INFLUENCE OF SEED PRIMING ON EMERGENCE AND YIELD OF WHEAT

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INFLUENCE OF SEED PRIMING ON EMERGENCE AND YIELD OF WHEAT

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CERTIFICATE

*This is to certify that the thesis entitled, " **INFLUENCE OF SEED PRIMING ON EMERGENCE AND YIELD OF WHEAT** " submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **NIBEDITA CHAKMA**, Registration No. **07-02574** 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:
Place: Dhaka, Bangladesh

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INFLUENCE OF SEED PRIMING ON EMERGENCE AND YIELD

OF WHEAT

ABSTRACT

The experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka from November, 2012 to March, 2013 to find out the effect of seed priming on two varieties of wheat. The experiment was conducted in split plot design with three replications. The experiment consisted of 10 different treatments i.e. P_1: no priming, P_2:3 hrs priming, P_3: 6 hrs priming, P_4: 9 hrs priming, P_5: 12 hrs priming & V_1: BARI Gom- 25, V_2 : BARI Gom-26 . So, the treatment combinations were 1. V_1P_1 : No priming of BARI Gom-25, 2. V_1P_2 : 3 hr priming of BARI Gom-25, 3.V_1P : 6 hr priming of BARI Gom-25, 4.V_1P_4: 9 hr priming of BARI Gom-25, 5.V_1P_5 :12 hr priming of BARI Gom-25, 6. V_2P_1 : No priming of BARI Gom-26, 7. V_2P_2 : 3 hr priming of BARI Gom-26, 8. V_2P_3 : 6 hr priming of BARI Gom-26, 9. V_2P_4 : 9 hr priming of BARI Gom-26, 10. V_2P_5 : 12 hr priming of BARI Gom-26. Results revealed that emergence rate of seedling both at 10 days after sowing and 15 days after sowing was found the highest at 9 hrs priming and lowest at no priming but in case of variety emergence rate was insignificant. In interaction both BARI Gom-25 and BARI Gom-26 gave higher emergence rate at 9 hrs priming and lower was also found at no priming with both the varieties. The highest LAI (7.28) at 60 days after sowing was observed at 9 hrs priming which was statistically similar with 6 hrs priming (7.01). The lowest LAI was at no priming (5.00). The highest number of effective tillers were recorded when seeds were primed for 9 hrs (37.67) and the lowest was recorded at no priming (32.83). Opposite result was recorded in case of ineffective tiller. The grain and straw yield for both the varieties showed statistically similar but the highest result at 9 hrs priming and lowest was recorded when both were not primed. Thousand grain weight was the highest at 9 hrs priming of BARI Gom-25 (49.82 g) and the lowest at no priming of BARI Gom-26 (38.64 g). It appeared from the above results that, the two varieties had no significant effect on emergence, growth and yield but priming showed significant result in all the cases where P_4 (9 hrs priming) showed superior performance. Hence irrespective of variety 9 hrs priming showed better emergence and yield of wheat.

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CHAPTER-I

INTRODUCTION

Wheat (*Triticum* spp.) is a cereal grain, originally from the Levant region of the Near East but now cultivated worldwide. In 2013, world production of wheat was 713 million tons, making it the third most-produced cereal after maize (1,016 million tons) and rice (745 million tons)(Weekipedia). Wheat was the second most-produced cereal in 2009; world production in that year was 682 million tons, after maize (817 million tons), and with rice as a close third (679 million tons) (Weekipedia)**.** It is the most important cereal crop in the world as well as in Bangladesh that provides about 20 % of total food calories. About two third of the total world's population consume wheat as staple food (Majumder, 1991). It contains carbohydrate (78.1%), protein (14.7%), minerals (2.1%), fat (2.1%) and considerable proportion of vitamins (Peterson, 1965). The crop is grown under different environmental condition ranging from humid to arid, subtropical to temperate zone (Saari, 1998).

In Bangladesh, wheat covers 42,9,607 hectares of land with an annual production of 12,54,778 metric tons (BBS, 2013-14). In the Market Year 2012-13 Bangladesh wheat crop (planted in November/December and harvested in March/April) is estimated at 1.15 million tons from 410,000 hectares of land (BGFA, 2013). While wheat area has increased in response to high prices, the growing scarcity of water for irrigation has prompted farmers to shift some Boro rice growing areas to wheat. While wheat only accounts for about 12 % of total cereal consumption, it is the second most important staple food in Bangladesh after rice. The wheat growing season overlaps with Boro rice and other remunerative crops like corn, potato, and winter vegetables. However, wheat cultivation remains a preferred option particularly for non-irrigated land with low input -use.

Though wheat is an important cereal crop in Bangladesh, the average yield is very low compared to that of the advanced countries. In order to meet the ongoing food deficit and to cope with the food demand for the increasing population, wheat production needs to be increased in Bangladesh. The scope of increasing the cultivated land is limited in Bangladesh due to occupation of land for accommodating the ever growing population. So, the only way to meet the food demand is to increase the total production as yield per unit area.

Germination and seedling establishment are critical stages in the plant life cycle and can contribute in increasing total crop production. Once sown, seeds spend a great deal of time just absorbing water from the soil. If this time is minimised by soaking seeds in water before sowing (seed priming), seed germination and seedling emergence is more rapid. It also causes higher seedling establishment. The three early phases of germination are: (i) imbibition, (ii) lag phase, and (iii) protrusion of the radical through the testa (Simon, 1984). Priming is a procedure that partially hydrates seed, followed by drying of seed, so that germination processes begin, but radicle emergence does not occur. Methods of seed priming have been described in detail by Bradford (1986) and Khan (1992) and include soaking seed in water or osmotic solution, and intermixture with porous matrix material. There are reports that hydration of seed up to, but not exceeding, the lag phase with priming permits early DNA replication (Bray *et al*., 1989), increased RNA and protein synthesis (Fu *et al*., 1988; Ibrahim *et al*., 1983), greater ATP availability (Mazor *et al*., 1984), faster embryo growth (Dahal *et al*., 1990), repair of deteriorated seed parts (Karssen *et al*., 1989; Saha *et al*., 1990), and reduced leakage of metabolites (Styer and Cantliffe, 1983) compared with checks. Priming of wheat seed in osmoticum or water may improve germination and emergence (Ashraf and Abu-Shakra, 1978) and promote vigorous root growth (Carceller and Soriano 1972). Harris (1996) demonstrated that simply soaking seeds in plain water before sowing could increase the speed and homogeneity of germination and emergence, leading to better crop stands, and stimulated seedlings to grow much more vigorously. Hydro priming, a simple hydration technique to a point of pre germination metabolisms without actual germination (Farooq *et al*., 2009), is one of the most pragmatic, simple, economic and short-term approaches to combat the effects of drought (Kaya *et al*., 2006) and other abiotic stresses (Jafar *et al*., 2012) on seedling emergence and crop establishment. Hydro primed seeds usually have early, higher and synchronized germination owing to reduction in the lag time of imbibitions otherwise required much time (Brocklehurst and Dearman, 2008) and build-up of germination enhancing metabolites (Farooq *et al*., 2006). Preliminary research has also identified a number of opportunities for priming to be used as a vehicle to introduce bio fertilizers, micronutrients and crop protection agents into seeds. Studies also suggested that it is possible to prime seeds with small amount of phosphate to good effect in the early root growth is stimulated allowing more effective uptake of available P in the soil (Johanson *et al*., 2004). Rajpar *et al*., (2006) reported that hydro-priming improved wheat yield under non-saline conditions. Good establishment increases competitiveness against weeds, increases tolerance to abiotic stress especially dry spells and ultimately maximizes the yields (Clark *et al*., 2001). Direct benefits due to seed priming includes, faster emergence, better and more uniform stands, more vigorous plants, better drought tolerance, earlier flowering and higher grain yield in many crops (Harris *et al*., 1999; Harris and Hollington, 2001).

An attempt, was therefore, desired to undertake a study on the influence of seed priming on emergence, growth and yield of wheat with the following objective:

1. To find out the effect of variety on emergence and yield of wheat.
2. To find out the effect of seed priming on emergence and yield of wheat.
3. To find out the interaction between varieties and seed priming on emergence and yield of wheat.

CHAPTER-II
REVIEW OF LITERATURE

Wheat is an important cereal crop throughout the world. In Bangladesh wheat is competing with Boro rice because of similar growing season. People are interested to grow boro rice instead of wheat because of higher production where there is no scarcity of water but water scarcity is becoming one of the major problems of Bangladesh. In regions where water is scarce people have to grow wheat as it requires much less water than boro rice. Priming of seeds can reduce the water requirement and increase total productivity of crops. Very few research works related to growth, yield and development of wheat varieties when they are primed have been carried out in Bangladesh. However, some research related to the use of different types of seed priming in different crops and effect of using different varieties have so far been done at home and abroad have been reviewed in this chapter under the following heads.

2.1 Effect of Seed Priming

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.

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 ($p\leq0.05$) 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.

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^{0}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-1.6MPa), 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.

Menon *et al*. (2013) conducted an experiment on seed priming with boron to observe the efficacy of priming on germination and growth related attributes of the broccoli seedlings. Broccoli seeds (cultivar Marathon) of SAKATA Seed Company were soaked in boric acid solution at 0.01, 0.05, 0.5 and 1% (w/v) for 18 hours. Seeds were also soaked in distilled water (hydropriming) and unprimed seeds were taken as control. The results showed that Germination percentage (GP), Mean germination time (MGT), Germination index (GI), Seedling vigor index (SVI), Chlorophyll content, Shoot and root related attributes were significantly influenced by primed seeds as compared to unprimed seeds. The highest germination index (6.289), seedling vigor index (1753.3), chlorophyll content (4.137 mg ml^{-1}) and less mean germination time (3.23 days), maximum length of shoot (5.97 cm), root (11.57 cm), weight of the shoot (15.35 g) and root (2.68 g) were observed from the treatment where seeds were primed with boron solution at the lowest concentration of 0.01%.

Miraj *et al*. (2013) set a field experiment to assess the effect of different phosphorus priming sources on seedling growth and yield of maize. Phosphorus concentration (1% P), using potassium dihydrogen phosphate (KH_2PO_4), single super phosphate (SSP) and di-ammonium phosphate (DAP) along with amended solutions of SSP (20 g l-1 KOH, 15 g l-1 NaOH and 12.5 g l-1 Na_2CO_3) were included in the experiment. Water primed and non primed seeds were also used as controls. Seeds were primed for 16 h and were then air-dried for 30 minutes. The nutrient uptake of seedling was increased four times due to 1 % P solution priming with KH_2PO_4. Yield of maize was also increased in response to P priming showing significant results in cobs yield, grain and straw yields. Phosphorus content of grain was also enhanced as compared to control. Priming maize with SSP + 20 g l-1 KOH showed almost the same effect as that of KH_2PO_4.

Dorna *et al*. (2013) reported that when primed and non-primed onion seeds stored in air-tight plastic containers for 6 and 12 months at 4 and 20°C the number of seeds infested with *Botrytis* spp. significantly decreased after priming and storage, especially at 20°C.

Shabbir *et al*. (2013) conducted a field experiment to investigate the effect of different seed priming agents on growth, yield and oil contents of fennel during winter 2010-11. Priming techniques used in the experiment were hydropriming with distilled water, osmopriming with $CaCl_2$ (2.2%), KCl (2.2%), moringa leaf extract (3.3%), salicylic acid (50ppm) and ascorbic acid (50ppm). Unprimed seeds were used as control treatment. They found that priming techniques significantly affected the parameters relating to seedling emergence. The $CaCl_2$ and KCl treatments showed exactly similar results for time taken to start seedling emergence (TTSE) as both took minimum TTSE (7 days). Mean emergence time and time taken to 50% seedling emergence were minimum in $CaCl_2$ (2.2%) treatment. Highest final emergence percentage and germination index were also recorded when seeds were primed with $CaCl_2$ (2.2%). The priming techniques also significantly affected the parameters regarding growth and yield (plant height, number of leaves per plant, fresh and dry weight per plant, number of umbels per plant, seeds per umbel, 1000-seed weight, seed yield, biological yield and harvest index). The seed primed with $CaCl_2$ (2.2%) produced the maximum seed yield 492.6 kg ha-^{1} that was at par with KCl treatment.

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 pre-germinating 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.

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 *P*n, 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.

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.

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.

Fabunmi *et al*. (2012) reported that early moisture stress led to significant reduction in seed yield of early maturing cowpea but reduction in growth was more with plants from unprimed seeds under severe moisture stress condition.

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-Sub1 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, 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 ($P \leq 0.05$) 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 ×various 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%, KH_2PO_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 I1 during 2004 and RGR showed the same trend at I1 and I2 during 2003.

Yari *et al*. (2010) conducted an experiment to evaluate the effect of different seed priming techniques on germination and early growth of two wheat cultivars (Azar-2 and Sardari 101) at the Seed and Plant Certification and Registration Research Institute, Karaj, Iran. Seeds were primed for 12, 24 and 36 hours at three temperature (20, 23 and 28°C) in seven priming media (Poly ethylene glycol (PEG_{6000}) 10%, PEG 20%, KCl 2%, KCl 4%, KH_2PO_4 0.5%, KH_2PO_4 1% and distilled water as control).Among them the maximum seed germination percentage in cv.Azar-2 was observed when the seeds primed by PEG 20% for 12h and at 20°C. The most stem length was obtained for seeds osmoprimed with PEG 10% for 24h. Osmoprimed seeds with PEG 20% for 24h produced maximum radicle length of cv. Sardari. Maximum vigor index (VI) of cv. Azar-2 was obtained from seeds primed with KH_2PO_4 0.5% while the lowest germination percent, speed of germination and VI were observed in seeds which subjected to KCl 4% solution. Speed of germination was improved when the seed soaked water and PEG 10%. The most germination percent, VI and speed of germination were observed on 12h.

Tzortzakis (2009) noted that halopriming (KNO3) or growth regulators (gibberelic acid; GA3) improved the rate of germination of endive and chicory and reduced the mean germination time needed. 30 min pre-sowing treatment with NaHClO3, methyl jasmonate and dictamus essential oil decreased seed germination as well as seed radicle length *in vitro*. 6 benzylaminopurine (BAP) or NaHClO3 treatment reduced plant growth. He suggested that KNO3 and secondly GA3 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 KNO3) on seed vigour of hot pepper cv. They found that all priming treatments significantly improved seed performance over the control. KNO3 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.

2.2 Effect of Variety

Alam (2013) conducted an experiment on growth and yield potentials of wheat as affected by management practices. He used four wheat varieties namely Protiva, Sourav, Shatabdi ,Prodip and two planting methods. He found that among the varieties Prodip showed better performance in bed planting system .

Hossain *et al*. (2013) carried out a field experiment on evaluation of growth, yield, relative performance and heat susceptibility of eight wheat (*Triticum aestivum* L.) genotypes grown under heat stress using varieties namely Prodip, Shatabdi ,Sufi ,Bijoy ,Gourab, Sourav, BARI Gom-25 and BARI Gom-26. They reported that BARI Gom-26,Shatabdi and Sufi have the greatest potential to be used as high-yielding wheat genotypes under warm to hot environments and could be used in a breeding programme to develop heat-tolerant wheat.

Al-Musa *et al*. (2012) noted that among the BARI varieties, BARI Gom-26 produced greater germination (61.00%) at 13 days judge against to other varieties. The taller plant (47.91 cm), higher LAI (1.84), maximum TDM (17.37 g plant-1) and effective tillers hill-1 (18.08) were also obtained with the similar variety. BARI ghom-26 was also most effective to produce the maximum grains spike-1 (38.52), higher weight of 1000-grains (49.38 g), higher grain (3.35 t ha-1) and straw (8.50 g plant-1) yield and greater HI (4.03%). So, the variety BARI Gom-26 produced the outstanding superiority among the varieties.

Rahman *et al.*(2010) conducted an experiment on the effect of variety and cultural method on the yield and yield attributes of wheat using four varieties viz. Kanchan, Protiva, Gourab and Shatabdi and two culture methods. They found that the different varieties significantly influenced the grain yield, straw yield, number of tillers plant^{-1}, number of effective tillers plant^{-1}, number of filled grains spike^{-1} and 1000 grain weight. The variety Shatabdi produced the highest grain yield (2.94 t ha^{-1}) and Kanchan produced the lowest grain yield (1.44 t ha^{-1}).

Rahman *et al.*(2009) conducted an experiment on growth and yield components of wheat genotypes exposed to high temperature stress under control environment with ten wheat genotypes. Among the ten genotypes three were characterized as high temperature tolerant based on their relative performance in yield components, grain yield and heat susceptibility index.

Tahir *et al.*(2008) reported that Inqlab-91 respond more to K level than Ufaq-2002 in field experiment at Faisalabad, Pakistan conducted during Nov. 2005

Maikstenience *et al*. (2006) carried out a field experiment at the Lithuanian Institute of Agriculture's Joniskelis Experimental Station in 2004-2005 to estimate the changes in productivity and quality indicators of winter wheat (Triticum aestivum) varieties differing in genetic characteristics as affected by various nitrogen rates applied in the form of urea solution at different ripening stages of cereals. The tests involved the following winter wheat varieties: Ada and Bussard (with very good food qualities), Lars and Tauras (with good food qualities) and Seda (with satisfactory food qualities). In that experiment it was found that higher grain yield (11.0t ha^{-1}) was produced by the varieties Lars, Tauras and Seda compared with Ada and Bussard.

Jalleta (2004) conducted an experiment in farmers' level with a number of improved bread wheat varieties for production in the different climatic zones. Farmers identified earliness, yield and quality as the main criteria for adaptation of wheat varieties and they also found that the variety HAR- 710 gave 2.56 t ha^{-1} and PAVON -76 gave 2.49 t ha^{-1}.

Sulewska (2004) carried out and experiment with 22 wheat genotypes for comparing vegetation period, plant height, number of stems and spikes, yield per spike and plant, resistance to powdery mildew and brown rust. He found a greater variability of plant and spike productively and of other morphological characters and he also reported that the variety Waggershauser Hohenh Weisser Kolben gave the highest economic value among the tested genotypes.

BARI (2004) tested different varieties of wheat and found Shatabdi produced highest yield (2.72 t ha^{-1}) followed by Gourab (2.66 t ha^{-1}) and lowest yield was produced by Kanchan (2.52 t ha^{-1})).

BARI (2003) Conducted an experiment in Wheat Research Centre at Nashipur, Dinajpur, tested some varietal performance in Rajshahi and found that Shatabdi produced highest (3.2 t ha^{-1}) followed by Gourab (3.13 t ha^{-1}) and lowest yield produced by Kanchan (2.96 t ha^{-1})

WRC (2003) conducted an experiment in the Heat Tolerant Screening Nursery in Barisal region with 50 advance lines/varieties. From following by E50 (3.94 t ha^{-1}), BAW 1048 (3.85 t ha^{-1}), BAW 1021 3.64 t ha^{-1}), BAW 1024 (3.6 t ha^{-1}), E45 (3.58 t ha^{-1}). Among the varieties produced by BARI (WRC) Protiva produced highest yield (2.97 t ha^{-1}).

WRC (2003) conducted an experiment in the Wheat Research Centre at Nashipur, Dinajpur to see the performance of genotypes among various tillage operations and to understand the effects of interaction between genotypes and tillage operations. Two cultivation methods bed and conventionally tilled flat were in the main plot and 10 wheat genotypes (Kanchan, Gourab, Shatabdi, Shourav, BAW 1008, BAW 1006, BAW 1004, BAW 969, BAW 968 and BAW 96) were tested in sub plots. The genotypes showed a wide range of variation for yield and related characters. Under bed condition, all the genotypes significantly produced higher grain yield except Gourab and shourav. Variety Shatabdi produced maximum grain spike $^{-1}$ and 1000- grain weight under both tillage operations. Among the varieties Shatabdi showed good stability for grain yields (5.40 t ha^{-1} in bed 5.0 t ha^{-1} in conventional methods).

Hussain *et al*. (2002) reported that among three varieties (Inqulab-91, Kharchia and Parwaz-94) Inqulab-91gives the highest results in case of grain yield, no. of fertile tiller, no. of grain/ spike and thousand grain wt.

Gwal *et al*. (1999) worked with four varieties of wheat sown in December at Sehore, Madhyha Pradesh, fertilized with 0-0-0, 60-30-30, 120-60-60 or 180-90-90kg N-P2O5- K2 O5 ha^{-1}, respectively. Averaged from the varieties, plant height, number of tillers plant $^{-1}$, spike length, grain protein content, grain yield and straw yield increased with NPK rate. Grain yield averaged 6.79, 9.98, 9.99 and 5.47 t ha^{-1} in cv. Lok -1, HD- 2236, WH- 147 and Raj- 1555 respectively.

Zhu *et al*. (1999) conducted and experiment with 100 varieties of wheat in zhejianf since 1954 and 27 of these have been grown over 34000 ha. Yields have increased greatly as a result of selective breeding. In 1990 mean production was 1.6 tha^{-1}, 1.4 times higher than in 1959. In 1994 production was 2.52 t ha-1 57% higher than in 1970, while in 1997 it reached 2.94t ha-1. Varieties have also been selected for quality as well as yield improvement.

Srivastava *et al*. (1998) conducted an experiment in India with nine wheat varieties, promising for rain fed conditions, together with their 36 f1, hybrids using a randomized block design with four replications. Observations were recorded on vegetative growth period, grain development period, flag leaf area (cm2), Spikelets $spike^{-1}$ and grain yield plant $^{-1}$. The genotypes were grouped into 10 clusters. Promising crosses for rainfed conditions were WL 2265X P20302, CPAN 1992 X P20302, WL2265X HDR 87 and WL 2265X CPAN 1992.

Litvinchko *et al*. (1997) reported that winter wheat with high grain quality for bread making is produced in Southern Ukraine. Wheat breeding began more than 80 years ago. Over this time, seven wheat varieties were selected where yield potential increased from 2.73 to 6.74 t ha^{-1} . This increase was due to a decrease in photoperiodic sensitivity and the introduction of semi dwarf genes. Genes for photoperiodic sensitivity and vernalization requirement were combined and the effect of these genes on grain yield, frost and drought resistance and growth and development rate of plant in autumn and early spring were studied.

Srinivas *et al*. (1997) studied 3 levels of nitrogen (80,120 and 160 kg ha^{-1}) and three wheat cultivars (HD-4502, HD-2189 and HD-2281 to study the response of wheat to dry matter production and noticed that HD 2189 gave the highest dry matter.

Arabinda *et al*. (1994) observed that the grain yield was significantly affected by different varieties in Bangladesh. The genotypes CB-15 produced higher grain yield (3.7 ha^{-1}) due to more number of spikes m^{-2} and grains $spike^{-1}$. Samson *et al*. (1995) reported that among the different varieties the significant highest grain yield 3.5ha^{-1} was produced by the variety Sawghat which was closely followed by the variety BAW-748. Other four varieties namely, Sonalika, CB- 84, Kanchan and Seri-82 yielded 2.70, 2.83, 3.08 and 3.15t ha^{-1} respectively.

Jahiruddin and Hossain (1994) observed that 1000-grain weight varied among the three varieties of wheat e.g. Sonalika, Kanchan and Aghrani.

Bakhshi *et al*. (1992) conducted field experiments at Ludhiana, Punjab with eight bread wheat and seven durum wheat varieties sown on 1 or 15 Nov. or 15 Dec., and given 0, 40, 80 or 120 kg N ha^{-1} with one or two irrigation. Grain yield was highest when wheat was sown on 1 Nov with 120kg N ha^{-1} and two irrigations. Varieties Raj 3037, HD- 4594, WL- 711 and WH-841 gave the highest grain yield.

CHAPTER-III
MATERIALS AND METHODS

A field experiment was conducted at Agronomy field of Sher-e-Bangla Agricultural University to find out the effect of seed priming on emergence, growth, yield & other crop characteristics of two wheat varieties. 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 Experiment site

The experimental field was located at 90.335^0 E longitude and 23.774^0 N latitude at an altitude of 8.6 meters above the mean sea level.

3.2 Climate and weather

The climate was subtropical with low temperature and minimum rainfall during December to March that was the main feature of the *rabi* season. The annual precipitation of the site was around 2200 mm and potential evapotranspiration was 1300 mm. The average maximum temperature was 30.34^0C and average minimum temperature was 21.21^0C. The average mean temperature was 25.17^0C. The experiment was done during the *rabi* season. Temperature during the cropping period ranged between 11.10^0C to 34.8^0C. The humidity varies from 55% to 79%. The day length was 10.5-11.0 hours only and there was no rainfall from the beginning of the experiment to harvesting.

3.3 Soil

The soil of the experimental field belongs to the Tejgaon soil series of the Madhupur Tract (AEZ-28). The general soil type of the experimental field was *Deep Red Brown Terrace* Soil. Topsoil was silty clay loam in texture. Organic matter content was very low (1.34 %) and soil pH varies from 5.8 – 6. The land was above flood level and well drained. The initial morphological, physical and chemical characteristics of soil are presented in Appendix II.

3.4 Crop/planting material

Two varieties of wheat seeds were used in this experiment (BARI Gom-25 & BARI Gom-26). Seeds were collected from seed technology division of Bangladesh Agricultural Research Institute.

3.4.1 Description of the wheat varieties

3.4.1.1 BARI Gom-25

BARI Gom-25 is a modern wheat variety released by Wheat Research Centre, BARI in 2010. The variety is semi-dwarf, early maturing and high yielding. Leaves are deep green and broad. It takes 57-61 days to heading. Spikes are long with 45-55 grains per spike. Grains are amber in colour, bright and larger in size (Thousand grain weight 54-58g). It shows moderate level of tolerance to heat stress giving 6-10% higher yield than Shatabdi under late seeding. There are very few hairs in the upper culm node. Glaucosity in the spike, culm and flag leaf sheath is medium dense. The shoulder of the lower glume of the spikelet is narrow and sloppy with short break (< 5.0 mm) with numerous spines. Sowing time November15-30, Harvesting time March-April. Crop duration is 102-110 days. It can be grown under both optimum and late seeding conditions.Specially suitable for growing well in southern region having salinity level of 8-10 dS/m at seedling stage. Highly tolerant to *Bipolaris* leaf blight and resistant to leaf rust diseases.

3.4.1.2 BARI Gom-26

BARI Gom-26 is a hybrid wheat varity released by Wheat Research Centre, BARI in March 2010. BARI Gom-26 commonly known as Hashi, and previously called

BAW 1064 has CIMMYT parental lines in its pedigree, fairly good resistance against variants of Ug99, and impressive agronomic performance. The variety is also tolerant to drought and suitable for late planting after harvesting of Aman rice. Leaves are deep green and broad. Height of plant having five to six tillers is 92-96 cm. It takes 60-63 days to heading and about 104-110 days to ripening. Under favourable condition yield is about 3.5-4.5 t/ha and for late sowing yield is about 10-12% higher than shatabdi. This variety is highly tolerant to *Bipolaris* leaf blight and resistant to leaf rust diseases.

3.5 Methods and treatments of the experiment

3.5.1 Methods

There were two factors viz., A. variety and B. seed priming. There were two varieties which were considered as 2 levels and seed priming at 3hrs, 6hrs, 9hrs, 12hrs and no priming i.e., 5 levels. Thus there were 10 treatment combinations. The experiment was laid out in split plot design with three replications where variety was assigned in the main plot and seed priming in sub-plots. Water was used as a media of seed priming. Similar amount of seeds for both varieties per plot was soaked in water for different durations as per treatment and removed from the water about 30 minutes before sowing.

3.5.2 Treatments

A. Variety Levels (2):

1. BARI Gom-25 (V_1)
2. BARI Gom-26 (V_2)

B. Seed priming (5):

1. No priming (P_1)
2. 3 hrs priming (P_2)
3. 6 hrs priming (P_3)
4. 9 hrs priming (P_4)
5. 12 hrs priming (P_5)

Thus the treatment combinations were :

V_1P_1 = BARI Gom- 25 with no priming

V_1P_2 = BARI Gom-25 with 3 hrs priming

V_1P_3 = BARI Gom-25 with 6 hrs priming

V_1P_4= BARI Gom-25 with 9 hrs priming

V_1P_5 = BARI Gom-25 with 12 hrs priming

V_2P_1 = BARI Gom-26 with no priming

V_2P_2 = BARI Gom-26 with 3 hrs priming

V_2P_3 = BARI Gom-26 with 6 hrs priming

V_2P_4 = BARI Gom-26 with 9 hrs priming

V_2P_5 = BARI Gom-26 with 12 hrs priming

3.6 Details of the field operations

The cultural operations that were carried out during the experimentation were presented below.

3.6.1 Land preparation

The experimental field was first ploughed on 10 November 2012. The land was ploughed thoroughly with a power tiller and then laddering was done to obtain a desirable tilth. The clods of the land were hammered to make the soil into small pieces. Weeds, stubbles and crop residues were cleaned from the land. The final ploughing and land preparation was done on 13 November 2012. The layout was done as per experimental design on 13 November 2012.

3.6.2 Fertilizer application

Fertilizers were applied at the rate of 100, 80, 25 and 20 kg ha^{-1} of NPK and S, respectively and 5 t ha^{-1} cowdung. The $2/3^{rd}$ urea and whole amount of other fertilizers were applied as basal dose during last ploughing and rest $1/3^{rd}$ urea was applied at crown root initiation stage (21 DAS) followed by an irrigation.

3.6.3 Seed treatment and sowing

Seeds were treated with Vitavax 200 @ 3 g kg^{-1} of seeds and sown in line on 16 November 2012 as per treatments. The recommended seed rates (120 kg ha^{-1}) of wheat variety was used. The seeds were placed in 20 cm apart lines as per treatments. After that the seeds were covered with loose friable soil.

3.7 Intercultural operations

3.7.1 Weeding

Weeds were controlled through two weedings at 11 December 2012, and 31 December 2012 just 25 and 45 days after sowing (DAS) i.e., with an interval of 21 days two weeding were done. The weeds identified were Kakpaya ghash (*Dactyloctenium aegyptium* L), Shama (*Echinochloa crussgalli*), Durba (*Cynodon dactylon*), Arail (*Leersia hexandra*), Mutha (*Cyperus rotundus* L), Bathua (*Chenopodiunm album*), Shaknatey (*Amaranthus viridis*), Foska begun (*Physalis beteophylls*), Titabegun (*Solanum torvum*) and Shetlomi (*Gnaphalium luteolabum* L) etc.

3.7.2 Irrigation

No irrigation were applied before emergence of the seedling. After emergence three irrigations were given at crown root initiation (20 DAS), maximum tillering stage(40 DAS) and heading stages (53 DAS). During irrigation care was taken so that water could not flow from one plot to another or overflow the boundary of the plots. Excess water of the field was drained out.

3.7.3 Harvesting and sampling

At full maturity, the wheat crop was harvested plot wise on 21 March 2013. Initially 10 plants were marked randomly and those plants from each plot were harvested and uprooted. Those were marked with tags, brought to the threshing floor where seeds and straw were separated, cleaned and dried under sun for 4 consecutive days. Crop of each plot was harvested from 5m x1.5m area, separately leaving the border lines to record the seed yield which was converted into t ha^{-1} basis.

3.8 Growth parameters, yield and other attributes

Growth parameters

a)Emergence data

b) Plant height (cm) at 30, 60, 90 DAS and at harvest from preselected 10 plants

c) No. of leaves/tiller at 30, 60, 90 DAS and at harvest from preselected 10 plants

d) No. of tillers/10 preselected plants at 60 and 90 DAS

e) No. of effective tiller/10 preselected plants

f) No. of ineffective tiller/ 10 preselected plants

Yield and other attributes

a) Length of spike

b) Number of spikes m^{-2}

c) Number of spikelets $spike^{-1}$

c) Weight of 1000 grains

d) Filled grains $spike^{-1}$

e) Unfilled grains $spike^{-1}$

f) Grain yield

g) Straw yield

h) Harvest index

i) Shelling %

3.8.1 Emergence

The emergence of the seedlings were counted from 50 cm of a line of every plot leaving first row from the left side of the plot at10 and 15 days after sowing.

3.8.2 Plant height (cm)

The heights of 05 selected plants were measured from the ground level to tip of either top leaf or spike and then averaged. It was taken at 30, 60 and 90 DAS (days after sowing) and at harvest. The plant height was taken from preselected (randomly) five plants from second row of opposite side of the plot from where dry weight was taken.

3.8.3 Number of leaves tiller^{-1}

Number of leaves per tiller were taken from 10 preselected plants at 30, 60 and 90 DAS. Number of leaves were than divided by number of tillers. It was then averaged to express as leaves tiller^{-1}.

3.8.4 Number of tiller/10 preselected plants

Number of tiller from 10 preselected plants were measured at 60 and 90 DAS. The area was selected randomly from 3rd line of each plot. Number of tillers were than averaged to get no. of tiller/10 preselected plants

3.8.5 Number of effective tiller/10 preselected plants

Number of effective tillers from 10 preselected plants were measured at 90 DAS. The area was selected randomly from 3rd line of each plot. Number of effective tillers are than averaged to get no. of effective tiller/10 preselected plants .

3.8.6 Number of ineffective tiller/10 preselected plants

Number of effective tillers from 10 preselected plants were measured at 90 DAS. The area was selected randomly from 3rd line of each plot. Number of effective tillers are than averaged to get no. of ineffective tillers/10 preselected plants .

3.8.7 Length of spike (cm)

Lengths of spike were measured from 10 randomly selected plants at harvest and then averaged. This was taken from at harvest and expressed in cm.

3.8.8 Number of spikes 0.5 linear m^{-1}

The numbers of spikes of 50 cm linear area were recorded from where other datas were collected at 90 DAS. It was than converted to m^{-2} and averaged to get no. of spike/m^{-2}

3.8.9 Number of spikelets spike^{-1}

Ten spikes from the second line of each plot were randomly collected at harvest. Number of spikelets were counted from each spike and averaged.

3.8.10 Weight of thousand grains (g)

One thousand cleaned dried grains were counted randomly from each harvested sample and weighed by using digital electric balance. It was expressed in gram.

3.8.11 Filled grains spike^{-1}

Ten spikes from the second line of each plot were collected at harvest. Number of filled grains spike^{-1} were counted from each spike and averaged.

3.8.12 Unfilled grain spike^{-1}

Ten spikes from the second line of each plot were randomly collected at harvest. Number of unfilled grains spike^{-1} were counted from each spike and averaged.

3.8.13 Grain yield (t ha^{-1})

The crop was harvested randomly from 5 m x 1.5 m area of each plot leaving the border areas. Then the harvested wheat was threshed, cleaned and then sun dried up to a constant moisture level. The dried grains were then weighed and averaged. The grain yield was converted into t ha^{-1} basis.

3.8.14 Straw yield (t ha^{-1})

Wheat was harvested randomly from 5 m x 1.5 m area of each plot. Then, the harvested wheat was threshed, cleaned and sun dried up to constant moisture level.

The dried straw were then weighted and averaged. Then the straw yield was converted into t ha^{-1} basis.

3.8.15 Leaf area index

Leaf area index was determined by counting number of leaves/plant, leaf length & breadth & then multiplying leaf area per m^2 and finally multiply by the constant number 0.75 as below

$$LAI = \frac{Total\ leaf\ area\ m-2}{Ground\ area\ (1m2)} \times 0.75$$

3.8.16 Harvest Index (%)

Harvest index was determined by dividing the economic yield (seed yield) to the biological yield (seed + straw yield) from the same area and then multiplied by 100.

$$\text{Harvest Index(\%)} = \frac{\text{Seed yield (t/ha)}}{\text{Seed yield (t ha}-1) + \text{Straw yield (t ha}-1)} \times 100$$

3.8.17 Shelling Percentage

Shelling percentage was determined by dividing wt. of grain to wt. of grain with shell and than multiplied by 100

$$\text{Shelling Percentage(\%)} = \frac{\text{Grain wt.}}{\text{Grain wt.+Shell wt.}} \times 100$$

3.8.18 Statistical analyses

Data collected from different parameters were compiled and tabulated in proper form. Appropriate statistical analysis was made by MSTATC computer package program and the treatment means were compared by least significance difference (LSD) at 5% level of significance (Gomez and Gomez, 1984).

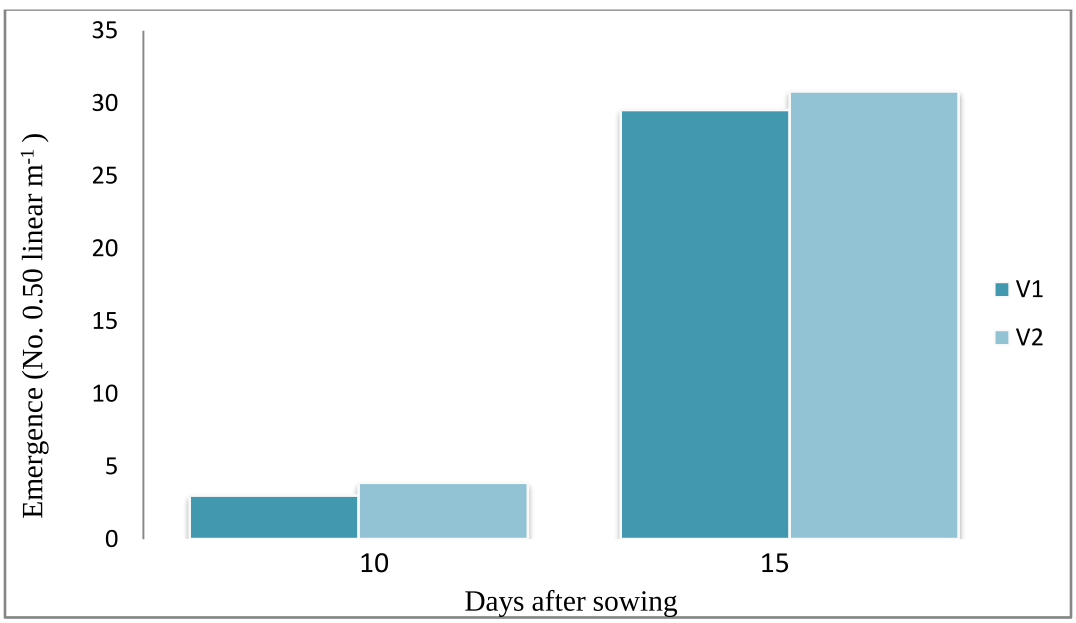
CHAPTER-IV
RESULTS AND DISCUSSION

The present experiment was conducted to study the ‘Influence of seed priming on emergence and yield contributing characters wheat. The analysis of variance data on two wheat varieties, five seed priming techniqcs and their interaction effects has been presented in this chapter. The results have been presented and discussed under the following headings.

4.1 Emergence

4.1.1 Effect of Variety

No statistically significant influence of varieties were recorded for emergence. Emergence data was recorded at 10 DAS & 15 DAS. Between the varieties V_2 that is BARI Gom- 26 gave the highest number of emergence in both cases & V_1 that is BARI Gom -25 gives lower but statistically similar emergence number.(Fig -1)



V_1 : BARI Gom- 25 V_2 : BARI Gom-26

Fig 1. Effect of varieties on emergence of two wheat varieties

4.1.2 Effect of priming

Priming significantly influenced emergence number at both 10 DAS and 15 DAS. At 10 DAS the highest number of emergence (4.50) was recorded at P_4 that is 9 hrs priming and lowest was recorded at no priming (1.33).In case of 15 DAS the highest result (41.67) was observed at 9 hrs priming and lowest was at no priming(23.33).This might be because of primed seeds requires less absorption of water than non primed seeds & germinate much earlier than non primed seeds (Table-1).

Table 1. Effect of priming on emergence (no./0.5 linear m) of wheat seeds

Treatments	Emergence (10DAS)	Emergence (15DAS)
P_1	1.33c	23.33e
P_2	3.67b	25.83d
P_3	4.17a	28.50c
P_4	4.50a	41.67a
P_5	3.50b	31.50b
$LSD_{(0.05)}$	0.37	0.50
CV(%)	8.82	1.35

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

Similar results found by Meena *et al.* (2013) who noted that hydro-primed and pre germinated seeds established earlier than dry seeds leading to better crop establishment under optimum, sub optimum soil moisture as well as dry soil conditions. Ali *et al.* (2013) also reported that seed priming treatments reduced the mean emergence time and promoted germination. Moghanibashi *et al.* (2012) reported that primed seeds produced higher germination rate and percentage

4.1.3 Interaction effect

Interaction of variety and priming showed statistically significant influence on emergence. At 10 DAS the highest emergence (5.00) was recorded at 9 hrs priming of both BARI Gom-25 and BARI Gom 26 and 6 hrs priming of BARI Gom-26.The lowest emergence (0.67) at 10 DAS was observed at no priming of BARI gom-25 (Table-2). At 15 DAS the highest emergence was recorded at 9 hrs priming of BARI Gom 26 (44.67) and the lowest (20.00) was recorded at no priming of BARI Gom-25 (V_1).

Table2. Interaction effect of variety and priming on emergence (no./0.5 linear meter) of wheat seeds

Treatments	Emergence (10DAS)	Emergence (15DAS)
V_1P_1	0.67e	20.00j
V_1P_2	2.33d	21.33i
V_1P_3	4.00b	27.67f
V_1P_4	5.00a	38.67b
V_1P_5	3.00c	34.00d
V_2P_1	2.00d	24.00h
V_2P_2	3.33c	26.67g
V_2P_3	5.00a	35.67c
V_2P_4	5.00a	44.67a
V_2P_5	4.00b	29.00e
$LSD_{(0.05)}$	0.53	0.71
CV(%)	8.82	1.35

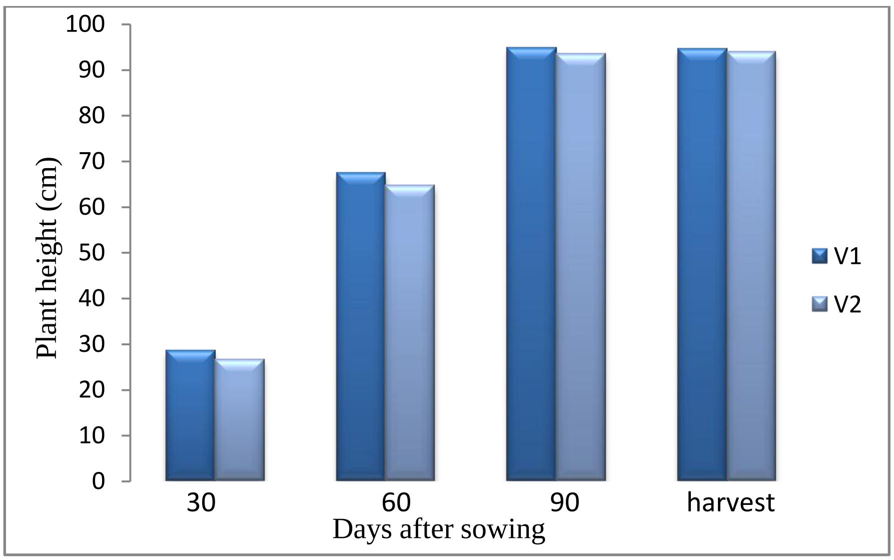
Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 =BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs priming V_2P_5= BARI Gom-26 with 12 hrs priming

Among the treatments 9 hrs priming (P_4) showed highest result with both the two varieties. The result was as per of the work of Giri and Schillinger. (2003) who reported that optimum soaking time for wheat should be less than 12 hrs. Ajirlo *et al.* (2013) reported that germination and early growth conditions improves by seed priming technique. Dastanpoor *et al*. (2013) also noted that hydro priming clearly improved the final germination percentage (FGP) and mean germination time (MGT).

4.2 Plant height

4.2.1 Effect of Variety

In all the cases (30, 60, 90&harvest) the highest plant height was found in BARI Gom-25(V_1) & lower plant height was observed in BARI Gom-26(V_2). This difference was might be due to physiological characteristics of variety (Fig-2).



V_1 : BARI Gom- 25 **V_2 : BARI Gom- 26**

Fig 2 . Effect of varieties on plant height of two wheat varieties LSD(0.05) = 1.8, 2.82, 1.17 & 0.67for 30,60, 90 & harvest respectively

4.2.2 Effect of priming

Nine hrs priming(P_4) gave the highest plant height (28.68 cm) at 30 DAS which was statistically similar to plant height at 6 hrs and 12 hrs seed priming of 27.51cm and 28.61 cm respectively. The lowest plant height was found in case of no priming that was 25.95 cm which was also statistically similar with 3 hrs seed priming (27.15 cm).

At 60 DAS the highest plant height was recorded at 9 hrs seed priming (67.15 cm) which was also statistically similar with plant height at 12 hrs priming (66.67 cm).

The lowest plant height was recorded at no priming (64.75 cm) that was statistically similar with plant height at 3 hrs priming (65.63 cm).

In both 90 DAS and at harvest the highest plant height were recorded at 9 hrs priming (95.44 cm and 96.33 cm respectively). The lowest plant height were recorded at no priming (93.44 cm and 92.17 cm) in both cases but in case of 90 DAS the lowest plant height was also statistically similar with 3 hrs and 6 hrs seed priming that was 93.50 cm and 93.67 cm respectively (Table-3).

Table 3. Effect of priming on plant height (cm) of wheat at different days after sowing

Treatments	30	60	90	Harvest
P_1	25.95c	64.75c	93.44c	92.17d
P_2	27.15bc	65.63bc	93.50c	93.00c
P_3	27.51ab	65.95b	93.67c	94.00bc
P_4	28.68a	67.15a	95.44a	96.33a
P_5	28.61ab	66.67ab	94.56b	94.67b
$LSD_{(0.05)}$	1.204	1.04	0.57	1.12
CV(%)	6.25	11.20	4.01	4.09

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

Plant height at no priming showed the lowest result in all studied durations. It increased with increasing priming duration till 9 hrs and then reduced or nearly statistically similar result was recorded at 12 hrs priming. Similar result was found by Ali *et al.* (2013) who noted that plant height increased when seeds were primed. Fabunmi *et al*. (2012) also found nearly similar result who noted that 6 and 8 hour priming showed some superiority in canopy height in case of cowpea than others.

4.2.3 Interaction effect

In case of interaction of variety and priming the highest plant height at 30 DAS was recorded at BARI Gom- 25 with 9 hrs priming (31.24cm) which was also statistically similar with plant height at 12hrs priming of BARI Gom-25 (29.66 cm). The lowest plant height was found at no priming of BARI Gom-25(25.68cm) which was statistically similar with plant height at no priming, 3 hrs priming and 6 hrs priming of BARI Gom-26 (25.99cm, 26.12cm and 26.23cm) respectively.

At 60 DAS the highest plant height was recorded at 9 hrs priming of BARI gom26 that is 68.500cm which was statistically similar with plant height at 9hrs priming of BARI Gom-25 (68.50cm) and 12 hrs priming of BARI Gom-26(68.08cm). The lowest plant height was recorded at no priming of BARI Gom-25(63.40 cm) ,which was also statistically similar with plant height at 3 hrs priming, 6 hrs priming of BARI Gom-25 and no priming of BARI Gom- 26 (64.3cm,64.33cm and 64.67cm) respectively (Table-4).

The highest plant height both at 90 DAS and at harvest were recorded at 9hrs priming of BARI Gom-25 (95.78cm and 96.667cm) respectively which were statistically similar with plant height at 12 hrs priming of BARI Gom-25 (95.78cm) incase of 90 DAS and 9 hrs priming of BARI Gom-26(96.00cm) in case of plant height at harvest. No priming of BARI Gom-26 seeds gave the lowest plant height (92.78cm) in case of plant height at 90 DAS which was also statistically similar with plant height at 3hrs, 6hrs and 12hrs seed priming of BARI Gom-26 (93.11cm, 93.22cm, 93.22cm) respectively. The lowest plant height at harvest was recorded at no priming of BARI Gom-26(91.67cm)which was also statistically similar with plant height at no priming of BARI Gom-25 (92.67cm) and 3 hrs priming of BARI Gom-26 (93.00cm).

Table 4. Interaction effect of variety and priming on plant height (cm) of wheat at different days after sowing

Treatments	30	60	90	Harvest
V_1P_1	25.68e	63.40e	93.78de	92.67ef
V_1P_2	27.53cd	64.30e	93.78de	94.00cde
V_1P_3	28.31bc	64.33e	94.56cd	94.00cde
V_1P_4	31.20a	68.50a	95.89a	96.67a
V_1P_5	29.66ab	64.83de	95.78ab	95.00bc
V_2P_1	25.99de	64.67e	92.78f	91.67f
V_2P_2	26.12de	66.22cd	93.11ef	93.00def
V_2P_3	26.23de	66.97bc	93.22ef	94.00cde
V_2P_4	27.56cd	69.00a	95.00bc	96.00ab
V_2P_5	27.49cd	68.08ab	93.22ef	94.33cd
$LSD_{(0.05)}$	1.70	1.48	0.81	1.58
CV(%)	6.25	11.20	4.01	4.09

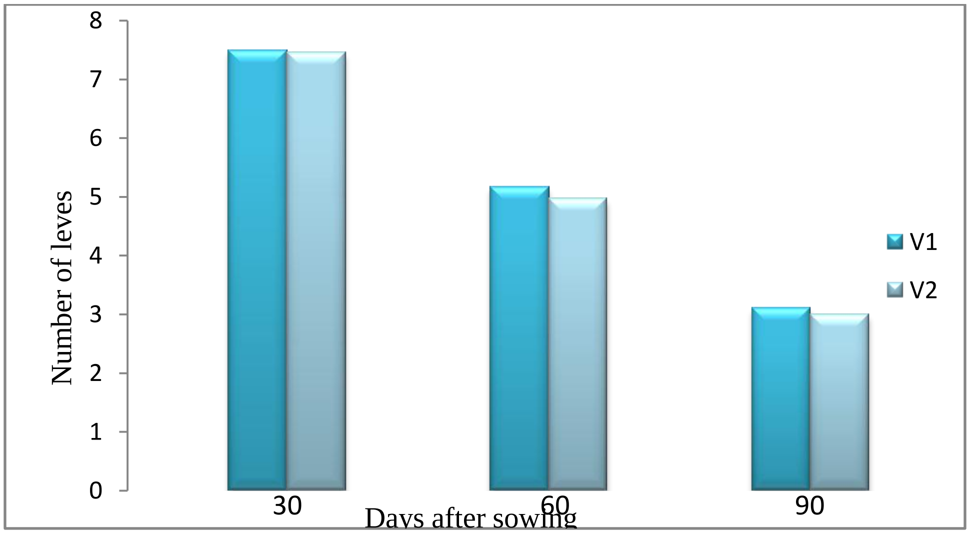
Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 =BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs primingV_2P_5 = BARI Gom-26 with 12 hrs priming

Plant height increases with increasing days after sowing and almost static at harvesting time. The highest plant height in almost all cases was found at 9 hrs priming of seed with both varieties and the lowest at no priming. It might be because of 9 hrs priming of seed gave the highest emergence rate & better establishment where as no priming shows lower emergence rate & poor establishment leading to lower plant height. Similar result found by Giri *et al.*(2003). Aymen *et al.*(2013) also reported that primed seeds possessed higher emergence and growth rate than control. Shabbir *et al*. (2013) also noted that priming techniques significantly affect plant height.

4.3 Number of leaves/tiller

4.3.1 Effect of variety

There was no significant difference observed among two varieties in number of leaves tiller^{-1} in all cases. But still BARI Gom-25 gave maximum number of leaves compared to that of BARI Gom-26 (Fig-3)



V_1 : BARI Gom- 25 V_2 : BARI Gom- 26

Fig 3. Effect of varieties on number of leaves tiller^{-1} of two wheat varieties

4.3.2 Effect of priming

Different seed priming treatments significantly influenced the number of leaves tiller^{-1} of the wheat varieties shown at different growth stages. But there is no significant variation in number of leaves at 90 DAS. Seeds primed for 9 hrs gives the highest number of leaves (8.30) at 30 DAS and the lowest was recorded when seeds were not primed (6.53). In case of 60 DAS highest number of leaves were recorded when seeds were primed for 9 hrs(5.41) which was statistically similar to12 hrs priming of seeds(5.26). No priming of seeds gives the lowest number of leaves (4.72) which was also statistically similar with seeds of 3 hrs priming (Table-5).

Table 5. Effect of priming on number of leaves tiller^{-1} of wheat at different days after sowing

Treatments	30	60	90
P_1	6.53c	4.72d	2.99
P_2	7.30b	4.87cd	3.03
P_3	7.60b	5.07bc	3.05
P_4	8.30a	5.41a	3.12
P_5	7.63b	5.26ab	3.07
$LSD_{(0.05)}$	0.57	0.25	Ns
CV(%)	12.80	9.67	7.56

Here,

P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

4.3.3 Interaction effect

At different growth stages the number of leaves of wheat was significantly influenced by the effect of different varieties and different seed priming treatments except at 90 DAS. Seeds of BARI Gom-25 primed at 9 hrs gave the highest number of leaves (8.87) at 30 DAS and the lowest was recorded at the seeds of BARI Gom-25 which were not primed (6.13). No priming seeds of BARI Gom-26(6.93) also showed statistically similar result. At 60 DAS the highest number of leaves were also recorded at 9 hrs priming of BARI Gom-25(5.52) which was statistically similar with seeds of BARI Gom-25 primed for 6 and 12hrs (5.18 ,5.32) and seeds of BARI Gom-26 primed for 6, 9 and 12 hrs(5.20, 5.30, 5.27) respectively. Seeds of BARI Gom-26 when not primed gave the lowest number of leaves (4.51) which was also statistically similar with 3 hrs priming of BARI Gom-26(4.57) seeds (Table-6).

Table 6. Interaction effect of variety and priming on number of leaves tiller^{-1} of wheat at different days after sowing

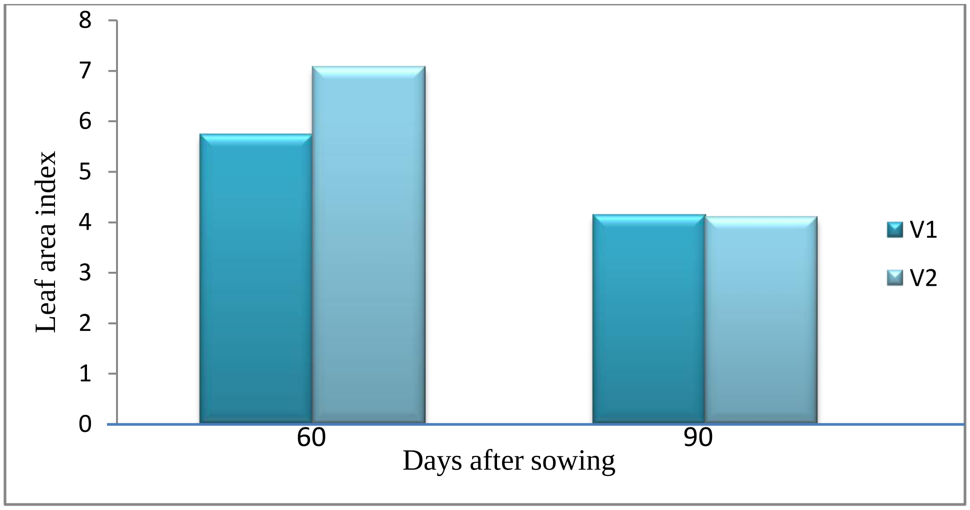
Treatments	30	60	90
V_1P_1	6.13d	4.87bc	3.04
V_1P_2	7.00c	4.97b	3.08
V_1P_3	7.27bc	5.18ab	3.08
V_1P_4	8.87a	5.52a	3.19
V_1P_5	8.00b	5.32a	3.13
V_2P_1	6.93cd	4.51d	2.84
V_2P_2	7.20bc	4.57cd	2.99
V_2P_3	7.60bc	5.20ab	3.01
V_2P_4	8.00b	5.30a	3.11
V_2P_5	7.73bc	5.27a	3.04
$LSD_{(0.05)}$	0.80	0.35	Ns
CV(%)	12.80	9.67	7.56

Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 = BARI Gom-26 with 3 hrs priming V_2P_3 =BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs priming V_2P_5= BARI Gom-26 with 12 hrs priming

4.4 Leaf Area Index

4.4.1 Effect of variety

There was no statistically significant influence of varieties on leaf area index. Still BARI Gom-26 gave the highest LAI at 60 DAS (7.07) and statistically similar LAI was also given by BARI Gom-25(5.73). In case of LAI at 90 DAS BARI Gom-25 showed the maximum LAI (4.12) & minimum but statistically similar LAI was given by BARI Gom-26(4.10)(Fig-4).



V_1 : BARI gom-25 V_2 : BARI gom-26

Fig 4. Effect of varieties on LAI of two wheat varieties

4.4.2 Effect of priming

Priming significantly influenced leaf area index at both 30 and 60 DAS. At 60 DAS the highest LAI (7.28) was recorded at 9 hrs priming of seed which was statistically similar with 6 hrs priming of seeds (7.01). LAI was lowest (5.00) when seeds were not primed. In case of 90 DAS the highest LAI was recorded at 9 hrs priming (4.54) which was statistically similar with 6 hrs & 12 hrs priming of seeds. The lowest (3.78) LAI was recorded at no priming of seeds which was also statistically similar with 3hrs, 6 hrs & 12 hrs priming of seeds (Table-7).

Table 7. Effect of priming on LAI of wheat

Treatment	LAI (60 DAS)	LAI (90 DAS)
P_1	5.00c	3.78b
P_2	6.45b	3.80b
P_3	7.01a	4.17ab
P_4	7.28a	4.54a
P_5	6.27b	4.31ab
$LSD_{(0.05)}$	0.50	0.54
CV(%)	6.33	10.71

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

4.4.3 Interaction effect

Statistically significant influence of interaction effect on LAI was found out. The highest LAI at 60 DAS was recorded at 9 hrs priming of BARI Gom-26 (8.61) which was statistically similar with 6 hrs priming of BARI Gom-26(8.26). The lowest LAI was observed when seeds of BARI Gom-26 were not primed (4.53) which was also statistically similar with no priming of BARI Gom-25(5.20). At 90 DAS the highest LAI was observed at 9 hrs priming of BARI Gom-26 (4.97) which was statistically similar with 3hrs and 6hrs priming of BARI Gom-25(4.23, 4.29) as well as12 hrs priming of BARI Gom-26 (4.33). The lowest LAI was observed at no priming of BARI Gom-26 (3.56). All priming treatments combined with BARI Gom-25, 3 hrs & 6 hrs priming of BARI Gom-26 gave statistically similar result with V_2P_1 (Table-8).

Table 8. Interaction effect of variety & priming on LAI of wheat

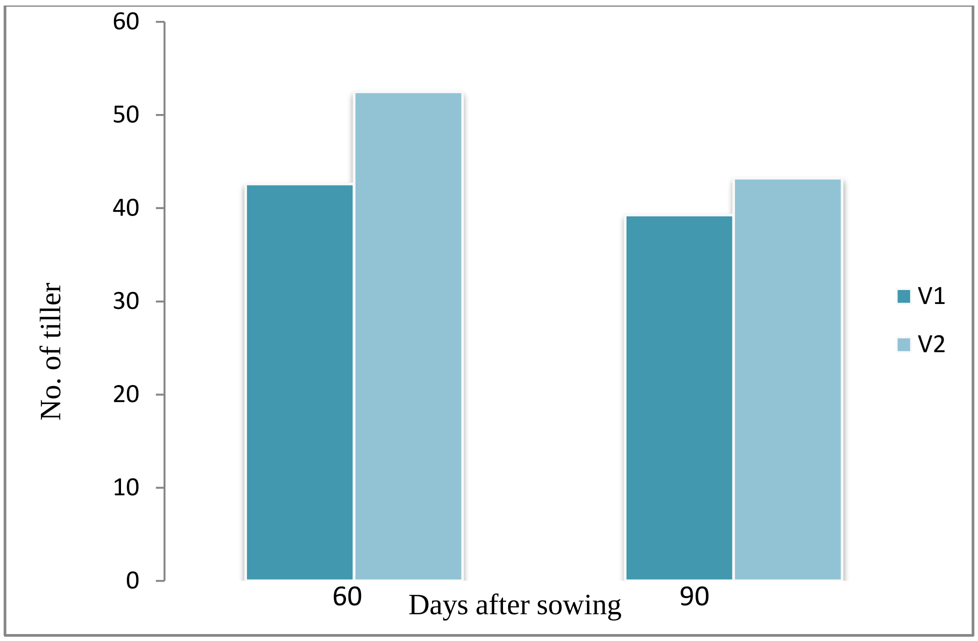
Treatments	**LAI (60 DAS)**	**LAI (90 DAS)**
V_1P_1	5.20fg	4.00bc
V_1P_2	5.76d-f	4.01bc
V_1P_3	5.96cde	4.28a-c
V_1P_4	6.28cd	4.29a-c
V_1P_5	5.46ef	4.11bc
V_2P_1	4.53g	3.56c
V_2P_2	6.62c	3.58bc
V_2P_3	8.26a	4.05bc
V_2P_4	8.61a	4.97a
V_2P_5	7.33b	4.33ab
$LSD_{(0.05)}$	0.70	0.76
CV(%)	6.33	10.71

Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 =BARI Gom-25 with 6 hrs priming V_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 =BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs priming V_2P_5=BARI Gom-26 with 12 hrs priming

4.5 Number of Tillers

4.5.1 Effect of variety

Number of tiller was significantly influenced by different varieties. The highest number of tillers were recorded at BARI Gom-26 in both 60 DAS and 90 DAS that is 52.47 and 43.20 respectively. BARI Gom-25 gave lower number of tillers in both cases (42.60 and 39.27) (Fig-5).



V_1 : BARI Gom-25 V_2 : BARI Gom-26

Fig 5. Effect of varieties on number of tillers at 60 and 90 days after sowing $LSD_{(0.05)}$ = 10.13 &3.93 respectively

4.5.2 Effect of priming

Different priming treatments significantly influenced number of tillers at both 60 DAS and 90 DAS. At 60 DAS the highest number of tillers were recorded at 9 hrs priming (53.17) which was statistically similar with 12 hrs priming (48.33). Number of tiller was recorded lowest at no priming of seeds (43.17) which was statistically similar with priming at 3 hrs and 6 hrs (46.17 and 46.83) respectively. In case of 90 DAS the highest number of tillers were also observed at 9 hrs priming of seed (45.00) and lowest was observed at no priming of seeds(38.33).The lowest result was also statistically similar with 12 hrs priming of seeds (38.50) (Table-9).

Table 9: Effect of priming on number of tillers/10 preselected plants of wheat at 60 an 90 days after sowing

Treatments	60	90
P_1	43.17c	38.33c
P_2	46.17bc	42.17b
P_3	46.83bc	42.17b
P_4	53.17a	45.00a
P_5	48.33ab	38.50c
$LSD_{(0.05)}$	5.01	2.79
CV(%)	8.61	6.95

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

The lowest number of tiller at no priming was found but the highest was at 9 hrs priming. This might be because of better establishment and growth of plants when seeds were primed. Seeds primed for 9 hrs also gave the highest number of leaves leading to higher photosynthesis rate and higher number of tillers. On the other hand no priming of seeds caused lower emergence, poor establishment, lower number of leaves and the lowest number of tillers. Similar result was found by Memon *et al*. (2013) who showed that germination percentage (GP), Mean germination time (MGT), germination index (GI), seedling vigor index (SVI), chlorophyll content, shoot and root related attributes were significantly influenced by primed seeds as compared to unprimed seeds .

4.5.3 Interaction effect

Interaction of variety & priming treatments also significantly influenced number of tillers. The highest number of tillers at 60 DAS (63.33) were recorded when BARI Gom-26 was primed for 9hrs and lowest (39.00) was recorded when BARI

Gom-25 seeds were not primed. Similar statistical result was observed in case of no priming, 3hrs priming, 6 hrs priming, 9 hrs priming of BARI Gom-25(40.67, 44.67, 43.00, 45.67) and no priming of BARI Gom-25 (41.67) respectively. At 90 DAS the highest tillers (50.67) were also observed when BARI Gom-26 was primed for 9 hrs (Table-10). The lowest tiller number (36.67) was recorded when BARI Gom-25 seeds were not primed which was also statistically similar with BARI Gom-25 primed for 3 hrs and 12 hrs (37.33, 39.33) & BARI Gom-26 was not primed (39.67) and primed for 3 hrs (40.00).

Table 10. Interaction effect of variety and priming on number of tillers/10 preselected of wheat

Treatments	No of tiller (60 DAS)	No. of tiller (90 DAS)
V_1P_1	39.00e	36.67e
V_1P_2	44.67de	37.33de
V_1P_3	43.00de	41.00b-d
V_1P_4	45.67de	42.00bc
V_1P_5	40.67e	39.33c-e
V_2P_1	41.67de	39.67b-e
V_2P_2	48.00cd	40.00b-e
V_2P_3	56.00b	43.33b
V_2P_4	63.33a	50.67a
V_2P_5	53.33bc	42.33bc
$LSD_{(0.05)}$	7.08	3.95
CV(%)	8.61	6.95

Here,

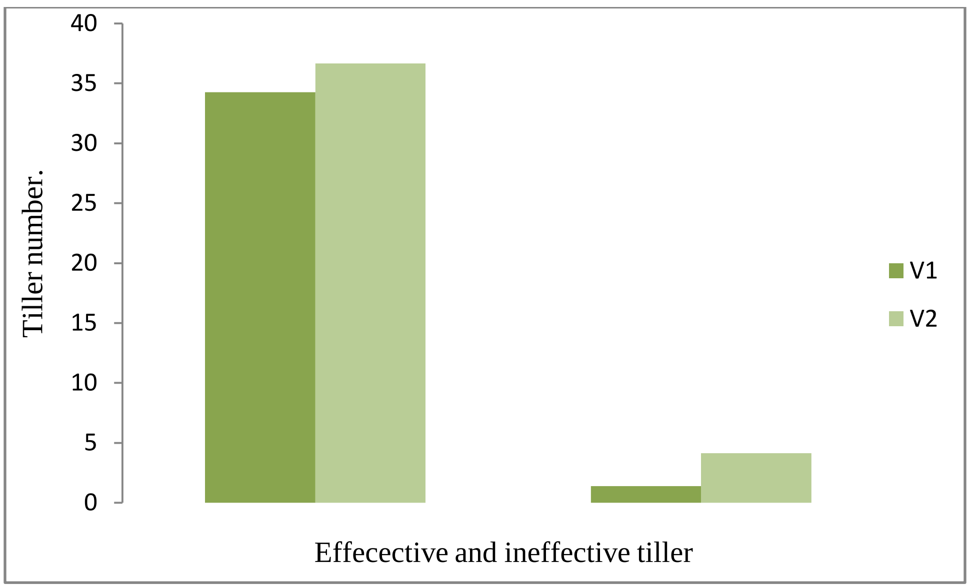
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 =BARI Gom-25 with 6 hrs priming V_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 = BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4 =BARI Gom-26 with 9 hrs priming V_2P_5=BARI Gom-26 with 12 hrs priming

The highest number of tillers at both 60 DAS and 90 DAS were found when BARI Gom-26 seeds were primed for 9 hrs. This might be because of BARI Gom-26 gave higher number of tillers than BARI Gom-25. The lowest number of tillers were found when BARI Gom-25 seeds were not primed, that statistically similar to BARI Gom-25 seeds when primed for 12 hrs. This result showed similarities with result found by Giri *et al.* (2003) who reported that optimum soaking time for wheat may be less than 12 hrs. Ali *et al.* (2013) also noted that seed priming treatments reduced the mean emergence time and promoted germination, early canopy development and tillering in comparision to the untreated control.

4.6 Effective and ineffective tillers

4.6.1 Effect of variety

Varieties did not significantly influenced on both effective and ineffective tiller though BARI gom-26 gave maximum number of effective (36.67) and ineffective tillers (4.13). The minimum number of effective tillers were given by BARI Gom-25(Fig-6)



V_1 : BARI Gom-25 V_2 : BARI Gom-26

Fig 6 . Effect of varieties on effective and ineffective tillers/10 preselected of wheat varieties

4.6.2 Effect of priming

Effective tiller

The number of effective tillers varied significantly with the effect of different priming hrs. The highest effective tillers (37.67) were found at 9 hrs priming of seeds which was statistically similar with 6 hrs priming of seeds (37.17).

Effective tillers were lowest (32.83) at no priming of seed (Table-11). The12 hrs priming of seed also gave the similar statistical result (33.33) with no priming of seeds.

Ineffective tiller

Ineffective tiller also influenced significantly by different priming treatments. The highest number (4.83) of ineffective tillers were recorded at no priming and the lowest were recorded at 9 hrs and 12 hrs priming of seeds (1.83)

Table 11. Effect of priming on effective and ineffective tillers/10 preselected of wheat

Treatment	Effective tiller	Ineffective of tiller
P_1	32.83c	4.83a
P_2	36.33ab	2.67b
P_3	37.17a	2.67b
P_4	37.67a	1.83c
P_5	33.33bc	1.83c
$LSD_{(0.05)}$	3.12	0.62
CV(%)	7.20	18.37

Here,
P_1: No priming, P_2: 3hrs priming P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

The highest number of effective tillers at 9 hrs priming might be because of the better benefit of light, nutrient, air etc. due to early emergence. The highest ineffective tillers were revealed in no priming treatment. This result showed similarities with Ali *et al.* (2013) who noted that number of fertile tillers increased by different priming techniques.

4.6.3 Interaction effect

Effective Tiller

Interaction effect has significant influence on number of effective tillers. The treatment V_2P_4 (BARI Gom-26+9 hrs priming) gave the highest number of effective tillers (39.33) which was statistically similar with V_1P_3 (BARI Gom-25 +

6hrs priming), V_1P_4 (BARI Gom-25 + 9 hrs priming), V_2P_2 (BARI Gom-26+3hrs priming), V_2P_3 (+ BARI Gom-26 + 6 hrs priming),V_2P_5 (BARI Gom-26 + 12 hrs priming). The lowest number of effective tillers (30.00) were found in V_1P_1 (BARI Gom-25+ no priming) which was statistically similar with V_1P_2 (BARI Gom-25 + 3 hrs priming), V_1P_5 (BARI Gom-25 + 12 hrs priming) and V_2P_1 (BARI Gom-26+ no priming).

Ineffective tiller

The treatment V_2P_1 (no priming of BARI Gom- 26) showed the higher number of ineffective tillers and lower number of tillers were found at V_1P_3 and V_1P_4 (0.67) which was also statistically similar with V_1P_4 (BARI Gom-25 + 9 hrs priming)(Table-12).

Table 12 . Interaction effect of variety & priming on effective and ineffective tillers/10 preselected of wheat

Treatments	Effective tiller	Ineffective tiller
V_1P_1	30.00d	2.33c
V_1P_2	33.33b-d	2.33c
V_1P_3	37.67ab	0.67d
V_1P_4	37.67ab	0.67d
V_1P_5	32.67cd	1.00d
V_2P_1	34.00b-d	7.33a
V_2P_2	36.67a-c	3.00c
V_2P_3	37.67ab	3.00c
V_2P_4	39.33a	2.67c
V_2P_5	35.67a-c	4.67b
$LSD_{(0.05)}$	4.42	0.88
CV(%)	7.20	18.37

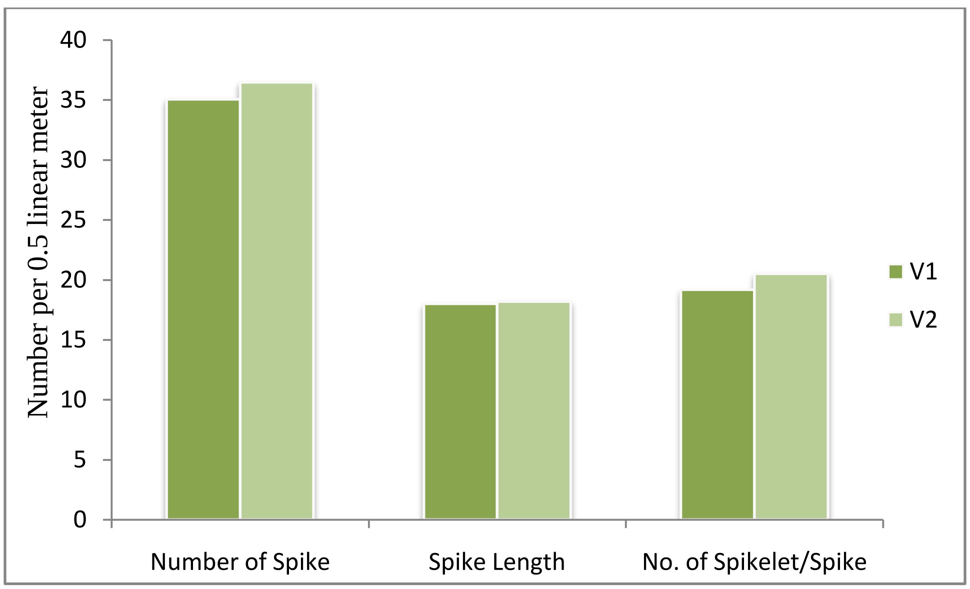
Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 = BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs priming V_2P_5= BARI Gom-26 with 12 hrs priming

Among the treatments the highest effective tillers were recorded at 9 hrs priming of BARI Gom-26 which might be because of earlier emergence of BARI Gom-26 and 9 hrs seed priming treatment that enjoyed maximum benefits of light, nutrients. The highest ineffective tiller was at no priming of BARI Gom-26 which might be because of lower number of leaves and lower number of tillers. Similar result was found by Tilahun *et al*.(2013) who reported that higher numbers of productive tillers were recorded in response to planting pre germinated seeds followed by soaked seeds.

4.7 Spike Characteristics

4.7.1 Effect of variety

Spike characteristics were not significantly influenced by varietal difference even though BARI Gom-26 gave maximum number of spikes (36.47), spike length (18.19) and number of spikelet spike^{-1} (20.51). BARI Gom-25 gives statistically similar result in all cases (Fig-7).



V_1 : BARI Gom-25 V_2 : BARI Gom-26

Fig 7. Effect of varieties on number of spikes, spike length and number of spikelets spike^{-1} of two wheat varieties

4.7.2 Effect of priming

Number of spike

A statistically significant influence on spikes of wheat at different seed priming treatments were found. The highest number of spike (38.67) was found in case of 9 hrs priming which was statistically similar with 3 hrs (36.00) and 12 hrs (37.50) priming of seeds. No priming gave the lowest number of spikes (32.67) which was statistically similar with 6 hrs priming (34.00) of wheat seeds (Table-13).

Spike length (cm)

Spike length also influenced by different seed priming treatments. The 9 hrs priming of seeds showed the highest spike length (19.28cm) which was statistically similar with 6 hrs seed priming (18.82cm). The lowest spike length (17.39 cm) was observed when seeds were not primed which was also statistically similar with seeds primed at 3 hrs and 12 hrs(17.54cm and17.48cm) respectively.

Number of Spikelets spike^{-1}

The highest significant result in case of number of spikelets/spike was found when seeds were primed for 9 hrs (20.15) and lowest was found when seeds were not primed (19.53).

Table 13. Effect of priming on number of spikes, spike length and number of spikelets spike^{-1} of wheat

Treatments	Number of spike	Spike length(cm)	No. of spikelets/spike
P_1	32.67c	17.39b	19.53c
P_2	36.00ab	17.54b	19.78b
P_3	34.00bc	18.82a	19.90b
P_4	38.67a	19.28a	20.15a
P_5	37.50a	17.48b	19.88b
$LSD_{(0.05)}$	3.23	0.94	0.16
CV(%)	7.38	8.88	5.08

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

The highest number of spikes, spike length & number of spikelets/spike were found at 9 hrs priming which was might be because of highest number of leaves leading to higher photosynthesis rate & higher number of effective tillers. The lowest was found at no priming treatment.

4.7.3 Interaction effect

Number of spike

Significant difference among different treatments were found in case of number of spikes. BARI Gom-26 when primed for 9 hrs gave the highest number of spikes (42.00) which was statistically similar with 9 hrs priming of BARI Gom-25(39.00) and 6 hrs priming of BARI Gom-26 (38.33). The lowest number of spikes were found in no priming of BARI Gom-25 (31.67) which was statistically similar with 3 and 12 hrs priming of BARI Gom-25(33.00, 34.67), no priming, 3hrs and 12 hrs priming of BARI Gom-26(33.33, 33.667, 35.00) respectively(Table-14).

Spike length

Spike length also showed significant results for interaction between different seed priming treatments and varieties. The highest spike length (20.95) was observed at 9 hrs priming of seeds of BARI Gom-26 (Table-14). The 6 hrs priming of BARI Gom-26 also gave statistically similar spike length (19.81). Spike length was the lowest (16.56cm) when seeds of BARI Gom-26 were not primed. Similar statistical results were observed in case of no priming and 12 hrs priming of BARI Gom-25(17.62cm and 17.82cm), 3 hrs and 12 hrs priming of BARI Gom-26(16.61cm and 17.03cm) respectively.

Number of Spikelets spike^{-1}

Statistically significant influence of interaction effects on number of spikelets spike^{-1}were found. The highest number of spikelets (21.12) were recorded at 9 hrs priming of BARI Gom-25 and the lowest (17.88) was recorded at not primed seeds of BARI Gom-26(Table-14).

Table 14. Interaction effect of variety and priming on number of spikes, spike length & number of spikelets spike^{-1} of wheat

Treatments	Number of spike	Spike length(cm)	No. of spikelets/spike
V_1P_1	31.67d	17.62c-f	19.67d
V_1P_2	33.00cd	17.92c-e	20.00c
V_1P_3	37.00bc	18.17cd	20.83b
V_1P_4	39.00ab	18.52bc	21.18a
V_1P_5	34.67b-d	17.82c-f	20.76b
V_2P_1	33.33cd	16.56f	17.88f
V_2P_2	33.67cd	16.61ef	18.80e
V_2P_3	38.33ab	19.81ab	19.57d
V_2P_4	42.00a	20.95a	20.13c
V_2P_5	35.00b-d	17.03d-f	19.47d
$LSD_{(0.05)}$	4.57	1.32	0.22
CV(%)	7.38	8.88	5.08

Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 = BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs primingV_2P_5 = BARI Gom-26 with 12 hrs priming

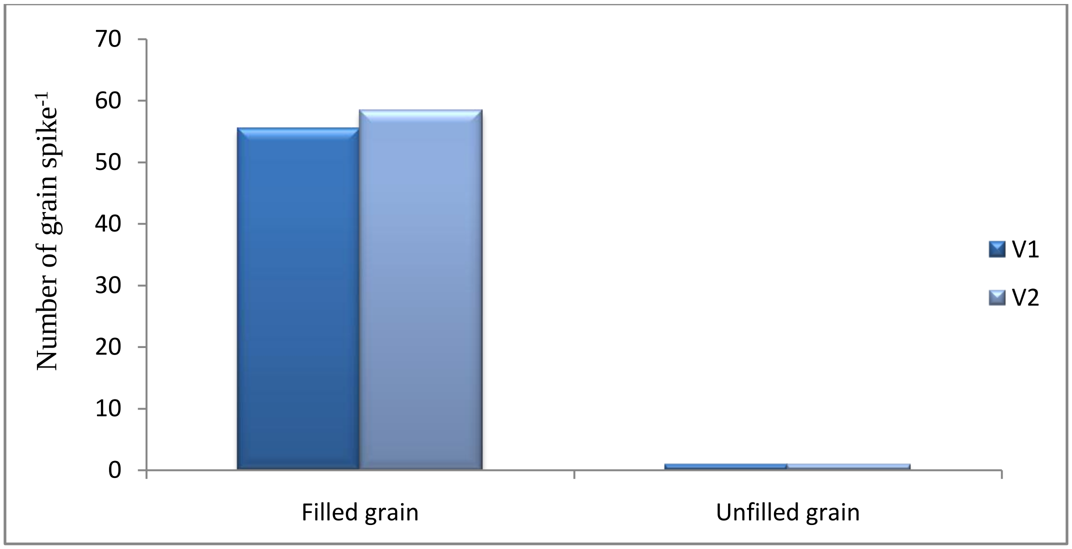
Variety might have no effect on number of spike because statistically similar results were found at 9 hrs priming of both BARI Gom-25 and BARI Gom-26. Number of spikelets spike^{-1} was the highest at 9 hrs priming of BARI Gom-25 which was might be because of highest plant height and number of leaves of BARI Gom-25.

4.8 Filled and unfilled grain

4.8.1 Effect of variety

There was no significant difference in filled and grain. The highest filled grain (58.37) was found in BARI Gom-26 which was statistically similar with BARI

Gom-25 (Fig-8). In case of unfilled grain highest (0.93) result was observed at BARI Gom-25 (V_1) which was statistically similar BARI Gom-26(V_2).



V_1 : BARI Gom-25 V_2 : BARI Gom-26

Fig 8. Effect of varieties on filled grain and unfilled grain on two wheat varieties

4.8.2.Effect of priming

Filled grain/spike^{-1}

Filled grain gave statistically significant result to different priming treatments. The highest filled grain (59.41) was recorded at P_4(9 hrs priming) and the lowest (53.96) was recorded at no priming (Table-15).

Unfilled grain/spike^{-1}

In case of unfilled grain significantly the highest result was recorded at P_1 (no priming) that was 1.22 g and lowest was recorded at P_4 (9 hrs priming) that was 0.54g (Table-15).

Table 15. Effect of priming on filled grain and unfilled grain per spike of wheat

Treatments	Filled grains spike^{-1}	Unfilled grains spike^{-1}
P_1	53.96d	1.22a
P_2	56.68c	1.12b
P_3	56.81bc	0.64c
P_4	59.41a	0.54d
P_5	57.55b	1.05b
$LSD_{(0.05)}$	0.80	0.10
CV(%)	7.95	8.71

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

Filled grains were the highest at 9 hrs priming which might be due better crop establishment, highest plant height & higher number of leaves. Unfilled grains were the lowest at 9 hrs priming because of the same reason & highest at no priming because of vice-versa.

4.8.3 Interaction effect

Filled grains spike^{-1}

Interaction of variety & priming significantly influenced the filled grain number spike^{-1}. Among all the combinations 9 hrs priming of BARI Gom-26 gives highest wt. (60.90) which was statistically similar with 12 hrs priming of BARI Gom-26 (60.12). The lowest filled grains (52.72) were observed at no priming of BARI Gom-25 (Table-16) which was also statistically similar with no priming of BARI Gom-26 (53.34).

Unfilled grains spike^{-1}

Unfilled grains also significantly influenced by interaction effects. The highest unfilled grains (2.07) were found at no priming of BARI Gom-26 and the lowest (0.27) was found at 9 hrs priming of BARI Gom-26 which was statistically similar with 9 hrs priming of BARI Gom -25(0.37).

Table 16. Effect of interaction of variety & priming on filled grain and unfilled grain of two wheat varieties

Treatments	Filled grains spike^{-1}	Unfilled grains spike^{-1}
V_1P_1	52.72f	1.37b
V_1P_2	54.59e	1.27b
V_1P_3	55.40e	0.60e
V_1P_4	58.70cd	0.37fg
V_1P_5	55.60e	1.02c
V_2P_1	53.34f	2.07a
V_2P_2	57.77d	0.87d
V_2P_3	59.70bc	0.48ef
V_2P_4	60.90a	0.27g
V_2P_5	60.12ab	0.83d
$LSD_{(0.05)}$	1.13	0.13
CV(%)	7.95	8.71

Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 = BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARIGom-26 with 9 hrs priming V_2P_5 = BARI Gom-26 with 12 hrs priming

In case of interaction the highest filled grains were observed at 9 hrs priming of BARI Gom-26 which might be because both 9 hrs priming and BARI Gom 26 gives highest number of effective tiller , number of spike and spikelet spike^{-1}.

4.9 Effect of 1000 grain wt., grain yield and straw yield

4.9.1 Effect of variety

BARI Gom-25 and BARI Gom-26 gives statistically similar result in case of 1000 grain weight, grain yield and straw yield.

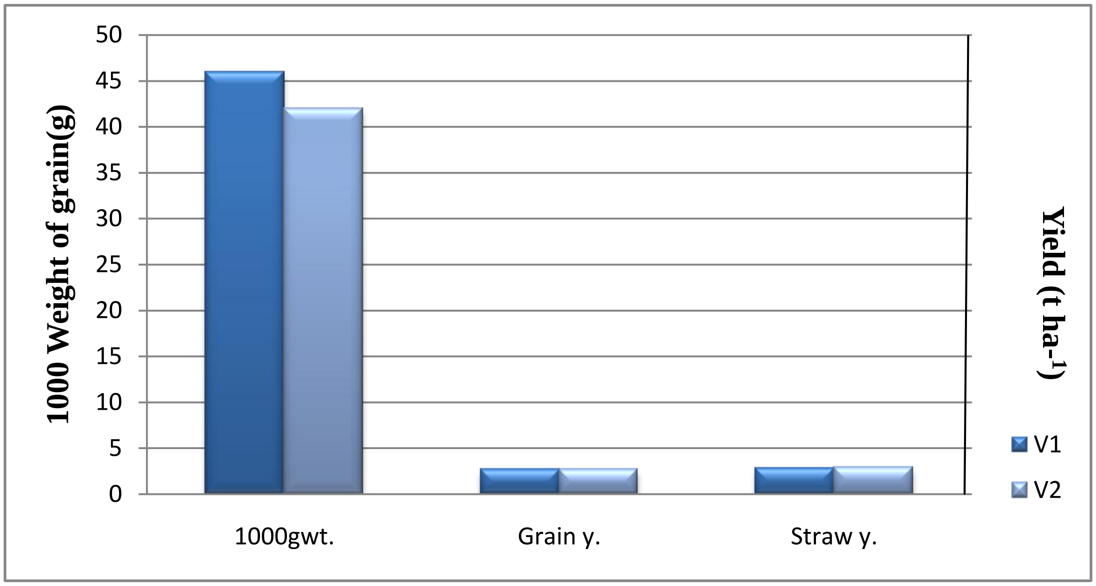


Fig 9. Effect of varieties on 1000 grain wt. (g), grain yield (t ha^{-1}) and straw Yield (t ha^{-1}) of two wheat varieties

4.9.2 Effect of priming

1000 grain wt.

In case of 1000 grain wt. the highest grain wt. (46.61g) was recorded at 9hrs priming (P_4) and the lowest grain wt.(41.28 g) was recorded at no priming (P_1)

Grain yield

There was significant variation observed on grain yield of wheat for the effect of different priming treatments. The highest grain yield (2.86t ha^{-1}) was observed at 9 hrs priming and the lowest was observed at no priming (2.61t ha^{-1}). The lowest grain yield was also statistically similar with 2 hrs, 6 hrs and 12 hrs (2.62, 2.63 & 2.66) priming respectively (Table-17).

Straw yield

No significant variation was observed between two varieties for straw yield. The highest straw yield (2.98tha^{-1}) was recorded at P_4 (9 hrs priming) which was statistically similar with 12 hrs priming of seed (2.93tha^{-1}). Straw yield was lowest (2.81tha^{-1}) at no priming which was also statistically similar with 3hrs priming (2.83tha^{-1}) of seeds (Table-17).

Table 17. Effect of priming on 1000 grain wt, grain yield and straw yield of wheat

Treatments	1000 grain wt.(g)	Grain yield(t ha^{-1})	Straw yield(t ha^{-1})
P_1	41.28d	2.61b	2.81c
P_2	43.39c	2.62b	2.83c
P_3	43.48c	2.63b	2.89b
P_4	46.61a	2.86a	2.98a
P_5	45.05b	2.66b	2.93ab
$LSD_{(0.05)}$	0.96	0.089	0.06
CV(%)	8.08	7.89	9.90

Here,
P_1: No priming, P_2: 3hrs priming P_3: 6 hrs priming,
P_4: 9 hrs priming , P_5: 12 hrs priming

Grain yield & straw yield were also highest at 9 hrs priming might be because of highest number of effective tillers, highest spike length and spikelets/spike, highest number of filled grain & lowest number of unfilled grain. Thousand grain wt. was higher at 9 hrs priming might be because of the same reason. This was as per the work of Raj Pal Meena *et al.* (2013) who noted that hydro-primed and pre germinated 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. Tilahun *et al.*(2013) also reported that higher numbers of productive tillers, filled spikelets, 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 soaked seeds. Ali *et al.* (2013) reported that number of fertile tillers, plant height, 1000-grain weight, and grain and biological yield were also increased by different priming techniques. Sarkar (2012) Priming had positive effects on yield and yield attributing parameters both under non-flooding and early flooding conditions.

4.9.3 Interaction effect

1000 Grain wt.

In case of 1000 grain wt. the higher result was observed at 9 hrs priming of BARI Gom-25 (49.82 g) and lower grain wt. was observed at no priming of BARI Gom-26 (38.64 g).

Grain yield

The highest grain yield (2.88t ha^{-1}) was recorded at 9 hrs priming of BARI Gom-25 which was statistically similar with 9 hrs priming of BARI Gom-26 (2.83 t ha^{-1}). Lowest yield (2.553 t ha^{-1})was recorded at no priming and 3 hrs priming of BARI Gom-25 which was statistically similar with 6 hrs priming of BARI Gom-25 (2.59 t ha^{-1}), no priming, 3hrs and 6 hrs priming of BARI Gom-26 (2.57, 2.66, 2.65 t ha^{-1})respectively.

Straw yield

Straw yield also significantly influenced by interaction effects. Straw yield was highest (3.01 t ha^{-1}) at 9 hrs priming of BARI Gom-25 which was statistically similar with 12 hrs priming of BARI Gom-25 (2.98 t ha^{-1}) and 9 hrs priming of BARI Gom-26 (2.97 t ha^{-1}). The lowest straw yield (2.72 t ha^{-1}) was recorded at no priming of BARI Gom-25 which was statistically similar with 3 hrs priming of BARI Gom-25 (2.77 t ha^{-1}).

Table 18. Interaction effect of variety and priming on 1000 grain wt., grain yield and straw yield of wheat

Treatments	Grain yield (t ha^{-1})	Straw yield (tha^{-1})	1000 grain wt.(g)
V_1P_1	2.55e	2.72g	43.93cd
V_1P_2	2.55e	2.77fg	44.98bc
V_1P_3	2.59de	2.85de	45.13bc
V_1P_4	2.88a	3.01a	49.82a
V_1P_5	2.76bc	2.98ab	45.74b
V_2P_1	2.57e	2.85ef	38.64f
V_2P_2	2.66cde	2.89cde	41.22e
V_2P_3	2.65cde	2.90cde	41.80e
V_2P_4	2.83ab	2.97abc	44.97bc
V_2P_5	2.71bcd	2.93bcd	43.40d
$LSD_{(0.05)}$	0.12	0.08	1.36
CV(%)	8.08	7.89	9.90

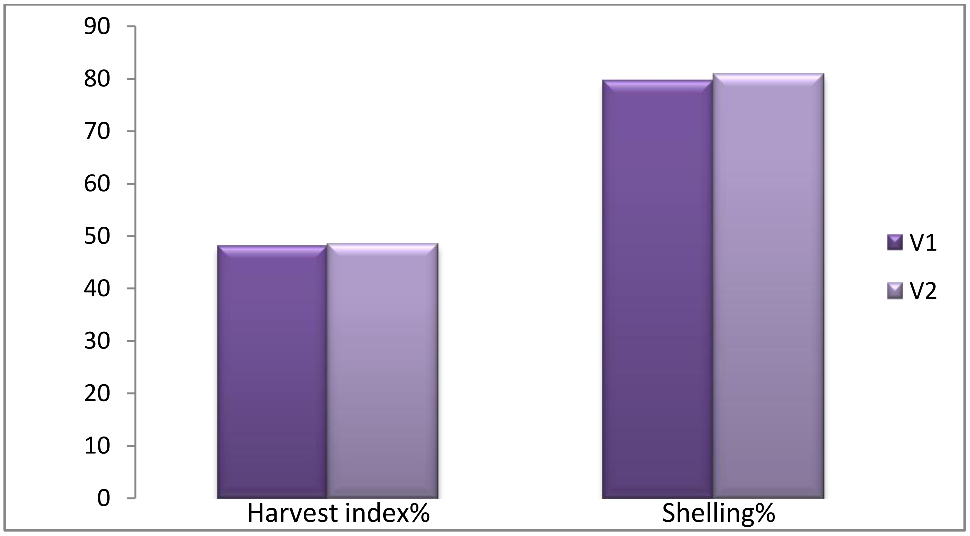
Here,
V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 = BARI Gom-25 with 6 hrs primingV_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2 =BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs priming V_2P_5= BARI Gom-26 with 12 hrs priming

Variety might have not affect the yield of crop because highest grain yield was recorded at 9 hrs priming of BARI Gom-25 which was statistically similar with 9 hrs priming of BARI Gom-26. Grain yield at 9 hrs priming was highest might be because of higher number of effective tillers, number of spikes , spikelets $spike^{-1}$ and filled grain. Nearly similar result was found by Sarkar (2012) who noted that priming had positive effects on yield and yield attributing parameters both under non-flooding and early flooding conditions.

4.10 Harvest Index & Shelling percentage

4.10.1 Effect of variety

Different varieties did not significantly influence both harvest index and shelling percentage (Fig-10).



V_1 : BARI Gom-25 V_2 : BARI Gom-26

Fig 10. Effect of varieties on harvest index and shelling percentage of two wheat varieties

4.10.2 Effect of priming

Priming gives significant influence on both harvest index and shelling%. In case of harvest index the highest result was obtained from 9 hrs priming (49.98) & lowest was obtained from no priming (47.22). Highest shelling percentage was recorded at 9 hrs priming (81.75) and lowest was recorded at no priming of seeds (78.25) (Table-19).

Table 19: Effect of priming on harvest index and shelling percentage of wheat

Treatment	Harvest index%	Shelling%
P_1	47.22d	78.25e
P_2	47.60c	80.45c
P_3	47.89c	80.73b
P_4	49.98a	81.75a
P_5	48.44b	80.03d
$LSD_{(0.05)}$	0.33	0.17
CV(%)	3.57	3.91

Here,
P_1: No priming, P_2: 3hrs priming, P_3: 6 hrs priming,
P_4: 9 hrs priming, P_5: 12 hrs priming

4.10.3 Interaction effect

In case of harvest index the highest result was recorded at 9 hrs priming of BARI Gom-25 (50.08) which was statistically similar with 9 hrs priming of BARI Gom-26 (49.88). The lowest harvest index was recorded at no priming of BARI Gom-26 (46.39). Shelling % was highest at 9 hrs priming of BARI Gom-25 (82.59) and lowest (75.78) was at no priming of BARI Gom-26(Table-20)

Table 20. Interaction effect of variety and priming on harvest index and Shelling percentage of wheat

Treatments	Harvest index	Shelling %
V_1P_1	47.64de	79.86d
V_1P_2	47.87c-e	80.68c
V_1P_3	48.05cd	80.72c
V_1P_4	50.08a	82.59a
V_1P_5	48.56b	80.68c
V_2P_1	46.39f	75.78f
V_2P_2	47.91c-e	79.38e
V_2P_3	47.57e	80.78c
V_2P_4	49.80a	81.04b
V_2P_5	48.32bc	80.91bc
$LSD_{(0.05)}$	0.46	0.24
CV(%)	3.57	3.91

Here,

V_1P_1 = BARI Gom- 25 with no priming V_1P_2 = BARI Gom-25 with 3 hrs priming
V_1P_3 =BARI Gom-25 with 6 hrs priming V_1P_4= BARI Gom-25 with 9 hrs priming
V_1P_5 = BARI Gom-25 with 12 hrs priming V_2P_1 = BARI Gom-26 with no priming
V_2P_2=BARI Gom-26 with 3 hrs priming V_2P_3 = BARI Gom-26 with 6 hrs priming
V_2P_4=BARI Gom-26 with 9 hrs primingV_2P_5 = BARI Gom-26 with 12 hrs priming

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka from November, 2012 to March, 2013 to find out the effect of seed priming on varieties of wheat. Five seed priming treatments with two varieties of wheat consisted of 10 different treatment combinations i.e.P_1:no priming, P_2: 3 hrs priming,P_3 :6 hrs priming,P_4 :9 hrs priming, P_5 :12 hrs priming & V_1 : BARI Gom- 25, V_2 : BARI Gom-26 . So, the treatment combinations were 1. V_1P_1 : No priming of BARI Gom-25, 2. V_1P_2 : 3 hr priming of BARI Gom-25, 3.V_1P_3 : 6 hr priming of BARI Gom-25, 4.V_1P_4: 9 hr priming of BARI Gom-25, 5.V_1P_5 : 12 hr priming of BARI Gom-25, 6. V_2P_1 : No priming of BARI Gom-26, 7. V_2P_2 : 3 hr priming of BARI Gom-26, 8. V_2P_3 : 6 hr priming of BARI Gom-26, 9. V_2P_4 : 9 hr priming of BARI Gom-26, 10. V_2P_5 : 12 hr priming of BARI Gom-26

The experiment was laid out in split plot design with three replications where variety was assigned in main plot and seed priming in the sub plots. The sowing date of wheat was on 16 th November, 2012. The unit plot size was 2.5m x 5m = 12.5 m^2. Observations were made on wheat as seed emergence, plant height, number of leaves $tiller^{-1}$, leaf area index, number of tillers, number of effective tillers, ineffective tillers, number of spikes, spike length, spikelest per spike, number of filled grains $spike^{-1}$, number of unfilled grains $spike^{-1}$, weight of 1000 grains, grain yield, straw yield, harvest index and shelling%. Emergence data was taken from 50 cm of a line of every plot leaving first row from the left side of the plot at 10 & 15 DAS, Ten plants were randomly selected per plot for plant height at 30 DAS, 60 DAS, 90 DAS and at harvesting, spike length , number of filled & unfilled grains $spike^{-1}$ at harvest, number of leaves $tiller^{-1}$ at 30 DAS, 60 DAS, 90 DAS, number of tiller, effective& ineffective tillers. Thousand grains weight (g) was measured from sample seed. An area of 6.25 m^2 from each plot was harvested for grain yield and straw yield. Harvest index% was calculated from grain yield and straw yield. Shelling% was calculated from grain wt. & grain wt. with shell.

The effect of different seed priming treatments on emergence of wheat seeds was found significant. Emergence rate of seedling both at 10 DAS & 15 DAS was found highest at 9 hrs priming & lowest at no priming but in case of variety emergence rate was insignificant. At interaction both BARI Gom-25 & BARI Gom-26 gives higher emergence rate at 9 hrs priming & lower was also found at no priming with both the varieties.

Different seed priming treatments showed significantly variable plant height at different days after sowing (DAS). The highest plant height (28.68 cm) at 30 DAS was recorded from 9 hrs priming which was statistically similar to 6 hrs & 12 hrs priming. The lowest plant height (25.953 cm) was found at no priming which was statistically similar with 3 hrs priming. Similar trends of result were noticed at 60,90 DAS & at harvest stage of wheat plant. The growth of wheat plants emerged from different seed priming treatments showed rapid growth up to 90 DAS but the growth stunted having reached at harvest stage. Different varieties insignificantly affect the plant height .Thus in case of interaction varieties play very little role.

Different seed priming treatments significantly influenced the number of leaves tiller^{-1} of the wheat varieties shown at different growth stages. But there was no significant variation in number of leaves at 90 DAS. Seeds primed for 9 hrs gives the highest number of leaves (8.30) at 30 DAS & the lowest was recorded when seeds were not primed (6.53). Similar trend was recorded in case of 60 DAS. In case of interaction similarly non significant result was recorded at 90 DAS. At 30 & 60 DAS number of leaves tiller^{-1} were influenced by priming but not by variety. Variety showed insignificant influence on number of leaves.

Leaf area index was not affected by varieties but affected by priming treatments. Highest LAI (7.28) at 60 DAS was observed at 9 hrs priming which was statistically similar with 6 hrs priming (7.01). Lowest LAI was at no priming (5.00). LAI at 90 DAS showed similar trend.

At 60 & 90 DAS 9 hrs priming showed highest (53.17, 45.00) number of tiller & the lowest was recorded at no priming in both cases. In case of interaction effect at 30 DAS BARI Gom-26 primed for 9 hrs gave the highest tiller number (63.333) & lowest was when BARI Gom-25 was not primed (39.00). Similar trend also recorded at 90 DAS.

The highest number of effective tillers were recorded when seeds were primed for 9 hrs (37.67) & the lowest was recorded at no priming (32.83). Opposite result was recorded in case of ineffective tiller. The highest ineffective tiller was at no priming (4.83) & the lowest at 9 hrs & 12 hrs priming. In case of interaction variety showed no effect on effective tiller but in case of ineffective tiller BARI Gom-26 when not primed gave the highest result (7.33).

Variety did not show any significant influence on number of spike, spike length & spikelets/spike. Different priming treatments significantly affect number of spike, spike length & spikelets/spike. The highest number of spike, spike length & spikelets/spike were recorded at 9 hrs priming. The lowest number of spike & spikelets/spike were recorded at no priming. But in case of spike length except the highest length all were statistically similar.

Filled grain spike^{-1}, 1000 grain wt., grain yield & straw yield were recorded highest at 9 hrs priming. Unfilled grain/spike was highest at no priming (1.22). In case of interaction filled grain was highest (60.90) at 9 hrs priming of BARI Gom-26. Unfilled grain was also highest at BARI Gom-26 when not primed (2.07). Variety showed no influence on grain & straw yield for both the varieties showed statistically similar highest result at 9 hrs priming & lowest was recorded when both were not primed. Thousand grain wt was highest at 9 hrs priming of BARI Gom-25 (49.82g) & lowest at no priming of BARI Gom-26 (38.64g).

No significant influence of variety on harvest index & shelling% were observed but priming showed significant influence on both harvest index & shelling%. The highest HI (49.98%) was recorded at 9 hrs priming & lowest was at no priming (47.21) of seed. Shelling% was also highest (81.75%) at 9 hrs priming.

So, two different varieties do not have very significant influence on yield & yield contributing characteristics but priming has quite significant influence on not only yield & yield contributing characteristics but also at emergence & better establishment. Specifically 9 hrs priming showed highly effective result at emergence & finally higher grain yield than control & other treatments.

To make a specific recommendation, more research work on wider range of seed priming effects on wheat should be done over different Agro-ecological zones.

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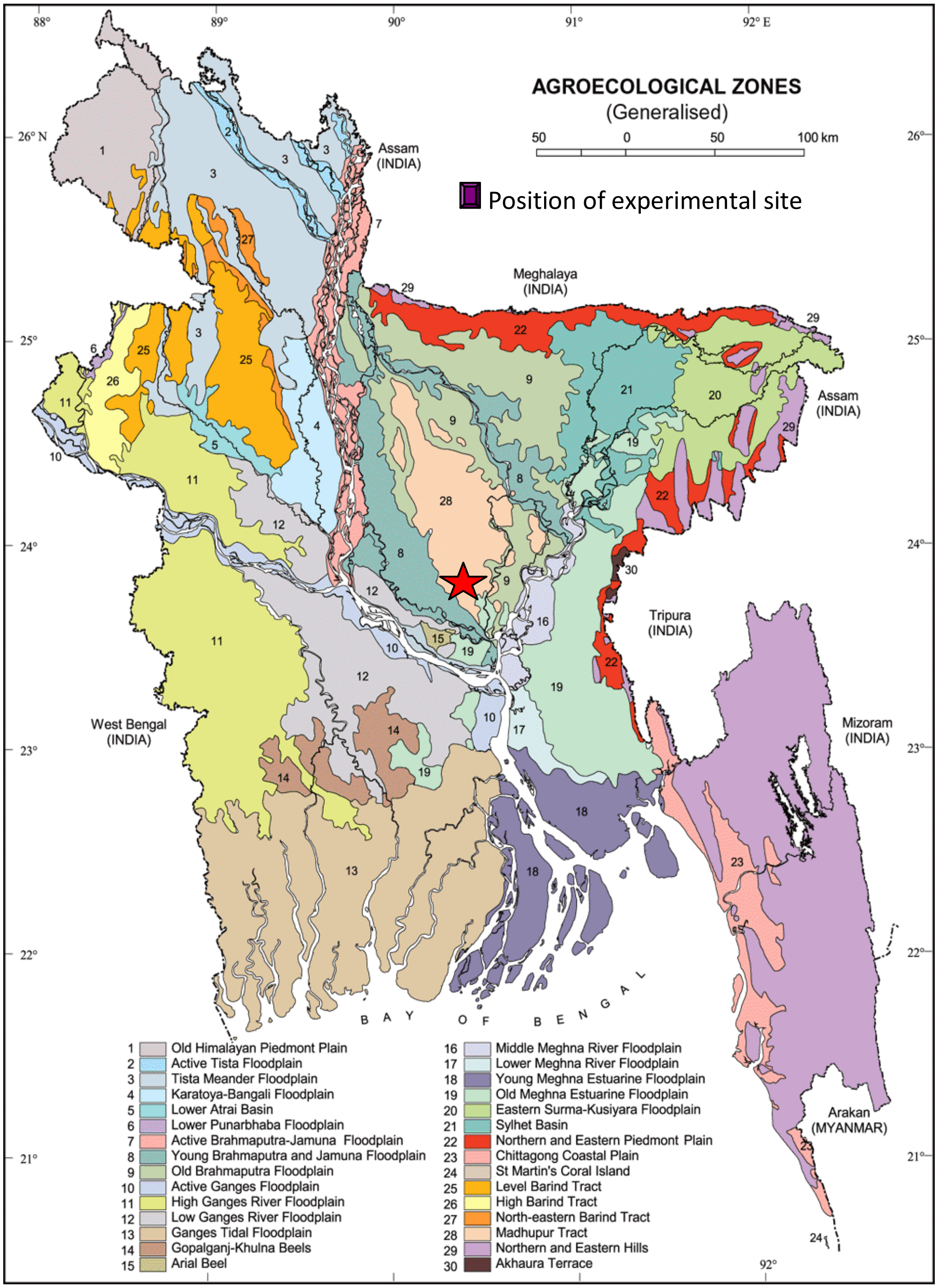
APPENDICES

Appendix I. Map showing the experimental site under study



★ Experimental site

Appendix II. Monthly average temperature, relative humidity, total rainfall and sunshine of the experimental site during the period of December, 2013 to April, 2014

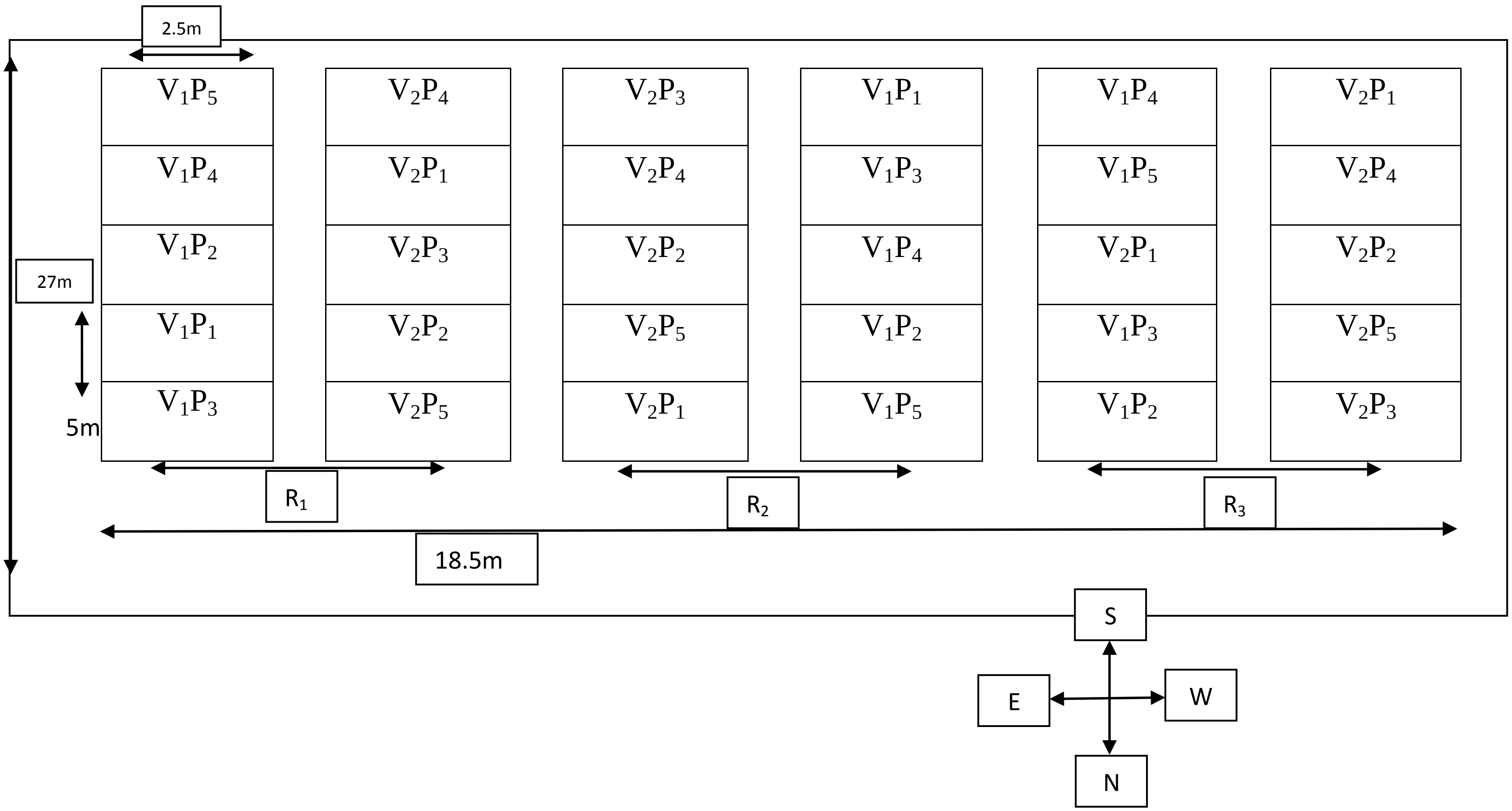
Month	Air temperature (ºC)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (h)
	Maximum	Minimum			
November, 2012	34.8	18.0	77	227	5.8
December, 2012	32.3	16.3	69	0	7.9
January, 2013	29.0	13.0	79	0	3.9
February, 2013	28.1	11.1	72	1	5.7
March, 2013	33.9	12.2	55	1	8.7
April, 2013	34.6	16.5	67	45	7.3

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka - 1212

Appendix III. Morphological characteristics of experimental field

Morphological Features	Characteristics
Location	Sher-e- Bangla Agril. University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Appendix IV. Layout of experimental field



Appendix V: ANOVA for plant height at 30 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	7.53	1.15
Factor A	1	24.480	3.74
Error	2	6.55	
Factor B		7.66	2.58*
AB	4	7.51	2.53 *
Error	4	2.97	

* Significant at 5% level NS= Non-Significant

Appendix VI: ANOVA for plant height at 60 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	220.67	68.28
Factor A	1	59.93	18.54 ns
Error	2	3.23	
Factor B	4	5.19	0.09*
AB	4	6.92	0.13*
Error	16	54.73	

* Significant at 5% level NS= Non-Significant

Appendix VII: ANOVA for plant height at 90 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	2.06	0.07
Factor A	1	12.03	0.44ns
Error	2	27.47	
Factor B	4	4.49	0.32*
AB	4	1.00	0.07*
Error	16	14.22	

* Significant at 5% level NS= Non-Significant

Appendix VIII: ANOVA for plant height at harvest

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	2.23	0.35
Factor A	1	3.33	0.52ns
Error	2	6.43	
Factor B	4	14.12	0.95*
AB	4	0.25	0.01*
Error	16	14.83	

* Significant at 5% level NS= Non-Significant

Appendix IX: ANOVA for number of leaves tiller^{-1} at 30 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.33	1.07
Factor A	1	0.01	0.04
Error	2	0.30	
Factor B	4	2.46	2.68*
AB	4	1.30	1.42 *
Error	16	0.92	

* Significant at 5% level NS= Non-Significant

Appendix X: ANOVA for number of leaves tiller^{-1} at 60 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.12	0.56
Factor A	1	0.28	1.35 ns
Error	2	0.21	
Factor B	4	0.48	1.99*
AB	4	0.22	0.89*
Error	16	0.27	

* Significant at 5% level NS= Non-Significant

Appendix XI: ANOVA for number of leaves tiller^{-1} at 90 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	016	1.20
Factor A	1	0.09	0.63ns
Error	2	0.13	
Factor B	4	0.01	0.26*
AB	4	0.03	0.48*
Error	16	0.05	

* Significant at 5% level NS= Non-Significant

Appendix XII: ANOVA for LAI at 60 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.12	0.28
Factor A	1	13.44	33.19ns
Error	2	0.41	
Factor B		4.72	28.74*
AB	4	3.71	22.60 *
Error	4	0.16	

Appendix XIII: ANOVA for LAI at 90 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.25	6.20
Factor A	1	0.01	0.25ns
Error	2	0.04	
Factor B		0.66	3.38*
AB	4	0.43	2.23 *
Error	4	0.19	

* Significant at 5% level NS= Non-Significant

Appendix XIV: ANOVA for number of tiller per 50 linear cm at 60 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	10.83	0.56
Factor A	1	730.13	37.96 ns
Error	2	19.23	
Factor B	4	80.70	4.82*
AB	4	143.13	8.54 *
Error	16	16.74	

* Significant at 5% level NS= Non-Significant

Appendix XV: ANOVA for number of tiller per 50 linear cm at 90 DAS

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	1.63	0.06
Factor A	1	116.03	4.63 ns
Error	2	25.03	
Factor B	4	47.72	5.81 *
AB	4	27.45	3.34 *
Error	16	8.21	

* Significant at 5% level NS= Non-Significant

Appendix XVI: ANOVA for number of spike per 50 linear cm

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	2.53	0.20
Factor A	1	14.70	1.18 ns
Error	2	12.40	
Factor B	4	36.30	5.21*
AB	4	30.533	4.38 *
Error	16	6.97	

* Significant at 5% level NS= Non-Significant

Appendix XVII: ANOVA for number of effective tiller per 50 linear cm

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	1.23	0.19
Factor A	1	43.20	6.85ns
Error	2	6.30	
Factor B	4	29.95	4.59*
AB	4	15.78	2.42 *
Error	16	6.52	

* Significant at 5% level NS= Non-Significant

Appendix XVIII: ANOVA for number of ineffective tiller per 50 linear cm

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.23	7.00
Factor A	1	56.03	1681.00ns
Error	2	0.03	
Factor B	4	9.05	35.03*
AB	4	4.62	17.87 *
Error	16	0.26	

* Significant at 5% level NS= Non-Significant

Appendix XIX: ANOVA for spike length

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	1.28	0.50
Factor A	1	0.25	0.09ns
Error	2	2.52	
Factor B	4	4.67	1.80*
AB	4	8.24	3.18 *
Error	16	2.58	

* Significant at 5% level NS= Non-Significant

Appendix XX: ANOVA for number of spikelet per spike

Sources of variation	**Degrees of Freedom**	**Mean Squares**	**F Value**
Replication	2	4.59	0.72
Factor A	1	30.12	4.73ns
Error	2	6.37	
Factor B	4	5.19	1.29*
AB	4	6.45	1.60 *
Error	16	4.04	

* Significant at 5% level NS= Non-Significant

Appendix XXI: ANOVA for number of filled grain per spike

Sources of variation	**Degrees of Freedom**	**Mean Squares**	**F Value**
Replication	2	0.08	0.01
Factor A	1	65.92	8.87ns
Error	2	7.43	
Factor B	4	23.10	1.13*
AB	4	18.67	0.91*
Error	16	20.43	

* Significant at 5% level NS= Non-Significant

Appendix XXII: ANOVA for number of unfilled grain per spike

Sources of variation	**Degrees of Freedom**	**Mean Squares**	**F Value**
Replication	2	0.03	1.50
Factor A	1	0.004	0.19ns
Error	2	0.02	
Factor B		0.54	86.00*
AB	4	1.46	231.48*
Error	4	0.006	

* Significant at 5% level NS= Non-Significant

Appendix XXIII: ANOVA for grain yield

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.16	11.17
Factor A	1	0.002	0.13ns
Error	2	0.01	
Factor B		0.06	1.42*
AB	4	0.03	0.66*
Error	4	0.05	

* Significant at 5% level NS= Non-Significant

Appendix XXIV: ANOVA for straw yield

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	0.06	0.89
Factor A	1	0.01	0.19ns
Error	2	0.06	
Factor B		0.03	0.33*
AB	4	0.03	0.33*
Error	4	0.08	

* Significant at 5% level NS= Non-Significant

Appendix XXV: ANOVA for 1000 grain wt.

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	3.46	0.24
Factor A	1	115.37	7.82ns
Error	2	14.75	
Factor B		24.03	1.91*
AB	4	8.72	0.69*
Error	4	12.61	

* Significant at 5% level NS= Non-Significant

Appendix XXVI: ANOVA for Harvest Index

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	4.34	0.93
Factor A	1	1.37	0.29ns
Error	2	4.66	
Factor B		6.96	2.34*
AB	4	0.73	0.24*
Error	4	2.97	

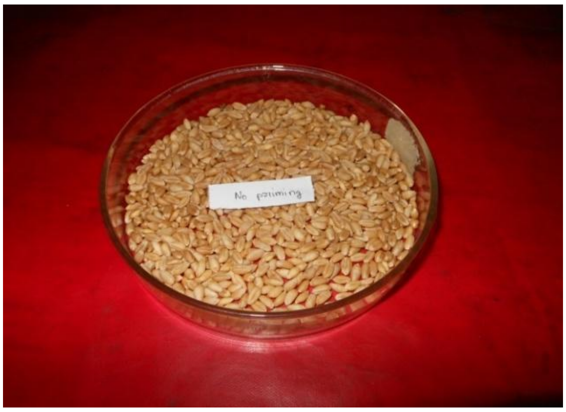
* Significant at 5% level NS= Non-Significant

Appendix XXVII: ANOVA for shelling percentage

Sources of variation	Degrees of Freedom	Mean Squares	F Value
Replication	2	20.72	3.53
Factor A	1	13.17	2.24ns
Error	2	5.87	
Factor B		9.85	1.00*
AB	4	8.07	0.82*
Error	4	9.82	

* Significant at 5% level NS= Non-Significant

PLATES



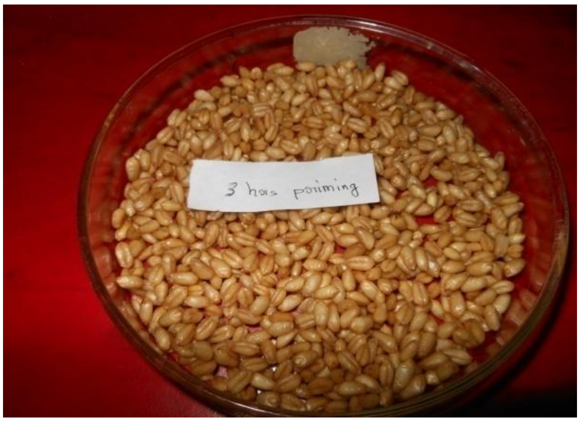


Plate1. Seed primed & not primed

Plate 2. Priming process of seed

Plate 3. Emergence of wheat seedlings (15 DAS)

Plate 4.Field view of ripen wheat

Plate 5. Harvesting of wheat