EFFECT OF PRIMING ON GROWTH, YIELD AND SEED QUALITY OF OKRA (*Abelmoschus esculentus* L.) VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PRIMING ON GROWTH, YIELD AND SEED QUALITY OF OKRA (*Abelmoschus Esculentus* L.) VARIETIES "** submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **SEED TECHNOLOGY**, embodies the result of a piece of *bona fide* research work carried out by **Md. Zahedur Rahman**, Registration No. **10-04019** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2016
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Dedicated To
My Beloved Parents

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ABSTRACT

The experiment was conducted into two parts. One was the field to assess the green pods (vegetable) and seed yield, and the other part was laboratory experiment for evaluating of seed quality after priming. The Research Field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from February-June 2015 to find out the effect of seed priming on yield(green pod)) and seed yield of different okra varieties. The experiment consisted of two factors: Factor A: Three varieties of okra. V_1**:** BARI Dheros-1, V_2: Hybrid Green Soft, V_3: Hybrid Sarika and Factor B: 5 levels of seed priming with different solutions. P_0: Control (no priming), P_1: priming with water (hydro priming), P_2: priming with 3% NaCl solution, P_3: priming with 3% KCl solution, P_4: priming with 3% $MgSO_4$ solution. Seeds were primed at the period of 24 hours. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters, and yield were recorded to find out the suitable variety and level of seed priming of okra. The maximum seed yield (0.633 t ha^{-1}), green pod yield (18.78 t ha^{-1}) were recorded from V_2 (Hybrid green soft). Due to seed priming treatment, maximum seed yield (0.626 t ha^{-1}), green pod yield (19.39 t ha^{-1}) were recorded from that is priming with 3 % $MgSO_4$ solution treatment (P_4) .In interaction effect of variety and seed priming V_2P_4 gave the maximum seed yield (0.695 t ha^{-1}) and green pod yield (21.30 t ha^{-1}) . In case of laboratory experiment the variety Hybrid green soft (V_2) and Priming of treatment with 3% $MgSO_4$ solution (P_4) showed higher germination (%) and seed vigority .so variety V_2 and Priming treatment P_4 and interaction of V_2P_4 seen maximum priming for okra.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	Etcetera
FAO	Food and Agricultural Organization
Fig	Figure
ns	Non Significant

ABBREVIATIONS	ELABORATIONS
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percent
m^2	Square meter
pod^{-1}	Per pod
J.	Journal
kg	Kilogram
No.	Number
NS	Non Significant
^0C	Degree Celsius
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science ’s
Vol.	Volume

CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an annual vegetable crop in tropical and sub-tropical parts of the world (Thakur *et al*, 1986) and one of the most widely known dicotyledonous plants and utilized species of the family Malvaceae (Naveed *et al*, 2009). Okra is also known in many English-speaking countries as lady's fingers, okra, or gumbo. It is a popular summer crop. Of the total vegetable production in Bangladesh, around 70% is produced during rabi season and the rest 30% in kharif season (Hossain, 1992). A power house of valuable nutrients, okra provides numerous health benefits. Known as a high-antioxidant food, okra may support improvement in cardiovascular and coronary heart disease, type 2 diabetes, digestive diseases, and even some cancers. Okra is also abundant in several vitamins and minerals, including thiamin, vitamin B_6, folic acid, riboflavin/vitamin B_2, zinc and dietary fiber. It's a high-fiber food, for starters: Nearly half of its nutrition is a soluble fiber in the form of gums and pectin's and pods are a good source of flavonoid antioxidants like beta carotene, xanthein and lutein (Dilruba *et al*, 2009). Okra flour has huge potential for use to enrich foods in order to provide adequate nutritional daily needs (Adelakun and Oyelade, 2011). Okra pods can be consumed in many ways as fresh (raw), dried, cooked, frozen, fried and pickled. Average mineral concentrations in raw and cooked okra (in mg/100 g) range from 366 to 325 (Ca); 0.102 to 0.052 (Cu); 267 to 97.7 (K); 45.3 to 18.3 (Mg); 18.3 to 7.00 (Na); 44.5 to 25.8 (P); and 0.233 to 0.094 (Zn) (Ivanice *et al.*, 2013). According to USDA Nutrient database, per 100 gm of okra contain 7.03 g carbohydrates, 1.20 g sugars, 3.2 g dietary fiber, 0.10 g fat, 2 g protein, 90.17 g water and 129 KJ energy.

Okra is nutritious but might have poor seedling emergence and vigor. It is intolerant to frost and its seeds do not germinate below 20^0 C. The slow and uneven germination of okra seed is the main hurdle in the early spring planting

(Pandita *et al.,* 2010). The percentage of seed germination of okra is relatively low, due to occurrence of hard seediness in this plant (Felipe *et al.,* 2010). Okra crop exhibits seed hardness that complicates its management. As the seed matured and by decreasing its moisture content, the percentage of hard seededness increased. This seed hardness interferes with seed germination, weed control, harvesting and other management factors (Mohammadi *et al.,* 2011). Seed moisture content is another factor that has effects on seed hardness (El-Balla *et al.,* 2011). The common ecological observation is that, after dispersal from the parent plant, the seeds fall into the surface litter of the soil, where they may be able to survive for long periods either continuously or intermittently imbibed, therefore, with high water content (Villiers and Edgecumbe, 1975).

Uniform and fast germinating seeds are of prime importance for agriculture. To improve the germination properties of seeds, different treatments are used including priming (Badek *et al.,* 2006). Seed priming is pre-sowing treatment used as a technique to enhance seed performance, notably with respect to rate and uniformity of germination, thereby improving seedling stand and enabling better crop establishment (Job *et al.,* 2000). It is a simple, low cost and effective approach for early seedling growth and yield under stressed and non stressed conditions. Priming allows some of the metabolic processes to occur necessarily for germination before actual germination to get start. Priming triggers the synthesis or activation of some enzymes that catalyze the mobilization of storage reserves in seed, while endosperm weakens by hydrolase activities. Priming may increase resistance to abiotic stresses (Farooq *et al.,* 2008). Priming could enhance the activity of anti-oxidative systems, resulting in lower rate of lipid peroxidation, contributing to seed invigoration and allows some of the metabolic process for germination to occur.

Out of several methods of seed priming, two of them namely hydropriming (soaking seeds in water) and osmopriming (soaking seeds in any osmotic

solution of inorganic salts such as KNO_3, K_3PO_4, KH $2PO_4$, $NaNO_3$, $MnSO_4$, $MgSO_4$, Na_2HPO_4, KCl and $MnCl_2$ are more prominent. Okra farmers in Punjab and other Northern states have a major problem of seeds not promptly germinating after planting. In order to address the problem of poor germination, as well as to evaluate the best soaking sources and priming period for okra. In a trail conducted at Pakistan, soaking okra seeds in a single super phosphate (SSP) solution induced a higher germination percentage (85.94%), survival percentage (94.05%), plant height (138.97 cm), number of leaves (26.69), number of pods (31.01), seeds/ pod (49.52), pod length (10.99 cm), pod yield (2702.69 kg/ ha), early emergence (7.79) and flowering (33.65). The highest plant weight (433.36 g) was observed in plots where seeds soaked with diammonium phosphate (DAP) were used (Shah *et al.,* 2011). Another experiment carried out in Swaziland by (Sikhondze and Ossom, 2011) aimed to determine how long okra seeds should be primed in order to influence seedling growth and development. Four time durations (6, 12, 24, or 36 were used for hydro priming okra seeds. Seedlings grown from seeds primed for 24 hours had the greatest mean length and mean stem diameter, as compared with those of the control (non primed seeds). The authors recommended priming okra seeds for 24 hours before planting. Hydropriming capsicum seeds for 0 to 12 h also resulted in lower days to emergence. An increase in hydropriming durations resulted in an increase in the seedling emergence, energy of emergence, seedling vigor and emergence index. Therefore, the study suggested the use of hydropriming as a simple and cost-effective strategy in pepper production, especially in developing countries (Adebisi *et al.,* 2013).

Moreover, seed priming is often implicated in improving the stress-tolerance of germinating seeds. A hypothetical model illustrating the cellular physiology of priming- induced stress-tolerance suggested achievement of two strategies (Chen and Arora, 2013). First, seed priming sets in motion germination-related activities that facilitate the transition of quiescent dry seeds into germinating state and lead to improved germination potential. Secondly, priming imposes a

biotic stress on seeds that repress radicle protrusion but stimulates stress responses, potentially inducing cross- tolerance. Together, these two strategies constitute a 'priming memory' in seeds, which can be recruited upon a subsequent stress-exposure and mediates greater stress-tolerance of germinating primed seeds. Osmopriming cumin seeds (−0.8 and −1.2 Mpa of PEG 6000 solution) accelerated seed germination to a largest extent and improved the germination rate and uniformity under drought stress, especially at 15 °C incubation as compared to 10 °C and 25 °C. Improved stress tolerant was evident as enhanced germination performance at 10, 15 and 25 °C and under water stress of −0.4 and −0.8 Mpa of PEG6000 solution (Rahimi, 2013).

Considering the above facts, the present investigation was undertaken with the following objectives:

- To know the effect of variety and seed priming on growth and yield of okra ,and
- To find out the interaction effect of variety and seed priming on the yield and seed quality of okra .

CHAPTER II

REVIEW OF LITERATURE

A number of research works have been conducted to trace the effect of seed priming for improving the seedling vigor in diverse parts of the world. Information of improve seedling vigor relevant to present research work has been reviewed in this chapter.

2.1 Literature on effect of variety and seed priming

Hussein (2015) conducted an experiment with Hydro-priming and different concentration of salicylic acid and found significant increase in seed germination percentage, germination speed index compared with control treatment. Seed priming to 100 mg\L of salicylic acid concentrations produced highest seedling length which reached to 29 cm compared to 5.33 cm in the control treatment. Root length increased significantly with increasing salicylic acid concentrations from 10 to 100mg\L at 25 C^{o}, and reached 11cm in 100 mg\L compared to 3cm in the control treatment. Priming treatment in the okra seeds with different concentrations of salicylic acid at 25 C^{o} for 4hr also caused significant increase in fresh weight 0.2867, 0.4612, 0.5950, 0.7677, 0.9413 & 0.9988 g respectively, and in dry weight 0.0113, 0.0262, 0.0362, 0.0448, 0.0546 &0.0603 g, respectively, of seedling compared to the control treatment.

Hardeep Kaur *et al.* (2015) observed that the germination percentage significantly increased in the treated seeds as compared to control. The results of various soaking durations indicate that the highest seed germination was recorded in the seeds which were soaked for 24 hr in all treatments .The maximum seedling length was observed in T_2 (osmo-priming with 5% Polyethylene glycol), T_3 (osmo-priming with 10% Polyethylene glycol) and T_1 (hydro-priming). Minimum seedling length was observed in T_4 (priming with

distilled water). Maximum root length in osmo-priming with 5 % polythene glycol than other priming treatments.

Pravisya and Jayaram (2015) investigation aimed to evaluate the effect of priming of *Abelmoschus esculentus* (okra) seeds with liquid phosphobaterium (LPB) on water stress. In the present study the seeds of okra cv. Arka anamika were subjected to priming treatment with 5% and 10% liquid phosphobaterium, and the parameters like biomass, relative water content, chlorophyll content, total protein and yield were studied. Priming with liquid phosphobaterium showed considerable variation in both the physiological and biochemical parameters. Among the concentrations of liquid phosphobaterium tested seeds primed with 10% liquid phosphobaterium were found to effective in mitigating the effect of water stress, stimulating early flowering and also increase in yield.

Sankar *et al.* (2015) observed that the germination percentage was recorded with the numerically maximum value by the variety Bhendi Anjali (92%) followed by Shakti (90.50%) and with minimum germination percentage value by the variety Arka Anamika (70.50%). The root length was recorded with the numerically maximum value by the variety Shakti (10.11cm) followed by Bhendi anjali (9.59 cm) and the minimum root length value by the variety Arka Anamica (7.38 cm) with mean value (8.8889 cm). Seedling weight was recorded with the numerically maximum value by the variety Sivam (0. 2850 g) followed by Shakti (0.2650 g) and the minimum dry seedling weight value by variety Arka Anamika (0.2125 g) with mean value (0.248 g).

Hegazi (2014) worked with priming solutions (Na_2HPO_4, MgSO4 and KCl) that showed significant increase in seedling height over the control. $MgSO_4$ gave higher values for plant height, fresh weight and dry weight.

Sharma *et al.* (2014) worked with four methods of seed priming , all the treatments of hydro-priming enhanced the seed germination even up to 76% in comparison to non-primed seeds i.e. control as 66%.

Kuppusamy and Ranganathan (2014) revealed that among the treatments, hydro-priming (both 12 and 24 h) was the only priming treatment which proved to be detrimental to seeds, in terms of seed germination. Also exmined hydro-priming (12, 24 h), sand matric-priming (60 % WHC; 3, 6 h), halo priming (3% NaCl; 12, 24 h) and osmo-priming (PEG,24 h) two osmotic levels (-1 and -1.5 Mpa) and revealed that among the treatments, hydro-priming (both 12 and 24 h) was the only priming treatment which proved to be detrimental to seeds, in terms of seedling height (cm).Hydro-priming (both 12 and 24 h) was the only priming treatment which proved to be detrimental to seeds, in terms of seedling length (cm).

Dkhil *et al.* (2014) conducted that KCl priming increased final germination percentage, radical length and seedling dry weight 100%, 40.94 mm, 0.03g respectively ascompared with non primed seeds. Also reported that NaCl didn't show any significant effect on fresh weight of primed seeds.

Neena *et al*. (2014) conducted that effect of seed priming treatments and soaking durations on activity and isozyme pattern of antioxidant enzymes was studied. Four treatments: hydropriming, osmo-priming with 5% PEG, osmo-priming with 10% PEG and distilled water with soaking durations from 6 to 48 h at 6 h interval h were used. Dry okra seeds (unsoaked) seved as control. Priming increased the activity of antioxidant enzymes. Maximum increase was observed with T2. Seeds soaked for 24 h showed maximum activity Priming with T2 treatment for 24 h soaking gave the best results, followed by T1 and T3, while unsoaked control seeds proved to be the poorest.

Abbas *et al.* (2014) observed that the germination index (GI) of tested okra cultivars depicted that it decreased significantly in response to salinity magnitude as maximum decrease in GI was noted under 8.0, followed by 6.0, 4.0 and 2.0 dS m^{-1} NaCl. All cultivars submitted to saline conditions, had minimum values for germination index than plants grown under non saline condition

Nirmala and Umarani (2014) conducted an experiment where the seeds of okra and beet root were subjected to four methods of priming , by including two durations viz., hydro priming (12, 24 hours), sand matrix priming (60 % WHC; 3, 6 hours), halopriming (3% NaCl; 12, 24 hours) and osmopriming (PEG, 24 hours two osmotic levels -1 and -1.5 MPa).The results revealed that sand matrix priming (3 hours in 60% WHC of sand) was found to be the best for okra, while for beet root; hydropriming (for 12 hours in water) was most suitable.

Sharma *et al.* (2014) studied the comparison of various seed priming methods for seed germination, seedling vigour and fruit yield in okra. Results revealed that hydropriming for 12 hours and solid matrix priming with calcium aluminium silicate (1:0.4:1; Seed:SM:Water) for 24 hours significantly increased the seed germination, seedling vigour, mean germination time and marketable fruit yield in okra cv. Hissar Unnat. Hydropriming, being simple, economical and safe, is recommended which can be effective to increase the fruit yield up to 55% as compared to control.

Raza *et al.* (2013) studied the effect of seed priming in okra in saline soil under field environment. A split plot design with two main factors including six priming treatments (control, hydropriming, ascorbic acid $50mgL^{-1}$, $100mgL^{-1}$ and salicylic acid $50mgL^{-1}$) and two stress levels (control and 1.25ml NaCl) was implicated. Results showed that hydropriming was quite effective in improving growth, pigments and yield as compared to control under both stress levels.

Nezhad *et al.*(2013) conducted that osmopriming (poly ethylene glycol 6000 (PEG) with 5%, 10% and 15% concentration, potassium nitrate (KNO_3) with 1%, 2% and 3% concentration, potassium chloride (KCL) with 1%, 2% and 4% concentration) and hydropriming (distilled water) in two 12 and 24-hour periods. Results showed that the qualities of germination rate, germination index, mean germination time, germination percentage and normal germination

percentage are meaningful at 1% probability level. Maximum mean germination time is obtained by KCL 4% and PEG 15% treatment during 24 hours.

Rahman *et al.* (2013) carried out the research work to find out whether through prestorage seed priming treatments, okra seed deterioration during storage can be controlled not. Mature okra seeds were primed with water, PEG 8000 and mannitol solutions while dry seeds used as control. Results showed the reduction in unsaturated fatty acids and protein content during storage for all the priming treatments.

Sahib *et al.* (2013) both hydro and KH_2PO_4 solution priming caused significant increase in seeds germination percentage compared to the control. The highest germination percentage was observed in 3% KH_2PO_4 82% and 81.33% at 25 and 30 C^o, respectively. Worked with hydro-priming, control, 1.5 % and 3% KH_2PO4 and observed that the highest germination index was obtained from seeds treated with 3% KH_2PO_4 solution at 25 and 30^0C, respectively. Results showed significant increased from 16.95 in control to 44.36 at 250C in 3% KH_2PO_4 treatment.

Lakkundi *et al.* (2013) visioned that the inorganic salt (KI 1%) recorded significantly maximum germination (75.29%) which was superior over other inorganic salts used in the study and also over the control. This treatment was followed by KNO_3 1% (74.04%) and KH_2PO4 (73.59%) which were at par with each other. Significantly least germination was recorded in $CaCl_2$ (72.17%) and NaCl 1% (72.50%) which are at par with each other. Maximum root length was recorded in T5 (14.40 cm) which was superior over all other inorganic salts used for priming in this study and also over the control. Maximum shoot length in T5 (18.85 cm) which was superior over all the inorganic salts used for priming in this study and also over the control .More seedling dry weight (27.31 mg) in priming with T5 inorganic salt which was superior over all other inorganic salts used in the study. This treatment was

followed by T_1 (26.99 mg), T_2 (26.86 mg), T_3 (26.96 mg) and T_5 (26.79 mg) which were at par with each other.

Basavaraj and Channaveerswami (2013) carried out to study the influence of chemopriming treatment on seed quality in okra (*Abelmoschus esculentus*). These treatments were included in the study i.e. Factor-I: Inorganic salts (T) T_1 - KNO_3 1%, T_2 - NaCl 1%, T_3 - KH_2PO_4 1%, T_4 - $CaCl_2$ 1%, T_5 - KI 1% and factor-II: Drying (D) with drying (D1), without drying (D2) with common control. Among the different inorganic salts used for priming in this study, T_5 recorded significantly highest germination (75.29%), root length (14.40cm), shoot length (18.85cm), seedling dry weight (27.31mg), seedling vigour index-I (2520), seedling vigour index-II (2063), field emergence (71.38%) and lowest electrical conductivity (0.665), among the drying treatments, significantly highest germination (80.38%), root length (14.61cm), shoot length (19.37cm), seedling dry weight (27.58mg), seedling vigour index-I (2732), seedling vigour index-II (2218), field emergence (76.87%) and lowest electrical conductivity (0.631) were recorded in D_1 and among interaction T_5D_1 recorded significantly highest germination (83.25%), root length (14.97cm), shoot length (20.39cm), seedling dry weight (28.14mg), seedling vigour index-I (2944), seedling vigour index-II (2343), field emergence (79.50%) and lowest electrical conductivity (0.609).

Yadav *et al.* (2012) conducted an experiment on 15 genotypes of okra planted in Augmented Block Design and subsequently seeds obtained were treated with three priming solutions in three replications. Three primers used for seed treatments were hydropriming, halopriming with calcium chloride and halopriming with potassium nitrate. The results showed that all seed priming treatments enhance the synchronous germination and speed of germination in genotypes IC411698 and IC89936.

Haq *et al.* (2012) found that genotypes, five NaCl concentrations and their interactions were significantly different (P≤0.01) from each other for shoot length.

Elouaer and Hannachi (2012) conducted a germination experiment at Tunisia in which safflower seeds were primed with 5 g/l NaCl and KCl solutions for 12 and 24 hour respectively at 20Úc. Results showed that seed priming increased germination by 8.66% and 5.06% using NaCl and KCl solutions as compared to non-primed seeds. In fact NaCl seed priming has the highest germination percentage (82.7%) followed closely by KCl seed priming (78.6%), control having the lowest total germination (73.6%) other parameters like germination index, coefficient of variation, shoot and root length was also recorded higher as compared to control.

Soughir *et al.* (2012) conducted a study to develop an optimum protocol for fenugreek and determinate the effect of NaCl seed priming on seed germination. Fenugreek seeds were primed with four concentrations of NaCl as priming media (0, 4, 6 and 8 g/l) for different durations. Results indicated that different priming concentration of NaCl and duration has significant effects on total germination percentage, mean germination tine, germination index and coefficient of velocity of fenugreek seeds and the best results was obtained with 4 g/l for 36 hour. The result of this experiment showed that under undesirable conditions such as salinity stress, priming with NaCl can prepare a suitable metabolic reaction in seeds and can improved seed germination.

Rahman (2011) cognizant that priming proved effective in improving percent germination (27%) and reducing mean germination time (17.8 h) as compared to unprimed seeds.

Maiti *et al.* (2011) founded that in case of hydro-priming-2 germination % is constant at 1st month and showing very little reduction up to 3rd month. Observed that 2 varieties treated with osmo-priming showed high increase in plant height followed by hydro-priming-2.

Selvarani and Umaran (2011) conducted to standardize the best methodology and method of priming, specific to each crop seed viz., okra. Four methods of priming viz., hydropriming, sand matricpriming , halopriming and osmopriming were evaluated by screening a range of durations and concentrations .The observation of parameters viz., i) percentage of radicle protrusion ii) days for 50 % germination iii) days for maximum germination iv) speed of germination and v) germination percentage revealed that the best methodology varied with the crop species . For okra, sand matric priming (24 h in 80% WHC of sand) recorded the highest improvement of 44, 43, 40, 58 and 7 percent over control, respectively for the above parameters.

Sikhondze and Ossom (2011) conducted an experiment to determine how long okra seeds should be primed in order to influence seedling growth and development. Four time durations (6, 12, 24, or 36 hours) were used for hydro priming okra seeds. The results showed that seedlings grown from seeds primed for 24 hours had the greatest mean length, leaf size, internode number and mean stem diameter, as compared to other durations and control.

Shah *et al.* (2011) studied the effect of seed priming on okra cv. Sabaz Pari with different sources of phosphorous and soaking durations. There were four priming resources (distilled water, 1% phosphorous, solution of each of Diammonium phosphate (DAP), single super phosphate (SSP), SSP+Na2Co3) with soaking durations from 4 hours and their two folds up to 48 hours alongwith unprimed seeds (control). Results showed that seed priming with SSP solution for 24 hours duration gave the best results, followed by DAP, while unprimed seeds proved to be the poorest.

Hegazi and Hamideldin (2010) studied the effect of different gamma irradiation doses (300, 400, 500 Gy) and water soaking (hydropriming) on okra seeds of two varieties (Sabahia and Balady). Both varieties showed similar trends in response to different treatments. From the result, it was concluded that pre-

sowing treatments were effective in improving plant growth, seed yield and seed quality.

Pandita *et al.* (2010) evaluated solid matrix priming (SMP) alone and in combination with Trichoderma viride or captan, hydropriming and non-primed seeds for seedling emergence at sub-optimal temperature. Hydropriming improved laboratory germination similar to SMP. The results suggested that solid matrix priming in combination with Trichoderma viride can be successfully used to improve seedling emergence and productivity of okra under low temperature.

Khan *et al.* (2009) evaluated the response of seeds primed with NaCl solution at different salinity levels 0, 3, 6 and 9 dSm^{-1} in relation to early growth stage and concluded that seed priming with NaCl has found to be better treatment as compared to nonprime seeds. Priming with NaCl and KCl was helpful in removing the deleterious effects of salts (Iqbal *et al*., 2006).

Sivritepe *et al.* (2003) studied the effect of NaCl priming on salt tolerance in melon seedlings grown under saline conditions. They reported that NaCl priming of melon seeds increased salt tolerance of seedling by promoting K and Ca accumulation, besides inducing osmo regulation by the accumulation of organic solutes. NaCl priming diminished inhibiting effect of salinity on seed germination and seedling growth in okra, cucumber and tomato.

Raun *et al.* (2002) reported that priming the rice seed with KCl improved its germination index. Greater efficiency of seed priming with KCl is possibly related to the osmotic advantage that K+ has in improving cell water saturation and that act as co-factor in activities of numerous enzymes (Taiz and Zeiger, 2002).

Iqbal *et al.* (2001) observed the effect of H_2O_2 priming on germination was significant. The highest germination (83.33%) was obtained at 2% solution.

The longest root (20.15 cm) was produced with 2% solution. That was significantly higher as obtained from rest 9 concentrations

Conway *et al.* (2001) evaluated the efficacy of solid matrix priming techniques, alone or in combination with fungicide seed treatment on seedling emergence and reduction of damping-off of okra in field soil naturally infested with *Pythium ultimum*. The following treatments were evaluated: thiram + carboxin (chemo-primed) (commercially applied), biological seed treatment (bio-primed) (*Trichoderma harzianum* isolate OK-110, 1 g suspended in 1% carboxymethylcellulose [CMC]), untreated seed (control), and a 1% CMC control. Chemo-primed seeds had a more uniform and faster emergence compared with untreated seeds at both field sites. Within 3 days, 92 and 78% of chemo-primed seeds had emerged at Stillwater and Bixby, respectively.

Van *et al.* (1996) studied the effect of hydration treatments on germination performance, moisture content, DNA synthesis and controlled deterioration tolerance in tomato. Hydropirming of seeds resulted on increased in resistance to deterioration and adverse effect of osmopriming were caused by a decrease in DNA repair activity.

Jagadish *et al.* (1994) reported that hydration-dehydration treatment improved germination capacity of slightly deteriorated seeds in okra, tomato, chilli and onion. They reported significant enhancement in germination and seedling growth when these seeds were treated with PEG @ 1.20 MPa.

Shahid *et al.* (1991) observed that pre-sowing treatment of seeds resulted in better establishment of okra seedlings. Treated seeds exhibited high percentage of germination, vigour index, seedling growth and dry weight of seedlings against untreated seed. Hydration-dehydration treatments, also known as priming is most effective in low vigour seed lots of okra. Dehydration of primed seed to their initial moisture content without embryo damage or loss of the metabolic enhancement induced during imbibition have been documented.

Doijode and Raturi (1987) reported pre-germination hydration-dehydration of tomato, radish, onion, gardenpea seeds exhibited high percentage of germination and seedling vigour. It was concluded that hydration- dehydration of seeds resulted in better establishment of seedling. Greater membrane integrity lowered electrical conductance of seed leachate, reduced leakage of sugars, higher activities of dehydrogenase enzymes and lower peroxidation values were also detected in hydration dehydration of okra, egg plants and radish seeds.

Burgass *et al.* (1984) noticed that hydration-dehydration of low vigour seeds for two hours showed an increased rate of germination per cent, emergence and establishment. Suggesting that seed invigrouration by hydration-dehydration results from repair of previously sustained deterioration

Saha and Basu (1981) concluded that hydration-dehydration treatment proved beneficial in reducing the loss of germinability of okra.

Kundu and Basu (1981) observed carrot seed, midstorage hydration-dehydration treatment for 2 h followed by drying effectively reduced physiological deterioration and also showed better field emergence.

Pathak and Basu (1980) noticed effective control in the loss of vigour and viability associated with increased germination and roots and shoot length in sunflower seeds, when soaked in water for two hours followed by drying.

Mishra and Dwibedi (1980) found that seed soaking in 2.5% KCl for 12 hour before sowing increased okra yield by 15%. KCl and KH_2PO_4 have been introduced as the osmotica which have shown good potential to enhance emergence and germination in okra.

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CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from February to June, 2015 to study the effect of priming on yield and seed quality of okra varieties. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Experimental site

The study was conducted in the Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the performance of okra in response to priming. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level.

3.2 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from January to July, 2015. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics were presented in Appendix II.

3.4 Planting materials

Three varieties of okra have been used as the planting materials. "BARI Dherosh-1", "Hybrid Green Soft" and "Hybrid Sharika" were used as the test crop of this experiment. The seed of BARI Dherosh-1 was collected from Bangladesh Agricultural Institute (BARI), joydebpur, Gazipur. Hybrid Green Soft was collected from ACI Seed Company and Hybrid Sharika was collected from Lal Teer Seed Company of Bangladesh.

3.5 Experimental treatments

The experiment was consisted of two treatment factors as follows:

Factor A: Variety - 3	**Factor B:** Priming - 5
V_1: BARI Dherosh-1	P_0: Control (no priming)
V_2: Green Soft	P_1: Priming with water (Hydro priming)
V_3: Sharika	P_2: Priming with 3% NaCl solution
	P_3: Priming with 3% KCl solution
	P_4: Priming with 3% $MgSO_4$ solution

Priming of seeds were done for 24 hours for all treatments.

3.6 Seed priming

For priming, okra seeds were subjected to hydro-priming (distilled water only) and priming with 3 % NaCl (Halo-priming), 3 % KCl (Halo-priming), 3 % $MgSO_4$ solution for 24 hours at 25^0 C to 30^0 C. Seed weight to solution volume ratio was 1:5 (w/v). For seed priming; seeds were soaked in the respective solutions or water for 24 hours. Thereafter, seeds were removed, given three surface washings and the seeds were dried at 25^0 C for 24 hours in the laboratory for close to original moisture level as described by (Khan *et al.*, 2009). Untreated seeds were used as control or non-priming treatment.

Two experiment were conducted with the primed seed. One experiment was done in laboratory for seed quality assessment of the priming seed. Another

experiment was done in field for assessment of green pod (vegetable) and seed yield.

3.7 Field experiment for green pod (vegetable) and seed yield

This experiment was conducted in the field by following steps

3.8 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 408 m^2 with length 24.00 m and width 17.00 m. The total area was divided into three equal blocks. Each block was divided into 15 plots where 15 treatments combination were allotted at random. There were 45 unit plots altogether in the experiment. The size of the each plot was 2.8 m × 2.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Seeds were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 50 cm, respectively. There were 20 plants were planted in each unit plot (Appendix III).

3.9 Land preparation

The plot selected for conducting the experiment was opened in the 1st week of March, 2016 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for sowing okra seeds. After final preparation of land the land the seeds were sown 11 March 2016.

3.10 Application of manure and fertilizers

Urea, TSP and MOP were applied at the rate of 600, 400 and 600 kg per hectare, respectively by following the Bangladesh Agricultural Research Institute recommendation (BARI,2002). Whole amount of TSP and 1/4 amount of MOP fertilizers except urea were applied as basal dose (during final land preparation). Total urea and rest of the fertilizers were applied at 20, 40 and 60 DAS at the rate of 3 equal splits. The applied manures were mixed properly

with the soil in the plot using a spade. As per recommendation the amount of urea, TSP and MOP were used in each plot at the rate of 336 g, 224 g and 336 g, respectively.

3.11 Intercultural operation

After raising seedlings, various intercultural operations such as irrigation, weeding and top dressing, plant protection measures etc. were accomplished for better growth and development of the okra seedlings.

3.12.1 Irrigation and drainage

Over-head irrigation was provided with a watering cane to the plots once immediately after raising of seedlings in every alternate day in the evening up to seedling establishment. Further irrigation was provided as and when needed. Excess water was effectively drained out at the time of heavy rains.

3.12.2 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully. Mulching for breaking the crust of the soil was done when needed.

3.12.3 Plant protection

Malathion 57 EC was applied @ 2 ml L^{-1} against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after seedling raising to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide. During foggy weather precautionary measured against disease infection of okra was taken by spraying Dithane M-45 fortnightly @ 2 g/L, at the early vegetative stage. Ridomil gold was also applied @ 2 g/L against blight disease of okra.

3.13 Harvesting

Harvesting was done in two steps. One is for green pod collection and another is for seed collection. Fruits were harvested at 3 days interval based on eating quality at green stage. Green harvesting was started from 02 May, 2016 and was continued up to 05 June, 2016. The seed purpose harvesting was done when the pods were became straw color on the plant end of the June, 2016.

3.14 Laboratory Experiment

Primed seeds were also used in laboratory experiment to evaluate their seed and seedling quality. For this purpose 25 seeds of each treatment (same as 3.5) were set for standard germination test in Petridis using sand media. After days of sowing the relevant data were collected.

3.15 Data collection

For taking green pod yield data 10 plants of middle area in each plot were selected and green pod were collected. Another $1m^2$ area of each plot was marked and dry pods were collected from that area for taking seed yield data. From the field experiment the following data were collected.

1. Plant height (cm)
2. Number leaves plant1
3. Number branches $plant^1$
4. Number pods $plant^1$
5. Pod length (cm)
6. Pod diameter (cm)
7. Green pod yield (t ha^1)
8. Number of seeds pod^1
9. 1000-seed weight
10. Seed yield (t ha^1)

From the laboratory the following data were collected.

1. Germination percentage
2. Shoot length
3. Root length
4. Fresh weight of seedling
5. Dry weight of seedling

3.16.1 Plant height (cm)

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after sowing (DAS) up to harvesting time to observe the growth of plants.

3.16.2 Number of leaves plant^{-1}

The total number of leaves per plant was counted from each of selected plants. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS up to harvesting time at 20 days interval.

3.16.3 Number of branches plant^{-1}

The total number of branches per plant was counted from each of selected plants. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS up to harvesting time at 20 days interval.

3.16.4 Number of pods plant^{-1}

The number of pods per plant was counted from the 5 sample plants and the total number of pods of the 5 plants were counted and average then to get number of pods per plant.

3.16.5 Pod length (cm)

The length of green pod was measured with a scale from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.16.6 Pod diameter (cm)

Diameter of green pod was measured at the middle portion of 10 selected marketable fruit from each plot with a slide calipers and there average was taken and expressed in cm.

3.16.7 Green pod yield (t ha^{-1})

Green pod yield of $1m^2$ area okra was collected and weighted in each plot and the weight was converted and expressed in t ha^1.

3.16.8 Number of seeds pod^{-1}

The number of seeds pod^{-1} was counted from the 10 sample pods in each plot and the average number of seeds per pod was calculated.

3.16.9 1000-seed weight

From the selected pods 1000 seeds were counted manually and weighted by the electrical balance in the laboratory and the result was expressed in g.

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

The total amount of seeds taken from $1m^2$ area were weighted by an electrical balance and averaged then to get the seed yield (weight basis) and calculated for one hectare of land and express in t ha^{-1}.

3.16.11 Germination percentage (%)

This experiment was conducted in laboratory and seed was primed as same as field experiment. Twenty five seeds were taken randomly from each treatment and they are uniformly placed on sand. The rolled towels were kept in the seed germinator and their constant temperature of 25±1°C, 95 percent relative humidity was maintained. The germination percentage was calculated based on the equation 1 of Anonymous (1999).

The germination percentage was calculated by the following formulae:

$$\text{Germination percentage} = \frac{\text{Number of total germinated seeds}}{\text{Number of total seeds sown}} \times 100$$

3.16.12 Root length (cm)

After fifteen days of growth, the seedlings were up rooted and washed with water to remove the foreign particles of sand. Root length of ten randomly selected seedlings from each replicate was measured in centimeters (cm) from the base of hypocotyls to the tip of the longest root with the help of meter scale. The average of each replication was calculated.

3.16.13 Shoot length (cm)

After fifteen days of growth, the seedlings were up rooted and washed with distilled water to remove the foreign particles of sand. Shoot length of ten randomly selected seedlings from each replicate was measured in centimeters (cm) from the base of hypocotyls to the tip of the shoot with the help of meter rod. The average of each replication was calculated.

3.16.14 Fresh weight of seedling (g)

After the measurement of root and shoot lengths, the seedlings were wrapped with filter paper to remove any drop of water present on their leaves and shoots. Then digital balance was used for the measurement of fresh weights.

3.16.15 Dry weight of seedling (g)

For dry weights, the ten randomly selected plants from each replicate were taken in paper bags and then placed in oven (Memmert-110, Schawabach) and dried at 70^0C for 72 hours. The dry weights of the seedling were measured in a digital balance and converted as dry weight seedling[1].

3.17 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments were calculated and analysis of variance for all characters was performed by F (variance ration) test. Difference between treatment means were determined by LSD according to Gomez and Gomez, (1984) at 5% level of significance.

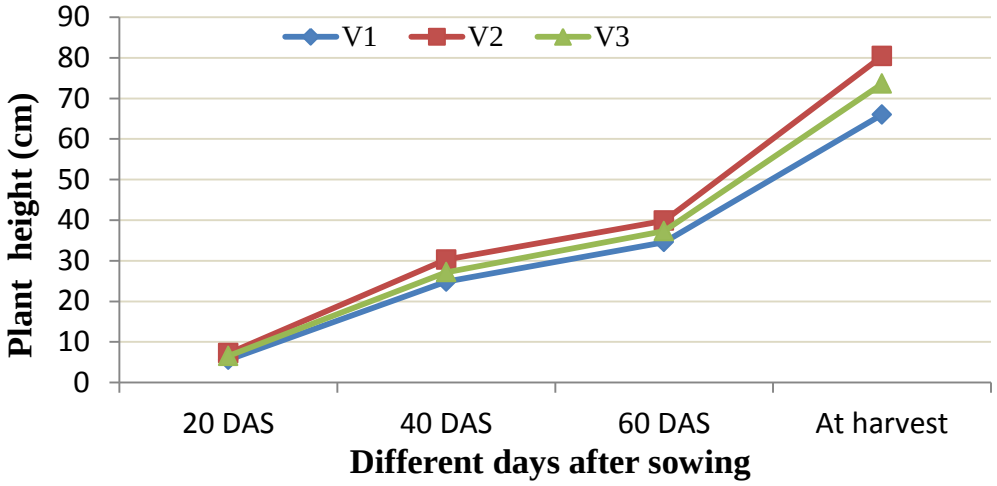
CHAPTER IV
RESULTS AND DISCUSSION

The present study was conducted to find the growth and yield of okra influenced by different varieties and seed priming. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix III-IX. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Plant height

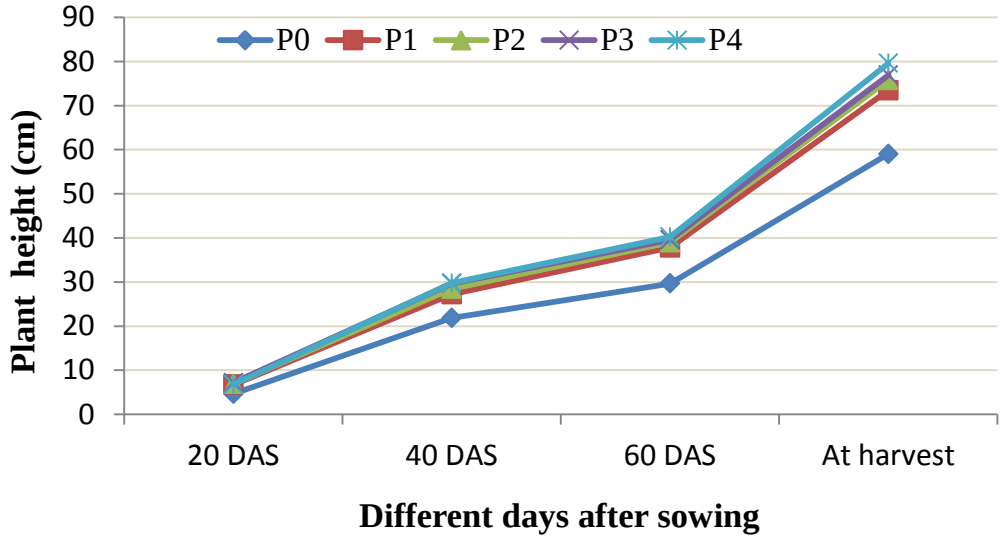
Significant difference was observed due to varieties on plant height at 20, 40, 60 DAS and at harvest. (Fig. 1 and Appendix IV). The figure indicated that irrespective of varieties plant showed an increasing trend with the advantages of growth stages of okra. The highest increase was found at harvest. The rate of increase was much higher from 60 DAS to at harvest. At 20 DAS to 60 DAS the rate of increase was faster than 40 DAS to 60 DAS. At 20, 40, 60 DAS and at harvest, the tallest plant (7.20 cm, 30.26 cm, 39.86 cm and 80.40 cm, respectively) was recorded from V_2 (Hybrid green soft) variety and on the other hand, the shortest plant (5.60cm, 24.84 cm, 35.56 cm and 66.00 cm, respectively) was found from V_1 (BARI Dheros-1) variety.

In case of seed priming treatment, significant difference was observed due to different priming treatments on plant height at 20, 40, 60 DAS and at harvest time (Fig. 2 and Appendix IV). At 20, 40, 60 DAS and at harvest time, the tallest plant (7.18 cm, 29.76 cm, 40.20 cm and 79.55 cm, respectively) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment and that of shortest plant (4.66 cm, 21.86 cm, 29.66 cm and 59.00 cm, respectively) was found from P_0 (no priming) treatment. The result agrees with the findings of Kuppusamy and Ranganathan (2014).



V1: BARI Dheros-1, V2: Hybrid Green Soft, V3: Hybrid Sarika

Fig 1. Effect of variety on plant height of okra at different days after sowing ($LSD_{0.05}$ = 0.14, 11.17, 0.58 and 1.15, at 20, 40, 60 DAS and at harvest time, respectively)



P_0: Control, P_1: priming with water, P_2: priming with 3% NaCl solution, P_3: priming with 3% KCl solution, P_4: priming with 3% $MgSO_4$ solution

Fig 2. Effect of seed priming on plant height of okra at different days after sowing ($LSD_{0.05}$ = 0.19, 1.15, 0.75 and 1.49, at 20, 40, 60 DAS and at harvest time, respectively)

Table 1. Interaction effect of variety and seed priming on plant height of okra at different days after sowing (DAS)

Treatments	Plant height (cm)			
	20 DAS	**40 DAS**	**60 DAS**	**At harvest**
V_1P_0	4.40 i	21.20 d	27.00 k	54.00 j
V_1P_1	5.90 fg	24.90 c	35.40 h	66.33 g
V_1P_2	5.73 g	24.90 c	36.86 fg	70.33 f
V_1P_3	5.76 g	26.60 bc	36.93 fg	70.66 f
V_1P_4	6.20 f	26.60 bc	36.60 gh	68.66 fg
V_2P_0	4.80 h	22.20 d	32.00 i	63.00 h
V_2P_1	7.60 c	28.50 b	40.00 cd	80.00 c
V_2P_2	8.20 b	32.20 a	41.00 bc	80.00 c
V_2P_3	8.60 a	34.20 a	42.30 b	88.00 b
V_2P_4	8.60 e	34.20 a	44.00 a	91.00 a
V_3P_0	4.80 h	22.20 d	30.00 j	60.00 i
V_3P_1	6.60 e	28.30 b	38.00 ef	74.00 e
V_3P_2	6.80 e	28.30 b	39.00 de	77.00 d
V_3P_3	7.20 d	28.50 b	39.40 d	78.00 cd
V_3P_4	7.30 cd	28.50 b	40.00 cd	79.00 cd
LSD $_{(0.05)}$	**0.33**	**2.63**	**1.31**	**2.58**
CV %	**3.77**	**5.74**	**5.11**	**7.10**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

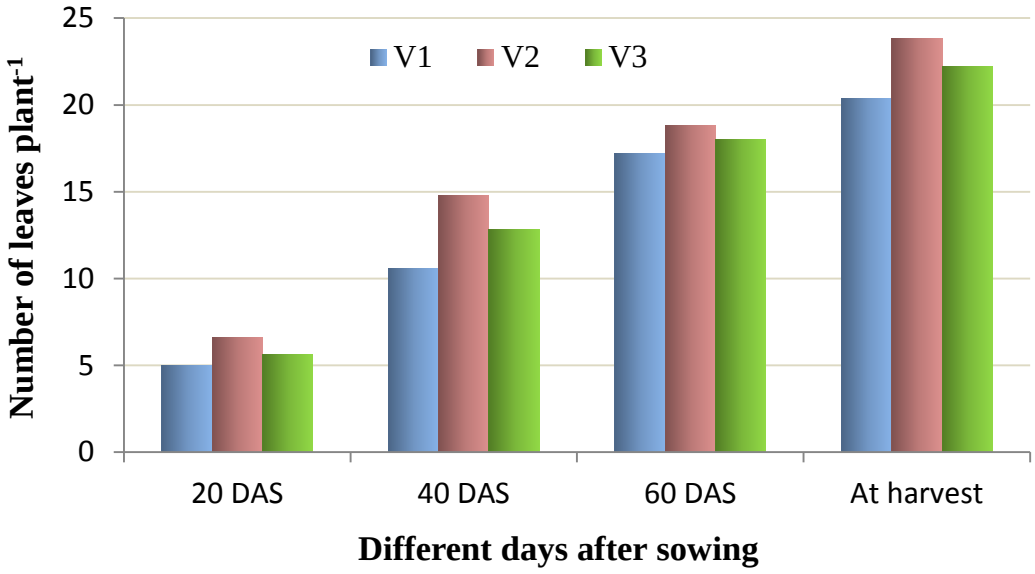
Interaction effects of variety and seed priming showed significant difference on plant height at 20, 40, 60 DAS and at harvest (Table 1 and Appendix IV). At 20, 40, 60 DAS and at harvesting time, the highest plant height (8.60 cm, 34.20 cm, 44.00 cm and 91.00 cm, respectively) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment

combination and on the contrary the shortest plant (4.40 cm, 21.20 cm, 27.00 cm and 54.00 cm) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination. Maiti *et al.* (2011) found the similar results with seed priming experiments on plant height on different varieties.

4.2 Number of leaves plant^{-1}

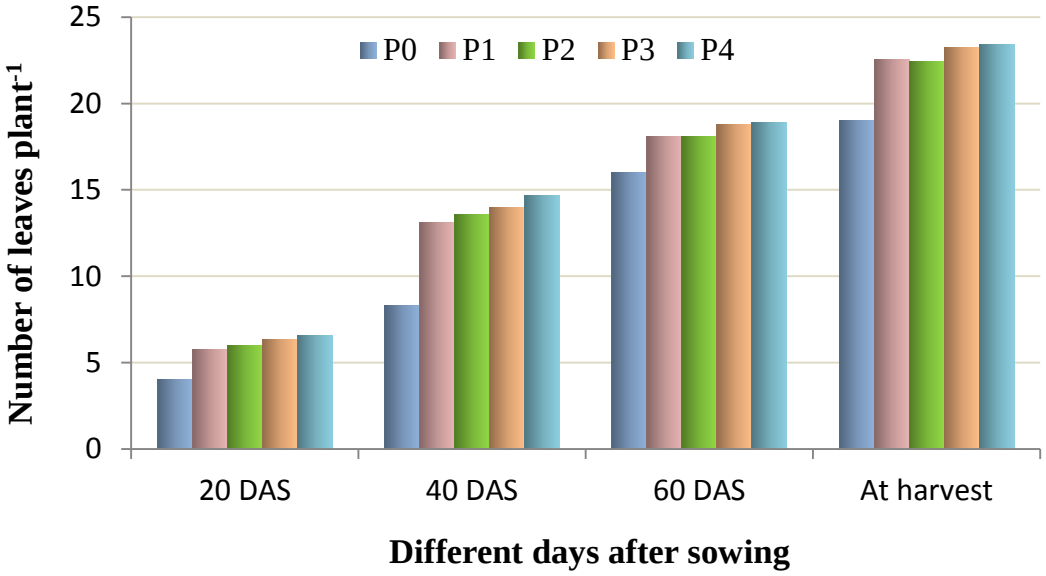
Number of leaves plant^{-1} differed significantly among the varieties for all sampling dates (20, 40, 60 DAS and at harvest) (Fig. 3 and Appendix V). For all sampling dates V_2 (Hybrid green soft) variety produced the highest number of leaves plant^{-1} than other tested varieties V_3 (Hybrid Sarika) and V_1 (BARI Dheros-1). At harvest V_2 variety showed significantly highest leaves plant^{-1} (23.80) and V_1 variety showed the lowest (20.40) leaves plant^{-1}. Hybrid green soft okra variety is the latest variety and it takes slightly more nutrient from soil and produces more leaf and branches than others. Sivritepe *et al.* (2003) supported the results of variation of leaves plant^{-1} due to varieties.

Seed priming treatments exhibited significant difference on number of leaves plant^{-1} at 20, 40, 60 DAS and at harvest of okra (Fig. 4 and Appendix V). Irrespective of priming treatments, production of leaves plant^{-1} showed a gradual increasing trend with the advances of growth stages and the highest increases was observed at harvest of okra. At harvest,the maximum number of leaves plant^{-1} (6.55, 14.66, 18.88 and 23.44 at 20, 40, 60 DAS and at harvest time, respectively) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment and on the other hand the minimum number of leaves plant^{-1} (4.00, 8.33, 16.00 and 19.00 at 20, 40, 60 DAS and at harvest time, respectively) was found from P_0 (no priming) treatment. Hussein (2015) also agreed with the results.



V_1: BARI Dheros-1, V_2: Hybrid Green Soft, V_3: Hybrid Sarika

Fig 3. Effect of variety on number of leaves plant^{-1} of okra at different days after sowing ($LSD_{0.05}$ = 0.16, 0.16, 0.23 and 0.36, at 20, 40, 60 DAS and at harvest time, respectively)



P_0: Control (no priming), P_1: priming with water, P_2: priming with 3% NaCl solution, P_3: priming with 3% KCl solution, P_4: priming with 3% $MgSO_4$ solution

Fig 4. Effect of seed priming on number of leaves plant^{-1} of okra at different days after sowing ($LSD_{0.05}$ = 0.21, 0.21, 0.29 and 0.47, at 20, 40, 60 DAS and at harvest time, respectively)

Interaction effects of variety and seed priming exerted significant effect on number of leaves plant^{-1} at 20, 40, 60 DAS and at harvest time except 20 DAS (Table 2 and Appendix V).

Table 2. Interaction effect of variety and seed priming on number of leaves plant^{-1} of okra at different days after sowing (DAS)

Treatments	Number of leaves			
	20 DAS	**40 DAS**	**60 DAS**	**At harvest**
V_1P_0	4.00 f	6.00 j	16.00 e	19.00 f
V_1P_1	5.33 de	11.33 gh	17.33 d	20.66 de
V_1P_2	5.00 e	11.66 fg	17.33 d	20.33 e
V_1P_3	5.00 e	12.00 f	17.66 cd	20.66 de
V_1P_4	5.66 cd	12.00 f	17.66 cd	21.33 cd
V_2P_0	4.00 f	11.00 h	16.00 e	19.00 f
V_2P_1	6.00 c	15.00 c	19.00 b	24.00 b
V_2P_2	7.00 b	15.00 c	19.00 b	24.00 b
V_2P_3	7.00 b	16.00 b	19.00 b	24.00 b
V_2P_4	8.00 a	17.00 a	20.00 a	25.00 a
V_3P_0	4.00 f	8.00 i	16.00 e	19.00 f
V_3P_1	6.00 c	13.00 e	18.00 c	22.00 c
V_3P_2	6.00 c	14.00 d	18.00 c	22.00 c
V_3P_3	6.00 c	14.00 d	19.00 b	24.00 b
V_3P_4	6.00 c	15.00 c	19.00 b	24.00 b
LSD $_{(0.05)}$	**0.36**	**0.36**	**0.51**	**0.81**
CV %	**3.81**	**5.71**	**6.65**	**5.29**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

At 20, 40, 60 DAS and at harvest the interaction of Hybrid green soft variety with priming with 3% $MgSO_4$ solution produced the maximum number of

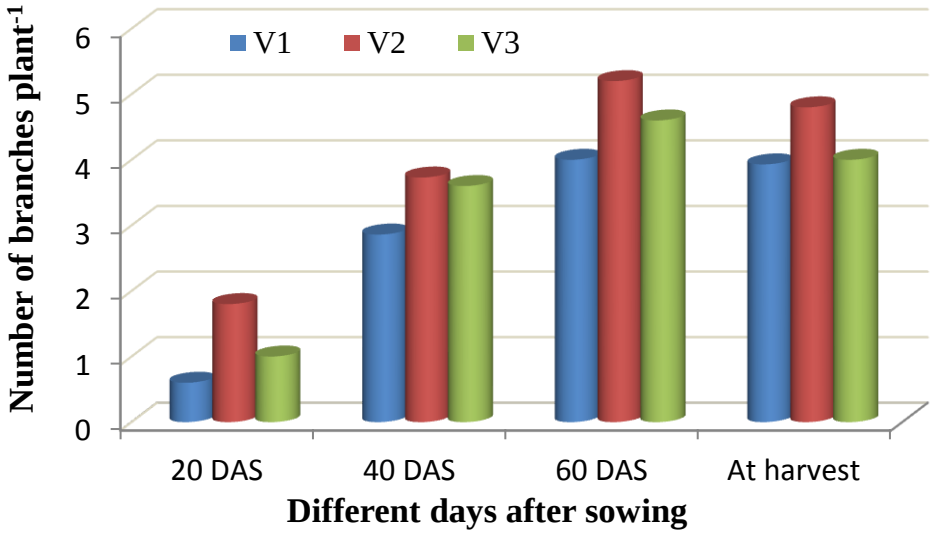
leaves plant^{-1} (8.00, 17.00, 20.00 and 25.00, respectively) and on the contrary the minimum number of leaves plant^{-1} (4.00, 6.00, 16.00 and 19.00, respectively) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination.

4.3 Number of branches plant^{-1}

Number of branches plant^{-1} had significant effect due to varieties on at 20, 40, 60 DAS and at harvest (Fig. 5 and Appendix VI). At 20, 40, 60 DAS and at harvesting time, the maximum number of branches plant^{-1} (1.80, 3.73, 5.20 and 4.80) was recorded from V_2 (Hybrid green soft) variety whereas the minimum number of branches plant^{-1} (0.60, 2.86, 4.00 and 3.93) was found from V_1 (BARI Dheros-1) variety. Hybrid green soft okra variety is the latest variety and it takes slightly more nutrient from soil and produces more leaf and branches than others. For this reasons this variety gives higher branches than other varieties.

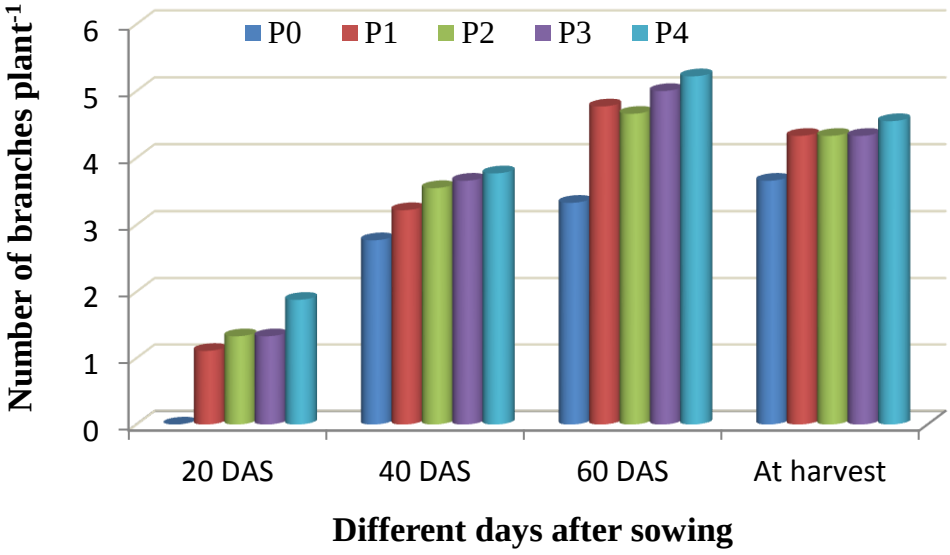
A significant difference was observed due to different priming treatments on number of branches plant^{-1} at 20, 40, 60 DAS and at harvest (Fig. 6 and Appendix VI). At 20, 40, 60 DAS and at harvesting time, the highest number of branches plant^{-1} (1.88, 3.77, 5.22 and 4.55, respectively) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment but the minimum number of branches plant^{-1} (0.00, 2.77, 3.33 and 3.66, respectively) was found from P_0 (no priming) treatment. Hardeep Kaur *et al.* (2015) found the similar results on their experiment.

In case of interaction effects of variety and seed priming, significant difference was observed due to planting of different varieties with different seed priming treatments on number of branches plant^{-1} at 20, 40, 60 DAS and at harvest (Table 3 and Appendix VI).



V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika

Fig 5. Effect of variety on number of branches plant^{-1} at different days after sowing of okra ($LSD_{0.05}$ = 0.16, 0.23, 0.16 and 0.22, at 20, 40, 60 DAS and at harvest time, respectively)



P_0: Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

Fig 6. Effect of seed priming on number of branches plant^{-1} at different days after sowing of okra ($LSD_{0.05}$ = 0.21, 0.29, 0.21 and 0.28, at 20, 40, 60 DAS and at harvest time, respectively)

Table 3. Interaction effect of variety and seed priming on number of branches plant^{-1} at different days after sowing (DAS) of okra

Treatments	Number of branches plant^{-1}			
	20 DAS	**40 DAS**	**60 DAS**	**At harvest**
V_1P_0	0.00 e	2.00 d	3.00 e	3.00 c
V_1P_1	0.33 de	3.00 c	4.33 cd	4.00 b
V_1P_2	1.00 c	3.00 c	4.00 d	4.00 b
V_1P_3	1.00 c	3.00 c	4.00 d	4.66 a
V_1P_4	0.66 cd	3.33 bc	4.66 bc	4.00 b
V_2P_0	0.00 e	3.33 bc	4.00 d	4.00 b
V_2P_1	2.00 b	3.66 ab	5.00 b	5.00 a
V_2P_2	2.00 b	3.66 ab	5.00 b	5.00 a
V_2P_3	2.00 b	4.00 a	6.00 a	5.00 a
V_2P_4	3.00 a	4.33 a	6.33 a	5.33 a
V_3P_0	0.00 e	3.00 c	3.00 e	4.00 b
V_3P_1	1.00 c	3.00 c	5.00 b	4.00 b
V_3P_2	1.00 c	4.00 a	5.00 b	4.00 b
V_3P_3	1.00 c	4.00 a	5.00 b	4.00 b
V_3P_4	2.00 b	4.00 a	5.00 b	4.00 b
LSD $_{(0.05)}$	**0.36**	**0.51**	**0.36**	**0.49**
CV %	**9.25**	**9.08**	**4.74**	**7.02**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

The highest number of branches plant^{-1} 3.00, 4.33, 6.33 and 5.33, respectively at 20, 40, 60 DAS and at harvest, were recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment combination and on the other hand the minimum number of branches plant^{-1} (0.00, 2.00, 3.00 and

3.00, respectively) were found from V_1P_0 (BARI Dheros-1 variety with no priming) combination.

4.4 Number of pods plant^{-1}

Number pods plant^{-1} differed significantly due to varieties (Table 4 and Appendix VII). V_2 (Hybrid green soft) variety maximum number of pods plant^{-1} (34.89) and the minimum number of pods plant^{-1} (26.58) was found from V_1 (BARI Dheros-1) variety.

Different priming treatments showed significant effect on number of pods plant^{-1} of okra (Table 5 and Appendix VII). The maximum number of pods plant^{-1} (34.64) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment which is statistically similar to P_2 treatment, on the other hand the minimum number of pods plant^{-1} (23.12) was found from P_0 (control) treatment (Table 8). Sharma *et al.* (2014) found the higher yield for seed priming. The findings of Raza *et al.* (2013) also agreed with the results.

Significant difference was observed due to interaction of variety and seed priming treatments on number of pods plant^{-1} of okra (Table 6 and Appendix VII). The maximum number of pods plant^{-1} (39.60) was recorded from combination of V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) which was statistically similar to V_2P_3 treatment combination and on the other hand the minimum number of pods plant^{-1} (20.70) was found from V_1P_0 (BARI Dheros-1 variety with no priming) combination.

4.5 Pod length (cm)

The values of length of pod were differed significantly due to varieties of okra (Table 4 and Appendix VII). The maximum pod length (12.70 cm) was recorded from V_2 (Hybrid green soft) variety and on the other hand the minimum pod length (10.32 cm) was found from V_1 (BARI Dheros-1) variety.

In case of different seed priming treatments, significant difference was observed due to different priming treatments on pod length of okra (Table 5 and Appendix VII). The longest pod length (12.11 cm) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment which was statistically similar to P_2 treatment, on the other hand the shortest pod (9.50 cm) was found from P_0 (control) treatment. Raza *et al.* (2013) and Sharma *et al.* (2014) found the higher yield for seed priming which agreed with the results of present experiment.

Significant difference was observed due to interaction of varieties and seed priming treatments on pod length of okra (Table 6 and Appendix VII). The longest pod (13.50 cm) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) combination which is statistically identical to V_2P_2 and V_2P_3 combinations and on the contrary the minimum pod length (8.50 cm) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination.

4.6 Pod diameter (cm)

Different okra varieties exerted significant difference on pod diameter of okra (Table 4 and Appendix VII). The maximum pod diameter (1.85 cm) was recorded from V_2 (Hybrid green soft) variety and the minimum pod diameter (1.40 cm) was found from V_1 (BARI Dheros-1) variety (Table 7).

Seed priming treatments had significant difference on pod diameter of okra (Table 5 and Appendix VII). P_4 (priming with 3% $MgSO_4$ solution) treatment showed the maximum pod diameter (1.86 cm) which was statistically higher than of other priming treatments. The minimum pod diameter (1.18 cm) was found from P_0 (control) treatment. Raza *et al.* (2013) and Sharma *et al.* (2014) found the higher pod diameter for seed priming which supports the present findings.

Variety and seed priming, effect exerted significant variation on pod diameter of okra (Table 6 and Appendix VII). The maximum pod diameter (2.11 cm) was recorded from the interaction of V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) which was statistically similar with the interaction of V_2P_2 and V_2P_3. Significantly the minimum pod diameter (1.04 cm) was found from the interaction of V_1P_0 (BARI Dheros-1 variety with no priming). Sharma *et al.* (2014) and Raza *et al.* (2013) found the higher pod diameter with primed seed which agreed with the results.

4.7 Number of seeds pod^{-1}

Number of seeds pod^{-1} showed significant variation due to varieties of okra (Table 4 and Appendix VII). V_2 (Hybrid green soft) variety showed the maximum number of seeds pod^{-1} (26.81) and the minimum number of seeds pod^{-1} (16.04) was found from V_1 (BARI Dheros-1) variety.

Seed priming treatment varied significantly on number of seeds pod^{-1} (Table 5 and Appendix VII). The highest number of seeds pod^{-1} (26.71) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment which was statistically similar to P_3 treatment. The lowest number of seeds pod^{-1} (14.26) was found from P_0 (control) treatment. Pravisya and Jayaram (2015) supported the results of the present experiment on number of seeds pod^{-1}.

Interaction effects of variety and seed priming, differed significantly on number of seeds pod^{-1} of okra (Table 6 and Appendix VII). Hybrid green soft variety priming with 3% $MgSO_4$ solution (V_2P_4) interaction produced the maximum number of seeds pod^{-1} (32.68) which was statistically simillar to V_2P_2 and V_2P_3 treatment combination and on the contrary the minimum number of seeds pod^{-1} (10.00) was found from V_1P_0 (BARI Dheros-1 variety with no priming) combination which is statistically similar to V_3P_0.

Table 4. Effect of variety on number of pods plant^{-1}, Pod length and Pod diameter and seeds pod^{-1}of okra

Treatments	Pods plant^{-1} (no.)	Pod length (cm)	Pod diameter (cm)	Seeds pod^{-1} (no)
V_1	26.58 c	10.32 c	1.40 c	16.04 c
V_2	34.89 a	12.70 a	1.85 a	26.81 a
V_3	31.70 b	10.94 b	1.58 b	22.96 b
LSD $_{(0.05)}$	**0.93**	**0.21**	**0.07**	**1.12**
CV %	**4.03**	**5.56**	**6.54**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika

Table 5. Effect of seed priming on number of pods plant^{-1}, Pod length and Pod diameter and seeds pod^{-1}of okra

Treatments	Pods plant^{-1} (no.)	Pod length (cm)	Pod diameter (cm)	Seeds pod^{-1} (no)
P_0	23.12 d	9.50 d	1.18 d	14.26 d
P_1	31.80 c	11.38 c	1.61 c	18.47 c
P_2	32.35 bc	11.66 bc	1.68 bc	24.76 b
P_3	33.38 b	11.93 ab	1.74 b	25.47 ab
P_4	34.64 a	12.11 a	1.86 a	26.71 a
LSD $_{(0.05)}$	**1.21**	**0.27**	**0.10**	**1.45**
CV %	**4.03**	**5.56**	**6.54**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

P_0: Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

Table 6. Interaction effect of variety and seed priming on pods plant^{-1}, Pod length and Pod diameter and seeds pod^{-1}of okra

Treatments	Pods plant^{-1} (no.)	Pod length (cm)	Pod diameter (cm)	Seeds pod^{-1} (no.)
V_1P_0	20.70 i	8.50 h	1.04 i	10.00 f
V_1P_1	27.64 fg	10.66 ef	1.43 fg	17.01 de
V_1P_2	27.15 g	10.50 f	1.43 fg	16.69 e
V_1P_3	28.07 fg	11.10 de	1.44 fg	16.78 e
V_1P_4	29.32 f	10.83 def	1.68 de	19.30 d
V_2P_0	25.03 h	10.50 f	1.32 gh	22.40 c
V_2P_1	35.77 cd	12.50 b	1.87 bc	15.20 e
V_2P_2	36.00 bc	13.50 a	1.98 ab	31.20 a
V_2P_3	38.07 ab	13.50 a	2.01 ab	32.60 a
V_2P_4	39.60 a	13.50 a	2.11 a	32.68 a
V_3P_0	23.63 h	9.50 g	1.18 hi	10.40 f
V_3P_1	32.00 e	11.00 de	1.54 ef	23.20 c
V_3P_2	33.90 de	11.00 de	1.65 de	26.40 b
V_3P_3	34.00 cde	11.20 d	1.78 cd	27.04 b
V_3P_4	35.00 cd	12.00 c	1.79 cd	28.16 b
LSD $_{(0.05)}$	**2.09**	**0.48**	**0.17**	**2.51**
CV %	**4.03**	**5.56**	**6.54**	**6.85**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

4.8 1000-seed weight (g)

In case of different okra varieties, significant difference was observed due to planting of different varieties on 1000-seed weight. Significantly the maximum 1000-seed weight (71.16 g) was recorded from V_2 (Hybrid green soft) variety

and on the other hand the minimum 1000-seed weight (54.58 g) was found from V_1 (BARI Dheros-1) variety (Table 7 and Appendix VIII). The result revealed that variety V_2 was only produced 16.58 g and 10.70 g higher 1000-seed weight than V_1 and V_3 variety respectively.

Weight of 1000-seed differed significantly due to different priming treatments, of okra (Table 8 and Appendix VIII). Seed priming treatment P_4 (priming with 3% $MgSO_4$ solution) produced the maximum 1000-seed weight (74.05 g) which was significantly highest than other priming treatments. The minimum 1000-seed weight (47.60 g) was found from P_0 (control) treatment. Khan *et al.* (2009) found similar results of seed weight that the increased seed weight due to priming seed.

Significantly the highest 1000-seed weight (97.60 g) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment combination and on the contrary the minimum 1000-seed weight (42.22 g) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination which was significantly lowest than other combinations (Table 9 and Appendix VIII).

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

In case of different okra varieties, significant difference was observed due to planting of different varieties on seed yield. Significantly the maximum seed yield (0.663 t ha^{-1}) was recorded from V_2 (Hybrid green soft) variety and the minimum seed yield (0.543 t ha^{-1}) was found from V_1 (BARI Dheros-1) variety (Table 7 and Appendix VIII).

Seed yield differed significantly due to different priming treatments, of okra (Table 8 and Appendix VIII). Seed priming treatment P_4 (priming with 3% $MgSO_4$ solution) produced the maximum seed yield (0.626 t ha^{-1}) which was

statistically similar to P_3 priming treatment. The minimum seed yield (0.512 t ha^{-1}) was found from P_0 (control) treatment.

Significantly the maximum seed yield (0.695 t ha^{-1}) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment combination and on the contrary the minimum seed yield (0.502 t ha^{-1}) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination which was significantly minimum than other combinations (Table 9 and Appendix VIII).

4.10 Green pod yield (t ha^{-1})

A significant difference was observed due to planting of different varieties on green pod yield (Table 7 and Appendix VIII). The maximum yield (18.78 t ha^{-1}) was recorded from V_2 (Hybrid green soft) variety and on the other hand the minimum yield (15.77 t ha^{-1}) was found from V_1 (BARI Dheros-1) variety which indicated that V_2 variety produced 19.08 % and 6.82 % higher yield than V_1 and V_3 variety, respectively.

Yield of okra exerted significant difference due to seed priming treatments (Appendix VIII). The P_4 (priming with 3% $MgSO_4$ solution) treatment showed the maximum green pod yield (19.39 t ha^{-1}) which was statistically simillar to P_3 treatment but that of lowest (11.61 t ha^{-1}) was found from P_0 (control) treatment (Table 8). Khan *et al.* (2009) and Sikhondze and Ossom (2011) observed that priming removes the salinity and improves the yield which agreed with the results.

Interaction effects of variety and seed priming exerted significant difference on yield of okra (Appendix VIII). The highest green pod yield (21.30 t ha^{-1}) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment combination which was statistically similar to V_2P_2 and V_2P_3 on the contrary the minimum yield (10.73 t ha^{-1}) was found from V_1P_0

(BARI Dheros-1 variety with no priming) treatment combination which was also statistically similar to V_3P_0 treatment combination (Table 9).

Table 7. Effect of variety on 1000-seed weight, germination percentage, seed yield and green pod yield of okra

Treatments	1000-seed weight (g)	Seed yield (t ha^{-1})	Green pod yield (t ha^{-1})
V_1	54.58 c	0.543 c	15.77 c
V_2	71.16 a	0.633 a	18.78 a
V_3	60.46 b	0.574 b	17.58 b
LSD $_{(0.05)}$	**0.67**	**0.006**	**0.59**
CV %	**5.46**	**5.42**	**7.52**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika

Table 8. Effect of seed priming on 1000-seed weight, seed yield and green pod yield of okra

Treatments	1000-seed weight (g)	Seed yield (t ha^{-1})	Green pod yield (t ha^{-1})
P_0	47.60 d	0.512 c	11.61 c
P_1	62.31 c	0.579 b	18.12 b
P_2	62.42 c	0.585 b	18.67 ab
P_3	63.94 b	0.617 a	19.09 a
P_4	74.05 a	0.626 a	19.39 a
LSD $_{(0.05)}$	**0.87**	**0.008**	**0.77**
CV %	**5.46**	**5.42**	**4.61**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

P_0: Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

Table 9. Interaction effect of variety and seed priming on 1000-seed weight, germination percentage, seed yield and green pod yield of okra

Treatments	1000-seed weight (g)	Seed yield (t ha^{-1})	Green pod yield (t ha^{-1})
V_1P_0	42.22 i	0.502 i	10.73 g
V_1P_1	57.63 fg	0.546 g	16.32 e
V_1P_2	56.86 g	0.548 fg	16.88 e
V_1P_3	57.23 g	0.554 efg	17.59 de
V_1P_4	58.96 f	0.568 de	17.32 de
V_2P_0	50.40 h	0.526 h	12.75 f
V_2P_1	68.40 c	0.618 c	19.62 bc
V_2P_2	69.00 bc	0.645 b	20.12 ab
V_2P_3	70.40 b	0.684 a	20.14 ab
V_2P_4	97.60 a	0.695 a	21.30 a
V_3P_0	50.20 h	0.508 i	11.37 g
V_3P_1	60.90 e	0.574 d	18.42 cd
V_3P_2	61.40 e	0.563 def	19.01 bc
V_3P_3	64.20 d	0.614 c	19.54 bc
V_3P_4	65.60 d	0.615 c	19.56 bc
LSD $_{(0.05)}$	**1.51**	**0.015**	**1.33**
CV %	**5.46**	**5.42**	**4.61**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

4.11 Germination percentage (%)

Different okra varieties exerted significant difference on germination percentage of okra seed (Table 10 and Appendix VIII). The maximum germination percentage (41.60 %) was recorded from V_2 (Hybrid green soft) variety and the minimum germination percentage (22.73 %) was found from V_1 (BARI Dheros-1) variety (Table 7).

Seed priming treatments had significant difference on germination percentage of okra (Table 11 and Appendix VIII). P_4 (priming with 3% $MgSO_4$ solution) treatment showed the maximum germination percentage (41.33 %) which was statistically higher than of other priming treatments. The minimum germination percentage (20.22 %) was found from P_0 (control) treatment. Raza *et al.* (2013) and Sharma *et al.* (2014) found the higher germination percentage for seed priming which supports the present findings.

Variety and seed priming, effect exerted significant variation on germination percentage of okra (Table 12 and Appendix VIII). The maximum germination percentage (64.00 %) was recorded from the interaction of V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution). Significantly the minimum germination percentage (20.00 %) was found from the interaction of V_1P_0 (BARI Dheros-1 variety with no priming).

4.12 Root length (cm)

Root length differed significantly due to varieties (Table 10 and Appendix IX). V_2 (Hybrid green soft) variety showed maximum root length (3.11 cm) and the minimum root length (2.64 cm) was found from V_1 (BARI Dheros-1) variety.

Different priming treatments showed significant effect on root length of okra seedlings (Table 11 and Appendix IX). The longest root (3.06 cm) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment on the other

hand the shortest root (2.62 cm) was found from P_0 (control) treatment. The findings of Raza *et al.* (2013) also agreed with the results.

Significant difference was observed due to interaction of variety and seed priming treatments on root length of okra (Table 12 and Appendix IX). The maximum root length (3.34 cm) was recorded from combination of V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) which was statistically similar to V_2P_3 treatment combination and the minimum root length (2.51 cm) was found from V_1P_0 (BARI Dheros-1 variety with no priming) combination.

4.13 Shoot length (cm)

Shoot length differed significantly due to varieties (Table 10 and Appendix IX). V_2 (Hybrid green soft) variety showed maximum shoot length (6.03 cm) and the minimum shoot length (4.29 cm) was found from V_1 (BARI Dheros-1) variety.

Different priming treatments showed significant effect on shoot length of okra seedlings (Table 11 and Appendix IX). The longest shoot (5.64 cm) was recorded from P_4 (priming with 3% $MgSO_4$ solution) treatment which is statistically similar to P_3 (priming with 3% KCL solution) and the shortest shoot (3.98 cm) was found from P_0 (control) treatment. The findings of Raza *et al.* (2013) also agreed with the results.

Significant difference was observed due to interaction of variety and seed priming treatments on shoot length of okra (Table 12 and Appendix IX). The maximum shoot length (6.70 cm) was recorded from combination of V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) which was statistically similar to V_2P_1 ,V_2P_2 and V_2P_3 treatment combination and the minimum shoot length (3.86 cm) was found from V_1P_0 (BARI Dheros-1 variety with no priming) combination.

4.14 Fresh weight of seedlings (g)

In case of different okra varieties, significant difference was observed due to planting of different varieties on fresh weight of seedling. Significantly the maximum fresh weight (3.61 g) was recorded from V_2 (Hybrid green soft) variety and on the other hand the minimum fresh weight (2.82 g) was found from V_1 (BARI Dheros-1) variety (Table 10 and Appendix IX).

Fresh weight of seedling differed significantly due to different priming treatments, of okra (Table 11 and Appendix IX). Seed priming treatment P_4 (priming with 3% $MgSO_4$ solution) produced the maximum fresh weight (3.51 g) which was significantly highest than other priming treatments. The minimum fresh weight of seedling (2.61 g) was found from P_0 (control) treatment. Khan *et al.* (2009) found similar results of seed weight that the increased seedling weight due to priming seed.

Significantly the highest fresh weight of seedling (4.21 g) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3% $MgSO_4$ solution) treatment combination and the minimum fresh weight (2.36 g) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination which was significantly lowest than other combinations (Table 12 and Appendix IX).

4.15 Dry weight of seedlings (g)

A significant difference was observed due to planting of different varieties on dry weight of seedling (Table 10 and Appendix IX). The maximum dry weight of seedling (0.33 g) was recorded from V_2 (Hybrid green soft) variety and on

Table 10. Effect of variety on germination (%), root length, shoot length, fresh weight of seedlings, dry weight of seedlings of okra

Treatments	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Fresh weight of seedlings (g)	Dry weight of seedlings (g)
V_1	22.73 c	2.64 c	4.29 c	2.82 c	0.23 c
V_2	41.60 a	3.11 a	6.03 a	3.61 a	0.33 a
V_3	28.13 b	2.87 b	5.03 b	3.07 b	0.28 b
LSD $_{(0.05)}$	0.58	**0.07**	**0.25**	**0.09**	**0.008**
CV %	2.54	**3.46**	**6.61**	**3.80**	**4.17**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.
V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika

Table 11. Effect of seed priming on germination (%), root length, shoot length, fresh weight of seedlings, dry weight of seedlings of okra

Treatments	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Fresh weight of seedlings (g)	Dry weight of seedlings (g)
P_0	20.22 d	2.62 c	3.98 c	2.61 c	0.20 e
P_1	28.55 c	2.89 b	5.08 b	3.09 b	0.27 d
P_2	32.00 b	2.86 b	5.33 ab	3.17 b	0.28 c
P_3	32.00 b	2.94 b	5.57 a	3.45 a	0.31 b
P_4	41.33 a	3.06 a	5.64 a	3.51 a	0.32 a
LSD $_{(0.05)}$	0.75	**0.09**	**0.32**	**0.11**	**0.011**
CV %	2.54	**3.46**	**6.61**	**3.80**	**4.17**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

P_0: Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

Table 12. Interaction effect of variety and seed priming on germination (%), root length, shoot length, fresh weight of seedlings, dry weight of seedlings of okra

Treatments	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Fresh weight of seedlings (g)	Dry weight of seedlings (g)
V_1P_0	20.00 g	2.51 h	3.86 e	2.36 i	0.19 g
V_1P_1	21.66 f	2.66 gh	4.13 de	2.67 h	0.20 g
V_1P_2	24.00 e	2.54 gh	4.15 de	2.80 gh	0.24 f
V_1P_3	24.00 e	2.68 fg	4.73 c	3.12 de	0.25 ef
V_1P_4	24.00 e	2.84 ef	4.60 cd	3.21 de	0.26 e
V_2P_0	20.00 g	2.71 fg	4.13 de	3.12 de	0.21 g
V_2P_1	36.00 c	3.14 bc	6.33 a	3.42 bc	0.35 bc
V_2P_2	44.00 b	3.17 bc	6.43 a	3.51 b	0.35 bc
V_2P_3	44.00 b	3.19 ab	6.60 a	4.12 a	0.36 b
V_2P_4	64.00 a	3.34 a	6.70 a	4.21 a	0.38 a
V_3P_0	20.66 fg	2.64 gh	3.95 e	3.09 de	0.21 g
V_3P_1	28.00 d	2.88 de	4.78 c	3.03 ef	0.26 e
V_3P_2	28.00 d	2.89 de	5.41 b	2.88 fg	0.26 e
V_3P_3	28.00 d	2.95 de	5.60 b	2.74 gh	0.33 d
V_3P_4	36.00 c	3.02 cd	5.41 b	3.25 cd	0.34 cd
LSD $_{(0.05)}$	1.30	**0.16**	**0.56**	**0.20**	**0.019**
CV %	2.54	**3.46**	**6.61**	**3.80**	**4.17**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

V_1: BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika, **P_0:** Control (no priming), **P_1:** priming with water, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution

the other hand the minimum dry weight (0.23 g) was found from V_1 (BARI Dheros-1) variety.

Dry weight of seedling of okra exerted significant difference due to seed priming treatments (Appendix IX). The P_4 (priming with 3% $MgSO_4$ solution) treatment showed the maximum dry weight of seedling (0.32 g) but that of lowest (0.20 g) was found from P_0 (control) treatment (Table 11). Khan *et al.* (2009) and Sikhondze and Ossom (2011) observed that priming removes the salinity and improves the dry weight of seedling which agreed with the results.

Interaction effects of variety and seed priming exerted significant difference on dry weight of seedling of okra (Appendix IX). The highest dry weight of seedling (0.38 g) was recorded from V_2P_4 (Hybrid green soft variety with priming with 3 % $MgSO_4$ solution) treatment combination. On the contrary the minimum dry weight of seedling (0.19 g) was found from V_1P_0 (BARI Dheros-1 variety with no priming) treatment combination which was statistically similar to V_1P_1 and V_2P_0 (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experiment Field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from February-June 2015 to to find out the effect of seed priming on yield of different okra varieties. The experiment consisted of two factors: Factor A: Three varieties of okra. viz. **V_1:** BARI Dheros-1, **V_2:** Hybrid Green Soft, **V_3:** Hybrid Sarika and Factor B: 5 levels of seed priming with different solutions. viz. **P_0:** Control (no priming), **P_1:** hydro priming, **P_2:** priming with 3% NaCl solution, **P_3:** priming with 3% KCl solution, **P_4:** priming with 3% $MgSO_4$ solution. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the suitable variety and level of seed priming of okra.

In case of variety, at harvesting time the longest plant (80.40 cm), maximum number of leaves plant^{-1} (23.80), maximum number of branches plant^{-1} (4.80), maximum number of pods plant^{-1} (34.89), maximum pod length (12.70 cm), maximum pod diameter (1.85 cm), maximum number of seeds pod^{-1} (26.81), maximum 1000-seed weight (71.16 g), maximum germination percentage (71.16 %), maximum seed yield (0.633 t ha^{-1}), maximum green pod yield (18.78 t ha^{-1}), maximum root length (3.11 cm), maximum shoot length (6.03 cm), maximum fresh weight of seedling (3.61 g), maximum dry weight of seedling (0.33 g) were recorded from V_2 (Hybrid green soft) okra variety. On the contrary, shortest plant (66.00 cm), minimum number of leaves plant^{-1} (20.40), minimum number of branches plant^{-1} (3.93), minimum number of pods plant^{-1} (26.58), minimum pod length (10.32 cm), minimum pod diameter

(1.40 cm), minimum number of seeds pod^{-1} (16.04), minimum 1000-seed weight (54.58 g), minimum germination percentage (22.73 %), minimum seed yield (0.543 t ha^{-1}), minimum green pod yield (15.77 t ha^{-1}), minimum root length (2.64 cm), minimum shoot length (4.29 cm), minimum fresh weight of seedling (2.82 g), minimum dry weight of seedling (0.23 g) were found from V_1 variety (BARI Dheros-1).

In case of seed priming treatment, at harvesting time the longest plant (79.55 cm), maximum number of leaves plant^{-1} (23.44), maximum number of branches plant^{-1} (4.33), maximum number of pods plant^{-1} (34.64), maximum pod length (12.11 cm), maximum pod diameter (1.86 cm), maximum number of seeds pod^{-1} (26.71), maximum 1000-seed weight (74.05 g), maximum germination percentage (41.33 %), maximum seed yield (0.626 t ha^{-1}), maximum green pod yield (19.39 t ha^{-1}), maximum root length (3.06 cm), maximum shoot length (5.57 cm), maximum fresh weight of seedling (3.51 g), maximum dry weight of seedling (0.32 g) were recorded from P_4 (priming with 3 % $MgSO_4$ solution) treatment. On the contrary, shortest plant (59.00 cm), minimum number of leaves plant^{-1} (19.00), minimum number of branches plant^{-1} (3.66), minimum number of pods plant^{-1} (23.12), minimum pod length (9.50 cm), minimum pod diameter (1.18 cm), minimum number of seeds pod^{-1} (14.26), minimum 1000-seed weight (47.60 g), minimum germination percentage (20.22 %), minimum seed yield (0.512 t ha^{-1}), minimum green pod yield (11.61 t ha^{-1}), minimum root length (2.62 cm), minimum shoot length (3.98 cm), minimum fresh weight of seedling (2.61 g), minimum dry weight of seedling (0.20 g) were found from P_0 treatment.

In case of interaction effective of variety and seed priming treatment, at harvesting time the longest plant (91.00 cm), maximum number of leaves plant^{-1} (25.00), maximum number of branches plant^{-1} (5.33), maximum

number of pods plant^{-1} (39.60), maximum pod length (13.50 cm), maximum pod diameter (2.11 cm), maximum number of seeds pod^{-1} (32.68), maximum 1000-seed weight (97.60 g), maximum germination percentage (64.00 %), maximum seed yield (0.695 t ha^{-1}), maximum green pod yield (21.30 t ha^{-1}), maximum root length (3.34 cm), maximum shoot length (6.70 cm), maximum fresh weight of seedling (4.21 g), maximum dry weight of seedling (0.38 g) were recorded from V_2P_4 (Hybrid green soft with priming with 3% $MgSO_4$ solution) treatment combination. On the contrary, shortest plant (54.00 cm), minimum number of leaves plant^{-1} (19.00), minimum number of branches plant^{-1} (3.00), minimum number of pods plant^{-1} (20.70), minimum pod length (8.50 cm), minimum pod diameter (1.04 cm), minimum number of seeds pod^{-1} (10.00), minimum 1000-seed weight (42.22 g), minimum germination percentage (20.00 %), minimum seed yield (0.502 t ha^{-1}), minimum green pod yield (10.73 t ha^{-1}), minimum root length (2.51 cm), minimum shoot length (3.86 cm), minimum fresh weight of seedling (2.36 g), minimum dry weight of seedling (0.19 g) were found from V_1P_0 (BARI Dheros-1 with no priming) treatment combination.

Conclusion

Considering the findings of the experiment, it can be concluded that –

- Hybrid green soft variety and priming with 3% $MgSO_4$ solution were superior for producing higher green pods(vegetable)and seed yield and seedling quality of okra .
- The combination of Hybrid green soft with priming with 3% $MgSO_4$ solution treatment may be the best to get highest growth and yield (green pods and seed) and also for good quality seedling of okra.

Recommendation

According to the present experiment hybrid green soft variety perform better with 3% $MgSo_4$ priming solution than other priming treatments. But due to limitation more priming treatment was not possible to in the present experiment. So the recommendation is –

- To reach a specific conclusion further research work may be under taken using more priming chemicals and their concentration with different okra varieties .

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from January-July, 2015

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
January, 2015	24.5	12.4	68	0
February, 2015	27.1	16.7	67	3
March, 2015	31.4	19.6	54	11
April, 2015	35.3	22.4	51	15
May, 2015	38.2	23.2	62	17
Jun, 2015	32.3	25.6	83	305
July, 2015	31.6	27.5	84	310

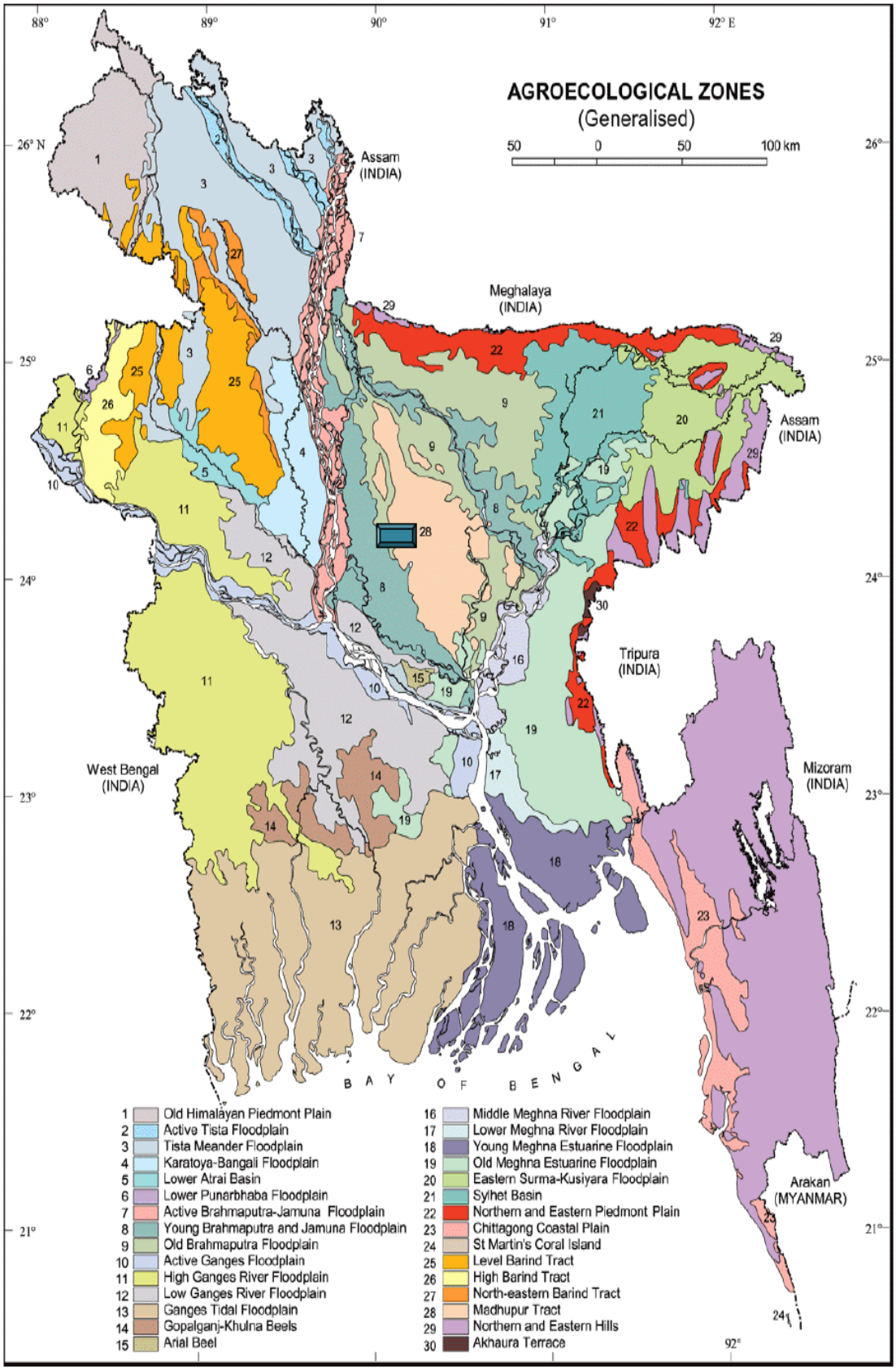
Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Experimental site on the AEZ map of Bangladesh



C. Mechanical analysis

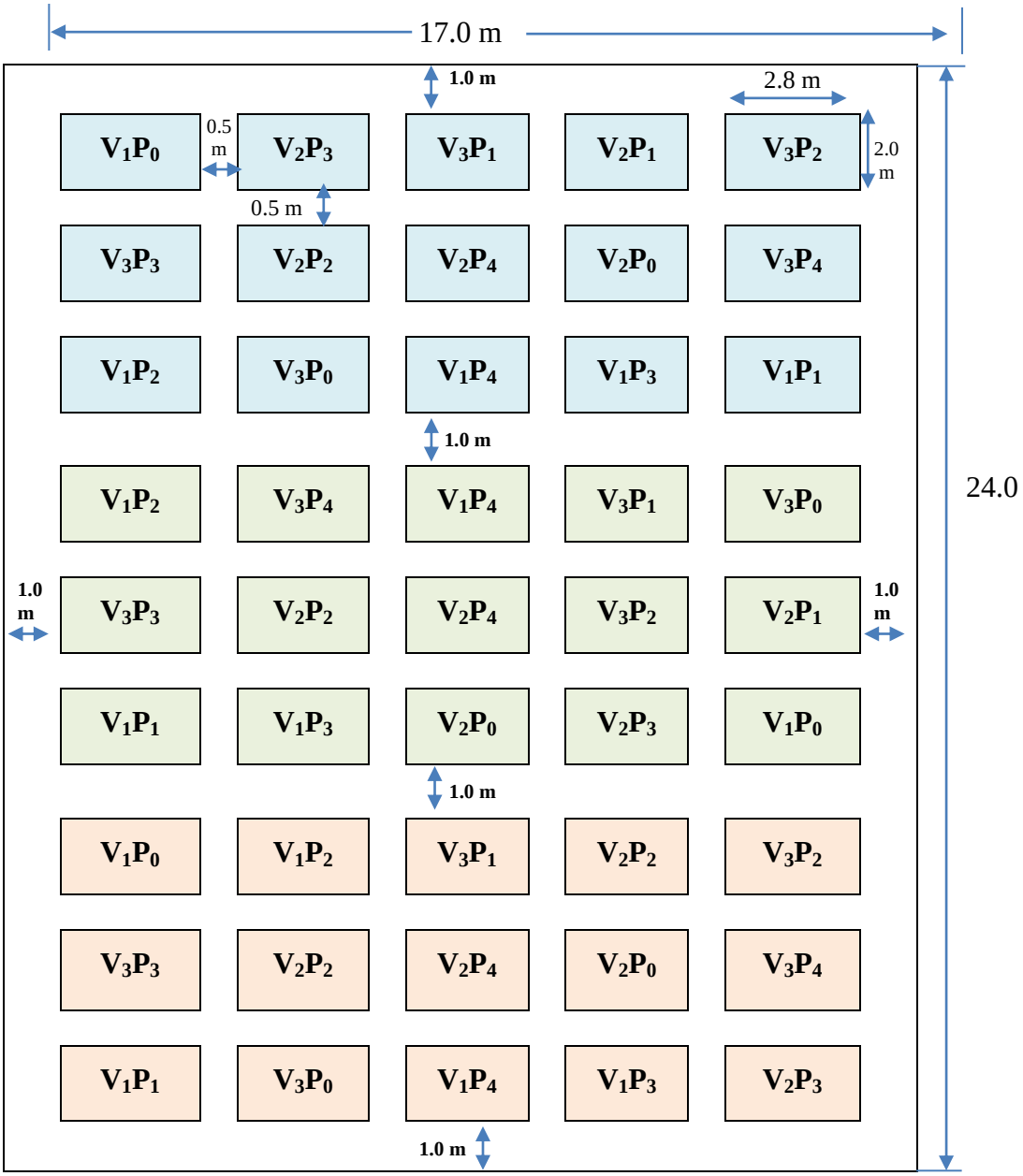
Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

D. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Field lay out of the experimental field



V_1: BARI Dherosh-1
V_2: Hybrid Green Soft
V_3: Hybrid Sharika

P_0: Control (no priming)
P_1: Priming with water (Hydro priming)
P_2: Priming with 3% NaCl solution
P_3: Priming with 3% KCl solution
P_4: Priming with 3% $MgSO_4$ solution

Appendix-IV. Analysis of variance of data on plant height at different days after sowing of okra

Source of variation	Degrees of freedom (df)	Mean square of plant height at			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	$1.83E^{-29}$	$1.35E^{-28}$	$2.71E^{-27}$	$3.98E^{-27}$
Factor A (Variety)	2	9.697*	110.917*	105.362*	778.395*
Factor B (Priming)	4	9.225*	96.523**	167.735*	630.942*
Interaction (A X B)	8	1.040*	9.044*	1.304*	25.166**
Error	28	0.039	2.477	0.619	2.380
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-V. Analysis of variance of data on number of leaves plant^{-1} at different days after sowing of okra

Source of variation	Degrees of freedom (df)	Mean square of number of leaves plant^{-1} at			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	$1.66E^{-29}$	$7.66E^{-29}$	$9.44E^{-29}$	$1.85E^{-28}$
Factor A (Variety)	2	9.800*	66.200*	9.600*	43.400*
Factor B (Priming)	4	9.255*	57.422*	12.611*	29.244*
Interaction (A X B)	8	1.355*	0.672*	0.7111*	3.594*
Error	28	0.047	0.047	0.095	0.238
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VI. Analysis of variance of data on number of branches plant^{-1} at different days after sowing of okra

Source of variation	Degrees of freedom (df)	Mean square of number of branches plant^{-1} at			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	$5.42E^{-31}$	$5.46E^{-30}$	$7.60E^{-30}$	0.088
Factor A (Variety)	2	5.600*	3.266*	5.400*	3.488*
Factor B (Priming)	4	4.355*	1.477*	4.922*	1.022*
Interaction (A X B)	8	0.655*	0.211*	0.372*	0.322**
Error	28	0.047	0.095	0.047	0.088
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VII. Analysis of variance of data on number of pods plant^{-1}, pod length, pod diameter and number of seeds pod^{-1} of okra

Source of variation	Degrees of freedom (df)	Mean square of			
		Number of pods plant^{-1}	Pod length (cm)	Pod diameter (cm)	Number of seeds pod^{-1}
Replication	2	3.29E^{-28}	0.072	0.011	1.66E^{-28}
Factor A (Variety)	2	263.905*	22.866*	0.767*	447.193*
Factor B (Priming)	4	187.838*	9.988*	0.613*	256.943*
Interaction (A X B)	8	4.917*	0.409*	0.014*	62.570**
Error	28	1.570	0.083	0.011	2.257
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VIII. Analysis of variance of data on 1000-seed weight, germination percentage, seed yield and green pod yield of okra

Source of variation	Degrees of freedom (df)	Mean square of			
		1000-seed weight	Germination Percentage (%)	Seed yield (t ha^{-1})	Green pod yield (t ha^{-1})
Replication	2	1.23E^{-27}	1.09	0.00005	1.61E^{-28}
Factor A (Variety)	2	1059.450*	1416.16*	0.03136*	34.567*
Factor B (Priming)	4	802.209*	519.20**	0.01811*	95.429*
Interaction (A X B)	8	155.121*	168.77*	0.00157*	0.588*
Error	28	0.81952	0.610	0.00009	0.641
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-IX. Analysis of variance of data on root length, shoot length, fresh weight of seedling, dry weight of seedling of okra

Source of variation	Degrees of freedom (df)	Mean square of			
		Root length (cm)	Shoot length (cm)	Fresh weight of seedling (g)	Dry weight of seedling (g)
Replication	2	0.026	0.107	0.049	0.00001
Factor A (Variety)	2	0.798*	11.479*	2.454**	0.03651*
Factor B (Priming)	4	0.239*	4.108*	1.158*	0.02024*
Interaction (A X B)	8	0.020*	0.572**	0.118*	0.00239*
Error	28	0.009	0.114	0.014	0.00014
** : Significant at 1% level of probability; * : Significant at 5% level of probability					