EFFECT OF IRRIGATION AND GROWTH REGULATOR ON CHLOROPHYLL CONTENT, RELATIVE WATER CONTENT AND YIELD OF MUNGBEAN (*Vigna radiate L.*)

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF IRRIGATION AND GROWTH REGULATOR ON CHLOROPHYLL CONTENT, RELATIVE WATER CONTENT AND YIELD OF MUNGBEAN (*Vigna radiate L.*)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science in Agricultural Chemistry**, embodies the result of a piece of bona fide research work carried out by **Md. Imran Hossain**, Registration No. **06-01849** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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The Author

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LIST OF ABBREVIATIONS OF SYMBOLS AND TERMS

Abbreviation	Full Word
et al.	And others (at elli)
BBS	Bangladesh Bereau of Statistics
CV	Coefficient of Variation
d.f.	Degrees of Freedom
DAE	Department of Agricultural Extension
etc.	Etcetera
e.g.	Example
ha	Hectare
Tk.	Taka
i.e.	That is
Km	Kilometer
viz.	Namely
NGO	Non-Government Organization
%	Percent
PCI	Problem Confrontation Index
r	Pearson's Product Moment Correlation Co-efficient

EFFECT OF IRRIGATION AND GROWTH REGULATOR ON CHLOROPHYLL CONTENT, RELATIVE WATER CONTENT AND YIELD OF MUNGBEAN (*Vigna radiate L.*)

ABSTRACT

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean during the period from March 2012 to May 2012. The experiment comprised of two different factors such as (1) two levels of irrigation viz. I_0 (control), and I_1 (irrigation at first flowering stage) and (2) five levels of GA_3 viz. G_0 (no GA_3), G_{20} (20 ppm per unit area of GA_3), G_{40} (40 ppm per unit area of GA_3), G_{60} (60 ppm per unit area of GA_3) and G_{80} (80 ppm per unit area of GA_3). The experiment was set up in Randomized Complete Block Design (factorial) with three replications. The highest plant heights (28.67, 64.33 and 70.33 cm at 30, 60 DAS and at harvest respectively), fresh weight plant^{-1} (16.30, 38.50 and 84.00 g at 30, 60 DAS and at harvest respectively), dry weight plant^{-1} (4.58, 9.92 and 14.01 g at 30, 60 DAS and at harvest respectively), number of flowers plant^{-1} (10.55, 6.88 and 4.28 at 30, 60 DAS and at harvest respectively), number of pods plant^{-1}, (13.83), number of seeds pod^{-1} (14.77), grain yield (1376.00 kg ha^{-1}) and harvest index (40.84%) were achieve with the combination of I_1G_{40}. But the highest 1000 seed weight (48.67 g) was found from I_1G_{60}. In case of chlorophyll content, the highest (0.7107 mg g^{-1} and 0.3330 mg g^{-1} at 663ηm and 645ηm respectively) was also obtained from I_1G_{60} treatment. Again, in terms of Relative Water Content (RWC), the highest result (84.12%) was obtained from I_1G_{60}.

CHAPTER I

INTRODUCTION

The major legumes in Asia are chickpea, (*Cicer arietinum* L), pigeonpea (*Cajanus cajan* L), and mungbean (*Vigna radiate L.*). Mungbean is a warm season crop requiring 90-120 days of frost free conditions from planting to maturity. Adequate rainfall is required from flowering to late pod fill in order to ensure good yield. Production of mung beans are worsening with the rapid expansion of water-stressed areas of the world (Postel, 2000). Yield of mungbean is more dependent on adequate supply of water than on any other single environmental factor (Kramer and Boyer 1997). Among the favorable characters of growing mungbean, fast growth, nitrogen fixation capability, soil reinforcement and prevention of soil erosion are in top. Mungbean is popular as inter crop, or as mixed crop with cash crops. The rice-wheat cropping system is practiced on 26 million ha in South and East Asia (Abro *et al.*, 1997; Timsina and Connor , 2007). Including mungbean in the rice rotation system has diversified and strengthened the cropping system, alleviated the disadvantages of the cereal–cereal cropping system, and improved the productivity of the soil. Mungbean enriches the soil and breaks the soil fatigue caused by cereal–cereal rotations. Inclusion mungbean in a rice rotation system has increased the yield of paddy and the income of farmers in Punjab (Weinberger,2003).

Among the pulse crops, mungbean (*Vigna radiata* L.) has special importance in intensive crop production of the country for its short growing period (Ahmed *et al.*, 1978). In Bangladesh, mungbean ranks third in acreage and production but ranks first in market price. Mungbean grain contains 51% carbohydrates, 26% protein, 10% moisture, 4% mineral and 3% vitamins (Kaul, 1982). The green plants can also be used as animal feed and its residues have capacity to improve soil fertility thus increase the productivity of land. It may play an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the acreage and production of mungbean is steadily declining (BBS, 2005). The dry period of Kharif-I is not favorable for mungbean germination. Kharif-II period is occupied by Transplanted Aman rice. Cultivation of high yielding varieties of wheat and winter rice have occupied considerable land suitable for mungbean cultivation in late robi season. Beside this, low yield potentiality of these crops is responsible for declining the area and production.

The average yield of mungbean is 0.69 t ha^{-1} (BBS, 2005), which is very poor in comparison to mungbean growing countries in the world. There are many reasons of lower yield of mungbean. Fertilizer and irrigation managements are less important in mungbean specially in kharif-II season.

In Bangladesh, Kharif-I mungbean is a rainfed crop, which grows on residual soil moisture. Mungbean responses favorably to added water resulting in higher yields, especially when irrigation is given at the time of flowering in kharif-I season (Miah and Carangal, 1981). One or two irrigation is useful to obtain higher yields. In summer cultivation when temperature is high, relative humidity is low and evapo-transpiration is greater, 3-4 irrigations may be needed to obtain higher yields of mungbean (Lal and Yadav, 1981). Irrigation during flowering stage helps for retention of flowers and pod development. Hence, the proper might have the positive effect on maximizing seed yield in mungbean.

Gibberellic acid (GA) is known to be importantly concerned in the regulation of plant responses to the external environment (Chakrabarti and Mukherji, 2003). Also, application of another plant growth bio-regulator has increased the salt tolerance of many crop plants (Haroun *et al.*, 1991, Hoque and Haque, 2002). GA has also been shown to alleviate the effects of salt stress on water use efficiency (Aldesuquy and Ibrahim, 2001).

Plant growth regulators are used to change the morphological characters in many crops. Growth regulator NAA (Naphthalene acetic acid) may influence on the factors, which are accelerating the morphological characters of mungbean. Yield characters are positively or negatively related with morphological characters. There are scopes for improving yield through changing the morphological characters by using plant growth regulators (PGRs) and manipulation of different management practices like irrigation. Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crop. Many developed countries like Japan, China, Poland and South Korea etc, have long been using PGRs for improving crop yield. A large number of research works with NAA has been carried out in many crops all over the world. But research work with GA_3 on changing the morphological characters of mungbean under irrigated and non-irrigated condition is first time in Bangladesh.

Considering the above views the present study was undertaken with the following objectives:

a) To study the individual effect of irrigation and GA_3 on chlorophyll content, relative water content, growth and yield of mungbean, and
b) To find out the suitable concentration of GA_3 with irrigation for the best performance regarding chlorophyll content, relative water content, growth and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of research in relation to irrigation requirements and growth regulators effects in different pulse crops. It is an established fact that plant growth regulators are substances, which affect the growth and development of plants significantly (Nickell, 1982). In recent years, many scientists are engaged to change the pattern of growth and development of plants for long time to achieve higher yield benefit. Among different growth regulators, GA_3, naphthalene acetic acid etc. have been found to have considerable effect on the growth, yield and yield contributing characters of different pulse crops along with mungbean. In Bangladesh, pulse crops are generally grown with/without irrigation. However, there is evidence that the yield of pulse can be increased substantially by using adequate moisture. Pulses, although fix nitrogen from atmosphere, it is evident that nitrogen application become helpful to increase the yield. Furthermore, literature revealed that irrigation and growth regulators interact each other to increase pulse yield (Jain *et al.*, 1995). Available literatures have been reviewed in this regard and presented below.

2.1 Effects of irrigation on mungbean

Water stress reduces plant growth and yield. However, water stress that exists at the reproductive stage severely affects grain yield of mungbean more than its occurrence at other stages (Thomas *et al.*, 2004). In addition, the time of flowering and maturity was shortened under stress compared to well-watered conditions. Leport *et al.*, (2006) found that pod production of chickpea was more affected by early podding water stress than by late podding water stress.

Tolerance to abiotic stresses is very complex at the cellular levels of the whole plant (Ashraf and Harris, 2004). This is in part due to the complexity of interactions between stress factors and various molecular, biochemical and physiological phenomena affecting plant growth and development (Zhu, 2001). Water stress is considered principal environmental factor limiting growth and yield (Sangakkara *et al.*, 2001).

In the arid and semi-arid regions, water deficit is the main factor that limits crops performance. Limitation of water source, irregular annual rainfall during growth season and lack of sources management cause severe decreasing in crops yield at these regions (Eack, 1996). Therefore, drought stress during growth season is an important problem that need to attention (Khodabandeh, 2005). Using crops with short-term growth is one of the procedures to drought tolerance in dry regions.

Mungbean is belong to fabaceae family that currently is grown in different parts of world and it have large role in nutrition at developing countries (Dhingra *et al.*, 1991). Due to short-term growth, nitrogen fixation capability, soil reinforcement and prevention of soil erosion, mungbean is superior to other plants for second culture. Mungbean is the most common crops in most tropical and sub-tropical regions that cultivated after harvesting of wheat and harvest before planting of autumn crops.

Informations is available on the time of irrigation and water requirement of this crop for tropical summer climatic conditions, because of limited water resources, particularly in the newly reclaimed land in the northern part of Egypt, mungbean crop have grow on a diminishing supply of soil water and are often subjected to water stress during the post flowering period causing significant yield reductions. Despite having a reputation for drought avoidance, Haqqani and Ponde (1994), mungbean yield has been shown to be responsive to irrigation De costa and Shanmugathasan (1996), as they indicated that the treatments which received irrigation during two or more stages had significantly higher yield than those received irrigation during only one stage, when at least two stage can be irrigated, irrigation during flowering produced the highest yield gain when only one stage could be irrigated. Sarkar (1992) stated that irrigation is an important factor for higher production if applied at critical physiological growth stages (flower initiation and pod formation).

Thalooth *et al.* (2006) carried out two field experiments at the Agricultural Experimental Station of National Research Centre, at Shalakan, Kalubia Governorate during the summer seasons of 2002 and 2003 to study the effect of foliar application of zinc, potassium or magnesium on growth, yield and yield components and some chemical constituents of mungbean plants grown under water stress conditions (missing one irrigation at vegetative, flowering and pod formation growth stages). The results revealed that missing one irrigation at any of the three studied stages significantly reduced all the tested growth parameters, yield and yield components as well as photosynthetic pigments content as compared with unstressed plants (control). However, subjecting mungbean plants to moisture stress at vegetative stage had the most negative effect on growth parameters. Meanwhile, stress at a pod formation stage produced the least yield and yield components' values. On the other hand, water stress had a stimulating effect on proline and crude protein contents. The present study also indicate that foliar application of Zn, K or Mg had a positive effect on growth parameters, yield and yield components but K application surpassed the two other nutrients.

Tawfik (2008) conducted a pot experiment to study the effect of extension of irrigation interval (2, 5, and 10 days) on growth, yield and metabolic changes in mungbean (*Vigna radiata* L.) var. VC 1000 in addition to potassiomag application. Generally, fresh, dry weights and yield were significantly reduced under water stress treatments. Treatment with K biofertilizer to some extent mitigated the effect of drought stress. The greatest vegetative growth was obtained for plants irrigated every two days and treated with potassiomag, while the greatest seed yield was obtained for plants irrigated every five days and treated with potassiomag. Osmoprotectants such as total soluble sugars, proline and glycine betaine increased in plants subjected to water stress. It could be concluded, that to maximize mungbean yield, irrigation should be extended through all phenological stages, specially the flowering and the pod-filling stages.

Asaduzzaman *et al.* (2008) conducted an experiment at the experiment field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to evaluate the effect of nitrogen and irrigation managements on dry matter accumulation and yield of mungbean (*Vigna radiata* L.) cv. BARI mung-5 during the period from March to May 2006. The trial comprised of ten treatments such as T_1=No fertilizer and irrigation (control), T_2=20 kg N ha^{-1} as basal, T_3=20 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_4=30 kg N ha^{-1} as basal, T_5=30 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_6=40 kg N ha^{-1} as basal, T_7=40 kg N ha^{-1} as basal + one irrigation at flower initiation stage, T_8= 10 kg N ha^{-1} as basal and 10 kg N ha^{-1} as split +one irrigation at first flowering stage, T_9= 15 kg N ha^{-1} as basal and 15 kg N ha^{-1} as split +one irrigation at flower initiation stage and T_{10}= 20 kg N ha^{-1} as basal and 20 kg N ha^{-1} as split +one irrigation at flower initiation stage. Irrespective of treatment differences the mungbean plant as a pulse crop showed a lag phase for slow dry matter production in early growth stage (up to 40 DAS) that increase up to harvest. Application of 30 kg N ha^{-1} as basal with one irrigation at flower initiation stage (35 DAS) significantly improved dry matter accumulation. This greater dry matter production eventually partitioned to pods per plant, seeds per plant and 1000-seed weight which is get her resulted with maximum seed yield per plant (5.53 g) or per hectare (1.65 t). A functional positive relationship was observed in with pods per plant and seeds per plant.

Some experiments show that mungbean contrary to popular belief, cannot tolerate drought stress (Rfiei shirvan and Asgharipur, 2009) but there are little reports about negative effects of drought stress on yield and physiological characteristics of mungbean. Therefore, this experiment was carried out with aim of understanding the effect of drought stress during vegetative and reproductive stages on some physiological traits, yield and yield components of mungbean.

Allahmoradi *et al.* (2011) carried out a field experiment as randomized complete block design with three treatments and three replications in order to investigation of resistance of mungbean and its physiological responses to drought stress.. This research was done at agriculture faculty, Razi university of Kermanshah, Iran. Water treatments were control (no drought stress) (S_1), drought stress during vegetative growth stage (S_2) and drought stress during reproductive growth stage (S_3). Results showed that there was no significant difference between control and drought stress during reproductive growth stage about yield and yield components, but drought stress during vegetative growth stage decreased significantly yield and yield components. Study of chlorophyll fluorescence showed a significant difference between S_2 treatment with S_1 and S_3 treatments on Performance Index (PI). Also, maximum quantum efficiency of photosystem II (Fv/Fm) in S_1 and S_3 treatments had regular process, but in S_2 treatment was out of regular process. However, these results obtained while that difference between each three treatments about Relative Water Content (RWC) was significant.

Ranawake *et al.* (2011) carried out a pot experiment at Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka. The present reveals the response of Mungbean for the water stress at three different growth stages; three weeks after planting (3 WAP), six weeks after planting (6 WAP) and eight weeks after planting (8 WAP). Plant height, number of leaves, number of floral buds dry matter weight of shoot system, number of lateral roots, length of tap root, number of root nodules, and dry matter weight of root system were measured after one week recovery period in stressed plants at three different growth stages and in relevant control plants. Water stress significantly affects on each measured parameter at 6 WAP when the flowering and pod filling stage of mungbean and only number of leaves was significantly affected at the 8 WAP. Further, all the measured parameters were significantly affected at 3 WAP under drought stress other than length of tap root and number of nodules per plant. Number of floral buds and number of pods were not affected by the drought stress at 8 WAP though there is no economical value of these characters as the pod filling efficiency is low in mungbean under drought stress.

Ibrahim and Al- Bassyuni (2012) conducted two field experiments at AL-Azhar Farm, faculty of Agriculture Assiut Branch, Egypt in 2009 and 2010 seasons to study the effect of irrigation intervals, phosphorus and potassium fertilization on productivity and chemical content of mungbean (*Vigna radiata* L. wilczek) cv. Kawmy-1. Results showed that Increasing period between irrigations from 10 to 20 days caused irrigation intervals significantly decreased for plant height at harvest, number of branches per plant, number of pods per plant, yield of pods per plant, yield of seeds per plant and yield of seeds per pod. in both seasons and number of seeds per pod in the second season only, also potassium % in the two seasons and phosphorus % in the second season only, while protein % increased by irrigation intervals. On the other hand increasing the rates of phosphorus and potassium up to (30 kg P_2O_5 + 36 kg K_2O / fed.), Led to significant increase in yield and yield components and chemical constituents compared with the other treatments in both seasons. Interaction between irrigation intervals, phosphorus and potassium rates were significant for number of pods per plant, number of seeds per pod, protein percentage and potassium percentage in the first season.

2.2 Effect of growth regulators

Kelaiya *et al.*, (1991) conducted an experiment with four growth regulators, such as, CCC (chlormequat), NAA, GA_3, and triacontanol and sprayed at 25, 50 and 75 days after sowing (DAS) on groundnut. In that experiment, they observed that where NAA was found to be most effective one in increasing the plant height. Application of 10 or 20 ppm planofix (NAA) on groundnut cv. DH3-30 increased the dry matter production when compared to the untreated control (Nawalagatti *et al.*, 1991). Kelaiya *et al.* (1991) also stated that spraying with 40 ppm of NAA and GA_3 on groundnut cv. GG2 increased 1000 seed weight.

Lakshmamma and Rao (1996) conducted a field experiment during the rabi season at Rajendranagar, Andhra Pradesh. Blackgram was sprayed with 0, 5, 10 or 20 ppm NAA and/or GA at 50% flowering stage. They found that application of NAA increased plant height of blackgram. They also found that blackgram when sprayed with 20 ppm of NAA at 50 % flowering stage decreased flower drop and increased seed yield.

Singh *et al.* (1982) conducted an experiment on groundnut to determine the effect of NAA. They observed that two foliar spray of 100-ppm planofix (NAA) to groundnut at 40 and 50 days after sowing increased the number of leaves per plant.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three mungbean cultivars and two levels of GA_3 (20 and 40 ppm). GA_3 sprayed at 30 days after sowing and at flowering stages and both the concentrations of GA_3 significantly increased the number of leaves, total dry matter production, number of flowers, number of pods per plant, pod length, number of seeds per pod, 1000 grain weight and grain yield of summer mungbean.

Lee (1990) found that soaking of groundnut seeds in solutions of 0, 50, and 100 ppm of GA_3 before sowing produced plants with greater number of flowers than those of the control.

Upadhyay (1994) conducted a field experiment at Faizabad, Uttar Pradesh. Chickpea cv. K-850 was treated with 10, 20 or 30 ppm of GA_3 at bud initiation and pod formation stages. It was reported that growth regulator increased the number of flowers. Seed yield was generally increased by the growth regulator and it was highest with 20 ppm.

Sharma *et al*. (1989) conducted a field trial with foliar applications of GA3 at anthesis and 10 days later on mungbean. Results revealed that the NAA application increased the number of pods per plant, the number of seeds per pod, 1000 seed weight and seed yield. Kalita *et al.* (1995) also reported that the regulatory effect of GA3 on number of pod of mungbean.

Subbian and Chamy (1982) mentioned that two foliar sprays of 40-ppm planofix (NNA) when applied to summer mungbean at the flower initiation stage and 15 days later significantly increased the seed yield.

Bai *et al*. (1987) investigated the effect of growth regulators (NAA and GA) on the yield performance of mungbean. They found that 25 ppm of NAA and 50 ppm of GA increased the yield of mungbean when compared with control.

Jaiswal and Bhambil (1989) conducted a field experiment to determine the effect of growth regulators on mungbean. It was observed that GA_3 and NAA resulted in the reduction of yield and yield components.

Islam (2010) carried out a study in the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh during 2005 to investigate the effect of GABA (a mixture of GA_3 and ABA) on morphological characters, yield and yield attributes of black gram. Four levels of GABA (0.25, 0.50, 1.0 and 2.0 mg/l) alongwith a control (fresh water) were studied in a randomized complete block design with four replications. The results revealed that GABA @ 1.0 mg/l significantly increased the plant height, number of branches per plant, number of leaves per plant, total chlorophyll content, number of pods per plant, pod length, number of seeds per pod and seed yield. The total chlorophyll content was higher at 1.0 mg GABA concentration. Among different concentrations GABA @ 1.0 mg performed better for yield and yield contributing characters. It gave the highest seed yield (1.50 t/ha) against the lowest (1.3 t/ha) from control.

2.3 Interaction effect of irrigation and growth regulators

Akbari *et al.* (2008) carried out an experiment to study the effect of gibberellic acid on agronomic traits of green gram (*Vigna radiata* L. Wilczek) irrigated with different levels of saline water. Salt concentration of water for treated were 0, 50, 100 and 150 mM NaCl and 200 mg L^{-1} gibberellic acid (100 mg L^{-1} as seed pre-soaking and 100 mg L^{-1} as foliar application) were used. Each treatment previously soaked in 100 mg L^{-1} GA_3 solution, sprayed with solution of 100 mg L^{-1} GA_3 at the stage of four leaf plant (14 day after emergence) as foliar application. Experimentation results showed that irrigation with saline water at levels of 50, 100 and 150 mM NaCl had progressive decrease of growth parameters. Different levels of saline water were reduced root and shoot lengths and dry weights of shoot and roots. The highest seed yield (13 g/plant) related to treated number 5 (0 mM NaCl + (100 mg L as seed pre-soaking + 100 mg L^{-1} as foliar application of gibberellic acid) and followed by control (0 mM NaCl + 0 mg L^{-1} gibberellic acid) (12 g/plant) which were significantly differed from other's. Number of pods per plant was significantly affected by GA_3 application and maximum biological yield (total dry matter) was recorded by treated number 5 (40.1 g/plant).

Shohag *et al*. (2008) conducted a study with mungbean (*Vigna radiata* L.) during the period from February to May, 2007 to investigate the effect of two levels of irrigation (Irrigated and non-irrigated) and five concentrations of growth regulator (0, 50, 100, 150 and 200 ppm NAA) on morphological parameters viz., plant height, root length, number of branches $plant^{-1}$, number of leaves $plant^{-1}$. Irrigation showed significant effect on all these parameters except some genetically regulated characters. Among the concentrations of growth regulator, 200 ppm NAA showed remarkable results on almost all these parameters. The interactions between irrigation and PGR showed better performance in most cases. The results revealed that NAA might be used under irrigated condition for better performance on morphological characters of mungbean.

CHAPTER III

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimental period are described.

3.1 Experimental site

The research work was carried out at the farm of Sher-e- Bangla Agricultural University, Dhaka during the period from February 2012 to March 2012. The field was located at the southeast part of the main academic building. The soil of the experimental plots belonged to the agro ecological zone Madhupur Tract (AEZ-28).

3.2 Soil

A soil sample from 0 - 15 cm depth was collected from experimental field. The physio-chemical properties of the soil are presented in Appendix 1.

3.3 Climate

The experimental area is under the subtropical climate. Usually the rainfall was heavy during kharif season and scanty in Rabi season. The atmospheric temperatures increased as the growing period proceeded in kharif season. The weather conditions of crop growth period such as monthly mean rainfall (mm), mean temperature (°C), sunshine hours and humidity (%) are presented in Appendix 2.

3.4 Planting material

The variety of mungbean used for the present study was BARI mung-3. The seeds of this variety were collected from the Pulse Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristics of these varieties are mentioned below:

BARI mung-3

Plants are of average 50 - 55 cm height. Leaves are darker green. If the variety is moderately resistant to cercospora leaf spot and yellow mosaic virus. Maximum pod yield is 1.2 - 1.3 ton per ha. Seeds contain 19 - 25% protein.

3.5 Land preparation

The land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing and harrowing with country plough and ladder. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 20 March and 27 March 2012, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly before planting.

3.6 Fertilizer application

Urea, triple super phosphate (TSP) and muriate of potash (MOP) were used as source of nitrogen, phosphorus and potassium, respectively. Urea, were applied at the rate of 45, 100 and 58 kg ha^{-1}, respectively (Afzal *et al.*, 1998)

3.7 Treatments of the experiment

The experiment was two factorials with two levels of irrigation and five levels of GA_3.

Factor A: Irrigation levels

The following irrigation levels were imposed in the experiment;

I_0	:	No irrigation (control)
I_1	:	Irrigation at first flowering stages at 35 DAS

Factor B : Growth regulater levels of GA_3

The following GA_3 levels were imposed in the experiment

G_0	:	0 ppm (No GA_3)
G_{20}	:	20 ppm GA_3
G_{40}	:	40 ppm GA_3
G_{60}	:	60 ppm GA_3
G_{80}	:	80 ppm GA_3

Combining two factors, 10 treatments combination were obtained;

I_0G_0	I_1G_0
I_0G_{20}	I_1G_{20}
I_0G_{40}	I_1G_{40}
I_0G_{60}	I_1G_{60}
I_0G_{80}	I_1G_{80}

3.8 Experimental design and lay out

The experiment was laid out in a Randomized Complete Block Design (factorial). Each treatment was replicated three times. The size of a unit plot was 5 m × 2 m. The distance between two adjacent replications (block) was 1m and row-to-row distance was 0.5 m. The inter block and inter row spaces were used as footpath and irrigation/ drainage channels.

3.9 Germination test

Germination test was performed before sowing the seeds in the field using petridishes. Three layers of filter paper were placed on petridishes and the filter papers were softened with water. Seeds were distributed at random in four petridishes. Each petridish contained 100 seeds. Germination percentage was calculated by using the following formula:

$$\text{Germination(\%)} = \frac{\text{Number of normal seedlings}}{\text{Number of seeds set for germination}} \times 100$$

3.10 Sowing of seeds in the field

The seeds of mungbean were sown in rows made by hand plough on March 29, 2012. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm from the soil surface. Row to row distance was 30 cm.

3.11 Intercultural operations

3.11.1 Irrigation and weeding

Irrigation water was applied as per treatments. The crop field was weeded twice; first weeding was done at 25 DAS (days after sowing) and second weeding at 40 DAS. Demarcation boundaries and drainage channels were also kept weed free.

3.11.2 Protection against insect and pest

At early stage of growth, few worms (*Agrotis ipsilon*) and virus vectors (Jassid) attacked the young plants. To control these pests, Diazinon 50 EC was sprayed by mixing 1ml diazinon per liter water.

3.12 Preparation and application of GA_3

The GA_3 solution of 20, 40, 60 and 80 ppm concentrations were prepared by dissolving 20, 40, 60 and 80 mg of GA_3 in 1 litre of distilled water respectively. To dissolve GA_3, little drops of 1% NaOH solution was used and thereafter volume was made by distilled water. GA_3 was applied in the form of fine foliar sprays. The spraying was done at 25 DAS with the help of a hand sprayer until all leaves were completely covered.

3.13 Crop sampling and data collection

The first crop sampling was done at 30 DAS and it was continued at an interval of 30 days. At each harvest, five plants were selected randomly from each plot. The selected plants of each plot were cut carefully at the soil surface level. The heights, flowers and pods were recorded separately. The components were oven dried at 60°C for 72 hours to record constant dry weights. Total dry matter was determined by recording the dry weight of each portion of the plants.

3.14 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of 1 m^2 at the centre of each plot. After harvesting, the samples were sun dried.

3.15 Data collection

The data on the following parameters of five plants were recorded at each harvest.

1) Days to emergence
2) Plant height (cm)
3) Total dry matter production per plant (g)
4) Number of flowers per plants
5) Number of pods per plants
6) Number of seeds per pod
7) 1000- seed weight
8) Seed yield (kg ha^{-1})
9) Harvest index (%)
10) Biochemical constituents
    i) Total chlorophyll content

ii) Relative water content (RWC)

3.16 Procedure of data collection

The following procedures were taken for measuring data from crop field:

3.16.1 Plant height

The heights of five plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.16.2 Total dry matter production per plant

The different parts from 5 randomly selected plants were separated, then dried in oven and weight was taken carefully. The sum of the plant parts constituted the total dry matter of a single plant after calculating average value.

3.16.3 Number of flowers per plant

Number of total flowers of five plants from each plot was counted and the number was expressed per plant basis.

3.16.4 Number of pods per plant

Number of total pods of five plants from each plot was counted and the number was expressed per plant basis

3.16.5 Numbers of seeds per pod

The number of grain in each pod was also recorded from ten randomly selected pods at the harvest.

3.16.6 Weight of 1000 seeds

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the weight was expressed in gram.

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

Weight of seed of the pre- demarcated area (1 m^2) at the centre of each plot was taken and then converted to t ha^{-1}.

3.16.8 Harvest index (%)

The harvest index was calculated on the ratio of grain yield to biological yield and expressed in terms of percentage. It was calculated by using the following formula (Donald and Hamblim, 1976).

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.16.9 Biochemical constituents

3.16.9.1 Total chlorophyll content

Chlorophyll content was determined at 40 DAE from the leaf samples using the methods of Wake black. (1985).

Reagent: Acetone (80%)

Procedure: The fresh leaf samples of 0.05g were taken in small vials containing 10 ml of 80% acetone and covered by alluminium foil and preserved in the dark for 72 hours. Then reading was taken at 663 ηm and 645 ηm wave lengths by a spectrophotometer (Systronics UV-VIS 118), and the result was expressed as mg g^{-1} fresh weight (fw).

The formula for computing chlorophyll a, b and total chlorophyll were-

$$\text{Chlorophyll a} = (13.19\ A_{663} - 2.57\ A_{645}) \times DF$$

$$\text{Chlorophyll b} = (22.10\ A_{645} - 2.57\ A_{663}) \times DF$$

$$\text{Total chlorophyll} = (7.93\ A_{663} + 19.53\ A_{645}) \times DF$$

Where,

A_{663} = Absorbance at 663 ηm wave lengths

A_{645} = Absorbance at 645 ηm wave lengths

7.93, 19.53, 13.19, 2.57, 22.10 and 5.26 are absorption co-efficient

$$DF = \text{Dilution Factor} = \frac{10}{1000 \times 0.05} = 0.2$$

3.16.9.2 Relative water content

Relative water content was estimated according to the method of Castillo (1996) and calculated in the leaves for each treatment. Samples (0.5 g) were saturated in 100 ml distilled water for 48 h at 4°C in the dark and their turgid weights were recorded. Then were oven-dried at 65°C for 48 h and their dry weights were recorded.

RWC was calculated as follows:

$$RWC\ (\%) = [(FW - DW) / (TW - DW)] \times 100,$$

Where,

FW = Fresh weight

DW = Dry weight

TW = Turgid weight

3.17 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-computer package program developed by Russel (1986). 5% level of significance (Gomez and Gomez, 1984) was used to compare the mean differences among the treatments. The analysis of variance of the data on different parameters has been presented in (Appendix 3).

CHAPTER IV

RESULTS AND DISCUSSION

Present experiment was conducted with different levels of irrigation and growth regulator (GA_3) to study their effects on summer mungbean. The results regarding the effect of irrigation and GA_3 and their interactions on chlorophyll content, relative water content and yield of mungbean are presented and discussed in this chapter.

4.1.1 Plant height

Results of plant height have been presented in Table 1. It is seen that plant height was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest plant height (25.07, 56.33 and 65.00 cm at 30, 60 DAS and at harvest respectively) was achieved from I_1 at all growth stages where the lowest plant height (22.73, 52.67 and 62.66 cm at 30, 60 DAS and at harvest respectively) was achieved from I_0 at all growth stages. These findings are conformity with the findings of Ibrahim and Al- Bassyuni (2012)

In terms of GA_3 application, it was observed that the highest plant height (27.33, 60.00, and 68.83 cm at 30, 60 DAS and at harvest respectively) was obtained from G_{60} which was statistically identical with G_{40} at 30 and 60 DAS where the lowest plant height (20.00, 49.50 and 57.83 cm at 30, 60 DAS and at harvest respectively) was achieve from G_{80} at all growth stages (Table 1). The results obtained from G_{20} and G_{40} showed intermediate level of plant height at all growth stages compared to highest and lowest plant height. The results obtained from the present study on plant height was similar with Kelaiya *et al.* (1991) and Islam (2010).

Interaction effect of irrigation and GA_{60} application had significant effect on plant height at all growth stages. Results were presented that the highest plant height (28.67, 64.33 and 70.33 cm at 30, 60 DAS and at harvest respectively) was found from I_1G_{60} which was closely followed by I_1G_{40} and I_1G_{20} at 30 DAS. On the other hand the lowest plant height (49.67 and 59.00 cm respectively) was obtained from I_0G_0 at 60 DAS and at harvest respectively.

Table 1: Effect on plant height with irrigation, growth regulator and their interaction on chlorophyll content, water relation and yield of mungbean

Treatments	**Plant height (cm)**		
	30 DAS	**60 DAS**	**At harvest**
Effect of irrigation			
I_0	22.73 b	52.67 b	62.67 b
I_1	25.07 a	56.33 a	65.00 a
$LSD_{0.05}$	1.264	2.183	1.856
Effect of growth regulator			
G_0	30.67 c	52.33 b	62.50 c
G_{20}	35.00 b	52.83 b	65.00 b
G_{40}	36.50 a	57.83 a	65.00 b
G_{60}	37.33 a	60.00 a	68.83 a
G_{80}	30.00 c	49.50 c	57.83 d
$LSD_{0.05}$	1.272	2.172	2.052
Interaction effect of irrigation and growth regulator			
I_0G_0	19.67 e	52.33 ef	61.33 e
I_0G_{20}	22.67 c	51.00 fg	63.67 d
I_0G_{40}	25.67 b	55.00 cd	64.33 cd
I_0G_{60}	26.00 b	55.67 c	67.33 b
I_0G_{80}	19.67 e	49.33 g	56.67 g
I_1G_0	21.67 cd	53.33 de	63.67 d
I_1G_{20}	27.33 ab	53.67 de	66.33 b
I_1G_{40}	27.33 ab	60.67 b	65.67 bc
I_1G_{60}	28.67 a	64.33 a	70.33 a
I_1G_{80}	20.33 de	49.67 g	59.00 f
$LSD_{0.05}$	1.809	1.881	1.718
CV(%)	6.842	7.984	8.466

I_0 = No irrigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

4.1.3 Fresh weight plant^{-1}

Results of fresh weight (g) have been presented in Table 2. From result we can say that fresh weight plant^{-1} was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest fresh weight plant^{-1} (13.10, 33.75 and 72.20 g at 30, 60 DAS and at harvest, respectively) was achieved from I_1 at all growth stages where the lowest fresh weight plant^{-1} (10.51, 26.97 and 63.70 g at 30, 60 DAS and at harvest respectively) was achieved from I_0 at all growth stages. Similar result was found by Tawfik (2008).

In terms of GA_3 application, it was observed that the highest fresh weight plant^{-1} (15.08, 37.00, and 80.25 g at 30, 60 DAS and at harvest respectively) was obtained from G_{60} where the lowest fresh weight plant^{-1} (7.53, 22.38 and 56.00 g at 30, 60 DAS and at harvest respectively) was achieve from G_0 at all growth stages (Table 2). The results obtained from G_{40} and G_{80} showed intermediate level of fresh weight plant^{-1} at all growth stages compared to highest and lowest fresh weight plant^{-1}.

Interaction effect of irrigation and GA_3 application had significant effect on fresh weight plant^{-1} at all growth stages. Results were presented in Table 2 shows that the highest fresh weight plant^{-1} (16.30, 38.50 and 84.00 g at 30, 60 DAS and at harvest, respectively) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest fresh weight plant^{-1} (6.64, 19.50 and 54.33 g respectively) was obtained from I_0G_0 at 30, 60 DAS and at harvest respectively which was closely followed by I_1G_{20} at 40 DAS. The treatment combinations of I_1G_{40} and I_0G_{60} also showed comparatively higher fresh weight plant^{-1} at all growth stages but significantly different from all other treatments. Again, I_1G_0 and I_0G_{20} showed comparatively lower fresh weight plant^{-1} at all growth stages compared to highest fresh weight plant^{-1}. The results obtained from all other treatment combinations showed intermediate level of fresh weight plant^{-1} at all growth stages.

Table 2: Effect of irrigation, growth regulator and their interaction on fresh weight plant^{-1} of mungbean

Treatments	Fresh weight plant^{-1} (g)		
	30 DAS	**60 DAS**	**At harvest**
Effect of irrigation			
I_0	10.51 b	26.97 b	63.70 b
I_1	13.10 a	33.75 a	72.20 a
$LSD_{0.05}$	1.364	2.685	3.119
Effect of growth regulator			
G_0	7.53 d	22.38 d	56.00 e
G_{20}	11.57 c	30.23 c	68.00 c
G_{40}	13.52 b	31.75 b	70.50 b
G_{60}	15.08 a	37.00 a	80.25 a
G_{80}	11.31 c	30.43 c	65.00 d
$LSD_{0.05}$	0.4357	0.7062	1.326
Interaction effect of irrigation and growth regulator			
I_0G_0	6.640 h	19.50 h	54.33 i
I_0G_{20}	9.840 f	25.63 fg	61.67 g
I_0G_{40}	11.85 e	26.50 f	62.00 g
I_0G_{60}	13.87 bc	35.50 c	76.50 c
I_0G_{80}	10.33 f	27.70 e	64.00 f
I_1G_0	8.417 g	25.27 g	57.67 h
I_1G_{20}	13.30 cd	34.83 c	74.33 d
I_1G_{40}	15.18 ab	37.00 b	79.00 b
I_1G_{60}	16.30 a	38.50 a	84.00 a
I_1G_{80}	12.29 de	33.17 d	66.00 e
$LSD_{0.05}$	1.356	0.9536	1.871
CV(%)	8.278	7.669	8.154

I_0 = No irrigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

4.1.4 Dry weight plant^{-1}

Dry weight (g) plant^{-1} has been presented in Table 3 to observe significance level regarding the present study. It was seen that dry weight plant^{-1} was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest dry weight plant^{-1} (3.70, 8.72 and 12.08 g at 30, 60 DAS and at harvest respectively) was achieved from I_1 at all growth stages where the lowest dry weight plant^{-1} (2.98, 6.96 and 10.63 g at 30, 60 DAS and at harvest respectively) was achieved from I_0 at all growth stages. Similar result was found by Tawfik (2008), Asaduzzaman *et al.* (2008) and Ranawake *et al.* (2011).

In terms of GA_3 application, it was observed that the highest dry weight plant^{-1} (4.26, 9.54 and 13.39 g at 30, 60 DAS and at harvest respectively) was obtained from G_{60} where the lowest dry weight plant^{-1} (2.14, 5.79 and 9.38 g at 30, 60 DAS and at harvest respectively) was achieved from G_0 at all growth stages (Table 3). The results obtained from G_{40} and G_{80} showed intermediate level of dry weight plant^{-1} at all growth stages compared to highest and lowest result. The results obtained from the present was conformity with the findings of Kelaiya *et al.* (1991) and Das and Prasad (2003).

Interaction effect of irrigation and GA_3 application had significant effect on dry weight at all growth stages. Results were presented in Table 4 that the highest dry weight plant^{-1} (4.58, 9.92 and 14.01 g at 30, 60 DAS and at harvest respectively) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest dry weight plant^{-1} (1.89, 5.01 and 9.08 g respectively) was obtained from I_0G_0 at30, 60 DAS and at harvest respectively which was also significantly different from all other treatments. The treatment combinations of I_1G_{40}, I_1G_{20} and I_0G_{60} also showed comparatively higher dry weight plant^{-1} at all growth stages but significantly different from all other treatments. Again, I_1G_0 and I_0G_{20} and I_0G_{40} showed comparatively lower dry weight plant^{-1} at all growth stages compared to highest dry weight plant^{-1}. The results obtained from all other treatment combinations showed intermediate level of dry weight plant^{-1} at all growth stages. Similar results were found from the findings of Akbari *et al.* (2008).

Table 3: Effect of irrigation, growth regulator and their interaction on dry weight plant^{-1} of mungbean

Treatments	**Dry weight plant^{-1} (g)**		
	30 DAS	**60 DAS**	**At harvest**
Effect of irrigation			
I_0	2.98 b	6.96 b	10.63 b
I_1	3.70 a	8.72 a	12.08 a
$LSD_{0.05}$	0.814	1.389	1.624
Effect of growth regulator			
G_0	2.14 d	5.79 d	9.38 e
G_{20}	3.27 c	7.78 c	11.39 c
G_{40}	3.81 b	8.22 b	11.75 b
G_{60}	4.26 a	9.54 a	13.39 a
G_{80}	3.21 c	7.88 c	10.88 d
$LSD_{0.05}$	0.1213	0.1758	0.1840
Interaction effect of irrigation and growth regulator			
I_0G_0	1.89 g	5.01 h	9.08 i
I_0G_{20}	2.79 e	6.60 g	10.30 g
I_0G_{40}	3.33 d	6.86 f	10.28 g
I_0G_{60}	3.94 c	9.15 c	12.77 c
I_0G_{80}	2.93 e	7.16 e	10.73 f
I_1G_0	2.38 f	6.56 g	9.667 h
I_1G_{20}	3.76 c	8.97 c	12.47 d
I_1G_{40}	4.29 b	9.57 b	13.23 b
I_1G_{60}	4.58 a	9.92 a	14.01 a
I_1G_{80}	3.49 d	8.60 d	11.02 e
$LSD_{0.05}$	0.1879	0.2486	0.2602
CV(%)	5.358	7.468	7.442

I_0 = No irrigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

4.1.5 Number of flowers plant^{-1}

Number of flowers plant^{-1} has been presented in Table 4 to observe significance level regarding the present study. It was seen that number of flowers plant^{-1} was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest number of flowers plant^{-1} (8.22, 4.88 and 2.96 at 30, 60 and 80 DAS respectively) was achieved from I_1 at all growth stages where the lowest number of flowers plant^{-1} (7.04, 3.96 and 2.43 at 30, 60 and 80 DAS respectively) was achieved from I_0 at all growth stages. Similar results were observed from the findings of Sarkar (1992), Thalooth *et al*. (2006) and Ranawake *et al.* (2011).

In terms of GA_3 application, it was observed that the highest number of flowers plant^{-1} (9.44, 5.62, and 3.69 at 30, 60 and 80 DAS respectively) was obtained from G_{60} where the lowest number of flowers plant^{-1} (5.89, 3.45 and 1.61 at 30, 60 and 80 DAS respectively) was achieve from G_0 at all growth stages (Table 4). The results obtained from G_{40} showed intermediate level of number of flowers plant^{-1} at all growth stages compared to highest and lowest number of flowers plant^{-1}. Similar results were also observed from the findings of Arora *et al.* (1998), Das and Prasad (2003), Lakshmamma and Rao (1996) and Upadhyay (1994).

Interaction effect of irrigation and GA_3 application had significant effect on number of flowers plant^{-1} at all growth stages. Results were presented in Table 4 that the highest number of flowers plant^{-1} (10.55, 6.88 and 4.28 at 30, 60 and 80 DAS respectively) was found from I_1G_{60} which was significantly different from all other treatments. The treatment combinations of I_0G_{60}, I_0G_{40} and I_1G_{40} showed comparatively higher number of flowers plant^{-1} at all growth stages.

On the other hand the lowest number of flowers plant^{-1} (5.77, 3.40 and 1.55 at 30, 60 and 80 DAS respectively) was obtained from I_0G_0 which was also significantly different from all other treatments. The treatment combinations of I_0G_{20} and I_1G_0

showed comparatively lower number of flowers plant^{-1} at all growth stages compared to highest number of flowers plant^{-1}. The results obtained from all other treatment combinations showed intermediate level of number of flowers plant^{-1} at all growth stages.

Table 4: Effect on number of flowers plant^{-1} with irrigation, growth regulator and their interaction on chlorophyll content, water relation and yield of mungbean

Treatments	Number of flowers plant^{-1}		
	30 DAS	**60 DAS**	**80 DAS**
Effect of irrigation			
I_0	7.04 b	3.96 b	2.43 b
I_1	8.22 a	4.88 a	2.96 a
$LSD_{0.05}$	0.848	0.561	0.142
Effect of growth regulator			
G_0	5.89 d	3.45 e	1.61 d
G_{20}	7.33 c	3.93 d	2.39 c
G_{40}	8.40 b	4.98 b	3.27 b
G_{60}	9.44 a	5.62 a	3.69 a
G_{80}	7.10 c	4.13 c	2.53 c
$LSD_{0.05}$	0.648	0.488	0.266
Interaction effect of irrigation and growth regulator			
I_0G_0	5.77 f	3.40 d	1.55 g
I_0G_{20}	6.55 e	3.66 d	2.11 f
I_0G_{40}	7.55 d	4.22 c	2.99 c
I_0G_{60}	8.32 c	4.35 c	3.10 c
I_0G_{80}	6.99 d	4.15 c	2.40 e
I_1G_0	6.00 e	3.49 d	1.66 g
I_1G_{20}	8.10 c	4.20 c	2.66 d
I_1G_{40}	9.24 b	5.74 b	3.55 b
I_1G_{60}	10.55 a	6.88 a	4.28 a
I_1G_{80}	7.21 d	4.10 c	2.65
$LSD_{0.05}$	0.846	0.562	0.168
CV(%)	6.384	8.366	8.926

I_0 = No irrigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

4.2 Yield and yield contributing parameters

4.2.1 Number of pods plant^{-1}

Results on number of pods plant^{-1} has been presented in Table 5 regarding the present study. It is seen that number of pods plant^{-1} was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest number of pods plant^{-1} (11.05) was achieved from I_1 where the lowest number of pods plant^{-1} (9.67) was achieved from I_0 at the time of harvest. Sarkar (1992), Leport *et al.*, (2006) and Thalooth *et al.* (2006) also showed similar results regarding irrigation on mungbean.

In terms of GA_3 application, it was observed that the highest number of pods plant^{-1} (12.33) was obtained from G_{60} which was significantly different from all other treatments where the lowest number of pods plant^{-1} (7.583) was achieved from G_0 which was also significantly different from all other treatments (Table 5). The results obtained from G_{20}, G_{40} and G_{80} showed intermediate level for number of pods plant^{-1} compared to highest and lowest number of pods plant^{-1}. Similar findings also found by Das and Prasad (2003), Upadhyay (1994) and Sharma *et al.* (1989).

Interaction effect of irrigation and GA_3 application had significant effect on number of pods plant^{-1}. Results were presented in Table 5 show that the highest number of pods plant^{-1} (13.83) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest number of pods plant^{-1} (7.33) was obtained from I_0G_0 which was statistically identical with I_1G_0.The results obtained from I_1G_4, I_1G_2 and $_0G_4$ showed comparatively higher results where I_0G_{20} and I_0G_{40} showed comparatively lower number of pods plant^{-1} compared to highest and lowest result of number of pods plant^{-1}. Similar results also found from the findings of Akbari *et al.* (2008).

4.2.2 Number of seeds pod^{-1}

Results on number of seeds pod^{-1} has been presented in Table 5 regarding the present study. It is seen that number of seeds pod^{-1} was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest number of seeds pod^{-1} (11.67) was achieved from I_1 where the lowest number of seeds pod^{-1} (10.51) was achieved from I_0 at the time of harvest. Similar result was found by Ibrahim and Al- Bassyuni (2012).

In terms of GA_3 application, it was observed that the highest number of seeds pod^{-1} (13.37) was obtained from G_3 which was significantly different from all other treatments where the lowest number of seeds pod^{-1} (8.83) was achieved from G_0 which was also significantly different from all other treatments (Table 5). The results obtained from G_{20}, G_{40} and G_{80} showed intermediate level for number of seeds pod^{-1} compared to highest and lowest number of seeds pod^{-1}. Similar results was also found by Das and Prasad (2003).

Interaction effect of irrigation and GA_3 application had significant effect on number of seeds pod^{-1}. Results were presented in table 5 show that the highest number of seeds pod^{-1} (14.77) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest number of seeds pod^{-1} (8.53) was obtained from I_0G_0 which was also significantly different from all other treatments.The results obtained from I_0G_{60}, I_0G_{80} and I_1G_{40} showed comparatively higher results where I_0G_{20} and I_1G_{80} showed comparatively lower number of seeds pod^{-1} compared to highest and lowest result of number of seeds pod^{-1}.

4.2.3 Seed yield (kg ha^{-1})

Results on seed yield (kg ha^{-1}) has been presented in Table 5 regarding the present study. It was seen that seed yield (kg ha^{-1}) was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest seed yield (1156.33 kg ha^{-1}) was achieved from I_1 where the lowest seed yield (1067.33 kg ha^{-1}) was achieved from I_0 at the time of harvest. Tawfik (2008) and Ibrahim and Al-Bassyuni (2012) showed similar results regarding increased seed yield with irrigation.

In terms of GA_3 application, it was observed that the highest seed yield (1314.00 kg ha^{-1}) was obtained from G_{60} which was significantly different from all other treatments where the lowest seed yield (856.70 kg ha^{-1}) was achieved from G_0 which was also significantly different from all other treatments (Table 5). The treatment from G_{40} showed comparatively higher level of seed yield (1213.00 kg ha^{-1}). The results obtained from G_{20} and G_{80} showed intermediate level for seed yield compared to highest and lowest seed yield (kg ha^{-1}). Kelaiya *et al.* (1991), Sharma *et al.* (1989) and Upadhyay (1994) showed similar results.

Interaction effect of irrigation and GA_3 application had significant effect on seed yield (kg ha^{-1}). Results were presented in Table 5 that the highest seed yield (1376.00 kg ha^{-1}) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest seed yield (830.00 kg ha^{-1}) was obtained from I_0G_0 which was also significantly different from all other treatments. The results obtained from I_0G_{60}, I_0G_{40} and I_1G_{40} showed comparatively higher results where I_0G_{20} and I_1G_0 showed comparatively lower seed yield compared to highest and lowest result of seed yield (kg ha^{-1}). Akbari *et al.* (2008) and Shohag *et al.* (2008) showed similar results.

4.2.4 Weight of 1000 seeds

Results on 1000 seed weight has been presented in Table 5 regarding the present study. It was seen that 1000 seed weight was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest 1000-seed weight (54.20 g) was achieved from I_1 where the lowest 1000-seed weight (52.47 g) was achieved from I_0 at the time of harvest.

In terms of GA_3 application, it was observed that the highest 1000-seed weight (57.33 g) was obtained from G_{80} which was significantly different from all other treatments where the lowest 1000-seed weight (49.50 g) was achieved from G_0 which was also significantly different from all other treatments (Table 5). The results obtained from G_{20}, G_{40} and G_{60} showed intermediate level for 1000-seed weight compared to highest and lowest 1000-seed weight. Similar findings was also found from the findings of Das and Prasad (2003) and Kelaiya *et al.* (1991).

Interaction effect of irrigation and GA_3 application had significant effect on 1000-seed weight. Results were presented in Table 5 that the highest 1000-seed weight (58.33 g) was found from I_1G_{80} which was significantly different from all other treatments. On the other hand the lowest 1000-seed weight (48.67 g) was obtained from I_0G_0 which was also significantly different from all other treatments. The results obtained from I_1G_{60}, I_0G_{80} and I_0G_{60} showed comparatively higher results where I_0G_{20}, I_1G_0 and I_1G_{20} showed comparatively lower 1000-seed weight compared to highest and lowest result of 1000-seed weight.

4.2.5 Harvest index

Results on harvest index has been presented in Table 5 regarding the present study. It was seen that harvest index was significantly influenced by different levels of irrigation, GA_3 and their interaction. Results showed that the highest harvest index (36.39%) was achieved from I_{20} where the lowest harvest index (33.35%) was achieved from I_0.

In terms of GA_3 application, it was observed that the highest harvest index (39.54%) was obtained from G_{30} which was significantly identical with G_{40} where the lowest harvest index (29.04%) was achieved from G_0 which was significantly different from all other treatments (Table 5). The results obtained from G_{20} and G_{80} showed intermediate level for harvest index compared to highest and lowest harvest index. Interaction effect of irrigation and GA_3 application had significant effect on harvest index. Results were presented in Table 5 that the highest harvest index (40.84%) was found from I_1G_{60} which was closely followed by I_1G_{40} and significantly different from all other treatments. On the other hand the lowest harvest index (28.14%) was obtained from I_0G_0 which was significantly different from all other treatments. The results obtained from I_0G_{40}, I_0G_{60} and I_1G_{20} showed comparatively higher results where I_0G_{20} and I_0G_{80} showed comparatively lower harvest index compared to highest and lowest result of harvest index.

Table 5: Effect of irrigation, growth regulator and their interaction on yield and yield contributing characters of mungbean

Treatments	Number of pods/plant	Number of seeds/pod	Seed yield (kg)	1000 seed weight	Harvest index
Effect of irrigation					
I_0	9.67 b	10.51 b	1067.33 b	52.47 b	33.35 b
I_1	11.05 a	11.67 a	1156.33 a	54.20 a	36.39 a
$LSD_{0.05}$	1.116	1.035	4.528	1.057	1.128
Effect of growth regulator					
G_0	7.58 e	8.83 e	856.70 e	49.50 e	29.04 c
G_{20}	9.62 d	9.95 d	1075.00 d	51.17 d	33.65 b
G_{40}	10.77 c	10.95 c	1213.00 b	52.67 c	38.39 a
G_{60}	12.33 a	13.37 a	1314.00 a	56.00 b	39.54 a
G_{80}	11.50 b	12.35 b	1101.00 c	57.33 a	33.74 b
$LSD_{0.05}$	0.5245	0.6279	2.862	0.7852	1.684
Interaction effect of irrigation and growth regulator					
I_0G_0	7.33 g	8.53 e	830.00 j	48.67 h	28.14 h
I_0G_{20}	9.00 f	9.60 cd	1027.00 h	50.67 g	30.40 f
I_0G_{40}	9.83 e	10.23 c	1133.00 d	52.00 f	36.86 c
I_0G_{60}	10.83 cd	11.97 b	1252.00 c	54.67 d	38.24 b
I_0G_{80}	11.33 bc	12.20 b	1095.00 g	56.33 c	33.12 e
I_1G_0	7.83 g	9.13 de	883.30 i	50.33 g	29.94 g
I_1G_{20}	10.23 de	10.30 c	1122.00 e	51.67 f	36.90 c
I_1G_{40}	11.70 b	11.67 b	1293.00 b	53.33 e	39.92 ab
I_1G_{60}	13.83 a	14.77 a	1376.00 a	57.33 b	40.84 a
I_1G_{80}	11.67 b	12.50 b	1107.00 f	58.33 a	34.36 d
$LSD_{0.05}$	0.7378	0.8831	3.665	0.9689	0.968
CV(%)	8.743	7.805	9.387	8.359	7.228

I_0 = No irrigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

4.2.6 Chlorophyll content

It was observed that chlorophyll content was not significantly influenced by different levels of irrigation but GA_3 and interaction of irrigation and GA_3 had significant effect on chlorophyll content (Table 6). Results showed that the highest chlorophyll content (0.564mg g^{-1} at 663ηm and 0.262 mg g^{-1} at 645ηm) was achieved from I_1 where the lowest chlorophyll content (0.563 mg g^{-1} at 663ηm and 0.261 mg g^{-1} at 645ηm) was achieved from I_0. Islam (2010) showed similar results.

In terms of GA_3 application, it was observed that the highest chlorophyll content (0.6510 mg g^{-1} at 663ηm and 0.3080 mg g^{-1} at 645ηm) was obtained from G_{60} where the lowest chlorophyll content (0.5035 mg g^{-1} at 663ηm and 0.2300 mg g^{-1} at 645ηm) was achieved from G_{20} (Table 6). The results obtained from G_0, G_{40} and G_{80} showed intermediate level for chlorophyll content compared to highest and lowest chlorophyll content. Islam (2010) showed similar results.

Interaction effect of irrigation and GA_3 application had significant effect on chlorophyll content. Results were presented in Table 6 that the highest chlorophyll content (0.7107 mg g^{-1} at 663ηm and 0.3330 mg g^{-1} at 645ηm) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest chlorophyll content (0.4843 mg g^{-1} at 663ηm and 0.2207 mg g^{-1} at 645ηm) was obtained from I_0G_{20} which was also significantly different from all other treatments.

4.2.7 Relative Water Content (RWC)

There was significant difference between two irrigation treatments in term of RWC (Table 6). I_1 treatment has the highest RWC (70.97%) and the lowest RWC (62.24%) belongs to I_0 treatment. Allahmoradi *et al.* (2011) also similar result.

The results with GA_3 application, it was observed that the highest RWC (79.75%) was obtained from G_{60} where the lowest RWC (50.33%) was achieved from G_0 (Table 6). The results obtained from G_{20}, G_{40} and G_{80} showed intermediate level for RWC compared to highest and lowest results. Allahmoradi *et al.* (2011) also showed similar result.

Interaction effect of irrigation and GA_3 application had significant effect on RWC. Results indicated that the highest RWC (84.12%) was found from I_1G_{60} which was significantly different from all other treatments. On the other hand the lowest RWC (48.39%) was obtained from I_0G_0 which was also significantly different from all other treatments. Here, the treatment combinations of I_0G_{60} and I_1G_{40} showed comparatively higher RWC where I_0G_{20} and I_0G_{80} showed lower RWC.

Table 6: Effect of irrigation growth regulator and their interaction on chlorophyll and relative water content of mungbean

Treatments	Chlorophyll content		RWC (%)
	663ηm	645ηm	
Effect of irrigation			
I_0	0.563 b	0.261 b	62.24 b
I_1	0.564 a	0.262 a	70.97 a
$LSD_{0.05}$	0.0012	0.0008	2.513
Effect of growth regulator			
G_0	0.5543 b	0.2573 b	50.33 d
G_{20}	0.5035 c	0.2300 c	64.11 c
G_{40}	0.5523 b	0.2577 b	75.26 b
G_{60}	0.6510 a	0.3080 a	79.75 a
G_{80}	0.5563 b	0.2563 b	63.59 c
$LSD_{0.05}$	0.01213	0.01213	2.143
Interaction effect of irrigation and growth regulator			
I_0G_0	0.5183 d	0.2400 c	48.39 j
I_0G_{20}	0.4843 e	0.2207 d	55.98 h
I_0G_{40}	0.4877 e	0.2280 cd	70.16 e
I_0G_{60}	0.6170 b	0.2830 b	75.38 c
I_0G_{80}	0.6177 b	0.2850 b	61.29 g
I_1G_0	0.5903 c	0.2747 b	52.26 i
I_1G_{20}	0.5227 d	0.2393 c	72.24 d
I_1G_{40}	0.5913 c	0.2873 b	80.36 b
I_1G_{60}	0.7107 a	0.3330 a	84.12 a
I_1G_{80}	0.4950 e	0.2277 cd	65.88 f
$LSD_{0.05}$	0.01715	0.01715	1.863
CV(%)	3.468	4.215	8.362

I_0 = No irigation
I_1 = Irrigation at first flowering stage

G_0 = 0 ppm (No GA_3)
G_{20} = 20 ppm GA_3
G_{40} = 40 ppm GA_3
G_{60} = 60 ppm GA_3
G_{80} = 80 ppm GA_3

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of irrigation and growth regulator on chlorophyll content, water relation, growth and yield of mungbean during the period from March 2012 to May 2012. The experiment comprised of two different factors such as (1) two levels of irrigation viz. I_0 (control), and I_1 (irrigation at first flowering stage) and (2) five levels of GA_3 viz. G_0 (no GA_3), G_{20} (20 ppm of GA_3), G_{40} (40 ppm of GA_3), G_{20} (60 ppm of GA_3) and G_{80} (80 ppm of GA_3).

The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 10 treatment combinations. The experimental plot was fertilized at the rate of 125 kg Triple Super Phosphate and 67 kg Muriate of Potash per hectare. Mungbean seed of cv. BARI mung-3 were sown on 29 March 2012 and harvested on 18 May 2012. Data on different growth and yield parameters were recorded and analyzed statistically.

Results showed that the effect of irrigation was significant in respect of various plant characters including yield and yield attributes. Days to emergence after sowing of mungbean was lowest (3.93 days) with irrigated field where non-irrigated condition required more time (4.40 days) for emergence of plant. Plant heights of mungbean were influenced significantly by irrigation water at different growth stages and the highest plant height (25.07, 56.33 and 65.00 cm at 30, 60 DAS and at harvest, respectively) were observed with irrigation condition where the lowest (22.73, 52.67 and 62.67 cm at 30, 60 DAS and at harvest, respectively) were with non-irrigated condition. Again, the highest fresh weight plant^{-1} (13.10, 33.75 and 72.20 g at 30, 60 DAS and at harvest, respectively), dry weight plant^{-1} (3.70, 8.72 and 12.08 g at 30, 60 DAS and at harvest, respectively), number of flowers plant^{-1} (8.22, 4.88 and 2.96 at

30, 60 DAS and at harvest, respectively), number of pods plant^{-1}, (11.05), number of seeds pod^{-1} (11.67), grain yield (1156.33 kg ha^{-1}), 1000- seed weight (54.20 g) and harvest index (36.39%) were achieve from irrigated field where the lowest fresh weight plant^{-1} (10.51, 26.97 and 63.70 g at 30, 60 DAS and at harvest, respectively), dry weight plant^{-1} (2.98, 6.96 and 10.63 g at 30, 60 DAS and at harvest, respectively), number of flowers plant^{-1} (7.04, 3.96 and 2.43 at 30, 60 DAS and at harvest, respectively), number of pods plant^{-1}, (9.67), number of seeds pod^{-1} (10.51), grain yield (1067.33kg ha^{-1}), 1000 seed weight (52.47 g) and harvest index (33.35%) were obtained with non-irrigated condition.

In case of chlorophyll content, the highest results (0.564 and 0.262 at 663ηm and 645ηm, respectively) were also obtained from irrigated field where the lowest (0.563 and 0.261 at 663ηm and 645ηm, respectively) were found from non-irrigated field. Again, in terms of relative water content (RWC), the highest (70.97%) were obtained from irrigated field where the lowest (62.24%) were found from non-irrigated field.

Results also showed that GA_3 had significant effect on growth, yield, chlorophyll content and relative water content. It was observed that the highest plant heights (27.33, 60.00 and 68.83cm at 30, 60 DAS and at harvest, respectively), fresh weight plant^{-1} (15.08, 37.00 and 80.25 g at 30, 60 DAS and at harvest, respectively), dry weight plant^{-1} (4.26, 9.54 and 13.39 g at 30, 60 DAS and at harvest, respectively), number of flowers plant^{-1} (9.44, 5.62 and 3.69 at 30, 60 DAS and at harvest, respectively), number of pods plant^{-1}, (12.33), number of seeds pod^{-1} (13.37), grain yield (1314.00 kg ha^{-1}), 1000- seed weight (56.00 g) and harvest index (39.54 %) were achieved with GA_3 application at the rate of 60 ppm (G_{60}) where the lowest plant height (20.67, 52.83 and 62.50 cm at 30, 60 DAS and at harvest respectively), fresh weight plant^{-1} (7.53, 22.38 and 56.00 g at 30, 60 DAS and at harvest, respectively), dry weight plant^{-1} (2.14, 5.79 and 9.38 g at 30, 60 DAS and at harvest, respectively), number of flowers plant^{-1} (5.89, 3.45 and 1.61at 30, 60 DAS and at harvest, respectively), number of pods plant^{-1} (7.58), number of seeds pod^{-1} (8.83), grain yield (856.70 kg ha^{-1}), 1000 seed weight (49.50 g) and harvest index (29.04%) were obtained with GA_3 (G_0) application.

In case of chlorophyll content, the highest results (0.6510 and 0.3080 at 663ηm and 645ηm respectively) were also obtained from GA_3 application at the rate of 60 ppm (G_{60}) where the lowest (0.5035 and 0.2300 at 663ηm and 645ηm respectively) were found from GA_3 application at the rate of 20 ppm (G_{20}). Again, in terms of relative water content (RWC), the highest (79.75%) was obtained from GA_3 application at the rate of 60 ppm (G_{60}) where the lowest (50.33%) was found from non-irrigated field.

In terms of interaction effect of irrigation and GA_3 application, the highest plant heights (28.67, 64.33 and 70.33 cm at 30, 60 DAS and at harvest, respectively), fresh weight $plant^{-1}$ (16.30, 38.50 and 84.00 g at 30, 60 DAS and at harvest, respectively), dry weight $plant^{-1}$ (4.58, 9.92 and 14.01 g at 30, 60 DAS and at harvest, respectively), number of flowers $plant^{-1}$ (10.55, 6.88 and 4.28 at 30, 60 DAS and at harvest, respectively), number of pods $plant^{-1}$ (13.83), number of seeds pod^{-1} (14.77), grain yield (1376.00 kg ha^{-1}) and harvest index (40.84%) were achieved with the combination of I_1G_{60} where the lowest plant height (19.67, 52.33 and 61.33 cm at 30, 60 DAS and at harvest, respectively), fresh weight $plant^{-1}$ (6.64 and 54.33 g at 30, 60 DAS and at harvest, respectively), dry weight $plant^{-1}$ (1.89, 5.01 and 9.08 g at 30, 60 DAS and at harvest respectively), number of flowers $plant^{-1}$ (5.77, 3.40 and 1.55 at 30, 60 DAS and at harvest respectively), number of pods $plant^{-1}$, (7.33), number of seeds pod^{-1} (8.53), grain yield (830.00 kg ha^{-1}) and harvest index (28.14%) were obtained with the combination of I_0G_0. But it was observed that the highest 1000-seed weight (58.33 g) was found from I_1G_{80} where the lowest 1000-seed weight (48.67 g) was found from I_0G_0.

In case of chlorophyll content, the highest (0.7107 and 0.3330 at 663ηm and 645ηm respectively) was also obtained from I_1G_{60} treatment where the lowest (0.4843 and 0.2207 at 663ηm and 645ηm respectively) was found from I_0G_{20} interaction. Again, in terms of relative water content (RWC), the highest (84.12%) was obtained from I_1G_{60} treatment where the lowest (48.39%) was found from I_0G_0.

From the above results, it may be concluded that both the treatments had significant effect on growth, yield and yield contributing characters of BARI mungbean-3. The plant height, total dry weight of plant, number of flowers, number of pods per plant, number of seeds per pod, 1000-seed weight, seed yield were enhanced significantly by irrigation and GA_3 (I_1G_{60}). So, It may be concluded that significantly higher yield of mungbean was achieved using one irrigation (I_1) along with 60 ppm of GA_3 (G_{60}).

REFERENCES

Abro I.P., Bronson, K.F., Duxbury, J.M. and Gupta, R.K. (1997). Long-term soil fertility experiments with rice-wheat rotation in South Asia. In Long-term soil fertility experiments with rice-wheat rotation in South Asia, Rice-Wheat Consortium Paper Series 1, ed. New Delhi: Rice-Wheat Consortium for the Indo-Gangetic Plains.

Afzal, M.A., Murshad, A.N.M.M., Bakar, M.A., Hamid, A. and Salahuddin, A.B.M. 1998. Mungbean cultivation in Bangladesh. Published by Pulse Research Station, BARI, Gazipur-1701, Bangladesh. p. 25.

Ahmed, Z.U., M.A.Q. Shaikh, A.I. Khan and A.K.Kaul, 1978. Evaluation of local, exotic and mutantgermplasm of mungbean for varietal characters and yield in Bangladesh. *SABRAO J.*, **10**: 48.

Akbari, N., Barani, M. and Ahmadi, H. (2008). Effect of Gibberellic Acid (GA_3) on Agronomic Traits of Green Gram (*Vigna radiata* L. Wilczek) Irrigated with Different Levels of Saline Water. Department of Agronomy, College of Agriculture, Lorestan University, Khoramabad, Iran. *World Applied Sciences Journal*, 5 (2): 199-203.

Aldesuquy,H.S. and Ibrahim, A.H. (2001). Interactive effect of seawater and growth bio-regulators on water relations,absicisic acid concentration and yield of wheat plants. *J. Agron. Crop. Sci.*, **187**: 185-193.

Allahmoradi, P., Ghobadi, M., Taherabadi, S. and Taherabadi, S. (2011). Physiological Aspects of Mungbean (*Vigna radiata* L.) in Response to Drought Stress. International Conference on Food Engineering and Biotechnology. IPCBEE vol.9. IACSIT Press, Singaoore.

Arora, N., Kaura, B., Singh, P. and Paramar, U. (1998). Effects of NAA and cycocel on yield contributing parameters of chickpea (*Cicer arietinum* L.). *Ann. Agril. Res.* **19**(3):279-281.

Asaduzzaman, M., Karim, M.F., Ullah, M.J. and Hasanuzzaman, M. (2008). Response of Mungbean (*Vigna radiata* L.) To Nitrogen and Irrigation Management. Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. American-Eurasian Journal of Scientific Research 3 (1): 40-43.

Ashraf, M. and M.R. Foolad, 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. *Environ. and Exp. Botany*, **59**: 206-216.

Bai, D. I. S., Abraham, A. T. and Mercy, S. T. (1987). Hormonal influence on crop performance in green gram. *Legume Res*. **10**(1):49-52.

BBS (2005). Monthly Statistical Bulletin of Bangladesh. March, 2005. Bangladesh Bureau of Statistics, Stat. Div., Min. Plan., Govt. People's Repub. Bangladesh, Dhaka. p. 57.

BBS (2006). Monthly Statistical Bulletin of Bangladesh. September, 2006. Bangladesh Bureau of Statistics, Stat. Div., Min. Plan., Govt. People's Repub. Bangladesh, Dhaka. p. 54.

Castillo, F.J. (1996). Antioxidative protection in the inducible CAM plant Sedum album L. following the imposition of severe water stress and recovery. Oecologia. 1996, 107: 469-477.

Chakrabarti,N. and Mukherji, S. (2003). Effect of Phytohormonepretreatment on nitrogen metabolism in Vigna radiate under salt stress. Biol. Plant., 46: 63-66.

Chellappa, M. and Karicaratharaju, T. V. (1973). Effect of pre sowing treatment with phytohormones on the yield of *Arachis hypogaea* L. *Madras Agril. J.* **60**(9/12):1462-1464.

Das, A. and Prasad, R. (2003). Effect of plant growth regulators CCC and GA_3 on the growth and yield of summer mungbean. *Ann. Agril. Res.* **24**(4): 874-879.

De costa, W.A. and Shanmugathasan, K.N. (1996b). Effects of irrigation at different growth stages and source–sink manipulations on yield and yield components of mung bean (Vigna radiata L. wilczek), in dry and intermediate Zones of Srilanka, J. Agron. Crop Sci., 183: 111-117.

Dhingra, K.K., Dhillon, M.S., Grewal, D.S. and Shorma, K. (1991). Performance of maize and mungbean intercropping different planting patterns and row orientation. *Indian J. Agron.*. **36**: 207-212.

Eack, H.V. (1996). Effect of water deficit on yield and yield components and water use efficiency of irrigated corn. *Agron J.*. **78**: 1083-1089

Haqqani. A.M. and Ponde, R.K. (1994). Response of mung bean to water stress and irrigation at various growth stages and plant densities. 1- Plant and crop growth parameters. *Trop. Agric.* (Trinidad) **71:** 281-288.

Haroun, S.A., Badawy, A.H. and Shukry, W.M. (1991). Auxin induced modification of Zea mays and Lupinustermis seedlings exposed to water stress imposedby polyethylene glycol (PEG 6000) *Sci. J.*, **18**: 335.

Hoque, M. and Haque, S. (2002). Effects of GA and 3 itsmode of application on morphology and yield parametersof mungbean (Vigna radiate L.). *Pakistan J. Biol. Sci.*, **5**: 281-283.

Ibrahim, M. M. and Al- Bassyuni, M.S.S. (2012). Effect of Irrigation Intervals, Phosphorus and Potassium Fertilization Rates on Productivity and Chemical Constituents of Mungbean Plants. Dept. of Agron., Fac. of Agric., Al-Azhar Univ., Assiut Branch, Egypt. Research Journal of Agriculture and Biological Sciences, 8(2): 298-304.

Islam, M.R. (2010). Effect of plant growth regulator (gaba) on morphological characters and yield of black gram (*Vigna mungo* L.). Plant growth regulator 'GABA' effect in black gram. *J. Agric. Res.,* **48**(1).

Jain, P. C., Chandra, A. Naidu, A. K. and Tiwari, J. P. (1995). Influence of nitrogen and naphthalene acetic acid on growth and yield parameters of cowpea (*Vingna unguilata* (L) walp) during summer. *JNKVV Res. J.* **27**(1):49-52.

Jaiswal, P. K. and Bhambil, S. (1989). Effect of growth regulating substances on podding and yield of *Vigna radiata. Acta Botanica Indica* **17**(1):54-58.

Kalita, P., Dey, S. C. and Chandra, K. (1995). Influence of foliar application of phosphorus and naphthalene acetic acid (NAA) on nitrogen, dry matter accumulation and yield of greengram (*Vigna radiata* L. Wilezek cv. AAU 34). *Indian J. Pl. Physiol.* **38**(3):197-202.

Kandagal, S. S., Panchal, Y. C. and Manjunath, S. (1990). Effects of growth regulators and nutrients on yield components of mungbean genotypes. *J. Maharashtra Agril. Univ.* **15**(2):199-200.

Kaul,A., 1982. Pulses in Bangladesh. Bangladesh Agricultural Research Council. Farmgate, Dhaka. pp: 27.

Kelaiya, V. V., Jethwa, M. G., Patel, J. C. and Sabria, S. G. (1991). Effect of growth regulators and their spraying schedules on groundnut. *Indian J. Agron.* **36**(1):111-113.

Khodabandeh, N. (2005). Cereals. University of Tehran Press, 2005.

Kramer PJ, Boyer JS 1997 Water relations of Plants and Soils, Academic Press, San Diago Arrese I Gonzalez EM Mariano D Landera R Larraiza E Gil-Quintana E 2009 Physiological response of legume nodules to drought, Plant stress, Global Science Book, 5 (special Issue):24-31

Lakshmamma, P. and Rao, I. V. S. (1996b). Response of blackgram (*Vigna mungo* L.) to shade and naphthalene acetic acid. *Indian J. plant physio.* **1**(1): 63-64.

Lal,S. and D.S. Yadav, 1981. Raise short duration pulses during summer. Indian Farming., **30**(11): 3-5.

Lee, H. S. (1990). Effects of pre-sowing seed treatments with GA_3 and IAA on flowering and yield components in groundnuts. *Korean J. Crop Sci.* **35** (1): 1-9.

Leport, L., N.C. Turner, S.L. Davies and K.H.M. Siddique, (2006). Variation in pod production and abortion among chickpea cultivars tinder terminal drought. *Europ. J. Agron,* **24**: 236-246.

Miah, M.Z.I. and V.R. Carangal, 1981. Yield of 10 mungbeancultivars evaluated in intensive rice based cropping system. *Intl. Rice Res. Newsl.,* **6**(4): 27.

Nawalagatti, C. M., Panchal, Y. C., Manjunath, S. and Channappagoudar, B. B. (1991). Effect of different levels of plant growth regulators on growth and yield of groundnut. *J. Maharashtra Agril. Univ.* **16**(1):122-123.

Nickell, L. G. (1982). Plant Growth Regulators: Agricultural Uses. Spring Verlag, Beslin. *Indian J. Pl. Physiol.* **36** (10):47 - 52.

Postel SL 2000 Entering an era of water scarcity: The challenges ahead. Ecological Applications, **10**: 941-948

Rafiei shirvan, M. and Asgharipur, M. R. (2009). Yield reaction and morphological characteristics of some mungbean genotypes to drought stress. *J.Modern Agric. Knowledge.* **5** (15): 67-76.

Ranawake, A.L., Amarasingha, U.G.S., Rodrigo, W.D.R.J., Rodrigo, U.T.D. and Dahanayaka, N. (2011). Effect of water stress on growth and yield of mungbean (*Vigna radiate* L.). Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka. Tropical Agricultural Research & Extension **14**(4): 2011.

Sangakkara, U.R., M. Frehner and J. Nosberger, 2001. Influence of soil moisture and fertilizer potassium on the vegetative growth of mungbean (Vigna radiata L.) and cowpea (Vigna unguiculata L.). *J. Agron. Crop Sci.,* **186**(2): 73-81.

Sarkar, R.K. (1992). Response of summer green gram (Phaseolus radiatus) to irrigation and phosphorus application. *Idian. J. Agron.*, **37**(1): 123-125.

Sharma, R., Sing, G. and Sharma, K. (1989). Effect of ricontanol, mixatol and GA3 on yield and its components in mungbean. *Indian Agriculturist.* **33**(1):59-60.

Shohag, M.J.I., Karim, M. A. and Rahman, M. S. (2008). Effect of growth regulator on morphological attributes of mungbean under irrigated and non-irrigated conditions. Department of Crop Botany, Bangladesh Agricultural University, Mymensingh. J. Agro. Environ. 2(1): 1-6.

Singh, G., Sharma, B. and Singh, G. (1982). Effect of growth regulators on groundnut productivity. *Indian J. Ecol.* **9**(2):281-285.

Subbian, P. and Chamy, A. S. P. (1984). Effect of growth regulators on pod setting of greengram. *Madras Agril. J.* **71**(2):129 - 131.

Tawfik, K.M. (2008). Effect of Water Stress in Addition to Potassiomag Application on Mungbean. Botany Department, Women's College, Ain Shams University, Cairo, Egypt. Australin J. Basic Appl Sci., **2**(1): 42-52

Thalooth, A.T., Tawfik, M.M. and Magda Mohamed, H. ().A Comparative Study on the Effect of Foliar Application of Zinc, Potassium and Magnesium on growth, Yield and Some Chemical Constituents of Mungbean Plants Grown under Water Stress Conditions. Department of Field Crops Research, National Research Centre, Dokki, Giza, Egypt. World J. Agri. Sci. **2** (1): 37-46.

Thomas, Robertson, M.J., S. Fukai and M.B. Peoples, (2004). The effect of timing and severity of water deficit on growth, development, yield accumulation and nitrogen fixation of mungbean. Field Crops Res., **86**: 67-80.

Timsina J and D J Connor (2001) Productivity and management of rice-wheat cropping systems: Issues and challenges. Field Crops Res. **69**: 93-132.

Upadhyay, R. G. (1994). Effect of bioregulators on growth, development, flowering behaviour and yield of chickpea (*Cicer arietinum* L.). *Legume Res.* **17**(1):60-62.

Weinberger, K. 2003. Impact analysis of Mungbean research in South and Southeast Asia. Final report of GTZ Project. The World Vegetable Center (AVRDC), Shanhua, Taiwan

Zhu, J.K., (2001). Plant Salt Tolerance. Trends Plant Sci., 66-71.

APPENDICES

Appendix 1. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0 - 15 cm depth).

Mechanical composition:

Particle size constitution

Sand	:	40%
Silt	:	40%
Clay	:	20%
Texture	:	Loamy

Chemical composition:

Soil characters	Value
Organic matter	1.44 %
Potassium	0.15 meq/100 g soil
Calcium	3.60 meq/100 g soil
Magnesium	1.00 meq/100 g soil
Total nitrogen	0.072
Phosphorus	22.08 μg/g soil
Sulphur	25.98 μg/g soil
Boron	0.48 μg/g soil
Copper	3.54 μg/g soil
Iron	262.6 μg/g soil
Manganese	164 μg/g soil
Zinc	3.32 μg/g soil

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

Appendix 2. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March 2012 to June 2012.

Year	Month	Air temperature (^0C)			Relative humidity (%)	Rainfall (mm)	Sunshine (h)
		Maximum	Minimum	Mean			
2012	March	32.20	21.80	27.00	66.69	66.70	155.0
	April	34.44	23.96	29.20	68.08	90.01	253.0
	May	33.23	24.11	28.67	96.13	297.9	96.0
	June	34.26	26.24	30.25	94.11	295.6	64.0

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

Appendix 3: Effect of irrigation and growth regulator showing days to emergence after sowing on chlorophyll content, water relation and yield of mungbean

Source of variation	Degrees of freedom	Mean square
		Days to emergence after sowing
Replication	2	1.433
Factor A	1	1.633*
Factor B	4	0.583**
AB	4	0.550**
Error	18	0.507

Appendix 4: Effect on plant height with irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean

Source of variation	Source of variation	Mean square of plant height (cm)		
		30 DAS	60 DAS	At harvest
Replication	2	2.100	2.800	1.233
Factor A	1	4.833*	10.83*	4.833*
Factor B	4	6.133*	11.75*	9.250*
AB	4	3.333*	18.08*	0.583**
Error	18	1.100	3.207	2.863

Appendix 5: Effect on fresh weight plant^{-1} with irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean

Source of variation	Degrees of freedom	Mean square of fresh weight plant^{-1} (g)		
		30 DAS	60 DAS	At harvest
Replication	2	1.000	0.725	2.325
Factor A	1	5.414*	5.441*	5.875*
Factor B	4	8.396*	4.506**	3.950**
AB	4	0.897**	3.776*	9.833*
Error	18	0.129	0.339	1.195

Appendix 6: Effect on dry weight plant^{-1} with irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean

Source of variation	Degrees of freedom	Mean square of dry weight plant^{-1} (g)		
		30 DAS	60 DAS	At harvest
Replication	2	0.078	0.162	0.069
Factor A	1	3.924*	2.408**	5.667*
Factor B	4	3.809*	8.869*	12.67*
AB	4	0.075**	0.898**	1.847**
Error	18	0.010	0.021	0.023

Appendix 7: Effect on number of flowers plant^{-1} with irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean

Source of variation	Degrees of freedom	Mean square of number of flowers plant^{-1}		
		40 DAS	60 DAS	80 DAS
Replication	2	0.214	0.611	0.422
Factor A	1	2.366*	3.124*	4.211*
Factor B	4	5.124*	5.291*	7.263*
AB	4	1.215**	2.322*	1.287*
Error	18	1.743	1.865	1.147

Appendix 8: Effect on yield and yield contributing characters with irrigation and growth regulator on chlorophyll content, water relation and yield of mungbean

Source of variation	Degrees of freedom	Mean square of				
		Number of pods/plant	Number of seeds/pod	Seed yield (kg)	1000 seed weight	Harvest index
Replication	2	0.507	0.324	2.233	1.233	1.088
Factor A	1	4.421*	10.21*	9.500*	6.533*	8.247*
Factor B	4	9.432*	19.77*	16.58*	14.42*	14.39*
AB	4	1.782**	1.511**	5.917*	0.617**	3.256*
Error	18	0.187	0.268	4.567	0.419	2.114

Appendix 9: Effect of irrigation and growth regulator on chlorophyll content and relative water content (RWC) for growth and yield of mungbean

Source of variation	Degrees of freedom	Mean square of chlorophyll content at		RWC (%)
		663ηm	645ηm	
Replication	2	0.083	0.021	1.014
Factor A	1	0.420**	0.042**	7.288*
Factor B	4	0.017**	0.005**	12.145*
AB	4	0.020**	0.004**	2.384*
Error	18	0.012	0.003	2.644