# COMPARISON OF VARIOUS SEED PRIMING TREATMENTS FOR SEED GERMINATION, SEEDLING VIGOR AND POD YIELD OF YARD LONG BEAN


**MD. NAZIUL KARIM**

**INSTITUTE OF SEED TECHNOLOGY**

**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**

**DHAKA-1207**


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**BY**

**MD. NAZIUL KARIM**

REGISTRATION NO. 11-04280

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**Approved by:**

**Assoc. Prof. Dr. Jasim Uddain**
**Supervisor**

**Prof. Dr. A. K. M Ruhul Amin**
**Co-supervisor**

**(Prof. Dr. Mohammad Ali)**
**Chairman**
**Examination committee**

# Institute of Seed Technology

Sher-e Bangla Agricultural University

Sher-e Bangla Nagar, Dhaka-1207

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## *CERTIFICATE*

*This is to certify that the thesis entitled, "**COMPARISON OF VARIOUS SEED PRIMING TREATMENTS FOR SEED GERMINATIN, SEEDLING VIGOR AND POD YIELD OF YARD LONG BEAN"**submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SEED TECHNOLOGY,** embodies the results of a piece of bona-fide research work carried out by **Md Naziul Karim**, Registration No. 11-04280 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.*

*Dated:*

*Dhaka, Bangladesh*

***Assoc. Prof. Dr. Jasim Uddain***

*Supervisor*

**DEDICATED TO MY ADORED PARENTS**

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*The Author*

# ABSTRACT

The present piece of work was conducted at the research field, Sher-e-Bangla Agricultural University, Dhaka from March, 2017 to June, 2017 to find out the effect of various seed priming treatments for seed germination, seedling vigor and pod yield of yard long bean. The experiment consists of thirteen treatments viz. $T_0$ = No priming, $T_1$ = Hydro priming at 12 hrs, $T_2$ = Hydro priming at 18 hrs, $T_3$ = Hydro priming at 24 hrs, $T_4$ = Hydro priming at 30 hrs, $T_5$ = Halo priming (1% $CaCl_2$) at 12 hrs, $T_6$ = Halo priming (1% $CaCl_2$) at 18 hrs, $T_7$ = Halo priming (1% $CaCl_2$) at 24 hrs, $T_8$ = Halo priming (1% $CaCl_2$) at 30 hrs, $T_9$ = Halo priming (2% $KNO_3$) at 12 hrs, $T_{10}$ = Halo priming (2% $KNO_3$) at 18 hrs, $T_{11}$ = Halo priming (2% $KNO_3$) at 24 hrs, $T_{12}$ = Halo priming (2%$KNO_3$) at 30 hrs. The experiment was laid out in randomized complete block design (RCBD) with three replications. The result showed that seed priming had significant influence on germination percentage, speed of germination, vigor index, fresh weight of seedling, dry weight of seedling, number of branches plant$^{-1}$, first flowering of plant, number of pods plant$^{-1}$, pod weight, , yield plant$^{-1}$ and weight of 100 seeds. In case of seedling growth and yield parameter treatment $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs ) showed the highest value of germination percentage, speed of germination, vigor index, and fresh weight of seedling, number of pods plant$^{-1}$, pod weight, yield plant$^{-1}$, weight of 100 seeds (86.66%, 6.76, 1833.80, 1.43g, 73.67, 24.93 g, 1500.80g and 16.37g), but $T_0$ (No priming ) showed the lowest value (36.66%, 1.18, 651.53, 0.31g, 16, 10.93g, 310g and 8.53g respectively). There had no significant effect of seed priming on root length, shoot length, seedling length and pod length of yard long bean. From this experiment it was clearly observed that seed priming played an important role in the field performance of yard long bean (BARI-Borboti 1). Actually treatment $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs) showed better field performance.

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# List of Acronyms

| Abbreviations | Full word |
|---|---|
| AEZ | Agro ecological zone |
| BARI | Bangladesh Agricultural Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| SAU | Sher-e-Bangla Agricultural University |
| cm | Centimeter |
| cv. | Cultivar |
| CV | Coefficient of Variation |
| DAS | Days After Sowing |
| *et al.* | And others (*et alibi*) |
| FAO | Food and Agriculture organization |
| g | Gram |
| ha | Hectare |
| HI | Harvest Index |
| Kg | Kilogram |
| LSD | Least Significance Difference |
| $m^2$ | Square Meter |
| MP | Muriate of potash |
| N | Nitrogen |
| No. | Number |
| NPK | Nitrogen phosphorus potassium |
| NS | Non Significant |
| % | Percent |
| df | Degree of freedom |
| $plant^{-1}$ | per plant |
| Seeds $pod^{-1}$ | Seeds per pod |
| t $ha^{-1}$ | Ton (s) per hectare |
| TSP | Triple super phosphate |
| $CaCl_2$ | Calcium chloride |
| $KNO_3$ | Potassium nitrate |
| hrs | Hour |

# CHAPTER 1

# INTRODUCTION

Yard long bean (*Vigna unguiculata* subsp. *sesquipedalis)* is one of the most popular vegetables in many countries of Southeast Asia. It is an important leguminous vegetable which are grown very profitably all over Bangladesh. It is cultivated to be eaten as green pods. It is also known as asparagus bean, string bean, snake bean or vegetable cowpea (Purseglove, 1977). It is mostly grown in Chattragram, Chattragram Hill Tracts (CHTs), Faridpur, Noakhali, Cumilla and Rangpur districts. At present, it is extensively grown in Dhaka, Chattragram, Cumilla, Narsingdi, and Joshore districts and also other districts of Bangladesh. It is extensively grown in kharif season when there is shortage of vegetables supply in the market.

Yard long bean is rich in protein, calcium, iron, riboflavin, phosphorus, potassium, and vitamin A. In addition, it is a very good source of vitamin C, folate, magnesium, and manganese (Asian Vegetable Research Development Center (AVRDC), 2015; Yamaguchi, 1983; Huqus *et al*., 2012). A serving of 100 g of yard long bean contains 50 calories, 9.0 g of total carbohydrates, 3.0 g of proteins, 0.2 g total fat and 0.8 g of minerals (Anon., 2013). Yard long bean is one of the economically important vegetable crops in Bangladesh.

The area occupied by this crop was 16908 acres and the production was 25815MT during the year 2015-2016 (BBS). It is one of the vegetables having exporting potential in Bangladesh.

Out of many constraints regarding low production of yard long bean, seed germination, growth and development, yield and crop quality are of prime importance. By providing some special pre-sowing treatments, seeds can be invigorated. There are many seed invigoration techniques such pre-sowing hydration treatments (priming), coating technologies and seed conditioning (Taylor *et al*., 1998).

In marginal lands and rain fed areas, patchy plant stands often result from the failure of seed to emerge quickly and uniformly. Seed germination is a serious problem in field crop. The yield of most of crops is reduced because enough seeds could not germinate and plants that eventually emerge often grow very slowly that are susceptible to drought, pests and disease infection. The rate of water absorption in initial 24 hours of imbibitions could improve the seedling vigor of crops.

Seed priming is a technique to reduce emergence time, accomplish uniform emergence time, better algometric (changes in growth of plant parts over time) attributes and provide requisite stand in many horticultural and field crops. Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Bradford, 1986). Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water). Hydropriming contributes to significant improvement in seed germination and seedling growth in different plant species.

Similar to other priming techniques, hydropriming generally enhances seed germination and seedling emergence, although there are exceptions. Harris *et al*. (1999) demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly can improve establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields.

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Bradford, 1986; Taylor and Harman, 1990). 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).

Seed priming is a generic technology and that it addresses a fundamental requirement for crop production need to have a field full of vigorous plants. Thus, it can be incorporated with almost any other technology or process that can be used to improve crop performance.

The cultivation of this crop faces various problems including germination, the pest management (Rashid, 1993). Rapid, uniform and complete germination is a pre requisite for successful transplant production and stand establishment in vegetable crops. But delayed and non-uniform germination and poor emergence are the characteristics problem in beans (Demir and Ermis, 2003).

It has also been reported that beans seed germination and emergence is slow and non-uniform under normal as well as stressed conditions (Demir and Okcu, 2004). Increased emergence of primed seeds over unprimed seeds is in accordance with the findings of Afzal *et al*. (2005). His findings also shown that seed priming also induced salt tolerance in beans seedlings.

Seed priming with different salts, especially $CaCl_{2,}$ NaCl, $KNO_3$ have shown to improve germination and growth of many crops under stressed conditions (Sivritepe and Sivritepe, 2007). Choudhary *et al*., (2008) studied the effect of priming and ageing on seed quality parameters of bean. Maximum increase in germination and other seedling parameters was witnessed in halopriming and in osmopriming. It could also improve the performance of crop by alleviating the effect of salts under saline soil conditions (Mohammadi *et al*., 2009). Furthermore salinity also affected bean production.

Quite a good number of works have been done on seed priming of yard long bean but under Bangladesh condition such works are scanty. The seed priming technology can enhance seedling emergence and ensure good plant stand which in turn can maximize yield and improve quality of the crop. Since the effect of seed priming on field emergence of yard long bean is poorly documented, the present study was undertaken to investigate the effects of priming on seed germination and field performance of yard long bean with the following objectives:

1. To evaluate the effects of priming treatments on the germination, seedling vigor, growth and pod yield of yard long bean, and

2. To compare the performance of pod yield of different primed seeds.

# CHAPTER 2

# REVIEW OF LITERATURE

The effect of priming on yard long bean and other crops in term of germination behavior and field performance has been studied throughout the world. Some of the important findings, that are relevant to the present study, have been reviewed here.

Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Ashraf and Foolad, 2005). Common priming techniques include osmopriming (soaking seeds in osmotic solutions), halo-priming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water) (Ghassemi-Golezani *et al*., 2008a).

The primed seed usually exhibit increased germination rate, greater germination uniformity and sometimes greater total germination percentage (Barsa *et al*., 2005). The direct effects of seed priming in all crops can lead to better stand establishment, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield (Harris *et al*., 1999; 2001a; 2002).

Rapid and uniform field emergences of seedlings are two essential prerequisites to increase yield and quality in annual crops (Finch-Savage, 1993). Priming is a non expensive and value added practice that greatly improves the yield. This might be due to some biochemical and physiological changes brought about by seed soaking (Khan *et al*., 2002).

Strategies for improving the growth and development of crop species have been investigated for many years. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Heydecker and Coolbar, 1978; Bradford, 1986; Taylor and Harman, 1990). During priming, seeds are partially hydrated so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level (McDonald, 2000).

The different soaking-drying treatments are highly effective in maintaining viability and vigor in most seeds, except a leguminous seed because soaking injury is observed due to rapid uptake of water (Som and Chattopadhyay, 1996).

Hydrating seeds with water and redrying them before they complete germination is a technique which minimizes the use of chemicals and avoids discarding materials that may be undesirable to the environment (McDonald, 2000). Priming could be defined as controlling the hydration level within seeds so that the metabolic activity necessary for germination can occur but radical emergence is prevented. Different physiological activities within the seed occur at different moisture levels (Leopold and Vertucci, 1989).

## 2.1 Effect of priming on yard long bean

The effects of osmo and hydro priming on partially aged seeds of the yard long bean variety were studied. Seeds were osmo conditioned in PEG solution of strength -0.75 MPa and hydro primed by (a) immersing in water for 3 hours; (b) allowing slow absorption of water from moist muslin for 36 hours; (c) humidifying over a water saturated atmosphere in an air-tight desiccator for 48 hours. The treated seeds were then equilibrated at 20°C and 45% RH for 48 hours to 6% moisture and packed in aluminium foil packets. Primed seeds were assessed immediately and after 10 months of storage at ambient conditions for their germination, mean germination time, leachate parameters, protein content and activities of amylase, acid phosphatase, peroxidase and catalase. Osmo conditioning and slow hydration treatments resulted in significant improvement in germination and vigour parameters in contrast to direct soaking of seeds in water. These observations are supported by decreased leakiness of electrolytes and UV absorbing materials and increased activity of free radical scavenging and reserve mobilising enzymes.

### 2.3 Effect of priming on other crops

Saeidi *et al*. (2008) observed that priming of mustard with different solutions increased the mean stem and root dry weight or mean germination rate at suitable priming times can cause better and faster seedling establishment in the early season and thus can improve the plant tolerance against unfavourable environmental conditions.

Golezani *et al*. (2008b) concluded that hydropriming is a simple, low cost and environmentally friendly technique for improving seed and seedling vigour of lentil. Seedling emergence rate was also enhanced by priming seeds with water. Hydropriming significantly improved imbibition rate, germination rate, seed vigour index, shoot, root and seedling dry weights, compared to other seed treatments.

A field experiment on a sandy soil in Rajasthan, India showed that emergence of pearl millet was only around 50 %, even in moist soils. However, primed seeds emerged better across a range of soil moisture levels and the relative increase due to priming increased from 15 % in moist soil to 45 % in dry soil. Priming was not able to compensate completely for the effects of low soil moisture at sowing but made a significant contribution across a range of soil moisture contents and was relatively more effective in drier soils (Harris, 2006).

Maiti *et al*. (2006) reported that simple technique of hydro priming (involving 15hrs of soaking the seeds in water followed by drying in room temperature for 3 days) was effectively utilize to break seed dormancy in seeds of sunflower.

Omidi *et al*. (2005) showed that osmopriming of rape seed under water stress condition had a significant effect on seedling parameters including seedling dry weight, rate and period of germination.

Priming seeds of six cultivars of finger millet with water for 8 hrs in eastern India resulted in taller, earlier-maturing plants that produced more yield than plants from non-primed seed in two on-station trials in 2000 and 2001 (Kumar *et al*., 2002). Priming significantly reduced the mean time to flowering and the mean time to maturity by about 6 days, increased mean plant height by 9 cm and resulted in 14 % extra grain yield.

Harris *et al*. (2001a) reported the germination of maize without priming from less than 40hr to more than 70hr in laboratory experiment. Priming seeds of maize for 12hr reduced the time for germination. The treatment reduced the range of germination times to between 20hr and 40hr in the field experiments, primed maize seed in water for 16hr or 18hr resulted in statistically significant positive benefits. Where priming was effective, the extra produce varied from 0.3 t/ha to about 14 t/ha and represented increases ranging from 17% to 76%.

Chivasa *et al*. (2000) in Zimbabwe reported that priming sorghum seeds for 10 hours speeded up seedling emergence by 23 % and increased final emergence percent. Fourteen-day-old seedlings from primed seeds also had significantly more leaves and root axes and were taller and heavier than nonprimed seedlings. In two field sowings in Botswana in 1991-92, primed sorghum seed gave similar results (Harris, 2006).

Harris *et al*. (1999) demonstrated that on-farm seed priming (soaking seeds overnight in water) markedly improved establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. This simple, low-cost, low-risk intervention also had positive impacts on the wider farming system and livelihoods and the technology has proved highly popular with farmers (Harris *et al*., 1999; 2001). Its value has already been shown for many crops, chickpea (Musa *et al*., 2001; Kaur *et al*., 2005), maize (Ashraf and Rauf, 2001), mungbean (Rashid *et al*., 2004), pigeonpea (Jyotsna and Srivastava, 1998), sunflower (Kaya *et al*., 2006).

The different soaking-drying treatments are highly effective in maintaining viability and vigor in most seeds, except leguminous seeds because soaking injury are observed due to rapid uptake of water (Som and Chattopadhyay, 1996).

Seed priming, a controlled hydration process followed by re-drying is pragmatic approach to counteract the salinity effects in many crops because of its simplicity, low cost and effectiveness (Wahid *et al*., 2007; Afzal *et al*., 2011). It improved the germination percentage and uniformity of growth following reduced emergence time and increased yields are reported in many field crops including rice (Farooq *et al*., 2006b; Afzal *et al*., 2006; Afzal *et al.*, 2011). But such enhancements are often found under non-saline conditions (Farooq *et al*., 2006a; 2006b) and few studies are available for alleviation of adverse salinity effects in rice during germination and early seedling growth by seed priming (Xu *et al*., 2011). Patade *et al*. (2009) suggest that salt priming is an effective pre-germination 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. The higher germination percentage in seeds primed with $CaCl_2$ is according to Ashraf and Rauf (2001) for wheat and Afzal et al.(2008b) for maize who reported an increase in germination percentage of plants raised from seeds primed with calcium salt under salinity stress. Short term seed priming with low NaCl concentration also increases germination rate, field emergence and acquired stress tolerance (Nakaune *et al.*, 2012). Sun *et al*., (2010) also concluded that PEG priming with moderate concentration resulted in higher tolerance to drought stress than hydro-priming, while higher concentrations of PEG had negative effects on seed germination. It was reported seed priming had significant effect on increment of germination percent; germination speed and seedling dry weight of sunflower vice versa of producing abnormal seedling decrement in drought condition (Demir Kaya *et al.*, 2006). Aerated hydration treatment of pepper at 250 0C followed by drying increased germination percentage were reported by (Demir and Okcu, 2004).

The final germination percentage of Melilotus officinalis was much higher than that of M. sativa and A. adsurgens at 300 mM NaCl (Wang *et al*., 2009b), and the germination rate in six alfalfa cultivars was also differentially affected by treatments with 200 mM

NaCl and 35% PEG (Wang et al., 2009a). Vicente *et al*. (2009) have observed varying responses to saline solution of the seeds of three plant species (Arthrocnemum macrostachyum, Juncus acutusand Schoenus nigricans) and different germination recovery of the seeds after submersion in hypersaline solution of different salt types. Seed primed with potassium hydrophosphate ($KH_2PO4$) and water improved germination percentage compared to untreated seed treatments. Similarly Korkmaz and Pill (2003) reported that priming with $KH_2PO4$ improved the germination synchrony of low vigour cultivar in lettuce. According to Ghana and Schillinger (2003) seed primed with $KH_2PO4$and water treatments enhanced germination in wheat under normal condition compared to untreated seed.

Basra et al. (2003) and Salinas (1996) reported improvement in germination percent, emergence and seedling stand by using seed priming techniques. In fact priming induces a range of biochemical changes in the seed that required initiating the germination process i.e., breaking of dormancy, hydrolysis or metabolism of inhibitors, imbibition and enzymes activation (Ajouri *et al.,* 2004). Some previous researcher indicated that some or all process that precede the germination are triggered by priming and persist following the redesiccation of the seed (Asgedom and Becker, 2001).Primed seed can rapidly imbibe and revive the seed metabolism, resulting in higher germination percentage and a reduction in the inherent physiological heterogeneity in germination (Rowse,1995). According to McDonald (2000), primed seeds acquire the potential to rapidly imbibe and revive the seed metabolism thus enhancing the germination rate.

Osmopriming with PEG was described as a good technique for improving seed germination of Bromus seeds under salt and drought stress (Tavili *et al*., 2011) and for increasing the germination percentage and seedling vigor of bersim (*Trifolium alexandrinum*) seeds (Rouhi *et al.,* 2010). In soybean too, seed priming with PEG was successfully carried out by Khalil *et al*. (2001). Osmopriming with PEG results in strengthening the antioxidant system and increasing the seed germination potential, finally resulting in an increased stress tolerance in germinating seeds of spinach (Chen and Arora, 2011). Osmo conditioning of Italian ryegrass (*Lolium multiflorum*) and sorghum (Sorghum bicolor) seeds with 20% PEG-8000 for 2 d at 10°C increased germination percentage, germination rate, seedling establishment and dry matter production under water stress, water logging, cold stress and saline conditions (Hur, 1991).According to Posmyk and Janas ( 2007), hydro priming and hydro priming along with proline can be used as a safe priming method for improving seed germination and growth of *Vigna radiata* seedlings at low temperature and also allowing fast repair of injuries caused by stress. More uniform germination and emergence were observed in primed seeds on canola (*Brassica compestris*) (Zheng *et al.,* 1994), wheat (*Triticum aestivum*) (Nayyar *et al.,* 1995) and rice (*Oryza sativa*) (Lee and Kim, 2000; Basra *et al*., 2003) who described improved germination rate and percentage in seeds subjected to hydro priming and seed hardening for 24 h (Farooq *et al.*, 2006b). Coobear and Grierson (1979) who reported that higher germination rate was a result of higher levels of nucleic acid in primed seeds of tomato cultivars. They indicated that increase in nucleic acid content in primed seeds was due to an enhanced ribonucleic acid (RNA) synthesis during and after priming treatment.

Ascorbic acid, another important vitamin is also used for priming due to its antioxidant nature. It has already been proved that a high level of endogenous acrobat is essential to maintain the antioxidant capacity that protects plants from oxidative stress (Zhou *et al*.,2009). Ascorbic acid pretreatment results in improved germination properties of Agropyron elongatum under salt stress condition (Tavili *et al*., 2009).ABA priming showed increased rate of germination as compared to non-primed seeds in Indian mustard (Srivastava et al., 2010a,b).The growth regulators IAA and GA3 were reported to improve germination of pyrethrum seeds under non-saline condition (Bisht *et al*.,2009).Salicylic acid priming in fennel seeds also showed better germination under low water potential (Farahbakhsh,2012). Moreover, in Salicornia utahensis, which is a halophyte, priming with growth regulators like fusicoccin, thiourea, kinetin, and ethephon alleviated the inhibitory effects of salinity on the germination, whereas GA3, proline, betaine and nitrate had little effect on germination at all salinities (Gul and Khan,2003). 3% KNO3 supplemented with 3 lM methyl jasm-onate (MeJA) could promote germination and emergence of dormant *Amaranthus cruentus* L. seeds (Tiryaki *et al.*, 2005). More recently, seeds of Agropyron elongatum primed with gibberellin (GA) and abscisic acid (ABA) exhibited induced CAT and SOD activities under drought conditions when compared to unprimed seeds (Eisvand *et al*., 2010).

In many crops, seed germination and early seedling growth are the most sensitive stages of water limitation and the water deficit may delay the onset and reduce the rate and uniformity of germination, leading to poor crop per dormance and yield (Demir *et al*., 2006). Therefore, the beneficial effects of priming may be more evident under unfavorable rather than favorable conditions (Parera and Cantliffe 1994). Primed seeds usually exhibit an increased germination rate, greater germination uniformity, and at times, greater total germination percentage (Basra *et al.*, 2005). These attributes have practical agronomic implications, notably under adverse germination conditions (McDonald 2000). Therefore, there is a strong interest in the seed industry to find suitable priming agent(s) that might be used to increase the tolerance of plants under adverse field conditions (Job *et al*., 2000).

Priming treatments are being used to shorten the time between planting and emergence and to protect seeds from biotic and abiotic factors during critical phase of seedling establishment. Such earlier and synchronized emergence often leads to uniform stands and improved yield (Farooq *et al.*, 2006b; Afzal *et al*., 2006; Afzal *et al*., 2011). Like germination percentage, prime seeds had lower mean emergence time (MET) compared with non-primed seeds. These positive effects are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in germinating seeds (Hassanpouraghdam *et al*., 2009; Sivritepe *et al*., 2003).Improved seed invigoration techniques were known to reduce emergence time, accomplish uniform emergence, and give better crop stand in many horticultural and field crops (Ashraf and Foolad  2005). Priming decreased the temperature optimum and ceiling temperature for germination and also helped in advancing the germination time and did not decrease the final percentage emergence (Finch-Savage *et al.,* 2004). ‘‘On-farm’’ seed priming (soaking seeds in water prior to sowing) has been shown to be effective in producing early germination, better establishment and increased yields in a wide range of crops in diverse environments (Rashid *et al.,* 2006). It had been a common pretreatment that reduces the time between seed sowing until emergence and synchronizes seedling emergence (Parera and Cantliffe 1994). According to Basra *et al*. (1989) priming of corn seed using polyethylene glycol or potassium salt ($K_2$HPO4 or $KNO_3$) resulted in accelerated germination.

Janmohammadi *et al*. ( 2008) presented hydro priming as a suitable, cheap and easy seed invigoration treatment for inbreed lines of maize, especially when germination is affected by salinity and drought stress. Hydro priming has been shown to result in the earlier germination of desert cacti (Dubrovsky 1996), Allium porrum(Ashraf and Bray 1993), pyrethrum (*Tanacetum cinerariifolium*) (Li *et al.,*2011), and coriander (Rithichai *et al*.,2009).Moradi Dezfuli *et al*., (2008) revealed hydro primed seeds for 36 h had lowest values (T50 and MGT).

Osmotic seed priming of maize caryopses resulted in more homogenous and faster seed germination as compared to the control wasreported by Fotia, *et al*., (2008). According to Gray *et al.,* (1990) (-0.5 MPa) lowered the mean germination time of seeds of lettuce, carrot and onion. Goobkin (1989) and Ozbingol, *et al.* (1999) also reported that PEG 6000 solution treated tomato seeds germinate faster than untreated seeds and this is due to more rapid water uptake. The probable reason for early emergence of the primed seed maybe due to the completion of pre-germination metabolic activities making the seed ready for radicle protrusion and the primed seed germinated soon after planting compared with untreated dry seed Arif (2005). Yamauchi and Winn (1996), indicated that seed priming may help in dormancy breakdown possibly by embryo development and leaching of emergence inhibitors which resulted in an earlier start of emergence.

Seed performance under drought or salt stress is also affected by the concentration of priming materials. It has been reported that, NaCl priming generally requires long term treatment periods using solutions with relatively high concentrations of NaCl; however, short term seed priming with a low NaCl concentration also increases germination rate, field emergence and acquired stress tolerance (Nakaune *et al*., 2012). Sun *et al.* (2010) also concluded that PEG priming with moderate concentration resulted in higher tolerance to drought stress than hydropriming, while higher concentrations of PEG had negative effects on seed germination.

In addition to better establishment, primed crops grew more vigorously, flowered earlier and yielded higher (Farooq *et al*., 2008). Ruan et al. (2002a) had observed that KCl and CaCl2 seed priming had improved germination index of rice. Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses (Dell Aquila and Tritto, 1991; Donaldson *et al*., 2001).Rashid *et al*. (2006) reported that priming enhanced germination, better establishment and increased yields in many diverse environments for a number of crops (Khan *et al.*, 2008). Seed priming could enhance sunflower seed germination under the stress conditions was found by Kaya *et al*., (2006). Bray et al., (1989) and Arif *et al.*, (2005) who reported that seed priming enhanced germination which may be attributed to repair processes, a buildup of germination metabolites or osmotic adjustments during priming treatment. Maiti *et al*. (2006) also reported that osmotic seed priming of maize caryopses in coper sulphate, zinc sulphate, manganese sulphate, or boric acid induced high levels of seed germination. Hydro priming was found to be the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 h compared to 48 h (Caseiro *et al*., 2004).It improved germination and later growth of different crops species such as in maize, rice, chickpea (Harris *et al*., 1999).

Improving germination and coefficient of velocity in treated fenugreek seeds may be explained by an increase of cell division in the seeds (Bose and Mishra, 1992).

Seed priming enhances speed and uniformity of germination (Khalil *et al.*, 2010; Khan *et al*., 2008; Heydecker *et al*., 1975), and induces several biochemical changes in the seed that are required to start the germination process such as breaking of dormancy, hydrolysis or mobilization of inhibitors, imbibition and enzyme activation. Some or all of these processes that precede the germination are trigged by priming and persist following the re-desiccation of the seeds (Asgedom & Becker, 2001). Thus upon seeding, primed seed can rapidly imbibe and revive the seed metabolism, resulting in a higher germination rate and a reduction in the inherent physiological heterogeneity in germination (Rowse, 1995). The resulting improved stand established can reportedly increase the drought tolerance, reduce pest damage and increase crop yield in cereals and legumes (Harris et al., 1999; Mussa *et al*., 1999; Harris *et al.*, 2000; Khan *et al*., 2005).Seed priming stimulates many of the metabolic processes involved in the early phases of germination, and it has been noted that seedlings from primed seeds emerge faster, grow more vigorously, and perform better in adverse conditions (Cramer, 2002). It has also been reported that seed priming improves emergence, stand establishment, tillering, allometry, grain and straw yields, and harvest index (Farooq *et al*., 2008).

Seed priming has been found a double technology to enhance rapid and uniform emergence, and to achieve high vigor and better yields in vegetables and floriculture (Dear man *et al*., 1987; Parera and Cantliffe, 1994; Bruggink *et al*., 1999) and some field crops (Hartz and Caprile 1995; Chiu *et al*., 2002; Giri and Schillinger 2003; Murungu *et al*., 2004; Basra *et al*., 2005; 2006; Kaur *et al*., 2005; Farooq *et al*., 2006 a, b; 2007 a, b). The enhanced phenology in mungbean due to primed seed is associated with faster emergence and reduced germination imbibition periods (Harris *et al*., 1999). It has been declared that priming had been resulted in more germination speed especially in drought stress, saline stress and low temperatures in sorghum, sunflower and melon (Sivritepe *et al*., 2003; Demir Kaya *et al.*, 2006; Foti *et al.*, 2002). Soybean seed priming are made better seedling emergence and yield improvement (Arif *et al*., 2008).

Seed priming techniques such as hydropriming, hardening, osmopriming, osmo hardening, hormonal priming and hydro priming have been used to accelerate emergence more vigorous plants and better drought tolerance in many field crop like wheat (Iqbal and Ashraf, 2007), chickpea (Kaur *et al*., 2002), sunflower (Kaya *et al.*, 2006), cotton (casenve and Toselli, 2007) triticale (Yagmur and Kaydan, 2008). Potassium hydro phosphate ($K_2HPO4$), polyethylene glycol (PEG6000) (Dell Aquila and Taranto, 1986) and potassium chloride (KCl) (Misra and Dwibedi, 1980) have been introduced as the osmoticum which have shown good potential to enhance germination, emergence, growth, and/or grain yield of wheat. Water has also been used successfully as a seed priming medium for wheat (Harris *et al*., 2001). Ghiyasi *et al.* (2008) declared osmopriming of maize (*Zea mays* L.) seeds with polyethylene glycol 8000 (PEG 8000) at -0.5 MPa osmotic potential had improved emergence, grain and biological yields compared with other treatments. The probable reason for early emergence of the primed seed maybe due to the completion of pre-germination metabolic activities making the seed ready for radicle protrusion and the primed seed germinated soon after planting compared with untreated dry seed (Arif, 2005). Halopriming with CaCl2 significantly improved emergence and seedling growth in Shaheen Basmati whereas as CaCl2 and KCl proved better in case of Basmati-2000 which could be related to dormancy breakdown of rice seeds due to enhanced seed K and Ca concentration and amylase activity (Farooq *et al.,* 2006b).

Zheng *et al.* (2002) reported earlier and uniform emergence in rice (*Oryza sativa*) seeds osmoprimed with KCl and $CaCl_2$ and mixed salts under flooded conditions. However, Nascimento and West (1999) reported early germination of primed seeds but not recorded any improvement in the growth of seedlings in muskmelon (*Cucumis melo*) seeds under laboratory conditions. Confounding results, where priming did not show any beneficial results, also reported by different research workers (Mwale *et al.,* 2003; Giri and Schillinger, 2003).

Priming with KNO3 can be used to increase watermelon germination (Demir and Mavi, 2004) and in tomato, seed priming with KNO3 increased germination percentage, germination index, root length, shoot length and seedling fresh weight (Nawaz et al., 2011).It was reported that osmo and hydropriming of chickpea seeds with mannitol and water alleviated the adverse effects of water deficiency and salt stress on seedling growth. The treatment of seeds with water, 2 and 4 % mannitol increased the length and biomass of roots and shoots of chickpea seedlings as compared to non-primed controls under salt stressed conditions (Kaur *et al*., 2002, 2005).Priming of chickpea seeds with mannitol and water improved seedling growth under salt stressed conditions (Kaur et al., 2003). Previous studies on tomato (Cuartero *et al.*, 2006) and melon(Sivritepe *et al.*, 2003), showed that seed priming improves seed germination, seedling emergence and growth under saline conditions.Farhoudi and Sharifzadeh (2006) and Sarwar *et al.* ( 2006) while working with canola and chickpea, respectively, reported salt priming-induced improvement in seed germination, seedling emergence and growth under saline conditions.

Priming of seeds with water promoted seedling vigor, yield and crop establishment of chickpea, maize and rice in India (Harris *et.al*., 1999). It is well documented that salinity reduces the germination as well as seedling growth in crop plants and seed priming ameliorates salinity affects during early seedling growth (Ashraf and Harris, 2004; Afzal et al., 2006).Paul and Choudhury (1991) also observed that seed soaking with 0.5 to 1% solution of KCl or potassium sulfate (K2SO4) significantly increased plant height, yield attributes, and grain yield in wheat. The beneficial effects of gibberellic acid (GA3) on germination are well known (Angrish *et al.*, 2001; Radi *et al*.,2001; Khan *et al*., 2002). GA3 (100 mg l-1) applied as pre-sowing treatment resulted in the highest K+ and Ca2+ content in the shoots of both faba beans (Vicia faba) and cotton (Gossypium barbadense) crops (Harb,1992). Recently, auxin is also used for priming (Akbari *et al.*,2007). In wheat seed germination, auxin treatments increased the hypocotyl length, seedling fresh and dry weight and hypocotyl dry weight (Akbari *et al*.,2007).

Seed priming techniques such as hydropriming, hardening, osmo-conditioning, osmo-hardening, and hormonal priming have been used to accelerate emergence of roots and shoots, more vigorous plants, and better drought tolerance in many field crops like wheat (Iqbal and Ashraf, 2007), chickpea (Kaur *et al*., 2002), sunflower (Kaya *et al*., 2006) and cotton (Casenave and Toselli, 2007).ABA-primed seeds of Brassica napus exhibited earlier (2–7 days) germination and higher final percent radicle protrusion than non-primed control seeds, under salt (100 mM NaCl) or water stress (20 % PEG 8000) and at a low temperature (8 LC) (Gao *et al*., 2002). Kulkarni and Eshanna (1988) stated that pre-sowing seed treatment with IAA at 10 ppm improved root length, rate of germination, and seedling vigor. Kathiresan *et al*. (1984) also found similar findings and reported maximum root and shoot growth; seedling height and field emergence in sunflower seeds in response to priming with CaCl2. Priming may improve germination by accelerating imbibition, which in turn would facilitate the emergence phase and the multiplication of radicle cells Kaya *et al*. (2006).

Osmopriming and hydropriming of wheat seeds may improve germination and emergence (Ashraf and Abu-Shakra, 1978) and may promote vigorous rootgrowth (Carceller and Soriano, 1972). Hydroprimed seeds produced the largest roots, compared to other seed treatments Kathiresan and Gnanarethinam (1985) in sunflower. This means that during priming, seeds would be simultaneously subjected to processes of repair and deterioration and force between the two determined the success or failure of the treatment (McDonald, 2000). Also, important to consider is the toxic effect reported for PEG (Grzesik and Nowek, 1998) and the decrease in oxygen solubility (Welbaum, 1998; Toselli and Casenave, 2002, 2003) that could be responsible for the anoxia damages suggested by Sung and Chang, (1993).

The increased shoot and root length in primed plants can be due to metabolic repair of damage during treatment and that change in germination events i.e., changes in enzyme concentration and formation and reduction of lag time between inhibition and radicle emergence (Bradford *et al*.,1990). Treated seeds had stronger embryos that were able to more easily emerge from seeds (Harris *et al*., 2005). Sekiya and Yano (2009) also found that enhanced root and shoot length of seedlings obtained from P enriched seeds. To contribute to plant growth and development seed priming has been widely reported technique (Harris et al., 2005). Ajouri *et al*. (2004) reported a stimulation of P and Zn uptake, as well as an improved germination and seedling growth in barley after soaking seeds in water and in solutions containing 5-500 mM P.

Hydropriming method has also been used successfully in wheat (Harris *et al*., 2001), in sunflower (Kaya *et al*., 2006), chickpea (Kaur *et al*., 2002) and cotton (Casenave and Toselli, 2007). Moreover, hydropriming increased germination and seedling growth under salt and drought stresses (Kaur *et al*., 2002; Kaya *et al.*, 2006; Casenave and Toselli, 2007). Emergence force and seedling growth were strengthened by hydropriming in watermelon seeds Sung and Chiu (1995). Elkoca *et al.* ( 2007), recommended that hydropriming for 12 h or osmopriming (PEG -0.5 MPa) for 24 h for a better germination of chickpeas under cold soil conditions. Compared to hydropriming, priming with PEG in a proper concentration was found to have a better effect on seed germination and seedling growth under drought stress (Yuan-Yuan *et al*.,2010).

PEG is frequently used to simulate drought stress (Chen *et al*., 2010; Farahani *et al*., 2010; He *et al.*, 2009; Khajeh-Hosseini et al., 2003; Tohidloo and Kruse, 2009; Zhu et *al*., 2006) as an inert osmoticum in germination tests (Dodd and Donovan, 1999) and is a non-penetrating solute (Almansouri *et al*., 2001), which results in osmotic stress that inhibits seed germination through the prevention of water uptake. However, it has been reported that the inhibitory effect of PEG on germination may not be solely related to water imbibition (Almansouri et al., 2001). Wang *et al.* (2009a) have observed that the fresh weight and the length of the roots and shoots of two alfalfa cultivars (Xinmu No.1 and Northstar) were significantly inhibited by 35% PEG treatment. For a potential medicinal plant, Matricaria chamomilla, both the seed germination rate and seedling growth have been found to be reduced with the PEG- mediated increasing osmotic potential of the growth medium (Afzali *et al.*, 2006). Rouhi *et al.* ( 2011) also suggested that different priming techniques (hydro and osmo priming) had a varying effects on germination on each of the four grass species (Bromus inermis, Festuca arundinacea, Agropyron elongatum and Festuca ovina) and the result showed that, for most evaluated germination parameters, osmopriming treatment (with PEG) was more useful technique to reduce abiotic stress than hydropriming treatment.

Although priming improves the rate and uniformity of seedling emergence and growth particularly under stress conditions (Parera and Cantliffe, 1991), the effectiveness of different priming agents varies under different stresses and different crop species (Iqbal and Ashraf, 2005). Patade *et al*., (2009) suggest that salt priming is an effective pre-germination 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. Paul and Choudhury (1991) also observed that seed soaking with 0.5 to 1% solutions with KCl or $K_2SO4$ significantly increased plant height, grain yield and its components in wheat genotypes. Priming of chickpea seeds with manitol and water improved seedling growth under salt stressed conditions (Kaur *et al*., 2003). Seed treatment with water and mannitol is also useful under water deficit stress and primed chickpea seeds gave high yield as compared to non-primed seeds (Kaur *et al.*, 2002). Musa *et al*. (1999) reported that overnight priming of chickpea seeds gave better crop production in Bangladesh. Priming with H2O2 failed to improve emergence and seedling growth in rice cultivars which is inconsistent with Wahid *et al*. (2007) who reported improved salt tolerance in wheat by alleviation of salt stress and oxidative damage by H2O2 pre-treatment.

Harris *et al*. (2004) reported that higher plant dry weight and seed yield following seed priming. The increase in the dry matter and grain yield of mungbean was due to better emergence and better performance per plant (Parera and Cantliffe, 1994). In basil (*Ocimum basilicum* L.) under saline conditions, the seedling vigor, germination percentage and seedling dry weight was found to increase due to hydropriming (Farahani and Maroufi, 2011).Increased plumule dry weight due to osmopriming was reported by Harris *et al*. (2004).

Sivritepe *et al*. (2002) 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.

Post-harvest seed enhancement treatments improve germination and seedling vigour (Taylor, 1998). Maiti *et al*. (2009) studied the effect of priming on seedling vigour and productivity of tomato, chilli, cucumber and cabbage during post-rainy seasons demonstrating that priming improved germination and seedling development and yield of these vegetable species. Seed priming significantly improved the germination rate and vigour of the mungbean seedlings (Umair *et al*., 2010). It is also reported that seed priming improve the antioxidant enzymes activity which decrease the adverse effects of Reactive Oxygen Species (ROS) (Del Ryo *et al*., 2002). Afzal et al. (2008 a) observed that the priming-induced salt tolerance was associated with improved seedling vigour, metabolism of reserves as well as enhanced K+ and Ca2+ and decreased Na+ accumulation in wheat plants. Seed priming is used for improvement of germination speed, germination vigour, seedling establishment and yield (Talebian *et al*., 2008). Afzal *et al.* ( 2005) also found that the priming-induced salt tolerance was associated with improved seedling vigor, metabolism of reserves as well as enhanced K+ and Ca2+ and decreased Na+ accumulation in wheat plants.

Primed crops grew more vigorously, flowered earlier and yielded higher (Farooq *et al.*, 2008). This technique used for improvement of germination speed, germination vigour, seedling establishment and yield (Talebian *et al*., 2008; Bodsworth and Bewley, 1981). Harris *et al.* (1999) demonstrated that onfarm seed priming (soaking seeds overnight in water) markedly improved establishment and early vigour of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. Similarly, vigorous early growth is often associated with better yields (Okonwo and Vanderlip, 1985; Austin, 1989; Carter *et al*., 1992).Seed-priming technology has twofold benefits: enhanced, rapid and uniform emergence, with high vigour and better yields in vegetables and floriculture (Bruggink *et al*.,1999) and some field crops (Basra *et al*.,2005; Kaur *et al*.,2005).It has been reported that primed seeds showed better germination pattern and higher vigour level than non- primed (Ruan *et al*., 2002a). It has been also reported invigorated seeds had higher vigour levels (Ruan *et al*., 2002b), which resulted in earlier start of emergence as high vigour seed lots performed better than low vigour ones (Hampton and Tekrony, 1995).

Seed priming techniques such as hydropriming, hardening, osmo conditioning, osmo hardening and hormonal priming have been used to accelerate emergence of roots and shoots, more vigorous plants, and better drought tolerance in many field crops like wheat (Iqbal and Ashraf, 2007), chickpea (Kaur et al., 2002), sunflower (Kaya et al., 2006) and cotton (Casenave and Toselli, 2007). Various works have shown that hydropriming of seeds have many advantages as compared to non-primed seeds. Hydropriming has resulted in 3 to 4-fold increases in root and shoot length in comparison with seedlings obtained from non-primed seeds in drought condition (Kaur *et al.,*2002). This phenomenon was explained to be due to faster emergence of roots and shoots, more vigorous plants, better drought tolerance under adverse conditions (Amzallag *et al.,* 1990; Passam and Kakouriotis,1994; Cayuela *et al*.,1996; Lee-suskoon *et al*.,1998). Fujikura et al. (1993) presented hydropriming as a simple and inexpensive method of seed priming and according to Abebe and Modi (2009), it is a very important seed treatment technique for rapid germination and uniform seedling establishment in various grain crops.

Priming of seeds with water promoted seedling vigor, yield and crop establishment of chickpea, maize and rice in India (Harris et.al., 1999).Harris *et al.* (1999) also found that hydropriming enhanced seedling establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. The resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield (Harris et al., 1999). Similarly, vigorous early growth is often associated with better yields (Okonwo and Vanderlip, 1985; Austin, 1989; Carter et al., 1992). Priming of tomato (*Lycopersicon lycopersicum*) seeds with NaCl had been reported to improve seedling growth.

Osmopriming with $KNO_3$ improved the rate and generally improved the uniformity of seedling emergence in leek (Brocklehurst *et al.,* 1984), sorghum (Moradi and Younesi,2009) and tomato (Heydecker et al.,1973; Ozbingol *et al.,* 1998). Chiu et al. (2006) reported that $KNO_3$ effectively improved germination, seedling growth and seedling vigour index of the seeds of sunflower varieties. Salt priming with KNO3, is an effective way to improve seed and seedling vigour of sunflower and cucumber (Singh and Rao, 1993; Ghassemi-Golezani and Esmaeilpour,2008).

Hydropriming improved the early and vigorous crop establishment in maize (Nagar *et al.*, 1998) and Heiichrysum bracteatum L. (Grzesik and Nowak, 1998). However, other studies resulted in poor emergence from hydroprimed Kentucky bluegrass seeds under field conditions (Pill and Necker, 2001). However Nascimento and West (1999) reported early germination of primed seeds but not recorded any improvement in the growth of seedlings in muskmelon seeds under laboratory conditions. Confounding results, where priming did not show any beneficial results, also reported by different research workers (Mwale *et al.*, 2003; Giri and Schillinger, 2003).

From the review as presented above, it is observed that seed priming techniques (hydro and osmopriming) favorably influence seed germination, seedling growth, yield and yield contributing characters of wheat and barley. This information is received mostly from aboard. Under Bangladesh conditions, therefore, studies are necessary for refinement of the techniques for adjustment and application of the seed priming techniques.

# CHAPTER 3

# MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the Kharif-1 season of March to June, 2017 to study the Comparison of Various Seed Priming Treatments for Seed Germination, Seedling Vigor and Pod Yield of Yard Long Bean. The materials used and methodology followed in the investigation have been presented details in this chapter.

## 3.1 Description of the Experimental Site:

### 3.1.1 Geographical location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.2 meter above the sea level (Anon., 2004).

### 3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

### 3.1.3 Soil

The soil of the experimental site belongs to the general soil type, shallow red brown terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level.

### 3.1.4 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March).

## 3.2 Details of the experiment

### 3.2.1 Treatments

The following hydropriming treatments were included in the experiment:

1. $T_0$ = No priming,
2. $T_1$ = Hydro priming at 12 hrs,
3. $T_2$ = Hydro priming at 18 hrs,
4. $T_3$ = Hydro priming at 24 hrs,
5. $T_4$ = Hydro priming at 30 hrs,
6. $T_5$ = Halo priming (1%$CaCl_2$) at 12 hrs,
7. $T_6$ = Halo priming (1%$CaCl_2$) at 18 hrs,
8. $T_7$ = Halo priming (1%$CaCl_2$) at 24 hrs,
9. $T_8$ = Halo priming (1%$CaCl_2$) at 30 hrs,
10. $T_9$ = Halo priming (2%$KNO_3$) at 12 hrs,
11. $T_{10}$ = Halo priming (2%$KNO_3$) at 18 hrs,
12. $T_{11}$ = Halo priming (2%$KNO_3$) at 24 hrs,
13. $T_{12}$ = Halo priming (2%$KNO_3$) at30 hrs,

### 3.2.2 Seed priming techniques

Procedures of pre-sowing seed treatments

I. 90 pieces of yard long bean (BARI Borboti 1) seeds was taken for each treatment .

II. The seeds were soaked in distilled water, halo priming (1% $CaCl_2$), halo priming (2% $KNO_3$) for 12 hr, 18 hrs, 24 hrs and 30 hrs separately at room temperature as per treatments.

III. 30 pieces of primed seeds were sown on each plot 2.7 $m^2$ (1.8m x 1.5m) for seedling emergence.

### 3.2.3 Experimental design and layout

The experiment was set up in a randomized complete block design with three replications. The plot size was 2.7 $m^2$(1.8m x 1.5m). The distance between two plots was 50cm.

### 3.2.4 Planting materials

The materials used in the study were yard long bean seeds (BARI Borboti -1) which were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Dhaka. The initial seed moisture content was in between 10-12%. The seeds were fresh, clean, and disease and insect free.

### 3.2.5 Preparation of experimental land

A pre-sowing irrigation was given on 25 March, 2017. The land was opened with the help of a tractor drawn disc harrow on 27 March, 2017. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on 30 March, 2017 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

### 3.2.6 Fertilizer application

Recommended doses of fertilizers and manures were 50-150-150-100-12.5-10-15000 kg $ha^{-1}$ of Urea, TSP, MoP, Gypsum, $ZnSO_4$, Borax and Cowdung respectively. Half amount of Urea, half amount of Muriate of Potash, all of TSP, Gypsum, $ZnSO_4$, Borax and Cowdung was applied to the soil at the time of final land preparation. The rest of the Urea and Muriate of Potash was top dressed after 30 days of seed sowing at vegetative stage.

### 3.2.7 Seed sowing

The seeds of Yard long bean (BARI Borboti -1) were sown by hand in 30 cm apart lines continuously at about 3 cm depth at the rate of 10 kg $ha^{-1}$ on March 31, 2017.

### 3.2.8 Intercultural operations

#### 3.2.8.1 Thinning

The plots were thinned out on 15 days after sowing to maintain a uniform plant stand.

#### 3.2.8.2 Weeding

The crop field was infested with some weeds during the early stage of crop establishment. Two hand weedings were done; first weeding was done at 15 days after sowing followed by second weeding at 15 days after first weeding.

#### 3.2.8.3 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre-sowing and other two were given 2-3 days before weedings.

#### 3.2.8.4 Drainage

There was a heavy rainfall during the experimental period. Drainage channels were properly prepared to easy and quick drained out of excess water.

#### 3.2.8.5 Plant protection measures

The crops were infested by insects and diseases. The insecticide Marshall 20 EC @ 30 ml/10L water was sprayed during the later stage of crop to control pests.

#### 3.2.8.6 Harvesting

Maturity of crop was determined when 80-90% of the pods become greenish in color. Four harvesting was done while the first harvesting of Yard long bean was done on 21 May, 25 May, 29 May and 3 June. The harvesting was done by picking pods from the selected plants for avoiding the boarder effects. The weight of harvesting pods plot$^{-1}$ was added and converted into t ha$^{-1}$.

#### 3.2.8.7 Seed collection

The last harvesting of pods were collected and properly sun dried. The collected seeds were sun dried and weighted to a control moisture level. The seed weight of harvesting pods plot$^{-1}$ was added and converted into t ha$^{-1}$.

### 3.3 Recording of data

The following data were recorded during the experimentation.

**A. Germination and Seedling growth parameter:**

1) Speed of Germination,
2) Germination percentage (%)
3) Root length,
4) Shoot length,
5) Seedling length,
6) Fresh weight of seedling and
7) Dry weight of seedling.

**B. Yield contributing parameter:**

1) Number of branch/plant (at 30DAS)

2) Date of 1st flowering/plot

3) Number of marketable pod/plant,

4) Pod length,

5) Individual pod weight,

6) Pod yield/plant (kg)

7) Pod yield(t/ha)

## 3.4 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study given below:

### 3.4.1. Germination and seedling growth characters

#### 3.4.1.1 Germination percentage

Numbers of seeds germinated per pot were counted from the next day after sowing (DAS) to the end of germination when maximum seeds are germinated and the mean values were determined in percentage.

#### 3.4.1.2 Speed of Germination

10 seeds were sown in a plot with three replications for germination. Number of seedlings emerging daily were counted from day of planting the seeds in the plot fill the time germination was completed.

#### 3.4.1.3 Seedling length (cm)

Plant heights of five randomly selected plants from each pot were measured at 15 days after sowing (DAS) and at harvest. The heights of the plants were determined by measuring the distance from the soil surface to the tip of the leaf of main shoot.

#### 3.4.1.4 Root length (cm) plant$^{-1}$

Five plants pot$^{-1}$ were uprooted continuously from second line and root lengths were counted at 15 DAS and at harvest and the mean values were determined.

#### 3.4.1.5 Shoot length (cm) plant$^{-1}$

The shoot lengths were counted from same five plants those were collected for root length measurement at 15 DAS and at harvest and the mean values were determined.

#### 3.4.1.6 Shoot/root ratio plant$^{-1}$

The sub-samples of five plants pot$^{-1}$ were uprooted from second line and root and shoot lengths were counted at 15 DAS and at harvest and the mean values of the ratio of shoot/root were determined.

#### 3.4.1.7 Fresh weight plant$^{-1}$ (g)

Five plants from each pot were collected for each recording data at 15 days after sowing (DAS). Then fresh weight of different plant parts were taken separately with an electric balance. The mean values were determined.

#### 3.4.1.8 Dry weight plant$^{-1}$ (g)

Five plants from each pot were collected for each recording data. The plant parts were separated and packed in separate paper packets then kept in the oven at $80^0$ C for two days to reach a constant weight. Then dry weight of different plant parts were taken separately with an electric balance. The mean values were determined.

#### 3.4.1.9 Vigor Index

Seed vigor index was calculated by multiplying germination (%) and seedling length

### 3.4.2 Yield contributing characters

#### 3.4.2.1 Number of branches plant$^{-1}$

The number of branches plant$^{-1}$ from five randomly selected plants of each plot were counted at 30 days after sowing (DAS) and at harvest and Mean values were calculated.

#### 3.4.2.2 Number of pods plant$^{-1}$

The total number of pods of five selected plants plot$^{-1}$ at harvest were counted and the average values were recorded.

#### 3.4.2.3 Pod length (cm)

Length of pod were measured from the five randomly selected plants of each plot. Then the average values were recorded.

#### 3.4.2.4 Pod weight( pod$^{-1}$ )

Weight of five selected pods were measured from the five randomly selected plants of each plot. Then the average values were recorded.

#### 3.4.2.5 Seed weight-100 (g)

A sub sample of seeds was taken from each plot from which 100 seeds were counted manually. One hundred seeds thus counted were weighed at 12% moisture level in a digital balance to obtain 100-seed weight (g).

#### 3.4.2.6 Seed yield (t ha$^{-1}$)

The pods were harvested as per experimental treatments and were threshed. Seeds were cleaned and properly dried under sun. Then seed yield plot$^{-1}$ was recorded at 12% moisture level and converted into t ha$^{-1}$.

### 3.5 Analysis of data

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. All mean data were analyzed one way ANOVA via SPSS software version 20. Comparisons of the mean data and standard error (S.E) were determined by DMRT (Duncuns multiple range tests) at $p \leq 0.5$ level of significance.

# CHAPTER 4

# RESULTS AND DISCUSSION

Effects of seed priming on the field performance of yard long bean were 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 4. The analysis of variance for different parameters have been presented in Appendices III through XVII. A discussion on the result of the experiment has been made in this chapter parameter-wise.

## 4.1 Effect of Seed Priming on Seedling growth characters

### 4.1.1 Effect of Seed Priming on Germination percentage

Germination percentage of yard long bean was significantly influenced by different seed priming treatments (Appendix III). The germination percentage was higher (86.66%) in $T_5$ treatment. The lowest (36.66%) germination percentage was found in $T_0$ and $T_{12}$ treatment . The treatments $T_3$ (70%), $T_4$ (66.66%) and $T_7$ (66.66%) showed the moderate germination percentage (Table 1). The primed seed usually exhibit increased germination rate, greater germination uniformity and sometimes greater total germination percentage (Barsa *et al*., 2005).

### 4.1.2 Effect of Seed Priming on Speed of Germination

Speed of germination of yard long bean was significantly influenced by different seed priming treatments (Appendix IV). The speed of germination was higher (6.76) in $T_5$ treatment. The lowest (1.18) speed of germination was found in $T_0$ treatment . The treatment $T_3$ (5.78%), showed the moderate speed of germination ( Table 1). Various prehydration or priming treatments have been employed to increase the speed and synchrony of seed germination (Ashraf and Foolad, 2005).

**Table 1. Effect of different seed priming treatments on germination percentage, speed of seed germination, vigor index and seedling length**

| Treatments | Germination Percentage | Speed of Germination | Vigor Index | Seedling Length (cm) |
|---|---|---|---|---|
| $T_0$ | 36.66±8.82 [c] | 1.18±0.14 [e] | 651.53±248.73 [c] | 17.72±3.91 |
| $T_1$ | 56.66±6.67 [bc] | 4.60±0.51 [a-c] | 1061.80±104.44 [bc] | 20.25±1.11 |
| $T_2$ | 43.33±8.82 [bc] | 3.04±0.79 [b-e] | 913.20±175.80 [bc] | 21.36±1.77 |
| $T_3$ | 70.00±10.00 [ab] | 5.78±0.40 [ab] | 1128.80±132.73 [bc] | 23.80±0.81 |
| $T_4$ | 66.66±14.53 [ab] | 4.81±1.13 [a-c] | 1067.46±41.23 [bc] | 22.08±1.33 |
| $T_5$ | 86.66±3.33 [a] | 6.76±0.49 [a] | 1833.80±99.23 [a] | 23.42±0.74 |
| $T_6$ | 63.33±6.67 [a-c] | 3.49±0.96 [b-e] | 1297.60±93.17 [b] | 23.04±0.42 |
| $T_7$ | 66.66±6.67 [ab] | 4.66±0.91 [a-c] | 1216.40±6.80 [b] | 21.09±0.77 |
| $T_8$ | 60.00±5.77 [a-c] | 4.43±0.56 [a-d] | 1247.00±128.16 [b] | 22.67±1.79 |
| $T_9$ | 56.66±6.67 [bc] | 4.71±0.94 [a-c] | 1180.46±53.58 [b] | 22.53±0.77 |
| $T_{10}$ | 46.66±6.67 [bc] | 3.17±1.45 [b-e] | 934.53±168.46 [bc] | 21.56±2.76 |
| $T_{11}$ | 43.33±8.82 [bc] | 2.43±0.77 [c-e] | 954.26±236.34 [bc] | 22.39±4.11 |
| $T_{12}$ | 36.66±12.02 [c] | 1.87±0.78 [de] | 858.43±268.09 [bc] | 23.81±1.21 |
| **Significant Level** | 0.010 | 0.003 | 0.005 | 0.757 |

The data represent the mean values ± standard error. Different letter (s) corresponds to significant differences at $p \leq 0.05$ by Duncans multiple range tests.

$T_0$ = No priming
$T_1$ = Hydro priming at 12 hrs
$T_2$ = Hydro priming at 18 hrs
$T_3$ = Hydro priming at 24 hrs
$T_4$ = Hydro priming at 30 hrs
$T_5$ = Halo priming(1%$CaCl_2$) at 12 hrs
$T_6$ = Halo priming(1%$CaCl_2$) at 18 hrs
$T_7$ = Halo priming(1%$CaCl_2$) at 24 hrs
$T_8$ = Halo priming(1%$CaCl_2$) at 30 hrs
$T_9$ = Halo priming(2%$KNO_3$) at 12 hrs
$T_{10}$ = Halo priming(2%$KNO_3$) at 18 hrs
$T_{11}$ = Halo priming(2%$KNO_3$) at 24 hrs
$T_{12}$ = Halo priming(2%$KNO_3$) at30 hrs

### 4.1.3 Effect of Seed Priming on Vigor Index

Vigor index of yard long bean seedling was significantly influenced by different seed priming treatments (Appendix V). The vigor index was higher (1833.80) in $T_5$ treatment. The lowest (651.53) vigor index was found in $T_0$ treatment . The treatments $T_6$ (1297.60), $T_7$ (1216.40), $T_8$ (1247) and $T_9$ (1180.46) showed the moderate vigor index (Table 1). Golezani *et al*. (2008b) concluded that halopriming significantly improved imbibition rate, germination rate, seed vigor index, shoot, root and seedling dry weights, compared to other seed treatments.

### 4.1.4 Effect of Seed Priming on Seedling Length

The priming treatments of yard long bean seed had no significant effect on seedling length (Appendix VI) . The seedling length was higher (23.81cm) in $T_{12}$ treatment. The lowest (17.73cm) seedling length was found in $T_0$ treatment ( Table 1). Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Heydecker and Coolbar, 1978; Bradford, 1986; Taylor and Harman, 1990).

### 4.1.5 Effect of Seed Priming on Shoot Length of Seedling

The priming treatments of yard long bean seed had no significant effect on shoot length of seedling (Appendix VII). The shoot length was higher (9.21cm) in $T_4$ treatment. The lowest (6.97cm) shoot length was found in $T_0$ treatment ( Table 2). Golezani *et al*. (2008b) concluded that halopriming significantly improved imbibition rate, germination rate, seed vigour index, shoot, root and seedling dry weights, compared to other seed treatments.

### 4.1.6 Effect of Seed Priming on Root Length of Seedling

The priming treatments of yard long bean seed had no significant effect on root length of seedling (Appendix VIII). The root length was higher (16.21cm) in $T_{12}$ treatment. The lowest (10.75) root length was found in $T_0$ treatment ( Table 2). Golezani *et al*. (2008b) concluded that halopriming significantly improved imbibition rate, germination rate, seed vigour index, shoot, root and seedling dry weights, compared to other seed treatments.

### 4.1.7 Effect of Seed Priming on Fresh Weight of Seedling

Fresh weight of seedling of yard long bean was significantly influenced by different seed priming treatments (Appendix IX). The fresh weight of seedling was higher (1.43g) in $T_5$ treatment. The lowest (0.31g) fresh weight of seedling was found in $T_0$ treatment . The treatment $T_2$ (0.99%), showed the moderate fresh weight of seedling ( Table 2).

**Table 2. Effect of different seed priming treatments on shoot length , root length , fresh weight and dry weight of seedling**

| Treatments | Shoot length of Seedling (cm) | Root length of Seedling (cm) | Fresh weight of Seedling (g) | Dry weight of Seedling (g) |
|---|---|---|---|---|
| $T_0$ | 6.97±1.11 | 10.75±2.80 | 0.31±0.10 $^{e}$ | 0.13±0.05 $^{ab}$ |
| $T_1$ | 8.69±0.28 | 11.56±0.88 | 0.87±0.21 $^{bc}$ | 0.22±0.04 $^{a}$ |
| $T_2$ | 8.66±0.48 | 12.70±1.35 | 0.99±0.08 $^{b}$ | 0.22±0.06 $^{a}$ |
| $T_3$ | 8.79±0.50 | 15.01±1.02 | 0.88±0.09 $^{bc}$ | 0.22±0.02 $^{a}$ |
| $T_4$ | 9.21±0.89 | 12.87±0.45 | 0.67±0.07 $^{b-d}$ | 0.19±0.03 $^{ab}$ |
| $T_5$ | 7.86±0.78 | 15.56±0.16 | 1.43±0.08 $^{a}$ | 0.17±0.02 $^{ab}$ |
| $T_6$ | 8.05±0.45 | 14.99±0.05 | 0.76±0.18 $^{bc}$ | 0.24±0.02 $^{a}$ |
| $T_7$ | 7.58±0.45 | 13.51±0.52 | 0.40±0.09 $^{de}$ | 0.10±0.01 $^{b}$ |
| $T_8$ | 8.70±0.89 | 13.97±1.01 | 0.58±0.02 $^{c-e}$ | 0.14±0.01 $^{ab}$ |
| $T_9$ | 8.50±0.62 | 14.03±0.26 | 0.67±0.11 $^{b-d}$ | 0.15±0.02 $^{ab}$ |
| $T_{10}$ | 7.61±0.72 | 13.96±2.11 | 0.52±0.05 $^{c-e}$ | 0.14±0.02 $^{ab}$ |
| $T_{11}$ | 7.91±1.35 | 14.48±2.82 | 0.52±0.13 $^{c-e}$ | 0.14±0.04 $^{ab}$ |
| $T_{12}$ | 7.60±0.33 | 16.21±0.90 | 0.67±0.05 $^{b-d}$ | 0.14±0.01 $^{ab}$ |
| **Significant Level** | 0.694 | 0.342 | 0.000 | 0.055 |

The data represent the mean values ± standard error. Different letter (s) corresponds to significant differences at $p \leq 0.05$ by Duncans multiple range tests.

$T_0$ = No priming
$T_1$ = Hydro priming at 12 hrs
$T_2$ = Hydro priming at 18 hrs
$T_3$ = Hydro priming at 24 hrs
$T_4$ = Hydro priming at 30 hrs
$T_5$ = Halo priming(1%$CaCl_2$) at 12 hrs
$T_6$ = Halo priming(1%$CaCl_2$) at 18 hrs
$T_7$ = Halo priming(1%$CaCl_2$) at 24 hrs
$T_8$ = Halo priming(1%$CaCl_2$) at 30 hrs
$T_9$ = Halo priming(2%$KNO_3$) at 12 hrs
$T_{10}$ = Halo priming(2%$KNO_3$) at 18 hrs
$T_{11}$ = Halo priming(2%$KNO_3$) at 24 hrs
$T_{12}$ = Halo priming(2%$KNO_3$) at30 hrs

### 4.1.8 Effect of Seed Priming on Dry Weight of Seedling

Dry weight of seedling of yard long bean was significantly influenced by different seed priming treatments (Appendix X). The dry weight of seedling was higher (0.24g) in $T_6$ treatment. The lowest (0.10g) dry weight of seedling was found in $T_7$ treatment (Table 2) Omidi *et al*. (2005) showed that halopriming of bean seed under water stress condition had a significant effect on seedling parameters including seedling dry weight, rate and period of germination.

## 4.2 Effect of Seed Priming on Plant Growth and Yield Contributing Characters

### 4.2.1 Effect of Seed Priming on Branch Number of Plant

Branch no of plant of yard long bean was significantly influenced by different seed priming treatments (Appendix XI). The branch number of plant was higher (7.20) in $T_5$ treatment. The lowest (4.13) branch number of plant was found in $T_7$ treatment . The treatment $T_9$ (6.80), and $T_1$ (6.67), showed the moderate branch number of plant (Table 3) .

### 4.2.2 Effect of Seed Priming on First Flowering of Plant

First flowering of plant of yard long bean was significantly influenced by different seed priming treatments (Appendix XII). The first flowering of plant was delayed (49.66 days) in $T_{11}$ treatment. The earlier (40 days ) first flowering of plant was found in $T_1$ treatment (Table 3). The direct effects of seed priming in all crops can lead to better stand establishment, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield (Harris *et al*., 1999; 2001a; 2002).

**Table 3. Effect of different seed priming treatments on branch no and first flowering of plant**

| Treatments | Branch Number Per Plant | First Flowering (Days) |
|---|---|---|
| $T_0$ | 4.47±0.48 $^{cd}$ | 41.00±1.00 $^{cd}$ |
| $T_1$ | 6.67±1.03 $^{a-c}$ | 40.00±1.15 $^{d}$ |
| $T_2$ | 5.20±1.71 $^{a-d}$ | 43.00±0.58 $^{b-d}$ |
| $T_3$ | 4.73±0.57 $^{b-d}$ | 47.00±1.73 $^{ab}$ |
| $T_4$ | 5.20±0.23 $^{a-d}$ | 47.33±1.76 $^{ab}$ |
| $T_5$ | 7.20±0.12 $^{a}$ | 43.00±1.00 $^{b-d}$ |
| $T_6$ | 6.13±0.41 $^{a-d}$ | 45.33±2.40 $^{a-c}$ |
| $T_7$ | 4.13±0.68 $^{d}$ | 47.33±0.67 $^{ab}$ |
| $T_8$ | 6.07±0.29 $^{a-d}$ | 45.00±1.53 $^{bc}$ |
| $T_9$ | 6.80±0.31 $^{ab}$ | 41.33±0.67 $^{cd}$ |
| $T_{10}$ | 5.80±0.42 $^{a-d}$ | 43.00±1.53 $^{b-d}$ |
| $T_{11}$ | 4.53±0.58 $^{b-d}$ | 49.66±1.45 $^{a}$ |
| $T_{12}$ | 4.67±0.41 $^{b-d}$ | 45.33±0.88 $^{a-c}$ |
| **Significant Level** | 0.050 | 0.001 |

The data represent the mean values ± standard error. Different letter (s) corresponds to significant differences at $p \leq 0.05$ by Duncans multiple range tests.

$T_0$ = No priming
$T_1$ = Hydro priming at 12 hrs
$T_2$ = Hydro priming at 18 hrs
$T_3$ = Hydro priming at 24 hrs
$T_4$ = Hydro priming at 30 hrs
$T_5$ = Halo priming(1%$CaCl_2$) at 12 hrs
$T_6$ = Halo priming(1%$CaCl_2$) at 18 hrs
$T_7$ = Halo priming(1%$CaCl_2$) at 24 hrs
$T_8$ = Halo priming(1%$CaCl_2$) at 30 hrs
$T_9$ = Halo priming(2%$KNO_3$) at 12 hrs
$T_{10}$ = Halo priming(2%$KNO_3$) at 18 hrs
$T_{11}$ = Halo priming(2%$KNO_3$) at 24 hrs
$T_{12}$ = Halo priming(2%$KNO_3$) at30 hrs

### 4.2.3 Effect of Seed Priming on Pod Length

The priming treatments of yard long bean seed had no significant effect on pod length (Appendix XIII). The pod length was higher (52.47cm) in $T_5$ treatment. The lowest (40.08cm) pod length was found in $T_{12}$ treatment (Table 4) .

### 4.2.4 Effect of Seed Priming on Pod Weight

Pod weight of yard long bean was significantly influenced by different seed priming treatments (Appendix XIV). The pod weight was higher (24.93g) in $T_5$ treatment. The lowest (10.93g) pod weight was found in $T_0$ treatment . The treatment $T_3$ (22.98g) showed the moderate pod weight (Table 4).

### 4.2.5 Effect of Seed Priming on Total Pod Number Per Plant

Total pod number per plant of yard long bean was significantly influenced by different seed priming treatments (Appendix XV). The total pod number per plant was higher (73.67) in $T_5$ treatment. The lowest (16.00) total pod number per plant was found in $T_0$ treatment . The treatments $T_9$ (62.00), $T_8$ (56.33) , and $T_6$ (61.00) showed the moderate total pod number per plant (Table 4). Priming is a non expensive and value added practice that greatly improves the yield. This might be due to some biochemical and physiological changes brought about by seed soaking (Khan *et al*., 2002).

**Table 4. Effect of different seed priming treatments on pod length, pod weight, total pod number per plant and 100 seed weight**

| Treatments | Pod length (cm) | Pod weight (g) | Total Pod Number per Plant | 100 Seed weight (g) |
|---|---|---|---|---|
| $T_0$ | 49.43±3.25 | 10.93±0.90 $^{d}$ | 16.00±2.08 $^{g}$ | 8.53±0.58 $^{c}$ |
| $T_1$ | 46.55±2.70 | 17.13±1.88 $^{b-d}$ | 45.33±2.91 $^{c}$ | 11.30±0.61 $^{bc}$ |
| $T_2$ | 42.62±4.59 | 16.73±1.07 $^{b-d}$ | 37.00±6.03 $^{c-e}$ | 12.07±0.84 $^{b}$ |
| $T_3$ | 51.57±0.76 | 22.98±0.53 $^{ab}$ | 27.33±2.73 $^{e-g}$ | 9.67±0.50 $^{bc}$ |
| $T_4$ | 42.99±3.99 | 15.53±0.96 $^{cd}$ | 22.33±5.78 $^{fg}$ | 11.63±1.67 $^{b}$ |
| $T_5$ | 52.47±0.69 | 24.93±1.10 $^{a}$ | 73.67±2.96 $^{a}$ | 16.37±0.92 $^{a}$ |
| $T_6$ | 47.05±4.10 | 18.89±1.78 $^{a-c}$ | 61.00±1.73 $^{b}$ | 10.67±0.78 $^{bc}$ |
| $T_7$ | 48.36±1.67 | 19.13±0.75 $^{a-c}$ | 39.67±3.18 $^{cd}$ | 11.67±1.04 $^{b}$ |
| $T_8$ | 52.13±3.42 | 20.87±2.65 $^{a-c}$ | 56.33±5.21 $^{b}$ | 10.27±0.91 $^{bc}$ |
| $T_9$ | 47.09±4.88 | 18.00±4.21 $^{a-d}$ | 62.00±2.52 $^{b}$ | 11.80±1.27 $^{b}$ |
| $T_{10}$ | 46.81±0.81 | 15.18±0.82 $^{cd}$ | 39.00±1.15 $^{c-e}$ | 10.97±0.87 $^{bc}$ |
| $T_{11}$ | 45.29±2.88 | 16.10±3.40 $^{b-d}$ | 31.67±5.49 $^{d-f}$ | 12.37±0.47 $^{b}$ |
| $T_{12}$ | 40.08±7.14 | 13.80±3.35 $^{cd}$ | 31.33±2.40 $^{d-f}$ | 10.63±0.49 $^{bc}$ |
| **Significant Level** | 0.421 | 0.008 | 0.000 | 0.001 |

The data represent the mean values ± standard error. Different letter (s) corresponds to significant differences at $p \leq 0.05$ by Duncans multiple range tests.

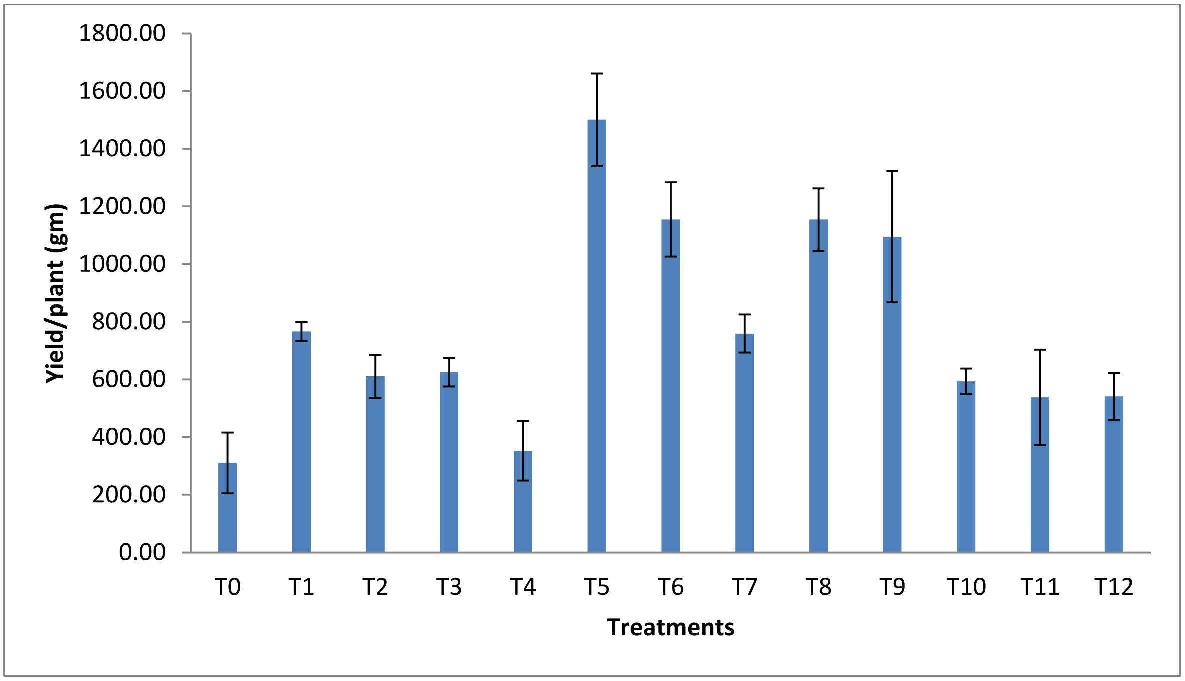
$T_0$ = No priming
$T_1$ = Hydro priming at 12 hrs
$T_2$ = Hydro priming at 18 hrs
$T_3$ = Hydro priming at 24 hrs
$T_4$ = Hydro priming at 30 hrs
$T_5$ = Halo priming(1%$CaCl_2$) at 12 hrs
$T_6$ = Halo priming(1%$CaCl_2$) at 18 hrs
$T_7$ = Halo priming(1%$CaCl_2$) at 24 hrs
$T_8$ = Halo priming(1%$CaCl_2$) at 30 hrs
$T_9$ = Halo priming(2%$KNO_3$) at 12 hrs
$T_{10}$ = Halo priming(2%$KNO_3$) at 18 hrs
$T_{11}$ = Halo priming(2%$KNO_3$) at 24 hrs
$T_{12}$ = Halo priming(2%$KNO_3$) at30 hrs

### 4.2.6 Effect of Seed Priming on Pod yield Per Plant (g)

Yield per plant of yard long bean was significantly influenced by different seed priming treatments (Appendix XVI). The yield per plant was higher (1500g) in $T_5$ treatment. The lowest (310gm) yield per plant was found in $T_0$ treatment. The treatments $T_6$ (1154.69g), and $T_8$ (1154.33g) showed the moderate yield per plant (Figure 1). Priming is a non expensive and value added practice that greatly improves the yield. This might be due to some biochemical and physiological changes brought about by seed soaking (Khan *et al*., 2002).

### 4.2.7 Effect of Seed Priming on 100 Seed Weight

100 Seed Weight of yard long bean was significantly influenced by different seed priming treatments (Appendix XVII). The value of 100 seed weight was higher (16.37g) in $T_5$ treatment. The lowest (8.53g) 100 seed weight was found in $T_0$ treatment. The treatments $T_2$ (12.07g), and $T_{11}$ (12.37g) showed the moderate 100 seed weight (Table 4).




The data represent the mean values ± standard error. Different letter (s) corresponds to significant differences at $p \leq 0.05$ by Duncans multiple range tests.

**Figure 1. Yield per plant of yard long bean as influenced by different seed priming treatments**

$T_0$ = No priming
$T_1$ = Hydro priming at 12 hrs
$T_2$ = Hydro priming at 18 hrs
$T_3$ = Hydro priming at 24 hrs
$T_4$ = Hydro priming at 30 hrs
$T_5$ = Halo priming(1%$CaCl_2$) at 12 hrs
$T_6$ = Halo priming(1%$CaCl_2$) at 18 hrs
$T_7$ = Halo priming(1%$CaCl_2$) at 24 hrs
$T_8$ = Halo priming(1%$CaCl_2$) at 30 hrs
$T_9$ = Halo priming(2%$KNO_3$) at 12 hrs
$T_{10}$ = Halo priming(2%$KNO_3$) at 18 hrs
$T_{11}$ = Halo priming(2%$KNO_3$) at 24 hrs
$T_{12}$ = Halo priming(2%$KNO_3$) at30 hrs

# CHAPTER 5

## SUMMARY AND CONCLUSION

The present piece of work was conducted at the research field, Sher-e-Bangla Agricultural University, Dhaka from March, 2017 to June, 2017 to find out the effect of various seed priming treatments for seed germination, seedling vigor and pod yield of yard long bean. The experiment consists of thirteen treatments viz. $T_0$ = No priming, $T_1$ = Hydro priming at 12 hrs, $T_2$ = Hydro priming at 18 hrs, $T_3$ = Hydro priming at 24 hrs, $T_4$ = Hydro priming at 30 hrs, $T_5$ = Halo priming (1% $CaCl_2$) at 12 hrs, $T_6$ = Halo priming (1% $CaCl_2$) at 18 hrs, $T_7$ = Halo priming (1% $CaCl_2$) at 24 hrs, $T_8$ = Halo priming (1% $CaCl_2$) at 30 hrs, $T_9$ = Halo priming (2% $KNO_3$) at 12 hrs, $T_{10}$ = Halo priming (2% $KNO_3$) at 18 hrs, $T_{11}$ = Halo priming (2% $KNO_3$) at 24 hrs, $T_{12}$ = Halo priming (2% $KNO_3$) at 30 hrs.  The experiment was laid out in randomized complete block design(RCBD) with three replications. The sowing date was on March 31, 2017.

Observation were made on germination percentage, speed of germination, vigor index, root length, shoot length, seedling length, fresh weight of seedling, dry weight of seedling, number of branches plant$^{-1}$, first flowering of plant, number of pods plant$^{-1}$, pod length, pod weight, , yield plant$^{-1}$, weight of 100 seeds. Germination percentage was recorded upto highest germination of seeds. Five plants were randomly selected from each unit plot for taking observations on first flowering of plant and number of branches plant$^{-1}$ after 45 days after sowing. Pods plant$^{-1}$, pod length, pod weight, yield plant$^{-1,}$ and weight of 100 seeds were recorded from the selected plants. All mean data were analyzed one way ANOVA via SPSS software version 20. Comparisons of the mean data and standard error (S.E) were determined by DMRT (Duncuns multiple range tests) at $p \leq 0.5$ level of significance.

In case of seedling growth parameter treatment $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs ) showed the highest value of germination percentage, speed of germination, vigor index, and fresh weight of seedling (86.66%, 6.76, 1833.80 and 1.43g), but $T_0$ (No priming ) showed the lowest value (36.66%, 1.18, 651.53 and 0.31g respectively). In case of dry weight of seedling $T_6$ (Halo priming 1% $CaCl_2$ at 18 hrs ) showed the higher value (0.24g) and $T_7$ (Halo priming 1% $CaCl_2$ at 24 hrs ) showed the lower value (0.10g). There had no significant effect of seed priming on root length, shoot length and seedling length.

In case of growth and yield parameter treatment $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs) showed the higher value of number of pods plant$^{-1}$, pod weight, yield plant$^{-1}$, weight of 100 seeds (73.67, 24.93g, 1500.80g and 16.37g), but $T_0$ (No priming ) showed the lower value (16, 10.93g, 310g and 8.53g respectively). In case of number of branches plant$^{-1}$ $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs) showed the higher value (7.20) and $T_7$ (Halo priming 1% $CaCl_2$ at 24 hrs) showed the lowed value. Effect of seed priming on first flowering of plant $T_{11}$ (Halo priming (2% $KNO_3$) at 24 hrs) showed the highest value (49.66DAS) and $T_1$ (Hydro priming at 12 hrs) showed the lowest value (40). There had no significant effect of seed priming on pod length of yard long bean.

From this experiment it is clearly observed that seed priming played an important role in the field performance of yard long bean (BARI-Borboti 1. Actually treatment $T_5$ (Halo priming 1% $CaCl_2$ at 12 hrs) showed better field performance.

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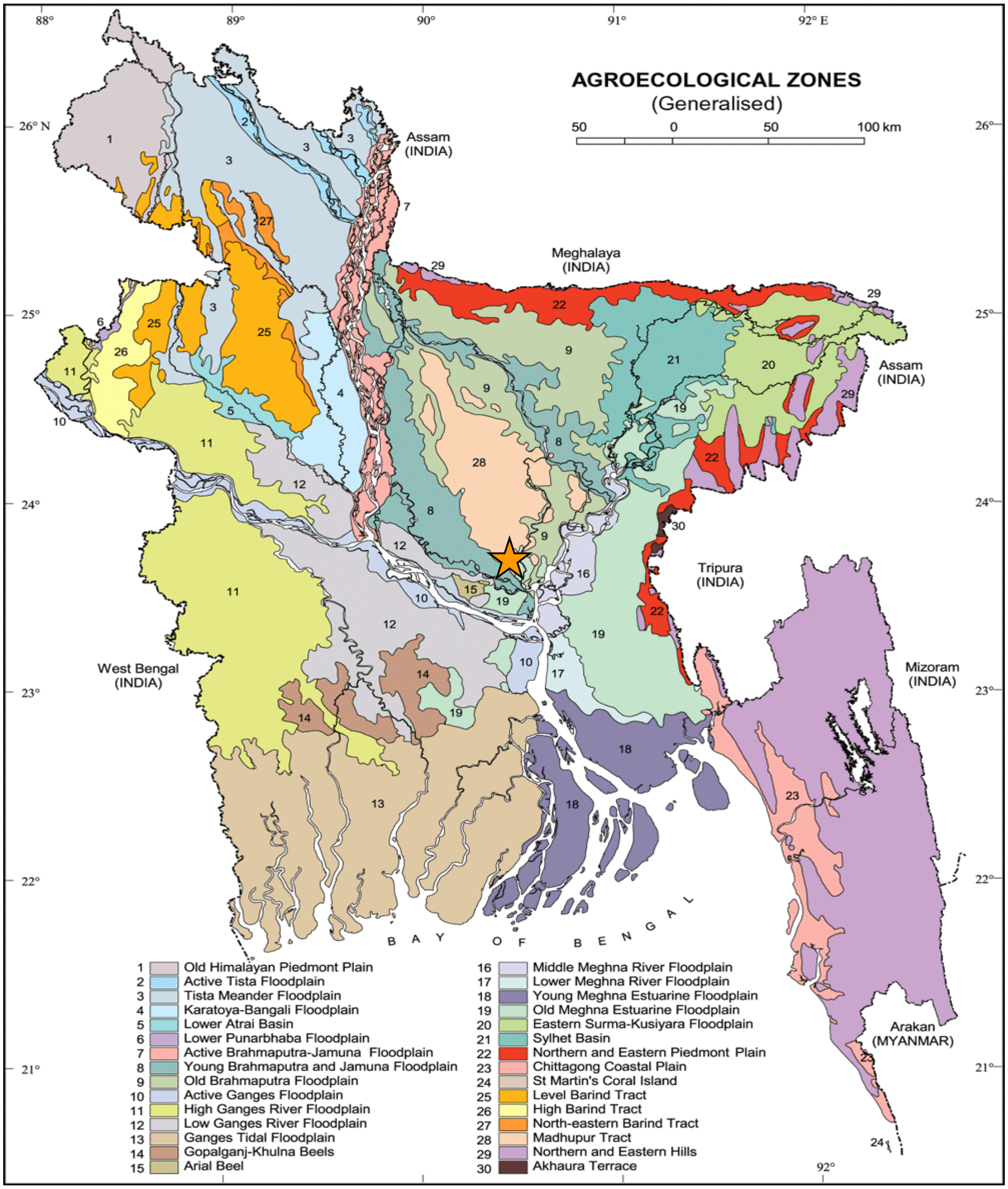
# APPENDICES

## Appendix I. Map showing the experimental sites under study




**The experimental site under study**

**Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from March 2017 to June 2017.**

| Month | Air temperature ($^0C$) | | Relative humidity (%) | Total rainfall (mm) | Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| March, 2017 | 32.5 | 20.4 | 64 | 65.8 | 5.2 |
| April, 2017 | 38.9 | 23.6 | 70 | 76.4 | 5.7 |
| May, 2017 | 40.5 | 24.5 | 75 | 80.6 | 5.8 |
| June, 2017 | 42 | 24 | 77 | 85.4 | 5.8 |

**Source**: Sher-e-Bangla Agricultural University Weather Station

**Appendix III. Analysis of Variance on Germination Percentage of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 7764.103 | 647.009 | 2.934 | 0.010 |
| Error | 26 | 5733.333 | 220.513 | | |
| Total | 38 | 13497.436 | | | |

**Appendix IV. Analysis of Variance on Speed of Germination of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 88.996 | 7.416 | 3.641 | 0.003 |
| Error | 26 | 52.966 | 2.037 | | |
| Total | 38 | 141.962 | | | |

**Appendix V. Analysis of Variance on Vigor Index of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 2895956.271 | 241329.689 | 3.299 | 0.005 |
| Error | 26 | 1901866.820 | 73148.724 | | |
| Total | 38 | 4797823.091 | | | |

**Appendix VI. Analysis of Variance on Seedling Length of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 99.806 | 8.317 | 0.678 | 0.757 |
| Error | 26 | 319.015 | 12.270 | | |
| Total | 38 | 418.821 | | | |

**Appendix VII. Analysis of Variance on Shoot Length of Seedling of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 14.929 | 1.244 | 0.748 | 0.694 |
| Error | 26 | 43.254 | 1.664 | | |
| Total | 38 | 58.183 | | | |

**Appendix VIII. Analysis of Variance on Root Length of Seedling of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 86.456 | 7.205 | 1.187 | 0.342 |
| Error | 26 | 157.800 | 6.069 | | |
| Total | 38 | 244.256 | | | |

**Appendix IX. Analysis of Variance on Fresh Weight of Seedling of Yard Long Bean (BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 3.037 | .253 | 7.160 | 0.000 |
| Error | 26 | .919 | .035 | | |
| Total | 38 | 3.957 | | | |

**Appendix X. Analysis of Variance on Dry Weight of Seedling of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | .071 | .006 | 2.101 | 0.055 |
| Error | 26 | .073 | .003 | | |
| Total | 38 | .144 | | | |

**Appendix XI. Analysis of Variance on Branch Number per plant of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 36.254 | 3.021 | 2.150 | 0.050 |
| Error | 26 | 36.533 | 1.405 | | |
| Total | 38 | 72.788 | | | |

**Appendix XII. Analysis of Variance on First Flowering of Yard Long Bean (BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 299.744 | 24.979 | 4.510 | 0.001 |
| Error | 26 | 144.000 | 5.538 | | |
| Total | 38 | 443.744 | | | |

**Appendix XIII. Analysis of Variance on Pod Length of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 512.872 | 42.739 | 1.084 | 0.412 |
| Error | 26 | 1025.523 | 39.443 | | |
| Total | 38 | 1538.395 | | | |

**Appendix XIV. Analysis of Variance on Pod Weight of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 508.966 | 42.414 | 3.070 | 0.008 |
| Error | 26 | 359.247 | 13.817 | | |
| Total | 38 | 868.213 | | | |

**Appendix XV. Analysis of Variance on Total Pod Number Per Plant of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 10552.103 | 879.342 | 20.873 | 0.000 |
| Error | 26 | 1095.333 | 42.128 | | |
| Total | 38 | 11647.436 | | | |

**Appendix XVI. Analysis of Variance on Yield Per Plant of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 4517118.021 | 376426.502 | 9.209 | 0.000 |
| Error | 26 | 1062721.256 | 40873.894 | | |
| Total | 38 | 5579839.277 | | | |

**Appendix XVII. Analysis of Variance on 100 Seed Weight of Yard Long Bean ( BARI Borboti-1)**

| Source of Variance | df | Sum of Squares | Mean Square | F value | P value |
|---|---|---|---|---|---|
| Treatment | 12 | 120.470 | 10.039 | 4.079 | 0.001 |
| Error | 26 | 63.993 | 2.461 | | |
| Total | 38 | 184.464 | | | |