SEED YIELD AND QUALITY OF MUNGBEAN AS AFFECTED BY SEED PRIMING

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CERTIFICATE

This is to certify that the thesis entitled **"SEED YIELD AND QUALITY OF MUNGBEAN AS AFFECTED BY SEED PRIMING"** submitted to the **INSTITUTE OF SEED TECHNOLOGY**, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **SEED TECHNOLOGY**, embodies the result of a piece of bonafide research work carried out by **MD. AMINUL HAQUE**, Registration No. **12-05085** 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.

June, 2018

Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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SEED YIELD AND QUALITY OF MUNGBEAN AS AFFECTED BY SEED PRIMING

ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from November 2017 to February 2018 to study the seed yield and quality of mungbean as affected by seed priming. The whole experiment was conducted in two different phases; the first at field condition and second in the Laboratory. Two varieties of mungbean *viz*. V_1 (BARI mung 6) and V_2 (BARI mung 8) and different priming chemicals including control *viz*. T_0 (control; No priming), T_1 (seed priming with water), T_2 (seed priming with PEG) and T_3 (seed priming with Mannitol) were considered as treatments of the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data on different parameters at field level and laboratory condition were recorded. Collected data were statistically analyzed. Variety, seed priming treatments and their combination showed significant influence on different growth and yield parameters. The highest grain yield ha^{-1} (1299.90 kg) and percent seedling emergence (84.20%) were found from V_1 (BARI mung 6) whereas the lowest grain yield ha^{-1} (1201.05 kg) and percent seedling emergence (81.34%) was from V_2 (BARI mung 8). Similarly, the highest grain yield ha^{-1} (1523.40 kg) and highest percent seedling emergence (91.45%) were achieved from the priming treatment, T_3 (seed priming with Mannitol) compared to control. Regarding, interaction effect of variety and seed priming treatments, the highest number of branches $plant^{-1}$ (2.70, 4.60 and 5.12 at 25, 40 and 55 DAS, respectively), number of pods $plant^{-1}$ (26.60), 1000 seed weight (51.12 g), grain weight $plant^{-1}$ (15.30 g) and grain yield ha^{-1} (1572.20 kg) were found from the treatment combination, V_1T_3 while the lowest from V_2T_0. The lowest days to 50% flowering (38.67) and days to 80% pod formation (48.67) were also found from the treatment combination of V_1T_3. The highest percent seedling emergence (92.30%) was also found from V_1T_3 whereas the lowest (70.75%) was from the V_2T_0. It can be concluded that the treatment combination of V_1T_3 can be considered as the best considering all other treatment combinations.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

In Bangladesh, mungbean (*Vigna radiata* L.) is an important grain legume belonging to the family Fabaceae which is considered as an excellent source of vegetable protein. It is characterized by good digestibility, flavor, high protein content and absence of any flatulence effects (Ahmed *et al*., 2008). Considering, protein content among the pulses, it holds the 3rd position. According, to production status, it is ranked 4th in both acreage and production in Bangladesh (MoA, 2014). It is extensively grown in the tropical and sub-tropical region. In our country, it is used as whole or split seed as Dal (soup) but in many countries sprouted seeds are widely used as vegetable. The whole seeds of the crop are rich in 348 kcal energy, 24.5 mg protein, 1.2 mg fat, 59.9 mg carbohydrate, 75 mg calcium, 8.5 mg minerals, 0.72 mg thiamin, 0.15 μg riboflavin, 49 μg beta-carotene (BARI, 2008). The lysine content makes mungbean a good complementary food for rice-based diets because lysine is usually the first limiting amino acid.

Besides, the crops have the capability to enrich soils through nitrogen fixation (Sharma and Behera, 2009). According to FAO (2013) recommendation, a minimum intake of pulse by a human should be 80 gm/day, whereas it is 7.92 g in Bangladesh (BBS, 2012). This is because of fact that national production of the pulses is not adequate to meet our national demand. In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman and Ali, 2007). This is mostly due to low yield (MoA, 2013).

At present, the area under pulse crop is 0.406 million hectare with a production of 0.322 million tons (BBS, 2013), where mungbean is cultivated in the area of 0.108

million ha with production of 0.03 million tons (BBS, 2014). Plant growth and productivity affected by nature's rage in the form of various abiotic stress factors.

There are many factors which affect germination, growth and yield performance of crops and resulted lower yield in most of the cases. Out of many constraints regarding low production of mungbean, seed germination, growth and development, yield and crop quality are of prime importance.

There are many strategies which have been adopted to overcome the negative effects of adverse situations. A good strategy is the selection of cultivars and species tolerant to related problems (Pavlousek, 2011). Variety is an important factor affecting farmer's yields and is also among the factors given the highest priority for immediate technology transfer. Diffusion of new varieties ensures continuing increase in productivity through the increased yield potential of new varieties; it reduces the investment, thereby increasing the returns and helps to maintain genetic resistance to different biotic and abiotic factors like salinity, drought, diseases and pests etc. (Heisey, 1990).

However, an alternative strategy for the possibilities also to overcome natural stress is by seed priming treatments (Ghiyasi *et al*., 2008). Seed priming was defined as pre-sowing treatments in water or in an osmotic solution that allows the seed to imbibe water to proceed to the first stage of germination, but prevents radical protrusion through the seed coat (Yari *et al*., 2012). By providing some special pre-sowing treatments, seeds can be invigorated. Seed priming techniques such as hydro priming, hardening, osmo priming, osmo hardening, hormonal priming have been used to accelerate emergence of more vigorous plants and better drought tolerance in many field crop like wheat (Iqbal and Ashraf, 2007), chickpea, sunflower (Kaya *et al*., 2006), cotton (Casenave and Toselli, 2007) triticale (Yagmur and Kaydan, 2008).

Seed priming leads to faster, more complete establishment of crops, a lower risk of crop failure and the need to re-plant, more vigorous growth, earlier flowering and maturity and higher yields. Improvement in germination of primed seeds may be attributed due to the fact that priming induced quantitative changes in biochemical activities including greater α-amylase activity, increasing free sugars and DNA during seed germination (Sung and Chang, 1993). During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radical protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000). In mungbean, 4 hours and 8 hours primed seeds showed significant difference in germination percentage and seed moisture percentage over non-primed seeds (Saha *et al*., 2006). Primed seeds usually to exhibit an increased germination rate, greater germination uniformity and greater total germination percentage. Increased germination rate and uniformity have been attributed to metabolic repair during imbibitions build up of germination enhancing metabolites (Abbasdokht, 2011).

In Bangladesh little is known about seed priming and information regarding seed priming with osmotic priming agent in mungbean or other crops in Bangladesh is scarce. Therefore, the present study will be undertaken with the following objectives:

1. To examine the influence of seed priming on the germination behavior of mungbean
2. To observe the emergence capability of mungbean seeds as influenced by priming
3. To investigate the seed priming effects on the field performance of mungbean

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crop in our country. Farmers suffer from various natural problems like germination, salinity etc. for mungbean cultivation. Seed priming can reduce the water requirement and increase germination percentage, adaptability to salinity and drought which contribute to increase total production of crops. In regions where water is scarce people have to grow mungbean as it requires much less water than boro rice. The following review is presented regarding seed yield and quality of mungbean as affected by seed priming.

2.1 Effect of variety

Haider and Ahmed (2014) conducted an experiment to assess the quality status of seeds of three varieties of mungbean (NIAB-2006, AZRI-2006 and Chakwal M-6) collected during 2010-11 from National Institute of Agriculture and Biology, Faisalabad (NIAB); Arid Zone Research Institute, Bhakkar (AZARI) and Barani Agriculture Research Institute, Chakwal (BARI). Purity percentage and germination percentage of the seeds of all varieties were higher than the national seed standard. The minimum purity was 99.33%, germination was 88.11% and moisture content of all seed samples was lower than the acceptable seed standard. The minimum moisture content of seed samples was 8.33% and the highest 8.75%. The highest 1000 seed weight differed from 56.58 to 63.33 g among the mungbean varieties.

Ali *et al*. (2014) conducted a field experiment to investigate the effect of sowing time on yield and yield components of different mungbean varieties. Different sowing times (15th June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties.

Parvez *et al*. (2013) conducted an experiment to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties *viz*. BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1}, and laid out in a Randomized Complete Block Design with three replications. Results revealed that the longest plant, highest number of branches $plant^{-1}$, number of total pods $plant^{-1}$, seeds $plant^{-1}$ and seed weight $plant^{-1}$ were obtained from BARI Mung-6. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8. The second highest and the lowest seed yield were recorded from Binamoog-4 and BARI Mung-6, respectively. The highest stover yield was obtained from Binamoog-8 followed by Binamoog-4. The lowest stover yield was recorded from BARI Mung-6.

Rasul *et al.* (2012) conducted an experiment to establish the proper inter-row spacing and suitable variety evaluation in Faisalabad, Pakistan. Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S1- 30 cm, S2- 60 cm and S3- 90 cm) respectively. Experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement randomizing varieties in the main and inter-row spacing in the sub-plots. The data recorded were analyzed statistically using Fisher's analysis of variance technique and Least Significant Difference (LSD) test at 5% probability level. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. The spacing 30 cm showed highest seed yield 675.84 kg ha^{-1} as compared to other spacing treatments. Low potential varieties and improper agronomic practices may be a serious cause of low productivity in pulses. The interaction of V_2S_1 exhibited significantly higher yield than other treatments. The lowest seed yield was obtained at V_3S_1 (462.8 kg ha^{-1}). The higher yield in V_2S_1 was characterized by more number of plants in narrow spacing of 30 cm (37 plants m^{-2}), plant height of 51.4 cm, higher number of fruit bearing branches (7 per plant), the highest number of pods per plant (18.86), number of seeds per pod (10.06), 1000 grain weight (4.8 g), the highest biological yield (4894.2 kg ha^{-1}) with a harvest index of (17.75) and the highest number of nodules per plant (15) were the components of high yield formation for mungbean variety V_2 under the inter-row spacing of 30cm. So it can be concluded that mungbean variety Nm-98 should be grown at inter row spacing of 30 cm under the agro-climatic conditions of Faisalabad.

Ahamed *et al.* (2011) conducted an experiment with five Mungbean varieties namely BARI Mung-2 (M2), BARI Mung-3 (M3), BARI Mung-4 (M4), BARI Mung-5 (M5) and BARI Mung-6 (M6) to observe their morpho-physiological attributes in different plant spacing viz. 20 × 10 cm (D1), 30×10 cm (D2) and 40× 10 cm (D3). The highest plant height of BARI Mung-4 is 49.38 cm that is statistically at per with the height of BARI Mung-3 (i.e. 48.38 cm). Leaf area of BARI Mung-3 was the highest (147.57 cm2). The variety BARI Mung-3 produced the lowest leaf area of 110.00 cm2. In the study BARI Mung-2 took 30.44 days for flowering that is statistically at per BARI Mung-6 (30.11) and BARI Mung-4 flower earliest (at 28.88 days after sowing) as compared to all other varieties.

Salah Uddin *et al.* (2009) carried out an experimental to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean during the summer season of 2007. Five levels of fertilizer viz. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Biofertilizer + P + K. and three varieties BARI mung 5, BARI mung 6 and BINA moog 5 were also used as experimental variables. The experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. BARI mung-6 obtained highest number of nodule plant-^{1} and higher dry weight of nodule. It also obtained highest number of pod plant-^{1}, seed plant-^{1}, 1000 seed weight and seed yield.

Kabir and Sarkar (2008) carried out an experiment to study the effect of variety and planting density on the yield of mungbean in *Kharif-I* season (February to June) of 2003. The experiment comprised five varieties viz. BARIMung-2, BARIMung-3, BARIMung-4, BARIMung-5 and BINAMung-2. The experiment was laid out in a Randomized Complete Block Design with three replications. It was observed that BARI Mung-2 produced the highest seed yield and BINA Moog-2 did the lowest.

Bhuiyan *et al.* (2008) carried out field studies with and without *Bradyrhizobium* was carried out with five mungbean varieties to observe the yield and yield attributes of mungbean. Five mungbean varieties viz. BARI Mung-2, BARI Mung-4, BARI Mung-5, BINA moog-2 and Barisal local, and the rhizobial inoculum *(Bradyrhizobium* strain BAUR-604) were used. The seeds and stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield attributing data were recorded from 10 randomly selected plants. BARI Mung-2 produced the highest seed yield (1.03 t/ha in 2001 and 0.78 t/ha in 2002) and stover yield (2.24 t/ha in 2001 and 2.01 t/ha in 2002). Higher number of pods/plant was also recorded in BARI Mung-2, while BARI Mung-5 produced the highest 1000-seed weight. Application of *Bradyrhizobium* inoculant produced significant effect on seed and stover yields in both trials conducted in two consecutive years. Seed inoculation significantly increased seed (0.98 t/ha in 2001, 27% increase over control and 0.75 t/ha in 2002, 29% increase over control) and stover (2.31 t ha^{-1} in 2001 and 2.04 t/ha in 2002) yields of mungbean. *Bradyrhizobium* inoculation also significantly increased pods $plant^{-1}$, seeds/pod and 1000-seed weight. Inoculated BARI Mung-2 produced the highest seed and stover yields as well as yield attributes, such as pods/plant and seeds/pod.

Muhammad *et al*. (2006) conducted an experiment to study the nature of association between *Rhizobium phaseoli* and mungbean. Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes *viz*., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches $plant^{-1}$ of all the genotypes. Strain Tal-169 in association with NCM- 209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment to evaluate the effect of biofertilizer *(Bradyrhizobium)* and plant growth regulators (GA3 and IAA) on growth of 3 cultivars of summer mungbean *(Vigna radiata* L.). Among the mungbean varieties, BINA moog 5 performed better than that of BINA moog 2 and BINA moog 4.

Bhati *et al.* (2005) conducted field studies to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean variety K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher seed yield and 13.7% higher fodder yield than the local cultivar.

Raj and Tripathi (2005) conducted a field experiment to evaluate the effects of cultivar (K- 851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. The cultivars K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). The Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session.

Madriz-Isturiz and Luciani-Marcano (2004) conducted a field experiment and found significant differences in the values of the parameters measured due to cultivar were recorded. The cultivars VC 1973C, Creole VC 1973A, VC 2768A, VC 1178B and Mililiter 267 were the most promising cultivars for cultivation in the area with the average yield was 1342.58 kg/ha.

Apurv and Tewari (2004) conducted a field experiment to investigate the effect of *Rhizobium* inoculation and fertilizer on the yield and yield components of three mungbean cultivars (Pusa 105, Pusa 9531 and Pant mung 2). The variety Pusa

9531 showed higher yield components and grain yield than Pusa 105 and Pant mung 2.

Ali *et al.* (2004) carried out an experiment at BARI, Joydebpur, Gazipur to find out the response of inoculation with different plant genotypes of mungbean. Three varieties of mungbean viz. BARI mung-1, BARI mung-2, BARI mung-3 and Rhizobial inoculums (BARI Rvr 405) were use in this experiment. Each variety was tested with and without inoculation. Inoculated plants gave significantly higher number of nodules.

Mondal *et al.* (2004) conducted an experiment at farmer's field of Rangpur zone during *kharif-1* season to evaluate the performance of four mungbean varieties viz. BINA moog-2, BINA moog-5, BARI mung-2 and BARI mung-5. Result revealed that BINA moog-5 had the highest seed yield (1091 kg ha^{-1}) than the other tested varieties because it produced the greater number of pods $plant^{-1}$ and 1000 seed weight. Moreover, BINA moog-5 matured 5 days earlier than the others.

Solaiman *et al.* (2003) studied on the response of mungbean cultivars BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, BINA moog-2 and BU mung-1 to *Rhizobium sp.* Strains TAL 169 and TAL441. It was observed that inoculation of the seeds increased nodulation.

Bhuiyan *et al.* (2003) conducted a field Experiment to study the response of inoculation with different plant genotypes. Four varieties of mungbean viz. BARI mung-2, BARI mung-3, BARI mung-4, BARI mung-5, and Rhizobial inoculum (Bradyrhizobium strain RVr-441) were used in this experiment. Each variety was tasted with/without inoculation. Inoculated plants gave significantly higher nodule number.

Navgire *et al.* (2001) conducted a field experiment with the seeds of mungbean cultivars BM-4, S-8 and BM-86 inoculated with *Rhizobium* strains M-11-85, M-6-

84, GR-4 and M-6-65 before sowing. S-8, BM-4 and BM-86 recorded the highest mean nodulation (16.66), plant biomass (8.29 q/ha) and grain yield (4.79 q/ha) during the experimental years. S-8, BM-4 and BM-86 recorded the highest nodulation, plant biomass and grain yield when their seeds were inoculated with *Rhizobium* strains M-6-84, M-6-65 and M-11-85, respectively.

2.2 Effect of priming

Nowadays various strategies are employed to generate plants that can withstand these stresses. In recent years, seed priming has been developed as an indispensable method to produce tolerant plants against various stresses. Seed priming is the induction of a particular physiological state in plants by the treatment of natural and synthetic compounds to the seeds before germination. In plant defense, priming is defined as a physiological process by which a plant prepares to respond to imminent abiotic stress more quickly or aggressively. Moreover, plants raised from primed seeds showed sturdy and quick cellular defense response against abiotic stresses. Priming for enhanced resistance to abiotic stress obviously is operating via various pathways involved in different metabolic processes. The seedlings emerging from primed seeds showed early and uniform germination. Moreover, the overall growth of plants is enhanced due to the seed-priming treatments. The main objective of this review is to provide an overview of various crops in which seed priming is practiced and about various seed-priming methods and its effects (Jisha, *et al.* 2013).

The effects of priming on seed germination properties have been well documented. High potential in improving field emergence and ensures early flowering and harvest under stress condition especially in dry areas and under drought stress. Patade *et al.* (2009) suggest that salt priming is an effective pregermination practice for overcoming salinity and drought induced negative effects in sugar-cane. Farhoudi and Sharifzadeh (2006) while working with canola reported salt priming induced improvement in seed germination, seedling emergence and growth under saline conditions. Priming led to an increased solubilization of seed storage proteins like the betasubunit of the 11S globulin and reduction in lipid peroxidation and enhanced antioxidative activity in seeds. Afzal *et al.* (2008) observed that the priming-induced salt tolerance was associated with improved seedling vigor, metabolism of reserves as well as enhanced K^+ and Ca^{2+} and decreased Na^+ accumulation in wheat plants. Sivritepe *et al.* (2003) evaluate the effect of salt priming on salt tolerance of melon seedling and reported that total emergence and dry weight were higher in melon seedlings derived from primed seeds and they emerged earlier than non-primed seeds. They also observed that total sugar and proline accumulation and prevented toxic and nutrient deficiency effects of salinity because less Na but more K and especially Ca was accumulated in melon in melon seedlings

2.3 Effect of seed priming

Meriem *et al.* (2014) carried out an experiment to evaluate the interactive effect of salinity and seed priming on coriander. The experiment was carried out in completely randomized design with three replications consisting of four coriander genotypes (Tunisian cv, Algerian cv, Syrian cv and Egyptian cv) at two seed conditions (seed priming with 4 g L^{-1} NaCl for 12h or no seed priming). Results showed that seed priming and salinity had significantly ($p<0.05$) affected all the parameters under study. Seed priming with NaCl had diminished the negative impact of salt stress in all cultivars and primed plants showed better response to salinity compared to unprimed plants.

Dalil (2014) reported that during seed priming in medicinal plants seeds are partially hydrated, so that pre-germinative metabolic activities proceed, while radicle protrusion was prevented, then were dried back to the original moisture level. Primed seeds are physiologically closer to germination and growth after planting than unprimed seeds.

Aymen *et al.* (2014) conducted an experiment to evaluate the effects of NaCl priming on growth traits and some biochemical attributes of safflower *(Carthamus tinctorius* L. cv Safola) in salinity conditions. Seeds of safflower were primed with NaCl (5 g L^{-1}) for 12 h in 23 °C. Primed (P) and non primed (NP) seeds were directly sown in the field. Experiments were conducted using various water concentrations induced by NaCl (0, 3, 6, 9 and 12 g L-1) in salinity experiment. They found that growth (plant height, fresh and dry weight) and biochemical (chlorophyll, proline and proteins content) of plants derived from primed seeds were greater of about 15 to 30% than that of plants derived from non primed seeds.

Saleem *et al.* (2014) set an experiment to study the effect of seed soaking on seed germination and growth of bitter gourd cultivars. Three cultivars of bitter gourd Faisalabad Long, Jaunpuri and Palee were soaked in water for various soaking durations (4, 8, 12 and 16 hours) along with control to determine the optimal soaking duration and find out the best growing cultivar. The highest germination percentage (85.18%), number of branches plant-1 (8.64), fruits $plant^{-1}$ (20.70) were obtained when the bitter gourd seeds soaked for 12 hours. Earlier emergence (6.28) and earlier flowering (39.40) were recorded in plants where seeds soaked for 16 hours. Seed soaking in water for 12 hours has the potential to improve germination, seedling growth of bitter gourd cultivars.

Mehta *et al.* (2014) reported that presowing seed priming helps to improve germination and stand establishment. Seeds of bitter gourd cultivar Solan Hara were hydro-primed at 20 C between wet germination papers for different durations keeping unprimed seeds as control. The plateau phase (Phase-II) with little change in water content from 53.3 to 57.3% (after 24 hours to 72 hours of seed priming) found as seed priming regime for bitter gourd. Significantly higher speed of germination, total% germination, seedling length, seedling dry weight, vigour index-I and II were recorded in hydro-priming for 72 hours as compared to other durations and control. Based on seed priming regime i.e. phase-II of seed germination and performance with respect to seed quality parameters it was found that 72 hours of seed priming is optimum in bitter gourd.

Abdoli (2014) set an experiment to evaluate the effects of seed priming on certain important seedling characteristic and seed vigor of fennel *(Foeniculum vulgare L.)* at Department of Agronomy and Plant Breading, Faculty of Agriculture, Maragheh University in Maragheh state, Iran. Treatment included untreated seeds (control) and those primed in water (H_2O), sodium chloride (NaCl, 100 mM) and polyethylene glycol 6000 (PEG-6000,water potential-1.6 MPa), in darkness for 18 hrs. Among them unsoaked seed (control) and hydropriming treatments had the lowest plumule, radicle and seedling length, seedling dry weight and seedling vigor index. PEG and NaCl in all of traits were better than the water priming treatments, respectively. PEG-6000 (1.6 MPa) is the best treatment for breaking of fennel seed dormancy.

Rastin *et al.* (2013) conducted an experiment in 2011 in Arak, Iran, to evaluate the effect of seed priming treatments on the seed quality of red bean. The experiment was conducted in split plot in the form of a randomized complete block design with three replications and two factors. The first factor was primary seed priming, in which seeds were or were not treated with water, for 14 hours. The second factor was complementary seed priming which was conducted after drying the seeds treated in the first stepand water, 100 ppm KCl, 0.5% $CaCl_2.2H_2O$, 50 ppm KH_2PO_4 and 20 ppm GA_3 were used to treat seeds for 14 hours.They found that Primary seed priming had no significant effect on none of the measured traits but complementary seed priming significantly affected plant dry matter, grain yield, 100 grain weight and the number of pods. The highest plant dry matter (53.06 g) and the highest grain yield (5.98 t/ha) were achieved when seeds were first treated with water (as the primary seed priming) and after drying were treated with GA3 (as the complementary seed priming).

Meena *et al.* (2013) conducted an experiment for two consecutive years 2010-11 and 2011-12 to evaluate the influence of hydropriming on the water use efficiency and grain yield of wheat *(Triticum aestivum* L.) under moisture stress. The hydro-primed and pregerminated seeds established earlier than dry seeds leading to better crop establishment under optimum, sub optimum soil moisture as well as dry soil conditions leading to higher tillering and grain yield.

Ajirlo *et al.* (2013) reported that germination and early growth under prevailing environmental conditions improves by seed priming technique. Their result showed that all the priming treatments significantly affect the fresh weight, shoot length, number of roots, root length, vigor index, time to start emergence, time to 50% emergence and energy of emergence of forage maize. The interactive effect of varieties and priming techniques were not significant for mean emergence time and coefficient of uniformity of emergence.

Aymen and Cherif (2013) reported that with increasing salinity, emergence traits (total emergence, mean emergence time), growth parameters (plant height, shoot fresh and dry weight) and mineral contents (K^+ and $Ca^{2+)}$ decreased, but to a less degree in primed seeds. At different salinity levels, primed seeds possessed higher emergence and growth rate than control.

Dastanpoor *et al.* (2013) carried out an experiment to find out the influence of hydro priming treatments on seed parameters of *Salvia officinalis* L. (sage). Seeds of sage were treated by hydro priming at three temperatures 10, 20, 30°C for 0, 12, 24 and 48 h. Hydro priming clearly improved the final germination percentage

(FGP), mean germination time (MGT) and synchronized the germination of seeds at each three temperature. All the treatments resulted in germination enhancement except hydro primed seeds for 48 h at temperature 30°C. Hydro priming (12 h at 30°C) was most effective in improving seed germination that FGP was increased by 25.5% as compared to that of non-primed seeds.

Kisetu *et al.* (2013) conducted a field study to assess the effects of priming okra *(Abelmoschus esculentus* L.) seeds var. clemson spineless in tap-water, di ammonium phosphate (DAP) and Minjingu (M) Mazao fertilizers at varying hours from non-primed (absolute control) to 48 h at an interval of 12 h. The priming materials used contained 0.115 g L^{-1} DAP, 1 g L^{-1} M-Mazao, and 1 L tap-water. Seeds primed with DAP for 36 h gave the highest number of pods (6) as compared with the absolute control (3), tap-water (5) at 36 h and M-Mazao (5) at 12 h. The highest yield (4.52 t/ha) was obtained for DAP at 36 h compared with M-Mazao (3.32 t ha^{-1}) at 12 h, tap-water (3.16 t ha^{-1}) at 36 h and absolute control (1.88 t ha^{-1}).

Ogbuehi *et al.* (2013) carried out a field experiment in 2012 at Teaching and Research Farm of faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri to assess the effect of hydro priming duration on performance of morphological indices of Bambara groundnut *(Vigna subterranean* (L.) Verdc). The treatments were 12hrs, 24 hrs, 36 hrs, 48 hrs and 0 hrs which served as control (untreated seeds). Among the treatments 24hours hydro priming duration found to improve the performance of growth indices measured whereas the 36 hours was the least effective.

Ali *et al.* (2013) reported that seed priming improves irrigation water use efficiency, yield, and yield components of late-sown wheat under limited water condition. Seed priming treatments reduced the mean emergence time and promoted germination, early canopy development, and tillering in comparison to the untreated control. The number of fertile tillers, plant height, 1000-grain weight, and grain and biological yield were also increased by different priming techniques. On-farm priming and hydropriming for 12 h gave higher grain and biological yields and higher harvest index than other priming treatments. Seed priming increased the irrigation water use efficiency (IWUE) of all irrigation regimes. Grain yields were linearly increased at 100% ETo while maximum IWUE was achieved at 80% ETo.

Amoghein *et al*. (2013) conducted an experiment on the effect of osmopriming and hydropriming on the different index of germination & early growth of wheat under salty stress. They reported that the simple effect of priming for all the characteristics under study, except of shoot dry weight and simple effect of salinity for all the characteristics under study in the experiment at 1% level was significantly simple effect of seed soaking time (4 hours) only on hypocotyle length was significantly. Interaction of salinity on seed priming for root dry weight, longest root on the 5% level showed a statistical significant difference. Also shoot dry weight had a positive and significant correlation with the first and second leaf length, root number and root longest at the %1 level.

Azadi *et al.* (2013) set an experiment on seed germination, seedling growth and enzyme activity of wheat seed primed under drought and different temperature conditions.They found that the highest germination percentage (GP) (94.33%), normal seedling percentage (NSP) (92%), germination index (GI) (44.85) and seedling length (11.03 cm) were attained from osmo-priming in control conditions. Seed priming with PEG 6000 significantly increased germination characteristics as compared to the unprimed seeds under drought stress. Osmopriming also increased catalase (CAT) and ascorbate peroxidase (APX) as compared to the unprimed.

Abbasdokhta *et al.* (2013) studied the effect of priming and salinity on physiological and chemical characteristics of wheat *(Triticum aestivum* L.). They showed that primed plants significantly reduced its gas exchanges by accelerating senescence under a series of salt stress, which became more serious along with the increasing of salt concentrations, especially at 21 d after anthesis. Under each level of salt stress, dry matter accumulation of primed plants was always higher than the non-primed plants. Primed plants had higher potassium selectivity against sodium than non-primed plants. Salt stresses caused significant declines in growth period of wheat by accelerating leaf senescence at reproductive stage. Primed plants of wheat successfully preserved normal growth by maintaining *Pn,* K+/Na+, leaf area duration (LAD) and dry matter accumulation (DMA), while non-primed plants decreased considerably in those parameters.

Dey *et al.* (2013) carried out an experiment at the Seed Laboratory of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period from January to April 2012 to study the effect of hydropriming on field establishment of seedlings obtained from primed seeds of *Boro* rice cv. BRRI dhan29. Seeds were soaked in water for 0, 24, 30, 36, 42, 48, 54 and 60 hours. They found that priming treatments had significant effect on germination and other growth parameters of rice seedlings. The highest germination, vigor index, population m-^{2}, length of shoot and root and their weights were found at 15 and 30 DAS. The lowest mean germination time was observed from hydropriming of seeds with 30 hours soaking. On the contrary, no priming treatment showed the lowest germination, vigor index, population m-^{2}, and the highest mean germination time.

Tilahun-Tadesse F *et al.* (2013) carried out a field experiment in 2010 and 2011 at Fogera plains, Ethiopia to study the effect of hydro-priming and pregerminating rice seed on the yield and response of the crop to terminal moisture stress. They found that planting pre-germinated seeds as well as seeds soaked and dried for 24 hrs at the local (farmers') sowing time resulted in significantly earlier seedling emergence, heading, and maturity. Higher numbers of productive tillers, filled spikeletes, leaf area index, crop growth rate, net assimilation rate, grain yield, biomass yield, and harvest index were recorded in response to planting pre germinated seeds followed by seeds soaked and dried for 24 hrs at farmers' sowing time.

Shirinzadeh *et al.* (2013) set an experiment to evaluate the effects of seed priming with Plant Growth Promoting Rhizobacteria (PGPR) on grain yield and agronomic traits of barley cultivars in 2009. Seed priming with Plant Growth Promoting Rhizobacteria affected plant height, spike length, number of spike per area, grains per spike, 1000-grain weight and grain yield, significantly. Maximum of these traits were obtained by the plots in which seeds were inoculated with *Azospirillium* bacteria. The highest grain yield (3063.4kg.ha^{-1}) was obtained in cultivar of Makori. Application of PGPR bacteria (especially Azospirillum) had an appropriate performance and could increase grain yield to an acceptable level and could be considered as a suitable substitute for chemical fertilizer in organic agricultural systems

Hoseini *et al.* (2013) examines the effect of priming on laboratory experiments and field studies. They found that the influence of various treatments on germination percentage and rate were significant. The length of plumule and radicle in magnetic field in comparision with others were the highest. Some treated seeds were stored and reduction of germination percentage were observed. Considering physiological characters, the most Leaf Area Index and Leaf Area Ratio were seen in magnetic field treatment. The effects of priming on plant height, biomass dry weight and essential oil were significant. Different durations of magnetic field had the most positive effect on essential oil.

Dastanpoor *et al.* (2013) carried out an experiment to find out the influence of hydro priming treatments on seed parameters of *Salvia officinalis* L. (sage). Seeds of sage were treated by hydro priming at three temperatures 10, 20, 30°C for 0, 12, 24 and 48 h. Hydro priming clearly improved the final germination percentage (FGP), mean germination time (MGT) and synchronized the germination of seeds at each three temperature. All the treatments resulted in germination enhancement except hydro primed seeds for 48 h at temperature 30°C. Hydro priming (12 h at 30°C) was most effective in improving seed germination that FGP was increased by 25.5% as compared to that of non-primed seeds.

Sarkar (2012) noted that seed priming improved seedling establishment under flooding. Acceleration of growth occurred due to seed pretreatment, which resulted longer seedling and greater accumulation of biomass. Seed priming greatly hastened the activities of total amylase and alcohol dehydrogenase in variety Swarna-Sub 1 than Swarna. Priming had positive effects on yield and yield attributing parameters both under non-flooding and early flooding conditions.

Moghanibashi *et al.* (2012) conducted a laboratory experiment to evaluate the effect of aerated hydropriming (24h) on two cultivar of sunflower (Urfloar and Blazar) seed germination under a range of drought stress and salt stress. They found that hydropriming for 24 h increased germination percentage, germination rate, germination index, root and shoot length, root and shoot weight of seed sunflower as compared with the control. Primed seeds produced higher germination rate and percentage, D50 and GI under all salinity and drought levels as compared with non-primed seeds. There was interaction between cultivar and priming on the germination rate and D50 as hydropriming was more effective in cultivar Urfloar.

Mirshekari (2012) studied the effects of seed priming with solutions of Fe and B, each at concentrations of 0.5%, 1%, 1.5%, and 2%, and 1.5% Fe + 1% B, on the germination and yield of dill *(Anethum graveolens)* in both field and laboratory condition .He found that in laboratory the effect of the studied treatments on the final germination percentage was significant. The seedling vigor index of dill was restricted when the Fe and B concentrations increased beyond 1.5% and 1%, respectively. The highest seed yield was recorded for the concentration of 1.5% Fe + 1% B in solution, which produced nearly 20% greater yield than the control. The essential oil concentration of the seeds ranged from 2.60% for 0.5% Fe to 2.81% for 1.5% B for the priming solutions. There was a positive response to seed priming with Fe and B regarding the essential oil yield. Priming dill seeds in the 1.5% Fe + 1% B solution resulted in a further increase in dill yield

Elouaer and Hannachi (2012) reported that in a study to the effect of seed priming with 5 g/L NaCl and KCl on germination and seedlings growth of safflower *(Carthamus tinctorius)* exposed to five levels of salinity (0, 5, 10, 15 and 20 g/L). NaCl and KCl priming have improved germination parameters (germination percentage, mean germination time, germination index and coefficient of velocity) and growth parameters (radicle and seedling length, seedling fresh and dry weight and Vigour Index) of safflower under saline condition.

Lemrasky and Hosseini (2012) conducted an experiment on the effect of seed priming on the germination behavior of wheat. They found that Maximum seed germination percentage was observed when seed primed by PEG 10% for 45 h. The most stem and radical length were obtained for seeds with KCl 2% and KCl 4% for 45 h. Rate of germination was improved when the seed soaked water and PEG 10%. There was interaction between seed priming media priming duration showed the beneficial effects on germination percentage and stem length.

Yousaf *et al.* (2011) noted that in an experiment of effects of seed priming with 30 mM NaCl on various growth and biochemical characters of 6 wheat varieties (Tatara-96, Ghaznavi-98, Fakhri Sarhad, Bakhtawar-92, Pirsabaq-2004 and

Auqab- 2000) under 4 salinity levels (0, 40, 80 and 120 mM), the effects of varieties and salinity were significant ($P < 0.05$) and of seed priming was non significant ($P > 0.05$) on plant height (cm), root length (cm) and shoot chlorophyll- a contents.

Sharifi *et al.* (2011) set an experiment to evaluate the effects of seed priming with Plant Growth Promoting Rhizobacteria (PGPR) on dry matter accumulation and yield of maize *(Zea mays* L.) hybrids in 2009 at the Research Farm of the Faculty of Agriculture University of Mohaghegh Ardabili. They showed that seed priming with Plant Growth Promoting Rhizobacteria affected grain yield, plant height, number of kernel per ear, number of grains per ear significantly. Maximum of these characteristics were obtained by the plots which seeds were inoculated with *Azotobacter* bacteria. Mean comparison of treatment compound corn hybrids xvarious levels of priming with PGPR showed that maximum grain yield and number of kernel per ear were obtained by the plots which was applied SC-434 hybrid with *Azotobacter* bacteria and minimum of it was obtained in SC-404 hybrid without of seed priming.

Yari *et al.* (2011) set an experiment on the effect of seed priming on grain yield and yield components of bread wheat. They found that osmotic priming with PEG10% had positive significant effects on emergence percentage, straw, grain and biological yield compared to other seed priming treatments (KCl 2%, KH2 PO_4 0.5% and distilled water). It was recognized that the maximum straw, biological yield, kernel weight, number of spikes per m^2 was obtained from Sardari-101 meanwhile the highest number of kernels per spike was achieved from Azar-2.

Arif *et al.* (2010) carried out an experimen to study the effect of seed priming on growth parameters of soybean *(Glycine max* L.) cv. William-82. Three seed priming durations (6, 12 and 18 h) and five Polyethylene glycol (PEG 8000) concentrations (0, 100, 200, 300 and 400 g L^{-1} water) along with dry seed (non primed) as control treatment were included in the experiment. They found that primed seed plots recorded higher AGR and CGR as compared with non-primed seed plots at I_1 during 2004 and RGR showed the same trend at I_1 and I_2 during 2003.

Tzortzakis (2009) noted that halopriming (KNO_3) or growth regulators (gibberelic acid; GA_3) improved the rate of germination of endive and chicory and reduced the mean germination time needed. 30 min pre-sowing treatment with $NaHClO_3$, methyl jasmonate and dictamus essential oil decreased seed germination as well as seed radicle length *in vitro*. 6 benzylaminopurine (BAP) or $NaHClO_3$ treatment reduced plant growth. He suggested that KNO_3 and secondly GA_3 treatments may improve rapid and uniform seedling emergence and plant development in nurseries and/or in greenhouses, which is easily applicable by nursery workers with economic profits.

Farahbakhsha *et al.* (2009) studied the effects of seed priming on agronomic traits in maize using NaCl solutions containing different salt concentrations. Salinity treatments were 0, 4, 8 and 12 dS.m-^{1} and salt solutions for priming were 0.0, 0.5 and 1.0 molar NaCl. Seed characteristics like shoot dry weight, stem length, number of leaves, leaf area, chlorophyll and ion leakage were measured. They found that the effects of salinity and seed priming on shoot dry weight, stem length, number of leaves, leaf area, chlorophyll and ion leakage were significant at the probability level of 1% ($P< 0.01$). The increase in salinity up to 12 dS.m-1 negatively influenced all traits except ion leakage and the amounts of reduction for the mentioned traits were 75.67, 52.25, 25, 69.97 and 21.17%, respectively, as compared with the control. In the case of ion leakage, the difference was 3.03 times less than that of control. Seed priming compensated the negative effects of salinity on plant traits and all the traits positively responded to the treatment of seed priming.

Amjad *et al.* (2007) set an experiment to evaluate the influence of seed priming using different priming agents (distilled water, NaCl, salicylic acid, acetyl salicylic acid, ascorbic acid, PEG-8000 and KNO_3) on seed vigour of hot pepper cv. They found that all priming treatments significantly improved seed performance over the control. KNO_3 primed seeds excelled over all other treatments; decreased time taken to 50% germination, increased root and shoot length, seedling fresh weight and vigour over all other priming agents. Seeds were primed in water (hydropriming) and NaCl (1% solution) (halopriming) and sown in pots at different salinity levels [1.17 (control), 3, 5 and 7 dS m-1], along with unprimed seeds. Emergence rate (ER), final emergence percentage (FEP), reduction percentage of emergence (RPE), shoots length, number of secondary roots, seedling fresh weight and vigour were significantly improved by both priming treatments over the control; halopriming was more effective than hydropriming. Number of secondary roots was maximum in haloprimed and unprimed seeds. Seed priming treatment did not significantly affect root length, fresh and dry weight of seedlings.

Ghana *et al.* (2003) reported that Insufficient stand establishment of winter wheat *(Triticum aestivum* L.) is a major problem in the low-precipitation (300mm annual) dryland summer fallow region of the inland Pacific Northwest, USA. A 2-yr rstudy involving laboratory, greenhouse, and field components to determine seed priming effects on winter wheat germination, emergence, and grain yield. They suggested that seed priming has limited practical worth for enhancing emergence and yield of winter wheat planted deep into summer fallow.

Giri *et al.* (2003) conducted an experiment at Washington State University showed that priming media enhanced germination during the first 24 to 48 h, but RGP of checks was generally equal to or greater than all priming treatments at 72

h. Water was equal to or more effective than any other priming media tested. Soaking seed for more than 12 h duration in any priming media tended to reduce rate and extent of germination, suggesting that optimum soaking time for wheat may be less than 12 h.

From the above review of literature it can be concluded that variety had a significant effect on growth and yield of mungbean. Moreover, seed priming technique also contributed to higher growth and yield of mungbean.

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University to find out the seed yield and quality of mungbean as affected by seed priming. This chapter provided a brief description on location, climate, soil, crop, fertilizer, experimental design, cultural operations, collection of plant samples, materials used in the experiment and the methods followed and statistical analyses.

3.1 Experimental site

The research work was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 to study the effect of organic manure and variety on the yield contributing characters and yield of mungbean during the period from February 2018 to June 2018. Experimental field was located at $90°22^{/}$ E longitude and $23°41^{/}$ N latitude and altitude of 8.2 m above the sea level. The experimental site is presented in Appendix I.

3.2 Climate

Experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high temperature and relatively long day period during “Kharif-1” season (April-September) and scarce rainfall, low humidity, low temperature and short day period during “Rabi” season (October-March). This climate is also characterized by distinct season, *viz*. the monsoon extending from May to October, the winter or dry season from November to February and per-monsoon period or hot season from March to April (Edris *et al.*, 1979). The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and soil temperature for the entire experimental period have been shown in Appendix II.

3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract in Agroecological Zone (AEZ)-28 (UNDP, 1988). It was medium high land and the soil series was Tejgaon (FAO, 1988). The soil was having a texture of sandy loam with pH and CEC were 5.6 and 2.64 meq/100 g soil, respectively. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix III.

3.4 Planting materials

The materials used in the study were mungbean seeds (cv. BARI mung 6, BARI mung 8) which were collected from BARI, Joydebpur, Gazipur, Bangladdesh. The initial seed moisture content was in between 10-12%. The seeds were fresh, clean, and disease and insect free.

3.5 Experimental Treatment

The following treatments were included in the experiment:

Factor A: Variety - Two varieties

1. V_1 = BARI mung 6
2. V_2 = BARI mung 8

Factor B: Priming - Four priming

1. T_0 = Control (No priming)
2. T_1 = Water
3. T_2 = PEG
4. T_3 = Mannitol

There were 8 (2×4) treatment combinations given below:

V_1T_0, V_1T_1, V_1T_2, V_1T_3, V_2T_0, V_2T_1, V_2T_2, V_2T_3.

3.6 Methods of seed priming techniques

Procedures of pre-sowing seed treatments

1. Two hundred gram of mungbean seeds were taken in each variety namely BARI mung 6 and BARI mung 8.

2. The seeds were soaked in different priming agent for 6 hours separately at room temperature as per treatments.

3. Primed seeds were sown on each plot for seedling emergence, growth and yield.

3.7 Land preparation and fertilizer dose

The experimental plot was thoroughly prepared by ploughing with power tiller followed by harrowing and laddering. After laddering, the weeds and the stubble of previous crops were removed from the land. Recommended doses of fertilizers and manures were 50-85-35-5-10000-1.5 kg ha^{-1} of Urea, TSP, MoP, Gypsum, Cowdung and Borax respectively. Half the amount of urea, all of TSP, MOP, Gypsum cowdung and borax was applied to the soil at the time of final land preparation. The rest of the urea was top dressed after 25days of sowing.

3.8 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 8 treatment combinations. In total of 24 unit plots and the size of each unit plot was 3 m × 2 m. The distance maintained between two replications and two plots were 1 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

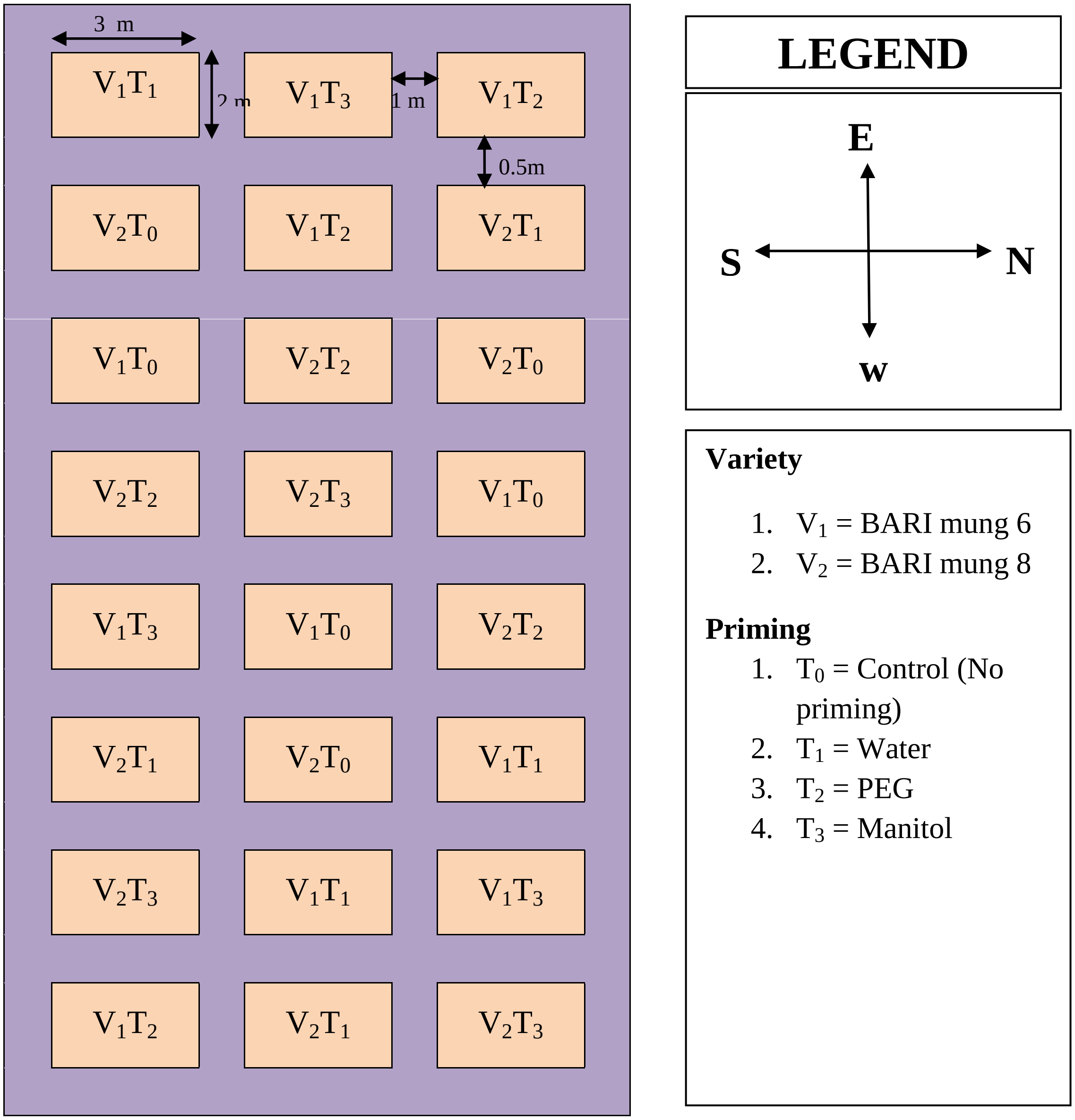


Fig. 1. Layout of the experimental plot

3.9 Sowing of seeds

The seeds of mungbean were sown in the field on 20 February 2018.

3.10 Intercultural operation

3.10.1 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedlings about 15 cm height were transplanted from border rows with roots plunged 5 cm below the soil in hills in the evening and watering was done to protect the seedlings from wilting. All gaps were filled up within two weeks after germination of seeds.

3.10.2 Thinning

When the plants established, one healthy plant per hill was kept and remaining one was plucked.

3.10.3 Weeding and mulching

Weeding and mulching were done whenever it was necessary to keep the plots free from weeds and to pulverize the soil.

3.10.4 Plant protection

Plant protection from insect and diseases were done whenever it was necessary to keep the disease and insect free.

3.11 Harvesting

Mungbean crops matured at different times. So harvesting of mungbean was done on 5 June, 2018. Five plants from each plot were randomly selected to collect data on plant parameters and these were harvested by uprooting. The whole plots were harvested to assess grain and straw yields.

3.12 Collection of experimental data

Data on the following characters were collected from experimental plots and selected plants.

3.12.1 Plant height

The height of sample plants were measured from the ground level to the tip of main shoot and mean plant height was recorded (cm).

3.12.2 Number of branches plant^{-1}

All the branches present on five sample plants were counted and were averaged.

3.12.3 Days to 50% flowering

Days to 50% flowering was recorded from the date of sowing (50% of the plants in a plot when opened flowers fully).

3.12.4 Days to 80% flowering

Days to 50% flowering was recorded from the date of sowing (80% of the plants in a plot when opened flowers fully).

3.12.5 Number of pods plant^{-1}

Number of pods for five sample plants was recorded and was averaged.

3.12.6 Number of seeds pod^{-1}

Randomly selected ten pods were taken from each sample plant and average number of seeds in a pod was determined.

3.12.7 Weight of 1000 seeds

One thousand clean dried seeds in each replicate was taken and weighed by an electrical balance.

3.12.8 Grain weight plant^{-1} (g)

From five randomly selected plants, grain weight was measured weighed by an electrical balance and then averaged and expressed in gram.

3.12.9 Grain yield ha^{-1} (kg)

After threshing, cleaning and drying the total seed yield from the harvested area including the five sampled plants were recorded as seed yield which was converted to t ha^{-1}.

3.12.10 Percent seedling emergence (% Germination)

After collection of harvested seeds, percent seedling emergence was tested in the Laboratory. Sample seeds from each replication collected from the experiment field were tested for percent seedling emergence. Data on percent seedling emergence was recorded at 4, 6, 8 and 10 days after sowing. Normal seedlings were counted and the number of emerged seedlings was recorded.

3.12.3 Seed viability test

Percent (%) seed germination

The number of sprouted and germinated seeds (Seedling emergence) was counted daily commencing. Germination was recorded at 24 hrs interval and continued up to 10th. More than 2 mm long plumule and radicle was considered as germinated seed. The germination rate (seedling emergence) was calculated using the following formula:

$$\text{Rate of germination (\%)} = \frac{\text{Total Number of germinated seeds}}{\text{Total seed placed for germination}} \times 100$$

Root length (cm)

The Root length of five seedlings from each sample was recorded finally at 10 DAS. Measurement was done using a meter scale and unit was expressed in centimeter (cm).

Shoot length (cm)

The shoot length of five seedlings from each sample was measured finally at 10 DAS. Measurement was done using the unit centimeter (cm) by a meter scale.

Seed vigor index

The vigor index (VI) of the seedlings can be estimated as suggested by Abdul-Baki and Anderson (1973):

$$VI = RL+SL \times GP,$$

Where

RL = root length (cm),

SL = shoot length (cm) and

GP = germination percentage.

3.13 Statistical analysis

The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package programme MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by Gomez and Gomez (1984).

CHAPTER IV

RESULTS AND DISCUSSION

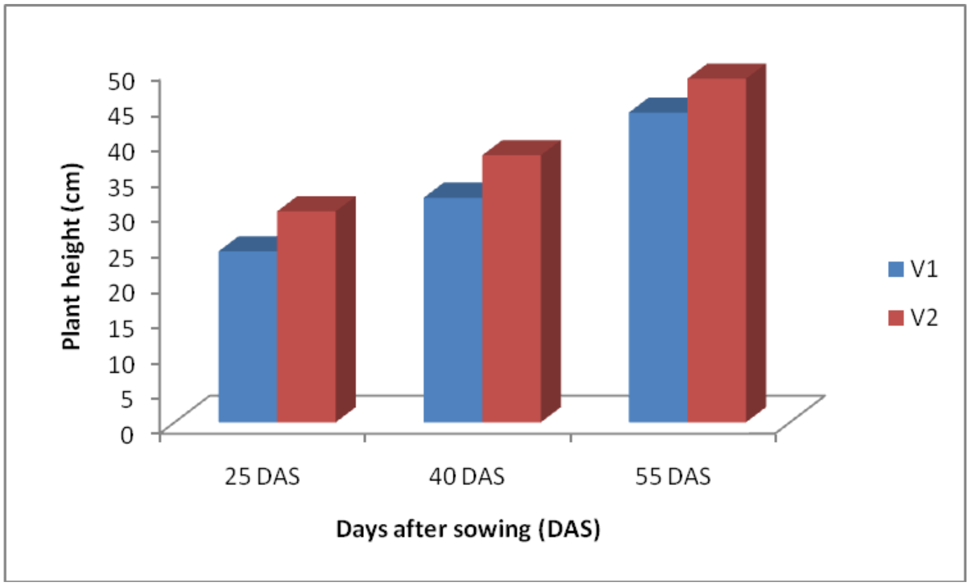
Effects of seed priming on the yield and quality of mungbean was studied in this experiment. The parameters studied in the experiment were statistically analyzed and the results obtained were presented in figures with an effective interpretation to arrive at logical conclusions as per objectives of the study. The mean results of the present experiment have been presented in Table 1 through 6 and figure 2 through 9. The analyses of variance for different parameters have been presented in Appendices IV through IX. A discussion on the result of the experiment has been made in this chapter parameter-wise.

4.1 Field performance of mungbean

4.1.1 Plant height (cm)

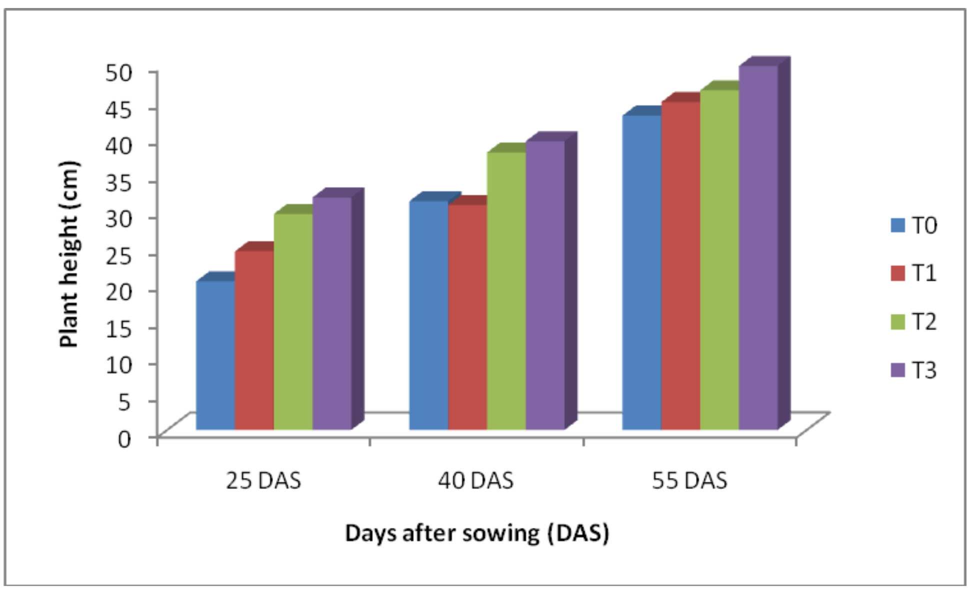
Effect of variety

There was a significant variation on plant height at different growth stages influenced by different varieties of mungbean (Fig. 2 and Appendix IV). Results revealed that the highest plant height (29.84, 37.77 and 48.60 cm at 25, 40 and 55 DAS, respectively) was found from the variety, V_2 (BARI mung 8). The lowest plant height (24.18, 31.76 and 43.80 cm at 25, 40 and 55 DAS, respectively) was found from the variety, V_1 (BARI mung 6). Similar result was also observed by Rasul *et al.* (2012) and d Ahamed *et al.* (2011).



V_1 = BARI mung 6, V_2 = BARI mung 8

Fig. 2. Plant height of mungbean as influenced by variety ($LSD_{0.05}$ = 1.51, 2.04 and 2.11 at 25, 40 and 55 DAS, respectively)



T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

Fig. 3. Plant height of mungbean as influenced by seed priming ($LSD_{0.05}$ = 0.41, 1.04 and 1.11 at 25, 40 and 55 DAS, respectively)

Effect of seed priming

Different seed priming treatments had significant influence on plant height of mungbean at different growth stages (Fig. 3 and Appendix IV). It was found that the highest plant height (31.76, 39.44 and 49.72 cm at 25, 40 and 55 DAS, respectively) was found from the priming treatment, T_3 (seed priming with Mannitol) which was significantly different from all other treatments followed by the treatment T_1 (seed priming with water). Similarly, the lowest plant height (20.32, 31.26 and 42.96 cm at 25, 40 and 55 DAS, respectively) was found from the priming treatment, T_0 (control; No priming) which was also significantly different from all other treatments followed by the treatment T_1 (seed priming with water). The result obtained from the present study was similar with the findings of Aymen *et al.* (2014), Ali *et al.* (2013) and d Shirinzadeh *et al.* (2013).

Interaction effect of variety and seed priming

Remarkable variation was observed on plant height at different growth stages influenced by interaction effect of variety and seed priming treatments (Table 1 and Appendix IV). Results indicated that the highest plant height (33.74, 40.78 and 52.60 cm at 25, 40 and 55 DAS, respectively) was found from the treatment combination of V_2T_3 which was statistically identical with V_2T_2 at 25 DAS but at 40 and d55 DAS it was significantly different from all other treatments followed by V_2T_1 and V_2T_2. The lowest plant height (18.77, 23.33 and 40.28 cm at 25, 40 and 55 DAS, respectively) was found from the treatment combination of V_1T_0 which was significantly different from all other treatments at all growth stages followed by V_1T_1.

Table 1. Plant height of mungbean influenced by variety and seed priming

Treatment	Plant height (cm) at		
	25 DAS	40 DAS	55 DAS
V_1T_0	18.77 e	28.72 e	40.28 f
V_1T_1	22.36 d	23.33 f	43.70 e
V_1T_2	25.82 c	36.88 c	44.36 d
V_1T_3	29.78 b	38.10 b	46.84 bc
V_2T_0	21.87 d	33.80 d	45.64 cd
V_2T_1	30.54 b	37.56 b	47.75 b
V_2T_2	33.20 a	38.92 b	48.42 b
V_2T_3	33.74 a	40.78 a	52.60 a
$LSD_{0.05}$	1.114	1.203	1.243
CV(%)	**7.387**	**9.247**	**8.611**

V_1 = BARI mung 6, V_2 = BARI mung 8
T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

4.1.2 Number of branches plant^{-1}

Effect of variety

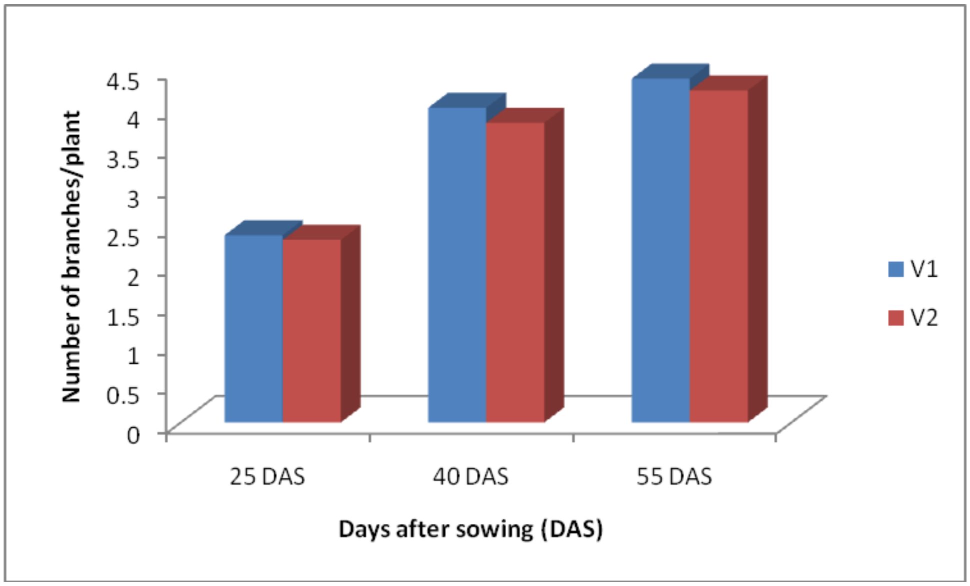
Number of branches plant^{-1} was not affected significantly by different varieties of mungbean at different growth stages (Fig. 4 and Appendix V). However, It was found that the highest number of branches plant^{-1} (2.38, 4.00 and 4.37 at 25, 40 and 55 DAS, respectively) was found from the variety, V_1 (BARI mung 6) and the lowest number of branches plant^{-1} (2.32, 3.81 and 4.22 at 25, 40 and 55 DAS, respectively) was found from the variety, V_2 (BARI mung 8).

Effect of seed priming

Significant variation was observed on number of branches plant^{-1} at different growth stages influenced by different seed priming treatments (Fig. 5 and Appendix V). Results signified that the highest number of branches plant^{-1} (2.69, 4.56 and 5.04 at 25, 40 and 55 DAS, respectively) was found from the priming treatment, T_3 (seed priming with Mannitol) which was significantly different from all other treatments where the lowest number of branches plant^{-1} (1.93, 3.16 and 3.55 at 25, 40 and 55 DAS, respectively) was found from the priming treatment, T_0 (control; No priming) which was also significantly different from all other treatments. Saleem *et al.* (2014) also found similar result with the present study.

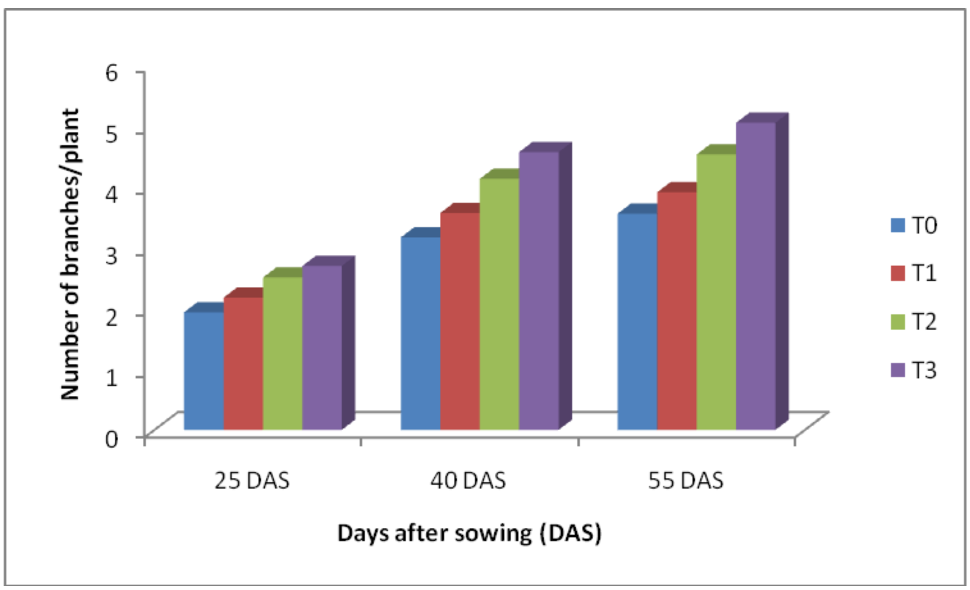
Interaction effect of variety and seed priming

Number of branches plant^{-1} was significantly varied due to interaction effect of variety and seed priming treatments at different growth stages (Table 2 and Appendix V). It was noted that the highest number of branches plant^{-1} (2.70, 4.60 and 5.12 at 25, 40 and 55 DAS, respectively) was found from the treatment combination of V_1T_3 which was statistically identical with V_2T_3 at all growth stages. The lowest number of branches plant^{-1} (1.87, 3.00 and 3.52 at 25, 40 and 55 DAS, respectively) was found from the treatment combination of V_2T_0 which was statistically identical with V_1T_0 at all growth stages.



V_1 = BARI mung 6, V_2 = BARI mung 8

Fig. 4. Number of branches plant^{-1} of mungbean as influenced by variety ($LSD_{0.05}$ = NS, NS and NS at 25, 40 and 55 DAS, respectively)



T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

Fig. 5. Number of branches plant^{-1} of mungbean as influenced by seed priming ($LSD_{0.05}$ = 0.14, 0.21 and 0.23 at 25, 40 and 55 DAS, respectively)

Table 2. Number of branches plant^{-1} of mungbean influenced by variety and seed priming

Treatment	Number of branches plant^{-1} at		
	25 DAS	40 DAS	55 DAS
V_1T_0	1.98 d	3.32 ef	3.58 e
V_1T_1	2.33 c	3.88 c	4.18 c
V_1T_2	2.52 ab	4.18 b	4.60 b
V_1T_3	2.70 a	4.60 a	5.12 a
V_2T_0	1.87 d	3.00 f	3.52 e
V_2T_1	2.24 c	3.64 cd	3.96 d
V_2T_2	2.48 ab	4.06 b	4.44 bc
V_2T_3	2.68 a	4.52 a	4.96 a
$LSD_{0.05}$	0.176	0.357	0.366
CV(%)	5.214	4.314	4.631

V_1 = BARI mung 6, V_2 = BARI mung 8
T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

4.1.3 Days to 50% flowering

Effect of variety

Significant influence was noted on days to 50% flowering affected by different varieties of mungbean (Table 3 and Appendix VI). It was found that the highest days to 50% flowering (41.67) was found from the variety, V_2 (BARI mung 8) whereas the lowest days to 50% flowering (41.17) was found from the variety, V_1 (BARI mung 6). Ahamed *et al.* (2011) and Mondal *et al.* (2004) also found similar result with the present study.

Effect of seed priming

Variation on days to 50% flowering was significant influenced by different seed priming treatments (Table 3 and Appendix VI). It was observed that the highest days to 50% flowering (43.00) was found from the priming treatment, T_0 (control; No priming) which was significantly different from all other treatments. The lowest days to 50% flowering (39.17) was found from the priming treatment, T_3 (seed priming with Mannitol) which was also significantly different from all other treatments.

Interaction effect of variety and seed priming

Days to 50% flowering of mungbean affect by interaction effect of variety and seed priming treatments was significant (Table 3 and Appendix VI). Results showed that the highest days to 50% flowering (43.33) was found from the treatment combination of V_2T_0 which was significantly different from all other treatment combinations followed by V_2T_0. The lowest days to 50% flowering (38.67) was found from the treatment combination of V_1T_3 which was also significantly different from all other treatment combinations followed by V_2T_3.

4.1.4 Days to 80% pod formation

Effect of variety

The recorded data on days to 80% pod formation was significant with different varieties of mungbean (Table 3 and Appendix VI). Results showed that the highest days to 80% pod formation (50.42) was found from the variety, V_2 (BARI mung 8) whereas the lowest days to 80% pod formation (49.84) was found from the variety, V_1 (BARI mung 6). Similar result was also observed by Ahamed *et al.* (2011).

Effect of seed priming

Considerable influence was observed on days to 80% pod formation persuaded by different seed priming treatments (Table 3 and Appendix VI). Results indicated that the highest days to 80% pod formation (51.84) was found from the priming treatment, T_0 (control; No priming) which was significantly different from all other treatments followed by T_1 (seed priming with water). The lowest days to 80% pod formation (49.00) was found from the priming treatment, T_3 (seed priming with Mannitol) which was also significantly different from all other treatments.

Interaction effect of variety and seed priming

Remarkable variation was identified on days to 80% pod formation due to the interaction effect of variety and seed priming treatments (Table 3 and Appendix VI). It was observed that the highest days to 80% pod formation (52.00) was found from the treatment combination of V_2T_0 which was significantly different from all other treatment combinations. The lowest days to 80% pod formation (48.67) was found from the treatment combination of V_1T_3 which was significantly different from all other treatment combinations followed by V_2T_3 and V_1T_1.

4.1.5 Number of pods plant^{-1}

Effect of variety

Number of pods plant^{-1}was found significant with the different varieties of mungbean (Table 3 and Appendix VI). The highest number of pods plant^{-1} (20.22) was found from the variety, V_1 (BARI mung 6) and the lowest number of pods plant^{-1} (18.89) was found from the variety, V_2 (BARI mung 8). Rasul *et al.* (2012) and Salah Uddin *et al.* (2009) also found similar results with the present study.

Effect of seed priming

Variation on number of pods plant^{-1} was significant influenced by different varieties of mungbean (Table 3 and Appendix VI). The highest number of pods plant^{-1} (26.18) was found from the priming treatment, T_3 (seed priming with Mannitol) which was significantly different from all other treatments followed by T_2 (seed priming with PEG). The lowest number of pods plant^{-1} (13.03) was found from the priming treatment, T_0 (control; No priming) which was also significantly different from all other treatments. The result obtained from the present study was similar with the findings of Rastin *et al.* (2013) and Kisetu *et al.* (2013).

Interaction effect of variety and seed priming

The recorded data on number of pods plant^{-1} was significant with interaction effect of variety and seed priming treatments (Table 3 and Appendix VI). The highest number of pods plant^{-1} (26.60) was found from the treatment combination of V_1T_3 which was significantly different from all other treatment combinations followed by V_2T_3. The lowest number of pods plant^{-1} (12.30) was found from the treatment combination of V_2T_0 which was significantly different from all other treatment combinations.

4.1.6 Number of seeds pod^{-1}

Effect of variety

Considerable influence was observed on number of seeds pod^{-1} persuaded by different varieties of mungbean (Table 3 and Appendix VI). It was observed that the highest number of seeds pod^{-1} (13.01) was found from the variety, V_2 (BARI mung 8) whereas the lowest number of seeds pod^{-1} (12.71) was found from the variety, V_1 (BARI mung 6). Similar result was also observed by Rasul *et al.* (2012).

Effect of seed priming

Remarkable variation was identified on number of seeds pod^{-1} due to the effect of different seed priming treatments (Table 3 and Appendix VI). The highest number of seeds pod^{-1} (14.69) was found from the priming treatment, T_3 (seed priming with Mannitol) and the lowest number of seeds pod^{-1} (10.56) was found from the priming treatment, T_0 (control; No priming). Both the highest and lowest treatment combination was significantly different from all other treatment combinations. The result obtained from the present study was similar with the findings of Rastin *et al.* (2013) and Kisetu *et al.* (2013).

Interaction effect of variety and seed priming

Significant influence was noted on number of seeds pod^{-1} affected by interaction effect of variety and seed priming treatments (Table 3 and Appendix VI). Results revealed that the highest number of seeds pod^{-1} (14.88) was found from the treatment combination of V_2T_3 which was statistically identical with the treatment combination of V_1T_3. The lowest number of seeds pod^{-1} (10.48) was found from the treatment combination of V_1T_0 which was statistically identical with the treatment combination of V_2T_0.

4.1.7 Weight of 1000 seeds (g)

Effect of variety

Weight of 1000 seeds varied significantly due to different varieties of mungbean (Table 3 and Appendix VI). It was found that the highest weight of 1000 seeds (48.13 g) was found from the variety, V_1 (BARI mung 6) whereas the lowest weight of 1000 seeds (29.43 g) was found from the variety, V_2 (BARI mung 8). The result obtained from the present study was similar with the findings of Haider and Ahmed (2014).

Effect of seed priming

Significant variation was remarked on weight of 1000 seeds as influenced by different seed priming treatments (Table 3 and Appendix VI). It was observed that the highest weight of 1000 seeds (41.37 g) was found from the priming treatment, T_3 (seed priming with Mannitol) followed by the treatment T_2 (seed priming with PEG) but significantly different from all other treatments. The lowest weight of 1000 seeds (36.20 g) was found from the priming treatment, T_0 (control; No priming) which was also significantly different from all other treatments. Similar result was also observed by Ali *et al.* (2013) and Shirinzadeh *et al.* (2013).

Interaction effect of variety and seed priming

Weight of 1000 seeds was found significant with the interaction effect of variety and seed priming treatments (Table 3 and Appendix VI). It was found that the highest weight of 1000 seeds (51.12 g) was found from the treatment combination of V_1T_3 which was significantly different from all other treatment combinations followed by V_1T_1 and V_1T_2. The lowest weight of 1000 seeds (26.80 g) was found from the treatment combination of V_2T_0 which was statistically identical with the treatment combination of V_2T_2.

Table 3. Yield contributing parameters of mungbean as influenced by variety and seed priming

Treatment	Yield contributing parameters				
	Days to 50% flowering	Days to 80% pod formation	Number of pods plant^{-1}	Number of seeds pod^{-1}	1000 seed weight (g)
Effect of variety					
V_1	41.17 b	49.84 b	20.22 a	12.71 b	48.13 a
V_2	41.67 a	50.42 a	18.89 b	13.01 a	29.43 b
$LSD_{0.05}$	0.204	0.303	0.522	0.416	3.524
CV(%)	7.289	9.314	6.289	5.349	8.572
Effect of seed priming					
T_0	43.00 a	51.84 a	13.03 d	10.56 d	36.20 d
T_1	42.33 b	50.61 b	15.79 c	11.77 c	37.54 c
T_2	41.50 c	49.67 c	21.84 b	13.81 b	39.34 b
T_3	39.17 d	49.00 d	26.18 a	14.69 a	41.37 a
$LSD_{0.05}$	0.247	0.304	2.144	0.676	1.032
CV(%)	7.289	9.314	6.289	5.349	8.572
Interaction effect of variety and seed priming					
V_1T_0	42.67 b	51.67 b	13.75 g	10.48 e	45.60 c
V_1T_1	42.00 c	49.33 e	17.75 e	12.18 cd	47.36 b
V_1T_2	41.33 e	49.67 d	22.78 c	13.66 b	48.44 b
V_1T_3	38.67 g	48.67 f	26.60 a	14.50 a	51.12 a
V_2T_0	43.33 a	52.00 a	12.30 h	10.64 e	26.80 f
V_2T_1	42.00 c	50.67 c	16.60 f	12.57 c	29.06 de
V_2T_2	41.67 d	49.67 d	20.90 d	13.96 b	30.24 d
V_2T_3	39.67 f	49.33 e	25.75 b	14.88 a	31.62 d
$LSD_{0.05}$	0.271	0.266	1.047	0.394	1.033
CV(%)	7.289	9.314	6.289	5.349	8.572

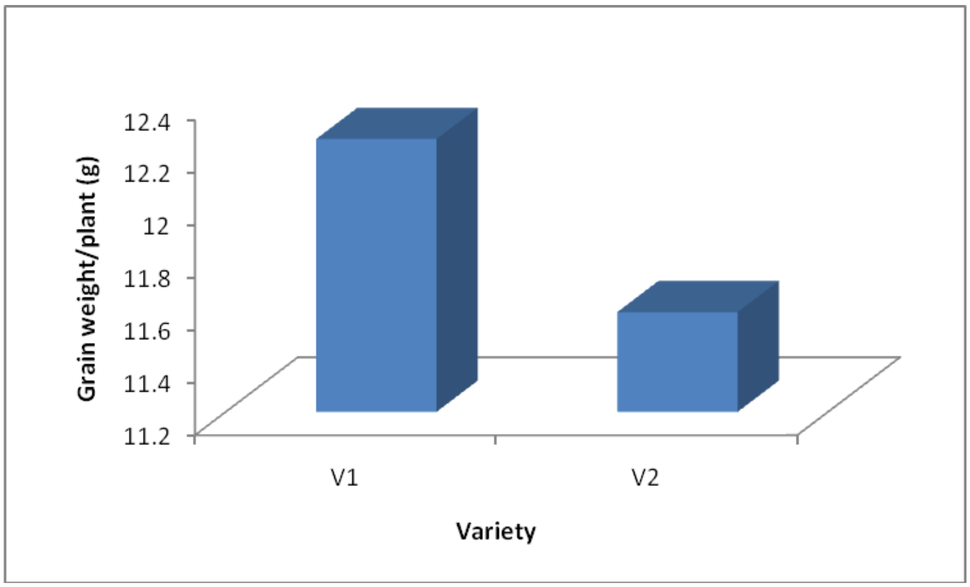
V_1 = BARI mung 6, V_2 = BARI mung 8

T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

4.1.8 Grain weight plant^{-1} (g)

Effect of variety

Grain weight plant^{-1} was not significant with different varieties of mungbean (Fig. 6 and Appendix VII). However, the highest grain weight plant^{-1} (12.24 g) was found from the variety, V_1 (BARI mung 6) and the lowest grain weight plant^{-1} (11.58 g) was found from the variety, V_2 (BARI mung 8).

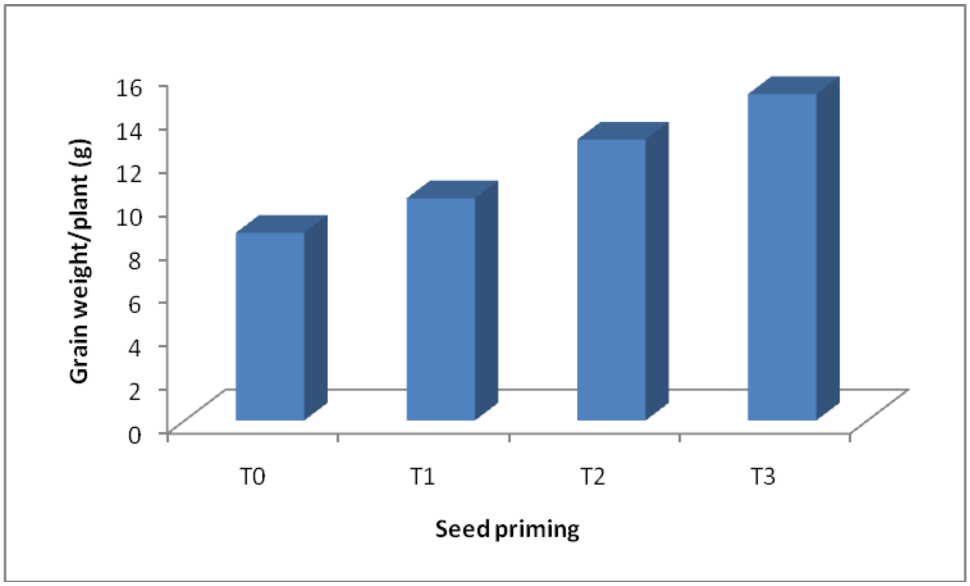


V_1 = BARI mung 6, V_2 = BARI mung 8

Fig. 6. Grain weight plant^{-1} of mungbean as influenced by variety ($LSD_{0.05}$ = NS)

Effect of seed priming

Variation on grain weight plant^{-1} was noted as influenced by different seed priming treatments (Fig. 7 and Appendix VII). Results indicated that the highest grain weight plant^{-1} (15.03 g) was found from the priming treatment, T_3 (seed priming with Mannitol) which was significantly different from all other treatments followed by T_2 (seed priming with PEG) where the lowest grain weight plant^{-1} (8.65 g) was found from the priming treatment, T_0 (control; No priming). The result obtained from the present study was similar with the findings of Rastin *et al.* (2013) and d Kisetu *et al.* (2013).



T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

Fig. 7. Grain weight plant^{-1} of mungbean as influenced by seed priming ($LSD_{0.05}$ = 1.13)

Interaction effect of variety and seed priming

The recorded data on grain weight plant^{-1} was significant with the interaction effect of variety and seed priming treatments (Table 4 and Appendix VII). The highest grain weight plant^{-1} (15.30 g) was found from the treatment combination of V_1T_3 which was statistically identical with the treatment combination of V_2T_3. The lowest grain weight plant^{-1} (8.58 g) was found from the treatment combination of V_2T_0 which was statistically identical with the treatment combination of V_1T_0.

4.1.9 Grain yield ha^{-1} (kg)

Effect of variety

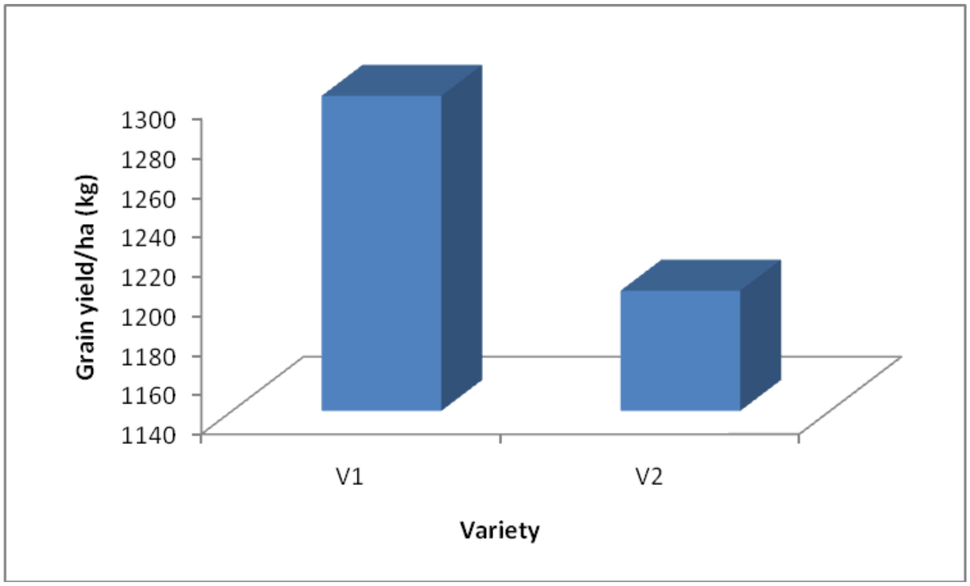
Considerable influence was observed on grain yield ha^{-1} affected by different varieties of mungbean (Fig. 8 and Appendix VII). It was found that the highest grain yield ha^{-1} (1299.90 kg) was found from the variety, V_1 (BARI mung 6) whereas the lowest grain yield ha^{-1} (1201.05 kg) was found from the variety, V_2 (BARI mung 8). Ali *et al*. (2014), Parvez *et al*. (2013) and Rasul *et al.* (2012) also found similar result with the present study.

Effect of seed priming

Remarkable variation was identified on grain yield ha^{-1} due to the effect of different seed priming treatments (Fig. 9 and Appendix VII). Results signified that the highest grain yield ha^{-1} (1523.40 kg) was found from the priming treatment, T_3 (seed priming with Mannitol) which was significantly different from all other treatments followed by T_2 (seed priming with PEG) where the lowest grain yield ha^{-1} (911.50 kg) was found from the priming treatment, T_0 (control; No priming). Rastin *et al.* (2013), Meena *et al.* (2013) and Kisetu *et al.* (2013) also found similar result which supported the present study.

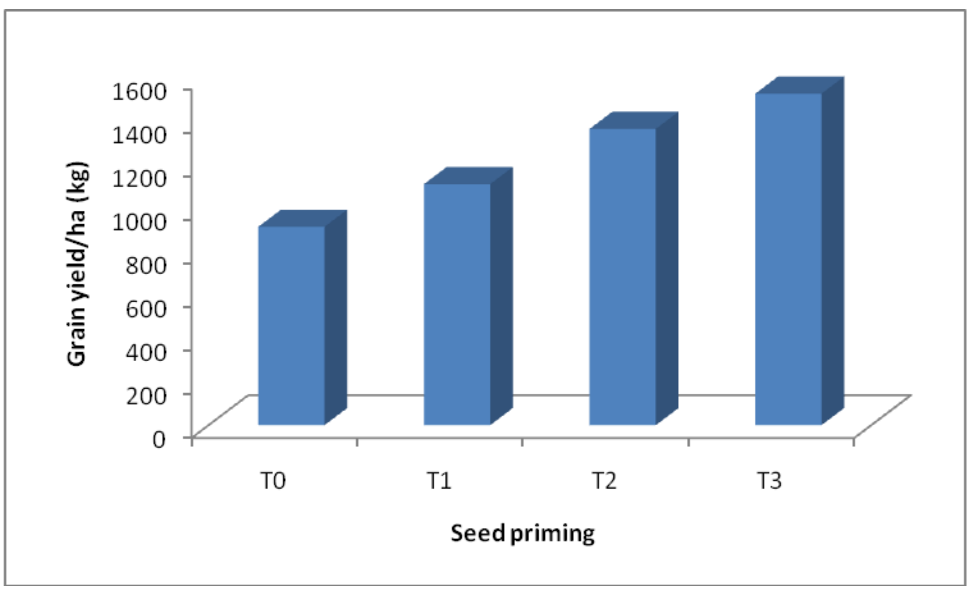
Interaction effect of variety and seed priming

Significant influence was noted on grain yield ha^{-1} affected by interaction effect of variety and seed priming treatments (Table 4 and Appendix VII). It was found that the highest grain yield ha^{-1} (1572.20 kg) was found from the treatment combination of V_1T_3 followed by V_2T_3 where the lowest grain yield ha^{-1} (966.20 kg) was found from the treatment combination of V_2T_0 which was significantly different from all other treatment combinations followed by V_1T_0.



V_1 = BARI mung 6, V_2 = BARI mung 8

Fig. 8. Grain yield ha^{-1} of mungbean as influenced by seed priming ($LSD_{0.05}$ = 14.28)



T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

Fig. 9. Grain yield ha^{-1} of mungbean as influenced by seed priming ($LSD_{0.05}$ = 11.75)

Table 4. Yield parameters of mungbean influenced by variety and seed priming

Treatment	Yield parameters	
	Grain weight plant^{-1} (g)	Grain yield ha^{-1} (kg)
Effect of variety		
V_1	12.24	1299.90
V_2	11.58	1201.05
$LSD_{0.05}$	NS	14.275
CV(%)	8.271	12.067
Effect of seed priming		
T_0	8.65	911.50
T_1	10.23	1107.53
T_2	12.94	1361.45
T_3	15.03	1523.40
$LSD_{0.05}$	1.133	13.687
CV(%)	8.271	12.067
Interaction effect of variety and seed priming		
V_1T_0	8.72 f	966.20 g
V_1T_1	11.72 d	1278.70 e
V_1T_2	13.22 b	1382.50 c
V_1T_3	15.30 a	1572.20 a
V_2T_0	8.58 f	856.80 h
V_2T_1	10.33 e	1132.40 f
V_2T_2	12.65 c	1340.40 d
V_2T_3	14.75 a	1474.60 b
$LSD_{0.05}$	0.566	11.754
CV(%)	8.271	12.067

V_1 = BARI mung 6, V_2 = BARI mung 8

T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

4.2 Seed quality attributes

4.2.1 Percent seedling emergence

Effect of variety

Percent seedling emergence varied significantly due to different varieties of mungbean (Table 5 and Appendix VIII). Results showed that the highest percent seedling emergence (9.23, 38.19, 70.28 and 84.20% at 4, 6, 8 and 10 DAS, respectively) was found from the variety, V_1 (BARI mung 6) whereas the lowest percent seedling emergence (8.00, 36.49, 67.15 and 81.34% at 4, 6, 8 and 10 DAS, respectively) was found from the variety, V_2 (BARI mung 8). Haider and Ahmed (2014) also found similar result with the present study.

Effect of seed priming

Significant variation was remarked on percent seedling emergence as influenced by different seed priming treatments (Table 5 and Appendix VIII). It was observed that the highest percent seedling emergence (11.85, 44.13, 79.50 and 91.45% at 4, 6, 8 and 10 DAS, respectively) was found from the priming treatment, T_3 (seed priming with Mannitol) where the lowest percent seedling emergence (5.25, 29.38, 53.50 and 71.68% at 4, 6, 8 and 10 DAS, respectively) was found from the priming treatment, T_0 (control; No priming). The result obtained from the present study was similar with the findings of Farhoudi and Sharifzadeh (2006) and Saleem *et al.* (2014).

Table 5. Effect of seed priming on % seedling emergence of mungbean

Treatment	Percent seedling emergence			
	4 DAS	6 DAS	8 DAS	10 DAS
Effect of variety				
V_1	9.23 a	38.19 a	70.28 a	84.20 a
V_2	8.00 b	36.49 b	67.15 b	81.34 b
$LSD_{0.05}$	0.523	0.614	1.022	1.314
CV(%)	5.289	8.352	8.359	7.267
Effect of seed priming				
T_0	5.25 d	29.38 d	53.50 d	71.68 d
T_1	6.98 c	33.63 c	62.17 c	77.53 c
T_2	9.50 b	40.10 b	75.35 b	87.50 b
T_3	11.85 a	44.13 a	79.50 a	91.45 a
$LSD_{0.05}$	0.417	3.514	3.055	3.207
CV(%)	5.289	8.352	8.359	7.267
Interaction effect of variety and seed priming				
V_1T_0	5.50 f	30.75 f	55.00 e	72.60 d
V_1T_1	8.50 d	36.50 d	70.50 c	82.40 b
V_1T_2	10.40 c	40.00 c	75.20 b	89.50 a
V_1T_3	12.50 a	45.50 a	80.40 a	92.30 a
V_2T_0	5.00 f	28.00 g	52.00 e	70.75 d
V_2T_1	7.20 e	35.00 e	62.50 d	78.50 c
V_2T_2	8.60 d	40.20 c	75.50 b	85.50 b
V_2T_3	11.20 b	42.75 b	78.60 a	90.60 a
$LSD_{0.05}$	0.752	1.046	2.716	3.211
CV(%)	5.289	8.352	8.359	7.267

V_1 = BARI mung 6, V_2 = BARI mung 8
T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

Interaction effect of variety and seed priming

Percent seedling emergence was found significant with the interaction effect of variety and seed priming treatments (Table 5 and Appendix VIII). Results showed that the highest percent seedling emergence (12.50, 45.50, 80.40 and 92.30% at 4, 6, 8 and 10 DAS, respectively) was found from the treatment combination of V_1T_3 which was statistically identical with the treatment combination of V_1T_2 and V_2T_3 at 10 days after sowing. The lowest percent seedling emergence (5.00, 28.00, 52.00 and 70.75% at 4, 6, 8 and 10 DAS, respectively) was found from the treatment combination of V_2T_0 which was statistically identical with the treatment combination of V_1T_0.

4.2.2 Root length (cm)

Effect of variety

Root length was not varied significantly due to different varieties of mungbean (Table 6 and Appendix IX). However, the highest root length (2.98 cm) was found from the variety, V_1 (BARI mung 6) whereas the lowest root length (2.71 cm) was found from the variety, V_2 (BARI mung 8).

Effect of seed priming

Significant variation was remarked on root length as influenced by different seed priming treatments (Table 5 and Appendix VIII). It was observed that the highest root length (3.38 cm) was found from the priming treatment, T_3 (seed priming with Mannitol) where the lowest root length (2.27 cm) was found from the priming treatment, T_0 (control; No priming).

Interaction effect of variety and seed priming

Root length was found significant with the interaction effect of variety and seed priming treatments (Table 6 and Appendix IX). Results showed that the highest root length (3.45 cm) was found from the treatment combination of V_1T_3 which was statistically identical with the treatment combination of V_2T_3. The lowest root length (2.07 cm) was found from the treatment combination of V_2T_0

4.2.3 Shoot length (cm)

Effect of variety

Shoot length was not varied significantly due to different varieties of mungbean (Table 6 and Appendix IX). However, the highest shoot length (6.26 cm) was found from the variety, V_1 (BARI mung 6) whereas the lowest shoot length (6.00 cm) was found from the variety, V_2 (BARI mung 8).

Effect of seed priming

Significant variation was remarked on shoot length as influenced by different seed priming treatments (Table 5 and Appendix VIII). It was observed that the highest shoot length (7.01 cm) was found from the priming treatment, T_3 (seed priming with Mannitol) where the lowest shoot length (4.90 cm) was found from the priming treatment, T_0 (control; No priming).

Interaction effect of variety and seed priming

Shoot length was found significant with the interaction effect of variety and seed priming treatments (Table 6 and Appendix IX). Results showed that the highest shoot length (6.92 cm) was found from the treatment combination of V_1T_3 which was statistically identical with the treatment combination of V_2T_3. The lowest shoot length (4.92 cm) was found from the treatment combination of V_2T_0

Table 6. Seed quality parameters of mungbean as influenced by variety and seed priming

Treatment	Seed quality parameters			
	Percent (%) seed germination (seedling emergence)	Root length (cm)	Shoot length (cm)	Seed vigor index
Effect of variety				
V_1	84.20 a	2.98	6.26	785.97 a
V_2	81.34 b	2.71	6.00	717.86 b
$LSD_{0.05}$	1.314	NS	NS	14.277
CV(%)	7.267	6.814	7.119	12.052
Effect of seed priming				
T_0	71.68 d	2.27 d	4.90 d	513.75 d
T_1	77.53 c	2.56 c	5.70 c	643.64 c
T_2	87.50 b	3.03 b	6.51 b	835.03 b
T_3	91.45 a	3.38 a	7.01 a	950.31 a
$LSD_{0.05}$	3.207	0.227	0.452	10.766
CV(%)	7.267	6.814	7.119	12.052
Interaction effect of variety and seed priming				
V_1T_0	72.60 d	2.46 e	4.92 d	535.79 g
V_1T_1	82.40 b	2.88 bc	6.44 b	767.97 e
V_1T_2	89.50 a	3.12 b	6.56 b	866.36 c
V_1T_3	92.30 a	3.45 a	7.10 a	973.77 a
V_2T_0	70.75 d	2.07 f	4.88 d	491.71 h
V_2T_1	78.50 c	2.52 d	5.75 c	649.20 f
V_2T_2	85.50 b	2.94 b	6.46 b	803.70 d
V_2T_3	90.60 a	3.31 a	6.92 a	926.84 b
$LSD_{0.05}$	3.211	0.214	0.311	12.385
CV(%)	7.267	6.814	7.119	12.052

V_1 = BARI mung 6, V_2 = BARI mung 8

T_0 = Control (No priming), T_1 = Water, T_2 = PEG, T_3 = Mannitol

4.2.4 Seed vigor index

Effect of variety

Vigor index was varied significantly due to different varieties of mungbean (Table 6 and Appendix IX). It was observed that the highest vigor index (785.97) was found from the variety, V_1 (BARI mung 6) whereas the lowest vigor index (717.86) was found from the variety, V_2 (BARI mung 8).

Effect of seed priming

Significant variation was remarked on vigor index as influenced by different seed priming treatments (Table 5 and Appendix VIII). It was observed that the highest vigor index (950.31) was found from the priming treatment, T_3 (seed priming with Mannitol) where the lowest vigor index (513.75) was found from the priming treatment, T_0 (control; No priming).

Interaction effect of variety and seed priming

Vigor index was found significant with the interaction effect of variety and seed priming treatments (Table 6 and Appendix IX). Results showed that the highest vigor index (973.77) was found from the treatment combination of V_1T_3 which was significantly different from all other treatment combinations. The lowest vigor index (535.79) was found from the treatment combination of V_2T_0.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted at Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from February 2018 to June 2018 to study the seed yield and quality of mungbean as affected by seed priming. The whole experiment was conducted in two different phases *viz*. growth and yield performance at field level and after that collected seeds from the experiment field was tested in Laboratory for seed quality. Mannitol ($C_6H_{14}O_6$), Polyethylene Glycol (PEG) and distilled water were used as seed priming chemical for osmo and hydro priming. Two varieties of mungbean *viz*. V_1 = BARI mung 6 and V_2 = BARI mung 8 and different priming chemicals including control *viz*. T_0 = control; no priming, T_1 = seed priming with water, T_2 = seed priming with PEG and T_3 = seed priming with Mannitol, were considered as treatments of the experiment under the present study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data on different crop characters, yield and seed quality attributes were recorded. Collected data were analyzed using a computer software MSTAT-C. The significance of difference among the treatments means was estimated by the least significant difference (LSD) at 5% level of probability.

The variety had significant influence on different growth and yield parameters. Plant height, days to 50% flowering, days to 80% pod formation, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight and grain yield ha^{-1} were significantly affected by variety. Results revealed that the highest plant height (29.84, 37.77 and 48.60 cm at 25, 40 and 55 DAS, respectively), and number of seeds pod^{-1} (13.01) were found from the variety, V_2 (BARI mung 8) but the highest days to 50% flowering (41.67) and days to 80% pod formation (50.42) were also found from the variety, V_2 (BARI mung 8). Similarly, the highest number of pods plant^{-1} (20.22), 1000 seed weight (48.13 g) and grain yield ha^{-1} (1299.90 kg) were found from the variety, V_1 (BARI mung 6). Again, the lowest plant height (24.18, 31.76 and 43.80 cm at 25, 40 and 55 DAS, respectively), days to 50% flowering (41.17), days to 80% pod formation (49.84) and number of seeds pod^{-1} (12.71) were found from the variety, V_1 (BARI mung 6) but the lowest number of pods plant^{-1} (18.89), lowest weight of 1000 seeds (29.43 g) and grain yield ha^{-1} (1201.05 kg) were obtained from the variety, V_2 (BARI mung 8). It was also found that there was no significant varietal effect on number of branches plant^{-1} and grain weight plant^{-1}. However, the highest number of branches plant^{-1} (2.38, 4.00 and 4.37 at 25, 40 and 55 DAS, respectively) and grain weight plant^{-1} (12.24 g) were found from the variety, V_1 (BARI mung 6) where the lowest number of branches plant^{-1} (2.32, 3.81 and 4.22 at 25, 40 and 55 DAS, respectively) and grain weight plant^{-1} (11.58 g) were obtained from the variety, V_2 (BARI mung 8). In terms of percent seedling emergence as influenced by variety, conducted in the laboratory (2nd phase), the highest percent seedling emergence (9.23, 38.19, 70.28 and 84.20% at 4, 6, 8 and 10 DAS, respectively), root length (2.98 cm), shoot length (6.26 cm) and vigor index (785.97) was found from the variety, V_1 (BARI mung 6) where the lowest percent seedling emergence (8.00, 36.49, 67.15 and 81.34% at 4, 6, 8 and 10 DAS, respectively), root length (2.71 cm), shoot length (6.00 cm) and vigor index (717.86) was recorded from the variety, V_2 (BARI mung 8).

In case of seed priming performance, different priming treatment showed significant variation among the treatments on plant height, number of branches plant^{-1}, days to 50% flowering, days to 80% pod formation, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight, grain weight plant^{-1} and grain yield ha^{-1}. Results indicated that the highest plant height (31.76, 39.44 and 49.72 cm at 25, 40 and 55 DAS, respectively), number of branches plant^{-1} (2.69, 4.56 and 5.04 at 25, 40 and 55 DAS, respectively), number of pods plant^{-1} (26.18), number of seeds pod^{-1} (14.69), weight of 1000 seeds (41.37 g) grain weight plant^{-1} (15.03 g) and grain yield ha^{-1} (1523.40 kg) were achieved from the priming treatment, T_3 (seed priming with Mannitol). The lowest days to 50% flowering (39.17) and days to 80% pod formation (49.00) were also found from the priming treatment, T_3 (seed priming with Mannitol). Likewise, the lowest plant height (20.32, 31.26 and 42.96 cm at 25, 40 and 55 DAS, respectively), number of branches plant^{-1} (1.93, 3.16 and 3.55 at 25, 40 and 55 DAS, respectively), number of pods plant^{-1} (13.03), number of seeds pod^{-1} (10.56), weight of 1000 seeds (36.20 g), grain weight plant^{-1} (8.65 g) and grain yield ha^{-1} (911.50 kg) was found from the control treatment, T_0 (no primed seed). The highest days to 50% flowering (43.00) and days to 80% pod formation (51.84) were also found from the control treatment, T_0 (No priming). In terms of percent seedling emergence as affected by seed priming treatments, conducted in the laboratory (2nd phase) was significant. The highest percent seedling emergence (11.85, 44.13, 79.50 and 91.45% at 4, 6, 8 and 10 DAS, respectively), root length (3.38 cm), shoot length (7.01 cm) and vigor index (950.31) was found from the priming treatment, T_3 (seed priming with Mannitol) and the lowest percent seedling emergence (5.25, 29.38, 53.50 and 71.68% at 4, 6, 8 and 10 DAS, respectively) root length (2.27 cm), shoot length (4.90 cm) and vigor index (513.75) was found from the priming treatment, T_0 (control; No priming).

Regarding, interaction effect of variety and seed priming treatments, all the studied parameters (plant height, number of branches plant^{-1}, days to 50% flowering, days to 80% pod formation, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight, grain weight plant^{-1} and grain yield ha^{-1}) were significantly affected. Results showed that the highest plant height (33.74, 40.78 and 52.60 cm at 25, 40 and 55 DAS, respectively) and number of seeds pod^{-1} (14.88) were found from the treatment combination of V_2T_3 but the highest number of branches plant^{-1} (2.70, 4.60 and 5.12 at 25, 40 and 55 DAS, respectively), number of pods plant^{-1} (26.60), 1000 seed weight (51.12 g), grain weight plant^{-1} (15.30 g) and grain yield ha^{-1} (1572.20 kg) was found from the treatment combination of V_1T_3. The lowest days to 50% flowering (38.67) and days to 80% pod formation (48.67) were also found from the treatment combination of V_1T_3. Again, the lowest plant height (18.77, 28.72 and 40.28 cm at 25, 40 and 55 DAS, respectively) and number of seeds pod^{-1} (10.48) were found from the treatment combination of V_1T_0 but the lowest number of branches plant^{-1} (1.87, 3.00 and 3.52 at 25, 40 and 55 DAS, respectively), number of pods plant^{-1} (12.30), weight of 1000 seeds (26.80 g), grain weight plant^{-1} (8.58 g) and grain yield ha^{-1} (966.20 kg) was found from the treatment combination of V_2T_0. The highest days to 50% flowering (43.33) and days to 80% pod formation (52.00) were also found from the treatment combination of V_2T_0. In terms of percent seedling emergence as influenced by interaction effect of variety and seed priming treatments, conducted in the laboratory (2nd phase) was significant. The highest percent seedling emergence (12.50, 45.50, 80.40 and 92.30% at 4, 6, 8 and 10 DAS, respectively), root length (3.45 cm), shoot length (7.10 cm) and vigor index (973.77) was found from the treatment combination of V_1T_3 whereas the lowest percent seedling emergence (5.00, 28.00, 52.00 and 70.75% at 4, 6, 8 and 10 DAS, respectively), root length (2.46 cm), shoot length (4.92 cm) and vigor index (535.79) was found from the treatment combination of V_2T_0.

Considering the above results, it may be concluded that growth parameters, seed yield and yield contributing parameters of mungbean are positively influence with variety and seed priming treatments. Therefore, the present experimental results suggest that the combined use of variety along with seed priming treatments would be beneficial to increase the seed yield of mungbean under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for analogy the accuracy of the experiment.
2. It needs to conduct more experiments using some other seed priming agents including PEG and mannitol whether can regulate the growth, yield and seed quality of mungbean.
3. It needs to conduct related experiment with other varieties of mungbean.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

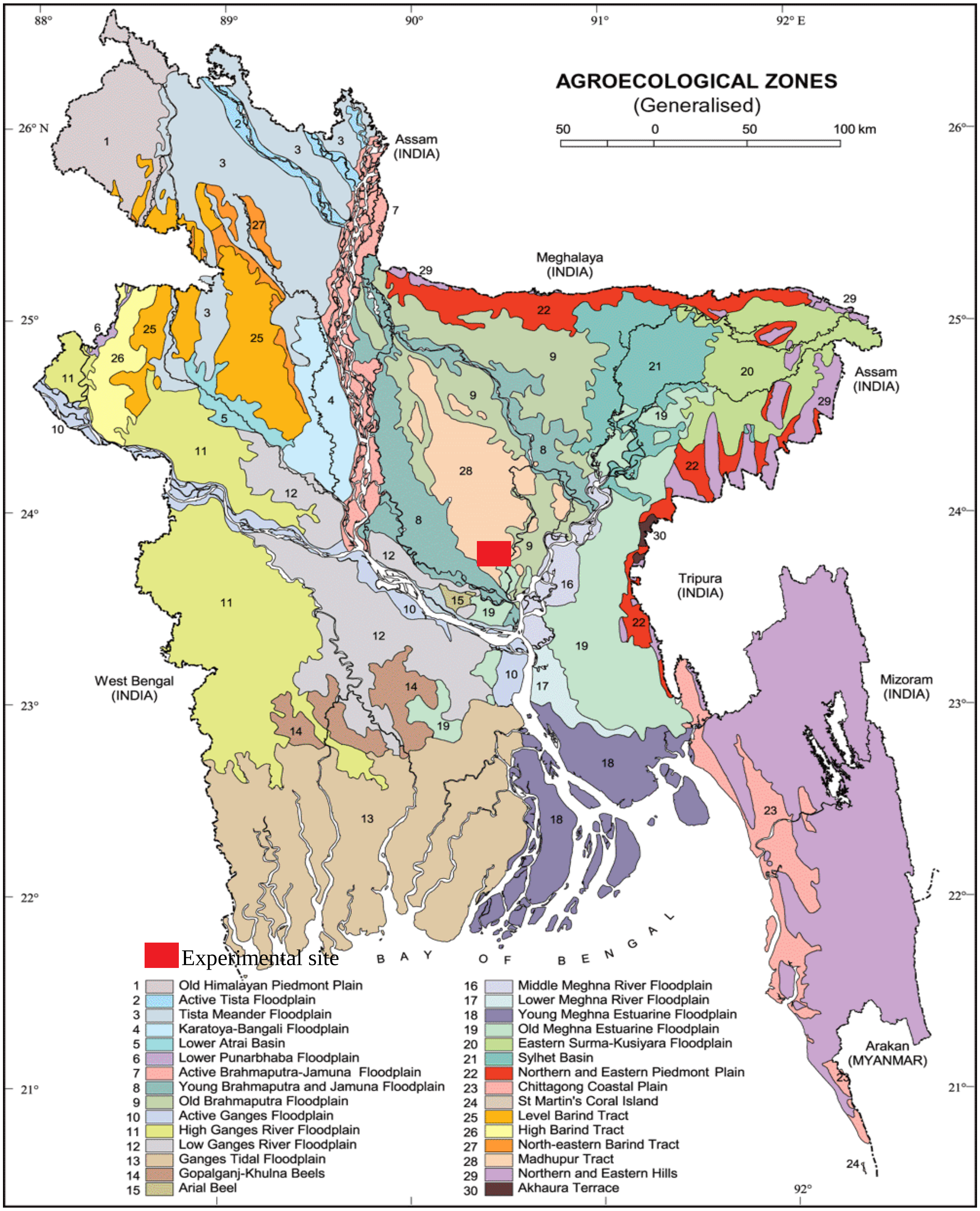

Fig. 10. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from February 2018 to June 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2018	February	22.75	14.26	18.51	37.90	0.0
2018	March	35.20	21.00	28.10	52.44	20.4
2018	April	34.70	24.60	29.65	65.40	165.0
2018	May	32.64	23.85	28.25	68.30	182.2
2018	June	27.40	23.44	25.42	71.28	190

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

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

A. Morphological characteristics of the experimental field

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

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of mungbean influenced by variety and seed priming

Sources of variation	Degrees of freedom	Plant height (cm)		
		25 DAS	40 DAS	55 DAS
Replication	2	0.314	1.106	2.522
Factor A	1	7.381*	9.38*	16.71*
Factor B	3	12.26*	18.29*	37.36*
AB	3	6.71**	16.81*	19.71*
Error	16	0.514	1.630	2.012

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Number of branches $plant^{-1}$ of mungbean influenced by variety and seed priming

Sources of variation	Degrees of freedom	Number of branches $plant^{-1}$		
		25 DAS	40 DAS	55 DAS
Replication	2	0.012	0.113	0.147
Factor A	1	1.128^{NS}	2.379^{NS}	4.211^{NS}
Factor B	3	2.709*	5.02*	6.307*
AB	3	0.363*	6.954**	6.108*
Error	16	0.140	0.316	0.314

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield contributing parameters of mungbean influenced by variety and seed priming

Sources of variation	Degrees of freedom	Yield contributing parameters				
		Days to 50% flowering	Days to 80% pod formation	Number of pods $plant^{-1}$	Number of seeds pod^{-1}	1000 seed weight (g)
Replication	2	1.301	1.077	1.314	0.006	2.058
Factor A	1	16.36*	22.39*	16.29*	1.348	18.38*
Factor B	3	32.78*	38.52*	30.71*	3.719*	39.41*
AB	3	14.93*	14.71*	12.36*	2.458*	16.27*
Error	16	0.175	0.211	2.052	0.307	1.533

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Yield parameters of mungbean influenced by variety and seed priming

Sources of variation	Degrees of freedom	Yield parameters	
		Grain weight plant^{-1} (g)	Grain yield ha^{-1} (kg)
Replication	2	0.044	2.077
Factor A	1	1.638^{NS}	76.89*
Factor B	3	7.487*	152.39*
AB	3	5.392**	82.74*
Error	16	0.028	5.288

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Effect of seed priming on % seedling emergence of mungbean

Sources of variation	Degrees of freedom	Percent seedling emergence			
		4 DAS	6 DAS	8 DAS	10 DAS
Replication	2	0.001	0.112	1.012	2.366
Factor A	1	5.368	8.375	14.278	24.40*
Factor B	3	4.521	16.233	22.637	41.33**
AB	3	3.289	12.378	8.964	18.536*
Error	16	0.066	1.371	1.452	3.247

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Seed quality parameters of mungbean influenced by variety and seed priming

Replication Factor A	Degrees of freedom	Seed quality parameters			
		Percent (%) seed germination (seedling emergence)	Root length (cm)	Shoot length (cm)	Seed vigor index
Replication	2	2.366	0.012	0.044	5.553
Factor A	1	24.40*	3.147^{NS}	5.517^{NS}	112.82*
Factor B	3	41.33**	9.604*	7.332*	214.48**
AB	3	18.536*	4.389*	7.765*	101.39*
Error	16	3.247	0.018	0.071	8.635