. 65580 ha^{-1}) was obtained from treatment S_1W_4 (application of Sunup 480 SL maintaining 20 cm x 10 cm spacing).The second highest gross return (Tk. 142710 ha^{-1}) was obtained from S_2W_3.

Table 13. Cost of production, return and Benefit cost ratio (BCR) of mungbean under different treatments

Treatments	Cost of production (Tk ha^{-1})			Gross return (Tk. ha^{-1})			Gross margin (Tk ha^{-1})	BCR
	Fixed cost	Weeding cost	Total	From grain	From straw	Total		
S_1W_1	43295	0	43295	93000	6320	99320	56025	2.29
S_1W_2	43295	13500	56795	82640	6800	89440	32645	1.57
S_1W_3	43295	27000	70295	134640	6890	141530	71235	2.01
S_1W_4	43295	2590	45885	61360	4220	65580	19695	1.43
S_1W_5	43295	2080	45375	121360	6290	127650	82275	2.81
S_2W_1	42605	0	42605	96360	4910	101270	58665	2.38
S_2W_2	42605	13500	56105	95360	4190	99550	43445	1.77
S_2W_3	42605	27000	69605	136360	6350	142710	73105	2.05
S_2W_4	42605	2590	45195	61640	4410	66050	20855	1.46
S_2W_5	42605	2080	44685	151000	5420	156420	111735	3.50
S_3W_1	42260	0	42260	100000	2210	102210	59950	2.42
S_3W_2	42260	13500	55760	115350	4640	119990	64230	2.15
S_3W_3	42260	27000	69260	130360	4910	135270	66010	1.95
S_3W_4	42260	2590	44850	94360	3890	98250	53400	2.19
S_3W_5	42260	2080	44340	86360	4190	90550	46210	2.04

Here,

S_1 = 20 cm × 10 cm
S_2 = 30 cm × 10 cm
S_3 = 40 cm × 10 cm
.

W_1 = No weeding
W_2 = 1 hand weeding at 20 DAS
W_3 = 2 hand weeding at 20 and 40 DAS
W_4 = Pre emergence herbicide, **Sunup** spraying after land preparation
W_5 = Post emergence herbicide, **Release** spraying at 15 DAG

4.10.2 Net return

Net return varied in different weed control treatments (Table 15). The highest net return (Tk. 111735 ha^{-1}) was obtained from the treatment S_2W_5. The second highest net return (Tk. 82275 ha^{-1}) was obtained from the treatment S_1W_5. Lowest net return (Tk. 20855ha^{-1}) was achieved from S_2W_4.

4.10.3 Benefit Cost ratio

Benefit cost ratio varied in different weed control treatments. It was evident that the release 9 EC herbicidal treated plots gave the higher BCR ranged from 2.07-3.05 than the other treatments. Release 9 EC maintaining 30 cm x 10 cm spacing (S_2W_5) gave the highest BCR (3.50). The treatment S_1W_4 showed the lowest BCR (1.43). This result supports the findings of Mirjha *et al.* (2013) who concluded that the highest (1.52) benefit cost ratio (BCR) was obtained by combined application of fenoxaprop-pethyl @ 50 g/ha + chlorimuron-ethyl @ 4.0 g/ha(PoE).

SUMMARY AND CONCLUSION

The present piece of work was done at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from August to November, 2013 to find out the influence of different plant spacing along with weed control methods on the growth and yield of mungbean.

The experiment was laid out in a split plot design with three replications. The size of the individual plot was 7.2 m^2 and total numbers of plots were 45. The experiment comprised with two factors viz. (i) Row spacing and (ii) Weed management. Three plant spacings (S_1= 20 cm x 10 cm, S_2= 30 cm x 10cm, S_3= 40 cm x 10 cm) and five weeding treatments no weeding (W_1), one hand weeding at 20 DAS (W_2), two hand weedings at 20 DAS and 40 DAS (W_3), Sunup 480 SL (Glyphoset) @ 3.7 l ha^{-1} (W_4) and Release 9 EC (Phenoxprop-p-ethayel) @ 650 ml ha^{-1} (W_5). Sunup 480 SL, a pre-emergence herbicide was applied after final land preparation. Release 9 EC, a post-emergence herbicide was applied at 15-20 DAS when weeds were 2-3 leaf stage were used. There were 15 treatment combinations. Plant spacing was placed along the main plot and weeding methods were placed along the sub plot. Data on different growth, yield contributing characters and yield were recorded from the experimental field and analyzed statistically.

The data on weed parameters were collected from 10 DAS to at harvest. Weed parameters such as total weed population (no. m^{-2}); relative weed density (RWD %), weed biomass (g m^{-2}) and weed control efficiency (%) were examined. The data on growth parameters viz. plant height, above ground dry matter weight $plant^{-1}$, branches $plant^{-1}$, crop growth rate and relative growth rate were recorded during the period from 10 DAS to at harvest. Yield contributing characters and yield parameters like number of pods $plant^{-1}$, seeds pod^{-1}, pod length, 1000 seeds weight, grain yield, straw yield, biological yield, harvest index and protein % of seeds were recorded.To determine the economic feasibility of different weed control methods on mungbean total cost of production, gross return and net return were calculated to determine the benefit cost ratio.

17 weed species infested the experimental plots belonging to eight families were found to infest the experimental crop. The most important weeds of the experimental plots were *Cynodon dactylon* , *Cyperus rotundus, Eleusine indica* , *Eichinochloa crussgali* respectively. Weed density, relative weed density, weed biomass and weed control efficiency were significantly influenced by the weed control treatments.

Results revealed that plant spacing of mungbean like 30 cm x 10 cm stand superior than other in respect of branches plant^{-1} (1.04), dry matter content plant^{-1} (10.48 g and 12.26 g), length pod^{-1} (9.02 cm), seeds pod^{-1} (10.71), seed yield (1.08 t ha^{-1}), respectively while maximum number of pods plant^{-1} (10.39), 1000-seeds weight (47.16 g) and harvest index (37.90 %) was found in 40 cm x 10 cm spacing. Among weed management practices, the highest plant height (65.60 cm), dry matter content plant^{-1} (13.37 g), length pod^{-1} (9.16 cm), seeds pod^{-1} (10.98) and straw yield (2.18 t ha^{-1}) was obtained by the application of post emergence herbicide at 15-20 DAG (W_5) while maximum number of pods plant^{-1} (9.89), grain yield (1.34 t ha^{-1}), biological yield (3.51 t ha^{-1}) and harvest index (38.71 %) was obtained from two hand weeding treatment.

In combination, it was observed that the lowest number of weed species and total number of weeds m^{-2} (8.23 and 75.25 respectively) was obscured in S_1W_5 (application of Release 9EC @ 650 ml ha^{-1} maintaining 20 cm x 10 cm spacing) . On the other hand, the highest number of weed species and total number of weeds m^{-2} (13.23 and 266.12 respectively) was obtained from S_3W_1. Different weed control treatments had significant effect on crop growth parameters viz. plant height, above ground dry matter weight plant^{-1}, crop growth rate (CGR) and relative growth rate (RGR) at different DAS. The highest plant height (53.62, 63.91, 68.18 and 68.57 cm at 30, 40, 50 DAS and at harvest respectively) was observed in the 20 cm ×10 cm spacing with post emergence herbicide for weed management (S_1W_5) and at 10 and 20 DAS, the tallest plant (23.00 cm and 38.58 cm) was observed with S_1W_4. At 30 DAS, the highest no. of branches plant^{-1} (1.47) was observed in S_2W_3. At 40 DAS, maximum no. of branches plant^{-1} (2.38) was observed with S_1W_5. But at 50 DAS and at harvest, the highest no. of branches plant^{-1} (2.98 and 3.53) were found in S_2W_5. Results indicated that the highest dry weight plant^{-1} (10.93, 13.98 and 15.48 g at 40, 50 DAS and at harvest, respectively) was observed in the treatment combination of S_2W_5. Crop growth rate (CGR) was highest with Release 9 EC (W_5). Spacing and weed control treatments had significant effect on the yield and yield contributing characters viz.length pod^{-1}, seeds pod^{-1}, grain yield, straw yield and biological yield was highest in 30 cm x 10 cm with Release 9 EC (S_2W_5) treatment and harvest index was highest in 40 cm x 10 cm with two hand weeding (S_3W_3) treatment. 1000 grain weight was found highest in S_3W_2 (40 cm x 10 cm with one hand weeding) treatment. It was observed that plant spacing 30 cm x 10 cm coupled with Release 9EC herbicide application (S_2W_5) emerged as economically viable treatment for greater yield (1.51 t ha^{-1}) with maximum BCR (3.50).

CONCLUSION

It may be concluded that mungbean crop could be grown giving 30 cm x10 cm plant spacing with one time spraying of post emergence herbicide, Release 9EC for better growth with maximum yield attributes of yield harvest which proved economically a viable treatment.

RECOMMENDATION

This type of experiment could be taken in different mungbean growing areas of Bangladesh for further testing the tratment performances.

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APPENDICES

Appendix I. Characteristics of experimental soil was analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	***Characteristics***
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	***Value***	
	Before sowing	***After harvest***
pH	6.0	5.7
Organic matter (%)	0.86	1.19
Total N (%)	0.05	0.06
Available P (ppm)	6.49	5.26
Exchangeable K (me/100 g soil)	0.18	0.21
Available S (ppm)	27.62	10.06
Available Ca (me/100 g soil)	10.06	14.08

Source: Soil Resource Development Institute (SRDI)

Appendix II. Monthly average air temperature, relative humidity, total rainfall,wind speed, sunshine hour and evaporation rate of the experimental site during the period from August to November, 2013.

Month	*RH (%)*	*Temperature (ºC)*		*Wind speed (km hr⁻¹)*	*Sunshine hour*	*Rain fall (mm day⁻¹)*	*Evaporation rate (mm day⁻¹)*
		Maximum	*Minimum*				
August	74.41	31.02	15.27	3	5.11	5.1	2.07
September	73.20	31.46	14.82	2	4.15	6.3	2.05
October	67.82	30.18	14.85	1	7.48	4.2	2.05
November	58.18	28.10	6.88	1	7.85	1.56	1.82

Source: SAU Meteorological Yard , Sher-e-Bangla Nagar, Dhaka-1207.

Appendix III. Effect of plant spacing and weed management on plant height of mungbean at different days

Source of variance	Degrees of Freedom	Mean square					
		10 DAS	20D AS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.993	1.396	3.733	3.394	1.077	1.797
Spacing (S)	2	4.808	6.212	10.582	18.642	16.024	12.858
Error (a)	4	1.031	0.347	0.560	1.796	0.564	0.247
Weeding (W)	4	28.139	40.071	44.660	80.715	69.066	64.938
S xW	8	1.326	9.508	8.739	22.569	24.313	24 362
Error (b)	24	0.731	0.681	0.687	0.786	4.624	4.332

Appendix IV. Effect of plant spacing and weed management on the on number of branches plant^{-1} of mungbean at different days

Source of variance	Degrees of Freedom	Mean square			
		30D AS	40 DAS	50 DAS	60 DAS
Replication	2	0.118	0.144	0.491	0.256
Spacing (S)	2	1.091	0.073	0.057	0.110
Error (a)	4	0.182	0.234	0.488	0.543
Weeding (W)	4	0.560	0.699	1.241	0.966
S xW	8	0.257	0.866	0.497	0.422
Error (b)	24	0.087	0.120	0.211	0.212

Appendix V. Effect of plant spacing and weed management on above ground dry matter weight plant^{-1} (g) of mungbean at different days

Source of variance	Degrees of Freedom	Mean square					
		10 DAS	20D AS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.003	0.343	0.350	6.594	7.783	11.065
Spacing (S)	2	0.002	0.056	1.322	20.148	23.391	23.600
Error (a)	4	0.006	0.044	0.123	0.740	1.694	1.810
Weeding (W)	4	0.000	0.159	0.627	14.479	17.898	14.971
S xW	8	0.001	0.055	0.786	2.108	2.008	2.049
Error (b)	24	0.002	0.057	0.343	1.826	1.524	1.289

Appendix VI. Effect of plant spacing and weed management on CGR (g m^{-2} day^{-1}) of mungbean at different days

Source of variance	Degrees of Freedom	Mean square				
		10-20 DAS	20-30 DAS	30-40 DAS	40-50 DAS	50-60 DAS
Replication	2	3.061	6.031	67.962	11.411	11.520
Spacing (S)	2	10.628	31.833	101.985	112.268	77.640
Error (a)	4	0.543	1.773	6.816	7.738	2.417
Weeding (W)	4	2.041	3.915	110.546	5.913	3.494
S xW	8	0.815	9.749	27.441	10.864	1.425
Error (b)	24	0.740	4.477	35.170	3.887	3.197

Appendix VII. Effect of plant spacing and weed management on yield contributing charecters of mungbean

Source of variance	Degrees of Freedom	Mean square			
		Pod length (cm)	Pods plant^{-1}	Seeds pod^{-1}	1000 seeds weight (g)
Replication	2	0.265	2.390	0.116	4.325
Spacing (S)	2	4.098	77.855	2.808	1.955
Error (a)	4	1.009	0.871	0.481	1.357
Weeding (W)	4	3.623	29.272	4.085	47.551
S xW	8	1.413	1.998	1.911	2.949
Error (b)	24	0.369	0.829	0.329	1.843

Appendix VIII. Effect of plant spacing and weed management on yields and harvest index of mungbean

Source of variance	Degrees of Freedom	Mean square			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
Replication	2	0.011	0.004	0.005	9.073
Spacing (S)	2	0.036	1.458	1.175	283.996
Error (a)	4	0.606	0.008	0.007	3.800
Weeding (W)	4	0.500	0.490	1.839	92.426
S xW	8	0.119	0.250	0.587	31.801
Error (b)	24	0.005	0.012	0.014	3.970

Appendix IX. Cost of production per hectare of mungbean excluding weeding cost for 20 cm x 10 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	23	90	2070
02.	Cost of fertilizers			
	a) Urea	45	15	675
	b) TSP	100	32	3200
	c) MOP	40	17	680
			Grand total =	6625

Appendix X. Cost of production per hectare of mungbean excluding weeding cost for 30 cm x 10 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	15	90	1350
02.	Cost of fertilizers			
	a) Urea	45	15	675
	b) TSP	100	32	3200
	c) MOP	40	17	680
			Grand total =	5905

Appendix XI. Cost of production per hectare of mungbean excluding weeding cost for 40 cm x 10 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	12	90	1080
02.	Cost of fertilizers			
	a) Urea	45	15	675
	b) TSP	100	32	3200
	c) MOP	40	17	680
			Grand total =	5635

Appendix XII. Weeding cost of different weed control treatments for one hectare of land of mungbean

Treatments	No. of labours	Labour cost	Herbicide cost	Total weeding cost
W_1	0	0	--	0
W_2	45	13500	--	13500
W_3	90	27000	--	27000
W_4	3	900	2590	3490
W_5	3	900	2080	2980

LIST OF PLATES

Plate 1: Field view of unweeded plot (W_1)

Plate 2: Field view of one hand weeding at 20 DAS treatments (W_2) plot

Plate 3: Field view of two hand weeding at 20 & 40 DAS treatments (W_3) plot

Plate 4: Field view of Sunup 480 SL (W_4) treated plot

Plate 5: Field view of Release 9 EC (W_5) treated plot