ROW SPACING AND NUMBER OF WEEDING ON THE PERFORMANCE OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled "Row Spacing and Number of Weeding on the Performance of Mungbean" 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 md. Akik Bin Zaher, Roll No. 01775, Registration. No. 05-01775, 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.

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Abstract

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during January to April 2012 to study the effect of intra- row spacing and time of weeding on the performance of mungbean (cv. BARI mung-4). The experiment comprised with two factors viz. (i) Intra-row spacing and (ii) Time of weeding. Four row spacing (S_1= 15 cm, S_2= 20 cm, S_3= 25 cm and S_4= 30 cm) and four weeding treatments (W_0= No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 days after sowing (DAS), and W_3 = Weeding at 15, 30 and 45 days after sowing (DAS) were used. There were sixteen treatment combinations under the present study. Results showed that the highest plant height (60.26 cm) was achieved by 15 cm row spacing with three times of weeding. The highest number of leaves plant^{-1} (11.08), dry weight plant^{-1} (15.63 g), number of pods plant^{-1} (43.29), pod length (6.69 cm), number of seeds pod^{-1} (9.43), 1000 - seed weight (30.49 g), grain yield (1591 kg ha^{-1}) and biological yield (3964 kg ha^{-1}) were gained by 30 cm row spacing with three times of weeding. The highest harvest index (44.26%) was achieved by 25 cm row spacing with two times of weeding. The highest weed biomass (fresh weight basis) was obtained with 25 cm row spacing with three times of weeding (654 kg ha^{-1}) where 15 cm row spacing with one weeding (330 kg ha^{-1}) showed the lowest weed biomass. But at the time of harvest the highest weed biomass was achieved from 15 cm row spacing with no weeding (796 kg ha^{-1}) where as the lowest was observed from 30 cm row spacing with three times of weeding (439 kg ha^{-1}). With the treatment combination of 25 cm row spacing with two times of weeding showed very close yield (1585 kg ha^{-1}) to the combination of 30 cm row spacing with three times of weeding (1591 kg ha^{-1}). Hence, the grain yield from 25 cm row spacing with two times of weeding (1585 kg ha^{-1}) and 30 cm row spacing with three times of weeding (1591 kg ha^{-1}) were significantly similar; so, from economic point of view, 25 cm row spacing followed by two times of weeding was the best treatment combination.

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LIST OF ABBRIVIATIONS

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

Chapter 1

INTRODUCTION

Mungbean [*Vigna radiata* (L.)] is one of the most important pulse crops in Bangladesh. Its edible grain is characterized by good digestibility, flavour, high protein content and absence of any flatulence effects (Ahmed *et al.*, 2008). In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman and Ali, 2007). This is mostly due to low yield (MoA, 2005). The reasons for low yield are manifold: some are varietals and some are agronomic management practices. Due to the shortage of land, the scope of its extensive cultivation is very limited. Therefore, attempts must be made to increase the yield per unit area by applying improved technology and management practices. For any yield improvement program selection of superior parents is an essential prerequisite i.e., possessing better heritability and genetic advance for various traits (Khan *et al*., 2005; Ahmad *et al*., 2008).

Various experiments and work on spacing of mungbean have been carried out in Bangladesh, as well as in other countries to find out the suitable plant population to get maximum yield (Mondal, 2007). Improper spacing reduced the yield of mungbean up to 20 to 40% (AVRDC, 1974) due to competition for light, space, water and nutrition. The optimum spacing favors the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients and thus increase grain yield (Miah *et al*., 1990). Plant spacing directly affects the physiological activities through intra-specific competition. Narrowing of plant spacing by increasing seed rate generally means a more uniform distribution of plants over a given area, thus matching the plant canopy effective in intercepting radiant energy and shading weeds. Though wider space allows individual plants to produce more branches and pods, but it provides smaller number of pods per unit area due to fewer plants per unit area.

Weed is one of the most important factors responsible for low yield of crops (Islam *et al.*, 1989). Mungbean is not very competitive against weed and therefore weed control is essential for mungbean production (Moody, 1978). Yield losses due to uncontrolled weed growth in mungbean range from 27 to 100% (Madrid and Vega, 1971). Dry weight of weed increases as the duration of weed competition increased in wheat (Islam *et al.*, 1989). All crops have a stage during their life cycle when they are particularly sensitive to weed competition. In general, it ranges up to first 25 to 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 average of weeds (Islam *et al.*, 1989).

Therefore, the optimum intra-row spacing and time of weeding could be the most important factors for better mungbean production. It is observed that mungbean seedlings and the weed seedlings emerge and grow simultaneously causing weed crop completion for nutrients, water, light etc. at the very early growth stages of the crop which continues till to the crop maturity. Weed also support to increase insect and disease infestation of the crop. The yield of mungbean may be increased through appropriate combination of optimum intra-row spacing and time of weeding.

The experimental evidences on the effect of intra-row spacing and time of weeding on the yield and yield components of mungbean are limited under Bangladesh condition. The present study was therefore, undertaken with the following objectives.

I. To examine the effect of intra- row spacing and time of weeding on the plant characters, yield and yield attributes of mungbean.

II. To quantify the relationship of mungbean seed yield to mungbean plant biomass and weed biomass.

III. To study the combined effect of intra- row spacing and time of weeding on the performance of mungbean.

CHAPTER 2

REVIEW OF LITERATURE

The growth and yield of mungbean are influenced by row spacing and time of weeding. Following review of literature includes reports as studied by several investigators who were engaged in understanding the problems that may help in the explanation and interpretation of results of the present investigation. In this chapter, an attempt has been made to review the available information in home and abroad regarding the effect of row spacing and time of weeding on the yield of mungbean.

2.1 Effect of row spacing on the performance of different legumes

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). Narrow spacing significantly increased dry matter production in pigeon pea (Madhavan *et al*., 1986).

Narrow spacing was significantly affected by population density. The crop growth rate increased from 20 - 50 day after emergence and then declined in sesame (Hossain and Salauddin, 1994). The maximum crop growth rate value was recorded at 40-50 days after emergence irrespective of population densities.

Miah (1988) recorded higher crop growth rate with higher planting density in cowpea and mungbean.

Muchow and Edwards (1982) reported significantly positive linear trends of dry matter production in three varieties of mungbean to increasing density.

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).

Ahmad *et al*. (2005) conducted an experiment in Faisalabad, Punjab, 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-seed weight) of mungbean cv. NM-92. Seed yield was the highest with 30 cm row spacing while pods per plant, seeds per pod and 1000seed 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.

Khan *et al*. (2001) conducted an experiment with mungbean during the summer season of 2000, in Peshawar, Pakistan, The row spacing treatments were 25 and 50 cm, while plant spacing were 5, 7.5 and 10 cm. Emergence of seedlings m^{-2}, days to flowering, days to maturity, number of grains pod^{-1}, number of branches $plant^{-1}$, plant height (cm), thousand grain weight (g), percent hard grain (%), biological yield (kg ha^{-1}) and grain yield (kg ha^{-1}) were significantly affected by row and plant spacing, while pods number $plant^{-1}$ and harvest index were not significantly affected at 5% level of significance with row and plant spacing. The results revealed that a spacing of 50 cm between rows and 10 cm within rows produced the maximum number of pods/plant, grains/pod, thousand grain weight, low percent hard grain and high biological yield, harvest index and grain yield (kg ha^{-1}).

Grain yield generally increases with raising plant population but this relationship is parabolic (Hamblin, 1976). In general, yield of edible podded pea decreased with increase in plant spacing and vegetable pea yield decreased with increase in line to line spacing. The closer spacing was suitable for higher vegetable pod and grain yield (Anonymous, 1996). It was stated that plant density is the most important non momentary input which can be maintained through plant and row spacing to obtain higher yield per unit land area (Iain and Chauhan, 1988).

Higher grain yield was recorded with 25 cm row spacing in pea and then was significant reduction in yield when the spacing was increased to 50 cm (Yadav *et al*., 1990).

Saimbhi *et al*. (1990) conducted an experiment with three spacings viz. 95cm x 10 cm, 30 cm x 7.5 cm and 30 cm x 10 cm to determine optimum plant spacing for green pod yield of pea. The spacing of 30 cm x 7.5 cm gave the highest pod yield, which was significantly higher than that of 30 cm x 10 cm spacing. The spacing of 45 cm x 10 cm gave the lowest pod yield in early pea, a spacing of 30 cm between the rows and 7.5 cm between the plants was the best.

Singh *et al*. (1993) reported that, pea genotypes do not respond significantly to plant density in terms of seed yield and attributes. Narrow row spacing with high plant density increased the grain yield of pea significantly (Singh and Yadav, 1978). However, Singh *et al*. (1981) obtained high grain yield of peas at 15 cm x 15 cm spacing and the grain yield decreased when the spacing was increased to 50 cm from 25 cm (Yadav *et al*., 1992).

In another study, inter row spacing of 22.5 cm produced highest grain yield of the pulses followed by 15 cm spacing (Tripurari and Yadav, 1990). Rajput *et al*. (1991) reported that significantly higher grain and straw yield was recorded under narrow row spacing (30 cm) than under wider row spacing (45 cm) in soybean.

Porwal *et al*. (1991) found that row spacing significantly affected seed yield and the seed index. Closer row spacing (30 cm) gave 11.90% higher seed yield over wider spacing (40 cm) in soybean. Agasimani *et al*. (1988) reported that 20 cm x 15 cm spacing gave higher yield in groundnut.

Seed yield was higher under 30 cm row spacing in dwarf pea because of more pods plant^{-1} and seeds pod^{-1} (Saharia and Thakuria, 1988)

Griepentrog and Tomar, (2000) also found that increasing wheat seed rates from 200-660 m^2 greatly increased weed suppression. However, sowing in a cross pattern at 12-8 cm, compared with a normal row pattern at the same width, suppressed weed biomass by a further 30%. Yield also increased by 60% over normal row pattern at 400 seeds n i-2.

Provisional Scottish results indicated that row width of about 16cm gives better weed suppression than narrower or wider row widths, but these trials are being repeated over two further seasons (Davi'es and Hoad, 2000).

Researchers in Arkansas, Louisiana, and Texas summarized 21 field experiments conducted over 14 yr to determine the effect of row spacing on seed yield in soyabean (Bowers *et al*., 2000). For all environments tested, narrow rows (< 40 cm) yielded equal to or greater than wider rows.These researchers concluded that narrow rows should be used to optimize yields in soyabean in the Midsouthern USA.

Research under many conditions and locations throughout the USA has investigated adjusting plant populations and row spacing to achieve suitable vegetative growth and increase yield (Bullock and Kraljevic, 1998).

Boquet (1998) found that planting date and cultivars selection were the most important factors for increasing yields in Louisiana while row spacing was less significant.
Low planting density due to wide spacing has been identified as one of the reasons responsible for low yield of garlic (Abubakar, 1998).

Bodnar *et al*. (1998) reported that widely spaced garlic plants tend to grow more vegetative and bear more leaves/plant. Highest bulb yield was obtained from 10 cm infra-row spacing while 20 cm infra-row spacing gave the lowest bulb yield of onions (John, 1997).

The positive increase in bulb yield of garlic at closer spacing might be ascribed to increase plant population per unit land area while the decrease in bulb yield at wider infra-raw spacing could be associated with decreased plant population per unit land area. It can thus be seen that, the total yield per unit area depends not only on the performance of individual plants but also on the number of plants per unit area (Babaji, 1996; Abubakar, 1997).

Hamid (1989) found that mungbean grown at very high density failed to produce yield because of high rate of mortality.

Plant density is achieved by varying the row spacing. Seed yield of soybean was significantly higher with high population in narrow rows than in the wide rows (Ethredge *et al*., 1989).

Plant density is the most important yield contributing character, which can maximize yield (Babu and Mitra, 1989).

Plant density has considerable effect on the suppression of weeds. Plant density, species proportion, and spatial arrangements are important considerations, that mediate the influence of environmental and biological factors (Radosevich, 1987).

Yield per hectare and number of seeds pod^{-1} increased with increasing plant density whereas yield plant^{-1} and number of pods plant^{-1} decreased with increasing plant density in mungbean (Panwar and Sirohi, 1987).

In Arkansas, Beatty and Aulakh (1982) adjusted plant population with row spacing and found that April plantings in 18-cm rows with 60 seeds m^{-2} and 48-cm rows with 46 seeds m^{-2} yielded more than May or June plantings at any row spacing.

High yield of good quality pod can be obtained from increased plant density and weed free environment in *vigna unguiculata* (Brathwaite, 1982).

Per plant dry matter yield decreased progressively with increasing density. Grain yield plant^{-1} decreased with increasing density but the yield density function constructed based on grain yield/unit area followed a quadratic relationship. Increased plant density resulted in plants bearing less pod and seed in *Vicia fava* L. (Zahab *et al*., 1981).

Increase in the planted density of crops is expected to suppress weed growth (Radosevich, 1987; Martin *et al*., 1987). The use of crop to compete against weeds and suppress them is a weed control techniques that is often overlooked (Moody, 1978).

One approach of elevating the seed yield of mungbean by Asian Vegetables Research and Development center (AVRDC) is to increase yield by increasing plant density. The yield of mungbean does not increase linearly with increase in density as it does in soybean. The number of pods per plant of mungbean decreases as density increases unlike soybean (MacKenzie *et al*., 1975).

2.2 Time of weed control and mungbean performance

Chattha *et al*. (2007) conducted a field study in Islamabad, Pakistan, during 2003-04 to determine the effect of different weed control methods on the yield and yield components of mungbean. Treatments were mechanical weeding after 20 days of crop sowing with a follow-up hand weeding after 50 days of crop sowing and/or two hands weeding after 20 and 40 days of crop sowing. 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. Similarly, this treatment out yielded other treatments in terms of number of pods per plant, number of seeds per pod, 1000 grain weight, grain yield and net benefits. The economic analysis of these weed control methods also showed better performance of chemical weeding at 2-3 leaf stage of weeds + hand weeding at 50 DAS as compared to rest of the treatments.

Malik *et al*. (2005) conducted a field experiment with mungbean cv. Asha in Hisar, Haryana, India, during kharif 2002 and 2003, involving 2 sowing methods and 5 weed control treatments, i.e. Pendimethalin at 1.5 kg/ha + hoeing at 45 days after sowing DAS (TI), 2 hoeings at 25 and 45 DAS (T2), 2 hand weedings at 25 and 45 DAS (T3), weedy (T4) and weed-free (TS). The maximum reduction in density and dry weight of weeds was achieved in T3, which was significantly better than Tl during 2002 but at par during 2003. T2 though reduced the density and dry weight of weeds significantly compared to T4, it was inferior to all other weed control treatments during both years. The sowing methods did not affect the crop performance. T1 proved superior in terms of crop dry matter accumulation at 60 DAS compared to T2 and T3. Plant height was statistically similar under different weed control practices. The highest seed yield of mungbean (1947 and 1870 kg/ha) was attained in T5, which was statistically at par with T, (1779 and 1727 kg/ha) and T3 (1785 and 1561 kg/ha), during 2002 and 2003.
Kumar *et al*. (2005) conducted a study to evaluate the benefits of these resource conservation technologies in mungbean during kharif 2004 in Haryana, India.

Treatments comprised: three sowing methods and seven weed control treatments. 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. The weedy control had the maximum uptake of both nutrients by weeds. Pendimethalin at 1.0 kg/ha + HW at 30 DAS resulted in significantly lower nutrient uptake by weeds compared to its individual application and other herbicidal treatments. Hand weeding at 20 and 40 DAS recorded the lowest nutrient uptake by weeds. Weed control treatments recorded higher dry weight of crop than the weedy control. Dry weight of crop was maximum under weedfree treatment. None of the sowing and weed control treatments could significantly influence nitrogen and phosphorus contents by mungbean. On average, weedy conditions reduced the seed yield to 31.6%. Grain yield was maximum (962 kg/ha) in weed-free treatment and minimum in weedy one (658 kg/ha).

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 extracts q11d 4nd weeding were applied twice, i.e. at 10 and 35 days after sowing. All the treatments significantly affected number of branches plant^{-1}, number of pods/plant, 1000-grain weight and grain yield. 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.

Pandey and Mishra (2003) conducted an experiment during 1997-99 in New Delhi India, involving 5 weed control treatments viz. weedy control, hand weeding, chemical, cultural, and chemical + cultural, in a rice-Indian mustardmungbean cropping system. Hand weeding in rice was performed at 30 days after transplanting, while in Indian mustard and mungbean at 20 DAS. In the cultural treatment, a hand-driven wooden hand plough was run between the line 35 DAS. Weed competition in the rice-Indian mustard-mung bean cropping system lowered the total grain productivity by 32%. The maximum decrease in grain productivity of rice, Indian mustard and mungbean was 35.3, 19.3 and 45.6%, respectively. The most principal weed species that competed were Echinochloa colonum (E. colona) and E. crus-galli in rice, Phalaris minor in Indian mustard and Trianthema portulacastrum in mungbean. The competitive effect of other weed species on grain yield was nominal as their population was sparse. In all the 3 crops, in all weed control treatments, weed population and weed dry weight were recorded significantly lower compared to the weedy control. Chemical + cultural, hand weeding and chemical treatments resulted in a marked decrease in weeds, the decreases being higher in the former two treatments. Weed control treatments caused a significant increase in grain yield of crops in both years. Chemical + cultural and hand weeding caused a significant increase in grain yield of rice, while hand weeding and chemical treatments did that in mustard and mungbean.

Weeds remain one of the most significant agronomic problems associated with organic arable crop production. It is recognized that a low weed population can be beneficial to the crop as it provides food and habitat for a range of beneficial organisms (Aebischer and Fuller, 1998).

Ahmed *et al*. (1992) found that one hand weeding at 10 or 20 DAE produced higher yield than unweeded plots in mungbean during early kharif. Ahmed *et al*. (1992) also observed highest grain yield of mungbean when weeded at 10 DAE.

The critical weed-free period represents the time interval between two separated measured components: the maximum weed-infested period or the length of time that weeds which have emerged with the crop can remain before they begin to interfere with crop growth; and the minimum weed free period or the length of time a crop must be free of weeds after planting in order to prevent yield loss (Weaver *et al*., 1992).

Bulb yield losses of about 79 - 89% due to weed infestation have been reported (Ahmed, 1991). Weeds can significantly reduce crop yield and quality in conventional and organic (Bulson, 1991) crops.

Maximum seed yield was obtained when weeds were removed 20 days after sowing. In competition study, 20 % yield reduction in soybean occurred if weed control measure was not taken prior to 5weeks after emegence (Crook and Renner, 1990; Marwat and Nafziger, 1990).

Critical period of weed competition is the minimum weed free period essential during the life cycle of a crop to prevent yield loss. The critical period of weed control in interference study is the period up to which the weeds would be allowed without significant yield losses of crops (Bryson, 1990). Every crop has a stage during its life cycle when it is particularly sensitive to weed competition (Islam *et al*., 1989).

Kumar and Kairon (1988) found that weed biomass increased and mungbean yield decreased with delay in weeding. However, delay in weeding did not affect the number of seeds pod^{-1}. Dry matter was maximum under weed free condition followed by weed removal at 30 and 40 days after sowing.

Higher yield of mungbean was observed in the early-weeded plots compared to late/unweeded plots (Singh *et al*., 1988).

Pascua (1988) determined the critical period of weed control and competition on mungbean yield. The treatments that gave lower fresh weight of weed had higher number of seeds/pod. Higher percent yield reduction was recorded when the mungbean plants were exposed to longer weed competition.

Karim *et al*. (1986) found that critical period of weed competition was in between 20 and 30 days after sowing in jute. The critical period of crop/weed competition was determined in direct seeded Aus rice (Mamun *et al*., 1986), transplanted Aus rice (Ahmed *et al*., 1986).

Sarker and Mondal (1985) observed that weeding at different dates after sowing affected some yield contributing characters and yield of mungbean. Grain yield was reduced by 49 to 55% when weeds were not removed at all.

Variable number of weedings in mungbean have been suggested viz., one weeding at 2 weeks after emergence (Sarker and Mondal, 1985), two weedings during early growth stage (Madrid and Vega, 1984).

Removal of weeds at 10, 20 or 30 days after sowing produced higher yields of mungbean than weedy check (Yadav *et al*., 1983).

The harmful effect of weed infestation does not begin just after emergence of seedling, rather the competition between the weeds and crop is the most severe at a particular stage of crop growth which is known as critical period of crop-weed competition (Shahota and Govinda, 1982).

Soybean seed weight, seeds/pod, pods/ plant was reduced due to long duration of wild oat competition (Rathmann and Miller, 1981).

The knowledge of critical period of weed competition is a pre-requisite for a good harvest. Panwar and Singh (1980) reported that weeding of mungbean at 20 DAE could effectively produce yields twice than that of unweeded plots.

Mungbean is not very competitive against weeds and, therefore, weed control is essential for mungbean production (Moody, 1978).

The yield loss of barley grain due to weed infestation ranges from 10-35% (Gupta and Lamb, 1978), it may even range upto 100% (Mann and Barnes, 1977).

Panwer and Pandey (1977) conducted an experiment in weed control in bengalgram in which grain yields of 1.63 t/ha, 2.72 t/ha and 3.25 t/ha were obtained for no- weeding control, two-hand weeding and weed-free condition respectively.

In a study on the competition of weeds in mungbean, Castin *et al*. (1976) observed that dry matter contents of weeds on the unweeded, one hand - weeded and two - hand weeded plots yielded 714, 1147 and 2539kg ha^{-1} respectively. Similar effect of weeds on the yield of mungbean was observed by Singh *et al*. (1971). Grain yield of 876 kg/ha and 1455 kg/ha were obtained from the unweeded control and the two-weeded treatment respectively.

Singh (1975) observed that mungbean plants grown in two-weeded plots were taller and had maximum number of branches and pods per plant. But the yield from the two-weeded plot was identical to that from one-weeded plot. Singh *et al*. (1975) also found that plant productivity (pods/plant) improved rapidly due to reduction in weed infestation in cowpea. Similarly, Pahuja *et al*. (1975) reported that weeding had significant influence on plant height, number of pods/plant, grain yield and dry matter production of gram.

The yield loss of mungbean was 95% during dry season in Philippines (Madrid and Vega, 1971). Yield losses due to uncontrolled weed growth in mungbean range from 27% to 100% (AVRDC, 1976; Vats and Sidhu, 1976; Madrid and Manimtim, 1977).

Vats and Sidhu (1976) reported that weeding in greengram two weeks after sowing was significantly superior to weeding four or eight weeks after sowing. The magnitude of yield loss due to weed depends on environmental condition and weed growth. Yield loss was 60% during spring and 27% during the summer in Taiwan (AVRDC, 1976).

Enyi (1973) reported that weeding up to 8weeks after sowing is reported for optimum yield of mungbean. He also reported that weed competition causes reduction in the number of pods/plant.

The longer the weeds are allowed to compete with crops, the lower is the yield of crop. Madrid and Vega (1971) reported that mungbean needs to be weeded for the first 5 weeks during wet season and only for 3 weeks during the dry season.

Weed is one of the major constraints to high production of this crop during the kharif season (Mian *et al*., 1970).

2.3 Interaction effect of intra-row spacing and time of weeding

Awan *et al*. (2009) was initiated a research project in 2009 at National Agricultural Research Centre, Islamabad to find out mechanical means of weed control in mungbean crop. Mungbean variety NM-06 was sown at varied row spacing. Different methods were employed to control weed flora. The experiment was laid out in a randomized complete block design with three replications. Besides fresh and dry weight of weeds, the data were recorded on various growth and yield parameters of mungbean plants. Results revealed significant variation in various plant traits and weeds population due to different row spacing and weed management practices. Among the various weed control methods, once manual weeding with hand-pulled terphali, a three angular tine device in 35 cm row spacing produced significantly higher yield of 649 kg ha^{-1} compared to control treatment (No weeding) with grain yield of 216 kg ha^{-1}. The data further revealed that maximum decrease in weed density of 75%, in weed fresh and dry weight of 31 and 45%, respectively occurred in 60 cm row spacing using tractor-pulled device when compared to control. The results suggest that use of hand-pulled terphali keeping row spacing at 35 cm seems an economical, safe and environment friendly way of weed control and improves grain yield in mungbean.

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to study the effect of intra- row spacing and time of weeding on the performance of mungbean (cv. BARI mung-4). Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Description of the experimental site

3.1.1 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.

3.1.2 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 prevailing weather conditions during the study period have been presented in Appendix-II.

3.2 Plant materials

BARI mung -4 was used as planting material. BARI Mung -4 (Rupsha) was released and developed by BARI in 1996. 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. One of the main characteristics of this cultivar is synchronization of pod ripening. Average yield of this cultivar is about 1400 kg ha^{-1}. The seeds of BARI mung-4 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. The seeds had a 30% yield advantage over BARI mung-2 (Afzal *et al*., 2003).

3.3 Treatments under investigation

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

A. Factor-1 (Row spacing: 4)

a) S_1= 15 cm
b) S_2= 20 cm
c) S_3= 25 cm
d) S_4= 30 cm

B. Factor-2 (Number of weeding: 4)

a) W_0= No weeding
b) W_1= 1 weeding at 15 DAS
c) W_2 = 2 weedings at 15 and 30 DAS
d) W_3 = 3 weedings at 15, 30 and 45 DAS

Treatment combination: Sixteen treatment combinations

S_1W_0	S_2W_0	S_3W_0	S_4W_0
S_1W_1	S_2W_1	S_3W_1	S_4W_1
S_1W_2	S_2W_2	S_3W_2	S_4W_2
S_1W_3	S_2W_3	S_3W_3	S_4W_3

3.4 Experimental design and layout

The experiment was laid out in a 2 factors randomized complete block design (RCBD) design having 3 replications. There are 16 treatment combinations and 48 unit plots. The unit plot size was 6 m^2 (3 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing respectively. Lay out of the experiment was done on 2nd February 2012.

3.5 Land preparation

The experimental land was opened with a power tiller on 25th January 2012. Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 1st February 2012 and was ready for sowing seeds.

3.6 Fertilizer application

The fertilizers were applied as basal dose at final land preparation where N, K_2O, P_2O_5, Ca and S were applied @ 20.27 kg ha^{-1}, 33 kg ha^{-1}, 48 kg ha^{-1}, 3.3 kg ha^{-1} and 1.8 kg ha^{-1} respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil (Afzal *et al*., 2003).

3.7 Sowing of seeds

Seeds were sown at the rate of 27 kg ha^{-1} in the furrow on 3rd February 2012 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.

3.8 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.

3.9 Intercultural operations

3.9.1 Weed control

Weed control was done as per experimental treatments.

3.9.2 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.

3.9.3 Insect and pest control

Hairy caterpillar was successfully controlled by the application of Malathion 57 EC @ 1.5 L ha^{-1} on the time of 50% pod formation stage (55 DAS).

3.10 Harvesting and sampling

The crop was harvested at 60 and 70 DAS. The crop was harvested plot wise when about 80% of the pods became mature. Samples were collected from different places of each plot leaving undisturbed very small 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 45 consecutive days for achieving safe moisture of seed.

3.11 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.

3.12 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.

3.13 Recording of data

The data were recorded on the following parameters

a. Plant height
b. Number of leaves plant $^{-1}$
c. Dry weight plant^{-1}
d. Number of pods plant^{-1}
e. Number of seeds pod^{-1}
f. 1000 seed weight
g. Grain yield
h. Harvest index
i. Weed fresh weight at 15, 30 and 45 DAS
j. Weed dry weight at 15, 30 and 45 DAS

3.15 Procedure of recording data

i. Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant at 15, 30, 45, 60 days after sowing (DAS) and at harvest time (70 DAS).

ii. Number of leaves plant^{-1}

Number of leaves per plant was counted from each selected plant sample and then averaged at 15, 30, 45, 60 DAS and at harvest time (70 DAS).

iii. Dry weight plant^{-1}

Ten plants were collected randomly from each plot at 15, 30, 45, 60 DAS and at harvest (80 DAS). The sample plants were oven dried for 24 hours at 70°C and then dry weight plant^{-1} was determined.

iv. Fresh weight of weed

Weed was collected from 1 m^2 in each plot and after cleaning fresh weed was weighed by eclectic balance and average weight of fresh weed from 1m^2 was converted to kg ha^{-1}.

iv. Dry weight of weed

Fresh weeds from 1 m^2 in each plot were collected at each time of weeding and washed by tap water. Weeds were oven dried for 72 hours at 70°C temperature and than weighed by eclectic balance, averaged and converted to kg ha^{-1}.

v. Number of pods plant^{-1}

Number of pods plants was counted from the 10 selected plant sample and then the average pod number was calculated.

vi. Number of seeds pod^{-1}

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

vii. Weight of 1000- seeds

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 (kg ha^{-1})

Seed yield was recorded on the basis of total harvested seeds plot^{-1} (6 m^2) and was expressed in terms of yield (kg ha^{-1}). Seed yield was adjusted to 12% moisture content.

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

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

x. Biological yield (kg 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.

Harvest index (HI %) = (Seed yield/ Biological yield) × 100
Here, Biological yield = Grain yield + stover yield

3.16 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 (Gomez & Gomez, 1986).

Chapter 4

RESULTS AND DISCUSSION

The results of the experiment were presented and discussed in this chapter. For the convenience of easy understanding result were presented and discussed under subheading and data were presented in Table or Graph.

4.1 Growth parameters

4.1.1 Plant height

4.1.1.1 Effect of intra-row spacing

Significant variation was observed in terms of plant height at all growth stages of mungbean under the present study (Fig. 1). Results showed that at 30, 45, 60 DAS and at harvest, lower spacing, (S_1) showed the tallest plant (28.84, 48.02, 51.45 and 54.20 cm, respectively). At 15 DAS, S_4 showed the tallest plant (10.07 cm) where the shortest plant was recorded in S_1 (6.90 cm). But at 45, 60 DAS and at harvest the shortest plant (44.65, 46.35 and 50.42 cm respectively) was observed from S_4. The results obtained from all other treatments showed intermediate results. The results under the present study was in agreement with the findings of Khan *et al*. (2001), Narayanan and Narayanan, (1987); Chimanshette and Dhoble (1992); Hossain and Salahuddin (1994).

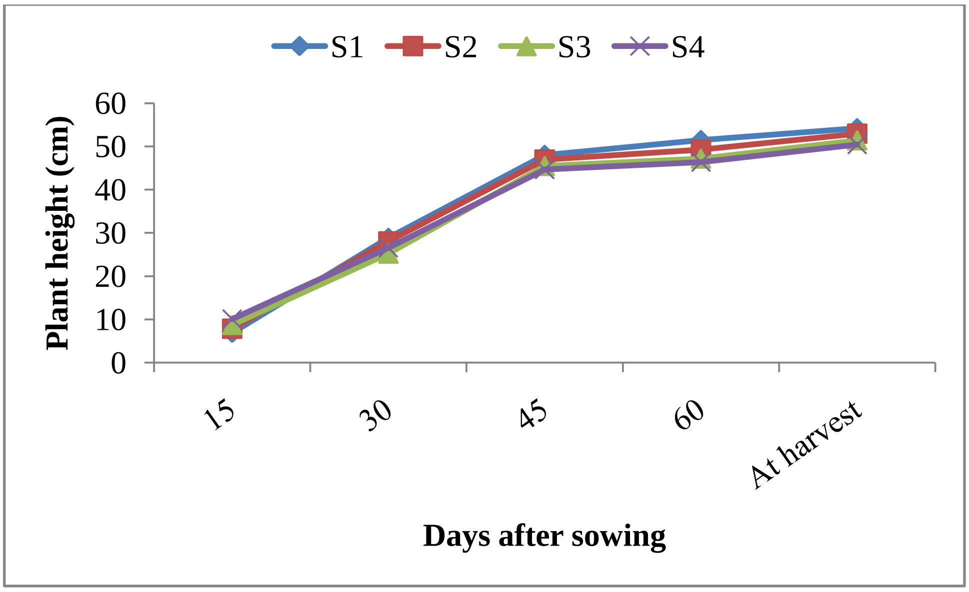

Fig. 1: Effect of intra- row spacing on plant height of mungbean ($LSD_{0.05}$ = 0.29, 0.302, 0.75, 0.713, 0.845 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
S_1 = 15 cm (Row spacing)
S_2 = 20 cm (Row spacing)
S_3 = 25 cm (Row spacing)
S_4 = 30 cm (Row spacing)

4.1.1.2 Effect of weeding

The plant height was significantly influenced by number of weeding at all growth stages of mungbean except 15 DAS (Fig. 2). The plant height increased with increasing time of weeding. At 30, 45, 60 DAS and at harvest, the highest plant height (28.83, 50.53, 54.98 and 57.50 cm respectively) was recorded in W_3 where the lowest was achieved with no weeding W_0 (23.37, 41.89, 42.60 and 47.65 cm, respectively). Intermediate plant height was obtained from W_1 and W_2. The result under the present study was in agreement with the findings of Singh (1975) and Chattha *et al*. (2007).

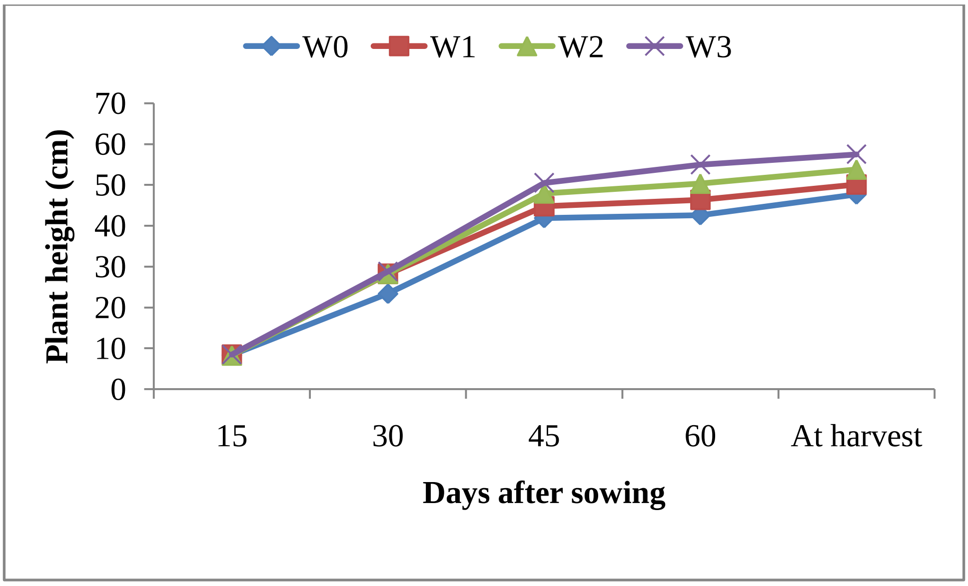

Fig. 2: Effect of number of weeding on plant height of mungbean ($LSD_{0.05}$ = NS, 0.325, 0.714, 0.642 and 0.733 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weeding at 15 and 30 DAS
W_3 = 3 weeding at 15, 30 and 45 DAS

4.1.1.3 Interaction effect of intra - row spacing and number of weeding

Interaction between intra- row spacing and number of weeding exerted significant effect on plant height (Table 1). The highest plant height (31.04, 52.61, 58.21 and 60.26 cm at 30, 45, 60 DAS and at harvest respectively) was observed in the 15 cm spacing with three times of weeding at 15, 30 and 45 DAS (S_1W_3) which was statistically similar with S_2W_3 at 45 DAS and at harvest. But at 15 DAS, the tallest plant (10.27 cm) was observed with S_4W_3 which was statistically similar with S_4W_0, S_4W_1 and S_4W_2. The shortest plant height was obtained with S_4W_0 (22.11, 39.63, 40.19 and 45.69 cm at 30, 45, 60 DAS and at harvest respectively) which was statistically similar with S_3W_0. The results obtained from all other treatment combinations were significantly different from highest and lowest plant height.

Table 1: Interaction effect of intra- row spacing and time of weeding on plant height of mungbean

Treatments	Plant height (cm) at different days after sowing				
	15 DAS	30D AS	45 DAS	60 DAS	At harvest
S_1W_0	6.61	24.11	43.99	45.15	49.09
S_1W_1	7.11	30.00	45.11	47.32	50.87
S_1W_2	6.86	30.21	50.38	55.11	56.56
S_1W_3	7.01	31.04	52.61	58.21	60.26
S_2W_0	8.16	23.76	42.31	43.03	48.61
S_2W_1	7.98	29.43	44.91	46.39	50.39
S_2W_2	7.59	29.86	48.43	51.10	54.40
S_2W_3	7.83	29.11	52.13	56.44	58.43
S_3W_0	8.69	23.51	41.63	42.01	47.23
S_3W_1	8.61	25.89	44.43	45.65	49.43
S_3W_2	8.78	25.11	46.91	48.00	52.89
S_3W_3	8.91	26.41	49.01	53.19	56.19
S_4W_0	9.99	22.11	39.63	40.19	45.69
S_4W_1	10.13	27.53	44.63	46.00	49.61
S_4W_2	9.89	27.83	45.99	47.11	51.24
S_4W_3	10.27	28.75	48.36	52.09	55.13
$LSD_{0.05}$	0.5824	0.6328	1.765	1.684	1.911
CV (%)	8.75	9.14	7.36	10.47	9.36

Here,

S_1 = 15 cm (Row spacing)
S_2 = 20 cm (Row spacing)
S_3 = 25 cm (Row spacing)
S_4 = 30 cm (Row spacing)

W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weedings at 15 and 30 DAS
W_3 = 3 weedings at 15, 30 and 45 DAS

4.1.2 Number of leaves plant $^{-1}$

4.1.2.1 Effect of intra-row spacing

Significant variation was observed in terms of number of leaves plant $^{-1}$ at all growth stages of mungbean except 15 DAS (Fig. 3). Results showed that higher and lower spacing indicates higher and lower number of leaves plant $^{-1}$ respectively. At 30, 45, 60 DAS and at harvest, S_4 showed the maximum number of leaves plant $^{-1}$ (7.68, 11.01, 11.24 and 9.51 respectively) where as the lowest number was achieved by S_1 (5.64, 6.74, 7.63 and 5.32, respectively). The results obtained from all other treatments showed intermediate results compared to the highest and the lowest values. The results under the present study was in agreement with the findings of Bodnar *et al*. (1998).

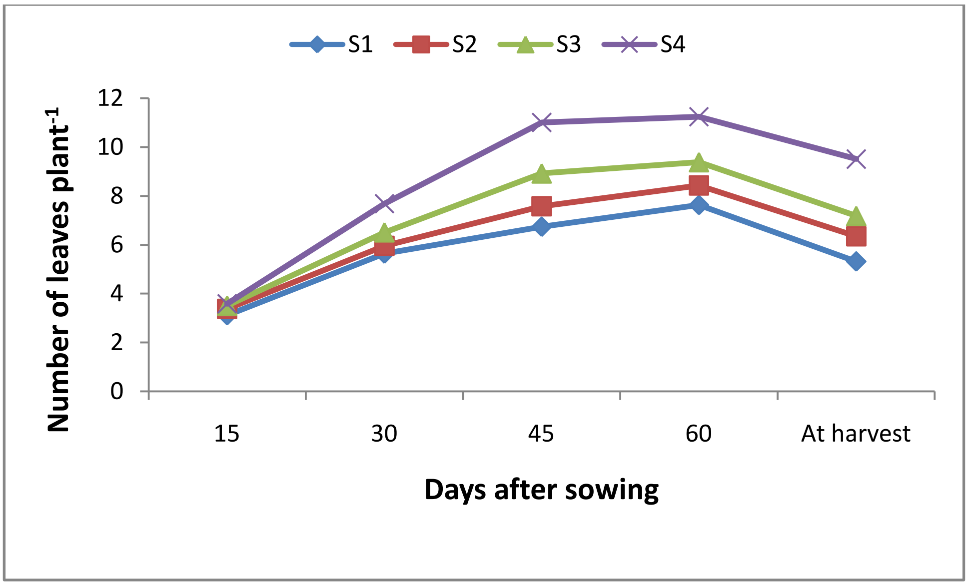

Fig. 3: Effect of intra- row spacing on the number of leaves plant^{-1} of mungbean ($LSD_{0.05}$ = NS, 0.08, 0.27, 0.34, 0.26 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,

S_1 = 15 cm (Row spacing)

S_2 = 20 cm (Row spacing)

S_3 = 25 cm (Row spacing)

S_4 = 30 cm (Row spacing)

4.1.2.2 Effect of weeding

Number of leaves plant $^{-1}$ was significantly influenced by number of weeding at all growth stages of mungbean except 15 DAS (Fig. 4). The increasing number of weeding significantly increased number of leaves plant $^{-1}$. At 30, 45, 60 DAS and at harvest, the highest number of leaves plant^{-1} (7.28, 10.16, 10.86 and 8.06 respectively) was recorded in W_3 which was closely followed by W_2 at harvest. The lowest number of leaves plant^{-1} was achieved with no weeding W_0 (4.62, 5.23, 5.81 and 4.95 at 30, 45, 60 DAS and at harvest respectively). Intermediate result on number of leaves plant $^{-1}$ was obtained from W_1 and W_2. This result under the present study might be due to cause of unavailability of nutrient, light, air etc. because of higher weed biomass.

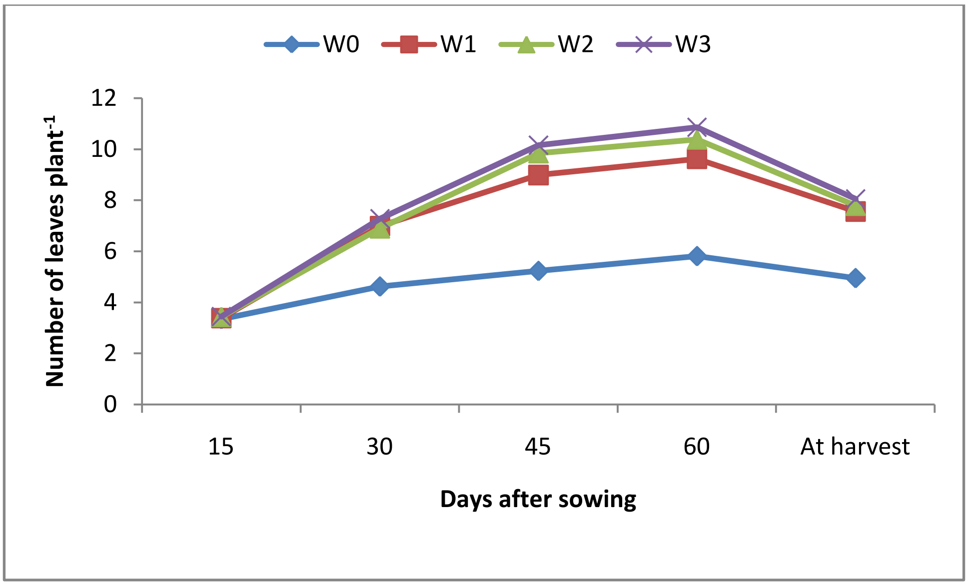

Fig. 4: Effect of number of weeding on the number of leaves plant^{-1} of mungbean ($LSD_{0.05}$ = NS, 0.08, 0.26, 0.36 and 0.28 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weeding at 15 and 30 DAS
W_3 = 3 weeding at 15, 30 and 45 DAS

4.1.2.3 Interaction effect of intra - row spacing and time of weeding

Interaction between spacing and number of weeding showed significant effect on number of leaves plant^{-1} at all growth stages except at 15 DAS (Table 2). Results indicated that the highest number of leaves plant^{-1} (8.84, 13.57, 13.90 and 11.08 at 30, 45, 60 DAS and at harvest, respectively) was observed in the treatment combination of S_4W_3 which was statistically identical with S_4W_1 and S_4W_2 at harvest. But the lowest number of leaves plant^{-1} was obtained with S_1W_0 (4.08, 4.79, 5.19 and 4.81 at 30, 45, 60 DAS and at harvest respectively) which was statistically identical with S_2W_0 and closely followed by S_3W_0 at the time of harvest. The results obtained from all other treatment combinations were significantly different compared to highest and lowest number of leaves plant^{-1}.

Table 2: Interaction effect of intra - row spacing and time of weeding on number of leaves plant^{-1} of mungbean

Treatments	Number of leaves plant^{-1} at different days after sowing				
	15 DAS	30DAS	45 DAS	60 DAS	At harvest
S_1W_0	3.11	4.08	4.79	5.19	4.81
S_1W_1	3.10	6.00	6.61	7.74	5.25
S_1W_2	3.16	6.21	7.44	8.69	5.44
S_1W_3	3.13	6.29	8.11	8.90	5.76
S_2W_0	3.30	4.44	5.00	5.71	4.86
S_2W_1	3.36	6.46	7.89	9.01	6.46
S_2W_2	3.44	6.34	8.63	9.41	6.80
S_2W_3	3.43	6.61	8.79	9.61	7.29
S_3W_0	3.43	4.86	5.26	5.99	5.00
S_3W_1	3.51	6.86	9.84	9.68	7.64
S_3W_2	3.49	6.92	10.37	10.80	7.97
S_3W_3	3.61	7.39	10.20	11.03	8.11
S_4W_0	3.54	5.11	5.89	6.34	5.11
S_4W_1	3.55	8.65	11.63	12.03	10.89
S_4W_2	3.61	8.11	12.97	12.67	10.94
S_4W_3	3.63	8.84	13.57	13.90	11.08
$LSD_{0.05}$	NS	0.19	0.56	0.766	0.22
CV (%)	4.54	8.36	7.58	9.62	9.74

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weedings at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weedings at 15, 30 and 45 DAS

4.1.3 Dry weight plant^{-1}

4.1.3.1 Effect of intra-row spacing

Dry weight plant^{-1} was significantly varied due to different treatment variations at all growth stages of mungbean (Fig. 5). Results showed that higher spacing indicated higher dry weight plant^{-1}. Under the present study, the highest dry weight plant^{-1} (2.36, 5.49, 7.79, 10.50 and 12.46 g at 15, 30, 45, 60 DAS and at harvest, respectively) was achieved by S_4 where the lowest was achieved by S_1 (0.85, 3.11, 5.28, 6.81 and 8.36 g at 15, 30, 45, 60 DAS and at harvest, respectively). The results obtained from S_2 and S_3 showed intermediate results compared to highest and lowest dry weight plant^{-1}. Similar results was found with the findings of Zahab *et al*. (1981).

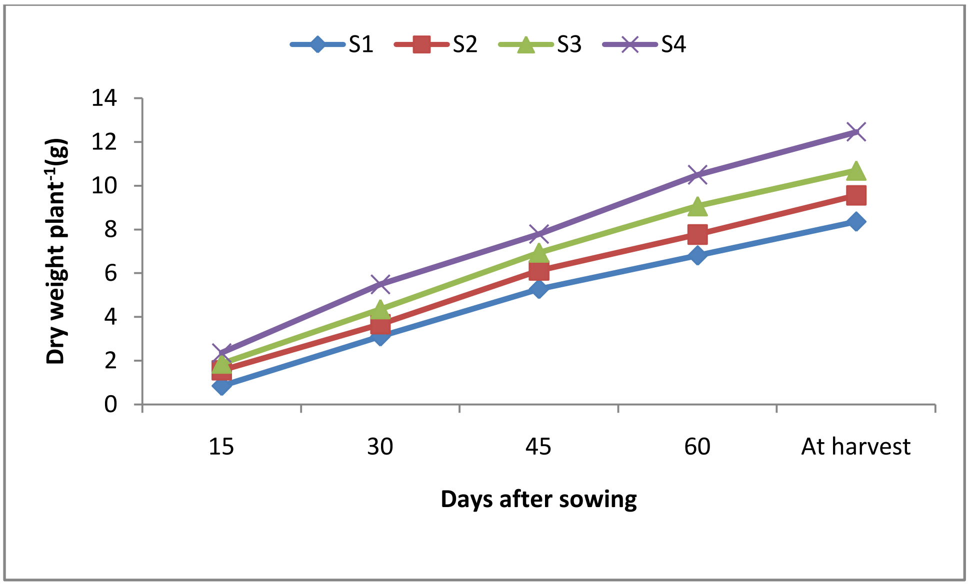

Fig. 5: Effect of intra- row spacing on the dry weight plant^{-1} (g) of mungbean ($LSD_{0.05}$ = 0.04, 0.05, 0.22, 0.30 and 0.31 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,

S_1 = 15 cm (Row spacing)
S_2 = 20 cm (Row spacing)
S_3 = 25 cm (Row spacing)
S_4 = 30 cm (Row spacing)

4.1.3.2 Effect of weeding

Dry weight plant^{-1} was significantly influenced by number of weeding at all growth stages of mungbean (Fig. 6). It is remarked from the present study that the increasing time of weeding significantly increased dry weight plant^{-1}. At 15, 30, 45, 60 DAS and at harvest, the maximum of dry weight plant^{-1} (1.74, 4.60, 7.75, 10.40 and 12.35 g respectively) was recorded in W_3 which was closely followed by W_2 at 15 DAS. The lowest dry weight plant^{-1} was achieved with no weeding, W_0 (1.61, 3.05, 4.19, 5.48 and 6.91 g at 15, 30, 45, 60 DAS and at harvest, respectively). Intermediate results on dry weight plant^{-1} were obtained from W_1 and W_2. The results under the present study was in agreement with the findings of Kumar and Kairon (1988) and Malik *et al.* (2005).

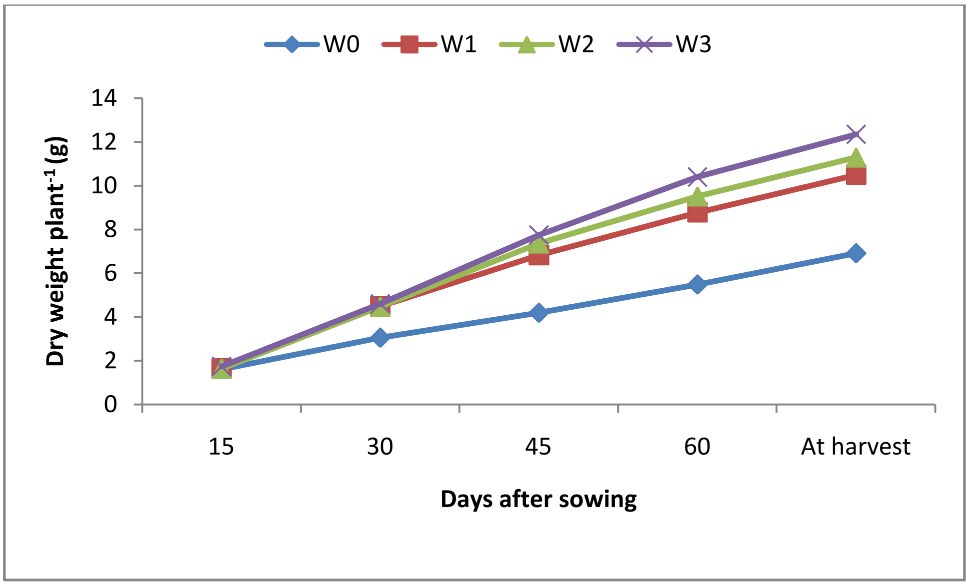

Fig. 6: Effect of number of weeding on the dry weight plant^{-1} (g) of mungbean ($LSD_{0.05}$ = 0.02, 0.04, 0.26, 0.36 and 0.22 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weedings at 15 and 30 DAS
W_3 = 3 weedings at 15, 30 and 45 DAS

4.1.3.3 Interaction effect of intra - row spacing and time of weeding

Significant influence was observed by interaction between spacing and number of weeding on dry weight plant^{-1} (Table 3). Results indicated that the highest dry weight plant^{-1} (2.45, 6.07, 9.31, 13.53 and 15.63 g at 15, 30, 45, 60 DAS and at harvest) was observed in the treatment combination of S_4W_3 which was closely followed by S_4W_1 at 15 DAS and S_4W_2 at 30 DAS. But the lowest dry weight plant^{-1} was obtained with S_1W_0 (0.79, 2.24, 3.54, 4.89 and 5.99 at 15, 30, 45, 60 DAS and at harvest respectively) which was statistically similar with S_2W_0 at 60 DAS. The results obtained from all other treatment combinations were significantly different compared to maximum and minimum dry weight plant^{-1}.

Table 3: Interaction effect of intra - row spacing and number of weeding on dry weight plant^{-1} (g) of mungbean

Treatments	Dry weight plant^{-1} at different days after sowing				
	15 DAS	30DAS	45 DAS	60 DAS	At harvest
S_1W_0	0.79	2.24	3.54	4.89	5.99
S_1W_1	0.86	3.6	5.39	6.94	8.44
S_1W_2	0.81	3.39	6.00	7.51	8.99
S_1W_3	0.94	3.54	6.19	7.89	10.00
S_2W_0	1.47	2.71	3.86	5.09	6.74
S_2W_1	1.57	4.06	6.69	8.16	10.07
S_2W_2	1.61	3.90	6.81	8.71	10.53
S_2W_3	1.60	3.99	7.11	9.12	10.90
S_3W_0	1.89	3.24	4.49	5.86	7.04
S_3W_1	1.80	4.76	7.00	9.26	11.10
S_3W_2	1.81	4.66	7.90	10.10	11.97
S_3W_3	1.96	4.80	8.40	11.07	12.87
S_4W_0	2.30	3.99	4.86	6.08	7.86
S_4W_1	2.39	5.89	8.24	10.77	12.50
S_4W_2	2.31	5.99	8.75	11.77	13.83
S_4W_3	2.45	6.07	9.31	13.53	15.63
$LSD_{0.05}$	0.07	0.10	0.55	0.62	0.65
CV (%)	5.62	8.45	7.69	9.28	10.12

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weeding at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weeding at 15, 30 and 45 DAS

4.1.4 Number of pods plant^{-1}

4.1.4.1 Effect of intra-row spacing

Number of pods plant^{-1} was significantly varied due to different spacing under the present study at all growth stages of mungbean (Fig. 7). Results showed that higher spacing indicates higher number of pods plant^{-1}. Under the present study, the highest number of pods plant^{-1} (12.00, 27.61 and 37.22 at 45, 60 DAS and at harvest respectively) was achieved by S_4 where the lowest was achieved by S_1 (6.47, 19.34 and 28.47 at 45, 60 DAS and at harvest respectively). The results obtained from S_2 and S_3 showed intermediate results compared to highest and lowest number of pods plant^{-1}. The results under the present study was in agreement with the findings of Ahmad *et al*. (2005) and Khan *et al*. (2001).

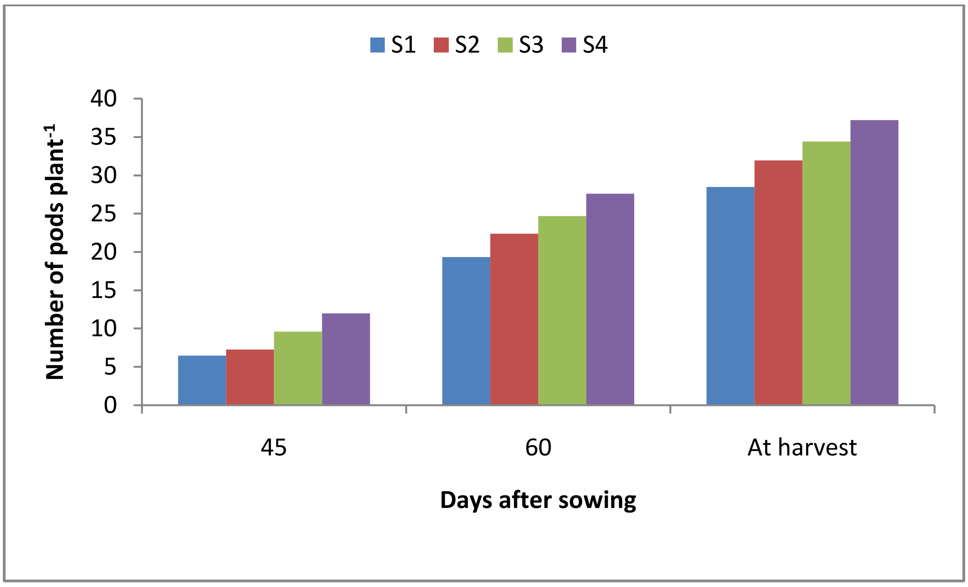

Fig. 7: Effect of intra- row spacing on the number of pods plant^{-1} of mungbean ($LSD_{0.05}$ = 0.22, 0.64 and 0.73 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
S_1 = 15 cm (Row spacing)
S_2 = 20 cm (Row spacing)
S_3 = 25 cm (Row spacing)
S_4 = 30 cm (Row spacing)

4.1.4.2 Effect of weeding

Number of pods plant^{-1} was significantly influenced by number of weeding at all growth stages of mungbean (Fig. 8). It is remarked from the present study that the increasing number of weeding significantly increased number of pods plant^{-1}. At 45, 60 DAS and at harvest, the maximum number of pods plant^{-1} (11.25, 27.50 and 37.21 respectively) was recorded in W_3. The lowest number of pods plant^{-1} was achieved with no weeding, W_0 (5.03, 16.84 and 25.95 at 45, 60 DAS and at harvest respectively). 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 Mansoor *et al*. (2004) and Rathmann and Miller (1981).

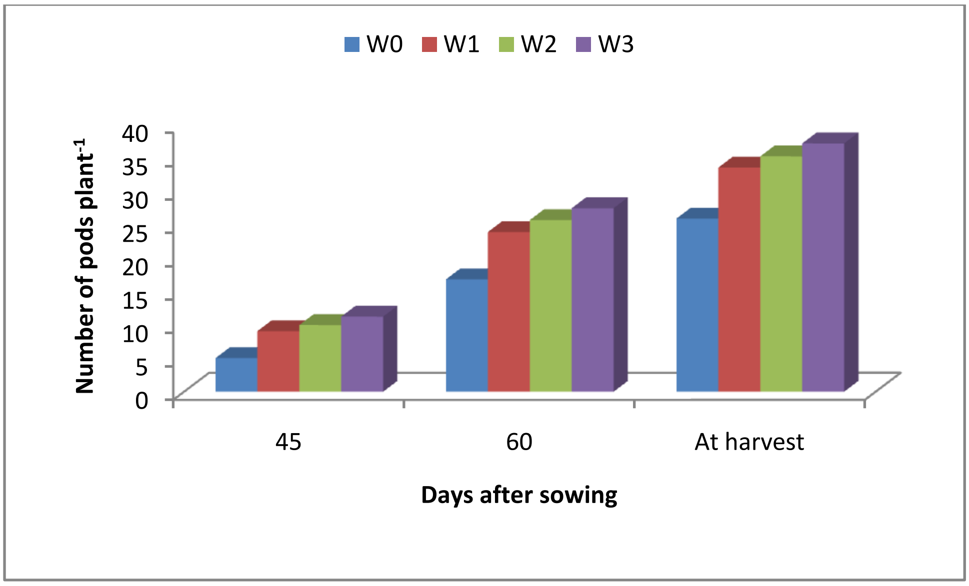

Fig. 8: Effect of number of weeding on the number of pods plant^{-1} of mungbean ($LSD_{0.05}$ = 0.25, 0.66 and 0.88 at 15, 30, 45, 60 DAS and at harvest respectively)

Here,
W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weeding at 15 and 30 DAS
W_3 = 3 weeding at 15, 30 and 45 DAS

4.1.4.3 Interaction effect of intra - row spacing and number of weeding

Significant influence was observed by interaction between spacing and number of weeding on number of pods plant^{-1} (Table 4). Results indicated that the highest number of pods plant^{-1} (15.53, 32.94 and 43.29 at 45, 60 DAS and at harvest) was observed in the treatment combination of S_4W_3 which was closely followed by S_3W_2 and significantly different from all other treatments. But the lowest number of pods plant^{-1} was obtained with S_1W_0 (4.39, 15.76 and 25.04 at 45, 60 DAS and at harvest respectively) which was statistically similar with S_2W_0 and S_3W_0 at 60 DAS and at the time of harvest. The results obtained from all other treatment combinations were significantly different compared to highest and lowest number of pods plant^{-1}.

Table 4: Interaction effect of intra - row spacing and time of weeding on pods plant^{-1} of mungbean

Treatments	Number of pods plant^{-1} at different days after sowing		
	45 DAS	60 DAS	At harvest
S_1W_0	4.39	15.76	25.04
S_1W_1	6.85	19.84	28.44
S_1W_2	7.00	20.51	29.46
S_1W_3	7.64	21.24	30.91
S_2W_0	4.89	16.04	25.54
S_2W_1	7.45	22.26	32.11
S_2W_2	8.21	24.31	34.24
S_2W_3	8.59	26.98	35.89
S_3W_0	5.11	16.71	26.31
S_3W_1	9.44	25.34	35.26
S_3W_2	14.01	31.06	41.24
S_3W_3	13.23	28.85	38.76
S_4W_0	5.74	18.86	26.89
S_4W_1	12.57	28.29	38.56
S_4W_2	14.17	30.36	40.14
S_4W_3	15.53	32.94	43.29
$LSD_{0.05}$	0.54	1.75	1.83
CV (%)	7.45	8.36	7.84

Here,

S_1 = 15 cm (Row spacing) W_0 = No weeding
S_2 = 20 cm (Row spacing) W_1 = 1 weeding at 15 DAS
S_3 = 25 cm (Row spacing) W_2 = 2 weedings at 15 and 30 DAS
S_4 = 30 cm (Row spacing) W_3 = 3 weedings at 15, 30 and 45 DAS

4.2 Yield contributing parameters

4.2.1 Pod length

4.2.1.1 Effect of intra-row spacing

Pod length was significantly influenced by different row spacing (Table 5). Results showed that higher row spacing indicated higher pod length. Under the present study, the highest pod length (6.35 cm) was achieved by S_4 where as the lowest was achieved by S_1 (5.71 cm). The results obtained from S_2 and S_3 showed intermediate results compared to longest and shortest pod length.

4.2.1.2 Effect of weeding

Results presented in Table 5 on pod length influenced by number of weeding were statistically significant. It is mentioned from the present study that the increasing time of weeding significantly increased pod length. The highest pod length (6.34 cm) was recorded in W_3 and the lowest pod length was achieved by no weeding, W_0 (5.50 cm). The results from W_1 and W_2 on pod length were intermediate compared to longest and shortest pod length.

4.2.1.3 Interaction effect of intra - row spacing and time of weeding

Table 5 showed statistically significant results the combination of row- spacing and number of weeding on pod length. Results indicated that the highest pod length (6.69 cm) was observed in the treatment combination of S_4W_3 which was closely followed by S_3W_2 and significantly different from all other treatment combinations. On the other hand, the lowest pod length was obtained with S_1W_0 (5.36 cm).

4.2.2 Number of seeds pod^{-1}

4.2.2.1 Effect of intra-row spacing

Number of seeds pod^{-1} was significantly influenced by different row spacing (Table 5). Results showed that higher row spacing indicated higher number of seeds pod^{-1}. Under the present study, the highest number of seeds pod^{-1} (8.65) was achieved by S_4 where as the lowest was in S_1 (7.33). The results obtained from S_2 and S_3 showed intermediate results compared to highest and lowest number of seeds pod^{-1}. Similar treat of findings were found by Ahmad *et al*. (2005) and Saharia and Thakuria (1988).

4.2.2.2 Effect of weeding

Results presented in Table 5 on number of seeds pod^{-1} influenced by number of weeding were statistically significant. It is mentioned from the present study that the increasing number of weeding significantly increased number of seeds pod^{-1}. The highest number of seeds pod^{-1} (8.83) was recorded in W_3 and the lowest number of seeds pod^{-1} was achieved by no weeding, W_0 (6.39). The results from W_1 and W_2 on number of seeds pod^{-1} were intermediate compared to highest and lowest number of seeds pod^{-1}. Similar findings were found by Kumar and Kairon (1988).

4.2.2.3 Interaction effect of intra - row spacing and number of weeding

Table 5 showed statistically significant results influenced by interaction between spacing and number of weeding on number of seeds pod^{-1}. Results indicated that the highest number of seeds pod^{-1} (9.43) was observed in the treatment combination of S_4W_3 which was closely followed by S_3W_2 but significantly different from all other treatment combinations. On the other hand, the lowest number of seeds pod^{-1} was obtained with S_1W_0 (6.04) which were also significantly different from all other treatment combinations.

4.2.3 Weight of 1000 seeds

4.2.3.1 Effect of intra-row spacing

Weight of 1000- seeds was significantly influenced by different row spacing (Table 5). Results showed that higher row spacing indicates higher 1000- seed weight. Under the present study, the highest 1000- seed weight (29.08 g) was achieved by S_4 where the lowest was achieved by S_1 (27.03 g). The results obtained from S_2 and S_3 showed intermediate results compared to highest and lowest1000- seed weight. Similar findings were found by Ahmad *et al*. (2005).

4.2.3.2 Effect of weeding

Results presented in Table 5 on 1000- seed weight influenced by mumber of weeding were statistically significant. It is mentioned from the present study that the increasing mumber of weeding significantly increased 1000- seed weight. The highest 1000- seed weight (28.95 g) was recorded in W_3 whereas, the lowest 1000- seed weight was achieved by no weeding, W_0 (26.63 g). The results from W_1 and W_2 on 1000- seed weight were intermediate compared to highest and lowest 1000- seed weight. Similar findings were found by Chattha *et al*. (2007).

4.2.3.3 Interaction effect of intra - row spacing and time of weeding

Table 5 showed statistically significant results influenced by interaction between spacing and number of weeding on 1000- seed weight. Results indicated that the maximum 1000 seed weight (30.49 g) was observed in the treatment combination of S_4W_3 which was closely followed by S_3W_2 but significantly different from all other treatment combinations. On the other hand, the lowest 1000- seed weight was obtained with S_1W_0 (26.31 g) which was also significantly different from all other treatment combinations.

Table 5: Effect of intra-row spacing and number of weeding on yield contributing characters of mungbean

Treatments	Yield contributing parameters		
	Pod length (cm)	**Number of seeds pod^{-1}**	**1000 grain weight (g)**
Effect of intra-row spacing			
S_1	5.71	7.33	27.03
S_2	5.94	7.83	27.78
S_3	6.08	7.80	28.25
S_4	6.35	8.65	29.08
$LSD_{0.05}$	0.05	0.03	0.09
Effect of weeding			
W_0	5.50	6.39	26.63
W_1	6.09	7.84	28.06
W_2	6.14	8.56	28.51
W_3	6.34	8.83	28.95
$LSD_{0.05}$	0.06	0.03	0.06
Interaction effect of intra - row spacing and number of weeding			
S_1W_0	5.36	6.04	26.31
S_1W_1	5.76	7.54	27.09
S_1W_2	5.81	7.81	27.29
S_1W_3	5.90	7.94	27.44
S_2W_0	5.46	6.21	26.59
S_2W_1	5.96	8.01	27.86
S_2W_2	6.01	8.26	28.06
S_2W_3	6.31	8.84	28.61
S_3W_0	5.51	6.41	26.71
S_3W_1	6.14	6.69	28.11
S_3W_2	6.59	9.22	29.94
S_3W_3	6.44	9.11	29.24
S_4W_0	5.69	6.89	26.89
S_4W_1	6.50	9.10	29.20
S_4W_2	6.54	9.19	29.74
S_4W_3	6.69	9.43	30.49
$LSD_{0.05}$	0.10	0.07	0.18
CV (%)	5.88	9.24	8.46

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weeding at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weeding at 15, 30 and 45 DAS

4.3 Yield parameters

4.3.1 Grain yield

4.3.1.1 Effect of intra-row spacing

Grain yield was significantly influenced by different row spacing (Table 6). Results showed that higher row spacing indicated higher grain yield. Under the present study, the highest grain yield (1380 t ha^{-1}) was achieved by S_4 where as the lowest was achieved by S_1 (1119 t ha^{-1}). The results obtained from S_3 also showed promising result and S_2 showed intermediate results compared to highest and lowest grain yield. Similar findings were found by Ahmad *et al*. (2005) and Khan *et al*. (2001).

4.3.1.2 Effect of weeding

Results presented in Table 6 on grain yield influenced by number of weeding were statistically significant. It is mentioned from the present study that the increasing number of weeding significantly increased grain yield. The highest grain yield (1370 t ha^{-1}) was recorded in W_3 while the lowest grain yield was achieved by no weeding, W_0 (1092 t ha^{-1}). The results from W_2 on grain yield also gave encouraging result where W_1 gave intermediate grain yield compared to highest and lowest grain yield. Similar findings were found by Yadav *et al*. (1983).

4.3.1.3 Interaction effect of intra - row spacing and number of weeding

Table 6 showed statistically significant results influenced by interaction between spacing and number of weeding on grain yield. Results indicated that the highest grain yield (1591 t ha^{-1}) was observed in the treatment combination of S_4W_3 which was closely followed by S_3W_2 (1585 kg ha^{-1}) and significantly different from all other treatment combinations. On the other hand, the lowest grain yield was obtained with S_1W_0 (1021 t ha^{-1}) which was also significantly different from all other treatment combinations.

4.3.2 Biological yield

4.3.2.1 Effect of intra-row spacing

Significant variation was observed on biological yield influenced by different row spacing (Table 6). Results showed that higher row spacing exhibited higher biological yield. Under the present study, the highest biological yield (3762 t ha^{-1}) was achieved by S_4 where as the lowest was recorded in S_1 (3571 t ha^{-1}). The results obtained from S_2 and S_3 showed intermediate results compared to highest and lowest biological yield. Similar findings were found by Ahmad *et al*. (2005) and Khan *et al*. (2001).

4.3.2.2 Effect of weeding

Biological yield was significantly influenced by number of weeding (Table 6). It is mentioned from the present study that the increasing number of weeding significantly increased biological yield. The maximum biological yield (3809 t ha^{-1}) was recorded in W_3 and the munimum biological yield was achieved by no weeding (3498 t ha^{-1}). The results from W_1 and W_2 on biological yield were intermediate compared to highest and lowest biological yield.

4.3.2.3 Interaction effect of intra - row spacing and time of weeding

Table 6 showed statistically significant results influenced by interaction between spacing and number of weeding on biological yield. Results indicated that the highest biological yield (3964 t ha^{-1}) was observed in the treatment combination of S_4W_3 which was significantly different from all other treatment combinations. On the other hand, the lowest biological yield was obtained from S_1W_0 (3453 t ha^{-1}) which was also significantly different from all other treatment combinations.

4.3.3 Harvest index

4.3.3.1 Effect of intra-row spacing

Significant variation was observed on harvest index influenced by different row spacing (Table 6). Results under the present study showed that the highest harvest index (40.37%) was achieved by S_3 whereas the lowest was achieved by S_1 (31.43%). The results obtained from S_2 and S_4 showed intermediate results compared to highest and lowest harvest index.

4.3.3.2 Effect of weeding

Harvest index was significantly influenced by number of weeding (Table 6). It stated from the present study that the highest harvest index (38.65%) was recorded in W_3 and the lowest harvest index was achieved by no weeding, W_0 (32.65%). The results from W_1 and W_2 on harvest index showed intermediate results compared to highest and lowest harvest index.

4.3.3.3 Interaction effect of intra - row spacing and time of weeding

Table 6 showed statistically significant results influenced by interaction between spacing and time of weeding on harvest index. Results indicated that the highest harvest index (44.26%) was observed in the treatment combination of S_3W_2 which was significantly different from all other treatment combinations. On the other hand, the lowest harvest index was obtained from S_1W_0 (29.56%) 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 6: Effect on with intra- row spacing and number of weeding on yield parameters of mungbean

Treatments	Yield parameters		
	Grain yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest index (%)
Effect of intra-row spacing			
S_1	1119	3571	31.43
S_2	1216	3580	34.62
S_3	1350	3590	40.37
S_4	1380	3762	37.24
$LSD_{0.05}$	2.65	2.92	0.47
Effect of weeding			
W_0	1092	3498	32.65
W_1	1232	3569	35.95
W_2	1345	3626	36.39
W_3	1370	3809	38.65
$LSD_{0.05}$	2.65	2.92	0.47
Interaction effect of intra - row spacing and number of weeding			
S_1W_0	1021	3453	29.56
S_1W_1	1131	3599	31.42
S_1W_2	1169	3556	32.87
S_1W_3	1170	3675	31.83
S_2W_0	1160	3491	33.22
S_2W_1	1191	3586	33.21
S_2W_2	1295	3456	37.47
S_2W_3	1309	3786	34.57
S_3W_0	1281	3444	37.19
S_3W_1	1445	3524	41.00
S_3W_2	1585	3581	44.26
S_3W_3	1487	3811	39.01
S_4W_0	1104	3605	30.62
S_4W_1	1361	3566	38.16
S_4W_2	1565	3911	40.01
S_4W_3	1591	3964	40.13
$LSD_{0.05}$	5.311	5.860	0.949
CV (%)	10.11	11.84	8.32

Here,

S_1 = 15 cm (Row spacing)
S_2 = 20 cm (Row spacing)
S_3 = 25 cm (Row spacing)
S_4 = 30 cm (Row spacing)

W_0 = No weeding
W_1 = 1 weeding at 15 DAS
W_2 = 2 weeding at 15 and 30 DAS
W_3 = 3 weeding at 15, 30 and 45 DAS

4.4 Weed biomass

4.4.1 Name of weeds

Table 7 showed that there were 10 weed species were found during the experiment. It was observed that the species, Durba (*Cynodon dactylon*) presented the highest in number and thereafter were Bindulata, Malancha, Hati shur and so on. The lowest number of weed in number was Helencha.

Number of weed species and total number of weeds in 6 m^2 were affected significantly by the different treatment combinations (Table 8). It was observed that the lowest number of weed species and total number of weeds in 6 m^2 was obscured in S_4W_3 (3.12 and 25.36 respectively) which was closely followed by S_4W_2 and S_3W_2. On the other hand, the highest number of weed species and total number of weeds in 6 m^2 (8.62 and 126.00 respectively) was obtained from S_1W_0 which was closely followed by S_2W_0 and S_3W_0, respectively.

Table 7: Name of weeds found in the experimental field

Common name	Scientific name	Family
1. Durba	*Cynodon dactylon*	Gramineae
2. Bindulata	*Convolvulus arvensis*	Convolvulaceae
3. Malancha	*Alternanthera philoxeroides*	Amaranthaceae
4. Bonpat	*Corchorus acutangulus*	Tiliaceae
5. Shyama	*Eichinochloa crussgali*	Gramineae
6. Khet papri	*Lindernia procumbens*	Scrophulariaceae
7. Hati shur	*Heliotropium indicum*	Boraginaceae
8. Helencha	*Enhydra fructuans*	Compositae
9. Bothua	*Chenopodium album*	Chenopodiaceae
10. Chapra	*Eleusine indica*	Gramineae

Table 8: Weed density as per treatment combinations

Treatments	Number of weed species	Total number of weeds presented in 1 m^2
S_1W_0	8.62	126.00
S_1W_1	6.28	85.12
S_1W_2	4.86	65.04
S_1W_3	3.95	50.13
S_2W_0	8.23	109.25
S_2W_1	5.14	64.22
S_2W_2	4.86	60.14
S_2W_3	4.42	54.23
S_3W_0	7.56	100.28
S_3W_1	4.24	50.28
S_3W_2	3.54	36.12
S_3W_3	3.88	45.35
S_4W_0	7.44	98.26
S_4W_1	3.72	38.24
S_4W_2	3.64	35.26
S_4W_3	3.12	25.36
$LSD_{0.05}$	0.32	2.56
CV(%)	8.36	9.25

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weedings at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weedings at 15, 30 and 45 DAS

4.4.2 Fresh weight of weed

Weed population had considerable effect on crop production. Data on table 9 showed that the highest fresh weight of weed (845 kg ha^{-1}) was observed in S_4W_0 where no weeding was done with higher row spacing. The lowest weed biomass (439 kg ha^{-1}) was observed in S_4W_3 where 3 weeding was done with higher row spacing. Again, presence of lower weed population increase grain yield (Table 6) where higher presence of weed biomass hamper grain yield.

Table 9: Effect of intra- row spacing and number of weeding with fresh weed biomass

Treatments	Fresh weight of weeds at different DAS (kg/ha)				Fresh weight of weeds at harvest (kg/ha)	Total fresh weed biomass (kg/ha)
	15 DAS	30 DAS	45 DAS	Total		
S_1W_0	--	--	--	--	796	796
S_1W_1	330	--	--	330	242	572
S_1W_2	354	100	--	454	94	548
S_1W_3	342	95	20	457	45	502
S_2W_0	--	--	--	--	814	814
S_2W_1	362	--	--	362	234	596
S_2W_2	372	65	--	437	55	492
S_2W_3	366	69	10	445	10	455
S_3W_0	--	--	--	--	832	832
S_3W_1	376	--	--	336	294	630
S_3W_2	378	55	--	433	32	465
S_3W_3	385	49	7	654	12	666
S_4W_0	--	--	--	--	845	845
S_4W_1	382	--	--	382	310	692
S_4W_2	387	40	--	427	40	467
S_4W_3	390	37	4	431	8	439
$LSD_{0.05}$	--	--	--	--	--	6.39
CV (%)	--	--	--	--	--	8.49

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weedings at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weedings at 15, 30 and 45 DAS

4.4.3 Dry weight of weed

Weed population had considerable effect on crop production. Data on table 10 showed that at primary stage (15 DAS) higher population density reduced weed population. But after certain duration it was increased. The highest dry weight of weed (118.30 kg ha^{-1}) was observed in S_4W_0 where no weeding was done with higher row spacing. On the other hand, the lowest dry weed biomass (62.60 kg ha^{-1}) was observed in S_4W_3 where 3 weeding was done. Again, presence of lower weed population increase grain yield (Table 6) where higher presence of weed biomass hamper grain yield.

Table 10: Effect of intra- row spacing and number of weeding on dry weed biomass

Treatments	Dry weight of weeds at different DAS (kg/ha)				Dry weight of weeds at harvest (kg/ha)	Total dry weed biomass (kg/ha)
	15 DAS	30 DAS	45 DAS	Total		
S_1W_0	--	--	--	--	110.40	110.40
S_1W_1	44.00	--	--	44.00	33.50	77.50
S_1W_2	48.00	15.00	--	63.00	12.70	75.70
S_1W_3	46.00	14.00	3.10	63.10	6.40	69.50
S_2W_0	--	--	--	--	114.20	114.20
S_2W_1	52.00	--	--	52.00	31.40	83.40
S_2W_2	55.00	9.00	--	64.00	6.80	70.80
S_2W_3	57.00	11.00	2.20	80.20	1.20	81.40
S_3W_0	--	--	--	--	116.10	116.10
S_3W_1	58.00	--	--	58.00	40.80	98.80
S_3W_2	57.00	7.00	--	64.00	3.80	67.80
S_3W_3	59.00	6.00	1.30	66.30	1.10	67.40
S_4W_0	--	--	--	--	118.30	118.30
S_4W_1	58.00	--	--	58.00	43.20	101.20
S_4W_2	59.00	6.00	--	65.00	4.90	69.90
S_4W_3	57.00	4.00	0.70	61.70	0.90	62.60
$LSD_{0.05}$	--	--	--	--	--	1.64
CV (%)	--	--	--	--	--	8.49

Here,

S_1	=	15 cm (Row spacing)	W_0	=	No weeding
S_2	=	20 cm (Row spacing)	W_1	=	1 weeding at 15 DAS
S_3	=	25 cm (Row spacing)	W_2	=	2 weedings at 15 and 30 DAS
S_4	=	30 cm (Row spacing)	W_3	=	3 weedings at 15, 30 and 45 DAS

Chapter 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka to study the effect of intra- row spacing and number of weeding on the performance of mungbean (cv. BARI mung-4). The experiment comprised with two factors viz. (i) Intra-row spacing and (ii) Number of weeding. Four row spacing (S_1= 15 cm, S_2= 20 cm, S_3= 25 cm and S_4= 30 cm) and four weeding treatments (W_0= No weeding, W_1= Weeding at 15 days after sowing (DAS), W_2 = Weeding at 15 and 30 DAS, and W_3 = Weeding at 15, 30 and 40 DAS were used. There were sixteen treatment combinations under the present study. Data were collected from the experimental field and analyzed statically.

Results showed that at 30, 45, 60 DAS and at harvest, S_1 showed the tallest plant (28.84, 48.02, 51.45 and 54.20 cm, respectively). But at 45, 60 DAS and at harvest the shortest plant (44.65, 46.35 and 50.42 cm, respectively) was observed from S_4.

The intra-row spacing, S_4 also showed the highest number of leaves plant^{-1} (7.68, 11.01, 11.24 and 9.51 respectively at 30, 45, 60 DAS and at harvest), highest dry weight plant^{-1} (7.68, 11.01, 11.24 and 6.00 gm respectively) and number of pods plant^{-1} (12.00, 27.61 and 37.22 at 45, 60 DAS and at harvest respectively) where the lowest number of leaves plant^{-1} (5.64, 6.74, 7.63 and 5.32 respectively), dry weight plant^{-1} (0.85, 3.11, 5.28, 6.81 and 8.36 g at 15, 30, 45, 60 DAS and at harvest respectively) and number of pods plant^{-1} (6.47, 19.34 and 28.47 at 45, 60 DAS and at harvest respectively) was achieved by S_1.

On the other hand, at 30, 45, 60 DAS and at harvest, the highest plant height (28.83, 50.53, 54.98 and 57.50 cm, respectively) was recorded in W_3 where the lowest was achieved with no weeding W_0 (23.37, 41.89, 42.60 and 47.66 cm respectively).

But at 30, 45, 60 DAS and at harvest, the highest number of leaves plant^{-1} (7.28, 10.16, 10.86 and 8.06 respectively), dry weight plant^{-1} (1.74, 4.60, 7.75, 10.40 and 12.35 g respectively) and pods plant^{-1} (11.25, 27.50 and 37.21 respectively) were recorded in W_3 where the lowest number of leaves plant^{-1} (4.62, 5.23, 5.81 and 4.95 at 30, 45, 60 DAS and at harvest respectively), dry weight plant^{-1} (1.61, 3.05, 4.19, 5.48 and 6.91 g at 15, 30, 45, 60 DAS and at harvest respectively) and number of pods plant^{-1} (5.03, 16.84 and 25.95 at 45, 60 DAS and at harvest respectively) were achieved with no weeding.

In terms of combined effect, the highest plant height (31.04, 52.61, 58.21 and 60.26 cm at 30, 45, 60 DAS and at harvest respectively) was achieve by S_1W_3 where the lowest was achieved by S_4W_0 (22.11, 39.63, 40.19 and 45.69 cm at 30, 45, 60 DAS and at harvest respectively). But in case of highest number of leaves plant^{-1} (8.84, 13.57, 13.90 and 11.08 at 30, 45, 60 DAS and at harvest respectively), dry weight plant^{-1} (2.45, 6.07, 9.31, 13.53 and 15.63 g at 15, 30, 45, 60 DAS and at harvest) and number of pods plant^{-1} (15.53, 32.94 and 43.29 at 45, 60 DAS and at harvest) was observed in the S_4W_3 where the lowest number of leaves plant^{-1} (4.08, 4.79, 5.19 and 4.81 at 30, 45, 60 DAS and at harvest respectively), dry weight plant^{-1} (0.79, 2.24, 3.54, 4.89 and 5.99 at 15, 30, 45, 60 DAS and at harvest respectively) and pods plant^{-1} was obtained with S_1W_0 (4.39, 15.76 and 25.04 at 45, 60 DAS and at harvest respectively) were achieved by S_1W_0.

In terms of yield and yield contributing parameters, the highest pod length (6.35 cm), maximum number of seeds pod^{-1} (8.65), highest 1000- seed weight (29.08 g), highest grain yield (1380 kg ha^{-1}) and highest biological yield (3762 kg ha^{-1}), were obtained by S_4. Where the lowest pod length (5.71 cm), seeds pod^{-1} (7.33), 1000- seed weight (27.03 g), grain yield (1119 kg ha^{-1}) and biological yield (3571 kg ha^{-1}), and harvest index (31.43%) were achieved by S_1. But for harvest index, the highest harvest index (40.37%) was achieved by S_3 and the lowest was by S_1.

Incase of number of weeding, the highest pod length (6.34 cm), number of seeds pod^{-1} (8.83), 1000- seed weight (28.95 g), grain yield (1370 kg ha^{-1}), biological yield (3809 kg ha^{-1}) and harvest index (38.65%) was found with W_3 where the lowest pod length (5.50 cm), number of seeds pod^{-1} (6.39), 1000 seed weight (26.63 g), grain yield (1092 kg ha^{-1}), biological yield (3498 kg ha^{-1}) and harvest index (32.65%) was found from no weeding, W_0.

In terms of combined effect, the highest pod length (6.69 cm), number of seeds pod^{-1} (9.43), 1000- seed weight (30.49 g), grain yield (1591 kg ha^{-1}) and biological yield (3964 kg ha^{-1}) were gained by S_4W_3 where the lowest pod length (5.36 cm), number of seeds pod^{-1} (6.04), 1000- seed weight (26.31 g), grain yield (1021 kg ha^{-1}) and biological yield (3453 kg ha^{-1}) were achieve by S_1W_0. The highest harvest index (44.26%) was achieved by S_3W_2 where the lowest (29.54%) was achieved by S_1W_0.

According to the weeding treatment the highest weed biomass (fresh weight basis) was obtained with S_3W_3 (654 kg ha^{-1}) where S_1W_1 showed lowest (330 kg ha^{-1}) weed biomass. But at the time of harvest the highest weed biomass (including control) was achieved from S_1W_0 (796 kg ha^{-1}) where the lowest was observed from S_4W_3 (439 kg ha^{-1}).

From the results of the study, it may be concluded that the performance of mungbean cv. BARI mung-4 was better in respect of growth, yield and yield components when sown at 30 cm row spacing followed 3 times of weeding. With this combination the yield was 1591 kg ha^{-1}. But with the treatment combination of S_3W_2 showed very close yield (1585 kg ha^{-1}) to S_4W_3. So, from economic point of view, 25 cm row spacing followed 2 times of weeding was the best treatment combination.

However, such result has made basis for further study that should be conducted in different season involving different factors of production of mungbean. Further research is, therefore, necessary to achieve at a definite conclusion.

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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***
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix II. Monthly average air temperature, relative humidity and total rainfall of the experimental site during the period from January to April 2012

Month	*RH (%)*	*Max. Temp. (ºC)*	*Min. Temp. (ºC)*	*Rain fall (mm)*
January	69.53	25.00	13.46	0
February	50.31	29.50	18.49	0
March	44.95	33.80	20.28	25
April	61.40	33.74	23.81	185

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Effect of intra- row spacing and number of weeding on plant height of mungbean

Source of variance	Degrees of Freedom	Mean square				
		15 DAS	30D AS	45 DAS	60 DAS	At harvest
Replication	2	0.001	0.002	0.007	0.004	0.002
Factor A	3	8.671*	9.735*	6.929*	6.980*	10.272*
Factor B	3	12.121*	14.653*	9.143*	13.386*	22.958*
AB	9	0.110**	3.114*	2.684*	1.235**	2.104*
Error	30	0.321	0.426	0.502	1.326	2.186

Appendix IV. Effect on number of leaves plant^{-1} with intra- row spacing and number of weeding on the performance of mungbean

Source of variance	Degrees of Freedom	Mean square				
		15 DAS	30D AS	45 DAS	60 DAS	At harvest
Replication	2	0.001	0.014	0.004	0.002	0.004
Factor A	3	NS	9.586*	4.751**	8.906*	15.895*
Factor B	3	NS	18.105*	6.012*	13.449*	17.202*
AB	9	NS	1.402**	2.830*	2.810*	1.424*
Error	30	0.014	0.236	0.321	1.001	2.244

Appendix V. Effect on dry weight plant^{-1} (gm) with intra- row spacing and number of weeding on the performance of mungbean

Source of variance	Degrees of Freedom	Mean square				
		15 DAS	30D AS	45 DAS	60 DAS	At harvest
Replication	2	0.000	0.000	0.000	0.005	0.001
Factor A	3	4.805	12.63*	13.995*	8.450*	6.677*
Factor B	3	0.035**	6.568*	31.093*	15.45*	14.30*
AB	9	0.007**	0.119**	0.430**	1.925*	1.777**
Error	30	0.012	0.124	0.238	0.402	0.431

Appendix VI. Effect on number of pods plant^{-1} with intra- row spacing and number of weeding on the performance of mungbean

Source of variance	Degrees of Freedom	Mean square		
		45 DAS	60 DAS	At harvest
Replication	2	0.012	0.008	0.016
Factor A	3	14.482*	17.037*	16.695*
Factor B	3	24.749*	26.958*	29.953*
AB	9	6.239*	8.254*	11.867*
Error	30	1.112	1.238	2.116

Appendix VII. Effect on yield contributing parameters with intra- row spacing and number of weeding on the performance of mungbean

Source of variance	Degrees of Freedom	Mean square		
		Pod length (cm)	Number of seeds pod^{-1}	1000 grain weight (g)
Replication	2	0.004	0.002	0.001
Factor A	3	0.879**	3.592*	8.849*
Factor B	3	1.547*	8.401*	12.155*
AB	9	0.230**	0.772**	1.621*
Error	30	0.026	0.224	1.822

Appendix VIII. Effect on with intra- row spacing and number of weeding on yield parameters of mungbean

Source of variance	Degrees of Freedom	Mean square		
		Grain yield (kg ha^{-1})	Biological Yield (kg ha^{-1})	Harvest index (%)
Replication	2	0.021	1.333	0.024*
Factor A	3	16.972*	22.076 *	7.070*
Factor B	3	36.472*	48.132*	12.569*
AB	9	8.398 *	9.150*	2.475*
Error	30	3.732	4.711	2.321