EFFECT OF ROW SPACING AND METHODS OF WEEDING ON THE YIELD OF MUNGBEAN (*Vigna radiata* L.)

BY

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This is to certify that the thesis entitled "EFFECT OF ROW SPACING AND METHODS OF WEEDING ON THE YIELD OF MUNGBEAN (*Vigna radita* L.)" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bonafide research work carried out by Md. Masud Rana, Registration No. 00909, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information as has been availed of during the course of this work has been duly acknowledged & style of the thesis have been approved and recommended for submission.

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Dedicated To

My Beloved Parents

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EFFECT OF ROW SPACING AND METHODS OF WEEDING ON THE YIELD OF MUNGBEAN (*Vigna radiata* L.)

ABSTRACT

An experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, during *Kharif*-1 season from the month of March to June, 2007 to study the effect of row spacing and methods of weeding on the yield of mungbean (cv. BARI mung-5). The treatments consisted of four row spacing viz. 20 cm, 25 cm, 30 cm, 35 cm and three weeding methods viz. hand weeding, raking and wheat straw mulching. The experiment was laid out in randomized complete block design (RCBD) with three replications. Row spacing and methods of weeding had significant influence on growth, yield and yield components of mungbean. Results showed that the tallest plant height was obtained from spacing 20 cm and mulching with wheat straw treatments. But, the highest number of leaves was obtained from the interaction treatment of 35 cm spacing and hand weeding. The highest dry weight of weeds per m^2 was recorded in 35 cm spacing and raking. The highest number of pods per plant (12.45), number of seeds per pod (13.07), thousand seed weight (41.10 g), yield per hectare (1.47 t) and harvest index (27.74 %) was recorded in 30 cm spacing and hand weeding interaction treatment.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	gram (s)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
mm	=	millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the leading pulse crop of Bangladesh. This commonly grown pulse crop belongs to the family leguminosae. It holds the 3rd in protein content and 4th in both acreage and production in Bangladesh (Sarkar *et al.*, 1982). The agro-ecological condition of Bangladesh is favourable for growing this crop. Pulses constitute the main source of protein for the people, particularly the poor sections of Bangladesh. These are also the best source of protein for domestic animals. Besides, the crops have the capability to enrich soils through nitrogen fixation. Mungbean contains 51% carbohydrates, 26% protein, 4% mineral and 3% vitamin. On the nutritional point of view, mungbean is one of the best among pulses (Khan, 1981). It is widely used as "Dal" in the country like other pulses.

Bangladesh is a developing country. The land of our country is limited. But the population is very high. More people need more food. We have to produce more food in our limited land. To meet up the increased demand of food, farmers are growing more cereal crops. Due to the high population pressure, the total cultivable land is decreasing day by day along with the pulse cultivable land. So, at present the cultivation of pulse has gone to marginal land because farmers do not want to use their fertile land in pulse cultivation. Pulse cultivation is also decreasing because of its low yield & production. The long term cereal crop cultivation also effects soil fertility and productivity.

Mungbean covers an area of 22267 hectare and production was about 17000 metric tons. The average production of mungbean in the country is about 763 kg ha^{-1}(BBS, 2006). About 3 t ha^{-1} of seed yield have been reported in a trial in Taiwan (Lawn, 1978) but in Bangladesh the average yield is very low. The yield difference indicates the wide scope for increasing yield of mungbean.

The climatic conditions of Bangladesh favour mungbean production almost throughout the year.

Mungbean has special importance in intensive crop production system of the country for its short growing period. It is drought tolerant and can be cultivated in low rainfall areas, but faces well in areas with 750 - 900 mm rainfall (Kay, 1979). The crop is grown with residual moisture under rainfed conditions. It is cultivated both in summer and winter season in many countries of the world (Bose, 1982; Singh and Bhardwaj, 1975). It is traditionally grown throughout the country during the month of September to December in *Rabi* season but across these days, this crop has been growing throughout the country in the month of March to June in summer.

The farmers of Bangladesh generally grow mungbean by one ploughing and hardly use any fertilizer and irrigation due to its lower productivity and also to their poor socio-economic condition and lack of proper knowledge. As a result the yield becomes low. There is an ample scope for increasing the yield of mungbean with improved management practices.

A significant number of farmers are still using broadcasting methods of seed sowing which causes uneven distribution of seed. The seeds at the bottom receive more moisture in comparison to those in the top, which may produce uneven emergence of seedlings and also uneven maturity of plants. Ultimately it creates a difficult situation for harvesting. This can easily be overcome by maintaining proper row spacing.

Weeds are most serious pests of mungbean reducing the growth and yield of crop. Modern agricultural practices contribute mostly on protection of the crop against competition from weeds. Weeds reduce yield by competing with crop plants for space, light, nutrients and carbon dioxide etc. There are different views about the intensity of weed losses but it is established fact that weeds cause great losses to crops, depending upon the degree of weed infestation, duration of weed competition, and soil and climatic conditions (Mansoor *et al.*, 2004).

Karim (1987) estimated that weeds caused a yield loss of 28% of total food crops, 33% in cereals, 14% in pulses, 27% in oil seeds and 33% in rice crops. In Bangladesh there is a general belief that mungbean does not require any weeding. So, the farmers usually do not give much attention in weed control in this crop. Probably this is one of the causes for lower yield of mungbean in this country.

There is no specific way to control weeds of all types because of different kinds of social, economical and environmental factors influence the choice of control method to be used. Quarshi *et al.* (2002) reported that weed could be controlled by manual, cultural and chemical methods. Although weed management practices like hand weeding and herbicide application are effective in weed control but are uneconomical due to higher costs (Cheema *et al.*, 2003). Moreover the chemical weed control method is hazardous for health and causes environmental pollution.

Therefore, the optimum row spacing and effective weed management 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 stage 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 row spacing and effective weeding methods in time.

The experimental evidences on the effect of row spacing and weeding regime 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 observe the effect of row spacing on the yield of mungbean,
ii. to find out the weeding method for maximum yield, and
iii. to identify the interaction effect of row spacing and weeding method on the yield of mungbean.

Chapter 2

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

The growth and yield of mungbean are influenced by row spacing and different method 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 different methods 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 per plant 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 *et al.*, 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 NP/ha 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, 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) and row spacing (30 and 45 cm) on the yield and yield components (pods per plant, seeds per pod and 1000-seed weight) of mungbean cv. NM-92. Seed yield was highest with 30 cm row spacing while pods per plant, seeds per pod and 1000-seed weight were highest with 45 cm row spacing. Phosphorus applied at 90 kg/ha gave the highest seed yield, pods per plant, seeds per pod and seed weight. Analysis of the interaction effect showed that 30 cm row spacing combined with 90 kg P/ha gave the highest seed yield.

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 spacings were 5, 7.5 and 10 cm. Emergence of seedlings/m^2, days to flowering, days to maturity, number of grains/pod, number of branches/plant, plant height (cm), thousand grain weight (g), percent hard grain (%), biological yield (kg/ha) and grain yield (kg/ha) were significantly affected by row and plant spacings, while pods number/plant and harvest index were not significantly affected at 5% level of significance with row and plant spacings. 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).

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 (Jain 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 × 10 cm, 30 cm × 7.5 cm and 30 cm × 10 cm to determine optimum plant spacing for green pod yield of pea. The spacing of 30 cm × 7.5 cm gave the highest pod yield, which was significantly higher than that of 30 cm × 10 cm spacing. The spacing of 45 cm × 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 × 15 cm spacing and the grain yield decreased when the spacing was increased to 50 cm from 25 cm (Singh and Yadav, 1978; Mera, 1984; 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 11.9% 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 and seeds/pod (Saharia and Thakuria, 1988)

Haque (1995) conducted a field trial in 1986 at Joydebpur, Bangladesh, *Vigna radiata* cv. BM-7703 was grown at populations of 250 000, 333333, 400 000 or 500 000 plants/ha using 40, 30, 25 and 20 cm row spacing, respectively. Seed yield was highest with 333333 plants/ha.

2.2 Effect of method of weeding on crop performance of mungbean

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.

Kohli, *et al.* (2006) conducted a field experiment in Hisar, Haryana, India, during the 2001 summer season to determine the effect of different weed management practices on the quality and economics of mungbean cv. K-851. The treatments comprised 0.75 kg Linuron/ha; 1.0 kg Linuron/ha; 0.75 kg Linuron/ha + hand weeding at 35 days after sowing (DAS); 1.0 kg Pendimethalin/ha; 1.25 kg Pendimethalin/ha; 1.0 kg Pendimethalin/ha + hand weeding at 35 DAS; 200 g Thiazopyr/ha; 240 g Thiazopyr/ha; 200 g Thiazopyr/ha + hand weeding at 35 DAS; 0.75 kg Acetachlor/ha; 1.0 kg Acetachlor/ha; 0.75 kg Acetachlor/ha + hand weeding at 35 DAS; hand weeding at 20 and 30 DAS; weed free; weedy control. Pendimethalin at 1.0 kg/ha + hand weeding at 35 DAS gave the highest grain yield (15.1 q/ha), net return (Rs. 24 095) and profit over weedy control (Rs. 10 595/ha). Acetachlor at 0.75 kg/ha + hand weeding at 35 DAS gave the highest P uptake (11.3 kg/ha) while hand weedings at 20 and 30 DAS gave the highest protein content (22.5).

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 (T_1), 2 hoeings at 25 and 45 DAS (T_2), 2 hand weedings at 25 and 45 DAS (T_3), weedy (T_4) and weed-free (T_5). The maximum reduction in density and dry weight of weeds was achieved in T_3, which was significantly better than T_1 during 2002 but at par during 2003. T_2 though reduced the density and dry weight of weeds significantly compared to T_4, it was inferior to all other weed control treatments during both years. The sowing methods did not affect the crop performance. T_1 proved superior in terms of crop dry matter accumulation at 60 DAS compared to T_2 and T_3. Plant height was statistically similar under different weed control practices. The highest seed yield of mungbean (1947 and 1870 kg/ha) was attained in T_5, which was statistically at par with T_1 (1779 and 1727 kg/ha) and T_3 (1785 and 1561 kg/ha), during 2002 and 2003.

Raman and Krishnamoorthy (2005) conducted a field experiment during the rice fallow season of 1999 in Annamalainagar, Tamil Nadu, India, to determine the most effective integrated methods of weed control in mungbean cv. VBN1. The treatments comprised Pendimethalin at 1.0 kg/ha, Fluchloralin at 1.0 kg/ha, Pendimethalin at 1.0 kg/ha+one hand weeding at 20 DAS, Fluchloralin at 1.0 kg/ha+one hand weeding at 20 DAS, twice hand weeding at 20 and 40 DAS and a weedy control. Pendimethalin at 1.0 kg/ha+one hand weeding at 20 DAS was the most effective method of weed control and resulted in the highest seed yield (921 kg/ha), followed by Fluchloralin at 1.0 kg/ha+one hand weeding at 20 DAS (843 kg/ha). Weedy condition for the entire crop season reduced the seed yield by 35% compared to twice hand weeding. Integration of one herbicide with one hand weeding provided better growth, yield attributes and consequently higher yield. In respect of nodulation, the twice hand weeding treatment recorded the highest nodule number and weight (31.0 and 4.98 g/plant), followed by Pendimethalin at 1.0 kg with one hand weeding treatment.

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 weed-free 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 and hand 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^{-1}, 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.

Tomar *et al.* (2004) conducted an experiment during the 1998 and 1999 summer seasons in Uttar Pradesh, India, to determine the most effective weed management practices and suitable intercropping systems. Seven weed management practices (weedy, weeding at 20 and 35 days after sowing (DAS), 1.0 kg Pendimethalin/ha (pre-emergence), 0.5 kg Fluchloralin/ha (pre-plant), 0.5 kg Pendimethalin/ha, 1.0 kg Pendimethalin/ha + hand weeding at 30 DAS, and 1.0 kg Fluchloralin/ha + hand weeding at 30 DAS). Pendimethalin at 1.0 kg/ha + hand weeding at 30 DAS gave the highest yield. Weed density and dry matter were lowest in pigeonpea + cowpea intercropping and Pendimethalin + hand weeding at 30 DAS treatments.

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 mustard-mungbean 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.

Cheema *et al.* (2001) conducted a field trial to determine the feasibility of using sorgaab (sorghum extract) as a natural weed inhibitor in spring mungbean during 1999, in Faisalabad, Pakistan. Sorgaab sprays were tested and compared with one hand weeding and pre-emergence application of Pendimethalin. Results showed that 3 foliar sprays of sorgaab, one hand weeding and Pendimethalin spray inhibited the total weed density by 31.58, 22.81 and 35.96%, respectively. An inhibition of 44.11, 28.00 and 43.93% in total weed dry weight was noticed by 3 sorgaab sprays, one hand weeding and Pendimethalin treatment, respectively. Three sorgaab sprays enhanced grain yield of mungbean by 18%, while hand weeding and Pendimethalin treatments increased grain yield by 10 and 13%, respectively.

Borah (1994) conducted a field trial at Shillongani, Assam in the 1990 - 91 rainy seasons. The effects of weed control treatments (no weed control, hand weeding at 20 or 30 days after sowing (DAS), or 1.5 kg Pendimethalin/ha pre-em.) and 0 or 50 kg Diammonium phosphate/ha on mungbeans cv. ML-131 were compared. The lowest weed dry weight at harvest was given by hand weeding at 30 DAS in 1990 and 20 DAS in 1991. Mean seed yield over 2 years was 0.37 t/ha without weed control, 0.72 and 0.69 t with hand weeding at 20 and 30 DAS, and 0.54 with Pendimethalin. Applied Phosphorus did not affect weed growth or crop yield.

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.

Panwar and Singh (1980) observed that the average yield of gram from no-weeding control was as low as 247 kg/ha. One hand-weeding treatment doubled the yield.

Erman *et al.* (2004) determined the most appropriate method for controlling weeds. Hand weeding (weed free control), weedy control (inoculated), weedy control (uninoculated), hand hoeing once, hand hoeing twice, Trifluralin, Imaethapyr, Linuron, Prometryn, Phenmedipham + Desmedipham, Trifluralin + hand hoeing and Linuron + hand hoeing treatments were evaluated. Prometryn, hand hoeing, Linuron and a combination of Linuron + hand hoeing were found to the most effective for control of weeds, resulting in the highest yield in winter lentil throughout the investigation.

Tepe *et al.* (2004) determined the most appropriate method for weed control. The use of hand hoeing, Lrifluralin, Imaethapyr, Linuron, Prometryn, Phenmedipham + Desmedipham, Trifluralin + hand hoeing and Linuron + hand hoeing, as an alternative to hand weeding, was studied. A combination of Linuron + hand hoeing, Linuron alone and hand hoeing were the most effective methods for weed control.

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 2539, 1147 and 714 kg/ha 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.

Detrimental effect of weeds on the quality of legumes has been reported. Singh and Gupta (1974) conducted an experiment on chemical composition of groundnut kernels as affected by weeding. It was observed that 28 percent of crude protein was present in the grain from the two-hand weeded plots while in chose from the minimum weeded plots.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the *Kharif* -1 season from March to June, 2007 to study the effect of row spacing and methods of weeding on the weed infestation and yield of mungbean (cv. BARI mung-5). 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 $23^0\,77^{'}$ latitude and $90^0\,33^{'}$ 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 silt clay with pH 8.0. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-1.

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-5 was used as planting material. BARI mung-5 was released and developed by BARI in 1997. 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-5 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 row spacing (i.e. line to line distance) and weeding methods as mentioned below:

A. Row spacing: 4

S_1 = 20 cm

S_2 = 25 cm

S_3 = 30 cm

S_4 = 35 cm

B. Weeding method: 3

W_1 = hand weeding

W_2 = raking

W_3 = wheat straw mulching

3.4 Experimental design and layout

The experiment was laid out in a two factors randomized complete block design (RCBD) design having three replications. Each replication had 12 unit plots to which the treatment combinations were assigned randomly. The unit plot size was 8.75 m^2 (3.5m ×2.5m). 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 21^{st} March, 2007.

3.5 Land preparation

The experimental land was opened with a power tiller on 17th March, 2007. Ploughing and cross ploughing were done with country plough followed by laddering. Land preparation was completed on 20th March, 2007 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 45 kg ha^{-1} in the furrow on April 04, 2007 and the furrows were covered with the soils soon after seeding. The line to line (furrow to furrow) distance was maintained 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.

Hand weeding: Two times hand weeding was done. First time 20 DAS and second time 35 DAS.

Mulching: Mulch application was done by spreading wheat straws on the soil surface after 15 days of germination at the rate 0.5 kg per m^2 between rows.

Raking: Raking was done at two times, when hand weeding was done.

3.9.2 Thinning

Thinning was done at 20 days after sowing (DAS) and 35 DAS. Plant to plant distance was maintained at 10 cm.

3.9.3 Irrigation and drainage

Presowing 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.

3.9.4 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 Determination of maturity

At the time when 80% of the pods turned brown colour, the crop was considered to attain maturity.

3.11 Harvesting and sampling

The crop was harvested at 70 DAS from prefixed 1.0 m^2 areas. Before harvesting ten plants were selected randomly from each plot and were uprooted for data recording. The rest of the plants of prefixed 1 m^2 area were harvested plot wise and were bundled separately, tagged and brought to the threshing floor.

3.12 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.

3.13 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.

3.14 Recording of characters

i. Plant height (cm)

The height of the selected plant was measured from the ground level to the tip of the plant at 20, 35, and 50 days after sowing (DAS) and at harvest time (70 DAS).

ii. Number of leaves per plant

Number of leaves per plant was counted from each selected plant sample and then averaged at 20, 35, and 50 days after sowing and at harvest (70 DAS).

iii. Leaf area index

Twenty leaflets were collected randomly from the field and the length and breadth of each leaflet were measured. Length and breadth were multiplied to get the area of individual leaflets. All the area were summed up and divided b 20 to get the average leaflet are. Real leaf area was then determined by using the followed formula:

Real leaf area= area of an individual leaflet × number of leaflets per plant × 0.65

iv. Dry weight of leaves per plant

Ten plants were collected randomly from each plot at 20, 35, 50 and 70 days after sowing. Those were the segmented into leaves. The leaves were oven dried 24 hours at 70° C and the dry weight of leaves per plant was determined by using the following formula:

$$\text{Dry weight of leaves per plant} = \frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$$

v. **Dry weight of stem per plant**

Ten plants were collected randomly from each plot at 20, 35, 50 and 70 days after sowing. Those were the segmented into stem. The sample plants were oven dried 24 hours at 70° C and the dry weight of stem per plant was determined by using the following formula:

$$\text{Dry weight of stem per plant} = \frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$$

vi. **Dry weight of root per plant**

Ten plants were collected randomly from each plot at 20, 35, 50 and 70 days after sowing with the help of a shovel in such a way that root had minimum damage and was intact. Those were then washed in running water and the soil was removed and the roots were the segmented from the plant. The sample parts were oven dried 24 hours at 70° C and the dry weight of root per plant was determined by using the following formula:

$$\text{Dry weight of root per plant} = \frac{\textbf{Dry weight (g)}}{\textbf{Number of plants}}$$

vii. **Dry weight of weed per m^2**

Weed was calculated from 1 m^2 in each plot when last weeding was done (35 DAS) and washed by tap water. Weeds were oven dried for 24 hours at 70° C temperature and than weighed by eclectic balance.

viii. **Number of pods per plant**

Number of pods plant^1 was counted from the 10 selected plant sample and then the average pod number was calculated.

ix. Number of seeds per pod

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

x. 1000 seed weight

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.

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

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

xii. Harvest index (%)

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

Harvest index (HI %) = (Seed yield/ Biological yield) × 100

3.15 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

CHAPTER 4
RESULTS AND DISCUSSION

Result obtained from the present study have been presented and discussed in this chapter. The data have been presented in different tables and figures and a summary of the analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendices V-XI. The results have been presented and discussed, and possible interpretations are given under the following headings.

4.1 Plant height

- **Effect of row spacing**

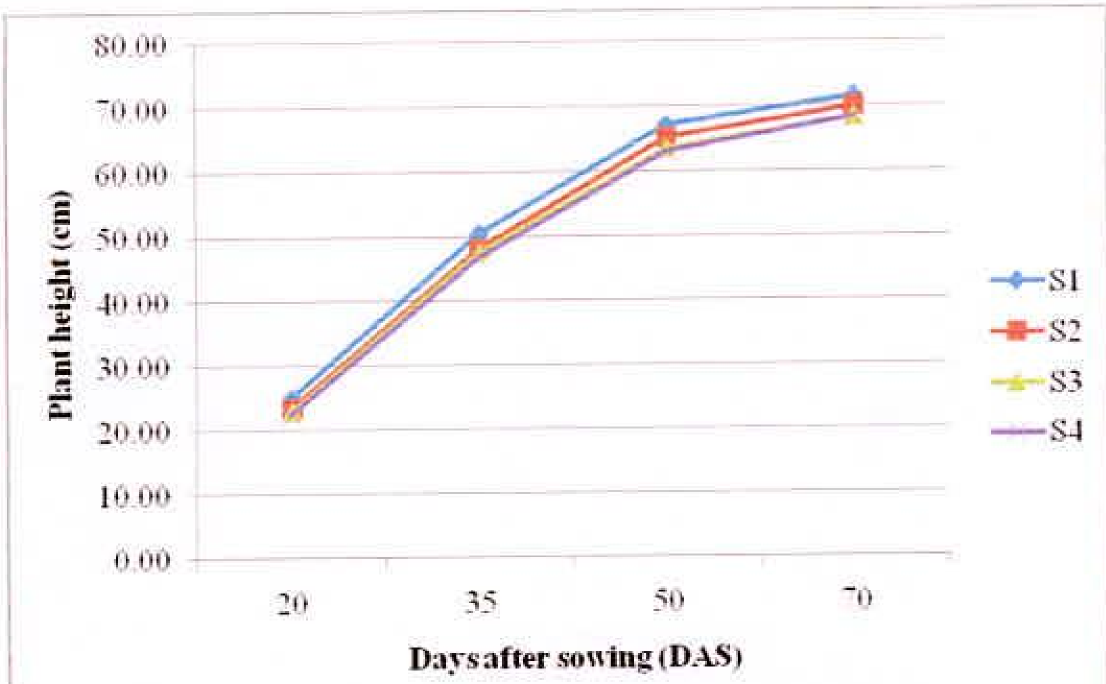
Data on plant height were recorded periodically at 20, 35, 50, and 70 days after sowing (DAS). The plant height was not significantly affected due to the different spacing at different days after sowing. The tallest plant height (25.17, 50.53 67.13 and 71.52 cm at 20, 35, 50, and 70 DAS, respectively) was obtained from S_1 (20 cm row spacing) and the shortest plant height (22.52, 46.66, 62.93 and 68.33 cm at 20, 35, 50, and 70 DAS, respectively) was obtained in S_4 (35 cm row spacing) (Fig. 1). The plant height was decreased with increasing in row spacing. The increased plant height at closer spacing was due to more competition for air and light. This is in agreement with the results of Rashid (1998), who obtained taller plants from closer spacing. But this is contradictory with the findings of Badaruddin and Haque (1997), Khushk *et al.* (1990) and Kumer *et al.* (1998) they found taller plant height at the wider spacing.

- **Effect of weeding methods**

Plant height was influenced by methods of weeding. The tallest plant (26.27, 55.56, 73.57 and 78.21 cm at 20, 35, 50, and 70 DAS, respectively) was obtained from W_3 (wheat straw mulching) treatment and the shortest (21.07, 43.99, 61.26 and 65.58 cm at 20, 35, 50, and 70 DAS, respectively) from W_2 (raking) (Fig. 2).

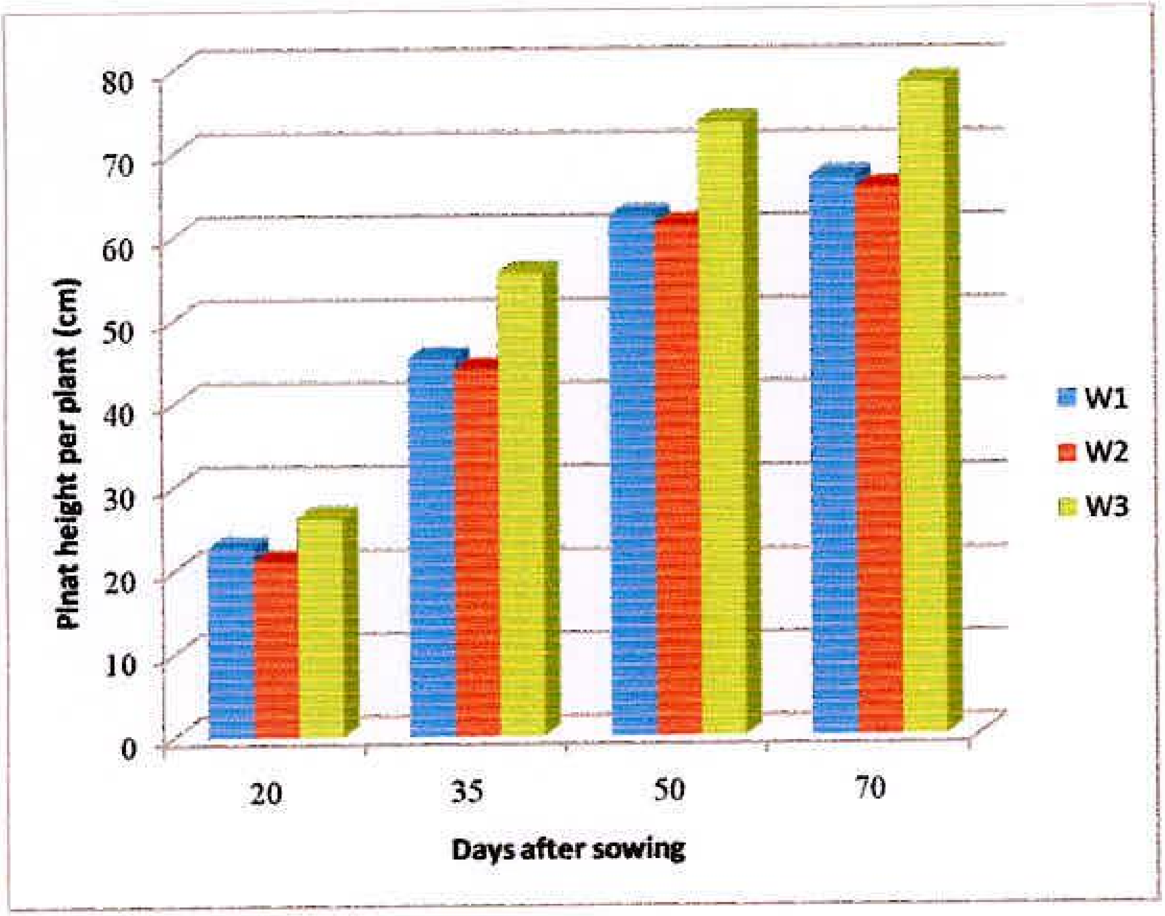
Effect of interaction of row spacing and weeding methods

Interaction effect of different row spacing and methods of weeding had a significant variation on plant height. The tallest plant (28.92, 59.11, 77.33 and 80.93 cm at 20, 35, 50, and 70 DAS, respectively) was obtained from S_1W_3 (20 cm row spacing with wheat straw mulching) treatment while the shortest (20.25, 42.87, 57.25 and 62.32 cm at 20, 35, 50, and 70 DAS, respectively) with S_4W_2 (35 cm row spacing with raking) (Table 1).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 1. Effect of row spacing on the plant height of mungbean at different days ($LSD_{(0.05)}$=2.70, 7.00, 5.57 and 4.33 at 20, 35, 50, and 70 DAS, respectively)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure 2. Effect of weeding methods on the plant height of mungbean at different days ($LSD_{(0.05)}$=3.65, 9.46, 7.53 and 5.86 at 20, 35, 50, and 70 DAS, respectively)

Table 1. Effect of row spacing and weeding methods interaction on the plant height of mungbean plant at different days

Treatment	Plant height (cm)			
	20 DAS	35 DAS	50 DAS	At harvest (70 DAS)
S_1W_1	24.89	47.69	61.72	68.10
S_1W_2	21.72	44.78	62.32	65.52
S_1W_3	28.92	59.11	77.33	80.93
S_2W_1	22.77	44.41	60.47	65.27
S_2W_2	20.77	43.07	61.10	65.80
S_2W_3	27.07	57.21	74.16	78.90
S_3W_1	22.06	45.52	57.91	64.03
S_3W_2	21.13	43.49	61.08	66.14
S_3W_3	26.85	54.67	71.77	76.55
S_4W_1	21.54	45.27	60.55	64.87
S_4W_2	20.25	42.87	57.25	62.32
S_4W_3	24.90	51.23	71.00	76.44
LSD (0.05)	1.76	4.56	3.63	2.82
CV (%)	4.38	5.37	3.31	2.40

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30 cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35 cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.2 Number of leaves per plant

- **Effect of row spacing**

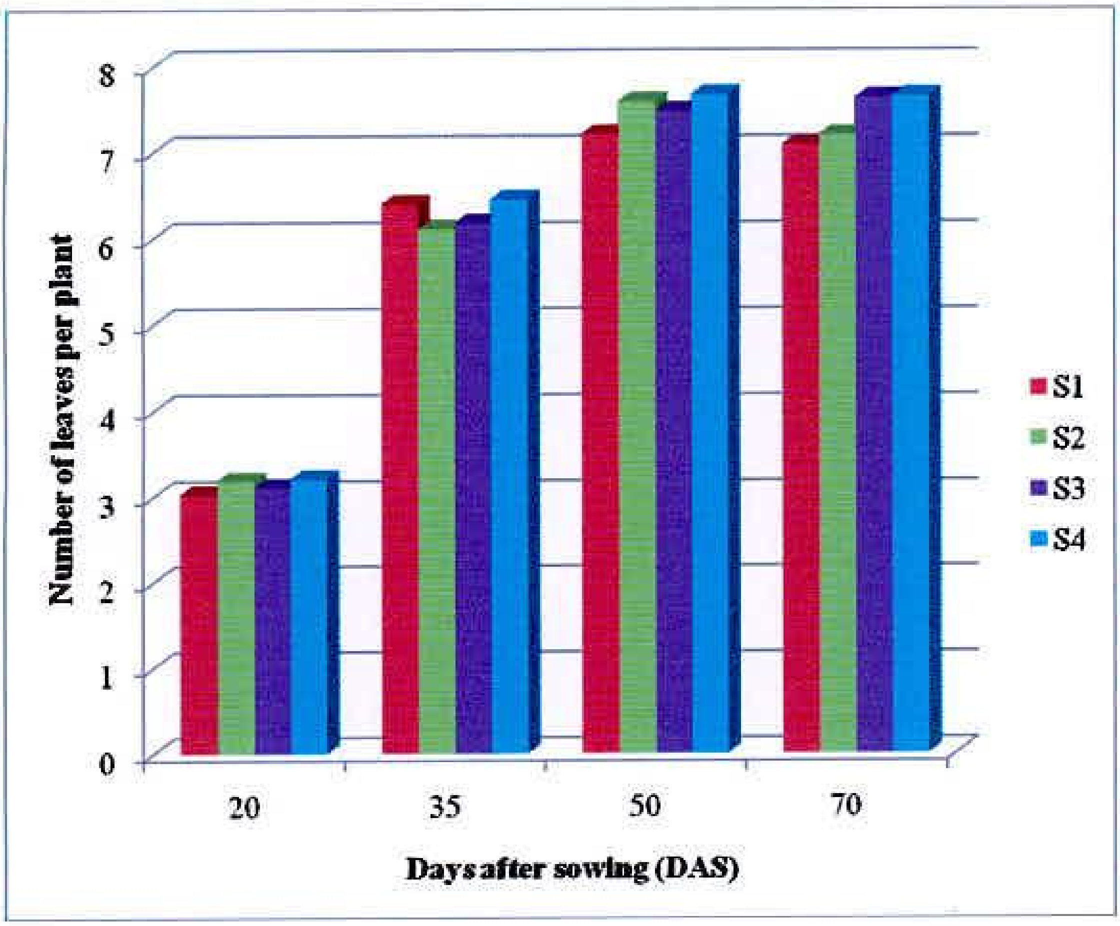
The number of leaves per plant counted at different days was no significantly influenced by spacing. Treatment S_4 produced maximum number of leaves (3.21, 6.46, 7.67 and 7.65 at 20, 35, 50 and 70 DAS, respectively) followed by S_3 and the minimum (3.03, 6.4, 7.21, and 7.09 at 20, 35, 50 and 70 DAS, respectively) number of leaves were recorded in S_1 treatment (Fig. 3). As the spacing was increased number of leaves was found to be increased. This might have been due to the absorption of more nutrients, getting more sunlight on larger leaf area and better aeration influenced by the gradual increase in the spacing. This result agrees well with the finding of Kumar *et al.* (1998) and Rashid (1998). They found increased number of leaves per plant at wider spacing.

- **Effect of different methods of weeding**

Significant difference was observed due to various methods of weeding in respect of number of leaf per plant. The highest number of leaves (3.30, 6.76, 8.41 and 8.50 at 20, 35, 50 and 70 DAS, respectively) was obtained from W_1 and the lowest (3.12, 5.8, 6.46 and 5.91 at 20, 35, 50 and 70 DAS, respectively) from in W_2 (Fig. 4).

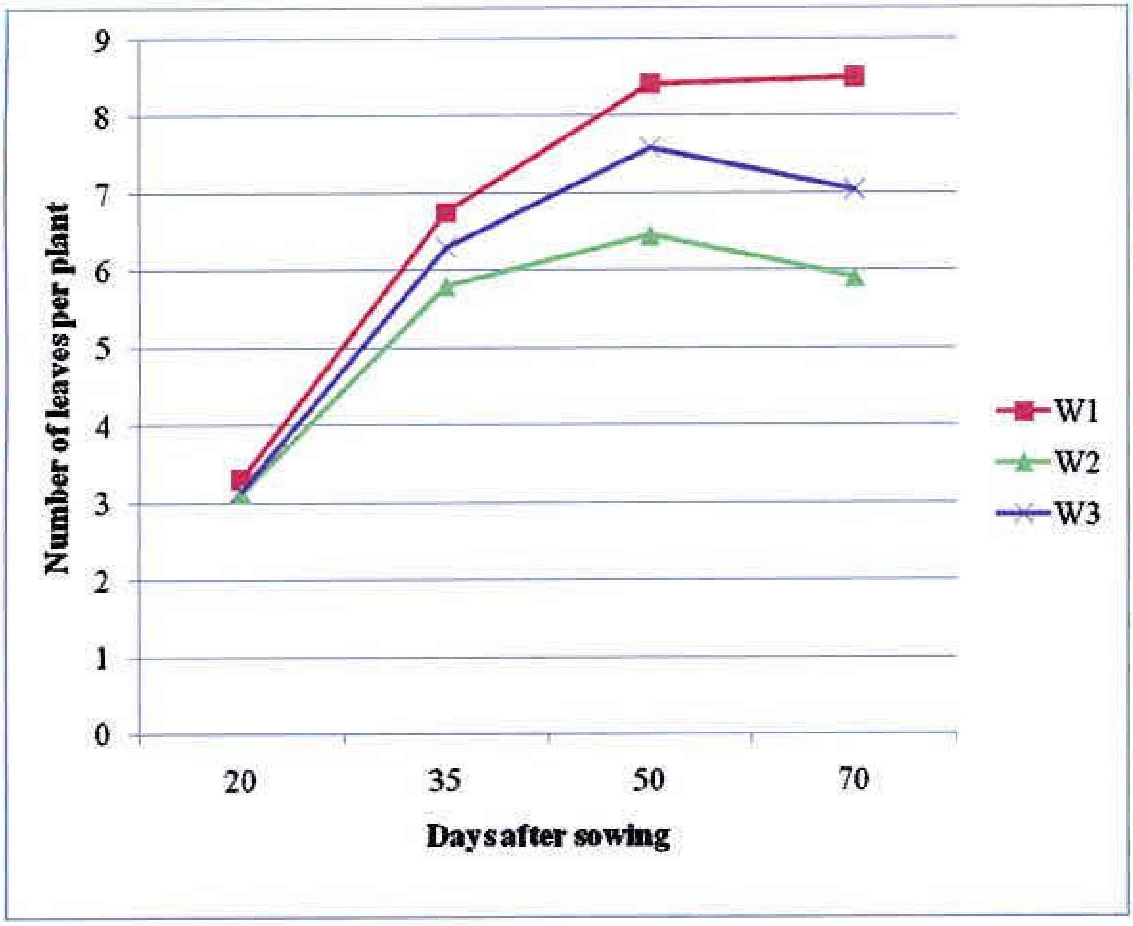
- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and different methods of weeding had a significant variation on number of leaves. The highest number of leaves (3.5, 7.5, 9.04 and 8.67 at 20, 35, 50 and 70 DAS, respectively) was obtained from S_4W_1 treatment while the lowest (3.0, 5.20, 6.20 and 5.67 at 20, 35, 50 and 70 DAS, respectively) with the 20 cm row spacing and raking (S_1W_2) combination (Table 2).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 3. Effect of row spacing on the number of leaves of mungbean plant at different days ($LSD_{(0.05)}$=0.47, 1.29, 1.81and 1.39 at 20, 35, 50, and 70 DAS, respectively)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure 4. Effect of weeding methods on the number of leaves of mungbean plant at different days ($LSD_{(0.05)}$=1.74, 2.44, 1.86 and 0.64 at 20, 35, 50, and 70 DAS, respectively)

Table 2. Effect of row spacing and weeding methods interaction on the number of leaves of mungbean plant at different days

Treatment	Number of leaves per plant			
	20 DAS	**35 DAS**	**50 DAS**	**At harvest(70 DAS)**
S_1W_1	3.02	6.73	8.50	8.07
S_1W_2	3.00	5.20	6.20	5.67
S_1W_3	3.08	6.40	7.64	6.53
S_2W_1	3.31	6.20	8.19	7.68
S_2W_2	3.13	6.00	6.58	6.17
S_2W_3	3.13	6.13	8.00	4.87
S_3W_1	3.46	6.60	7.92	7.60
S_3W_2	3.29	5.60	7.19	7.93
S_3W_3	3.18	6.33	7.33	6.37
S_4W_1	3.5	7.50	9.04	8.67
S_4W_2	3.06	5.53	6.55	7.40
S_4W_3	3.18	6.33	7.42	6.88
LSD(0.05)	0.8381	1.178	0.904	0.3076
CV (%)	7.62	7.62	9.26	7.47

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.3 leaf area index (LAI)

- **Effect of row spacing**

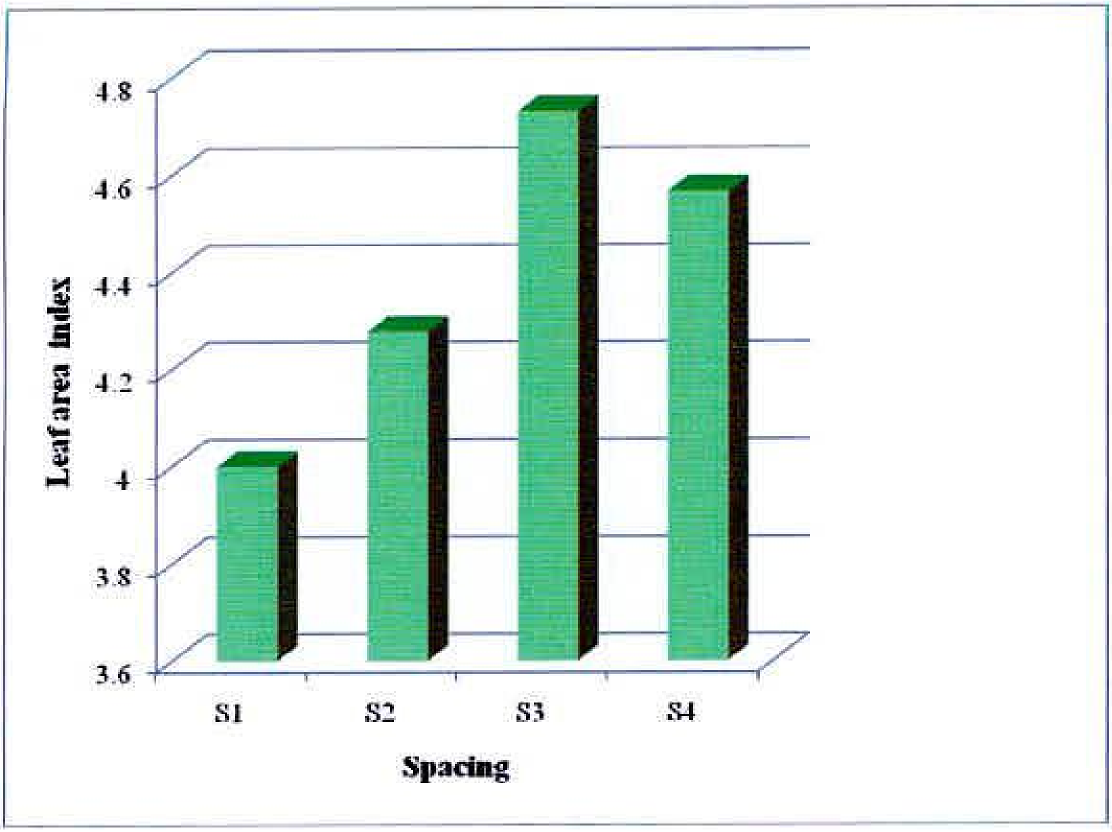
The leaf area index was significantly influenced by spacing. Treatment S_3 produced maximum leaf area index (4.73) followed by S_4 and the minimum (4.00) leaf area index was recorded in S_1 treatment (Figure 5). As the spacing was increased leaf area index was found to be increased.

- **Effect of weeding methods**

The leaf area index was not significantly influenced by various methods of weeding. The highest leaf area index (4.73) was obtained from W_1 and the lowest (4.15) from in W_2 (Fig. 6).

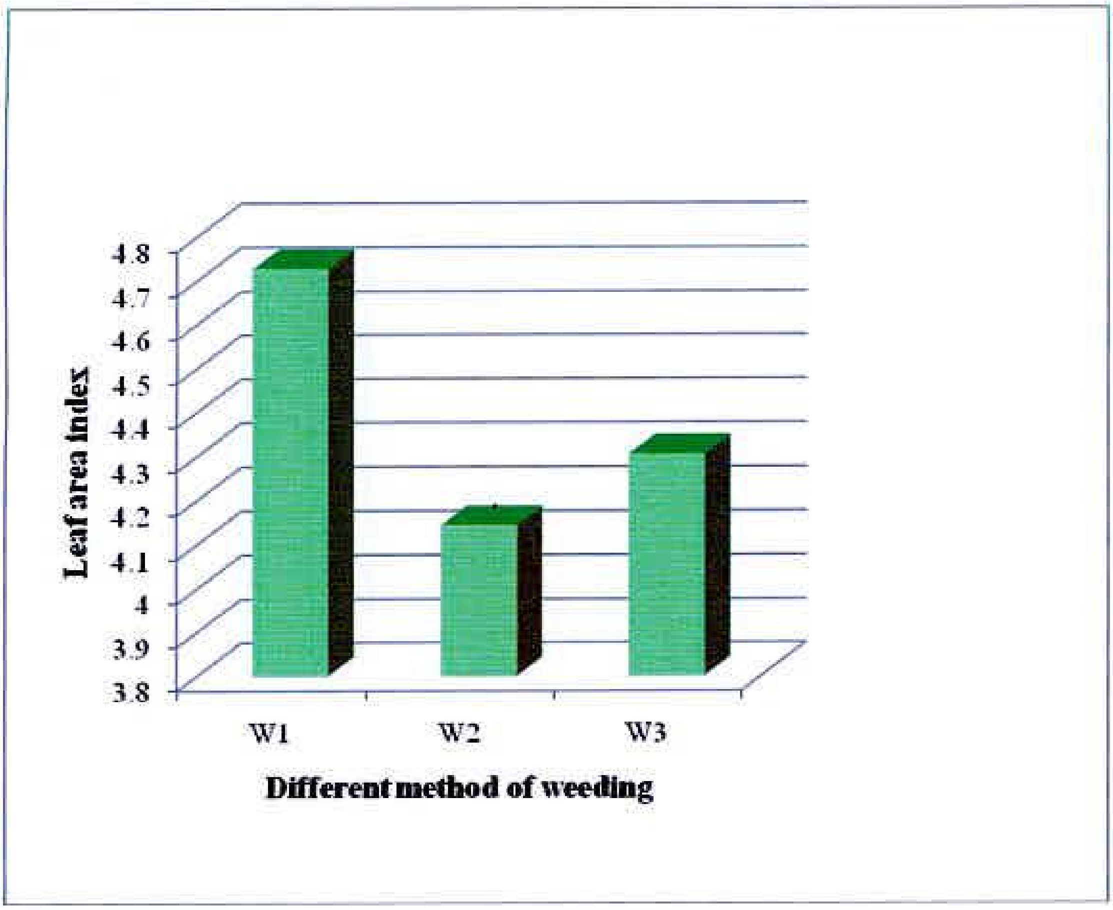
- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and different methods of weeding had a significant variation on leaf area index. The highest leaf area index (5.25) was obtained from S_3W_1 treatment while the lowest (3.90) with the 20 cm row spacing and raking (S_1W_2) combination (Table 3).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 5. Effect of row spacing on the leaf area index of mungbean plant ($LSD_{(0.05)}$=0.581)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure 6. Effect of weeding methods on the leaf area index of mungbean plant ($LSD_{(0.05)}$ = 0.786)

Table 3 Effect of row spacing and weeding methods interaction on the leaf area index of mungbean plant.

Treatment	Leaf area index
S_1W_1	4.10
S_1W_2	3.90
S_1W_3	4.00
S_2W_1	4.50
S_2W_2	4.03
S_2W_3	4.30
S_3W_1	5.25
S_3W_2	4.35
S_3W_3	4.59
S_4W_1	5.07
S_4W_2	4.29
S_4W_3	4.33
$LSD_{(0.05)}$	0.38
CV (%)	5.11

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.4 Dry weight of leaf per plant

- **Effect of row spacing**

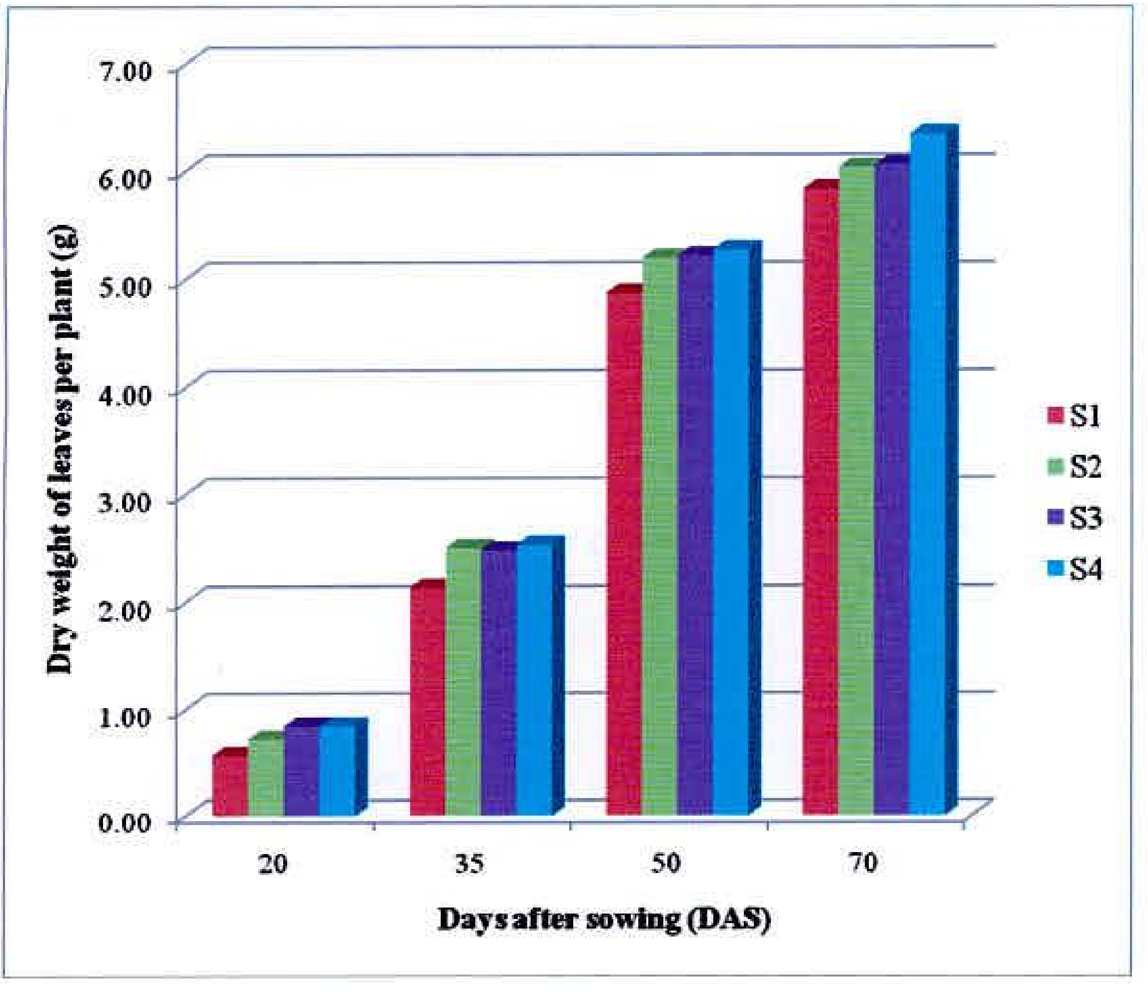
Row spacing had an insignificant variation on the dry weight of leaves per plant. The highest dry weight of leaves per plant (0.84, 2.53, 5.27 and 6.34 g at 20, 35, 50 and 70 DAS, respectively) was recorded in S_4 and the lowest (0.57, 2.13, 4.87 and 5.83 g at 20, 35, 50 and 70 DAS, respectively) in S_1 (Fig. 7).

- **Effect of weeding methods**

However, there was a significant variation in the dry weight of leaves per plant due to the different method of weeding. The maximum dry weight of leaves per plant (0.81, 2.58, 5.91 and 6.85 g at 20, 35, 50 and 70 DAS, respectively) was obtained from W_1 treatment and the minimum (0.71, 2.24, 4.53 and 5.55 g at 20, 35, 50 and 70 DAS, respectively) from W_2 treatment (Fig. 8).

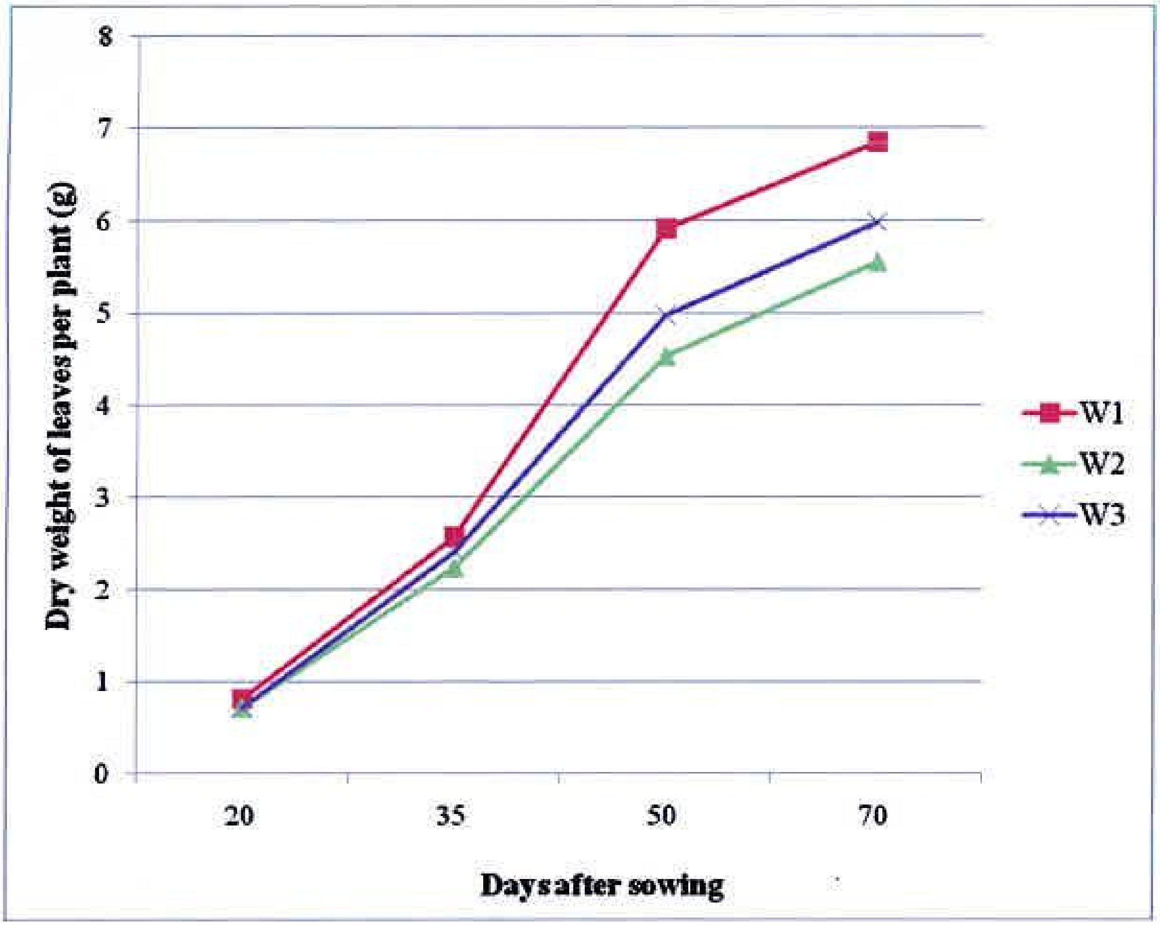
- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and methods of weeding had a significant variation on dry weight of leaves per plant. The highest dry weight of leaves per plant (0.96, 2.90, 6.38 and 7.23 g at 20, 35, 50 and 70 DAS, respectively) was obtained from S_4W_1 treatment while the lowest (0.52, 2.07, 3.88 and 4.97 g at 20, 35, 50 and 70 DAS, respectively) from S_1W_3 combination (Table 4).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 7. Effect of row spacing on the dry weight of leaf of mungbean plant at different days ($LSD_{(0.05)}$= 0.18, 0.69, 1.09 and 0.93 at 20, 35, 50, and 70 DAS, respectively)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure 8. Effect of weeding methods on the dry weight of leaf of mungbean plant at different days ($LSD_{(0.05)}$= 0.248, 0.94, 1.48 and 1.252 at 20, 35, 50, and 70 DAS, respectively)

Table 4. Effect of row spacing and weeding methods interaction on the leaf dry weight of mungbean plant at different days

Treatment	Leaf dry weight (g/plant)			
	20 DAS	35 DAS	50 DAS	70 DAS
S_1W_1	0.62	2.22	5.98	6.88
S_1W_2	0.57	2.12	4.73	5.63
S_1W_3	0.52	2.07	3.88	4.97
S_2W_1	0.73	2.48	5.63	6.73
S_2W_2	0.72	2.33	4.12	5.43
S_2W_3	0.71	2.68	5.82	6.68
S_3W_1	0.92	2.70	5.63	6.95
S_3W_2	0.80	2.08	4.80	5.35
S_3W_3	0.77	2.62	4.45	5.58
S_4W_1	0.96	2.90	6.38	7.23
S_4W_2	0.80	2.44	4.46	5.78
S_4W_3	0.82	2.28	5.72	6.68
LSD(0.05)	0.12	0.45	0.71	0.60
CV (%)	9.36	11.02	8.19	5.81

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.5 Dry weight of stem per plant

➢ **Effect of row spacing**

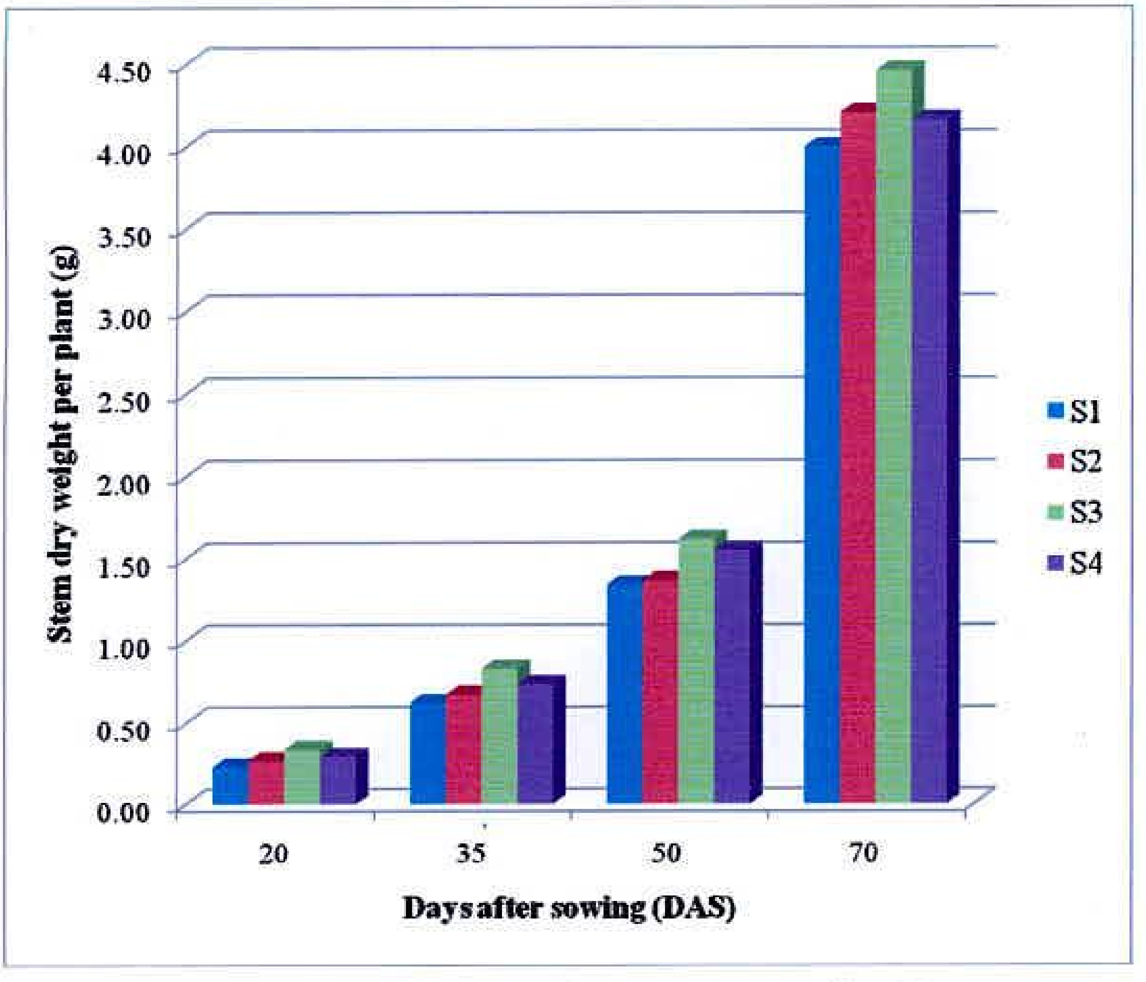
Row spacing did not show any significant variation on the dry weight of stem per plant. The highest dry weight of stem per plant (0.34, 0.83, 1.62 and 4.46 g at 20, 35, 50 and 70 DAS, respectively) was recorded in S_3 and the lowest (0.23, 0.62, 1.34 and 3.99 g at 20, 35, 50 and 70 DAS, respectively) in S_1 (Fig. 9).

➢ **Effect of weeding methods**

There was also an insignificant variation in the dry weight of stem per plant due to the methods of weeding. The maximum dry weight of stem per plant (0.29, 0.72, 1.55 and 4.23 g at 20, 35, 50 and 70 DAS, respectively) was obtained from W_1 treatment and the minimum (0.28, 0.67, 1.46 and 4.21 g at 20, 35, 50 and 70 DAS, respectively) from W_2 treatment (Fig. 10).

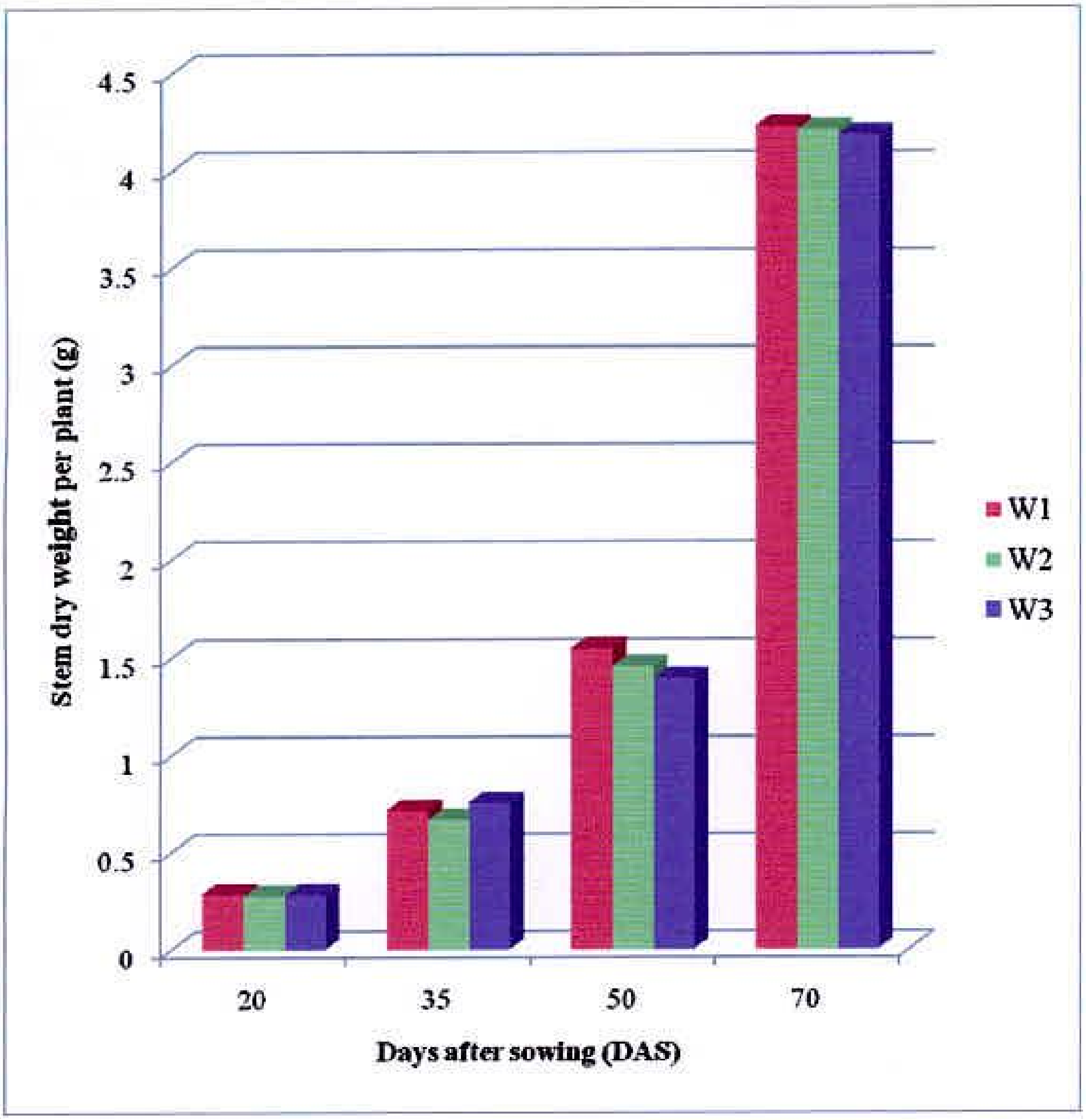
➢ **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and methods of weeding had a significant variation on dry weight of stem per plant. The highest dry weight of stem per plant (0.37, 0.91, 1.75 and 4.62 g at 20, 35, 50 and 70 DAS, respectively) was obtained from S_3W_1 treatment while the lowest (0.22, 0.58, 1.47 and 3.97 g at 20, 35, 50 and 70 DAS, respectively) from S_1W_2 (Table 5).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 9. Effect of row spacing on the dry weight of stem of mungbean plant at different days ($LSD_{(0.05)}$= 0.08, 0.20, 0.38 and 0.30 at 20, 35, 50, and 70 DAS, respectively)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure10. Effect of weeding methods on the dry weight of stem of mungbean plant at different days ($LSD_{(0.05)}$=0.11, 0.27, 0.51 and 0.40 at 20, 35, 50, and 70 DAS, respectively)

Table 5. Effect of row spacing and weeding methods interaction on the stem dry weight of mungbean at different days

Treatments	Stem dry weight (g $plant^{-1}$)			
	20 DAS	35 DAS	50 DAS	70 DAS
S_1W_1	0.23	0.63	1.33	4.00
S_1W_2	0.22	0.58	1.47	3.97
S_1W_3	0.24	0.65	1.22	4.02
S_2W_1	0.24	0.61	1.49	4.15
S_2W_2	0.26	0.59	1.32	4.37
S_2W_3	0.31	0.82	1.28	4.10
S_3W_1	0.37	0.91	1.75	4.62
S_3W_2	0.34	0.75	1.53	4.37
S_3W_3	0.30	0.83	1.57	4.39
S_4W_1	0.30	0.72	1.62	4.13
S_4W_2	0.29	0.76	1.52	4.13
S_4W_3	0.29	0.73	1.52	4.21
LSD (0.05)	0.05	0.13	0.25	0.19
CV (%)	8.65	10.57	9.88	2.70

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.6 Dry weight of root per plant

➢ **Effect of row spacing**

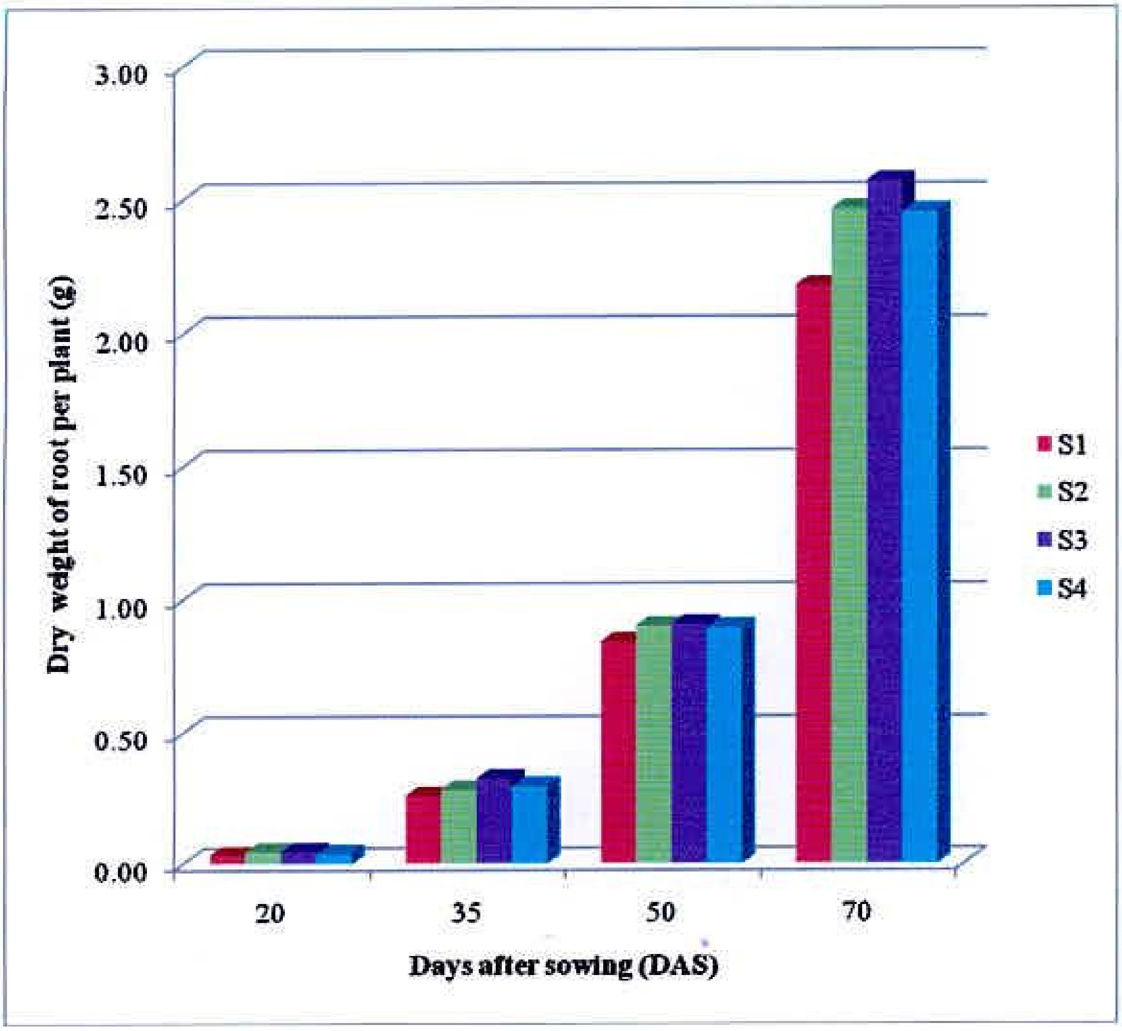
Row spacing had a significant variation on the dry weight of root per plant. The highest dry weight of root per plant (0.05, 0.32, 0.91 and 2.57 g at 20, 35, 50 and 70 DAS, respectively) was recorded in S_3 and the lowest (0.03, 0.26, 0.84 and 2.18 g at 20, 35, 50 and 70 DAS, respectively) in S_1 (Fig. 11).

➢ **Effect of weeding methods**

But, there was an insignificant variation in the dry weight of root per plant due to the different methods of weeding. The maximum dry weight of root per plant (0.05, 0.31, 0.89 and 2.51 g at 20, 35, 50 and 70 DAS, respectively) was obtained from W_1 treatment and the minimum (0.04, 0.27, 0.88 and 2.36 g at 20, 35, 50 and 70 DAS, respectively) from W_3 treatment (Fig. 12).

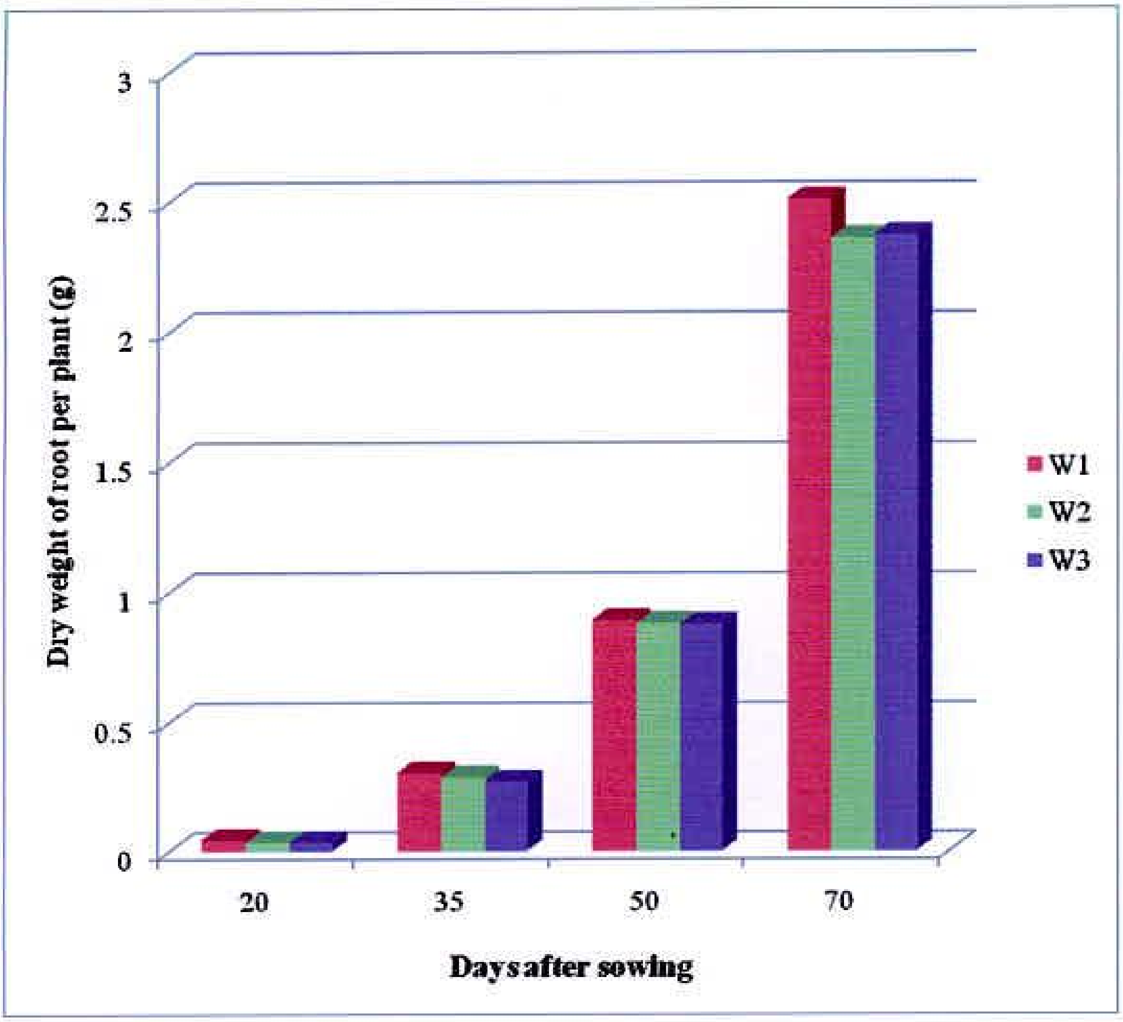
➢ **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and methods of weeding had a significant effect on dry weight of root per plant. The highest dry weight of root per plant (0.06, 0.37, 0.94 and 2.80 g at 20, 35, 50 and 70 DAS, respectively) was obtained from S_3W_1 treatment while the lowest (0.03, 0.25, 0.83 and 2.12 g at 20, 35, 50 and 70 DAS, respectively) from S_1W_2 (Table 6).



S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

Figure 11. Effect of row spacing on the dry weight of root of mungbean plant at different days ($LSD_{(0.05)}$= 0.03, 0.03, 0.08 and 0.20 at 20, 35, 50, and 70 DAS, respectively)



W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

Figure 12. Effect of weeding methods on the dry weight of root of mungbean plant at different days ($LSD_{(0.05)}$=0.04, 0.04, 0.11 and 0.2742 at 20, 35, 50, and 70 DAS, respectively)

Table 6. Effect of row spacing and weeding methods interaction on the root dry weight of mungbean at different days

Treatments	Root dry weight (g $plant^{-1}$)			
	20 DAS	35 DAS	50 DAS	70 DAS
S_1W_1	0.03	0.27	0.84	2.14
S_1W_2	0.03	0.25	0.83	2.12
S_1W_3	0.03	0.26	0.85	2.27
S_2W_1	0.05	0.30	0.92	2.60
S_2W_2	0.04	0.31	0.91	2.43
S_2W_3	0.04	0.30	0.89	2.47
S_3W_1	0.06	0.37	0.94	2.80
S_3W_2	0.05	0.27	0.87	2.41
S_3W_3	0.04	0.28	0.88	2.38
S_4W_1	0.04	0.31	0.89	2.71
S_4W_2	0.04	0.31	0.91	2.47
S_4W_3	0.04	0.26	0.89	2.38
LSD(0.05)	NS	0.07	0.05	0.13
CV (%)	12.54	5.80	2.71	3.40

S_1W_1= 20 cm spacing + Hand weeding

S_1W_2= 20 cm spacing + Raking

S_1W_3= 20 cm spacing + Wheat straw mulching

S_2W_1= 25 cm spacing + Hand weeding

S_2W_2= 25 cm spacing + Raking

S_2W_3= 25 cm spacing + Wheat straw mulching

S_3W_1= 30 cm spacing + Hand weeding

S_3W_2= 30cm spacing + Raking

S_3W_3= 30 cm spacing + Wheat straw mulching

S_4W_1= 35cm spacing + Hand weeding

S_4W_2= 35 cm spacing + Raking

S_4W_3= 35 cm spacing + Wheat straw mulching

4.7 Dry weight of weed per m^2

- **Effect of row spacing**

Row spacing did not have significant effect on the dry weight of weed per m^2. The highest dry weight of weed per m^2 (68.27 g) was recorded in S_4 and the lowest (58.43 g) in S_1 (Table 7).

- **Effect of weeding methods**

But, there was a significant variation in the dry weight of weeds per m^2 due to the different method of weeding. The maximum dry weight of weeds per m^2 (100.15 g) was obtained from W_2 treatment and the minimum (12.32 g) in W_1 treatment (Table 7).

- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and methods of weeding had a significant variation on dry weight of weeds per m^2. The highest dry weight of weed per m^2 (112.52 g) was obtained from S_4W_2 treatment while the lowest (10.80 g) from S_1W_1 (Table 7).

4.8 Number of pods per plant

- **Effect of row spacing**

Number of pods per plant is one of the most important yield contributing characters in mungbean. Row spacing had a significant variation on the number of pods per plant. The highest number of pods per plant (11.78) was recorded in S_3 and the lowest (9.39) in S_1 (Table 8).

- **Effect of weeding methods**

However, there was no significant variation in the number of pods per plant due to the methods of weeding. Numerically maximum number of pods per plant (11.05) was obtained from W_1 treatment and the minimum (10.64) was obtained in W_2 treatment (Table 8).

Table 7. Effect of row spacing and weeding methods interaction on the weed dry weight (g) of mungbean (35 DAS)

Treatment	Weed dry weight (g)
Spacing (S)	
S_1	58.43
S_2	58.47
S_3	62.76
S_4	68.27
$LSD_{(0.05)}$	NS
Weeding method (W)	
W1	12.32
W2	100.15
W3	73.48
LSD(0.05)	5.16
Interaction (S × W)	
S_1W_1	10.80
S_1W_2	93.05
S_1W_3	71.57
S_2W_1	11.48
S_2W_2	92.23
S_2W_3	71.59
S_3W_1	12.15
S_3W_2	102.82
S_3W_3	73.30
S_4W_1	14.83
S_4W_2	112.52
S_4W_3	77.47
LSD(0.05)	2.49
CV (%)	2.37

S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and different method of weeding had a significant variation on number of pods per plant. The highest number of pods per plant (12.45) was obtained from S_3W_1 treatment while the minimum (9.07) from S_1W_2 combination (Table 8).

4.9 Number of seeds per pod

- **Effect of row spacing**

The number of seeds per pod was not significantly affected by row spacing. The highest number of seeds per pod (12.66) was recorded in S_3 and the minimum (11.73) in S_1 (Table 8). BARI (1983) reported that density of lentil did not significantly influence the number of seeds per pod.

- **Effect of weeding methods**

Like row spacing treatment, there was no significant variation in the number of seeds per pod due to the different method of weeding. The maximum number of seeds per pod (12.19) was obtained from W_1 treatment which was followed by W_3 and the minimum (12.05) was from W_2 treatment (Table 8).

- **Effect of interaction of row spacing and weeding methods**

Interaction effect of different row spacing and methods of weeding had a significant effect on number of seeds per pod. The highest number of seeds per pod (13.07) was obtained from S_3W_1 treatment while the lowest (11.20) from S_1W_2 (Table 8).

Table 8. Effect of row spacing and weeding method interaction on the yield contributing characters of mungbean

Treatment	pod per plant	Seeds per pod	Thousad seed weight (g)	Seed yield (t ha $^{-1}$)	Harvest index (%)
Spacing (S)					
S_1	9.39	11.73	37.42	1.26	21.48
S_2	10.56	12.19	38.85	1.31	24.26
S_3	11.78	12.66	40.24	1.33	25.91
S_4	11.60	11.88	37.53	1.02	19.55
$LSD_{(0.05)}$	1.24	NS	0.87	0.31	3.81
Weeding method (W)					
W1	11.05	12.19	39.98	1.34	23.91
W2	10.64	12.05	36.89	1.13	21.8
W3	10.82	12.11	38.66	1.22	22.69
LSD(0.05)	1.67	NS	NS	NS	NS
Interaction (S × W)					
S_1W_1	9.60	11.40	38.07	1.30	23.92
S_1W_2	9.07	11.20	36.20	1.15	20.20
S_1W_3	9.50	11.40	38.00	1.25	20.34
S_2W_1	10.60	12.50	40.30	1.41	23.98
S_2W_2	10.36	11.80	37.15	1.20	23.11
S_2W_3	10.73	12.28	39.10	1.33	25.69
S_3W_1	12.45	13.07	41.10	1.47	27.74
S_3W_2	11.39	12.41	39.15	1.22	24.97
S_3W_3	11.50	12.50	40.47	1.30	24.38
S_4W_1	11.55	11.80	40.47	1.10	19.37
S_4W_2	11.73	11.83	35.07	0.95	18.91
S_4W_3	11.53	12.00	37.07	1.00	20.37
LSD(0.05)	0.81	0.77	0.56	0.20	2.48
CV (%)	4.84	3.72	3.26	9.43	6.42

S_1= 20 cm S_2= 25 cm S_3= 30 cm S_4= 35 cm

W_1= Hand weeding W_2= Raking W_3= Wheat straw mulching

4.10 1000 seed weight

- **Effect of row spacing**
- Thousand seed weight of mungbean (BARI mung-5) differed significantly due to row spacing. The highest thousand seed weight (40.24 g) was obtained from S_3 and the minimum (37.42 g) from S_1 (Table 8).

- **Effect of weeding methods**

There was no significant variation in the thousand seed weight due to the methods of weeding. The maximum thousand seed weight (39.98) was obtained from W_1 treatment which was followed by W_3 and the minimum (36.89 g) from W_2 (Table 8).

- **Effect of interaction of row spacing and weeding methods**

Combined effect of different row spacing and methods of weeding had a significant variation on thousand seed weight. The highest thousand seed weight (41.10 g) was obtained from S_3W_1 treatment while the lowest (35.07 g) from S_4W_2 combination (Table 8).

4.11 Seed yield (t ha^{-1})

- **Effect of row spacing**

The seed yield per hectare was significantly affected by row spacing (Table 8). The maximum seed yield per hectare (1.33 tons) was observed in S_3, which was statistically similar to S_2. The lowest yield per hectare (1.02 ton) was observed from S_4 (Table 8).

- **Effect of weeding methods**

But, there was no significant variation in the seed yield per hectare due to the methods of weeding. The maximum seed yield per hectare (1.34 ton) was obtained from W_1 treatment and the minimum (1.13) was obtained in W_2 treatment (Table 8).

- **Effect of interaction of row spacing and weeding methods**

Combined effect of different row spacing and methods of weeding had a significant variation on seed yield per hectare. The highest seed yield per hectare (1.47 ton) was obtained from S_3W_1 treatment while the lowest (0.95 ton) from S_4W_2 combination (Table 8).

4.12 Harvest index (HI)

- **Effect of row spacing**

Harvest index indicates the partitioning of dry matter between reproductive and vegetative part. The ratio of economic yield to biological yield is termed as harvest index. Higher HI might be beneficial in obtaining higher economic yield. A significant increase in HI of was found in mungbean due to different row spacing. The highest HI of 25.91% was observed in treatment S_3 (30 cm row spacing) and the lowest (19.55%) from S_4 (Table 8).

- **Effect of weeding methods**

There was no significant variation in harvest index due to the methods of weeding. The maximum HI (23.51%) was obtained from W_1 treatment and the minimum (21.80%) was obtained in W_2 treatment (Table 8).

- **Effect of interaction of row spacing and weeding methods**

Combined effect of different row spacing and different method of weeding had a significant variation on HI. The highest HI (27.74%) was obtained from S_3W_1 treatment while the lowest (18.91%) from S_4W_2 (Table 8).

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

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This experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, during the period of *Kharif*-1 season from March to June, 2007 to study the effect of row spacing and methods of weeding on the yield of mungbean (cv. BARI mung-5). In experiment, the treatment consisted of four row spacing viz. S_1 (20 cm), S_2 (25 cm), S_3 (30 cm) and S_4 (35 cm) and three different weeding method viz. W_1 (hand weeding), W_2 (raking) and W_3 (wheat straw mulching).

The experiment was laid out in a two factors randomized complete block design (RCBD) with three replications. The seeds of BARI mung-5 variety were sown. Seeds were sown at the rate of 45 kg ha^{-1} in the furrow. The land was fertilized with N, K_2O, P_2O_5 Ca and S @ 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. Necessary intercultural operations were done as and when necessary.

Results showed that a significant variation was observed among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect.

In the study, it was observed that the plant height was not significantly affected due to the different spacing. The tallest plant height (25.17, 50.53 67.13 and 71.52 cm at 20, 35, 50, and 70 DAS, respectively) was obtained from spacing S_1 (20 cm). The plant height was significantly affected due to the different method of weeding. The tallest plant (26.27, 55.56, 73.57 and 78.21 cm at 20, 35, 50, and 70 DAS, respectively) was obtained from W_3 (mulching with wheat straw) treatment and the shortest (20.25, 42.87, 57.25 and 62.3 cm at 20, 35, 50 and 70 DAS, respectively) from W_2 (weeding method of raking).

Interaction effect of different row spacing and methods of weeding had a significant variation on plant height. The tallest plant (28.92, 59.11, 77.33 and 80.93 cm at 20, 35, 50 and 70 DAS, respectively) was obtained from S_1W_3 (20 cm row spacing with mulching).

Number of leaves was not significantly influenced by row spacing. The highest number of leaves was obtained from S_4 (35cm). Number of leaves per plant was significantly influenced by methods of weeding. The highest number of leaves (3.30, 6.76, 8.41 and 8.50 at 20, 35, 50 and 70 DAS, respectively) was obtained from W_1 (hand weeding). Interaction effect of different spacing and methods of weeding had a significant variation on number of leaves per plant. The highest number of leaves (3.5, 7.5, 9.04 and 8.67 at 20, 35, 50 and 70 DAS, respectively) was obtained from S_4W_1 treatment.

Dry weight of leaves, dry weight of stem and dry weight of root per plant were not significantly influenced by different spacing. The highest dry weight of leaves per plant was recorded in S_4 (35 cm). The highest dry weight of stem per plant was recorded in S_3 (30 cm). Dry weight of root per plant was significantly influenced by different spacing. The highest dry weight of root per plant was recorded in S_3 (30 cm). Dry weight of leaves per plant was significantly influenced by methods of weeding. Dry weight of stem and dry weight of root per plant were not significantly influenced by methods of weeding. The highest dry weight of leaves, dry weight ofstem, and dry weight of root per plant was recorded in W_1 (35 cm). Interaction effect of different spacing and methods of weeding had a significant variation on dry weight of leaves, dry weight of stem, and dry weight of root per plant. The highest dry weight of leaves per plant was obtained from S_4W_1. The highest dry weight of stem and root per plant were obtained from S_3W_1 treatment.

The dry weight of weed per m^2 was not significantly influenced by different spacing. The highest (68.27 g) dry weight of weed per m^2 was recorded in S_4. There was a significant variation in the dry weight of weeds per m^2 due to the methods of weeding. The maximum dry weight of weeds per m^2 (100.15 g) was obtained from W_2 treatment. Interaction effect of different row spacing and methods of weeding had a significant variation on dry weight of weeds per m^2. The highest dry weight of weed per m^2 (112.52 g) was obtained from S_4W_2 treatment.

Number of pods per plant was significantly influenced by row spacing. The highest number of pods per plant (11.78) was recorded in S_3. There was not significant variation in the number of pods per plant due to the different methods of weeding. The maximum number of pods per plant (11.05) was obtained from W_1 treatment. Interaction effect of different row spacing and methods of weeding had a significant variation on number of pods per plant. The highest number of pods per plant (12.45) was obtained from S_3W_1 treatment.

The number of seeds per pod was not significantly affected by row spacing but thousand seed weight of mungbean (BARI mung-5) were significantly affected by row spacing. The highest number of seeds per pod and thousand seed weight were recorded in S_3. The number of seeds per pod and thousand seed weight of mungbean (BARI mung-5) were not significantly affected by methods of weeding. The maximum number of pods per plant and thousand seed weight were obtained from W_1 treatment. Interaction effect of different row spacing and methods of weeding had a significant variation on number of seeds per pod and thousand seed weight. The highest number of seeds per pod and thousand seed weight were obtained from S_3W_1 treatment.

The seed yield per hectare was also significantly affected by row spacing. The maximum seed yield per hectare (1.33 tons) was observed in S_3. There was not significant variation in the seed yield per hectare due to the different method of weeding. The maximum seed yield per hectare (1.34 ton) was obtained from W_1 treatment. Combined effect of different row spacing and methods of weeding had a significant variation on seed yield per hectare. The highest seed yield per hectare (1.47 ton) was obtained from S_3W_1 treatment.

A significant increase in harvest index (HI) was found in mungbean due to different row spacing. The highest HI of 25.91% was observed in treatment S_3 (30 cm row spacing). There was not significant variation in the harvest index due to the different methods of weeding. The maximum HI (23.51%) was obtained from W_1 treatment which was followed by W_3. Combined effect of different row spacing and methods of weeding had a significant variation on HI. The highest HI (28.38%) was obtained from S_3W_1 treatment

From the results of the study, it may be concluded that the performance of mungbean cv. BARI mung-5 was better in respect of growth, yield and yield components when sown at 30 cm row spacing followed by hand weeding. 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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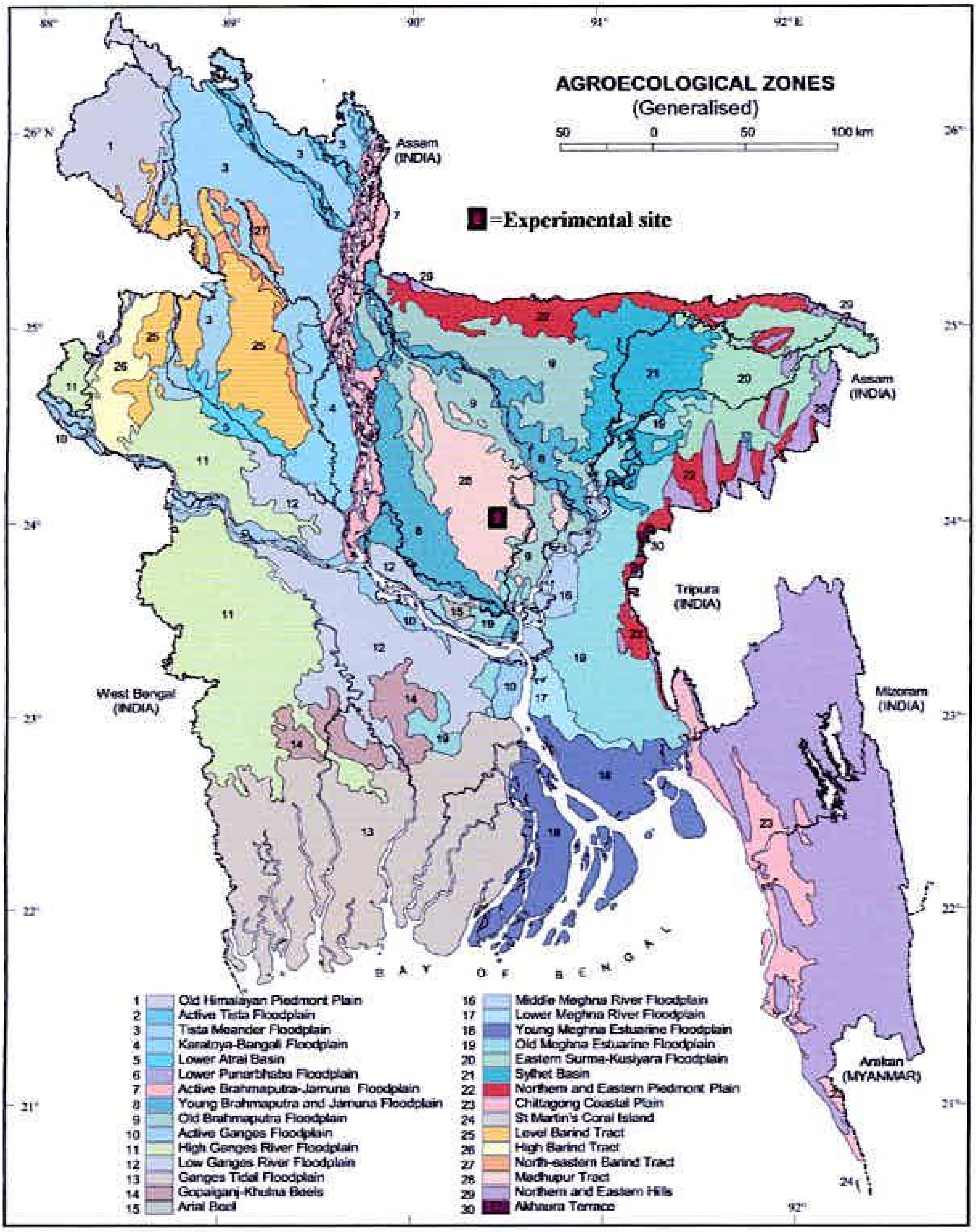
Appendices

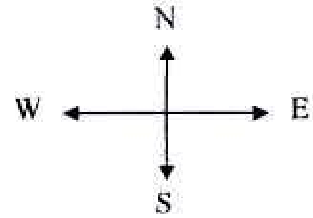
APPENDICES

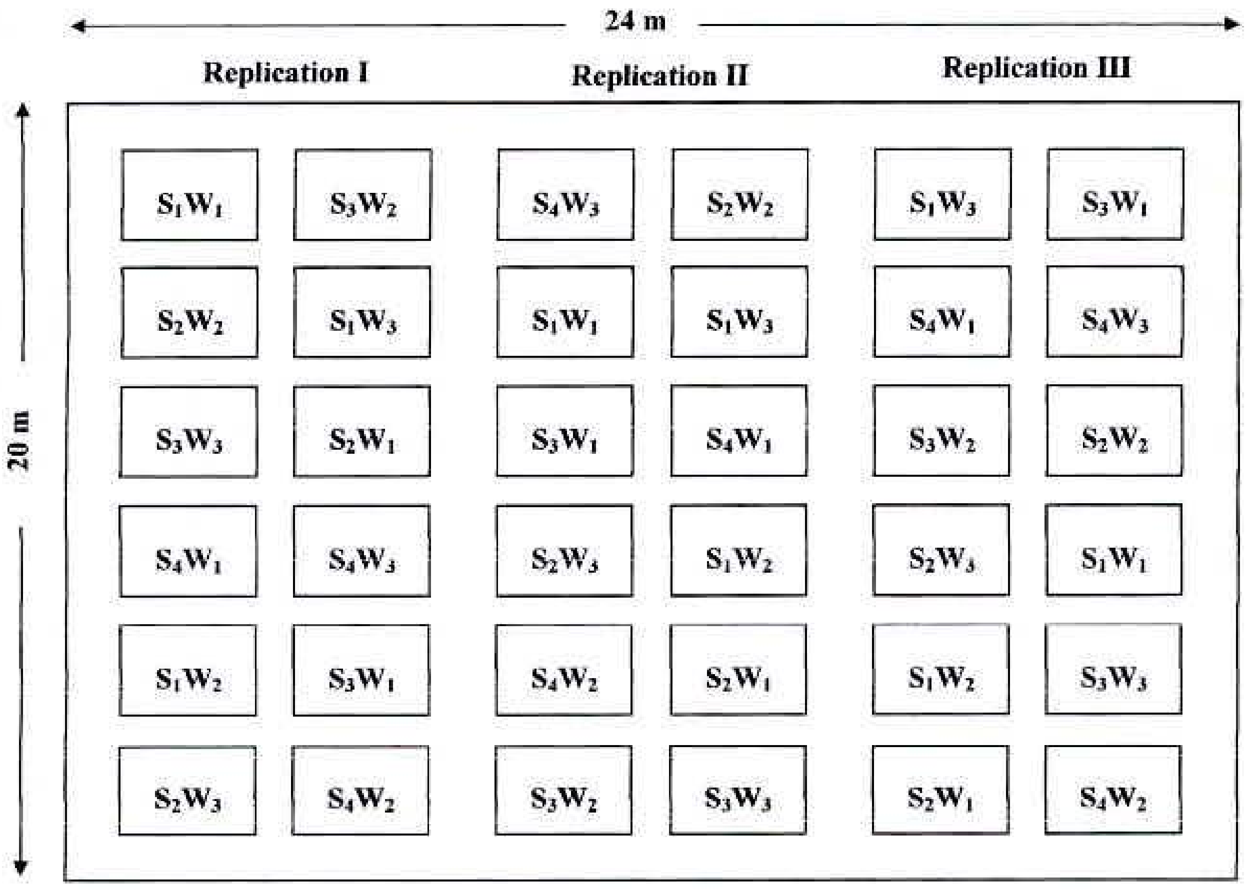
Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Design of the experimental plot

Plot size = 3.5 m × 2.5 m
Plot to plot distance = 0.5 m
Replication to replication distance = 1m





Appendix III. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from March to July 2007

Month	Air temperature (^0C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
March 2007	31.25	21.55	26.40	74.65	35
April 2007	32.98	23.72	28.35	88.24	65
May 2007	34.00	24.65	34.33	79.55	155
June 2007	33.85	26.15	30.0	69.05	184
July 2007	34.20	24.50	29.35	89.5	281

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth).

Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	**Value**
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix V. Analysis of variance of the data on plant height of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Plant height			
		20 DAS	35 DAS	50 DAS	At harvest
Replication	2	2.734	10.651	2.898	1.431
Factor A	3	5.043^{NS}	14.935^{NS}	31.616^{NS}	20.25^{NS}
Factor B	2	84.768*	432.33*	715.081*	672.091*
AB	6	3.439*	10.821*	3.894*	6.089*
Error	22	1.08	7.257	4.595	2.781

* = Significant at 5% level of probability
NS = Non Significant

Appendix VI. Analysis of variance of the data on number of leaf per plant of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Number of leaf per plant				Leaf area index
		20 DAS	35 DAS	50 DAS	At harvest	
Replication	2	0.243	0.243	0.243	0.243	5.135
Factor A	3	0.169^{NS}	0.169^{NS}	0.169^{NS}	0.169^{NS}	0.933*
Factor B	2	1.56^{NS}	1.56^{NS}	1.56^{NS}	1.56^{NS}	1.093^{NS}
AB	6	0.124*	0.124*	0.124*	0.124*	0.106*
Error	22	0.245	0.245	0.245	0.245	0.05

* = Significant at 5% level of probability
NS = Non Significant

Appendix VII. Analysis of variance of the data on leaf dry weight of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Leaf dry weight			
		20 DAS	35 DAS	50 DAS	At harvest
Replication	2	0.014	0.014	0.014	0.014
Factor A	3	0.134*	0.134*	0.134*	0.134*
Factor B	2	0.016^{NS}	0.016^{NS}	0.016^{NS}	0.016^{NS}
AB	6	0.002*	0.002*	0.002*	0.002*
Error	22	0.005	0.005	0.005	0.005

* = Significant at 5% level of probability
NS = Non Significant

Appendix VIII. Analysis of variance of the data on stem dry weight of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Stem dry weight			
		20 DAS	35 DAS	50 DAS	At harvest
Replication	2	0.007	0.037	0.008	0.057
Factor A	3	0.015*	0.06*	0.167^{NS}	0.332^{NS}
Factor B	2	0^{NS}	0.022^{NS}	0.07^{NS}	0.006^{NS}
AB	6	0.002*	0.013*	0.022*	0.04*
Error	22	0.001	0.006	0.021	0.013

* = Significant at 5% level of probability
NS = Non Significant

Appendix IX. Analysis of variance of the data on root dry weight of mungbean plant and weed dry weight per m^2 as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Root dry weight				Weed dry weight
		20 DAS	35 DAS	50 DAS	At harvest	
Replication	2	0	0	0	0.021	16.835
Factor A	3	0^{NS}	0.003*	0.009^{NS}	0.189*	195.254
Factor B	2	0^{NS}	0.001^{NS}	0.001^{NS}	0.024^{NS}	24335.9
AB	6	0^{NS}	0.001*	0.002*	0.021*	55.314
Error	22	0	0	0.001	0.006	2.159

* = Significant at 5% level of probability
NS = Non Significant

Appendix X. Analysis of variance of the data on number of pods per plant, number of seeds per pod, thousand seed weight of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Pods per plant (No.)	Seeds per pod (No.)	Thousand seed weight (g)
Replication	2	0.113	0.005	0.609
Factor A	3	10.945*	1.512^{NS}	15.725*
Factor B	2	0.519*	0.064^{NS}	28.87^{NS}
AB	6	0.295*	0.579*	2.468*
Error	22	0.227	0.207	0.11

* = Significant at 5% level of probability
NS = Non Significant

Appendix XI. Analysis of variance of the data on seed yield, harvest index of mungbean plant as influenced by row spacing and methods of weeding

Source of Variance	Degrees of Freedom	Seed yield (t ha $^{-1}$)	Harvest Index
Replication	2	0.017	4.716
Factor A	3	0.19*	72.244*
Factor B	2	0.138^{NS}	13.524^{NS}
AB	6	0.002*	6.89*
Error	22	0.014	2.145

* = Significant at 5% level of probability
NS = Non Significant

Appendix XII. Plates

Plate 1. Photograph showing the plot weeded by hand weeding

Plate 2. Photograph showing the plot weeded by wheat straw mulching

Plate 3. Photograph showing the plot weeded by raking