PERFORMANCE OF GROUNDNUT UNDER DIFFERENT PLANT POPULATION AND WEED MANAGEMENT

MD. MAMUNUR RASHID

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

JULY-DECEMBER, 2014

PERFORMANCE OF GROUNDNUT UNDER DIFFERENT PLANT POPULATION AND WEED MANAGEMENT

BY

MD. MAMUNUR RASHID

Registration No.: 08-02666

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRONOMY

SEMESTER: JULY -DECEMBER, 2014

Approved by:

(Prof. Dr. Md. Fazlul Karim)	**(Assoc. Prof. Dr. Mirza Hasanuzzaman)**
Supervisor	**Co-supervisor**

(Prof. Dr. Md. Fazlul Karim)

Chairman
Examination Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 9110351 & 9144270-79

CERTIFICATE

*This is to certify that the thesis entitled"**PERFORMANCE OFGROUNDNUT UNDER DIFFERENT PLANT POPULATION AND WEED MANAGEMENT**"submitted to theDepartment 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.MAMUNUR RASHID**, Registration. No. **08-2666**, 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 and style of this thesis have been approved and recommended for submission.

Date:(Prof. Dr. Md. FazlulKarim)
Place: Dhaka, BangladeshSupervisor
Dept. of Agronomy
SAU, Dhaka

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

Alhamdulillahi Rabbil Al-Amin, all praises goes to Almighy Allah, the Supreme Ruler of the universe who enabled the Author to complete the present piece of work and the thesis leading to Master of Science in Agronomy.

The author would like to express his heartfelt gratitude and most sincere appreciations to his Supervisor Professor Dr. Md. Fazlul Karim, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his scholastic guidance, careful planning, valuable suggestions, advice, continuous encouragements, all kind of help and support throughout the period of research work and preparation of this manuscript. Likewise grateful appreciation is conveyed to Co-supervisor Dr. Mirza Hasanuzzaman, Associate Professor, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.

The author also would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

The author wishes to extend his special thanks to Ahsan Habib, Esratunnesa Easha, Sonia, Md. Sujon Ali Sheikh for their help during experimentation. Special thanks to all other friends for their support and encouragement to complete this research works.

The author is deeply indebted and grateful to his parents, sister and other relative's for their moral support, encouragement and love with cordial understanding.

Finally the author express his heart full appreciation towards the staffs of the Department of Agronomy and farm, Sher-e-Bangla Agricultural University, Dhaka, for their logistic support, without which cooperation research work was not possible successfully.

PERFORMANCE OF GROUNDNUT UNDER DIFFERENT PLANT POPULATION AND WEED MANAGEMENT

ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during November 2013 to April 2014 to study the effect of row spacing and weed management on the performance of groundnut (cv. BARI Chinabadum-8). The experiment comprised of two factors viz., (i) plant spacing and (ii) weed management with three levels of plant spacing (S_1 = 20 cm × 15 cm, S_2 = 30 cm × 15 cm, S_3 = 40 cm × 15 cm) and five levels of weeding treatments (W_0= No weeding, W_1= Hand weeding at 20 DAS, W_2 = Hand weeding at 20 and 45 DAS, W_3= Pre emergence herbicide, Sunup 480 SL spraying after land preparation, W_4 = Post emergence herbicide, Release 9 EC spraying at 20 DAS . Results revealed that plant spacing with 30 cm × 15 cm stand superior than other in respect of plant height (33.67 cm) above ground dry matter weight plant^{-1} (30.35 g), kernel pod^{-1} (1.63), pods plant^{-1} (14.87), 1000-seeds weight (455.13 g), shelling % (67.80), pod yield (1.78 t ha^{-1}), stover yield (3.38 t ha^{-1}), biological yield (4.86 t ha^{-1}) and harvest index (35.91 %) respectively while maximum number of branches plant^{-1} (8.27) and leaves plant^{-1} (85.95) were found in 40 cm × 15 cm spacing at harvest. Among 5 weed management practices, the highest plant height (38.14 cm), branches plant^{-1} (9.95), leaves plant^{-1} (111.10), dry matter content plant^{-1} (40.46 g), kernel pod^{-1} (1.75), pods plant^{-1} (19.05), 1000-seeds weight (481.22 g), shelling % (71.11), pod yield (2.21 t ha^{-1}), stover yield (3.47 t ha^{-1}), Biological yield (5.69 t ha^{-1}), and harvest index (38.85 %) were obtained by 2 hand weeding management practice at harvest. In interaction, the maximum plant height (39.40 cm), dry matter content plant^{-1} (44.71g), branches plant^{-1} (11.00), leaves plant^{-1} (120.17), kernel pod^{-1} (1.77), pods plant^{-1} (21.14), 1000-seeds weight (495.33g), shelling % (72.21), pod yield (2.48 t ha^{-1}), stover yield (3.86 t ha^{-1}), biological yield (6.02 t ha^{-1}) and harvest index (41.11%) were induced with 30 cm × 15 cm row spacing followed by 2 hand weeding at harvest.

LIST OF CONTENTS

LIST OF CONTENTS

LIST OF CONTENTS

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
$^{\circ}$C	=	Degree Centigrade
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
DAS	=	Days after sowing
DF	=	Degrees of Freedom
et al.	=	and others *(at elli)*
g	=	gram (s)
HI	=	Harvest Index
kg	=	Kilogram
kg ha^{-1}	=	Kilogram per hectare
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
m	=	Meter
No	=	Number
NS	=	Non Significant
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resource Development Institute
t ha^{-1}	=	ton hectare^{-1}
TSP	=	Triple Super Phosphate
%	=	Percent

Chapter I

Introduction

CHAPTER I

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) under the family of Fabaceae is the most important oil seed crop in the world. It is an annual legume which is known as peanut and it is the 13th most important food crop and 4th most important oil seed crop of the world (Vijaya *et al.,* 1997). The cultivated area of groundnut is 25.2 million hectares with a total production of 35.9 million metric tons (FAO, 2006). Asia alone produces 17.9 million tons, 70% of global production. It is grown over 20 million hectares in the tropical and sub tropical part of about one hundred countries in the world. The total annual world production amounts to about 25 million tons of unshelled nuts, 70% of which is contributed by India, China and U.S.A. (Khidir, 1997; El Naim *et al.,* 2010). Groundnut is essentially a tropical plant and requires a long and warm growing season. The favorable climate for groundnut is a well-distributed rainfall of at least 500 mm during the crop-growing season, and with abundance of sunshine and relatively warm temperature. Temperature in the range of 25 to 30º C is optimum for plant development (Weiss, 2000).

It is an excellent source of plant nutrients contains 45-50% oil, 27-33% protein as well as essential minerals and vitamins (Ahmed M. El Naim *et al.,* 2011). They play an important role in the dietary requirements of resource poor women and children and stovers are used as livestock feed. Groundnut oil is composed of mixed glycerides and contains a high proportion of unsaturated fatty acids, in particular, oleic (50-65%) and linoleic (18-30%) (Young, 1996). The oil of groundnut is one of the most important vegetable oil in regions where other oily vegetables cannot grow up (Norman *et al*., 2005; Samrat, 1994). Increasing of global demands this crop from one side and various productions and by-products from the other side determine the economic importance of this crop (Samrat, 1994). In Bangladesh, it occupies third place in respect of area and production after mustard and sesame. In rabi and kharif seasons a total of about 36 thousands hectare of land in under groundnut cultivation. In the river bank or in the char areas it is mainly grown where no other crops are grown. The main problem limiting production of groundnut in Bangladesh is poor cultural practices where optimum spacing and weed management (Easha, 2014). Spacing is average distance between seeds in a given row of planted seeds. Weeds are those plants which are out of place, unwanted, non-useful, often prolific and persistent, competitive, harmful, even poisonous which interfere with agricultural operation, increase labour, add to costs, reduce yields and detract from comforts of life (Crafts and Robbins, 1973). According to Americanos (1994) groundnut crop is highly sensitive to competition by weeds and yield reduction could be severe reaching up to 70 per cent. Yield loss due to weed infestation amounts to 80 per cent in groundnut (Murthy *et al*., 1994) Weeds are potential competitors with crops for nutrients, moisture, light and space. Weeds reduce yields by competing with the groundnut plant for resources, such as sunlight, space, moisture, and nutrients (Upadhyay, 1984) not only throughout the growing season, but also create problem during digging and inverting procedures and reduce harvesting efficiency. Considering the above fact the experiment will be conducted with following objectives.

i. To study the influence of plant spacing on growth and yield of groundnut.
ii. To determine methods of weed control for maximum yield of groundnut
iii. To find out the combined effect of plant population and weed management on growth and yield of groundnut.

Chapter II

Review of literature

CHAPTER II
REVIEW OF LITERATURE

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

2.1 Effect of different level of plant spacing

2.1.1 Effect on growth characters

2.1.1.1 Plant height

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

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

Nwokwu (2011) reported that the highest groundnut plant height was obtained at the the closest spacing (20x15cm) and least and no significant different widest spacing (30 cm × 15 cm) and (40 cm × 15 cm).

The increasing plant height at closer spacing might have been caused due to increased plant population density. The higher population density caused mutual shading in plants that contributed to stem elongation and ultimately plant height increased (Pendersen and Lauer, 2003; Rahman *et al.*, 2004).

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

2.1.1.2 Branches plant^{-1}

Easha (2014) observed that plant spacing with 30 cm × 10 cm stand superior than other in respect of branches plant^{-1} (1.04) in mungbean.

Momoh and Zhou (2001) who stated that the number of effective branches and per branch decreased with increasing plant density in rapeseed.

Mozingo and Steele (1989) also reported that increasing intra-row spacing among five groundnut cultivars resulted in decreased main stem height and lateral branch length obviously decreasing plant height. They further reported that main stems were taller for each increment in plant spacing.

2.1.1.3 Leaves plant^{-1}

Nwokwu (2011) observed that the number of leaves of ground increased as the spacing increased with the highest number of leaves at the widest spacing (40 cm ×15 cm) while the least at the closest spacing (20 cm ×15 cm).

2.1.1.4 Total dry matter production

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

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

2.1.2 Effect on yield contributing characters

2.1.2.1 Pods plant^{-1}

El Naim *et al.,* (2010) and El Naim and Jabereldar (2010) reported that closer spacing reduced the number of pods per plant in cowpea.

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

Yilmaz (1999) also reported that number of pods plant^{-1}` was decreased with increasing population densities (closer spacing). At closer spacing, the number of mature pods/ plant and dry weight of pods plant^{-1} were drastically reduced in groundnut.

2.1.2.2 Seeds pod^{-1}

Easha (2014) found that the highest number of seeds pod^{-1} (10.71) in 30 cm × 10 cm spacing which was superior that other spacing in mungbean.

Hasanuzzaman *et al.,* (2008) stated that the number of seeds per siliqua significantly decreased with the increase of population density of *Brassica campestris* L.

Rana (2008) was found that the highest number of seeds pod^{-1} in 30 cm spacing and lowest in 20 cm in mungbean.

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

Ozer (2003) who stated that with increase in row spacing resulted consistent increase in the number of seeds per siliqua in rapeseed.

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

2.1.2.3 1000-Seeds weight (g)

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

Nwokwu (2011) reported that 1000 seeds weight of mungbean was obtained at spacing of 30 cm x 15 cm while the least was obtained a 20 cm x15 cm and among three (40x15cm 30x15cm and 20x15cm) spacing 40 cm x15cm and 30x15cm did not differ significantly .

The maximum 1000- seeds weight (5.02 g) was observed in (15 × 30 cm), whereas minimum (4.49 g) 1000-seed weight was attained by (15 × 10 cm). These results are in line with those of Hasanuzzaman and Karim (2007) who reported that higher 1000-seed weight of (*Brassica campestris* L.) was attained with wider plant spacing.

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

2.1.2.4 Effect on pod yield

These results are conformity with the findings of El Naim *et al.,* (2010). Weeding increased number of pods per plant, 100 kernel weight, pods yield per plant and final pods yield (ton ha^{-1}). This is because hand-weeding resulted in a better performance of growth and yield components in sesame.

Howladar *et al.*, (2009) also investigated the effect of plant spacing on the yield and yield attributes of groundnut and the result revealed that erect type of groundnut variety required closer spacing (30x10cm) to express its maximum yield potentiality.

Naeem *et al.*, (2007) reported that among different row spacing the highest yield of groundnut was recorded at spacing of 30x15cm.

The highest seed yield of mungbean (1046.0 kg ha^{-1}) was obtained at 30 cm × 10 cm spacing followed in order by 20 cm × 20 cm and 40 cm × 30 cm spacing was observed by Kabir and Sarker (2008).

Howlader *et al.*, (2009) Dhaka-1 required closer spacing (30 cm × 10 cm) to express its maximum yield potentiality, on the other hand spreading or semi-spreading type groundnut variety required wider plant spacing (40 cm × 20 cm) to express its maximum yield potentiality.

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

Achakzai *et al.(*2007) conducted a field experiment at Agricultural Research Institute, Quetta in year 2003 to study the influence of six different row spacing i.e., 20, 25, 30, 35, 40 and 45 cm on the growth, yield and yield attributes of mashbean grown under semi-arid climate. Results revealed that except of harvest index all the parameters including growth, yield and yield components were not influenced by various levels of row spacing. Maximum harvest index (61.44%) was obtained in row spacing of 40 cm.

Dapaah *et al.,(*2007) reported that haulm, pod and seed yields of peanuts increased with increased plant population or plant density .

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

Chaniyarha *et al.*, (2001) who reported that pod yield of groundnut increased with narrow row spacing compared to wider spacing.

Basak *et al.*, (1995) reported that Jhingabadam (an erect plant type similar to that of Dhaka-1) Howlader *et al.*, Int. J. Sustain. Crop Prod. 4(1) (February 2009) 43 were sown at 30 cm, 40 cm or 50 cm × 10 cm, 15 cm or 20 cm spacing. The highest pod yield was obtained with the closest spacing of 30 cm × 10 cm, whereas the lowest yield was obtained with the widest spacing of 50 cm × 20 cm.

Ah-Khan and Kiehn (1989) found that lentil yield increased as row spacing was decreased from 30 cm to 15cm.

Nevertheless, in environments with high yield potentials, higher seeding rates generally produce proportionately higher yields at narrower row spacing than at wider spacing compared with low seeding rates (Johnson, 1983; Marshall and Ohm, 1987).

Levy *et al.*, (1985) pointed that seed yield plant^{-1} substantially decreased with increasing plant population. They attributed this reduction to inter plant competition for assimilates and low pod yield. In contrast, increasing plant spacing increased seed yield (t ha^{-1}).

2.2 Effect of weed management

2.2.1 Effect on growth characters

2.2.1.1. Plant height

Various rates of herbicide (2, 3 and 4 ha^{-1}) including hand weeding were tried for weed control, of mungbean at Arid Zone Research Institute, D.I. Khan, Pakistan by Khan *et al.* (2011) and maximum plant height (67.30 and 59.73 cm) of mungbean was recorded in the treatment of hand weeding. It showed non-significant difference with the lowest rate of pendimethalin (2 ha^{-1}, 62.8 and 57.63 cm).

Weeding twice had a highest plant height of groundnut. Weeding facilitates plants to have more resources for growth, these results agreed with Joshi (2004), Mubarak (2004) and Bedry (2007); they found that, increasing weeding frequency increased plant height, due to efficient weed control.

Kundu *et al.*, (2009) found that among different weed control methods, chemical-weeding at 2 - 3 leaf stage of weeds + 2hand-weeding at 50 DAS gave maximum plant height compared to weedy check treatment in groundnut.

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

The maximum plant height, maximum number of pods plant and the highest grain yield were obtained from weed freed treatment and the lowest from no weeding control (Naseem, 1995).

2.2.1.2 Dry matter weight $plant^{-1}$

Integration of hand weeding with pre-plant application of fluchloralin at 0.67 kg ha^{-1} and trifluralin at 0.75 kg $ha^{-1}$and pre-emergence application of pendimethalin at 0.75 kg ha^{-1}, oxyfluorfen at 0.25 kg ha^{-1} and alachlor at 1.25 kg ha^{-1} resulted significant reduction in dry matter production of groundnut by weeds as compared to the recommended weed management practice (Walia *et al.*, 2007).

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

Dry matter accumulations of weeds was found to be lower in plots treated with pendimethalin and oxyfluorfen + one hand weeding 30 DAS at all the stages of groundnut growth (20, 30 and 40 DAS). Reduced weed population and weed dry matter by integrated weed management with PE application of oxyfluorfen 0.1 to 0.5 kg ha^{-1} followed by one hand weeding 30 DAS compared to pendimethalin and one hand weeding was also reported by Rajendran and Lourduraj (1999).

Pannu *et al.* (1991) reported that the partitioning of biomass in groundnut was significantly affected due to presence of weeds during the whole season and also CGR were significantly less in the plots kept weedy.

Glyphosate, a non-selective and phloem mobile herbicide, acts primarily on the shikimate pathway and blocks the synthe-sis of aromatic amino acids (AAA) and other phenolic com- pounds, including cinnamic acid (Canal *et al.,* 1987), flavons (Ishikura *et al.,* 1986) and flavanoids (Laanest, 1987). Presum- ably, the inhibition of AAA synthesis eventually leads to depletion of protein and therefore, lack of some essential protein function eventually leads to a decrease in plant growth. The phytotoxic action of glyphosate on total dry matter production could also be due to decreased starch synthesis (Greiger and Bestman, 1990).

The unweeded condition of groundnut adequate availability of light, optimum temperature, adequate space along with improvement in physiological and morphological characters of the plant can be responsible for greater photosynthetic rate for more accumulation of plant dry matter (Duncan, 1971).

2.2.1.3 Branches plant^{-1}

2.2.2 Effect on yield contributing characters

2.2.2.1 Pods plant^{-1}

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

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

Jain *et al.,* (2000) confirmed that pre-emergence application of pendimethalin at 1.5 kg ha-1 reduced the weed density, weed biomass and increased the weed control efficiency as well as number of pods plant^{-1} in groundnut.

Yadava and kurnar (1987) and reported that weed control in peanut led to increased seed yield per plant compared to non weeded plants. Weeding increased number of pods per plant.

2.2.2.2 Seeds pod^{-1}

Easha (2014) reported that number of seeds pod^{-1} (10.98) in the weed management by the application of post emergence herbicide (Release 9 EC spraying at) which superior that other weed control method in mungbean.

Kundu *et al.*,(2009) said that seeds pod^{-1} of groundnut was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE.

Rana (2008) found that the number of seeds pod^{-1} (13.07) in hand weeding method and lowest number of seeds pod^{-1} (6.23) were recorded in un-weeded conditions in groundnut.

2.2.2.3 1000-Seeds weight (g)

Vilas *et al.,* (2012) reported that hand weeding twice at 15 and 30 DAS resulted in significantly more pod yield (1741 kg ha^{-1}) than the weedy check (677 kg ha^{-1}). Pre-emergence application of Pendimethalin @1.0 kg a.i. ha^{-1} produced pod yield of 16.58 kg ha^{-1}, comparable to the complete weed free condition and on par with cultivation method of weed control. Post emergence application of Quizolofop ethyl @ 50 g a.i. ha^{-1} at 15 DAS resulted in 1233 kg ha^{-1}of dry pod yield, comparable to other herbicides and also to cultivation practices. Haulm yield, shelling % and 1000 kernel weights were improved in herbicide treatments which were comparable to the cultural method of weed control.

Ishag (1971), Mubarak (2004), Bedry (2007) and kumar (2009) observed that in groundnut crop pod yield was greatly increased with weeding treatments, which encouraged early flowering, increased flowering, developed higher leaf area index, increased number of pods and branches per plant and finally maximized pod yield. Weeding twice resulted in increased 1000-kernels weight.

2.2.2.4. Effect on pod yield

Olabode and Sangodele (2014) showed that the herbicides adequately reduced both seedling recruitment and growth of weeds on Corchorus plots thereby allowing adequate growth due to reduced competition from weed confronting corchorus growers. Furthermore, the successful employment of these herbicides for weed control in corchorus might enable growers to expand their production for more gains yield of groundnut.

Easha (2014) found that application of post emergence herbicide (Release 9 EC @ 650 ml ha^{-1}) for weed control was the best treatment. This treatment showed 62.32% higher seed yield than control.

Kumar *et al.,* (2013) reported that the pre-emergent application of pendimethalin accompanied with one hand weeding at 45 DAS and application of imazethapyr @ 50 g a.i./ha at 20 DAS (T7) helped in controlling weed which in turn might have reduced weed crop competition for space, light, nutrients and oil moisture. The treatment, therefore, resulted in higher growth and yield parameters which ultimately led to higher pod, haulm and kernel yield of groundnut.

Priya *et al.,* (2013) reported groundnut weeds comprise diverse plant species from grasses to broad-leaf weeds and sedges and cause substantial yield losses (15-75%) which are more in bunch type than in virginia groundnut.

El Naim Ahmed *et al.,* (2011) reported that Weeding twice had the highest number of pods per plant, 100- Kernel weight, pods yield per plant and final pod yield (t/h) of groundnut. Weeds reduced pod yield by about 40% in ground.

Every year the lowest haulm (2051 kg ha^{-1}), pod (1606 kg ha^{-1}) and kernel yield (1103kg ha^{-1}) of groundnut were recorded in unweeded control. Presence of weeds in the groundnut field revealed the losses varied from 61-63 %. This was in agreement with the findings of Meena and Mehta (2009).

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

Kundu (2009) studied an experiment in India and concluded that the seed yield (1327 kg ha^{-1}) of mungbean was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE.

The critical period of grass weed control was found to be from four to nine weeks after planting whereas, the critical period of broad leaved weeds control was from two to eight weeks. It is important to remove weeds in groundnut at 15, 30, 45, 60 days after sowing and upto maturity to maximize yield and net returns (Nambi and Sundari, 2008).

Madhavi *et al.*, (2008) reported that the farmers practice of hand weeding twice on 20 and 40 DAS resulted in lower weed dry matter and higher pod yield (1496 kg ha^{-1})in rabi groundnut compared with application of pendimethalinat 1.0 kg ha^{-1} (714 kg ha^{-1}).

Madhu *et al.*, (2006) found that Pod yield of groundnut and seed yield of sunflower was significantly influenced by weed control treatments. Significantly highest pod yield (12.00 q ha^{-1}) and shelling percentage (73.5 %) of groundnut and seed yield (6.30 q ha^{-1}) and seed weight per head (21. 73 g) of sunflower was obtained from the weed free check and was on par with pendimethalin, trifluralin, fluchloralin and metolachlor each combined with one inter cultivation and one hand weeding.

Jhala *et al.*, (2005) noted that the weedy conditions in the un-weeded control treatment reduced pod yield by 30 to 36 per cent as compared to integrated weed control method.

Zimdhal (2004) reported that Groundnut yield decreased with increasing time of weed interference with all type of weed species.

Among herbicides, tank mixture of fenoxaprop-p-ethyl @ 50 gha^{-1} + chlorimuron-ethyl @ 4.0 g ha^{-1} (PoE) consistenly increased all the yield attributes *viz*. pods/plant, pod length and grains/pod and was statistically at par to 2-HW. The results are in conformity with the findings of Dungarwal *et al*., (2003).

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

Groundnut pod yield was reduced up to 62 per cent in a multispecies weed complex (Paulo *et al.,* 2001).

Martin *et al.,* (2001) showed an increase in grain yield by controlling weeds and yield loss as the duration of weed interference with canola increased. Oil and biological yield were also reduced as weed interference durations increased and weed-free durations decreased.

The results corroborate the findings of Vyas *et al.,* (2000) and Pandya *et al*., (2005) and many others who reported enhanced soybean yield due to various weed control treatments. Weedy check produced lowest yield of soybean which was significantly inferior to different weed control treatments.

Jain *et al.,* (2000) confirmed that pre-emergence application of pendimethalin at 1.5 kg ha^{-1} reduced the weed density, weed biomass and increased the weed control efficiency as well as number of pods plant ha^{-1} and weight of pods in soybean.

The loss of yield in groundnut due to weeds depends on the density and type of weed flora and the loss may range from 17 to 96 per cent (Rajendran and Lourduraj, 1999).

Competitional stresses of weeds exert reduction in pod yield to the extent of 17- 84% (Guggari *et al.,* 1995).

Suresh and Nanjappa (1994) reported that the pod and haulm yield of groundnut decreased with increased crop weed competition up to harvest and the highest pod yield was realized under completely weed free condition.

Among them weed infestation is considered to be one of the major problems. Yield loss due to weed infestation amounts to 80 % in groundnut (Murthy *et al.,* 1994).

Varaprasad and Shanti (1993) and Murthy *et al.,* (1994) reported yield losses to the tune of 35 to 80 % due to weed competition in groundnut.

Itnal *et al.,* (1993) showed that pre-emergence application of Pendimethalin 1.0 kg a.i. ha^{-1} followed by one hand weeding was most effective not only to control weeds but also in obtaining higher pod yield of groundnut.

Everaarts (1992) suggested an initial weed free period of 15 days from sowing and subsequently the competition should be avoided during 35 to 60 DAS for profitable groundnut yield.

Peanut cultivars with high haulm production could offer some measure of weed suppression to reduce weed-peanut interference and promote higher haulm and pod yield (Akobundu, 1987).

Pre-emergence application of Pendimethalin 1.0 kg a.i. ha^{-1} reduced monocot and dicot populations in the early stage of crop growth which permitted better growth of crop, pod bearing and thus finally improved pod yield. Similar observations were reported by Rathi *et al.,* (1986) who also stated that Pandimethalin @ 1.5 kg a.i.ha^{-1} was as effective as two hand weeding.

Yadava and kurnar (1981) reported that weed control in peanut led to increased seed yield per plant compared to non weeded plants. Weeding increased number of pods per plant, 100 seed weight pods yield per plant and final pods yield.

After a long review of literatures it may be concluded that plant spacing and weed management had significant influence on groundnut and other crops to produce increased plant growth and yield characters. Plant spacing as 30 cm × 15 cm and weeding method as hand weeding, herbicide use or combined effect of both produced maximum growth and yield value of groundnut.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207 during robi season from November 2013 to April 2014 to study of different levels of plant spacing and weed management on yield performance of groundnut (cv. BARI chinabadam-8). 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 Location

The field experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207.

3.1.2 Site and soil

Geographically the experimental field was located at 23° 77' N latitude and 90° 33' E longitudes at an altitude of 9 m above the mean sea level. The soil belonged to the Agro-ecological Zone - Modhupur Tract (AEZ-28). It is general soil type, Shallow red brown terrace soils under Tejgaon series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.7-6.0 and had organic carbon 0.86% and 1.19 % before sowing and after harvest respectively. The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix-I.

3.1.3 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. (Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from mini weather station, Sher-e-bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-II.

3.2 Plant materials

BARI Chinabadam-8 was used as planting material. BRRI chinabadam-8 is a high yielding variety of groundnut was developed by the Oil Seed Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh in 2006. It takes about 140-150 days to mature in rabi season and 125-140 days during khrif season. It attains a plant height of 35-42 cm at maturity. Leaf color deep green, it contains 20-25 nuts per plant with cluster, the shells are smooth and whitish in color and soft in nature, seeds are reddish brown in color. Medium 100 seeds weight of about 55-60 g with a shelling percentage is about 65-70%. The cultivar gives a pod yield of 2.3-2.5 t ha^{-1} of unshelled nuts.

3.3 Treatments under investigation

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

A. Factor-1 (Plant spacing: 3)

i. S_1 = 20 cm ×15 cm

ii. S_2 = 30 cm ×15 cm

iii. S_3 = 40 cm ×15 cm

B. Factor-2 (Weed management : 5)

i. W_o = No weeding (control),

ii. W_1= One hand weeding at 20 days after sowing (DAS),

iii.W_2 = Two hand weeding at 20 and 45 days after sowing (DAS),

iv. W_3 = Pre emergence herbicide, Sunup 480 SL spraying after land preparation,

v. W_4= Post emergence herbicide, Release 9 EC spraying at 20 days after sowing (DAS).

Treatment combination: Fifteen treatment combinations are as follows

S_1W_0	S_2W_0	S_3W_0
S_1W_1	S_2W_1	S_3W_1
S_1W_2	S_2W_2	S_3W_2
S_1W_3	S_2W_3	S_3W_3
S_1W_4	S_2W_4	S_3W_4

3.4 Description of herbicides

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

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

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

3.5 Experimental design and layout

The experiment was laid in a split-plot design with three replications having 3 spacing in the main plots and 5 levels of weeding in the sub-plots. There were 15 treatment combinations. The total numbers of unit plots were 45. The size of unit plot was 6.84 m^2 (3.8 m × 1.8 m). Distances between replication to replication and plot to plot were 1 m and 0.5 m respectively. The layout of the experiment has been shown in Appendix-VII.

3.6 Detail of experimental preparation

3.6.1 Land preparation

The plot selected for the experiment was opened in the first week of November 2013 with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross- ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed from the experimental field. Land preparation was completed on 20 November, 2013 and was ready for sowing seeds.

3.6.2 Fertilizer application

The recommended chemical fertilizer dose used for groundnut varieties was 25, 165, 90, 165 kg ha^{-1} of Urea, TSP, MoP and Gypsum, respectively. Half of urea, gypsum and total dose of MoP, TSP fertilizer as basal dose were applied at final land preparation respectively in all plots. All fertilizers were applied by broadcasting and mixed thoroughly with soil. Rest fertilizer urea and gypsum were applied after 45 days after sowing (DAS) by side dressing in all plots.

3.6.3 Sowing of seeds

Seeds of BARI chinabadam-8 were sown at the rate of 150, 110 and 75 kg ha^{-1} (unshelled groundnut) for 20 cm × 15 cm, 30 cm × 15 cm and 40 cm × 15 cm respectively in the furrow on 21 November, 2013 and the furrows were covered with the soils soon after seeding. Before sowing seeds germination percentage data was recorded 87%. The groundnuts were first unshelled and treated with Bavistin 250 WP @ 2g kg^{-1} seed, then sown in maintaining row to row and plant to plant distance as per treatment having 2 seeds $point^{-1}$ in the well prepared plot.

3.7 Intercultural operations

3.7.1 Thinning

Thinning was done to maintain optimum plant population and plant to plant distance after 8 days of germination and 13 days after germination.

3.7.2 Weed control

Weed control was done as per experimental treatments

3.7.3 Irrigation and drainage

Pre-sowing irrigation was given to ensure the maximum germination percentage. Generally for upland soil 2 irrigations were required but considering the experiment field soil condition several times irrigation were given. I was given 5 irrigations in my experiment field. First irrigation was given 15 days after sowing and other four irrigations were given 20 days interval. Irrigations were given depending on the soil moisture content after soil moisture testing by hand. Before harvesting a last irrigation was given for convenience harvesting. Though it was rabi season, drain was prepared for precautionary measure because at the last stage there was heavy rainfall and excess water was drained out.

3.7.4 Plant protection measures

Savin was directly applied in the row to control ant. Insecticides Admire 200 SL @ 1 ml lit^{-1} water and Ripcord 10 EC @ 1 ml $litre^{-1}$ water were mixed and then sprayed on the leaves two times by knap sack sprayer on 18, February, 2014 and 2 March, 2014 to control jessed to protect the crop. To control foot and root rot of groundnut Bavastin 250 WP @ 1 g $liter^{-1}$ water was sprayed on 10 January, 2014 to protect the crop plants.

3.8 Harvesting and sampling

Harvesting was done on 30 April, 2014. The crop was harvested at 160 DAS. There is a thumb rule that the crop should be harvested when about 80% of the pods became mature. After observing some maturity indices such as leaf became yellow, spots on the leaf, pod became hard and tough and dark tannin discoloration inside the shell crops were harvested. The samples were collected the area of 2 m^2 of each plot avoiding the border plants. During harvest the pod contained 37% moisture. The harvested crops were tied into bundles and carried to the threshing floor.

3.9 Threshing, drying, cleaning and weighing

The pods were separated from the plants .The separated pod and the stover were sun dried by spreading those on the threshing floor. The separated pods were clean and dried in the sun for 3 to 5 consecutive days for achieving constant level of moisture (12%) and weighing pod in sample wise. Then kernels were separated from pod and weighing 1000-kernels in sample wise. Finally the well dried stovers were weighed in sample wise.

3.10 Recording of data

The data were recorded on the following parameters

i. Weed parameter

1. Weed density
2. Weed biomass
3. Weed control efficiency
4. Relative weed density

ii. Crop Growth parameters

a. Plant height (cm) at 20 days interval up to harvest.

c. Branches plant^{-1} at 20 days interval up to harvest.

d. Leaves plant^{-1} at 20 days interval up to harvest.

e. Above ground dry matter weight plant^{-1} at 20 days interval upto harvest.

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

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

iii. Yield contributing parameter

a. Pods plant^{-1}

b. Kernel pod^{-1}

c. 1000 seeds weight (g)

iv. Yield parameter

a. Pod yield

b. Stover yield

c. Shelling percentage

d. Biological yield

e. Harvest Index

v. Economic return

a. Gross return

b. Net return

c. Benefit cost ratio

3.11 Procedure of recording data

3.11.1 Weed parameters

i. Weed density

The data on weed infestation as well as density were collected from each treated plot at 20 days interval up to harvest. A plant quadrate of 1.0 m^2 was placed at three different spots of 6.84 m^2 of the plot. The middle quadrate was remained undisturbed for yield data. The infesting species of weeds within the first and third quadrate were identified and their number was counted species wise alternately at different dates.

i. Weed biomass

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

iii. Weed control efficiency

Weed control efficiency was calculated with the following formula:-

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

Where,

DWC = Dry weight of weeds in unweeded treatment

DWT = Dry weight of weeds in weed control treatment

iv. Relative weed density (%)

Relative weed density was calculated by using the following formula:

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

3.12 Crop growth parameter

The parameters were taken of 20 DAS interval starts from 20 DAS to harvest by destructive sampling.

3.12.1 Plant height

Five plants were collected randomly from inner row of each plot .The height of the plants were measured from the ground level to the tip of the plant. The mean value of plant height was recorded in cm.

3.12.2 Leaves plant^{-1}

Five plants were collected randomly from inner row of each plot . It was done by counting total number of leaves of all sampled plants.

3.12.3 Branches plant^{-1}

The branches plant^{-1} was counted from ten randomly sampled plants. It was done by counting total number of branches of all sampled plants.

3.12.4 Above ground dry matter weight plant^{-1}

Five plants of above ground were collected randomly from inner row of each plot. The sample plants were placed in oven maintaining 70^0 C for 72 hours for oven dry until attained a constant level and the mean of dry weight of leaves plant^{-1} was determined.

3.13 Yield contributing characters

Recorded were taken at harvest

3.13.1 Pods plant^{-1}

Number of pods plants^{-1} was counted from the 5 plants sample and then the average pod number was calculated.

3.13.2 Kernel pod^{-1}

Number of Kernel pod^{-1} was counted from 20 pods of plants and It was done by counting total number of Kernels and divided by total number of sampled pods.

3.13.3 Weight of 1000 - seeds (g)

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

3.14 Yield

3.13.1 Pod yield

Pod yield was calculated from unshelled, cleaned and well dried grains collected from the central 2 m^2 area of all 4 inner rows of the each plot (leaving two boarder rows) and expressed as t ha^{-1} on 12% moisture basis.

3.13.2 Kernel yield

Kernel yield was calculated from Shelled, cleaned and well dried pod collected from each plot and expressed as t ha^{-1} on 12% moisture basis and converted to tha^{-1}.

3.13.3 Stover yield

After separation of pod from plants the stover and shell of harvested area was sun dried and the weight was recorded and then converted to tha^{-1}.

3.13.4 Biological yield

It was the total yield including both the economic yield (pod yield) and stover yield.

Biological yield = pod yield + Stover yield.

3.13.5 Harvest index (%)

Harvest index is the relationship between grain yield and biological yield
(Gardner *et al.*,1985)

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

Here, Biological yield = Pod yield + Stover yield

3.13.6 Crop Growth Rate (CGR)

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

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

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

3.13.7 Relative growth rate (RGR)

Relative growth rate (RGR) is the growth rate relative to the size of the population. Relative growth rate was calculated using the following formula developed by Radford (1967):

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

Where,

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

ln = Natural logarithm

3.14 Economic analysis

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

i. Input cost

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

A. Non-material cost (labor)

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

B. Material cost

The seed of groundnut (BARI Chinabadam-8) was purchased from BARI Headquarter @ Tk.70 per kg. Chemical fertilizers eg. Urea, TSP, and MoP were bought from the authorized dealer at local market. Irrigation was done from the existing facilities of irrigation system of the Sher-e-Bangla Agricultural University field. Herbicides were bought from the respective dealers at local market.

ii. Overhead cost

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

iii. Miscellaneous overhead cost (common cost)

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

iv. Gross Return

Gross return from groundnut (Tk. ha^{-1}) = Value of pod (Tk. ha^{-1}) + Value of Stover (Tk. ha^{-1})

v. Net return

Net return was calculated by using the following formula:

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

vi. Benefit cost ratio (BCR)

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

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

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 Statics 10 and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance.

Chapter IV

Results and Discussion

CHEPTER IV

RESULTS AND DISCUSSION

The results of the weed parameters, crop characters and economic evaluation of the production of BARI Chinabadam-8 as influenced by different plant spacing and weed control treatments have been presented and discussed in this chapter.

4. 1 Weed parameter

4.1.1 Weed density

It is a general observation that conditions favorable for growing groundnut is also favorable for exuberant growth of numerous kinds of weeds that compete with crop plants. This competition of weeds tends to increase when the weed density increases and interfere with the crop growth and development resulting poor yield. Table 1 showed that 16 weed species were found during the experiment. It was observed that the species, Shama (*Echinochloa crus-galli*) accounted the highest in number and thereafter were Chapra, Durba, Mutha, Anguli,and so on. The lowest weed in number was Bon morich.

Table 1. Name of weeds found in the experimental field

SL. No.	Local name	Common name	Scientific name	Family
1.	Boro shama	Barnyardgrass	*Echinochloa crus-galli*	Gramineae
2.	Chapra	Indian goosegrass	*Eleusine indica*	Gramineae
3.	Durba	Bermuda Grass	*Cynodon dactylon*	Gramineae
4.	Anguli gash	Smooth crabgrass	*Digitaria ischaemum*	Gramineae
5.	Mutha	Purple nut sedge	*Cyperus rotundus*	Cyperaceae
6.	Foska begun	Clammy groundcherry	*Solanum torvum*	Solanaceae
7.	Chanchi	Chanchi	*Alternanthera philoxeroides*	Amaranthaceae
8.	Kanta notea	Spiny amaranth	*Amaranthus spinosus*	Amarnthaceae
9.	Bon shorisha	Wild mustard	*Brassica kaber*	Labiatea
10.	Bothua	Lambs quarter	*Chebopodium album*	Labiatea
11.	Hatir shur	Indian heliotrope	*Heliotropium indicum*	Boragiaceae
12.	Nuna	Common purslane	*Portulaca oleracea*	Tiliaceae
13.	Khet papri	Khet papri	*Lindernia procumbens*	Scrophulariaceae
14.	Shusni	4-leavded water clover	*Marsilea quadrifolia*	Papayeraceae
15.	Chota dudhia	Prostate spurge	*Euphorbia parviflora*	Euphorbiaceae
16.	Bon morich	Bonpland's croton	*Croton bonplandianus sparsuflorus*	Euphorbiaceae

Number of weed species and total number of weeds in 1 m^2 were affected significantly by the different treatment combinations (Table 2). It was observed that the lowest number of weed species and total weeds m^{-2} was observed in S_2W_2 (9.77 and 178.69

respectively). On the other hand, the highest number of weed species and total number of weeds m^{-2} (13.00 and 474.12 respectively) was obtained from S_2W_0. Easha (2014) observed that the lowest number of weed species and total weeds m^{-2} was observed in 30 cm× 10 cm + post emergence herbicides (8.23 and 75.25, respectively). On the other hand, the highest number of weed species and total number of weeds m^{-2} (13.23 and 266.12, respectively) was obtained from 40cm × 10 cm + no weeding.

Table 2. Weed density as per treatment combinations

Treatment combinations	Number of weed species	No. of weeds m^{-2} at different days after sowing			Total weeds m^{-2} during crop growing period
		20DAS	45 DAS	At harvest	
S_1W_0	12.33	--	--	454.66	454.66
S_1W_1	11.67	125.33	--	137.54	262.54
S_1W_2	10.34	130.67	35.23	36.67	202.57
S_1W_3	12.00	--	--	273.67	273.67
S_1W_4	10.83	128.54	--	120.07	248.67
S_2W_0	13.00	--	--	474.12	474.12
S_2W_1	11.87	122.33	--	154.67	274.00
S_2W_2	9.77	115.67	27.40	31.62	174.69
S_2W_3	12.00	--	--	246.22	246.22
S_2W_4	10.57	125.30	--	127.33	252.63
S_3W_0	12.00	--	--	463.67	463.67
S_3W_1	11.17	119.67	--	155	274.67
S_3W_2	10.83	110.43	39.33	35.73	185.49
S_3W_3	11.67	--	--	265.33	265.33
S_3W_4	11.00	115.24	--	135.12	250.36

Here,

S_1 = 20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.1.2 Weed biomass

Weed population had considerable effect on crop production. Data on (Table 3) showed that the highest dry weight of weed (502.73 g m^{-2}) was observed in S_2W_0. The lowest dry weed biomass (83.33 g m^{-2}) was observed in S_2W_2 where two hands were done. Kumar *et al,.* (2013) found that maximum weed dry matter accumulation of 5098 kg ha^{-1} was recorded in un - weeded control, which was significantly higher than other treatments and weed-free check plot recorded the lowest weed dry matter accumulation at 30 DAS and at harvest followed by (pendimethalin + 2 HW at 45 DAS+ imazethapyr @ 50 ga.i. ha^{-1} at 20 DAS) (619 kg ha-1). Similar results were also reported by Meena and Mehta (2009) and Patel *et al.,* (2007).

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

Treatment combinations	Dry weight of weeds at different DAS ($g\ m^{-2}$)			Total dry weight of weed ($g\ m^{-2}$) during crop growing period
	20DAS	40 DAS	At harvest ($g\ m^{-2}$)	
S_1W_0	--	--	476.73	476.73
S_1W_1	44.50	--	87.81	132.31
S_1W_2	59.28	14.70	20.56	94.54
S_1W_3	--	--	221.21	221.21
S_1W_4	42.23	--	75.41	117.64
S_2W_0	--	--	502.73	502.73
S_2W_1	41.25	--	98.96	140.21
S_2W_2	49.52	12.45	19.33	81.33
S_2W_3	--	--	191.67	191.67
S_2W_4	50.11	--	80.56	130.67
S_3W_0	--	--	396.78	396.78
S_3W_1	41.72	--	95.03	136.75
S_3W_2	46.34	15.71	21.32	83.37
S_3W_3	--	--	213.27	213.27
S_3W_4	43.50	--	84.33	127.83

Here,

S_1=20 cm × 15 cm,

S_2 = 30 cm × 15 cm,

S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2 Growth parameters

4.2.1 Plant height (cm)

4.2.1.1 Effect of plant spacing

Environmental factors and genetic characteristics of plants play an important role in determining the plant height. Data on plant height at different days of groundnut was influenced by varying row spacing have been presented in Fig. 1. Plant height varied significantly at 60, 80, 100, 120, 140 DAS and at harvest for space management (Figure 1) and non significant at other stages. At 60 DAS, S_2 (30 cm × 15 cm) scored the highest plant height (16.91 cm) which was statistically similar (16.49 cm) with spacing S_1 (30 cm × 15 cm) and the lowest plant height (14.85 cm) was found from spacing S_3 (40 cm × 15 cm). On 80 DAS, the longest plant height (22.45 cm) was recorded from spacing S_1 (30 cm × 15 cm) which was statistically similar (22.20 cm) with spacing S_2 (30 cm × 15 cm). At 100 DAS, the tallest plant height (27.92 cm) was given by spacing S_2 (30 cm × 15 cm) which was statistically similar (26.55cm) with spacing S_1 (20 cm × 15 cm). In case of 120,140 and at harvest the tallest plant height (3.36, 34.31, 34.65 cm) were observed from S_1 (20 cm × 15 cm) which were statistically identical (31.65, 33.43, and 33.67 cm) with S_2 (40 cm × 15 cm) and in (60 cm, 80 cm, 100 cm, 120 cm, 140 cm and at harvest) stages the shortest plant height (19.34, 24.81, 29.37, 31.53 and 31.80 cm) recorded from spacing S_3 (40 cm × 15 cm) which was different from other two treatments. The similar result was observed Nwokwu (2011).

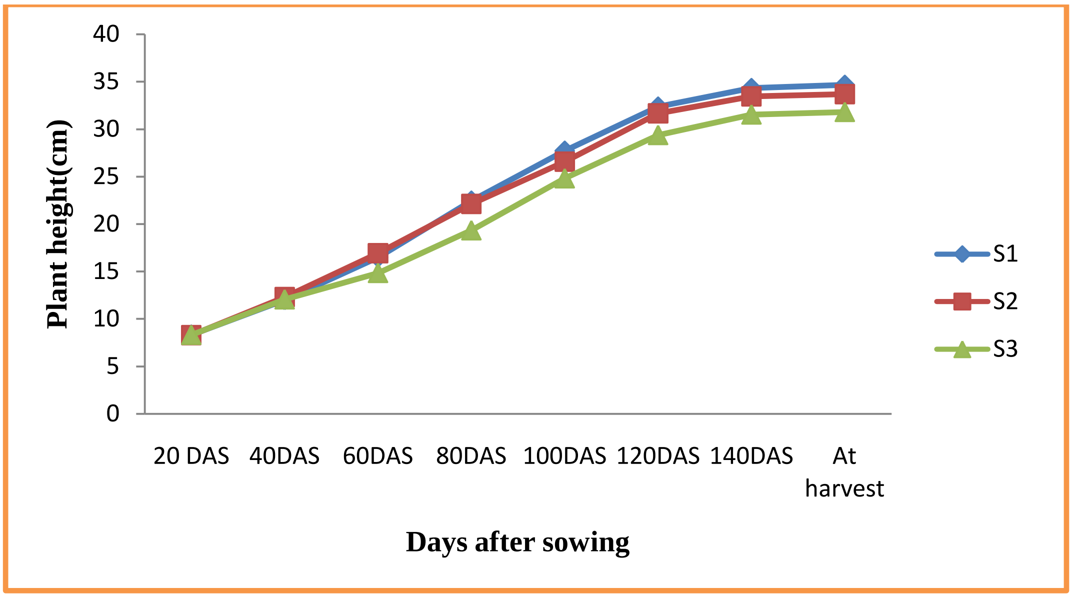

Figure 1. Effect of row spacing on plant height of groundnut at different ages ($LSD_{(0.05)}$ = NS, NS, 1.12, 1.74, 1.32, 1.19, 1.01 and 1.2 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.1.2 Effect of weed management

The plant height was significantly influenced by weed management at all growth stages of groundnut (Fig. 2). At 20 DAS, the highest plant height (8.88 cm) was recorded in W_3 which was statistically similar (8.34 cm) with W_1. At 40 DAS the highest plant height (12.35 cm) was recorded from W_1 and W_2 which were statistically similar (12.28 and 12.44 cm) with W_3 and W_4. At 60 DAS the highest plant height (17.96 cm) was recorded from W_2 which was statistically similar (16.83 and 17.62 cm) with W_3 and W_4. At 80 DAS the highest plant height (24.86 cm) was recorded from W_2 which was statistically similar (23.39 cm) with W_4. At 100, 120, 140 DAS and harvest, the highest plant height (31.10, 35.76, 37.88 and 38.10 cm) was recorded in W_2 and in (40 cm, 60 cm, 80 cm, 100 cm, 120 cm, 140 cm and at harvest) stages the shortest plant height (11.18, 12.64, 15.30, 19.83, 25.44, 28.37 and 29.02 cm) recorded from W_0. At harvest stage the 2nd plant height was found (35.00 cm and 35.30 cm) from W_1 and W_4 .The result under the present study was in agreement with the findings of Kundu *et al.* (2009).

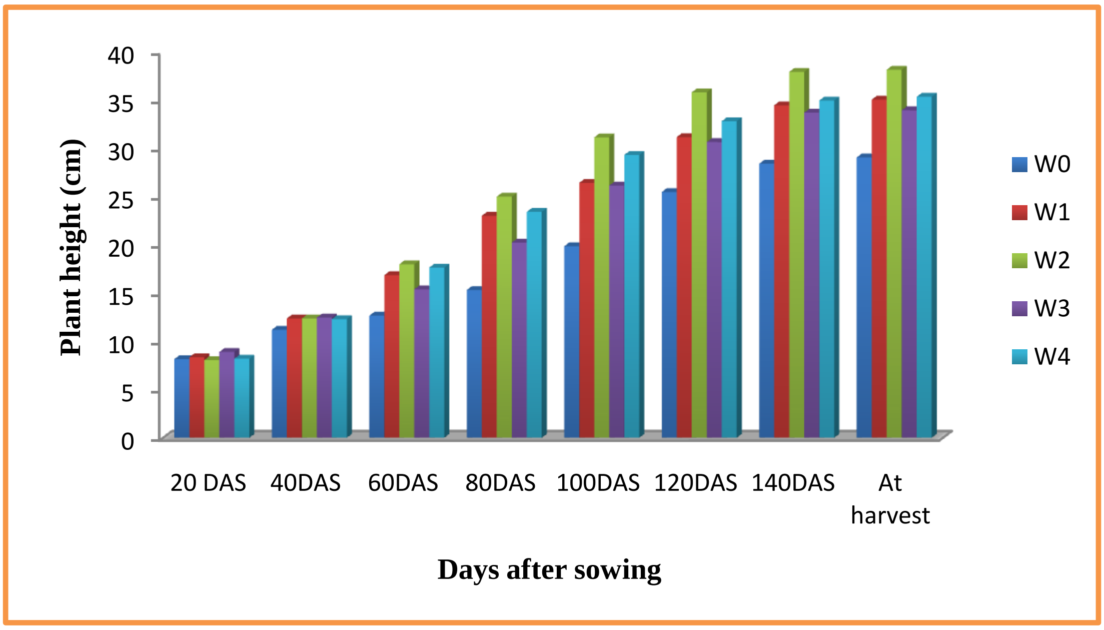

Figure 2. Effect of weed control methods on plant height of groundnut at different ages ($LSD_{(0.05)}$ = 0.66, 0.88, 1.23, 1.66, 1.47, 1.25, 1.54 and 1.33 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.1.3 Combined effect of row spacing and weed management

Statistically significant variation was recorded for different treatments at 40, 60, 80, 100, 120, 140 DAS and at harvest (Table 4). At 40DAS the highest plant height (12.74 cm) was observed in the 40 cm ×15 cm spacing with pre emergence herbicide for weed management (S_3W_3) which was statistically similar with S_1W_1 (12.00 cm), S_1W_2 (12.50 cm), S_1W_3 (12.67 cm), S_1W_4 (11.94 cm), S_2W_1 (12.49 cm), S_2W_2 (12.34 cm), S_2W_3 (11.92 cm), S_2W_4 (12.47 cm), S_3W_0 (11.48 cm), S_3W_1 (12.55 cm), S_3W_2 (12.43 cm) and S_3W_4 (12.43 cm). In this stage the lowest plant height was found S_1W_0 (10.88 cm) which was statistically similar with S_1W_4 (11.94 cm), S_2W_0 (11.18cm), S_2W_2 (12.34 cm), S_2W_3 (11.91 cm), S_3W_0 (11.48 cm), S_3W_2 (12.21 cm).At 60 DAS the highest plant height (19.23 cm) was observed in the 40 cm × 15 cm spacing with two hand weeding for weed management (S_3W_2) which was statistically similar with S_2W_2 (18.54 cm), S_2W_4(18.83 cm) and S_3W_4(18.79 cm). In this stage the lowest plant height was found S_1W_0 (11.32 cm) which was statistically similar with S_2W_0 (13.12 cm), S_3W_0 (13.49 cm).At 80 DAS the highest plant height (26.61 cm) was observed in the 30 cm × 15 cm spacing with two hand weeding for weed management (S_2W_2) which was statistically similar with S_2W_1 (24.54 cm), S_2W_4 (24.59 cm), S_3W_1 (21.32 cm), S_3W_2 (26.16 cm) and S_3W_4 (24.39 cm). In this stage the lowest plant height was found S_1W_0 (14.88 cm) which was statistically similar with S_2W_0 (15.60 cm), S_3W_0 (15.43 cm). At 120, 140 DAS and harvest the highest plant height (36.79 cm, 39.23 cm and 39.40 cm) was observed in the 30 cm × 15 cm spacing with two hand weeding for weed management (S_2W_2) which was statistically similar with (S_2W_2) (35.82, 37,95 and 38.35 cm respectively). In case of 100, 120, 140 DAS and harvest stages the lowest plant height was observed S_1W_0 (14.88, 19.74, 25.17, 27.98 and 28.64 cm) which was statistically similar with S_2W_0 (15.60, 19.82, 25.34, 28.39 and 29.46 cm at 100, 120, 140 DAS and harvest respectively) and S_3W_0 (15.43, 19.93, 25.79, 28.74 and 28.95 at 100, 120, 140 DAS and harvest respectively). The results obtained from all other treatment combinations were significantly different from each other except 20 DAS.

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

Treatment combinations	Plant height (cm)							
	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	At Harvest
S_1W_0	8.22	10.88 c	11.32 h	14.88 d	19.74 g	25.17 f	27.98 g	28.64 g
S_1W_1	8.27	12.00a-c	15.87 de	20.10 c	24.53 ef	29.13 e	31.59 de	32.47 ef
S_1W_2	7.95	12.50 ab	16.13c-e	21.81 bc	28.14b-d	33.47 bc	35.19 bc	35.51b-d
S_1W_3	8.99	12.67 ab	15.71 de	19.03 c	24.13 f	28.67 e	31.01 ef	31.42 f
S_1W_4	8.22	11.94a-c	15.24d-g	20.89 c	27.49 cd	30.45 de	32.56c-e	33.53 de
S_2W_0	8.15	11.18 bc	13.12 gh	15.60 d	19.82 g	25.34 f	28.39 g	29.46 g
S_2W_1	8.12	12.49 ab	17.08b-d	24.54 ab	27.58 cd	33.25 bc	35.11 bc	36.76 b
S_2W_2	8.31	12.34a-c	18.54a-c	26.61 a	32.50 a	36.79 a	39.23 a	39.40 a
S_2W_3	8.92	11.91a-c	15.03e-g	20.60 c	27.35 d	31.61 cd	34.34 bc	36.47 bc
S_2W_4	8.15	12.47 ab	18.83 ab	24.49 a	30.27 ab	33.81 b	36.06 b	36.73 b
S_3W_0	8.05	11.48a-c	13.49f-h	15.43 d	19.93 g	25.79 f	28.74 g	28.95 g
S_3W_1	8.61	12.55 ab	17.34b-d	21.32 ab	27.06 de	33.11 bc	35.96 b	36.53 b
S_3W_2	7.86	12.21a-c	19.33 a	26.16 a	32.19 a	35.82 a	38.87 a	39.20 a
S_3W_3	8.73	12.74 a	15.36d-f	21.00 c	26.84 de	31.55 cd	34.02b-d	34.11c-e
S_3W_4	8.17	12.43 ab	18.79 ab	24.39 ab	30.08a-c	34.06 b	36.11 b	36.43 b
LSD(0.05)	NS	1.50	2.19	3.08	2.62	2.25	2.81	2.37
CV%	8.20	7.43	7.85	8.00	5.70	4.10	4.45	3.98

Here,

S_1=20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.2 Branches plant^{-1}

4.2.2.1 Effect of plant spacing

Significant variation of branches plant^{-1} was found due to different row spacing at 80, 100, 120, 140 and at harvest except 20, 40, 60 DAS. At 80 and 100 DAS highest Branches plant^{-1} were found S_2 (5.22 cm and 6.56 cm) which was similar with S_3 (5.31 cm and 6.47 cm). At 120, 140 and harvest stage the highest Branches plant^{-1} were found from S_3 (7.70, 8.23 and 8.27 cm respectively) which were similar with S_2 (7.65, 8.16 and 8.20 cm respectively) varietal variation at 30, 50, 110, 130, 150 DAS and at harvest except 70 DAS and 90 DAS (Figure 3). In case of 80, 100, 120, 140 DAS and harvest stages the lowest Branches plant^{-1} was observed S_1 (14.88, 19.74, 25.17, 27.98 and 28.64 cm) which was statistically similar with S_2 (4.21, 5.65, 6.21, 6.46 and 6.50 cm at 80,100, 120, 140 DAS and harvest respectively). The similar result was observed Nwokwu (2011).

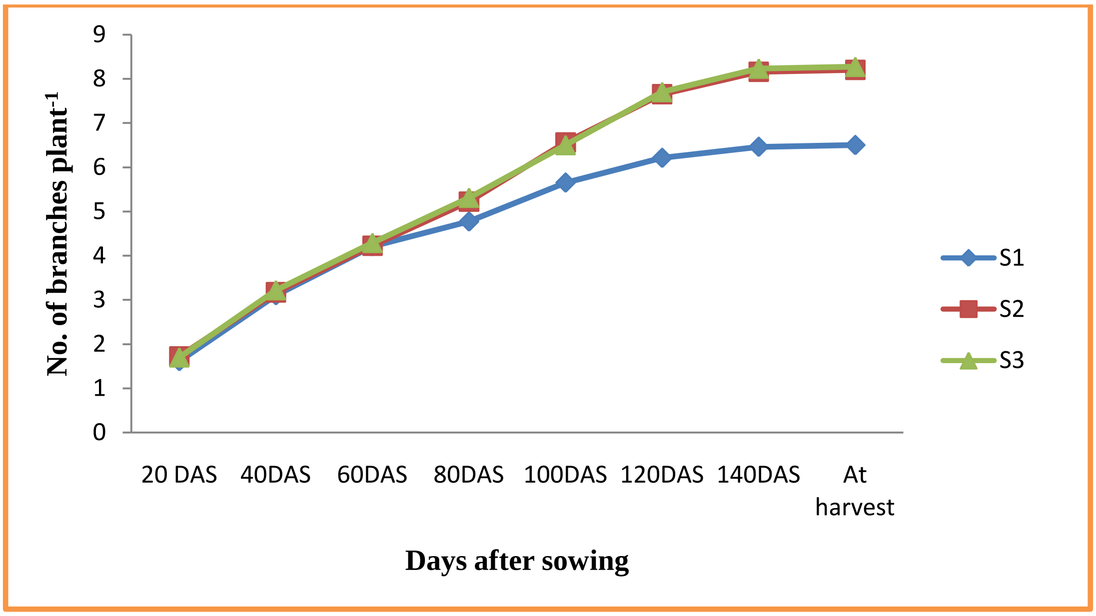

Figure 3. Effect of row spacing on the no.of branches plant^{-1} of groundnut at different ages ($LSD_{(0.05)}$ = 0.26, 0.24, 0.02, 0.07, 0.47, 0.56, 0.44 and 0.17 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.2.2 Effect of weed management

Branches $plant^{-1}$ was significantly influenced by different weed management at 60, 80, 100, 120, 140 DAS and harvest stages of groundnut (Fig. 4). At 60 DAS the highest no. of branches $plant^{-1}$ (4.52) was recorded in W_2 which was statically similar with W_3 and W_4 and the lowest no. of branches $plant^{-1}$ (3.82) was found from W_4. In 80,100,120,140 DAS and harvest stages the highest no. of branches $plant^{-1}$ (7.45, 9.33, 9.90 and 9.95 respectively) was recorded from W_2 and the lowest no. of branches $plant^{-1}$ (3.96, 4.44, 4.99, 5.03 and 5.11 respectively) were found from W_0. Intermediate no. of branches $plant^{-1}$ was obtained from W_1 and W_4. Mohamed *et al*., (1997) reported that twice hand weeding were applied days after sowing significantly affected number of branches $plant^{-1}$.

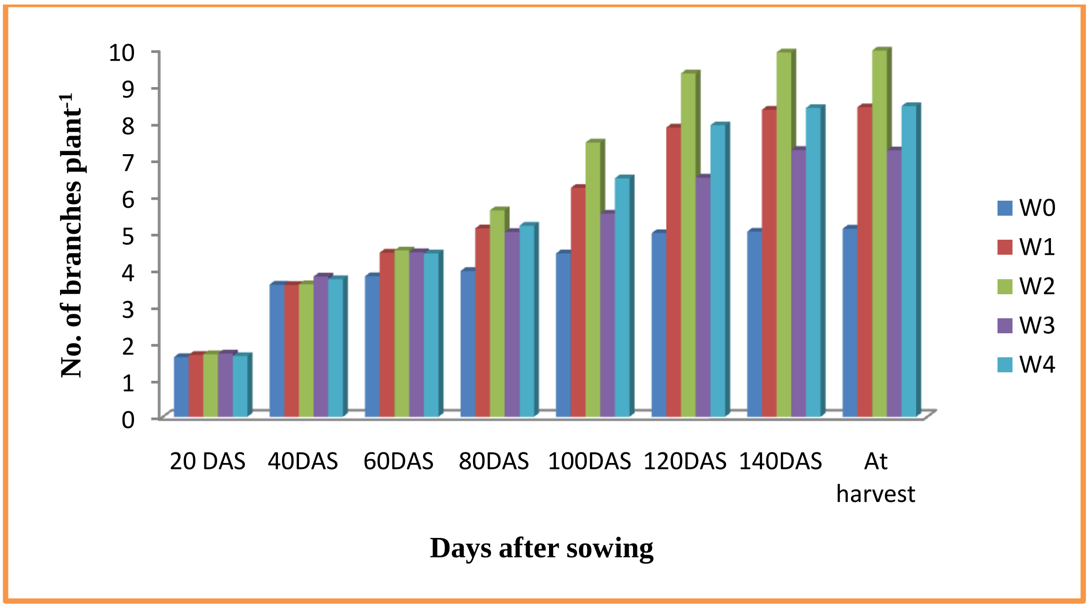

Figure 4. Effect of weed control methods on no. of branches $plant^{-1}$ of groundnut at different ages ($LSD_{(0.05)}$ = 0.14, 0.22, 0.20, 0.28, 0.29, 0.65, 0.57 and 0.35 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.2.3 Combined effect of plant spacing and weed management

Branching is basically a genetic character but environmental conditions may also influence the number of branches per plant and play an important role in enhancing seed yield. Data given in (Table 5) revealed that the number of branches plant^{-1} was affected significantly by combination of varying plant spacing and weed control methods except 20 DAS. The highest no. of branches plant^{-1} (11.00) was observed in S_2W_2 among all combinations. The At 40 DAS, the highest no. of branches plant^{-1} (4.11) was observed in S_3W_3 which was statistically similar with S_2W_2 (3.75) and S_3W_4 (3.86) and the lowest the highest no. of branches plant^{-1} (3.44) was found from S_2W_3 which was statistically similar with others combination except S_3W_3 and S_3W_4. At 60 DAS, the highest no. of branches plant^{-1} (4.65) was observed in S_1W_2 which was statistically similar with S_1W_4, S_2W_1, S_2W_2, S_2W_3, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. In this stage the minimum no. of branches plant^{-1} (3.77) was recorded from S_1W_0 which was statistically similar with S_2W_0 (3.81) and S_3W_0 (3.87). At 80 DAS, the highest no. of branches plant^{-1} (5.75) was observed in S_3W_2 which was statistically similar with S_1W_2, S_2W_2, S_3W_1 and S_3W_4. At 100 and 120 DAS the highest no. of branches plant^{-1} (7.85 and 9.96) was observed from S_3W_2 which was statistically similar with S_2W_2. At 140 DAS and harvest the highest no. of branches plant^{-1} (11.00 and 10.86) was observed from S_2W_2 which was statistically similar with S_3W_2. The minimum no. of branches plant^{-1} were obtained from S_1W_0 (3.88, 4.21, 4.74, 4.80 and 4.86) at 80, 100, 120, 140 DAS and harvest respectively which were statistically similar with S_2W_0 and S_3W_0.

Table 5. Combined effect of row spacing and weed management on branch of groundnut at different days

Treatment combinations	Branches plant^{-1}							
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**	**140 DAS**	**At Harvest**
S_1W_0	1.54	3.50 bc	3.77 c	3.88 f	4.21 g	4.74 d	4.8 f	4.86 f
S_1W_1	1.64	3.58 bc	4.57 ab	4.75 de	5.26 de	6.70 c	7.04 de	7.31 d
S_1W_2	1.68	3.62 bc	4.65 a	5.40 a-c	6.76 b	8.16 b	8.60 bc	8.40 c
S_1W_3	1.63	3.62 bc	4.27 b	4.71 e	5.00 ef	5.76cd	6.54 e	6.56 e
S_1W_4	1.56	3.65 bc	4.37 ab	4.96 c-e	5.92 c	6.66 c	7.17 de	7.45 d
S_2W_0	1.65	3.63 bc	3.81 c	3.99 f	4.49 fg	5.08 d	5.17 f	5.23 f
S_2W_1	1.76	3.62 bc	4.28 ab	5.15 b-d	6.58 b	8.52 b	8.87 b	8.81 bc
S_2W_2	1.76	3.75 a-c	4.41 ab	5.68 a	7.74 a	9.85 a	11.00 a	10.86 a
S_2W_3	1.77	3.68 bc	4.56 ab	5.13 b-e	5.83 cd	6.84 c	7.64 cd	7.74 d
S_2W_4	1.64	3.69 bc	4.46 ab	5.17 b-d	6.68 b	8.51 b	8.97 b	8.68 bc
S_3W_0	1.67	3.64 bc	3.87 c	4.01 f	4.60 fg	5.17 d	5.11 f	5.23 f
S_3W_1	1.65	3.55 bc	4.53 ab	5.46 ab	6.80 b	8.36 b	9.10 b	9.12 b
S_3W_2	1.65	3.44 c	4.48 ab	5.75 a	7.85 a	9.96 a	10.47 a	10.44 a
S_3W_3	1.76	4.11 a	4.58 ab	5.23 bc	5.69 cd	6.91 c	7.57 d	7.45 d
S_3W_4	1.76	3.86 ab	4.49 ab	5.46 ab	6.84 b	8.59 b	9.04 b	9.19 b
LSD(0.05)	NS	0.42	0.38	0.4395	0.65	1.15	0.98	0.57
CV%	8.69	6.21	4.80	5.78	5.06	9.19	7.54	4.63

Here,

S_1=20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 =1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.3 Leaves plant^{-1}

4.2.3.1 Effect of plant spacing

There was a marked difference among the spacing on leaves plant^{-1} 100, 120, 140 DAS and at harvest showed significant differences (Figure 3). At 100 DAS the highest no. leaves plant^{-1} (64.21) was found in S_2 which was statistically similar with S_3 (64.02). At 120, 140 DAS and harvest stage the highest no. leaves plant^{-1} (80.69, 85.87 and 85.95) were found in S_3 which was statistically similar with S_2. The lowest the highest no. leaves plant^{-1} (51.95, 64.82, 72.22 and 70.64 at 100, 120, 140 DAS and harvest respectively) were found in S_1 which deceased at harvest stage. The similar result was observed Nwokwu (2011).

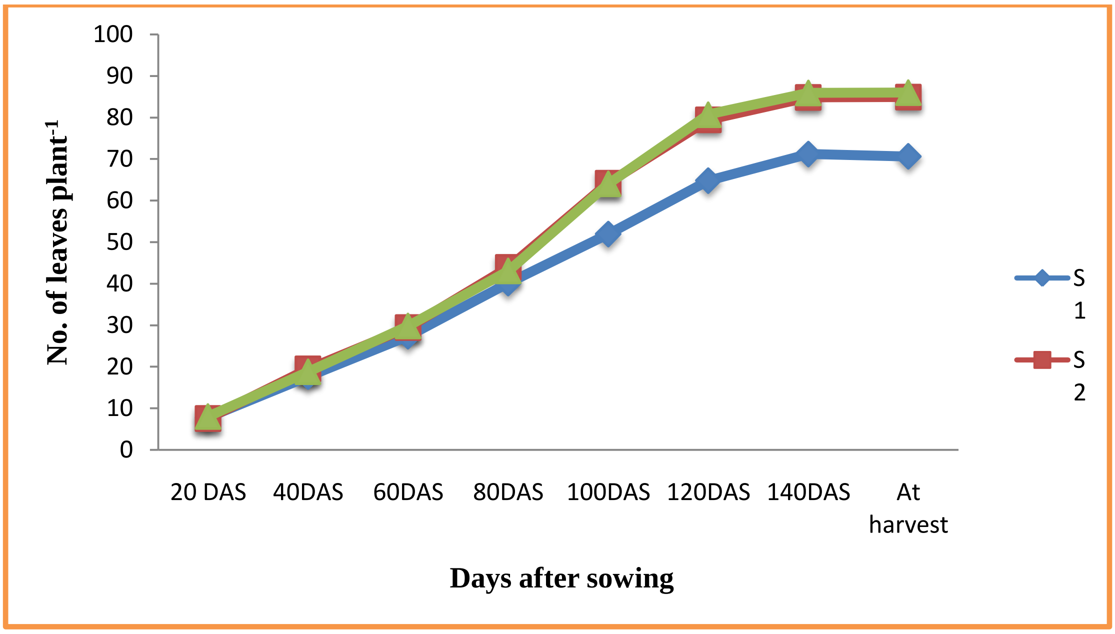

Figure 5. Effect of row spacing on the no. of leaves plant^{-1} of groundnut at different ages ($LSD_{(0.05)}$ = NS, NS, NS, NS, 5.30, 11.98, 5.68 and 6.97 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.3.2 Effect of weed management

Leaves plant^{-1} was significantly influenced by different weed management at 40, 60, 80, 100, 120, 140 DAS and harvest stages of groundnut (Fig. 6). At 40 DAS, the highest no. leaves plant^{-1} (20.27) was found in W_2 which was statistically similar with W_1.W_3 and W_4. In this stage the lowest no. leaves plant^{-1} (17.12) was observed in W_0 which was statistically similar with W_1.W_3 and W_4. At 60 DAS the highest no. leaves plant^{-1} (32.19) was found in W_2 which was statistically similar with W_3 and lowest no. leaves plant^{-1} (25.93) was found in W_0 which was statistically similar with W_1 and W_4. In case of the highest no. leaves plant^{-1} (87.74, 102.52, 109.56 and 11.10 at 80, 100, 120, 140 DAS and at harvest respectively) was found in W_2 and the minimum no. leaves plant^{-1} (37.76, 47.56, 52.09, and 53.31at 80, 100, 120, 140 DAS and at harvest respectively) was found in W_0. Intermediate no. of leaves plant^{-1} was obtained from W_1 and W_4. Yadava and kurnar (1981) and Weiss (1983) reported that weed control in peanut led to increased number of leaves per plant compared to unweeded plants.

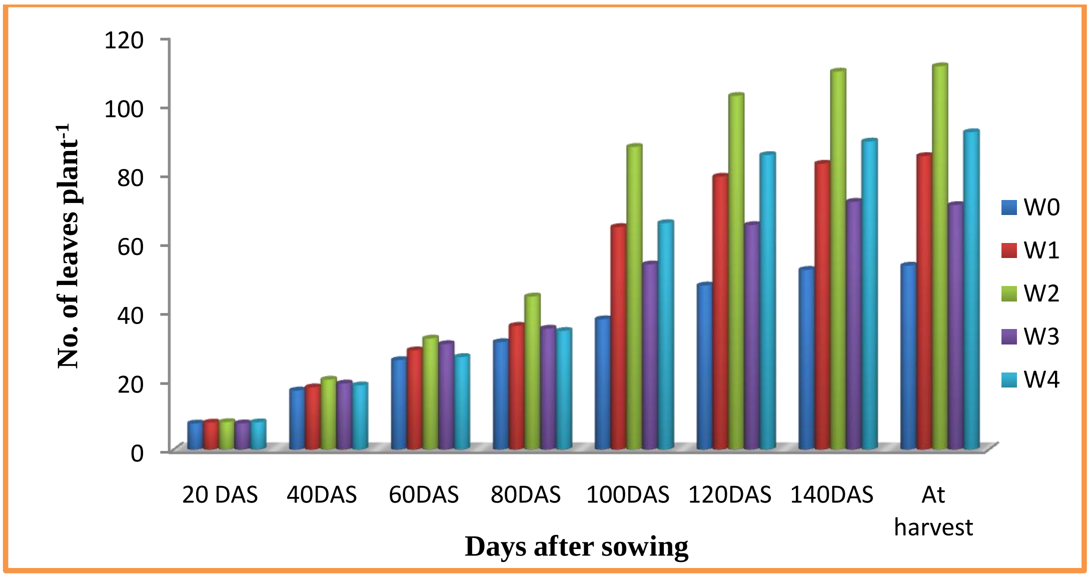

Figure 6. Effect of weed control methods on number of leaves plant^{-1} of groundnut at different ages ($LSD_{(0.05)}$: NS, 1.49, 3.08, 2.42, 5.00, 9.63, 7.46 and 6.66 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

W_0 No weeding W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.3.3 Combined effect of plant spacing and weed management

Interaction effect of variety and different levels of weed control methods significant variation on leaves plant^{-1} throughout the growing period at 60, 80, 100, 120, 140 DAS and harvest (Table 2). At 60 DAS the highest no. leaves plant^{-1} (33.27) was recorded from the combination of S_2W_2 which was statistically similar with S_1W_2, S_1W_3, S_2W_1, S_2W_3 S_3W_1, S_3W_2 and S_3W_3. In this stage the lowest no. leaves plant^{-1} (24.55) was recorded from the combination of S_1W_1 which was statistically similar with S_1W_0, S_1W_3, S_1W_4, S_2W_0, S_2W_3, S_2W_4, S_3W_0 and S_3W_4. At 80 DAS and 100 DAS the highest no. leaves plant^{-1} (41.33 and 87.44) was observed in S_2W_2 which was no significantly different from S_3W_2 and statistically similar with S_1W_2. The lowest the highest no. leaves plant^{-1} S_3W_0 (29.69) 80 DAS was statistically similar with S_1W_0 and S_2W_0. On the other hand 100 DAS the lowest no. leaves plant^{-1} S_1W_0 (36.08) which statistically similar with S_2W_0 and S_3W_0. At 120,140 DAS and harvest stages the highest no. leaves plant^{-1} (111.2, 117 and 120.17) was recorded from the combination of S_2W_2 which was statistically similar with S_3W_2. The lowest no. leaves plant^{-1} (44.44, 48.31 and 49.31 at 120,140 DAS and harvest respectively) was recorded from the combination of S_1W_0 which were statistically similar with S_1W_3, S_2W_0 and S_3W_0 at 120 DAS; S_2W_0 and S_3W_0 at 140 DAS and harvest.

Table 6. Combined effect of row spacing and weed management on leaf of groundnut at different days

Treatment combinations	Leaves plant^{-1}							
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**	**140 DAS**	**At Harvest**
S_1W_0	7.27	15.85	25.61 cd	31.44 ef	36.08 i	44.44 h	48.31 g	47.22 h
S_1W_1	7.80	16.71	24.55 d	37.16 bc	60.67d-f	72.00 e-g	75.03 de	79.03 fg
S_1W_2	8.00	18.40	30.72a-c	38.55ab	78.45 ab	87.66 c-e	96.22 b	98.00 cd
S_1W_3	8.07	17.20	29.78a-d	34.72 b-e	46.55 gh	56.67 gh	63.48 ef	69.11 g
S_1W_4	7.67	20.03	26.00 cd	33.78 c-e	53.00 fg	73.31 d-g	78.08 cd	75.82 ef
S_2W_0	7.47	17.73	25.83 cd	32.28 d-f	38.75 hi	48.33 h	53.53 fg	55.19 h
S_2W_1	7.67	19.33	30.66a-c	35.83 b-d	64.53c-e	81.03 c-f	84.08b-d	90.75 d-f
S_2W_2	7.67	21.57	33.27 a	41.33 a	87.44 a	111.22 a	117.34 a	120.17 a
S_2W_3	7.27	21.04	30.11a-d	35.66 b-d	57.89 ef	70.22 e-g	75.31 de	80.97 e-g
S_2W_4	7.53	17.73	27.22b-d	34.44 c-e	72.45 bc	91.42 b-d	93.06 b	91.83 de
S_3W_0	7.90	17.78	26.33 cd	29.69 f	38.45 hi	49.89 h	54.44 fg	55.14 h
S_3W_1	8.03	18.13	31.11a-c	34.61 b-e	68.28 cd	84.28 c-f	89.44 bc	91.44 de
S_3W_2	8.27	20.84	32.59 ab	41.22 a	85.33 a	108.67 ab	115.11 a	118.74ab
S_3W_3	7.47	19.20	31.80 ab	34.77 b-e	56.58 ef	68.28 fg	73.64 de	80.53 e-g
S_3W_4	8.50	18.10	27.27b-d	34.94 b-e	71.47 bc	97.36 a-c	96.72 b	107.39 bc
$LSD_{(0.05)}$	NS	NS	5.78	4.03	9.31	18.953	12.81	12.352
CV%	10.53	17.01	10.96	7.02	8.42	12.97	9.48	8.08

Here,

S_1=20 cm × 15 cm,

S_2 = 30 cm × 15 cm,

S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

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

4.2.4.1 Effect of plant spacing

Dry matter is the material which was dried to a constant weight. Above ground dry matter (AGDM) production indicates the production potential of a crop. AGDM of leaves and stem and pods were measured at 20, 40, 60, 80, 100, 120, 140 DAS and at harvest Above ground dry matter weight plant^{-1} was significantly varied due to different treatment variations at 100, 120, 140 DAS and harvest stages of groundnut (Fig. 5). Under the present study, the highest dry matter weight plant^{-1} (10.97, 17.12, 23.48 and 30.35 g at 100, 120, 140 DAS and harvest, respectively) was achieved by S_2 where 140 DAS Above ground dry matter weight plant^{-1} S_2 was statistically similar with S_3 .The lowest was achieved by S_1 (8.17, 13.96, 20.34 and 24.03g At 100, 120, 140 DAS and harvest respectively). The results obtained from S_3 showed intermediate results. Similar result was found by Easha (2014). She observed that the highest dry matter plant^{-1} was produced at spacing of 30 cm × 10 cm, which was identical to that of 40 cm × 30 cm and the lowest dry matter was plant^{-1} 20 cm ×10 cm pacing.

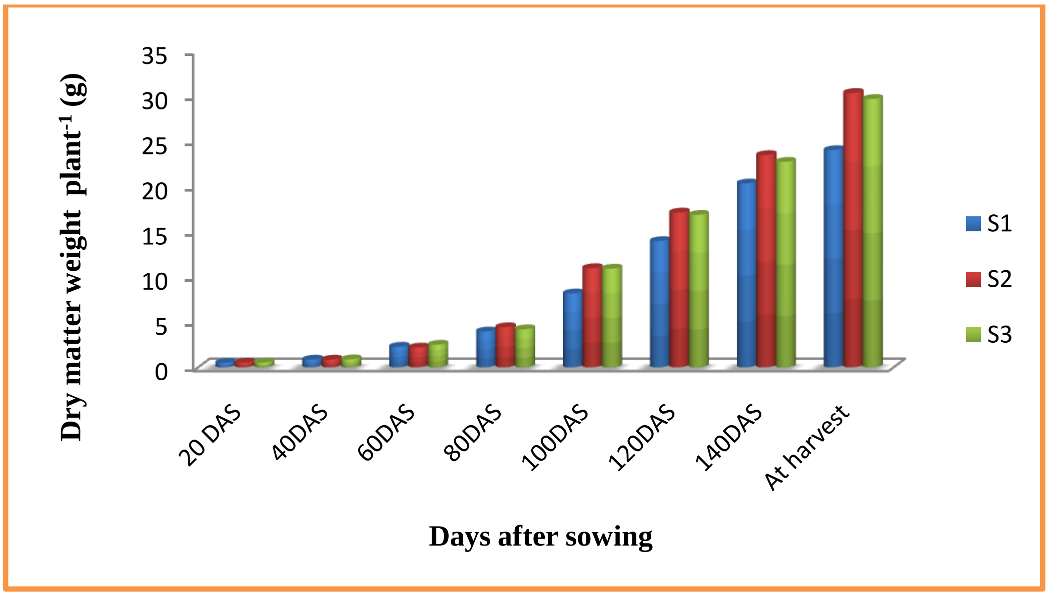

Figure 7. Effect of plant spacing on above ground dry matter weight plant^{-1} of groundnut at different ages (($LSD_{(0.05)}$ = NS, NS, NS, NS, 1.78, 2.28, 2.96 and 1.98 97 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.4.2 Effect of weed management

Above ground dry matter weight plant^{-1} was significantly influenced by number of weeding at all growth stages of groundnut (Fig. 6). It is remarked from the present study that the increasing time of weeding significantly increased dry weight plant^{-1}. At 20 DAS the maximum amount of dry weight plant^{-1} 0.59 g was recorded from W_3. In this stage the minimum dry weight plant^{-1} (0.47, 0.47, 0.48 and0.49 g was achieved from W_0, W_2, W_1 and W_4 respectively which were no significantly different. At 40 DAS all treatments were no significantly different except W_0. At 60 DAS and 80 DAS the highest dry matter weight plant^{-1} (2.63 g and 5.14 g) was recorded from in W_2 which was statistically similar with W_1 and W_4. The lowest dry weight plant^{-1} (1.79 g) was found in W_0 and at 80 DAS the lowest dry weight plant^{-1} (3.05 g) which was no significantly variation with W_3. At 100, 120, 140 DAS and harvest the highest amount of dry weight plant^{-1} (13.22, 20.92, 30.96 and 40.46 g respectively) was recorded from in W_2 only 100 DAS stages W_2 (13.22) which was statistically similar with W_1. The lowest dry weight plant^{-1} (5.94, 10.24, 12.56 and15.16 g at 100, 120, 140 and harvest respectively) was found in W_0. The results under the present study were in agreement with the findings of Karunakar *et al.* (2002) and Malik *et al*. (2008).

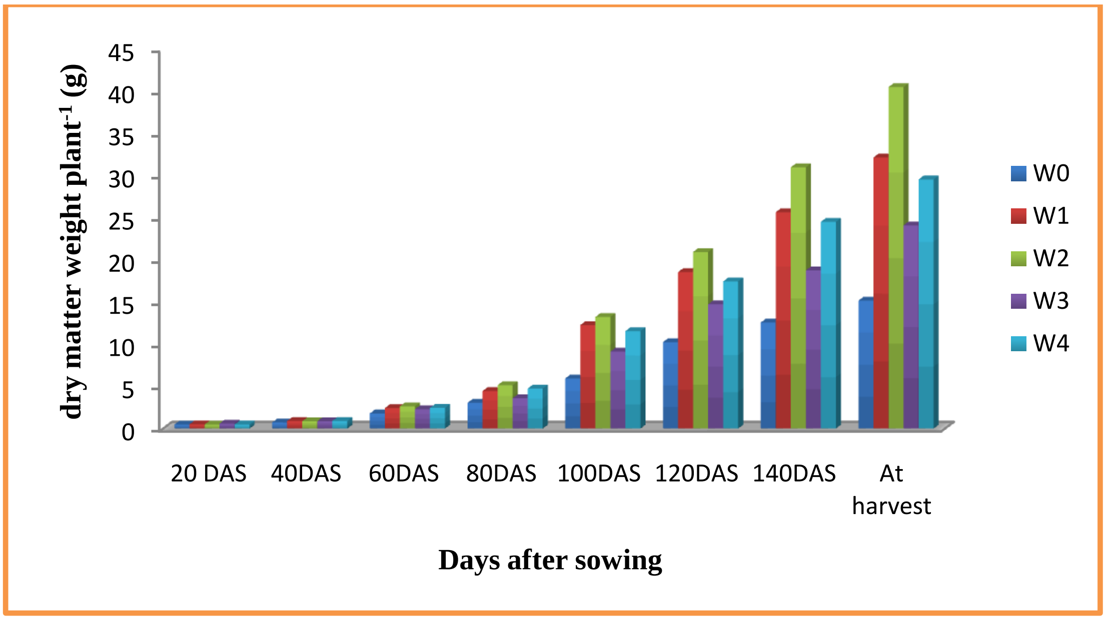

Figure 8. Effect of weed control methods on above ground dry matter weight plant^{-1} of groundnut at different ages ((LSD$_{(0.05)}$ = 0.07, 0.14, 0.28, 0.81, 2.36, 2.38, 2.56, 2.48 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively).

Here,

W_0 = No weeding W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.4.3 Combined effect of plant spacing and weed management

Significant influence was observed by combination of different spacings and weeding methods on above ground dry weight plant^{-1} except 20 DAS (Table 7). Results indicated that the highest above ground dry weight plant^{-1} (0.98 g and 0.92 at 40 DAS) was observed in the treatment combination of S_1W_1 and S_1W_4 respectively which were closely followed by S_1W_0, S_1W_2, S_1W_3, S_2W_0, S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_3W_0 S_3W_1, S_3W_2, S_3W_3 and S_3W_4 where as the lowest above ground dry weight plant^{-1} was obtained in S_1W_0 which was at per S_1W_2, S_1W_3, S_2W_0, S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_3W_0, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. At 60 DAS, S_3W_2 gave the highest above ground dry weight plant^{-1} (2.85 g) which was no significant variation with S_3W_2 and was statistically similar with S_1W_2, S_1W_3, S_1W_4, S_2W_1, S_2W_2, S_2W_3, S_2W_4 and S_3W_4. In this stage the lowest above ground dry weight plant^{-1} was obtained from S_2W_0 was statistically similar with S_2W_0 and S_3W_0. At 80 DAS, maximum AGDM weight plant^{-1} was obtained from S_2W_2 (5.53 g) which was statistically similar with $S_1W_{1,}$ S_1W_2, S_1W_4, S_2W_3, S_2W_4, S_3W_1 and $S_3W_{2.}$ The lowest above ground dry weight plant^{-1}(2.88 g) which was which was no significant variation with S_2W_0 and S_3W_3 in the other hand it was statistically similar with $S_1W_{1,}$ S_1W_3, S_2W_0, S_2W_1, S_2W_3, S_2W_3. At 100 DAS the maximum above ground dry matter weight plant^{-1}(14.74 g) which was statistically similar with $S_2W_{1,}$ S_2W_4, S_3W_1, S_3W_2 and S_3W_4 but in this stage the minimum above ground dry matter weight plant^{-1} (5.43 g) which was statistically similar with $S_1W_{1,}$ S_1W_3, S_1W_4, S_2W_0 and S_3W_0. At 120, 140 DAS and harvest stages S_2W_2 gave the maximum above ground dry matter weight plant^{-1}(23.31, 34.58 and 44.7 g respectively). The lowest above ground dry matter weight plant^{-1} (8.12, 11.75 and 13.84 g at 120, 140 and at harvest stages respectively) was found in S_1W_0 which was statistically similar with S_2W_0 and S_3W_0.

Table 7. Combined effect of row spacing and weed management on above ground dry weight of groundnut at different days

Treatment combinations	Above ground dry weight (gp^{-1})							
	20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	At Harvest
S_1W_0	0.45	0.68 b	1.83 de	2.88 e	5.43 f	8.32 f	11.75 f	13.84 e
S_1W_1	0.45	0.98 a	2.20b-e	4.24 a-e	8.00 c-f	14.36 de	22.51 de	26.31 c
S_1W_2	0.46	0.79ab	2.653ab	4.66a-d	10.25 b-d	18.69 bc	27.18 bc	34.77 b
S_1W_3	0.57	0.85ab	2.30a-d	3.40 c-e	7.91 c-f	12.75 e	18.84 e	20.44 d
S_1W_4	0.47	0.92 a	2.41 a-c	4.63a-d	9.27 b-f	15.05 c-e	22.41 de	24.80 c
S_2W_0	0.47	0.72ab	1.62 e	3.346de	6.283 d-f	9.22 f	12.66 f	14.63 e
S_2W_1	0.51	0.81ab	2.28a-d	4.09b-e	11.18 a-c	18.97 b-d	27.16 cd	34.21 b
S_2W_2	0.47	0.92ab	2.41a-d	5.63 a	14.74 a	23.31 a	34.58 a	44.71 a
S_2W_3	0.58	0.88ab	2.31a-d	4.42 a-e	9.74 b-e	15.11 c-e	18.51 e	25.87 c
S_2W_4	0.48	0.87ab	2.33a-d	4.65a-d	12.79 ab	18.20 b-d	26.08 cd	32.65 b
S_3W_0	0.49	0.73ab	1.92 c-e	2.92 e	6.12ef	9.80 f	13.27 f	16.01 de
S_3W_1	0.53	0.92ab	2.81 a	5.04 ab	11.90 a-c	19.31 b-d	25.74 cd	32.63 b
S_3W_2	0.48	0.90ab	2.85 a	5.13 ab	14.68 a	20.77 ab	31.14 ab	41.88 a
S_3W_3	0.62	0.89ab	2.26b-d	2.95 e	9.68 b-e	16.33 c-e	18.88 e	25.93 c
S_3W_4	0.49	0.91ab	2.61 ab	4.95 a-c	12.57 ab	19.06 a-c	25.00 cd	31.11 b
LSD(0.05)	NS	0.37	0.58	1.57	4.05	4.3140	4.91	4.29
CV%	16.16	15.65	12.50	19.82	24.22	15.37	11.87	9.08

Here,

S_1=20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.5 Crop growth rate (CGR)

4.2.5.1 Effect of plant spacing

Crop growth rate is a measure of the increase in size, mass or number of crops over a period of time. The increase can be plotted as a logarithmic or exponential curve in many cases. It varied significantly due to spacing at 40-60, 100-120 DAS and120-140 DAS shown in (Fig.9). Under the present study, the highest CGR (2.38 $gm^{-2}day^{-1}$) was found in S_1 at 40-60 DAS. In this stage the lowest CGR (1.43 g $m^{-2}day^{-1}$) was found from S_3 which statistically similar with S_2. At 100-120 and 120-140 stages the highest CGR was (6.57, 6.63 g $m^{-2}day^{-1}$ respectively) was achieved by S_1 which was statistically similar with S_2 where as the lowest was achieved by S_3 (5.07, and 4.71 g $m^{-2}day^{-1}$). The similar result was observed Easha (2014).

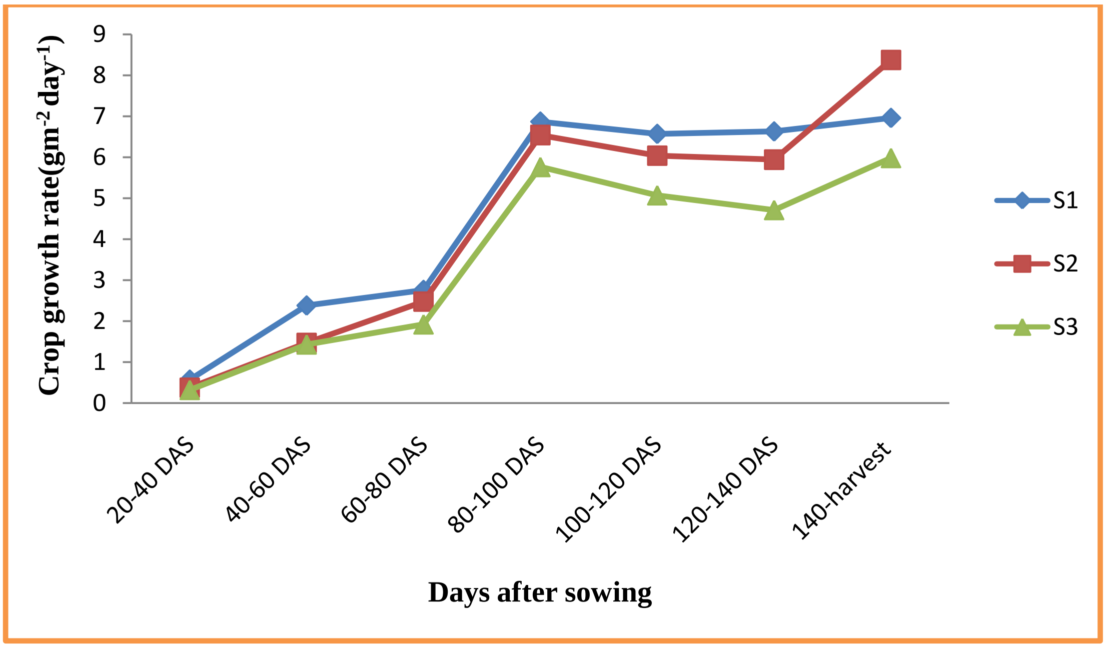

Figure 9. Effect of plant spacing on the crop growth rate of groundnut at different ages ($LSD_{(0.05)}$ = NS, 0.40, NS, NS , 2.17, 3.82, NS at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.5.2 Effect of weed management

Significant variation was recorded for CGR due to weed management at all the stages except 20-40 (Fig. 10). At 40-60 DAS, the maximum (2.16 g m^{-2} day^{-1}) CGR was recorded from W_2 which was statistically similar with W_1 while the minimum (1.37 g m^{-2} day^{-1}) in W_0 which was statistically similarW_3. At 40-80 DAS, the highest value (3.02 $gm^{-2}day^{-1}$) was recorded from W_2 which was statistically similar to W_1 and W_4. The lowest value of CGR was recorded from W_0 (1.74 g $m^{-2}day^{-1}$) which was statistically similar W_3. At 80-1000 DAS, W_2 was given the highest CGR (8.92 g m^{-2} day^{-1}) which was statistically similar with W_4 while the lowest CGR (3.38 g $m^{-2}day^{-1}$) was recorded from W_0 which was similar to W_1. The highest value (8.13 g m^{-2} day^{-1}) at 100-120 DAS was recorded from W_2 which was significantly similar with W_1, W_3 and W_4 while the lowest CGR (4.20 g m^{-2} day^{-1}) was found from W_0. At 120-140DAS the highest CGR (9.42 g m^{-2} day^{-1}) was observed from W_2 which was statistically similar with W_1 and W_4. The lowest CGR (2.48 g m^{-2} day^{-1}) was observed from W_0 which was statistically similar with W_3. At 140 DAS and harvest stages the maximum was observed from W_2 (13.11 g m^{-2} day^{-1}) while the minimum in CGR was found from W_0 (2.92 g m^{-2} day^{-1}) which was statistically similar with W_3 and W_4.

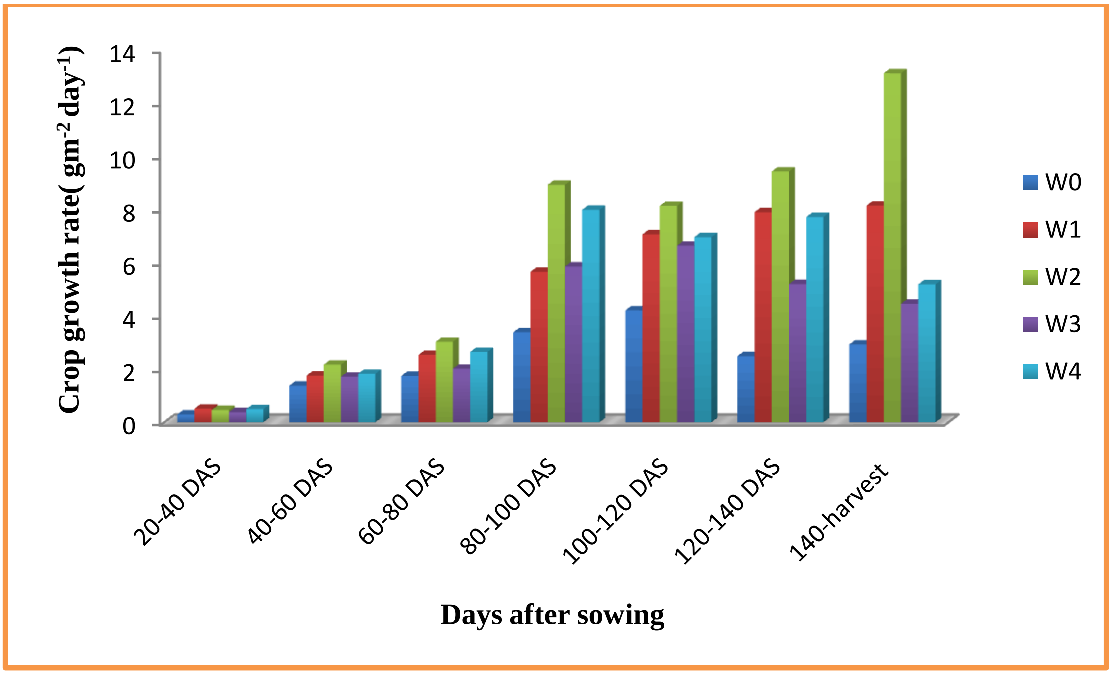

Fig. 10. Effect of weed control methods on crop growth rate of groundnut at different ages (($LSD_{(0.05)}$ = NS, 0.36, 0.73, 2.34, 2.01, 4.11and 3.59 at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively)

Here,

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.5.3 Combined effect of row spacing and weed control methods

The combination of weed control treatments and variety significantly influenced the CGR throughout the growing period (Table 7). At the beginning of the crop growth (20-40 DAS), S_1W_1 gave the highest CGR (0.88 g m^{-2} day^{-1}) which was statistically similar with S_1W_2, S_1W_4, S_2W_2 and S_2W_4 where as the lowest CGR (0.20 g m^{-2} day^{-1}) was found in S_3W_0 which was significantly and statistically similar with other treatment combinations except S_1W_1. At 40-60 DAS the highest CGR (3.10 g m^{-2} day^{-1}) was found in S_1W_2 which was statistically similar with S_1W_4. In this stage the lowest CGR (1.00 g m^{-2} day^{-1}) was found in S_2W_0 which was statistically similar with S_2W_1, S_2W_2, S_2W_3, S_2W_4, S_3W_0, S_3W_1, S_3W_3 and S_3W_4. At 60-80 DAS the highest CGR (3.57 g m^{-2} day^{-1}) was found in S_2W_2 which was statistically similar with S_1W_1, S_1W_2, S_1W_4, S_2W_3 and S_2W_3. In this stage the lowest CGR (1.76 g m^{-2} day^{-1}) was found in

S_1W_0 which was significantly and statistically similar S_1W_3, S_2W_0, S_2W_1, S_2W_3, S_2W_4, S_3W_0, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. The highest CGR (10.16 g m^{-2} day^{-1}) which recorded from S_2W_2 at 80-100 DAS which was statistically similar with S_1W_2, S_1W_4, S_2W_4, S_3W_2 and S_3W_4 while the lowest CGR (2.66 g m^{-2} day^{-1}) was recorded from S_3W_0 which was similar to S_1W_0, S_1W_1, S_1W_3, S_2W_0, S_2W_1, S_2W_3, S_3W_1 and S_3W_3. At 100-120 DAS the highest CGR (11.54 g m^{-2} day^{-1}) was found in S_1W_2 which was statistically similar with S_1W_1, S_1W_3 and S_1W_4. In this stage the lowest CGR (3.49 g m^{-2} day^{-1}) was found in S_3W_0 which was statistically similar S_1W_0, S_2W_0, S_2W_1, S_2W_3, S_2W_4, S_3W_1, S_3W_2, S_3W_3 and S_3W_4. At 120-140 DAS, the highest CGR (12.48 g m^{-2} day^{-1}) was found in S_1W_2 which was statistically similar with S_1W_1, S_1W_3, S_1W_4, S_2W_1, S_2W_2, S_2W_4, S_3W_1, S_3W_2, and S_3W_4 whenever the lowest CGR was recorded (1.82 g m^{-2} day^{-1}) from S_2W_0 which was statistically similar with S_2W_3, S_2W_4, S_3W_0, S_3W_1, S_3W_3, and S_3W_4.At 140 DAS -harvest stage S_2W_2 gave maximum CGR (17.17g m^{-2} day^{-1}) which was statistically similar with S_1W_2. In this the lowest CGR value (2.18 g m^{-2} day^{-1}) was found in S_2W_0 which was similar to S_1W_0, S_1W_1, S_1W_3, S_1W_4, S_2W_3, S_3W_4, S_3W_0, S_3W_1, S_3W_3 and S_3W_4. The results obtained from all other treatment combinations were significantly different compared to others.

Table 8. Combined effect of plant spacing and weed management on crop growth rate at different days (g m^{-2} day^{-1}) of groundnut

Treatment combinations	Crop growth rate (g m^{-2} day^{-1})						
	20-40 DAS	40-60 DAS	60-80 DAS	80-100 DAS	100-120 DAS	120-140 DAS	140 DAS-harvest
S_1W_0	0.37 b	1.91 b-d	1.76 c	4.23 cd	3.99 ef	3.57 b-e	3.47 e
S_1W_1	0.88 a	2.04 bc	3.39 ab	6.28 b-d	10.60 ab	9.10 a-d	7.99 b-e
S_1W_2	0.54 ab	3.10 a	3.35 ab	9.30 ab	11.54 a	12.48 a	11.55 ab
S_1W_3	0.47 b	2.40 b	1.84 c	6.29 b-d	8.08 a-d	10.14 ab	2.66 e
S_1W_4	0.62 ab	2.47 ab	3.46 ab	7.74 a-c	9.63 a-c	9.60 a-c	3.98 e
S_2W_0	0.29 b	1.00 e	1.68 c	3.26 d	5.12 d-f	1.82 e	2.18 e
S_2W_1	0.32 b	1.64 c-e	2.34 a-c	4.60 cd	5.79 d-f	6.21 a-e	10.38 b-d
S_2W_2	0.50 ab	1.60 c-e	3.57 a	10.16 a	7.60 b-e	6.30 a-e	17.17 a
S_2W_3	0.32 b	1.57 c-e	2.35 a-c	5.65 b-d	5.88 c-f	2.66 c-e	4.83 c-e
S_2W_4	0.51 ab	1.56 c-e	2.46 a-c	9.05 ab	5.81 d-f	6.53 a-e	7.30 b-e
S_3W_0	0.20 b	1.22 de	1.76 c	2.66 d	3.49 f	2.06 de	3.11 e
S_3W_1	0.32 b	1.57 c-e	1.86 c	6.07 b-d	4.78 d-f	8.36 a-e	6.06 b-e
S_3W_2	0.35 b	1.79 b-d	2.14 a-c	7.29 a-c	5.24 d-f	9.47 a-c	10.62 bc
S_3W_3	0.37 b	1.14 e	1.83 c	5.61 b-d	5.93 c-f	2.79 c-e	5.87 b-e
S_3W_4	0.37 b	1.41 c-e	1.99 bc	7.17 a-c	5.41 d-f	7.03 a-e	4.26 de
$LSD_{(0.05)}$	0.48	0.69	1.48	3.81	3.77	8.08	6.20
CV%	53.71	21.55	31.45	37.81	31.38	61.35	54.60

Here,

S_1 = 20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.6 Relative growth rate (RGR)

4.2.6.1 Effect of plant spacing

Relative growth rate is the increase of materials per unit of plant materials per unit of time. RGR was higher at early stage of growth and declined with time. In case of BARI Chinabadam-8, non significant differences were obtained for relative growth rate (RGR) for different row spacing (Fig. 11).

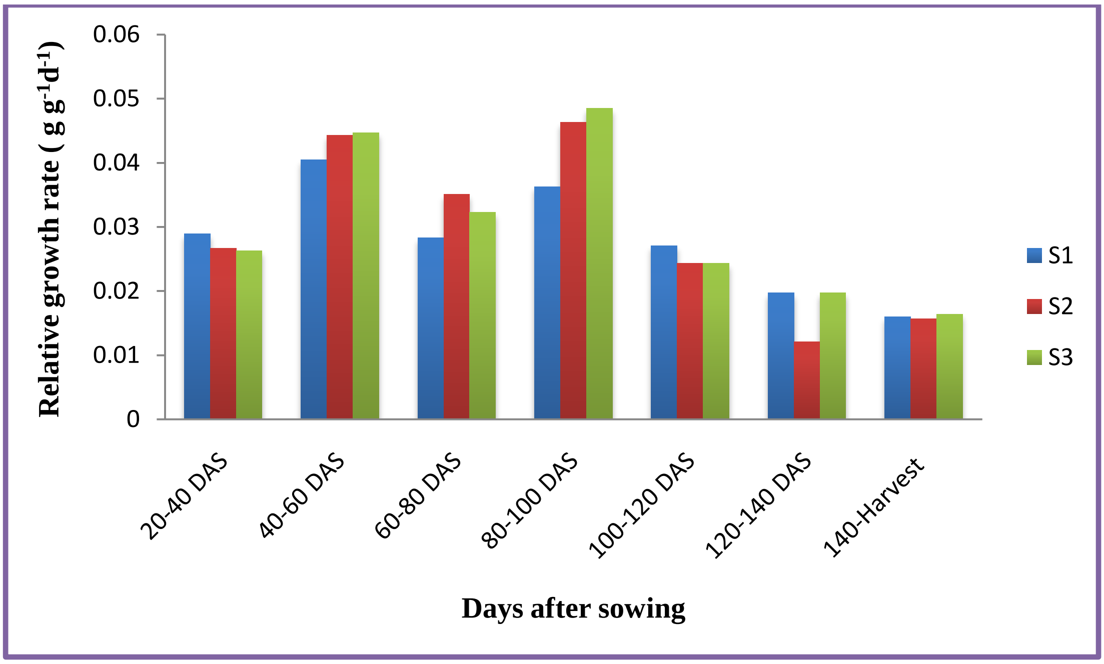

Figure 11. Effect of plant spacing on the RGR of groundnut at different ages ($LSD_{(0.05)}$ = NS, NS, NS, NS, NS, NS, NS and NS at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively).

Here,

S_1= 20 cm ×15 cm, S_2= 30 cm ×15 cm, S_3= 40 cm × 15 cm

4.2.6.2 Effect of weed management

Relative growth rate was significantly affected at 20-40 DAS, 40-60 DAS 80-100 DAS stages (Fig. 12). At 20-40 DAS, the highest RGR(0.0316 g g^{-1} day^{-1}) was found in W_2 which was statistically similar to W_1 and W_4 while W_3 gave the lowest RGR (0.14 g g^{-1} day^{-1}) which was statistically similar to W_3. At 40-60 DAS stage the highest RGR (0.0505 g g^{-1} day^{-1}) was found in W_2 which was statistically similar with W_1, W_3 and W_4. The lowest RGR (0.0460 g g^{-1} day^{-1}) was found from W_0. AT 80-100 DAS stage the maximum RGR (0.0571 g g^{-1} day^{-1}) was found in W_2 which was statistically similar with W_1, W_3 and W_4. In this stage the lowest RGR (0.0343 gg^{-1} day^{-1}) was recorded from W_0 which was statistically similar with W_1, W_3 and W_4.

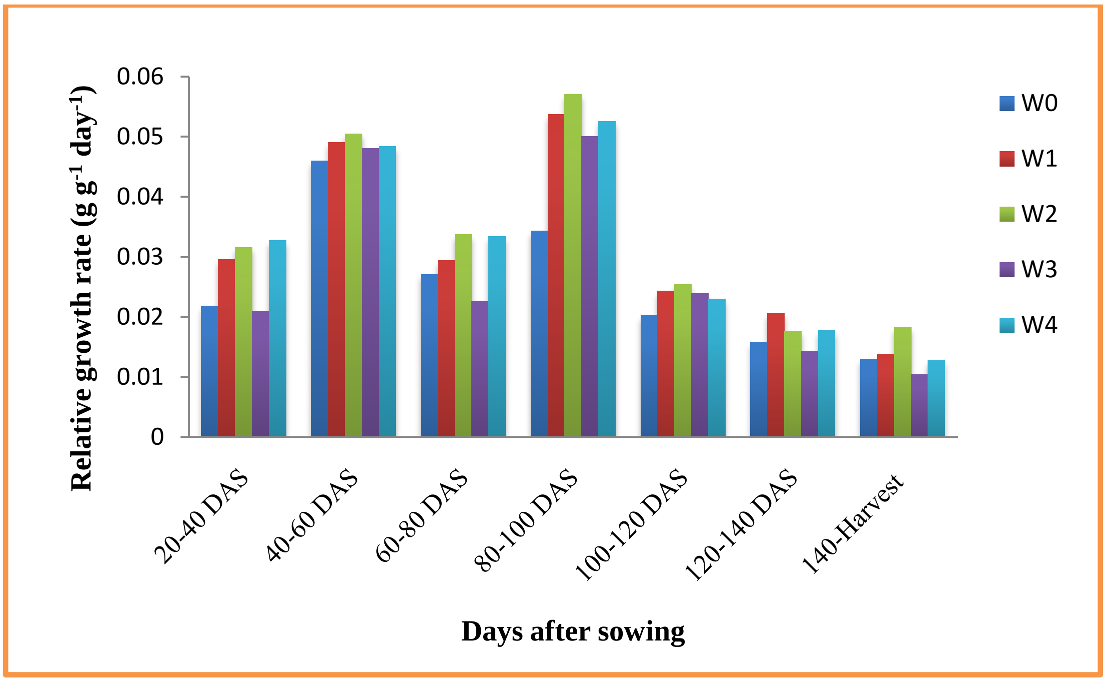

Figure 12: Effect of weed control methods on RGR of groundnut at different ages ($LSD_{(0.05)}$ = 8.370, 9.715, NS, 0.0342, NS, NS a NS at 20, 40, 60, 80, 100, 120, 140 DAS and harvest, respectively).

Here,

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.2.6.3 Combined effect of plant spacing and weed control treatments

RGR of BARI Chinabadam-8 was significantly influenced by the combined effect of the weed control treatments and plant spacing in all dates of observations except 100-120 and 120-140 DAS shown in Table 9. Results showed that at 20-40 DAS, S_2W_5 and S_1W_4 gave the highest RGR (0.0367 g g^{-1} day^{-1}) which was significantly and statistically similar with other treatment combinations except S_1W_3 while the lowest RGR (0.197 g g^{-1} day^{-1}) was found in S_1W_3 which was at per other treatment combinations except S_1W_1 and S_1W_4. At 40-60 DAS, the maximum RGR (0.0617 g g^{-1} day^{-1}) was found in S_2W_2 which was closed to the other combination except S_1W_1 and S_2W_0. In this stage the lowest result was observed in S_2W_0 (0.0403 g g^{-1} day^{-1}) which was significantly and statistically similar with other treatment combinations except S_2W_2. At 60-80 DAS, the highest RGR (0.0427 g g^{-1} day^{-1}) was recorded from S_2W_2 which was statistically similar with S_1W_1, S_1W_2 , S_1W_3, S_1W_4, S_2W_1, S_2W_3, S_2W_4, S_3W_0, S_3W_1, S_3W_2 and S_3W4 where as the lowest result was obtained from S_3W_3 which was significantly and statistically similar with other treatment combinations except S_2W_2. At 80-100 DAS, the highest RGR (0.1430 g g^{-1} day^{-1}) was recorded from S_2W_2. In this stage the lowest result of RGR (0.0300 g g^{-1} day^{-1}) was obtained from S_1W_0 which was significantly similar with other treatment combinations except S_2W_2. At 140 DAS and harvest stage the highest RGR (0.0333 g g^{-1} day^{-1}) was recorded from S_2W_2 which was significantly similar with other treatment combinations except S_1W_4 and S_2W_0 while the lowest RGR (0.0053 g g^{-1} day^{-1}) was found in S_2W_0 which was significantly and statistically similar with other treatment combinations except S_2W_2.

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

Treatment combinations	Relative growth rate (g m^{-2} day^{-1})						
	20-40 DAS	40-60 DAS	60-80 DAS	80-100 DAS	100-120 DAS	120-140 DAS	140 DAS-harvest
S_1W_0	0.023ab	0.049ab	0.015b	0.030 b	0.0247	0.0150	0.0067 ab
S_1W_1	0.036a	0.043b	0.032ab	0.031 b	0.0310	0.0233	0.0113 ab
S_1W_2	0.028ab	0.048ab	0.029ab	0.040 b	0.0307	0.0187	0.0133 ab
S_1W_3	0.019b	0.050ab	0.021ab	0.043 b	0.0243	0.0207	0.0270 ab
S_1W_4	0.036a	0.048ab	0.034ab	0.036 b	0.0247	0.0210	0.0077 b
S_2W_0	0.022ab	0.040b	0.016b	0.031 b	0.0300	0.0090	0.0053 b
S_2W_1	0.024ab	0.052ab	0.027ab	0.047 b	0.0247	0.0157	0.0193 ab
S_2W_2	0.034ab	0.062a	0.042a	0.143 a	0.0220	0.0120	0.0333 a
S_2W_3	0.022ab	0.047ab	0.033ab	0.039 b	0.0240	0.0097	0.0120 ab
S_2W_4	0.030ab	0.048ab	0.035ab	0.050 b	0.0210	0.0140	0.0127 ab
S_3W_0	0.020ab	0.048ab	0.020ab	0.040 b	0.0307	0.0233	0.0267 ab
S_3W_1	0.027ab	0.056ab	0.028ab	0.043 b	0.0203	0.0227	0.0107 ab
S_3W_2	0.032ab	0.058ab	0.028ab	0.054 b	0.0177	0.0220	0.0177 ab
S_3W_3	0.021ab	0.046ab	0.013b	0.057 b	0.0293	0.0127	0.0160 ab
S_3W_4	0.033ab	0.049ab	0.031ab	0.048 b	0.0233	0.0180	0.0110 ab
LSD(0.05)	0.024	0.019	0.025	0.068	NS	NS	0.0228
CV (%)	31.51	20.04	42.65	71.69	37.21	54.82	88.35

Here,

S_1=20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.3 Yield contributing parameters

4.3.1 Pods plant^{-1}

4.3.1.1 Effect of plant spacing

Number of pods plant^{-1} is a key factor for determining the yield performance in leguminous plants. The productive capacity of groundnut plant is ultimately considered by the number of pods plant^{-1}. Table 10 showed that number of pods plant^{-1} was significantly varied due to different spacing under the present study. Under the present study, S_2 produced the highest number of pods plant^{-1} (14.87) as no significantly different from S_2 (14.68) but was significant different from S_1 (12.11) which was gave about 33.96% higher yield than S_1 value. S_1 had minimum value i.e. 11.10 pods plant^{-1}. Intermediate value (6.68) was obtained from S_2. Nadeem *et al.,* (2004) found the similar result and he observed that the 60cm apart double row produced more number of pods per plant than 40 cm apart single row strips in all legume crops.

4.3.1.2 Effect of weed management

Number of pods plant^{-1} was significantly influenced by weed management at all growth stages of groundnut (Table 10). It is remarked from the present study that the increasing number of weeding significantly increased number of pods plant^{-1}. W_2 produced maximum number of pods plant^{-1} (19.05) which was significantly different with other treatment. The lowest number of pods plant^{-1} was achieved with W_0 (7.67). Intermediate results on number of pods plant^{-1} were obtained from W_1 and W_4 which were significantly similar. The result under the present study was in agreement with the findings of Easha (2014) observed that the increasing number of weeding significantly increased number of pods plant^{-1}. 2 hand weeding produced maximum number of pods plant^{-1} which was similar with spraying post emergence herbicide. The lowest number of pods plant^{-1} was achieved with un-weeded treatment.

4.3.1.3 Combined effect of row spacing and weed management

Significant influence was observed by combined effect of spacing and weed management on number of pods plant^{-1} (Table 10). Results indicated that the highest number of pods plant^{-1} (21.14) was observed in the treatment combination of S_2W_2 which was significantly similar with S_2W_2 (19.72) but different from other treatments combinations. The lowest number of pods plant^{-1} was obtained with S_1W_0 (6.81) which statistically similar with S_1W_0 and S_1W_0. The results obtained from all other treatment combinations were significantly different compared to other treatments.

4.3.2 Kernel pod^{-1}

4.3.2.1 Effect of plant spacing

Number of kernel pod^{-1} is considered an important factor that directly imparts in exploiting potential yield recovery in leguminous crops. Data regarding number of seeds per pod given in (Table 10) revealed that varying row spacing had a significant effect on the number of seeds per pod. Under the present study, the highest number of seeds pod^{-1} (1.63) was achieved by S_2 which was significantly similar with S_3 (1.58) where as the lowest was in S_1 (1.50). Similar findings were found by Rasul *et al.,* (2012). Rasul *et al.,* (2012) observed that the inter-row spacing S_3 (60 cm) and S_2 (45 cm) were statistically similar and produced significantly more number of seeds per pod (10.55 and 10.37, respectively) than produced by S_1 (30 cm) inter-row spacing treatment.

4.3.2.2 Effect of weed management

Results presented in Table 10 on number of seeds pod^{-1} influenced by number of weeding were statistically significant. It is mentioned from the present study that the highest number of seeds pod^{-1} (1.75) was recorded in W_2 and the lowest number of seeds pod^{-1} was achieved by W_0 (1.32). The results from W_1 and W_4 on number of seeds pod^{-1} were intermediate compared to highest and lowest number of seeds pod^{-1}. Similar findings were found by Kundu *et al.,*(2009).They said that seeds pod^{-1} was highest in the treatment having quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 21 DAE + 2 HW at 28 DAE. This was closely followed by the treatment with quizalofop-p-ethyl @ 50 g a.i. ha^{-1} at 14 DAE + HW at 21 DAE.

4.3.2.3 Combined effect of plant spacing and weed management

Table 10 showed statistically significant results from the combined effect of spacing and weeding methods on number of seeds pod^{-1}. Results indicated that the highest number of seeds pod^{-1} (1.77) was observed in the treatment combination of S_2W_2 which was statistically similar with S_1W_2, S_2W_1, S_2W_4, S_3W_2 and S_3W_4. On the other hand, the lowest number of seeds pod^{-1} was obtained with S_1W_0 (1.28) which was closely followed by S_1W_0 and W_2S_0 but significantly different from all other treatment combinations.

4.3.3 Weight of 1000 kernels (g)

4.3.3.1 Effect of plant spacing

Among the various parameters contributing towards final yield of a crop, 1000-seeds weight is of prime importance. Data presented in Table 10 revealed that weight of 1000- seeds was significantly influenced by different row spacing. Under the present study, the highest 1000- seeds weight (455.13 g) was achieved by S_2 which was significantly similar with S_3 where the lowest was achieved by S_1 (430.20 g). The similar result was reported by Nwokwu (2011).

4.3.3.2 Effect of weed management

Results presented in Table 10 on number of seeds pod^{-1} influenced by number of weeding were statistically significant. It is mentioned from the present study that the 1000- seeds weight (481.22) was recorded in W_2 and the lowest 1000- seeds weight was achieved by W_0 (381.56). The results from W_1 and W_4 on 1000- seeds weight were intermediate compared to highest and lowest 1000- seeds weight. Kumar (2009) Weeding twice resulted in increased 100-seed weight of groundnut.

4.3.3.3 Combined effect of row spacing and weed management

Table 10 showed statistically significant results influenced by combined effect of spacing and weeding methods on 1000- kernels weight. Results indicated that the maximum 1000 kernels weight (495.33 g) was observed in the treatment combination of S_2W_2 which was closely followed by S_3W_2 but significantly different from all other treatment combinations. On the other hand, the lowest 1000- kernels weight was obtained with S_1W_0 (370.67 g) which was closely followed by S_1W_0 and W_2S_0 but significantly different from all other treatment combinations.

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

Treatments	Pods plant^{-1} (no.)	Kernel pod^{-1} (no.)	1000-seeds weight (g)
Effect of row spacing			
S_1	12.11 b	1.50 b	430.20 b
S_2	14.87 a	1.63 a	455.13 a
S_3	14.68 a	1.56 a	452.60 a
$LSD_{(0.05)}$	0.28	0.04	13.77
CV%	2.05	2.32	3.05
Effect of weed management			
W_0	7.67 d	1.32 d	381.56 d
W_1	15.07 b	1.60 b	458.78 b
W_2	19.05 a	1.75 a	481.22 a
W_3	12.71 c	1.53 c	440.67 c
W_4	14.00 b	1.58 b	456.67 b
$LSD_{(0.05)}$	1.02	0.06	11.80
CV%	7.52	4.11	2.72
Interaction effect of row spacing and weed management			
$\mathbf{S_1W_0}$	6.81 e	1.28 f	370.67 g
$\mathbf{S_1W_1}$	13.40 c	1.55 de	443.33 e
$\mathbf{S_1W_2}$	16.38 b	1.70 a-c	463.00 b-e
$\mathbf{S_1W_3}$	10.79 d	1.46 e	418.00 f
$\mathbf{S_1W_4}$	12.73 c	1.53 de	438.00 e
$\mathbf{S_2W_0}$	7.97 e	1.33 f	384.33 g
$\mathbf{S_2W_1}$	15.95 b	1.67 a-c	470.67 b-d
$\mathbf{S_2W_2}$	21.14 a	1.77 a	495.33 a
$\mathbf{S_2W_3}$	13.76 c	1.55 de	454.00 c-e
$\mathbf{S_2W_4}$	14.96 b	1.64 a-c	463.33 b-d
$\mathbf{S_3W_0}$	8.25 e	1.35 f	389.67 g
$\mathbf{S_3W_1}$	15.84 b	1.63 cd	462.33 c-e
$\mathbf{S_3W_2}$	19.72 a	1.75 ab	487.33 ab
$\mathbf{S_3W_3}$	13.58 c	1.58 d	450.00 de
$\mathbf{S_3W_4}$	14.82 b	1.61 a-c	460.67 a-c
$LSD_{(0.05)}$	1.59	0.10	22.68
CV%	7.52	4.11	2.72

Here,

S_1 = 20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.4 Yield parameters

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

4.4.1.1 Effect of plant spacing

Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, biochemicals, phenological and morphological events occurring in the plant system. Pod yield of a variety is the result of interplay of its genetic makeup and environmental factors in which plant grow. Data pertaining to the pod yield (Table 11) elucidated that grain yield was significantly influenced by different row spacing. Under the present study, the highest grain yield (1.78 t ha^{-1}) was achieved by S_2 where as the lowest was achieved by S_1 (1.48 t ha^{-1}) which was 20.27% higher than S_1 value. The result obtained from S_3 was intermediate regarding the value of grain yield. The similar result was reported by Easha (2014). Easha (2014) found that the highest grain yield (1.08 t ha^{-1}) was achieved by 30 cm × 10 cm where as the lowest was achieved by 20 cm × 10 cm (0.99 t ha^{-1}) which was 9.1% higher than S_1 value. The result was obtained from 40 cm × 10 cm which was intermediate regarding the value of pod yield.

4.4.1.2 Effect of weed management

Results presented in Table 11 on grain yield influenced by number of weeding were statistically significant. The highest pod yield (2.21 t ha^{-1}) was recorded in W_2 which was 1.51% higher than lowest value while the lowest grain yield was achieved by W_0 (0.88 t ha^{-1}). The 2^{nd} value was given by W_1 and W_4 which were significantly similar. Sukhadia *et al.* (1998) reported that two hand weeding produced higher yield than other weeding method.

4.4.1.3 Combined effect of row spacing and weed management

Table 11 showed statistically significant results influenced by the combined effect of spacing and weeding methods on pod yield. Results indicated that the highest pod yield (2.48 t ha^{-1}) was observed in the treatment combination of S_2W_2which was 181.82 % higher than minimum value. The lowest pod yield was obtained with S_3W_0 (0.88 t ha^{-1}) which was also significantly similar with S_1W_0 and S_2W_0 but different from all other treatment combinations. It is noted here that one hand weeding gave grain yield (1.76-2.06 t ha^{-1}) as next to higher production (S_2W_1) which could be the alternative choice of weed management.

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

4.4.2.1 Effect of plant spacing

There was significant variation observed for strover yield due to plant spacing (Table 11). The higher stover yield (3.38 t ha^{-1}) was recorded from S_1 and the lower stover yield (2.60 t ha^{-1}) from S_3. The similar result was reported by Easha (2014) the higher stover yield (3.33 t ha^{-1}) was recorded from 20 cm × 10 cm spacing and the lower stover yield (2.77 t ha^{-1}) from 40 cm × 10 cm spacing.

4.4.2.2 Effect of weed management

Stover yield of groundnut varied significantly due to different weed managements (Table 11). The highest stover yield (3.47 t ha^{-1}) was observed from W_2 which was statistically similar with W_1 while the lowest stover yield (2.28 t ha^{-1}) from W_1. The similar result was reported by Easha (2014).

4.4.2.3 Combined effect of row spacing and weed managements

The stover yield varied significantly due to different row spacing and weed managements combinations (Table 11). The highest stover yield (3.86 t ha^{-1}) was observed from S_1W_2 and it was statistically similar with S_1W_1, S_1W_4 and $S_2W_2$where as the lowest stover yield (2.05 t ha^{-1}) was found in S_3W_0 which was similar with S_2W_0 and S_3W_3.

4.4.3 Shelling (%)

4.4.3.1 Effect of plant spacing

There was significant variation observed for shelling % due to plant spacing (Table 11). The higher shelling % yield (67.80t ha^{-1}) was recorded from S_2 was significantly similar with S_3 and the lower shelling % yield (65.73 t ha^{-1}) from S_3.

4.4.3.2 Effect of weed management

Shelling % of groundnut varied significantly due to different weed managements (Table 11). The highest shelling % yield (71.11t ha^{-1}) was observed from W_2 while the lowest shelling % yield (62.44t ha^{-1}) from W_1. The results from W_1 and W_4 shelling % were intermediate compared to highest and lowest shelling % and significantly similar one another.

4.4.3.3 Combined effect of row spacing and weed managements

The shelling % of groundnut varied significantly due to different row spacing and weed managements combinations (Table 11). The highest shelling % (72.21t ha^{-1}) was observed from S_2W_2 and it was significantly similar with S_3W_2 (71.00). The lowest shelling % (61.66t ha^{-1}) was found in S_1W_0 which was statistically similar with S_2W_0 and S_3W_0.

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

4.4.4.1 Effect of plant spacing

The productivity of a crop is largely determined by the biological yield. Data regarding biological yield per hectare given in Table 11 revealed that there were significant differences among the row spacing that affected the biological yield. Under the present study, the highest biological yield (4.89 t ha^{-1}) was achieved by S_1 which was significantly similar with S_2 (4.86 t ha^{-1}) where as the lowest was recorded in S_3 (4.14 t ha^{-1}). Similar findings were found by Ahmad *et al*. (2001), Khan *et al*. (2011) and Easha (2014).

4.4.4.2 Effect of weed management

Biological yield was significantly influenced by number of weeding (Table 11). It is mentioned from the present study that the increasing number of weeding significantly increased biological yield. The maximum biological yield (5.69 tha^{-1}) was recorded in W_2 and the minimum biological yield was achieved by W_0 (3.17 t ha^{-1}). Similar findings were found by Easha (2014).

4.4.4.3 Combined effect of plant spacing and weed management

Table 11 showed statistically significant results influenced by interaction between spacing and weed management on biological yield. Results indicated that the highest biological yield (6.02 t ha^{-1}) was observed in the treatment combination of S_2W_0 which was statistically similar with S_1W_2 but significantly different from other treatment combinations. On the other hand, the lowest biological yield was obtained from S_3W_0 (2.87 t ha^{-1}) which was statistically similar with S_2W_0.

4.4.5 Harvest index (%)

4.4.5.1 Effect of plant spacing

Harvest index is a measure of physiological productivity potential of a crop variety. It is the ability of a crop plant to convert the dry matter into economic yield. The calculated values of Harvest index presented in Table 11 indicated that spacing differed significantly on account of conversion efficiency of assimilates. The maximum value of harvest index (35.91%) was achieved by S_3 where as the lowest was achieved by S_1 (30.83%). The results obtained from S_2 showed intermediate results compared to highest and lowest harvest index. Same result was representing by Nwokwu (2011) and Easha (2014).

4.4.5.2 Effect of weed management

Harvest index was significantly influenced by weeding (Table 11). It stated from the present study that the highest harvest index (38.85%) was recorded in W_2 and the lowest harvest index was achieved by W_0 (28.06%). The results from W_1 and W_4 on harvest index showed intermediate results compared to highest and lowest harvest index. Weeding twice had the highest harvest index. This result confirmed the findings of El Naim *et al.* (2011) and Easha (2014).

4.4.5.3 Combined effect of plant spacing and weed management

Table 11 showed statistically significant results influenced by interaction between spacing and weeding on harvest index. Results indicated that the highest harvest index (41.11%) was observed in the treatment combination of S_2W_2 which was significantly similar S_3W_2 but different from all other treatment combinations. On the other hand, the lowest harvest index was obtained from S_1W_0 (26.08%) which was significantly different from all other treatment combinations.

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

Treatments	Pod Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Shelling (%)	Biological Yield (t ha^{-1})	Harvest Index (%)
	Effect of row spacing				
S_1	1.51 b	3.38 a	65.93 b	4.89 a	30.83 b
S_2	1.78 a	3.08 b	67.80 a	4.86 a	35.87 a
S_3	1.53 b	2.60 c	67.63 a	4.14 b	35.91 a
$LSD_{(0.05)}$	0.14	0.18	0.37	0.27	1.24
CV%	8.71	6.00	1.51	5.66	3.59
	Effect of weed management				
W_0	0.88 d	2.28 d	62.44 d	3.17 d	28.06 d
W_1	1.83 b	3.33 ab	67.66 b	5.15 b	35.60 b
W_2	2.21 a	3.47 a	71.11 a	5.69 a	38.85 a
W_3	1.30 c	2.69 c	65.77 c	3.99 c	32.58 c
W_4	1.53 b	3.00 b	68.44 b	4.53 c	33.77 c
$LSD_{(0.05)}$	0.10	0.17	0.62	0.23	1.48
CV%	6.44	5.70	1.96	5.15	4.47
	Interaction effect of row spacing and weed management				
$\mathbf{S_1W_0}$	0.88 g	2.49 g	61.66 g	3.37 e	26.09 g
$\mathbf{S_1W_1}$	1.74 cd	3.70 ab	66.66 c-e	5.44 bc	31.66 e
$\mathbf{S_1W_2}$	2.05 b	3.86 a	69.33 b	5.85 ab	35.02 cd
$\mathbf{S_1W_3}$	1.33 f	3.17 c-e	64.66 ef	4.50 d	29.55 ef
$\mathbf{S_1W_4}$	1.55 de	3.50 ab	67.33 b-d	5.05 c	30.69 e
$\mathbf{S_2W_0}$	0.95 g	2.30 gh	63.00 fg	3.25 ef	29.26 ef
$\mathbf{S_2W_1}$	2.06 b	3.44 bc	67.66 b-d	5.50 bc	37.50 bc
$\mathbf{S_2W_2}$	2.48 a	3.54 ab	72.21 a	6.02 a	41.11 a
$\mathbf{S_2W_3}$	1.42 ef	2.68 ef	66.00 de	4.10 d	34.63 d
$\mathbf{S_2W_4}$	1.61 bc	3.00 cd	69.00 b	4.61 c	34.92 bc
$\mathbf{S_3W_0}$	0.83 g	2.05 h	62.66 fg	2.87 f	28.84 f
$\mathbf{S_3W_1}$	1.68 de	2.82 f	68.66 bc	4.47 d	37.63 b
$\mathbf{S_3W_2}$	2.10 b	2.99 d-f	71.00 a	5.20 c	40.43 a
$\mathbf{S_3W_3}$	1.26 f	2.36 gh	66.66 c-e	3.62 e	34.80 b-d
$\mathbf{S_3W_4}$	1.43 de	2.66 ef	69.00 b	4.09 d	34.96 b-d
$LSD_{(0.05)}$	0.21	0.31	1.07	0.44	2.60
CV%	6.44	5.70	1.96	5.15	4.47

Here,

S_1 = 20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation and W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.5 Economic performance of different combination of spacing and weeding methods

This economic analysis revealed the performance of weed control methods. Cost of production mainly varied due to weed management. As number of labours are varied differently with weed management treatments. The cost involved in seed quantity due to different spacing is equal as different spacing had continuous sowing in line with equal seed rate. No weeding, one hand weeding, two hand weeding required 0, 42 and 84 respectively number of labour(s) rate 300 Tk. per days for one hectare of land when herbicide spraying with Release 9 EC and Sunup 480 SL required only three labours in each case. The highest cost of production was (Tk. 69569 ha^{-1}) for the treatment S_1W_2 (two hand weeding) and the lowest cost of production was (Tk. 41379 ha^{-1}) for the treatment S_3W_0 (Table 12). The costing of the experiment has been given in Appendices X, XI, XII and XIII.

4.5.1 Gross return

The highest gross return (Tk. 170050 ha^{-1}) was obtained from the treatment S_2W_2 (two hand weeding 30 cm x 15 cm spacing) and the second highest gross return (Tk. 143975 ha^{-1}) was obtained from S_3W_2. The lowest gross return (Tk. 59075 ha^{-1}) was obtained from treatment S_3W_0 (No weeding).

Table 12. Cost of production, return and Benefit cost ratio (BCR) of groundnut under different treatment combinations

Treatment combinations	Cost of production ($Tk.\ ha^{-1}$)			Gross return ($Tk.\ ha^{-1}$)			Net income ($Tk.\ ha^{-1}$)	BCR
	Fixed cost	Weeding cost	Total	From grain	From straw	Total		
S_1W_0	47069	0	47069	57200	6225	63425	16356	1.35
S_1W_1	47069	13500	60569	113100	9250	122350	61781	2.02
S_1W_2	47069	22500	69569	133250	9650	142900	73331	2.05
S_1W_3	47069	3490	50559	86450	7925	94375	43816	1.87
S_1W_4	47069	2980	50049	100750	8750	109500	59451	2.18
S_2W_0	44269	0	44269	61750	5750	67500	23231	1.52
S_2W_1	44269	13500	57769	133900	8600	142500	84731	2.47
S_2W_2	44269	22500	66969	161200	8850	170050	105081	2.54
S_2W_3	44269	3490	47759	92300	6700	99000	51241	2.07
S_2W_4	44269	2980	47249	104650	7500	112150	64901	2.37
S_3W_0	41379	0	41379	53950	5125	59075	17696	1.43
S_3W_1	41379	13500	54879	109200	7050	116250	61371	2.12
S_3W_2	41379	22500	63879	136500	7475	143975	80096	2.25
S_3W_3	41379	3490	44869	81900	5900	87800	42931	1.96
S_3W_4	41379	2980	44359	92950	6650	99600	55241	2.24

Here,

S_1=20 cm × 15 cm,
S_2 = 30 cm × 15 cm,
S_3 = 40 cm × 15 cm

W_0 = No weeding, W_1 = 1 hand weeding at 20 DAS, W_2 = 2 hand weeding at 20 and 45 DAS, W_3 = Pre emergence herbicide, Sunup spraying after land preparation, W_4 = Post emergence herbicide, Release spraying at 20 DAS.

4.5.2 Net return

Net return varied in different weed control treatments (Table 12). The highest net return (Tk. 105081 ha^{-1}) was obtained from the treatment S_2W_2. The second highest net return (Tk. 84731ha^{-1}) was obtained from the treatment S_2W_1. Lowest net return (Tk. 16356 ha^{-1}) was achieved from S_1W_0.

4.5.3 Benefit Cost ratio

Benefit cost ratio varied in different weed control treatments. Two hand weeding and 30 cm x 15 cm spacing (S_2W_2) gave the highest BCR (2.54). The treatment S_1W_0 (un-weeded + 20 cm× 15 cm) showed the lowest BCR (1.35). Similar result was also reported by Sardana *et al* (2006).

Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The present piece of work was done at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka during the period from November, 2013 to April, 2014 to find out the influence of different plant spacing along with weed control methods on the growth and yield of groundnut.

The experiment was laid out in a split plot design with three replications. The experiment comprised with two factors viz. (i) Row spacing and (ii) Weed management. Three plant spacings (S_1= 20 cm x 15 cm, S_2= 30 cm x 15cm, S_3= 40 cm x 15 cm) and five weeding treatments no weeding (W_0), one hand weeding at 20 DAS (W_1), two hand weeding at 20 DAS and 45 DAS (W_2), Sunup 480 SL (Glyphoset) @ 3.7 L ha^{-1} (W_3) and Release 9 EC (Phenoxprop-p-ethayel) @ 650 ml ha^{-1} (W_4). Sunup 480 SL, a pre-emergence herbicide was applied after final land preparation. Release 9 EC, a post-emergence herbicide was applied at 20 DAS when weeds were 2-3 leaf stage was used. There were 15 treatment combinations. Plant spacing was placed along the main plot and weeding methods were placed along the sub plot. Data on different growth, yield contributing characters and yield were recorded from the experimental field and analyzed statistically.

The data on weed parameters were collected from 20 DAS to at harvest. Weed parameters such as total weed population (no. m^{-2}); relative weed density (RWD %), weed biomass (g m^{-2}) and weed control efficiency (%) were examined. The data on growth parameters viz. plant height, above ground dry matter weight $plant^{-1}$, leaves number $plant^{-1}$, branches $plant^{-1}$, crop growth rate and relative growth rate were recorded during the period from 20 DAS to at harvest. Yield contributing characters and yield parameters like number of pods $plant^{-1}$, kernel pod^{-1}, 1000 kernels weight, shelling%, pod yield, strover yield, biological yield, harvest index and were recorded. To determine the economic feasibility of different weed control methods on groundnut total cost of production, gross return and net return were calculated to determine the benefit cost ratio.

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

Results revealed that plant spacing with 30 cm x 15 cm stand superior than other in respect of plant height (33.67 cm) above ground dry matter weight plant^{-1} (30.35 g), kernels pod^{-1} (1.63), pods plant^{-1} (14.87), 1000-seeds weight (455.13 g), shelling % (67.80), pod yield (1.78 t ha^{-1}), stover yield (3.38 t ha^{-1}), biological yield (4.86 t ha^{-1}) and harvest index (35.91 %) respectively while maximum number of branches plant^{-1} (8.27) and leaves plant^{-1} (85.95) were found in 40 cm x 15 cm spacing. Among weed management practices, the highest plant height (38.14 cm), branches plant^{-1} (9.95), leaves plant^{-1} (111.10), dry matter content plant^{-1} (40.46 g), kernel pod^{-1} (1.75), pods plant^{-1} (19.05), 1000-seeds weight (481.22 g), shelling % (71.11), pod yield (2.21 t ha^{-1}), stover yield (3.47 t ha^{-1}), Biological yield (5.69 t ha^{-1}), and harvest index (38.85 %) were obtained by 2 hand weeding of weed management.

In combination, it was observed that the lowest number of weed species and total number of weeds m^{-2} (9.77 and 174 respectively) was obscured in S_2W_2 (two hand weeding weed management maintaining 30 cm x 15 cm spacing). On the other hand, the highest number of weed species and total number of weeds m^{-2} (13.00 and 474 respectively) was obtained from S_2W_0. Different weed control treatments had significant effect on crop growth parameters viz. plant height, above ground dry matter weight plant^{-1}, crop growth rate (CGR) and relative growth rate (RGR) at different DAS. The highest plant height (17.96, 24.86, 30.94, 35.66, 37.73 and 38.14 cm at 60, 80, 100, 120, 140 DAS and at harvest respectively) was observed in the 30 cm ×15 cm spacing with two hand weeding for weed management (S_2W_2) and at 20 and 40 DAS, the tallest plant (8.88 cm and 12.44 cm) was observed with S_3W_3. The maximum number of branches plant^{-1}, dry weight plant^{-1} was observed in the treatment combination of S_2W_2. Crop growth rate (CGR) was highest with two hand weeding. Spacing and weed control treatments had significant effect on the yield and yield contributing characters viz. pod^{-1}, 1000 kernels, weight kernel pod^{-1}, pod yield, shelling, strover yield, biological yield and harvest index was highest in 30 cm x 15 cm with two hand weeding treatment. It was observed that plant spacing 30 cm x 15 cm coupled with two hand weeding of weed management method as economically viable treatment for greater yield (2.48 t ha^{-1}) with maximum BCR (2.54).

It may be concluded that groundnut crop could be grown giving 30 cm x 15 cm plant spacing with 2 time hand at 20 DAS and 45 DAS (W_2), for better growth with maximum yield attributes of yield harvest which was proved economically a viable treatment.

RECOMMENDATION

This type of experiment could be taken in different groundnut growing areas of Bangladesh for further testing the said treatment under different cultivation of the environments.

References

REFERENCES

Achakzai, A. K. K. and M.K. Panizai. (2007). Effect of row spacing on growth, yield and yield components of mashbean. *Sarhad J. Agric.* 23(1).

Ah-Khan and F.A. Kiehn. (1989). Effect of date and rate of seeding, row spacing and fertilization on lentil. *Can. J. Plant Sci*. **69**:377-381.

Ahmad, I. (2001). Effect of row spacing and phosphorous level on growth, yield and quality of mungbean. M.Sc.Thesis. Deptt. Agron. Uni. Agri. Faisalabad, Pakistan.

Ahmed, El Naim., Mona., A. Eldouma., Elshiekh., A. Ibrahim., Moaya and M. B. Zaied. (2011). Influence of Plant Spacing and Weeds on Growth and Yield of Peanut (*Arachis hypogaea* L) in Rain-fed of Sudan. *Adv. Life Sci.* **1**(2): 45-48

Akobundu, I. O. (1987). Weed control in other food crops. In Weed Science in the Tropics: Principles and Practices. A John Wiley and Sons publication, Chichester. 522 p.

Akter, R., M.A. Samad., F. Zaman and M. S. Islam. (2013). Effect of weeding on the growth, yield and yield contributing characters of mungbean (*Vigna radiata* L.). *J. Bangladesh Agril. Univ.* **11**(1): 53–60.

Americanos, PG. (1994). Weed management in oil crops. FAO Plant Protection Paper. F.A.O. 331-338.

Anwar, S., W.A. Shah., J. Bakht and U. Jabeen. (2004). Comparison of sorghum extracts, chemical and hand weeding management in wheat Crop. *J. Agron.* **3**(1): 59-67.

Aslam, M. N., S. A. Khan., M. S. Mirza and U. Naeem. (1993). Effect of different row and plant spacing on soybean yield and its components. *Pakistan J. Agri. Res.* **14**(293): 143-148.

Awan, F.K., M. A. Zahid and M. Yaqoob. (2009). Weed management in mungbean (*Vigna radiata* L.) using different methods and row spacing. *Pak. J. Weed Sci. Res.* **15**(4): 269-274.

Basak, N. C., M. K. Chowdhury and F. U. Mia. (1995). Effect of spacing on the yield and economoics of groundnut. *Legume-Res.* **18** (1): 45-49.

Bedry, K. A. (2007). Effect of weeding regimes on faba bean (*Vicia faba* L.) yield in the Northern State of Sudan. University of Khartoum. *J. Agric. Sci.* **15**: 220-231.

Bueren, E.T.L., P.C. Struik and E. Jacobsen. (2002). Ecological concepts in organic farming and their consequences for an organiccrop ideotype. *J. Life Sci.* **50**: 1-26.

Canal, M. J., R. S. Tames and B. Fernandez. (1987). Glyphosate increased levels of indole –3-acetic acid in yellow nutsedge leaves correlated with gentisic acid levels. *Physiol. Plant.* **71**: 384–388.

Chaniyara, N. J., R. M. Solanki and V. B. Bhalu. (2001). Response of summer ground to spacing and plant population legume research. **24**: 4.

Chimanshette, T. G. and V. V. Dhoble. (1992). Effect of sowing date and plant density on seed yields of sesame (*Sesamum indicum*) varieties. *Indian J. Agron*. **37**(2): 280-282.

Crafts, A. S. and W. W. Robbins. (1973). Weed Control. A Text Book and Manual. Tata Mc Graw Hill. Pub. Co. Ltd.

Dapaah, H. K., H. Asumadu., J. N. L. Lamptey., J. Haleegoah and B. Asafo Adjei. (2007). Farmer participation in groundnut varietal selection. Proceedings of the 18th African Crop Science Society Conference. **8**:1435-1439.

Duncan, W. G. (1971). Leaf angle, leaf area and canopyphotosynthesis. *Crop Sci.***11:** 482-485.

Dungarwal, H. S., Chaplot, P. C. and Nagda, B. L. (2003). Chemical weed control in mungbean (*Phaseolus radiatus* L.). *Ind. J. Weed Sci*. **35:** 283-284.

Easha, N. (2014). Weed Management For Mungbean Under Different Level Of Plant Spacing. MS. Thesis, SAU, Dhaka-2107.

El Naim, A. M. and A. A. Jabereldar. (2010). Effect of Plant density and cultivar on growth and yield of cowpea (*Vigna unguiculata* L.). *Aust. J. Basic and Appli. Sci.* **4**(8): 3148-3153.

El Naim, A. M., E. M. El day and A. A. Ahmed. (2010). Effect of plant density on the performance of some sesame (*Sesamum indicum* L.) cultivars under Rain fed. *Res. J. Agric. Biol. Sci*. **6**(4): 498-504.

Everaarts, A. P. (1992). Effects of competition with weeds on growth, development and yield of groundnut. *Netherland J. Agric. Sci.* **4** (1): 73-90.

FAO. (2006). FAO production yearbook. Vol 60, Rome Italy.

Gardner, F. P., R. B. Pearce and R. L. Mistechell. (1985). Physiology of crop plants. Iowa State Univ. Press. Iowa. 500010. p. 66.

Greiger, D. R. and H. D. Bestman. (1990). Self limitation of herbicide mobility by phytotoxic action. *Weed Sci.* 38: 324–329.

Guggari, A. K., Manjappa, K., Desai, B. K. and Chandranath, H.T., 1995. Integrated Weed Management in groundnut. Journal of Oil Seeds Research 12(1): 65-68.

Gul, B., K. B. Marwat., M. Saeed., Z. Hussain and H. Ali. (2011). Impact of tillage, plant population and mulches on weed management and grain yield of maize. *Pak. J. Bot*. **43**(3): 1603-1606.

Hasanuzzaman, M. and M. F. Karim. (2007). Performance of Rapeseed (*Brassica campestris* L.) cv. SAU sarisha under different row spacing and irrigation levels. *Res. J. Agri. & Bio. Sci*. **3**: 960-965.

Hasanuzzaman, M., M. F. Karim and M. J. Ullah. (2008). Growth dynamics of rapeseed (*Brassica campestris* L.) cv. SAU sarisha as influenced by irrigation levels and row spacings. *Aust. J. Basic Appl. Sci*. 2: 794-799.

Hossain, M. A. and A. B. M. Salauddin. (1994). Growth and yield of sesame in relation to population density. *Bangladesh J. Life Sci*. **6**(1): 59-65.

Howlader S. H., M. S. Bashar Islam., M. H. Mamun and S. M. H. Jahan. (2009). Effect of Plant Spacings on the Yield and Yield Attributes of Groundnut. *Int. J. Sustain. Crop Prod.* **4**(1):41-44.

Ishag, H. M. (1971). Weed control in irrigated groundnut ((*Arachis hypogaea* L). in the Sudan Gezira. *J. Agric. Sci*. **77:** 237-242.

Ishikura, N., S. Teramoto., Y. Takeshima and S. Mitsui. (1986). Effects of glyphosate on the shikimate pathway and regulation of phenyl alanine ammonia-lyase in Cryptomeria and Perilla cell suspension cultures. *Plant Cell Physiol*. **27**: 677–684.

Itnal, C. J., B. S. Lingaraju and C. B. Kurdukeri. (1993). Effect of herbicides and cultural methods on weed control in irrigated groundnut. *Indian J. Weed Sci.* **25** (3 and 4): 27-31.

Jain, V. K., Y. S. Chauhan., M. K. Bhargava and A. K. Sharma. (2000). Chemical weed control in soybean (Glycine max). *Indian J. Agron.* **45** (1): 153-157.

Jhala, A. P., H. Rathod., K. C. Patel and P.V. Damme. (2005). Growth and yield of groundnut (*Arachis hypogaea* L.) as influenced by weed management practices and Rhizobium inoculation. *Agric. Appl. Biol. Sci*. **70:** 493-5006.

Johnson, W. E. (1983). Cropping practices: Canadian prairies. pp. 407-417. IN H.E. Dregneand W.O. Willis, eds., Dryland Agriculture, Agron. Monograph No. 23., Am. Soc. Agron., Madison, WI.

Joshi, K. R. (2004). Effect of time of weeding and levels of N and P2 P5 fertilizers on the grain yield of maize. *Nepal Agric. Res. J*. **5**. 69-70.

Kabir , M. H. and M. A. R. Sarkar. (2008). Seed yield of mungbean as affected by variety and plant spacing in *Kharif*-I season. *J. Bangladesh Agril. Univ*. **6**(2): 239–244.

Karunakar, A. P., D. J. Jiotode and R.V. Nalamvar. (2002). Basis of variation in pod yield of kharif groundnut under delayed sowings. *Res. Crops.* **3**(3): 546-550.

Khan, R. U., A. Rashid and M. S. Khan. (2011). Impact of various rates of pendimethalin herbicide on weed control, seed yield and economic returns in mungbean under rainfed conditions. *J. Agric. Res.* **49**(4).

Khidir, M. O. (1997). Oil seed crops in the Sudan. Khartoum University press. Khrtoum, Sudan.

Kumar, N. S. (2009). Effect of plant density and weed management practices on production potential of groundnut (*Arachis hypogaea* L.). *Indian J. Agric. Res.* **43**: 1.

Kumar, Y., R. Saxena., K. C. Gupta., V. D. Fagaria and R. Singh, (2013). Yield attributes and yield of groundnut (*Arachis hypogaea* L.) as influenced by weed management practices in semi arid region. *J. Crop Weed.* **9**:185-89.

Kundu, R., P. S. Bera and K. B. Chari. (2009). Effect of different weed management practices in summer mungbean (*Vigna radiata* L.) under new alluvial zone of West Bengal. *J. Crop Weed.* **5**(2): 117-121.

Laanset, L. (1987). Incorporation of exogenous tyrosine and phenyl alanine into c-glycosylflavones in glyphosate treated barley seedlings. *Eesti NSV Tead. Akad. Toim. Biol*. **36:** 204–209.

Levy, A., D. Palevitch and J. Kleifeld. (1985). Evaluation of Sesame cultivars and Cultural practice. In: FAO Plant Production and protection Sesame Technical paper. No. **66**:107-114.

Madhavi, M., D. M. Reddy., M. P. Devi and CN. Reddy. (2008). Integrated weed management in maize-groundnut cropping system in southern Telangana zone of Andra Pradesh. In: Biennial conference on weed management in modern agriculture: Emerging challenges and opportunities. 27-28 February. Organised by ISWS, NRCWS, Jabalpur (M.P) and Rajendra Agricultural University, Pusa (Bihar). p.125.

Madhu, S. C., M. Appa, B.T. Pujari and Somasekhar. (2006). Effect of Integrated Weed Management on Nutrient Uptake and Yield in Groundnut and Sunflower Intercropping System. *Karnataka. J. Agric. Sci.***19** (1): (5-8).

Malik, M.S., J. K. Norsworthy., A. S. Culpepper., M. B. Riley and W. Bridges. (2008). Use of wild radish (*Raphanus raphanistrum*) and rye cover crops for weed suppression in sweet corn. *Weed Sci.* **56:** 588-595.

Marshall, G. C., and H. W. Ohm. (1987). Yield response of 16 winter wheat cultivars to row spacing and seeding rate. *Agron J.* **79:** 1027-1030.

Martin, S. G., R. C. Van Acker and L. F. Friesen. (2001). Critical period of weed control in spring canola. *Weed Sci*. **49**: 326-333.

Meena, S.S. and R. S. Mehta. (2009). Integrated weed management in coriander (*Coriandrum sativum*). *Indian J. Agric. Sci.* **79:** 824-26.

Mian, A. L. and M. S. U. Bhuiya. (1977). Cost, output and return in crop production. *Bangladesh J. Agron*. **1**(1-2):8.

Mohamed E. S. A. H. Nourai. G. E. Mohamed, M. I. Mohamed and M. C. Saxena. (1997). Weeds and weed management in irrigated lentil in northern Sudan. *Weed Res.* **37:** 211–218.

Momoh, E. J. J. and W. Zhou. (2001). Growth and yield responses to plant density and stage of transplanting in winter oilseed rape (*Brassica napus* L.). *J. Agron*. *Crop Sci*. **186**:253-259.

Mozingo, R. W. And J. L. Steele. (1989). Intra-row spacing effects on morphological characteristics, yield, grade and net value of five peanut cultivars. *Peanut Sci*. **16**: 95-99.

Mubarak, H. A. (2004). Studies on weed management in irrigated groundnuts (*Arachis hypogaea* L) in Sudan. Ph.D. Thesis. Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

Muchow, R. C. and D. A. C. Edwards. (1982). A physiological analysis of mungbean at a range of plant densities in tropical Australia. *Aust. J. Agric. Res*. **33:** 41-51.

Murthy, B. G., C. A. Agasimani., B. H. Banalad and N. C. Prathiba. (1994). Studies on integrated weed control in kharif groundnut. *Fmg. Syst.* **19** (3&4): 66-69.

Nadeem, M. A., A. Ali, R. Sohail and M. Maqbool. (2004). Effect of Different Planting Pattern on Growth, Yield and Quality of Grain Legumes. *Pak. J. Life Soc. Sci.* **2**(2): 132-135.

Naeem, A., R. Mohammed and U. Khan. (2007). Evaluation of Different varieties, Seed rates and row spacing of groundnut planted under agro ecological Conditions of Makaland Division: *J. Agron.* **6**(2)385 -387.

Nambi, J. and A. Sundari. (2008). Phytosociological studies of weed flora of groundnut (Arachis hypogaea L.) fields in Cuddalore district of Tamilnadu. In: National symposium on IAPEA. pp. 122-124.

Narayanan, V. V. and A. Narayanan. (1987). Yield variation caused by cultivar, season and population density of sesame. *Indian J. Oil Seed Res*. **4:** 193-201.

Naseem, S. M. (1995). Performance of mungbean as influenced by different seeding technique under varying cultural practices. *Bangladesh J. Sci. Ind. Res*. **30:** 63-69.

Norman, K., L. Wieck., P. Harden and G. Baker, (2005). Peanut production guide. National Library of Australia Cataloguing-in-Publication Data. p. 36.

Nwokwu, G. N. (2011). Influence of phosphorus and plant spacing on the growth and yield of groundnut (*Arachis hypogeae* L.). *Inter. Sci. Res. J*. **3:** 97 – 103.

Olabode, O. S. and A.O. Sangodele. (2014). Effect of pre emergence herbicides on the growth, yield and drawing quality of jute mallow (C*orchorus olitorius*). *Inter. J. Sci, Environ. Technol.* **3**(1): 48 – 54.

Ozer, H. (2003). The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. *Plant Soil Environ*. **4**: 422-426.

Pandya, N., G. S. Chouhan, and V. Nepalia. (2005). Effect of varieties, crop geometries and weed management on nutrient up take by soybean (*Glycine max*) and associated weeds. *Indian J. Agron.* **50**(3): 218-220.

Pannu, RK. RK. Malik., KP. Singh and DS. Malik. (1991). Influence of weeds on the growth and partitioning of biomass in groundnut. *Crop Res.* **4** (2): 181-187.

Patel, J. C., P. P. Patel and G. L. Jat. (2007). Integrated weed management infenugreek (*Trigonella foenum-graecum* L.). *Proc. Nat. Sem. On Production, Development, Quality and Export of Seed Spices - Issues and Strategies,* held during 2–3 February 2007 at NRCSS, Ajmer, Rajasthan.

Paulo, E. M., F. S. Kasai and J. C. Carichioli. (2001). Effect of weeds competition periods on peanut. Wet season crop. Bragantia. **60:** 27-33.

Pendersen, P. and J. G. Lauer. (2003). Corn and soybean response to rotation sequence, row spacing and tillage system. *Agron. J*. **95:** 965-997.pp.

Priya, S. R., C. Chinnusamy, P. Manickasundaram., E. P. Prostko and T. L. Grey. (2013). A comparison of full and reduced rate weed management programs in peanut. University of Georgia, College of Agricultural and Environmental Sciences, Tifton, GA, US.

Radford, P. J. (1967). Growth analysis formula,their use and abuse. *Crop Sci.* **7:**171-175.

Rana, M. M. (2008). Effect of tow spacing and methods of weeding on the yield of mungbean. MS. Thesis, SAU, Dhaka-2107.

Rahman, M. M., M. G. Mwakangwale., J. G. Hampton and M. J. Hill. (2004). The effect of plant density on seed yield of two cool tolerant soybean cultivars in Canterbury. *Agron. New Zealand*. **34:** 149-159.

Rajendran, K. and A. C. Lourduraj. (1999). Weed management in groundnut–Areview. *Agric. Rev.* Karnal. **20:** 59-62.

Rasul, F., M. A. Cheema., A. Sattar., M. F. Saleem and M. A. Wahid. (2012). Evaluating the performance of three mungbean varieties grown under varying inter-row spacing. *J. Anim. Plant Sci.* **22**(4): 1030-1035.

Rathi, G.S., R. S. Sharma and M. P. Dubey. (1986). Studies on integrated weed control in rainfed groundnut. *Indian J. Weed Sci.* **18**(4): 220-225.

Samrat, J. (1994). The groundnut crop: A scientific basis for improvement. *Crop Sci.* **18**: 1015-1021. P.734.

Sardana, V., U. S. Walia and S.S. Kandhola. (2006). Productivity and economics of summer groundnut (*Arachis hypogaea* L.) cultivation as influenced by weed management practices. *Indian J. Weed Sci.* **18:** 156-58.

Sharar, M. S., M. Ayub, M. A. Nadeem and S. A. Noori. (2001). Effect of different row spacing and seeding densities on the growth and yield of gram (*Cicer arietinum* L.). *Pakistan J. Agri. Sci.* **38:** 51-53.

Singh, V.B. and G. Giri. (2001). Influence of intercropping and weed control measures on dry matter accumulation and nutrient uptake by sunflower and groundnut and their effect on succeeding maize. *Indian J. Agron.* **46 :**50-55.

Sukhadia, N. M., B. B. Ramani., K. B. Asodaria and M. M. Modhwadia. (1998). Comparative efficacy of pre and post-emergence herbicide application in spreading groundnut. *Indian J. Weed Sci.* **30** (3 and 4): 163-167.

Suresh, B. V. and H. V. Nanjappa. (1994). Critical stages of crop weed competition in groundnut under kharif rainfed conditions. *Crop Res.* **7** (1): 153-155.

Tayyab, M. (2000). Determining suitable planting geometry for two mungbean cultivers under Faisalabad condition. M. Sc. Thesis. Deptt. Agron. Uni. Agri. Faisalabad, Pakistan.

Upadhyay, U. C. (1984). Weed Management in Oilseed Crops. Proc. Symp. - Oilseed Production, Utilization, Constraints and Opportunities, pp. 491–99.

Varaprasad, P. V and M. Shanti. (1993). Increase oilseed productivity through integrated weed management systems in A.P. In: National Seminar on Oilseed Research and Development in India: Status and Strategies, held at Directorate of seeds Research Hyderabad, pp. 221-222.

Vijaya, K. R., Y. S. Ramakinshna., k. Krishna Maity., B. Ashok Kumar and A.M. Shekh. (1997).Identifying the climatic constraints for optimum Identifying the climatic constraints for optimum Production of groundnut production and delineating the areas with highest Production potential on climatic basis: In production of the symposium on Tropical crop research and development. Indian International, Trissur India.

Vilas, M., Bhale1., Jayashri., V. Karmore., Yuvraj., R. Patil and Dr. P. D. Krish. (2012). Ntegrated weed management in groundnut (Arachishypogea). *Pak. J. Weed Sci. Res*. **18:** 733-739.

Vyas, M. D. and P. P. Singh. (2000). Weed management in soybean (*Glycine max*) Merill. Ann. *Plant Protec. Sci*. **8**(1):76-78.

Walia, US., Surjit Singh and Buta Singh. (2007). Integrated approach for the control of Hardy weeds in groundnut (Arachis hypogaea L.). *Indian J. Weed Sci.* **39** (1&2): 112-115.

Weiss E.A. (1983). Oil seed crops. Longman Inc. New York.

Weiss, E. A. (2000). Oilseed Crops. London: Blackwell Science.

Yadava, T. P. and Kurnar. (1981). Stability analysis for pods yield and maturity in bunch group of groundnut (Arachis hypogaea L). *Indian J. Agic. Res.* **12:**14.

Yilmaz, H. A. (1999). Effect of different plant densities of two groundnut (*Arachis hypogaea* L.) genotypes on yield, yield components, oil and protein contents. *Turkish J. Agric. For.* **23** (3): 299-308.

Young, C. (1996). Peanut oil. Bailey's Industrial Oil and Fat Product. **2**: 337-392.

Zimdhal, R. L. (2004). Weed Crop Competition: A Review. Ames, IA: Blackwell Publishing Professional. pp. 49 -50.

Appendices

APPENDICES

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

A. Morphological characteristics of the experimental field

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

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value	
	Before sowing	**After harvest**
pH	6.00	5.70
Organic matter (%)	0.86	1.19
Total N (%)	0.05	0.06
Available P (ppm)	6.49	5.26
Exchangeable K (me/100 g soil)	0.18	0.21
Available S(ppm)	27.62	10.06
Available Ca (me/100 g soil)	10.06	14.08

Source: Soil Resource Development Institute (SRDI)

Appendix II. **Monthly average air temperature, rainfall and relative humidity of the experimental site during the period from November 2013 to April 2014.**

Months	Air temperature (^{0}c)		Relative humidity (%)	Total rainfall (mm)
	Maximum	Minimum		
November, 2013	28.10	6.88	58.18	1.56
December, 2013	25.36	5.21	54.30	0.63
January, 2014	21.17	15.46	64.02	0.00
February, 2014	24.30	19.12	53.07	2.34
March, 2014	29.78	22.37	48.66	0.12
April, 2014	33.82	22.85	51.02	2.19

Source: Mini weather station, Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-2007.

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

Source of variance	**df**	**Mean square**							
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**100 DAS**	**120 DAS**	**140 DAS**	**At harvest**
Replication	2	0.61	0.34	0.27	5.4	0.302	1.16	1.23	1.19
Spacing (S)	2	0.01^{NS}	0.32^{NS}	17.74^{*}	45.50^{*}	32.98^{*}	40.02^{*}	42.76^{*}	54.55^{*}
Error (a)	4	0.48	0.41	1.22	2.95	1.7	1.38	0.94	1.42
Weeding (W)	4	0.99^{*}	2.52^{*}	42.34^{*}	128.31^{*}	162.264^{*}	126.76^{*}	98.62^{*}	102.42^{*}
S ×W	8	0.11^{NS}	0.29^{*}	2.59^{*}	3.08^{*}	2.25^{*}	2.06^{*}	2.07^{*}	3.11^{*}
Error (b)	24	0.46	0.81	1.59	2.91	2.28	1.64	2.24	1.86

*= Significant at 5% level

^{NS} = Non significant at 5% level

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

Source of variance	df	Mean square							
		20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	At harvest
Replication	2	0.04	0.05	0.21	0.36	0.55	1.07	1.64	1.69
Spacing (S)	2	0.05^{NS}	0.06^{NS}	0.03^{NS}	0.76^{*}	3.93^{*}	9.45^{*}	10.77^{*}	9.24^{*}
Error (a)	4	0.06	0.06	0.05	0.01	0.22	0.30	0.18	0.03
Weeding (W)	4	0.01^{NS}	0.09^{NS}	0.77^{*}	3.38^{*}	11.41^{*}	24.17^{*}	30.56^{*}	28.63^{*}
S ×W	8	0.01^{NS}	0.07^{*}	0.05^{*}	0.04^{*}	0.17^{*}	0.40^{*}	0.61^{*}	0.61^{*}
Error (b)	24	0.02	0.05	0.04	0.08	0.09	0.45	0.34	0.13

*= Significant at 5% level of significance

^{NS} = Non significant

Appendix V. Effect of plant spacing and weed management on number of leaves plant^{-1} of groundnut at different days

Source of variance	df	Mean square							
		20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	At harvest
Replication	2	1.64	16.68	12.16	6.43	93.70	78.43	102.26	36.12
Spacing (S)	2	0.98^{NS}	13.05^{NS}	26.79^{NS}	3.38^{NS}	420.40^{*}	1021.56^{*}	856.09^{*}	958.01^{*}
Error (a)	4	0.68	17.29	10.94	2.27	27.27	139.67	31.39	47.31
Weeding (W)	4	0.32^{NS}	12.52^{*}	60.22^{*}	99.50^{*}	2575.62^{*}	3982.91^{*}	4110.94^{*}	4275.55^{*}
S ×W	8	0.26^{NS}	4.92^{NS}	6.05^{*}	4.01^{*}	42.87^{*}	64.19^{*}	38.82^{*}	71.89^{*}
Error (b)	24	0.66	10.06	10.01	6.17	26.45	98.00	58.83	46.88

*= Significant at 5% level of significance

^{NS} = Non significant

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

Source of variance	df	Mean square							
		20 DAS	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	At harvest
Replication	2	0.01^{NS}	0.11^{NS}	0.16^{NS}	1.22^{NS}	10.50*	2.23*	83.44*	77.86*
Spacing (S)	2	0.01	0.03	0.35	0.80	39.11	38.35	68.36	209.63
Error (a)	4	0.01	0.06	0.15	0.92	3.11	4.85	7.29	4.30
Weeding (W)	4	0.02*	0.06*	0.93*	6.59*	67.83*	124.83*	335.57*	772.38*
S ×W	8	0.01^{NS}	0.01*	0.06*	0.66*	2.29*	0.85*	4.38*	12.93*
Error (b)	24	0.01	0.02	0.08	0.69	5.91	6.21	10.41	6.41

*= Significant at 5% level of significance
^{NS} = Non significant

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

Source of variance	df	Mean square						
		20-40 DAS	40-60 DAS	60-80 DAS	80-100 DAS	100-120 DAS	120-140 DAS	140 DAS-At harvest
Replication	2	0.16	0.16	0.71	8.32	16.26	86.32	13.71
Spacing (S)	2	0.27^{NS}	4.37*	2.77^{NS}	4.22^{NS}	51.95*	72.23*	29.24^{NS}
Error (a)	4	0.12	0.16	0.95	1.42	4.60	13.38	7.68
Weeding (W)	4	0.07^{NS}	0.71*	2.36*	42.31*	18.93*	66.36*	145.89*
S ×W	8	0.04*	0.18*	0.71*	2.48*	7.63*	7.17*	10.53*
Error (b)	24	0.05	0.14	0.56	5.78	4.28	16.12	13.64

*= Significant at 5% level of significance
^{NS} = Non significant

Appendix VIII. Effect of plant spacing and weed management on yield contributing characters of groundnut

Source of variance	df	Mean square		
		Pods plant^{-1}	kernel pod^{-1}	1000 kernels weight (g)
Replication	2	2.072	0.0061	1.40
Spacing (S)	2	35.927*	0.0246*	2824.60*
Error (a)	4	0.081	0.0013	184.40
Weeding (W)	4	155.366*	0.2386*	13623.40*
S ×W	8	1.073*	0.0007*	90.70*
Error (b)	24	1.092	0.0041	147.20

*= Significant at 5% level of significance

^{NS} = Non significant

Appendix IX. Effect of plant spacing and weed management on yields and harvest index of groundnut

Source of variance	df	Mean square				
		Pod yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Shelling (%)	Harvest index (%)
Replication	2	0.05	0.03	0.11	3.29	7.45
Spacing (S)	2	0.33*	2.28*	2.67*	15.29*	127.87*
Error (a)	4	0.02	0.03	0.07	1.02	1.50
Weeding (W)	4	2.23*	2.13*	8.66*	93.69*	141.60*
S × W	8	0.02*	0.03*	0.06*	0.54*	1.88*
Error (b)	24	0.01	0.03	0.05	1.72	2.33

*= Significant at 5% level of significance

^{NS} = Non significant

Appendix X. Cost of production per hectare of groundnut excluding weeding cost for 20 cm x 15 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	150(with shell)	70	10500
02.	Cost of fertilizers			
	a) Urea	25	16	400
	b) TSP	165	22	3630
	c) MOP	95	15	1425
	d) Gypsum	165	8	1320
				Grand total = 17275

Appendix XI. Cost of production per hectare of groundnut excluding weeding cost for 30 cm x 15 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	110 ((with shell)	70	7700
02.	Cost of fertilizers			
	a) Urea	25	16	400
	b) TSP	165	22	3630
	c) MOP	95	15	1425
	d) Gypsum	165	8	1320
				Grand total = 144

Appendix XII. Cost of production per hectare of groundnut excluding weeding cost for 40 cm x 15 cm plant spacing

Sl. No.	Item	Quantity (kg ha^{-1})	Rate (tk kg^{-1})	Cost (tk)
01.	Cost of seed	70 ((with shell)	70	4900
02.	Cost of fertilizers			
	a) Urea	25	16	400
	b) TSP	165	22	3630
	c) MOP	95	15	1425
	d) Gypsum	165	8	1320
			Grand total =	11585

Appendix XIII. Weeding cost of different weed control treatments for one hectare of land of groundnut

Treatments	No. of labours	Labour cost	Herbicide cost	Total weeding cost
W_0	0	0	--	0
W_1	45	13500	--	13500
W_2	75	22500	--	22500
W_3	3	900	2590	3490
W_4	3	900	2080	2980

Appendix XIV. Layout of the experimental field.

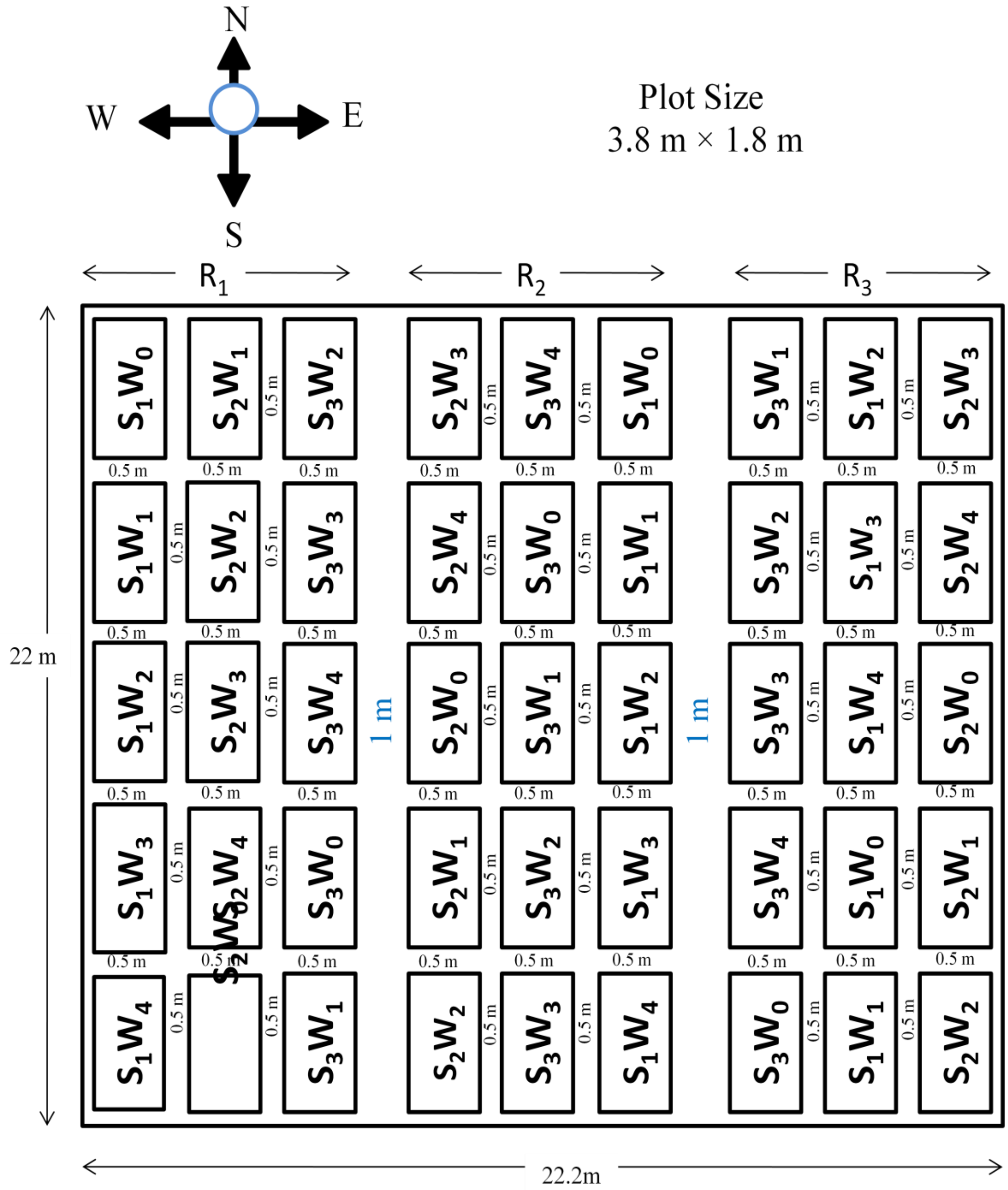

Fig. Layout of the Experimental Field

LIST OF PLATES

Plate 1. Field view of un-weeded plot (W_0)

Plate 2. Field view of one hand weeding at 20 DAS treated (W_1) plot

Plate 3. Field view of two hand weeding at 20 & 45 DAS treated (W_3) plot

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

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