EFFECT OF SEED PRIMING ON SEEDLING GROWTH AND YIELD OF DIFFERENT SOYBEAN VARIETIES

A THESIS

BY

DEBDAS BARMAN
Student No. 1701205
Session: 2022-2023
Semester: January-June 2024

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IN

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DEPARTMENT OF AGRONOMY

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DINAJPUR-5200

JUNE 2024

DEDICATED
TO MY
BELOVED PARENTS
AND
AFFECTIONATE BROTHER

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ABSTRACT

A field experiment was conducted at the research field of Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200 during the period from January, 2023 to May, 2023 to study the effect of seed priming on yield attributes and yield of the soybean varieties. The experiment comprised of two factors, A. Three varieties of soybean viz; V_1= Binasoybean-7, V_2 = Binasoybean-3, V_3 = Binasoybean-5 and B. Four priming treatments viz; P_1 = Hydropriming, P_2 = 1% Potassium nitrate, P_3 = 1% Hydrogen peroxide and P_4 = 5% *Moringa* leaf extract were considered as treatments of the experiment. The experiment was layout by randomized complete block design (RCBD) with three replications it consisted of twelve different treatment combinations. Thus, there were 36 unit plots in this experiment. The maximum of growth parameters of soybeans were found statistically significant such as plant height (cm) in different days of interval (20, 40, 60 days after sowing and at harvest), Number of branches plant^{-1} also at (40, 60 days after sowing and at harvest), number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, weight of 1000-seed (g), seed yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). However, considering the varietal characteristics the maximum seed yield (2.36 t ha^{-1}) was observed in Binasoybean-5 (V_3) while minimum (1.79 t ha^{-1}) was produced by Binasoybean-7 (V_1) and also maximum stover yield (4.21 t ha^{-1}) recorded in Binasoybean-5 while the minimum was found (3.69 t ha^{-1}) from Binasoybean-7 (V_1). In case of different priming treatments, the effect of Hydrogen peroxide generated the maximum seed yield (2.31 t ha^{-1}) whereas hydropriming (P_1) produced the minimum seed yield (1.89 t ha^{-1}). Hydrogen peroxide showed the maximum (4.09 t ha^{-1}) stover yield and hydropriming treatment showed the minimum (3.89 t ha^{-1}) results respectively. In treatment combination, V_3P_3 generated maximum (2.31 t ha^{-1}) seed yield and stover yield (4.37 t ha^{-1}) whereas the minimum seed yield (1.89 t ha^{-1}) and stover yield (3.53 t ha^{-1}) were recorded from V_1P_1 treatment combination. So, it may be suggested that Binasoybean-5 (V_3) primed with 1% Hydrogen peroxide (P_3) showed better result for growth and yield of soybean.

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%	Percentage
Adv.	Advanced
AEZ	Agro-Ecological Zone
Appl.	Applied
Biom.	Biomedical
CM	Centimeter
CV	Coefficient of Variance
DAS	Days after sowing
df	Degrees of freedom
et al.	And others
FAO	Food and Agriculture Organization
HI	Harvest Index
Int.	International
LSD	Least Significance Difference
Physiol.	Physiology
Regul.	Regulation
SRDI	Soil Resource Development Institute

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L.) is one of the most popular legumes due to its versatile usage and good source of protein crop around the world and economic importance (Liu *et al.*, 2020). Soybean is one of the most multipurpose, nutritionally and economically important legumes due to its unique seed composition (Shea *et al.*, 2020). According to USDA (2018), Mature raw soybean seed contains 36.5% protein, 20% lipids, 30% carbohydrates, and 9% dietary fiber. It is a good source of unsaturated fatty acids, minerals like Ca and P including vitamin A, B, C and D can meet up different nutritional needs (Rahman, 1982). It is a prominent source of proteins and edible oil, it has valuable uses as food, feed and oil seed crop (Liu *et al.*, 2020).

According to USDA (2021), about 391.40 million tons of soybean are produced around the world from a cultivated area of 121.69 million hectares with an average yield of 2.76 t ha^{-1}. The United States, Brazil, and Argentina are the leading soybean-producing countries in the world and are responsible for 81% of the total production. Worldwide, the total annual production of soybean is 390.53 million tons from an area of land total 135.03 million hectare (USDA 2022). Although soybean cultivation in Bangladesh is quite limited. There is an ample scope of increasing its cultivation through agronomic management. Soybean can play a vital role in balancing the protein-calorie malnutrition in Bangladeshi diet. The present nutritional situation of third world and some developing countries like Bangladesh is matter of great concern since the most of the people are suffering from malnutrition. Soybean can play an important role in this case and can help to meet up the nutritional deficiency problem (Mahbub *et al.*, 2015). Bangladesh could meet 40 percent of its soybean oil demand by producing Soybean locally, as there is a bright prospect for its farming.

Soybean is grown in different agro-ecological conditions; thus, seed germination and vigor are affected by various unfavorable environmental factors such as drought, extreme temperatures, untimely sowing, etc. (Casenave and Toselli, 2007). One of the methods which can overcome this problem is priming, i.e., soaking the seed prior to sowing (Ashraf and Foolad, 2005). Seeds undergo deterioration at various levels during storage resulting in decline in a vigor and viability (Bordolui *et al.*, 2015). Seed priming is one of the most important physiological methods which improves the seed performance and provides faster and synchronized germination (Chakraborty and Bordolui, 2021). Seed priming using micronutrient showed the satisfactory result with an improved plant growth characteristic and withstand better under stress, compared to control or no priming through enhancing antioxidant activities (Mangena *et al.,* 2020). Priming enhanced grains per plant, grain yield per plant and per unit area (Kazem *et al.,* 2012).

The direct benefits of seed priming in all crops included: faster emergence, better, more and uniform stands, less need to re-sow, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield. Literature shows that rice seedlings boosted salt resistance due to seed priming, and supplemented (H_2O_2) application also boosted salinity resistance in rice seedlings (Roy *et al.,* 2016). It is reported that H_2O_2-primed rice seeds had better germination and growth when compared with hydro-primed and unprimed (Hemalatha *et al.,* 2017). Earth atmosphere consists of approximately 78% of the total gaseous part, but the plant is not able to absorb it in gaseous form. The nitrogen cycle transforms this nitrogen into nitrogen-based compound via the chemical and biological method, thus it is available for application in several ways (Bose and Mondal, 2013). Plants take up nitrogen in the form of nitrate (NO_3) or in some cases ammonium (NH_3/ NH_4^+) (Fischer *et al.,* 2013). Mineralization process helps in converting other forms of nitrogen into available forms easily accessible to plant. Plant absorbs available form of nitrogen via the root system and uses them for protein and other organic matter production. Deficiency of nitrogen severely affects the growth and yield of crops, while the excess supply of inorganic N creates problems in the soil and water ecosystem (Vitousek *et al.,* 2009; Liao *et al.,* 2012). Nitrate (NO_3) is a soluble form of nitrogen which can easily move with soil water, taken up by plant roots and distributed to other plant parts. Leaf blade has lower nitrate content than the stem and petioles. It is also accumulated in seed and affects seed dormancy (Alboresi *et al.,* 2005). Nitrate interaction with gibberellic acid and abscisic acid decreases the thermo-inhibition of lettuce seeds (Dong *et al.,* 2012). It can also break the dormancy of Arabidopsis thaliana seeds (Bethke *et al.,* 2006). Nitrogen metabolism in plants depends on its uptake, assimilation and remobilization that may be transformed to improve nitrogen use efficiency (Masclaux-Daubresse *et al.,* 2010; Srivastava *et al.,* 2017), mediated through nitrate transporters (Singh *et al.,* 2018). Nitrate is important for early embryo development and has a potential role during seed germination (Chopin *et al.,* 2007). Potassium is associated with stomata movement, enzyme activity, osmoregulation and membrane stability in plants. It is also involved in maintaining plant water status and xylem phloem transport (Ahmad *et al.,* 2014; Erel *et al.,* 2015). Potassium nitrate (KNO_3) is a promising compound for priming purpose. Priming treatment with KNO_3 improves germination and related traits such as germination percentage, germination energy, germination time, seedling growth, root shoot length, vigor index of various vegetable and field crops such as wheat, rice, barley, sorghum, maize, oat, asparagus, capsicum, tomato (Shafi *et al.,* 2006; Tzortzakis, 2009). KNO_3 significantly increases fertile tiller, biomass, grain number per panicle, grain yield and grain protein. Increment in grain protein is directly associated with higher nutrient uptake (Kalpana *et al.,* 2015). It is indicated that primed seeds with nitrate solutions produced vigorous seedlings, more dry matter accumulation and root length in compared with non-primed seeds (Kattimani, *et al.,* 1999). Seed priming with plant growth regulators or plant extracts containing plant growth promoters is also found to be effective in increasing crops germination and seedling establishment (Imran *et al.*, 2013). *Moringa* belongs to *Moringa*ceae family and it is the only genus of this family. *Moringa* leaf extract (MLE) is considered to be rich with a variety of natural plant growth regulators such as zeatin which belong to class of cytokinin and can be used as a source of cytokinins (Iqbal, 2014). It is also enriched with various macro-nutrients such as phosphorous and potassium along with micro-nutrients. Makkar *et al.,* stated that *Moringa* leaf extract was might be due to zeatin which is a natural plant growth regulator and other nutrients different priming techniques. Present in *Moringa* leaf extract. These results are in complete confirmation with those of Phiri and Mbewe who observed more germination and seedling growth triggered by zeatin.

The seed priming technology can enhance seedling emergence and ensure good plant stand which in turn can maximize yield and improve quality of the crop. In Bangladesh little is known about inorganic priming and information regarding seed priming with osmotic priming agent for inducing drought tolerant capability in soybean or other crops in Bangladesh is scarce. Therefore, the present study will be undertaken with the following objectives:

- To find out the suitable priming for maximum growth and yield of soybean
- To detect the appropriate variety of soybean for the northern region
- To assess the interaction effect of seed priming and of soybean variety

CHAPTER II

REVIEW OF LITERATURE

Soybean is a vital source of proteins and edible oils, it has valuable uses as food, feed and oil seed crop all over the world. In Bangladesh, Noakhali and Lakshmipur are the leading regions in the soybean production (Miah *et al.*, 2015; Salam and Kamruzzaman, 2015). Soybean has proved to be an important crop among oilseed crops in the country but productivity of soybean continuous to be low than its potential. One of the critical factors for low productivity of soybean is low germination. Productivity of crop depends on high germination and better crop stand. Now days, there is much problem related to poor germination and crop establishment. Seed priming is a tool to enhance the germination and retain high vigor. Several experiments have been conducted which shows advantage of seed priming. Different priming techniques such as osmopriming, hydro priming, organic priming, hydrogen-peroxide priming, potassium-nitrate priming etc. used with different priming time on different crops were found. Some important findings about hydrogen-peroxide (H_2O_2) priming and potassium-nitrate (KNO_3) priming are cited here. The review of literature given below was based on the performance of different priming on different crops cultivation.

Nejad *et al.* (2022) stated that Poor germination and the length of time required for the growth of seedlings appropriate for planting in the farm affect the cultivation of medicinal plants such as yarrow (*Achillea millefolium* L). Different concentrations of gibberellic acid (GA_3) and potassium nitrate (KNO_3), mechanical scarification, and hydropriming to improve seed germination and dormancy release in yarrow. Seeds were germinated on filter paper in Petri dishes and supplemented with 0, 100, 200, 400, or 800 mg L^{-1} GA_3; 0%, 0.2%, 0.5%, 1.0%, or 2.0% w/v KNO_3; 0, 24, or 48 h of hydropriming; and mechanical scarification. Seed priming with GA_3 (800 mg L^{-1}) or 1% KNO_3 at 48 h priming time improved the mean daily germination. Application of 1% KNO_3 had the highest seed germination around 91%.

Marashi *et al.* (2023) conducted an experiment on wheat (*Triticum aestivum* L.) under salt stress. The studied treatments include salinity stress in the form of irrigation with normal water (0.4) and with salinity of 4 and 8 dS/m of NaCl salt and seed priming with hydrogen peroxide, including no priming and seed priming in 25 and 50 mM solutions. The interaction effect of salinity stress and hydrogen peroxide on the studied traits was significant except germination rate. The maximum percentage of germination, length and dry matter of root and stem and seed vigor index was obtained under absence of stress (normal water) and application of 50 mM hydrogen peroxide and the minimum was under salinity of 8 dS/m and no application hydrogen peroxide.

Ellouzi *et al.* (2021) studied the impact of three seed priming agents; H_2O_2, GA_3 and NaCl on the oxidative stress status in primed seed germination dynamics and growth establishment of cauliflower seedlings subsequently grown under salt stress. Results showed beneficial effect of all priming agents in improving plant responses to salinity. However, specific differences, depending on development stage, organ and priming type were recorded. At the germination stage, GA_3 was the most advantageous agent to accelerate seedling emergence. At the seedling stage, seedlings obtained from redried H_2O_2 -primed seeds showed the highest level of seed superoxide anion (5-fold) and H_2O_2 (4-fold), resulting in higher MDA content (2.4-fold).

Sheteiwy *et al.* (2021) investigated the effect of 60 µmol L^{-1} of JA in seed priming (P) at 15 °C in darkness for 24 h, foliar application (F), and/or their combination effect (P + F) on two soybean cultivars – "Nannong 99-6" (salt tolerant) and "Lee 68" (salt sensitive) – under salinity stress (100 mmol L^{-1} sodium chloride (NaCl)). Salinity stress reduced seedling growth and biomass compared with that in the control condition. Priming and foliar application with JA and/or their combination significantly improved water potential, osmotic potential, water use efficiency, and relative water content of both cultivars under salinity stress.

Asif *et al.* (2021) was conducted to check the impact of four seed primers (hydro-priming, KNO_3, $MgSO_4$ and $CaCl_2$) on growth and yield of three soybean cultivars (Ajmeri, Rawal-1 and NARC-2) under agro-climatic condition of Sargodha, Pakistan. Experiment was laid out as randomized complete block design (RCBD) with split plot arrangement having replications during 2018. Results confirmed that priming of cultivar NARC-2 with 0.5% KNO_3 solution showed highest germination count (34.22 m-2), maximum leaf area index (0.85), number of branches (8.53), number of pods per plant (25.65), number of seeds per plant (51.53), 1000-seed weight (121.49 g), seed yield (793.82 kg ha^{-1}), biological yield (8041.3 kg ha^{-1}) and seed oil contents (13.49%) as compared to all other treatments.

Karimi *et al.* (2020) examined the combined effects of hydrogen peroxide (H_2O_2) and nitric oxide (NO) on the responses of oilseed rape (*Brassica napus* L.) plants to salt stress under acclimated and non-acclimated conditions. The results of the shoot and root dry weight traits together with the measurement of malondialdehyde (MDA) indicated that salt acclimation with a low concentration of NaCl (50 mM) could not alleviate the inhibitory effect of high salinity (200 mM NaCl). Under acclimated conditions, seed priming with H_2O_2 or NO resulted in effective protection against salt stress, however, maximum amelioration of salt stress was found by the combined treatments of H_2O_2+NO. Interestingly, in the salt-exposed non-acclimated plants, only seed priming with H_2O_2+NO was effective in improving salt tolerance.

Imriz (2020) reported that Seed priming with hydrogen peroxide at 1% was the most effective concentration for plants watered at 100% of field capacity (FC) in terms of all physiological parameters promoted the growth of pepper plants nicely at full FC by enabling it to obtain the maximum plant length (11.00 cm), root length (11.08 cm), fresh plant weight (9.45 g) and number of leaves (10.33). The results concluded that seed with lower concentration (1%) hydrogen peroxide might be used to improve growth for pepper plants under water deficit conditions. Jasmonic acid (JA) is an important molecule that has a regulatory effect on many physiological processes in plant growth and development under abiotic stress.

Weeraphorn *et al.* (2020) stated that Drought stress is a major factor limiting crop growth and yield. Hydrogen peroxide (H_2O_2) is known as a signaling molecule in the plant cell in which activates multiple physiological changes that play essential roles in tolerance mechanism. seed priming with H_2O_2 on growth, some physiological characteristics and antioxidant enzyme activities in rice seedling under drought stress. Rice (*Oryza sativa* L.) cv. Khao Dawk Mali 105 seeds were primed with 0 (distilled water), 1, 5, 10, and 15 mM H_2O_2 and grown for 21 days. The seedlings were subjected to drought stress by withholding water for 7 days. The results showed that priming with low concentrations of H_2O_2 improved plant growth and biomass as well as relative water content, malondialdehyde content, electrolyte leakage. It is concluded that seed priming with 2-10 mM H_2O_2, is beneficial for enhancing drought tolerance in rice seedling by increasing antioxidant capacity, which in turn reduces oxidative stress and damages to the cellular components.

Cokkizgin *et al.* (2019) conducted research to study the effect of Mannitol ($C_6H_{14}O_6$) on the germination of *Vicia faba* L seed was investigated. Broad bean (*Vicia faba* L.)

genotypes, Sevilla and Emiralem seeds were treated in various levels of Mannitol ($C_6H_{14}O_6$) (1%, 2.5% and 5%) and distilled water (2.5µs/cm) at 20°C. The experiment was arranged under completely randomized design (CRD) with three replicates in Petri dishes. In the research Seedling Length (SL), Germination Percentage (GP%), Seed Vigor Index (SVI) and Angular Transformation Value (Arcsin) was used. Accordingly, Sevilla broad bean cultivar has higher values for SL, SVI and Arcsin parameters however has a lower value for GP parameter. The seedling length and seed vigor index are important parameters for strong emergence of plants. It's observed that 1% mannitol ($C_6H_{14}O_6$) application has the highest value for both parameters.

Kiani *et al.* (2018) examined the effect of drought stress induced by mannitol at three levels (0, 88 and 176 mM) on biochemical and polyphenolic traits of six F1 broccoli hybrids, a factorial experiment based on completely randomized design in three replications was implemented at research station of Agricultural Sciences and Natural Resources University, Sari, Mazandaran, Iran in 2016. The results showed that mannitol stress reduced dry weight and shoot length significantly for all varieties but with a different rate. Total phenolic, flavonoid, and anthocyanin contents, the activity of enzymatic antioxidants, and DPPH activity were significantly higher under 176 Mm mannitol application condition than control.

An experiment was conducted in Post Graduate Laboratory, Department of Genetics and Plant Breeding, SHUATS, Allahabad, U.P. during Rabi (2016), in order to standardize the best method of Osmopriming specific to chickpea. One method of priming viz., osmopriming, on two durations that is 6hrs and 12 hrs were evaluated by screening a range of durations and concentrations viz., T0 - Unprimed Control, T1–Polyethylene glycol (PEG) (for 6hrs & 12hrs), T2 –Mannitol 4% (6hrs & 12hrs) T3–Glycerol 5% (6hrs & 12hrs). It was found that all the priming methods showed significance difference with the control and the highest germination %, seedling length (cm), seedling fresh weight (g), seedling dry weight (g) and vigor index were observed in T2 for PEG 6000 priming for 12 hrs. Among all the osmopriming treatments, osmopriming PEG 6000 was found to be the best osmopriming treatment followed by Mannitol. The study helps to improve the quality of seeds with the help of seed osmopriming treatments which are cost effective and economic, non-toxic, eco- friendly sources (Kumar *et al.*, 2017).

According to Singh *et al.* (2015) strategies for improving the growth and development of crop species have been investigated for many years. Rapid germination and emergence are essential for successful crop establishment, for which seed priming could play an important role. Seed priming is an effective technology to enhance rapid and uniform emergence and to achieve high vigor, leading to better stand establishment and yield. It is a simple and low- cost hydration technique in which seeds are partially hydrated to a point where pre- germination metabolic activities start without actual germination, and then re-dried until close to the original dry weight. Seed priming is employed for better crop stand and higher yields in a range of crops.

Yan (2015) studied that drought stress influence seed germination and seedling growth of many plants. Seed priming could be used to alleviate the depressive effects of drought stress. The improving effects are influenced by many factors including priming methods, plant species and drought intensity. The mechanisms of drought tolerance induced by seed priming have not been clearly elucidated. The study was carried out to assess whether drought tolerance could be enhanced by seed priming at the germination stage and characterize the potential physiological and biochemical alternation of drought tolerance in Chinese cabbage. The seeds were soaked at 20°C for 8h in distilled water, 200 m mol/l potassium nitrate (KNO_3), 200 m mol/l urea, respectively. Both primed and unprimed seeds germinated under six levels of drought stress (0, −1.0, −2.0, −3.0, −4.0 and −5.0 MPa osmotic potential) induced by PEG 6000. Results indicated that germination traits (germination percentage, potential and seedling vigor index) of Chinese cabbage all decreased gradually with increasing drought intensity. The results suggested that priming could serve as an appropriate treatment to increase the germination and early seedling growth of Chinese cabbage under drought stress conditions.

Toklu (2015) conducted an experiment under laboratory and field conditions in order to evaluate the effects of different priming treatments, specifically KNO_3(1%), KCl (2%), KH_2PO_4 (1%), $ZnSO_4$ (0.05%), PEG-6000 (20%), IBA (100 ppm), Mannitol (4%), GA_3 (100 ppm) and distilled water on seed germination properties and several agro-morphological plant characteristics of red lentil. Seeds not primed were used as a control. GA_3 treatment increased shoot length. The control (non-primed seeds) treatment resulted in increased seedling root number and length. Distilled water, $ZnSO_4$ and control treatments increased germination rate and percentage. The results of this study showed that $ZnSO_4$, GA_3 and PEG-6000 seed priming treatments may be useful tools due to their positive effects on germination rate, germination percentage, yield component and grain yield of lentil.

Kumar *et al.* (2014) reported that three varieties of *Sesamum indicum* L. viz., T-4, T-12 and Shekhar were primed with varying concentrations of nitrate salts i.e. KNO_3 (10mM, 15mM) along with distilled water primed or hydro primed as control. The observation was recorded at 15, 30 and 45 days after sowing (DAS) for the evaluation of nitrate reductase activity and chlorophyll content. Among treatments seed primed with 15mM KNO_3 showed increased NR activity and chlorophyll content. Highest NR activity, 280.65 (n mol NO^{-2} h^{-1} g^{-1} leaf fresh weight) and chlorophyll content, 40.30 (SPAD unit) was obtained in T-4 variety in respect to T-12 and Shekhar. However, all the varieties showed significant results in 15mM KNO_3 primed seeds as compared to 10Mm KNO_3 and control (hydroprimed). Among treatments 15 mM KNO_3 primed seeds showed better performance in respect to chlorophyll content and nitrate reductase (NR) activity. Thus, this treatment could be beneficial for cultivation of sesame under late sown condition.

Musa *et al.* (2014) conducted two field trials to evaluate the effect of hydropriming duration on the growth and yield of amaranth. Treatments consisted of four hydropriming durations (2, 4, 6, and 8 hours) and control (where no priming was applied). The treatments were laid out in a completely randomized design (CRD) replicated three times for the germination test and randomized complete block design (RCBD) for the field trial. Data were collected on days to 50% germination, percentage germination, days to 50% emergence, and percentage emergence. Results revealed significant effect of hydropriming duration on days to 50% germination, percentage germination, and days to 50% emergence. Soaking seeds for 2 hours reduced the number of days to 50% germination and emergence and also recorded higher germination.

Jalal *et al.* (2014) conduct an experiment in green house resulted that seed priming was used to reinforcement of barley seedling growth under water deficit stress in a greenhouse condition. Barley seeds were primed with humic acid, Pseudomonas Spp., Marmarin, distilled water (hydropriming) and none (as control) under four levels of water deficit stress (irrigation at 20 (I1), 40 (I2), 60 (I3) and 80% (I4) field capacity). Results indicated that all measured parameters were decreased with increasing the stress levels, except root length and root-shoot ratio. The highest value of root length (18.42 cm) and root-shoot ratio (2.84) was obtained in the I1 irrigation regime. However, I2, I3 and I4 irrigation regimes did not significantly affect on barley seedling traits, but I1 irrigation regime exhibited better growth.

Mir-Mahmoodi *et al.* (2013) conducted a field experiments and laboratory evaluations to investigate the effects of hydropriming durations on sunflower seed. Field tests were conducted in a RCB design in 2011 and 2012 to evaluate the effects of various durations of hydropriming treatment on evaluations for seed germination, seedling vigor and field establishment of sunflower seeds. Seeds were divided into five sample sets, one of which was used as the control (non-primed) and the other four sample sets were soaked in distilled water for durations of 6, 12, 18 and 24h and then dried off to reach a moisture content of about 10- 12%. Linear regression showed that a longer duration of hydropriming improved evaluations for germination percentage and mean time for germination. Records were taken for seed response in terms of dry weight of shoot, root and seedling and electrical conductivity.

Moghanibashi *et al.* (2012) carried out a laboratory experiment to evaluate the effect of aerated hydro priming (24 h) on two cultivar of sunflower (Urfloar and Blazar) seed germination under a range of drought stress and salt stress. Cultivar Urfloar had the more germination rate (R50), days to 50% germination (D50), germination index (GI), root and shoot length and dry weight as compared with cultivar Blazar. Hydro priming for 24 h increased germination percentage, germination rate, germination index, root and shoot length, root and shoot weight of seed sunflower as compared with the control. Primed seeds produced higher germination rate and percentage, D50 and GI under all salinity and drought levels as compared with non-primed seeds.

Ahmadvand *et al.* (2012) examined the effect of seed priming with potassium nitrate (KNO_3) on germination and emergence traits of two soybean cultivars under salinity stress, two laboratorial and greenhouse experiments were carried out as a factorial experiment based on a completely randomized design with 4 replications in the Seed Physiology Research Department of Agricultural Faculty of Bu-Ali Sina University, Iran. Treatments were included of two soybean cultivars (Sahar and Gorgan-3), two levels of non-priming and priming with potassium nitrate at 6 gl concentration and three levels of salinity (0, 4 and 8 Ds m induced by sodium chloride). The results showed that Sahar cv. was superior to Gorgan-3 cv. in all traits and in both experiments. Seed priming with potassium nitrate (KNO_3) significantly increased germination and emergence percentages, radicle and plumule length, seedling dry weight, plant height, plant leaf area and plant dry weight. Also at the salinity stress, mean germination and emergence time of primed seeds were less than non-primed seeds, significantly.

Yucel (2012) in order to develop suitable techniques to improve lentil seed germination capacity, research was conducted with cultivar Local Red lentil cultivar. Seeds were fully soaked in KH_2PO_4(1%), KNO_3(1%) solutions for osmopriming, and distilled water for hydro priming treatments, for 12 and 24 hours at a 24°C and untreated seeds as control. After the priming treatments, seeds were germinated at six different (5, 10, 15, 20, 25 and 30 ± 0.5°C) constant temperatures. In terms of both germination percentage and MGT, the highest results were obtained from priming treatment of water at germination temperature of 20°C in priming times of 12h and 24h. The best germination synchrony value was obtained from water treatment for 12h at 15°C.

Rehman *et al.* (2011) reported that seed priming is a cost-effective technology that can enhance early crop growth leading to earlier and more uniform stand with yield associated benefits in many field crops including oilseeds. Various seed priming techniques have been developed which include hydro-priming, halo priming, osmo priming and hormonal priming. Hydro-priming soaking the seeds in water before sowing and may or may not be followed by air drying of the seeds. Hydro-priming may enhance seed germination and seedling emergence under both saline and non- saline conditions. Roy and Srivastava (1999) found that soaking wheat kernels in water improved their germination rate under saline conditions.

Ghassemi- Golezani *et al.* (2010) concluded that hydropriming is a simple, low cost and environmentally friendly technique for improving seed and seedling vigor of lentil. Seedling emergence rate was also enhanced by priming seeds with water. Hydropriming significantly improved imbibition rate, germination rate, seed vigor index, shoot, root and seedling dry weights, compared to other seed treatments. The different soaking-drying treatments are highly effective in maintaining viability and vigor in most seeds, except leguminous seeds because soaking injury are observed due to rapid uptake of water.

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.

Dezfuli *et al.* (2008) conducted study to evaluate the influence of seed priming techniques on germination and early growth of two maize inbred lines including B73 and MO17. Seeds were hydro primed for 12, 24, 36 and 48h, osmoprimed in urea solution and in solution of polyethylene glycol-6000 (PEG-6000) for 96h (4 days) (water potential -1.2 MPa). Priming techniques affected seed germination and early growth of both inbred lines. Hydropriming resulted in lower time taken to germination and higher germination index, vigor index and final germination percentage in both genotypes. Maximum invigoration was observed in seeds hydro primed for 36h as indicated by higher germination rate, radical length. Conversely, for most germination parameters osmoprimed seeds behaved similar to or even poor than that of control.

Harris *et al.* (2007) reported that seed priming led to better establishment and growth, earlier flowering, increase seed tolerance to adverse environment and greater yield in maize. The beneficial effects of seed priming have been demonstrated for many field crops such as wheat, sweet corn, mung bean, barley, lentil, cucumber etc. (Sadeghian and Yavari, 2004).

Kaya *et al.* (2006) examined that the treated seeds (control, KNO_3 and hydropriming) of sunflower (*Helianthus annuus* L.) cultivars were evaluated at germination and seedling growth for tolerance to salt (NaCl) and drought conditions induced by PEG-6000 at the same water potentials of 0.0, −0.3, −0.6, −0.9 and −1.2 MPa. Results revealed that germination delayed in both solutions, having variable germination with different priming treatments. Germination, root and shoot length were higher but mean germination time and abnormal germination percentage were lower in NaCl than PEG at the same water potential. Seeds were able to germinate at all concentrations of NaCl but no seed germination was observed at −1.2 MPa of PEG treatments. NaCl had less inhibitor effect on seedling growth than the germination. It was concluded that inhibition of germination at the same water potential of NaCl and PEG resulted from osmotic effect rather than salt toxicity. Hydropriming increased germination and seedling growth under salt and drought stresses.

Mwale *et al.* (2003) reported that one of the major obstacles to high yield and production of crop plants is the lack of synchronized crop establishment due to poor weather and soil conditions. On the other hand, seeds are occasionally sown in seedbeds having unfavorable moisture because of the lack of rainfall at sowing time which results in poor and unsynchronized seedling emergence (Angadi and Entz, 2002).

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analyses.

3.1. Experimental period

The experiment was conducted at the Agronomy research field during the period from January 06, 2023 to May 04, 2023 in Rabi season.

3.2. Description of experimental site

3.2.1. Geographical location

The field experiment was conducted at the Agronomy research field, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur. The experimental area was geographically located at 25°44.574" N and 88°40.344" E longitude at an elevation of 40 m above from the sea level.

3.2.2. Agro-Ecological Zone

The experimental site was belonged to the Agro-ecological Zone “AEZ-1” Old Himalayan Piedmont Plain (Anon., 1988a). This was a region of complex relief and deep, rapidly permeable sandy loams and sandy clay loams are predominant in this region. Organic matter contents are generally higher than in most floodplain soils of Bangladesh (Anon., 1988b). The location of the experimental site has been shown in Appendix I.

3.2.3. Climate of the experimental site

The experimental area is situated in the hot, wet and humid tropical climate. Under the Köppen climate classification, Dinajpur has a tropical wet and dry climate. The district has a distinct monsoonal season, with an annual average temperature of 25 °C (77 °F) and monthly means varying between 18 °C (64 °F) in January and 29 °C (84 °F) in August. The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February. Plenty of sunshine prevails during experimental period, which is suitable for soybean growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix II.

3.2.4. Soil

The soil of the research field is slightly acidic in reaction with low organic matter content. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. The experimental plot was also high land, having pH 5.8.

3.3. Details of the Experiment

3.3.1. Experimental treatments

The experiment consisted of two factors such as variety and priming solution. The treatments were as follows:

Factor A: Variety

- V_1 = Binasoybean-7
- V_2 = Binasoybean-3
- V_3 = Binasoybean-5

Factor B: Priming solution

- P_1 = Normal water (H_2O)
- P_2 = Potassium Nitrate (KNO_3) 1%
- P_3 = Hydrogen-Peroxide (H_2O_2) 1%
- P_4 = *Moringa* 5g

There were 12 (3*4) treatment combinations such as

- V_1P_1
- V_1P_2
- V_1P_3
- V_1P_4
- V_2P_1
- V_2P_2
- V_2P_3
- V_2P_4
- V_3P_1
- V_3P_2
- V_3P_3
- V_3P_4

3.3.2. Design and layout of the experiment

The experiment was laid out in two factor Randomized Complete Block Design with three replications. The size of the individual plot was 2.00 m x 1.50 m and total numbers of plots were 36. There were 12 treatment combinations. Each block was divided into

12-unit plots. Layout of the experiment was done on January, 2023 with inter plot spacing of 0.50 m and inter block spacing of 0.75 m.

3.4 Description of the cultivar

3.4.1 Planting material

The varieties of soybean used in this experiment was Binasoybean-3; Binasoybean-5 and Binasoybean-7. The seed of this varieties were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. These released varieties have excellent seed quality and superior to others.

3.4.2 Binasoybean-3

Binasoybean-3 is released in 2013. The plant height is 71.6-71.8 cm. Maturity period ranges from 95-107 days. Brighter yellow seed coat color. It is resistant to yellow mosaic virus (YMV) and collar rot diseases. It can produce seed yield of 2.3-2.5 t/ha.

3.4.3 Binasoybean-5

Binasoybean-5 is released in 2017. The plant height is 50-60 cm. Maturity period ranges from 109-116 days. Brighter yellow seed coat color. Moderately resistant to yellow mosaic virus disease and the variety is also 8 ds/m. tolerant to a degree of salinity. It can produce seed yield of 2.4-3.0 t/ha**.**

3.4.4. Binasoybean-7

Binasoybean-7 is released in 2022. The plant height is 50-58cm. Maturity period ranges from 105-110 days. Brighter yellow seed coat color. It is resistant to yellow mosaic virus (YMV) and tolerate up to 12 dS/m salinity. It can produce seed yield of 2.6-3.0 t/ha.

3.5. Crop management

3.5.1. Land preparation

The land of the experimental field was first opened on 6 January, 2023 with a power tiller. Then it was exposed to the sunshine for several days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field.

3.5.2. Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum and boric acid were used as a source of nitrogen, phosphorous, potassium, sulphur, and boron respectively. The fertilizers urea, TSP, MoP, gypsum, boric acid was applied at the rate of 50-60 kg, 150-175 kg, 100-120 kg, 80-115 kg and 8-10 kg ha^{-1} respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation (BARI, 2011). All of the fertilizers were applied during the final pot preparation.

3.5.3. Sowing of seeds

Sowing was done on 9 January 2023. Seeds were sown in 30 cm apart rows and seed to seed distances were maintained at first in 7 cm. Furrows were made by hand rake and seeds were placed in the furrows by hand and then covered properly with soil.

3.5.4. Priming technique

For hydro priming Binasoybean-3, Binasoybean-5 and Binasoybean-7 were immersed in distilled water 6 hours. For Potassium Nitrate (KNO_3) and Hydrogen Peroxide (H_2O_2) priming Binasoybean-3, Binasoybean-5 and Binasoybean-7 immersed in 1% solution respectively for 6 hours. For *Moringa* priming Binasoybean-3, Binasoybean-5 and Binasoybean-7 immersed in 5g solution. Different plastic pots were used with lids for avoiding evaporation loss. Seeds were taken off from the priming solution at the required time. The primed seeds were rinsed with distilled water three times gently and removed excess moisture by using tissue paper and finally air dried (Umair *et al.*, 2011) in room temperature for 72 hours to back the original moisture level.

3.5.5. Intercultural operations

After raising seedlings, various intercultural operations such as weeding, watering, pest and disease control etc. were accomplished for better growth and development of the soybean seedlings.

3.5.5.1. Thinning

Seeds started germination within four days after sowing (DAS). Emergence of seedling was completed within 10 days after sowing. Overcrowded, unhealthy and lineless seedlings were thinning at 25 DAS to maintain optimum plant population in each plot. Optimum plant population per square meter was 50-60.

3.5.5.2. Weeding

Weeding was done 20-25 days after germination. The crop was weeded twice. First weeding was done at 25 days after sowing (DAS) and second weeding was done at 45 DAS. Demarcation boundaries and drainage channels were also kept weed free.

3.5.5.3. Irrigation

Irrigation was done at 30 DAS after sowing (pre-flowering) stage and then at 60 DAS (pod formation stages) as per recommendation (BARI, 2011). Proper drainage system was also made for draining out excess water.

3.5.5.4. Plant protections

The soybean plants were infested by hairy caterpillars (Dlaerisia oblique) and cutworm at early growth stage which was controlled by applying Sumithion 50 EC @1.01 ha^{-1}. On the other hand, picking of infested leaves with caterpillar larvae was also done as a control measure. Diseased or off type plants were uprooted as and when required.

3.5.6. General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

3.5.7. Sampling and data collection

Five plants from each plot were randomly selected and marked with sample card. Plant height and number of branches $plant^{-1}$ were recorded from selected plants at an interval of 20 days started from 40 DAS to 80 DAS and at harvest.

3.5.8. Harvesting and post-harvest operation

Maturity of crop was determined when 95 % of the pods become brown in color. Five sample plants were collected from each plot before harvesting for taking yield attributes data. The plants of central 1 m^2 area were harvested by placing quadrates at random for recording yield data. Harvesting was done on 4 May, 2023. The harvested crops from each plot were tied up into bundles separately, tagged and brought to the clean threshing floor. The same procedure was followed for sample plants.

3.5.8.1. Threshing

The crop bundles were sun dried for four days by spreading them on the threshing floor. Seeds were separated from the stover by hand machine and rubbing.

3.5.8.2. Drying Seeds and stover were cleaned and dried in the sun for four consecutive days.

After proper drying of seeds to a moisture content of 12 % were kept in polythene bags. Moisture contents were determined by moisture meter. 20.

3.5.8.3. Cleaning and weighing

Dried seeds and stover was weighed plot wise. After that the weights were converted into t ha^{-1}.

3.5.9. Data collection

The following data were collected

A. Crop growth characters

i. Plant height at 20, 40, 60 DAS and at harvest

ii. Number of branches $plant^{-1}$ 40, 60 DAS and at harvest

B. Yield contributing characters

i. Number of pods $plant^{-1}$

ii. Pod length (cm)

iii. Number of grain pod^{-1}

iv. Thousand grain weight (g)

v. Grain yield (t ha^{-1})

vi. Stover yield (t ha^{-1})

vii. Biological yield (t ha^{-1})

viii. Harvest index (%)

3.5.10. Procedure of data collection

A. Crop growth characters

i. Plant height

The height of the soybean plants was recorded at 20, 40, 60 DAS and at harvest. The heights of sample plants were measured from the ground level to the tip of the shoot. Five plants per plot were randomly selected and data was collected in CM.

ii. Number of branches $plant^{-1}$

The total number of branches $plant^{-1}$ was counted from five selected plants per plot and counted at 40, 60 DAS and at harvest.

B. Yield contributing characters

i. Number of pods $plant^{-1}$

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as $plant^{-1}$ basis.

ii. Pod length

Pod length was taken of randomly selected ten pods and the mean length was expressed on pod^{-1} basis.

iii. Number of grains pod^{-1}

The number of grains pod^{-1} was recorded from randomly selected 10 pods at the time of harvest. Data were recorded as the average of 10 pods from each pot.

iv. Thousand grain weight

Thousand cleaned sun-dried grains were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

v. Grain yield plant^{-1} (Kg)

The seeds collected from each plot were cleaned. The weight of seeds was taken and recorded in kg plot^{-1}.

vi. Stover yield (t ha^{-1})

The stover collected from each plot was sun dried properly. The weight of strover was taken and recorded in t ha^{-1}.

vii. Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + stover yield (t ha^{-1})

viii. Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula:

HI (%) = Grain yield (t ha^{-1}) / Biological yield (t ha^{-1}) × 100

3.5.11. Statistical analysis

The data collected on different parameters were statistically analyzed to obtain the level of significance by using Statistix 10.0 computer package program. The significant differences among the treatment means were compared by LSD and Duncan’s Multiple Range Test (DMRT) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to investigate the effect of seed priming with water, Potassium Nitrate, Hydrogen Peroxide and *Moringa* which enhance the germination capability of soybean varieties cv. Binasoybean-3, Binasoybean-5 and Binasoybean-7 are discuss and present below. The results of the germination and growth parameters of soybean as influenced by different concentration of priming agents have been presented in this chapter. Some of the data have been presented and expressed in table and other in figures for easy discussion, comparison and understanding. The results of each parameter have been discussed and possible interpretations where ever necessary have been given under the following headings:

4.1. Crop growth characters

4.1. 1. Plant height

4.1.1.1. Effect of variety on plant height at 20 DAS, 40 DAS, 60 DAS and at harvest

There was a significant variation on plant height at different growth stages influenced by different varieties of soybean. Plant height of soybean was varied significantly due to different soybean varieties at different days after sowing (DAS) but non-significant at 20 DAS and 40 DAS (Table 1 and Appendix IV). Plant height gradually increased up to 60 DAS and thereafter at harvest respectively. It could be inferred from the figure that, V_3 (Binasoybean-5) showed the tallest plant (9.60 cm, 22.57 cm, 32.46 cm and 47.75 cm) and V_1 (Binasoybean-7) showed the shortest (7.73 cm, 19.10 cm, 25.70 cm and 34.67 cm) for sampling dates of 20 DAS, 40 DAS, 60 DAS and at harvest, respectively which was also significantly different from all other variety followed by V_2 (Binasoybean-3).

Table 1: Effect of variety on plant height at 20 DAS, 40 DAS, 60 DAS and at harvest

Variety	20 DAS	40 DAS	60 DAS	At Harvest
V_1	7.73 b	19.10 c	25.70 c	34.67 c
V_2	8.36 b	21.34 b	29.78 b	41.50 b
V_3	9.60 a	22.57 a	32.46 a	47.75 a
LSD	0.65	1.02	1.87	1.94
CV (%)	9.01	5.73	7.55	5.56
LS	**	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.1.1.2. Effect of priming

Different seed priming treatments had significant influence on plant height of Soybean at different growth stages (Table 2 and Appendix IV). It was found that the highest plant height (9.09 cm, 20.75 cm, 32 cm and 44.22 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) was found from the priming treatment, P_3 (seed priming with Hydrogen per-oxide) which was statistically identical with P_1 (seed priming with water), P_2 (seed priming with potassium nitrate) at 40 DAS and P_4 (seed priming with *Moringa*) at 60 DAS but at 20DAS and at harvest it was significantly different from all other treatments followed by P_3 (seed priming with Hydrogen per-oxide). Similarly, the lowest plant height (8.17 cm, 21.86 cm, 26.39 cm and 37.89 cm at 20 DAS, 40 DAS, 60 DAS, respectively) was found from the priming treatment, P_1 (seed priming with water) which was also significantly different from all other treatments

Table 2: Effect of priming concentrations on plant height at 20 DAS, 40 DAS, 60 DAS and at harvest

Priming	Plant height (cm)			
	20 DAS	40 DAS	60 DAS	At harvest
P_1	8.17 b	21.86 a	26.39 b	37.89 c
P_2	8.35 ab	21.60 a	28.33 b	40.67 b
P_3	9.09 a	20.75 ab	32.00 a	44.22 a
P_4	8.63 ab	19.81 b	30.52 a	42.44 ab
LSD	0.75	1.18	2.16	2.24
CV (%)	9.01	5.73	7.55	5.56
LS	NS	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.1.1.3. Interaction effect of variety and seed priming

Remarkable variation was observed on plant height at different growth stages influenced by interaction effect of variety and seed priming treatments (Table 3 and Appendix IV). Results indicated that the highest plant height (9.92 cm, 24.33 cm, 35.33 cm and 51.33 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) was found from the treatment combination of V_3P_3 which was significantly different from all other treatments followed by V_3P_1 and V_2P_2. The lowest plant height (6.98 cm, 18.03 cm, 23.38 and 31.67 at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) was found from the treatment combination of V_1P_1 which was significantly different from all other treatments at all growth stages followed by V_1P_1.

Table 3: Interaction effect of variety and seed priming on plant height of soybean at 20 DAS, 40 DAS, 60 DAS and at harvest

Treatment combination	Plant height(cm)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1P_1	6.98 e	18.03 g	23.38 h	31.67 g
V_1P_2	7.57 de	20.35 def	24.33 gh	34.33 fg
V_1P_3	7.87 cde	18.47 fg	28.00 efg	37.00 f
V_1P_4	8.26 bcde	19.54 efg	27.07 fgh	35.67 f
V_2P_1	8.11 bcde	20.08 def	26.79 fgh	37.67 ef
V_2P_2	8.52 bcd	20.76 cde	28.67 def	41.00 de
V_2P_3	8.13 bcde	22.77 abc	32.67 abc	44.33 cd
V_2P_4	8.90 abc	21.77 bcd	31.00 bcde	43.00 cd
V_3P_1	9.01 abc	21.31 cde	29.00 cdef	44.33 cd
V_3P_2	9.35 ab	21.14 cde	32.00 abcd	46.67 bc
V_3P_3	9.92 a	24.33 a	35.33 a	51.33 a
V_3P_4	10.12 a	23.50 ab	33.50 ab	48.67 ab
LSD	1.31	2.04	3.75	3.89
CV (%)	9.01	5.73	7.55	5.56
LS	*	*	*	*

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.1.2. Number of branches plant^{-1}

4.1.2.1. Effect of variety

Number of branches plant^{-1} of soybean varied significantly with different varieties at different growth stages (Table 4 and Appendix V). However, it was found that the highest number of branches plant^{-1} (3.85, 4.26 and 4.76 at 40 DAS, 60 DAS and at harvest, respectively) was found from the variety, V_3 (Binasoybean-5) which was statistically identical with V_2 (Binasoybean-3) at 60 DAS and at harvest. The lowest number of branches plant^{-1} (3.08 cm, 3.65 cm and 4.15 cm at 40 DAS, 60 DAS and at harvest, respectively) was found from the variety, V_1 (Binasoybean-7) which was statistically identical with V_2 (Binasoybean-3) at 40 DAS.

Table 4: Effect of variety on number of branches plant^{-1} at 20 DAS, 40 DAS, 60 DAS and at harvest

Variety	Number of branches plant^{-1}		
	40 DAS	60 DAS	At Harvest
V_1	3.08 b	3.65 b	4.15 b
V_2	3.28 b	4.03 a	4.53 a
V_3	3.85 a	4.26 a	4.76 a
LSD	0.23	0.34	0.34
CV (%)	8.01	10.07	8.95
LS	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
V_1= Binasoybean-7
V_2= Binasoybean-3
V_3= Binasoybean-5
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.1.2.2. Effect of seed priming

The pronounced effect was observed on number of branches plant^{-1} at different growth stages influenced by different seed priming treatments (Table 5 and Appendix V). Results signified that the highest number of branches plant^{-1} (3.79, 4.42 and 4.92 at 40 DAS, 60 DAS and at harvest, respectively) was found from the priming treatment, P_3 (seed priming with Hydrogen per-oxide) which was significantly different from all other treatments where the lowest number of branches plant^{-1} (2.78, 3.33 and 3.83 at 40 DAS, 60 DAS and at harvest, respectively) was found from the priming treatment, P_1 (seed priming with water) which was also significantly different from all other treatments.
Saleem *et al.* (2014) also found similar result with the present study.

Table 5: Effect of priming on Number of branches plant^{-1} at 20 DAS, 40 DAS, 60 DAS and at harvest

Priming	Number of branches plant^{-1}		
	40 DAS	60 DAS	At Harvest
P_1	2.78 c	3.33 c	3.83 c
P_2	3.41 b	3.97 b	4.47 b
P_3	3.79 a	4.42 a	4.92 a
P_4	3.62 ab	4.20 ab	4.70 ab
LSD	0.27	0.39	0.39
CV (%)	8.01	10.07	8.95
LS	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.1.2.3. Interaction effect of variety and seed priming

Number of branches plant^{-1} was significantly varied due to interaction effect of variety and seed priming treatments at different growth stages (Table 6 and Appendix V). It was noted that the highest number of branches plant^{-1} (4.20, 4.67 and 5.17 at 40 DAS, 60 DAS and at harvest, respectively) was found from the treatment combination of V_3P_3 which was statistically identical with V_3P_4 at 60 DAS and at harvest and differentiate with V_3P_1, V_3P_2 followed by V_3P_4 all growth stages. And also, statistically identical with V_2P_3 at 60 DAS and at harvest but at 40 DAS it was significantly different from all other treatments followed by V_2P_1, V_2P_2 and V_2P_4. The lowest number of branches plant^{-1} (2.30, 3.10 and 3.60 at 40 DAS,60 DAS and at harvest, respectively) was found from the treatment combination of V_1P_1 which was statistically identical with V_2P_1 at 40 DAS growth stages but at 60 DAS and at harvest it was significantly different from all other treatments followed by V_2P_2, V_2P_3 and V_2P_4.

Table 6: Interaction effect of variety and priming concentrations on number of branches plant^{-1} of soybean at different DAS

Treatment combination	Number of branches plant^{-1}		
	40 DAS	60 DAS	At Harvest
V_1P_1	2.30 f	3.10 d	3.60 d
V_1P_2	3.17 e	3.63 bcd	4.13 bcd
V_1P_3	3.50 cde	4.10 abc	4.60 abc
V_1P_4	3.35 de	3.77 bcd	4.27 bcd
V_2P_1	2.67 f	3.30 d	3.80 d
V_2P_2	3.23 de	4.03 abc	4.53 abc
V_2P_3	3.67 bcd	4.50 a	5.00 a
V_2P_4	3.53 bcde	4.30 ab	4.80 ab
V_3P_1	3.37 de	3.60 cd	4.10 cd
V_3P_2	3.83 abc	4.23 abc	4.73 abc
V_3P_3	4.20 a	4.67 a	5.17 a
V_3P_4	3.98 ab	4.53 a	5.03 a
LSD	0.46	0.68	0.68
CV (%)	8.01	10.07	8.95
LS	*	*	*

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.

Legend,

V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.2. Yield contributing characters

4.2.1. Pod length

4.2.1.1. Effect of variety

The highest pod length (3.67 cm) was found from V_3 (Binasoybean-5) which was statistically identical and differentiate from others varieties, while the lowest pod length (3.37 cm) was found V_1 (Binasoybean-7) which was statistically identical (Table 7).

4.2.1.2. Effect of seed priming

The highest pod length (3.65 cm) was found from P_3 (seed priming with hydrogen peroxide) which was statistically identical and differentiate from others varieties, while the lowest pod length (3.37 cm) was found P_1 (seed priming with water) which was statistically identical (Table 8).

4.2.1.3. Interaction effect of variety and seed priming

Remarkable variation was identified on interaction effect of variety and seed priming significantly in terms of pod length. Among the combination of variety and seed priming (3.82 cm) was taken from V_3P_3. The minimum (3.17 cm) pod length was found in V_1P_1 combination which was statistically identical (Table 9).

4.2.2. Number of pods plant^{-1}

4.2.2.1. Effect of variety

Number of pods plant^{-1} was found significant with the different varieties of soybean (Table 7 and Appendix VI). The highest number of pods plant^{-1} (40.75) was found from the variety, V_3 (Binasoybean-5) and the lowest number of pods plant^{-1} (32.78) was found from the variety, V_1 (Binasoybean-7). Rasul *et al.* (2012) and Salah Uddin *et al.* (2009) also found similar results with the present study

4.2.2.2. Effect of seed priming

Variation on number of pods plant^{-1} was significant influenced by different varieties of soybean (Table 8 and Appendix VI). The highest number of pods plant^{-1} (39.11) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was significantly different from all other treatments followed by P_2 (seed priming with Potassium nitrate). The lowest number of pods plant^{-1} (33.82) was found from the priming treatment, P_1 (seed priming with water) which was also significantly different from all other treatments. The result obtained from the present study was similar with the findings of Rastin *et al. (*2013) and Kisetu *et al*. (2013).

4.2.2.3. Interaction effect of variety and seed priming

The recorded data on number of pods plant^{-1} was significant with interaction effect of variety and seed priming treatments (Table 9 and Appendix VI). The highest number of pods plant^{-1} (43.33) was found from the treatment combination of V_3P_3 which was significantly different from all other treatment combinations followed by V_3P_2. The lowest number of pods plant^{-1} (30.13) was found from the treatment combination of V_1P_1 which was significantly different from all other treatment combinations.

4.2.3. Number of grain pod^{-1}

4.2.3.1. Effect of variety

Considerable influence was observed on number of grain pod^{-1} persuaded by different varieties of soybean (Table 7 and Appendix VI). It was observed that the highest number of grain pod^{-1} (2.34) was found from the variety, V_3 (Binasoybean-5) which was statistically identical with V_2 (Binasoybean-3). Whereas the lowest number of grain pod^{-1} (2.13) was found from the variety, V_1 (Binasoybean-7). Similar result was also observed by Rasul et al. (2012).

4.2.3.2. Effect of seed priming

Remarkable variation was identified on number of grain pod^{-1} due to the effect of different seed priming treatments (Table 8 and Appendix VI). The highest number of grain pod^{-1} (2.41) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was statistically identical with P_2 (Potassium nitrate) and P_4 (seed priming with *Moringa*). The lowest number of grain pod^{-1} (2.10) was found from the priming treatment, P_1 (seed priming with water) which was significantly different from all other priming combinations. The result obtained from the present study was similar with the findings of Rastin *et al.* (2013) and Kisetu *et al.* (2013).

4.2.3.3. Interaction effect of variety and seed priming

Significant influence was noted on number of grain pod^{-1} affected by interaction effect of variety and seed priming treatments (Table 9 and Appendix VI). Results revealed that the highest number of grain pod^{-1} (2.53) was found from the treatment combination of V_3P_3

which was statistically identical with all other priming combinations. The lowest number of grain pod^{-1} (1.93) was found from the treatment combination of V_1P_1 which was significantly different from all other priming combinations.

4.2.4. 1000-grain weight

4.2.4.1. Effect of variety

Weight of 1000 grains varied significantly due to different varieties of soybean (Table 7 and Appendix VI). It was found that the highest weight of 1000 grains (142.70 g) were found from the variety, V_3 (Binasoybean-5) which was statistically identical followed by V_2 (Binasoybean-3). Whereas the lowest weight of 1000 grains (123.17 g) were found from the variety, V_1 (Binasoybean-7) which was statistically identical and was significantly different from all other varieties. The result obtained from the present study was similar with the findings of Haider and Ahmed (2014).

4.2.4.2. Effect of seed priming

Significant variation was remarked on weight of 1000 grains as influenced by different seed priming treatments (Table 8 and Appendix VI). It was observed that the highest weight of 1000 grains (139.11 g) were found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) followed by the treatment P_2 (seed priming with Potassium nitrate) and P_4 (seed priming with *Moringa*) but significantly different from all other treatments. The lowest weight of 1000 grains (126.22 g) were found from the priming treatment, P_1 (seed priming with water) which was also significantly different from all other priming treatments. Similar result was also observed by Ali *et al.* (2013) and Shirinzadeh *et al.* (2013).

4.2.4.3. Interaction effect of variety and seed priming

Weight of 1000 grains was found significant with the interaction effect of variety and seed priming treatments (Table 9 and Appendix VI). It was found that the highest weight of 1000 grains (150.07g) was found from the treatment combination of V_3P_3 which was significantly different from all other treatment combinations. The lowest weight of 1000 grains (116.67 g) were found from the treatment combination of V_1P_1 which was statistically identical and was also significantly different from all other priming treatments.

Table 7: Effect of variety on pod length, number of pod plant^{-1}, grain pod^{-1} and 1000-grain weight

Variety	Pod Length(cm)	Number of Pod Plant^{-1}	Number of Grain Pod^{-1}	1000-grain Weight (g)
V_1	3.37 c	32.78 c	2.13 b	123.17 c
V_2	3.54 b	36.33 b	2.37 a	132.68 b
V_3	3.67 a	40.75 a	2.34 a	142.70 a
LSD	0.09	1.96	0.14	3.53
CV (%)	2.90	6.33	7.33	3.13
LS	**	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

Table 8: Effect of priming on pod length, number of pod plant^{-1}, grain pod^{-1} and 1000-grain weight

Priming	Pod Length(cm)	Number of Pod Plant^{-1}	Grain Pod^{-1}	1000-grain Weight (g)
P_1	3.37 c	33.82 c	2.10 b	126.11 c
P_2	3.52 b	36.33 b	2.28 a	131.76 b
P_3	3.65 a	39.11 a	2.41 a	139.22 a
P_4	3.57 ab	37.22 ab	2.33 a	134.32 b
LSD	0.10	2.27	0.16	4.07
CV (%)	2.90	6.33	7.33	3.13
LS	**	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
P_1= Water
P_2= Potassium nitrate (KNO_3) 1%
P_3= Hydrogen-peroxide (H_2O_2) 1%
P_4= 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

Table 9: Interaction effect of variety and priming concentrations on pod length, number of pod plant^{-1}, grain pod^{-1} and 1000-gain weight

Treatment combination	Pod Length(cm)	Number of Pod Plant^{-1}	Grain Pod^{-1}	1000-grain Weight (g)
V_1P_1	3.17 f	30.13 g	1.93 d	116.67 h
V_1P_2	3.35 e	32.33 fg	2.16 cd	122.79 gh
V_1P_3	3.52 cd	35.00 def	2.24 bc	129.20 efg
V_1P_4	3.43 de	33.67 efg	2.20 bcd	124.03 g
V_2P_1	3.43 de	33.00 fg	2.22 bc	126.67 fg
V_2P_2	3.57 bcd	36.00 cdef	2.40 abc	131.67 def
V_2P_3	3.62 bc	39.00 bc	2.45 ab	138.40 bcd
V_2P_4	3.55 cd	37.33 bcde	2.40 abc	134.00 cde
V_3P_1	3.52 cde	38.33 bcd	2.16 cd	135.00 cde
V_3P_2	3.63 bc	40.67 ab	2.29 abc	140.83 bc
V_3P_3	3.82 a	43.33 a	2.53 a	150.07 a
V_3P_4	3.73 ab	40.67 ab	2.38 abc	144.92 ab
LSD	0.17	3.93	0.28	7.05
CV (%)	2.90	6.33	7.33	3.13
LS	*	*	*	*

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.

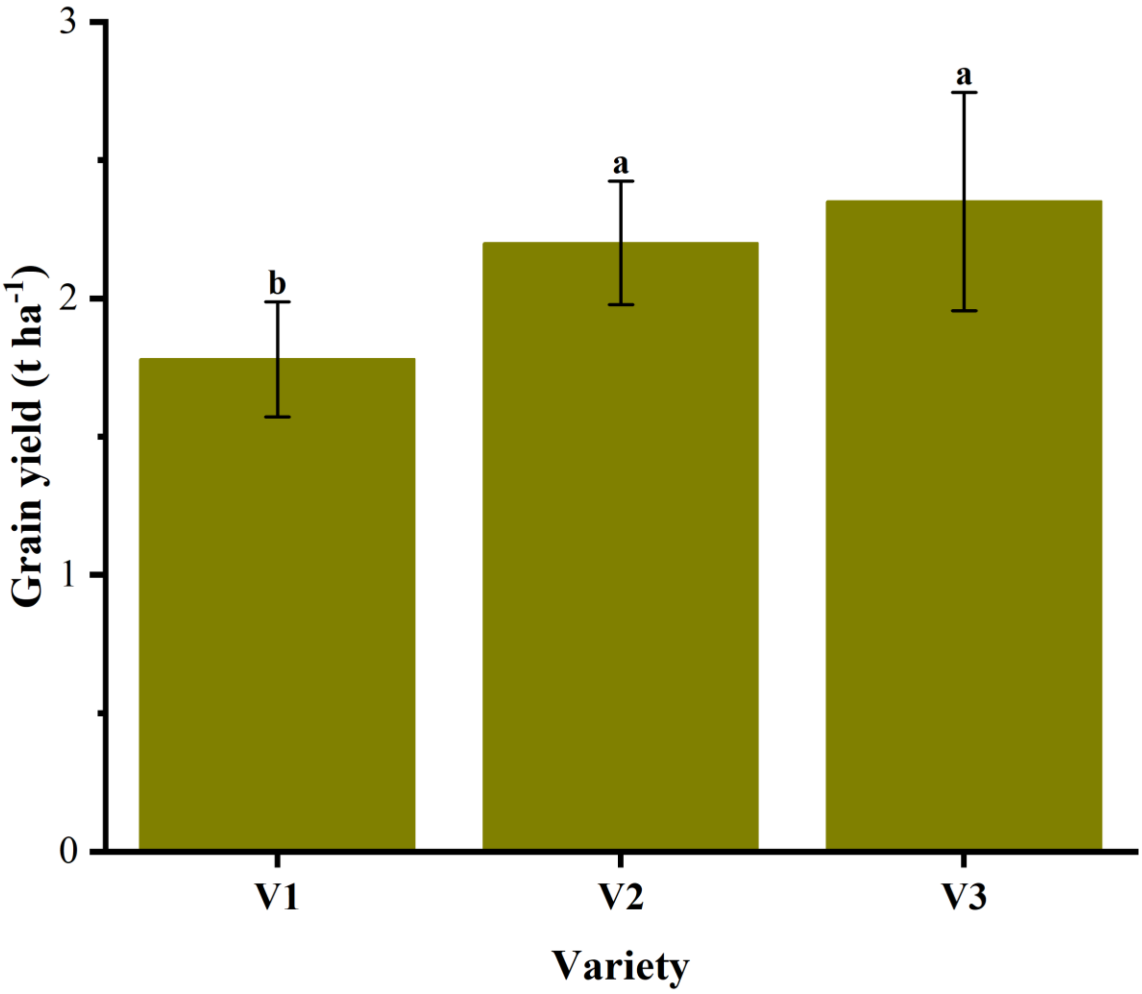
Legend,

V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

4.3. Grain yield (t ha^{-1})

4.3.1. Effect of variety

Considerable influence was observed on grain yield ha^{-1} affected by different varieties of soybean (Table 10 and Appendix VII). It was found that the highest grain yield ha^{-1} (2.36 t) was found from the variety, V_3 (Binasoybean-5) whereas the lowest grain yield ha^{-1} (1.79 t) was found from the variety, V_1 (Binasoybean-7). Ali *et al.* (2014), Parvez *et al.* (2013) and Rasul *et al.* (2012) also found similar result with the present study.

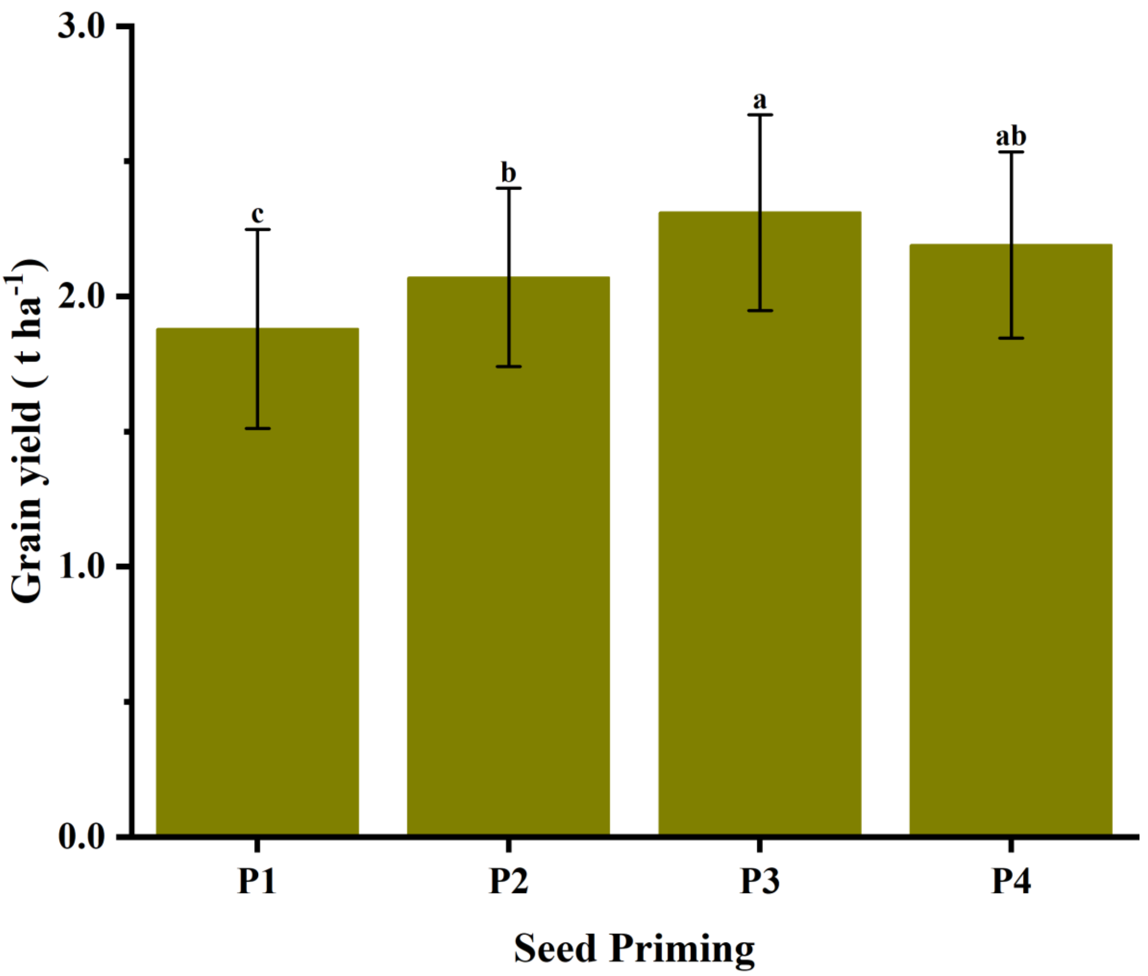


Legend: V_1= Binasoybean-7, V_2= Binasoybean-3, V_3= Binasoybean-5

Fig. 1. Grain Yield t ha^{-1} of soybean as influenced by variety

4.3.2. Effect of seed priming

Remarkable variation was identified on grain yield ha^{-1} due to the effect of different seed priming treatments (Table 11 and Appendix VII). Results signified that the highest grain yield ha^{-1} (2.31 t) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was significantly different from all other treatments followed by where the lowest grain yield ha^{-1} (1.89 t) was found from the priming treatment, P_1 (seed priming with water). Rastin *et al.* (2013), Meena *et al.* (2013) and Kisetu *et al.* (2013) also found similar result which supported the present study.

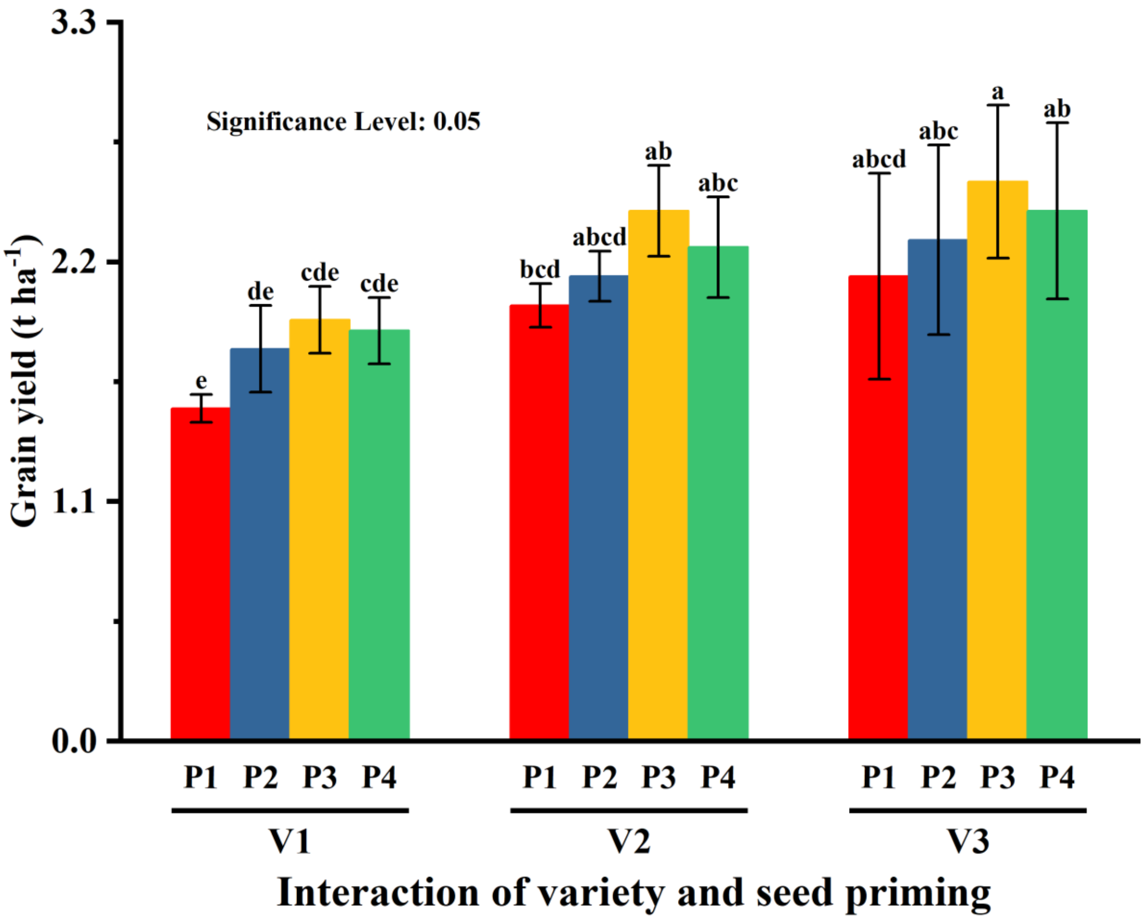


Legend: P_1 = Water, P_2 = Potassium nitrate (KNO_3) 1%, P_3 = Hydrogen-peroxide (H_2O_2) 1%, P_4 = 5g *Moringa*

Fig. 2. Grain Yield t ha^{-1} of soybean as influenced by priming

4.3.3. Interaction effect of variety and seed priming

Significant influence was noted on grain yield ha^{-1} affected by interaction effect of variety and seed priming treatments (Table 12 and Appendix VII). It was found that the highest grain yield ha^{-1} (2.57 t) was found from the treatment combination of V_3P_3 where the lowest grain yield ha^{-1} (1.53 t) was found from the treatment combination of V_1P_1 which was significantly different from all other treatment combinations.



Legend: V_1 = Binasoybean-7, V_2 = Binasoybean-3, V_3 = Binasoybean-5

P_1 = Water, P_2 = Potassium nitrate (KNO_3) 1%, P_3 = Hydrogen-peroxide (H_2O_2) 1%, P_4 = 5g *Moringa*

Fig. 3. Grain Yield t ha^{-1} of soybean as influenced by interaction effect between variety and seed priming

4.4. Biological yield (t ha^{-1})

4.4.1. Effect of variety

Biological yield of soybean had significant effect on different Soybean varieties (Table 10 and Appendix IX). Numerically the maximum biological yield of soybean (6.57 t) was recorded from V_3 (Binasoybean-5) whereas, the minimum (5.48 t) was recorded from V_1 (Binasoybean-7).

4.4.2. Effect of seed priming

Remarkable variation was identified on biological yield ha^{-1} due to the effect of different seed priming treatments (Table 11 and Appendix VII). Results signified that the highest biological yield ha^{-1} (6.40 t) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was significantly different from all other treatments followed by where the lowest biological yield ha^{-1} (5.71 t) was found from the priming treatment, P_1 (seed priming with water).

4.4.3. Interaction effect of variety and seed priming

Significant influence was noted on biological yield ha^{-1} affected by interaction effect of variety and seed priming treatments (Table 12 and Appendix VII). It was found that the highest biological yield ha^{-1} (6.93 t) was found from the treatment combination of V_3P_3 where the lowest biological yield ha^{-1} (5.06 t) was found from the treatment combination of V_1P_1 which was significantly different from all other treatment combinations.

4.5. Stover yield (t ha^{-1})

4.5.1. Effect of variety

Stover yield of soybean showed significant effect on different varieties of soybean (Table 10 and Appendix IX). Numerically the maximum Stover yield of soybean (4.21 t) was recorded from V_3 (Binasoybean-5) treatment whereas, the minimum (3.69 t) was recorded from V_1 (Binasoybean-7) treatment. Similar result was also found by Khatun *et al.* (2016)

4.5.2. Effect of seed priming

Remarkable variation was identified on stover yield ha^{-1} due to the effect of different seed priming treatments (Table 11 and Appendix VII). Results signified that the highest stover yield ha^{-1} (4.09 t) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was significantly different from all other treatments where the lowest stover yield ha^{-1} (3.82 t) was found from the priming treatment, P_1 (seed priming with water).

4.5.3. Interaction effect of variety and seed priming

Significant influence was noted on stover yield ha^{-1} affected by interaction effect of variety and seed priming treatments (Table 12 and Appendix VII). It was found that the highest stover yield ha^{-1} (4.37 t) was found from the treatment combination of V_3P_3 where the lowest stover yield ha^{-1} (3.53 t) was found from the treatment combination of V_1P_1 which was significantly different from all other treatment combinations.

4.6. Harvest index (%)

4.6.1. Effect of variety

Considerable influence was observed on harvest index affected by different varieties of soybean (Table 10 and Appendix VII). It was found that the highest harvest index (35.76%) was found from the variety, V_3 (Binasoybean-5) which is statistically similar in V_2 (35.61%) whereas the lowest harvest index (32.51%) was found from the variety, V_1 (Binasoybean-7).

4.6.2. Effect of seed priming

Remarkable variation was identified on harvest index due to the effect of different seed priming treatments (Table 11 and Appendix VII). Results signified that the highest harvest index (35.97%) was found from the priming treatment, P_3 (seed priming with Hydrogen peroxide) which was statistically similar in P_4 (seed priming with *Moringa*) treatments where, the lowest harvest index (32.82%) was found from the priming treatment, P_1 (seed priming with water).

4.6.3. Interaction effect of variety and seed priming

Significant influence was noted on harvest index affected by interaction effect of variety and seed priming treatments (Table 12 and Appendix VII). It was found that the highest harvest index (37.21%) was found from the treatment combination of V_2P_3 which is followed by V_3 P_3 (37.00%) where the lowest harvest index (30.16%) was found from the treatment combination of V_1P_1 which was significantly different from all other treatment combinations.

Table 10: Effect of variety on grain yield, biological yield, stover yield and harvest index

Variety	Grain Yield ($t\ ha^{-1}$)	Biological Yield ($t\ ha^{-1}$)	Stover Yield ($t\ ha^{-1}$)	Harvest Index (%)
V_1	1.79 b	5.48 c	3.69 c	32.51 b
V_2	2.21 a	6.19 b	3.98 b	35.61 a
V_3	2.36 a	6.57 a	4.21 a	35.76 a
LSD	0.16	0.29	0.18	1.66
CV (%)	8.94	5.62	5.42	5.67
LS	**	**	**	**

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

Table 11: Effect of priming on grain yield, biological yield, stover yield and harvest index

Priming	Grain Yield ($t\ ha^{-1}$)	Biological Yield ($t\ ha^{-1}$)	Stover Yield ($t\ ha^{-1}$)	Harvest Index (%)
P_1	1.89 c	5.71 c	3.82 b	32.82 b
P_2	2.08 b	6.01 bc	3.93 ab	34.41 ab
P_3	2.31 a	6.40 a	4.09 a	35.97 a
P_4	2.19 ab	6.19 ab	4.00 ab	35.29 a
LSD	0.19	0.33	0.21	1.92
CV (%)	8.94	5.62	5.42	5.67
LS	**	**	NS	*

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test.
Legend,
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance,
LS = Level of Significance
CV = Coefficient of variance

Table 12: Interaction effect of variety and priming concentrations on grain yield, stover yield, biological yield and harvest index

Treatment combination	Grain Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Harvest Index (%)
V_1P_1	1.53 f	5.06 h	3.53 f	30.16 e
V_1P_2	1.80 ef	5.50 gh	3.70 ef	32.67 de
V_1P_3	1.93 de	5.73 efg	3.80 cdef	33.69 bcd
V_1P_4	1.88 de	5.62 fgh	3.73 def	33.50 cd
V_2P_1	2.00 cde	5.87 defg	3.87 cdef	34.10 abcd
V_2P_2	2.13 bcd	6.10 cdef	3.97 bcde	34.97 abcd
V_2P_3	2.43 ab	6.53 abc	4.10 abc	37.21 a
V_2P_4	2.27 abc	6.27 bcde	4.00 bcde	36.14 abc
V_3P_1	2.13 bcd	6.20 bcde	4.07 abcd	34.21 abcd
V_3P_2	2.30 abc	6.43 abcd	4.13 abc	35.57 abcd
V_3P_3	2.57 a	6.93 a	4.37 a	37.00 ab
V_3P_4	2.43 ab	6.70 ab	4.27 ab	36.24 abc
LSD	0.32	0.58	0.36	3.32
CV (%)	8.94	5.62	5.42	5.67
LS	*	*	*	*

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test
NS = Non-significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance
LS = Level of Significance
CV = Coefficient of variance
V_1 = Binasoybean-7
V_2 = Binasoybean-3
V_3 = Binasoybean-5
P_1 = Water
P_2 = Potassium nitrate (KNO_3) 1%
P_3 = Hydrogen-peroxide (H_2O_2) 1%
P_4 = 5g *Moringa*

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at agronomic research field, Hajee Mohammad Danesh Science and Technology university, Dinajpur, during January, 2023 to May, 2023 with a view to find out the influence of seed yield and quality of soybean as affected by seed priming. The whole experiment was conducted in field level under the Old Himalayan Piedmont Plain (AEZ-1). Distilled water, Potassium nitrate (KNO_3), Hydrogen peroxide (H_2O_2), *Moringa* were used as seed priming. Three varieties of soybean *viz*. V_1= Binasoybean-7, V_2= Binasoybean-3 and V_3= Binasoybean-5 different priming chemicals including control *viz*. P_1 = seed priming with water, P_2= seed priming with Potassium nitrate (KNO_3), P_3 = seed priming with Hydrogen peroxide and P_4= seed priming with *Moringa* were considered as treatments of the experiment under the present study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Total numbers of plot were 36. There were 12 treatment combinations. The data on crop growth characters like plant height, number of branches plant^{-1}. Yield and quality attributing parameters like, number of pods plant^{-1}, pod length, number of grains pod^{-1}, 1000-grains weight, grain yield, stover yield, biological yield and harvest index. Data were analyzed using Statistix 10.0 computerized package program. The mean differences among the treatments were compared by Least Significance Difference (LSD) at 5% level of significance.

The variety had significant influence on different growth and yield parameters. Plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of grains pod^{-1}, 1000 grains weight and grain yield ha^{-1} were significantly affected by variety.

Results revealed that the highest plant height (9.60, 22.57, 32.46 and 47.75 cm at 20DAS, 40DAS, 60 DAS and at harvest, respectively) in V_3 (Binasoybean-5), Number of branches plant^{-1} (3.85, 4.26 and 4.76 at 40 DAS, 60 DAS and at harvest, respectively) was found from the variety, V_3 (Binasoybean-5) which was statistically identical with V_2 (Binasoybean-3) at 60 DAS and at harvest. The highest pod length (3.67 cm) was found in V_3 (Binasoybean-5). Similarly, the highest number of pods plant^{-1} (40.75), 1000-grain weight (142.70 g), grain yield ha^{-1} (2.36 t) were found from the variety, V_3 (Binasoybean-5).

Again, the lowest plant height (7.73, 19.10, 25.70 and 34.67 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively), were found from the variety, V_1 (Binasoybean-7) but the lowest number of pods plant^{-1} (32.78), lowest weight of 1000-grain (123.17 g) and grain yield ha^{-1} (1.79 t) were obtained from the variety, V_1 (Binasoybean-7).

The lowest number of branches plant^{-1} (3.08 cm, 3.65 cm and 4.15 cm at 40 DAS, 60 DAS and at harvest, respectively) was found from the variety, V_1 (Binasoybean-7) which was statistically identical with V_2 (Binasoybean-3) at 40 DAS.

In case of seed priming performance, different priming treatment showed significant variation among the treatments on plant height, number of branches plant^{-1}, pod length, number of pods plant^{-1}, number of seeds pod^{-1}, 1000-grain weight, and grain yield ha^{-1}.It was found that the highest plant height (9.09, 20.75, 32 and 44.22 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) was found from the priming treatment, P_3 (seed priming with Hydrogen per-oxide) which was statistically identical with P_1 (seed priming with water), P_2 (seed priming with potassium nitrate) at 40 DAS and P_4 (seed priming with *Moringa*) at 60 DAS but at 20 DAS and at harvest it was significantly different from all other treatments followed by P_3 (seed priming with Hydrogen per-oxide).

The highest number of branches plant^{-1} (3.79, 4.42 and 4.92 at 40 DAS, 60 DAS and at harvest, respectively) was found from the priming treatment, P_3 (seed priming with Hydrogen per-oxide) which was significantly different from all other treatments. The highest pod length (3.65 cm) was found from P_3 (seed priming with hydrogen peroxide). Similarly, the highest number of pods plant^{-1} (39.11), 1000-grain weight (139.11 g), grain pod^{-1} (2.41) and grain yield ha^{-1} (2.31 t) were achieved from the priming treatment, P_3 (seed priming with Hydrogen per-oxide). Likewise, the lowest plant height (8.17 cm, 21.86 cm, 26.39 cm and 37.89 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively), number of branches plant^{-1} (2.78, 3.33 and 3.83 at 40 DAS, 60 DAS and at harvest, respectively), number of pods plant^{-1} (33.82), number of grain pod^{-1} (2.10), weight of 1000-grain (126.22 g), pod length (3.37 cm) and grain yield ha^{-1} (1.89 t) was found from the priming treatment, P_1 (seed priming with water).

Regarding, interaction effect of variety and seed priming treatments, all the studied parameters (plant height, number of branches plant^{-1}, number of pods plant^{-1}, number of grain pod^{-1}, 1000-grain weight, pod length and grain yield ha^{-1}) were significantly affected. Results showed that the highest plant height (9.92 cm, 24.33 cm, 35.33 cm and 51.33 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) and number of grain pod^{-1} (2.53) were found from the treatment combination of V_3P_3 but the highest number of branches plant^{-1} (4.20, 4.67 and 5.17 at 40 DAS, 60 DAS and at harvest, respectively), number of pods plant^{-1} (43.33), 1000-grain weight (150.07 g), pod length (3.82 cm) and grain yield ha^{-1} (2.57 t) were found from the treatment combination of V_3P_3. Again, the lowest plant height (6.98, 18.03, 23.38 and 31.67 cm at 20 DAS, 40 DAS, 60 DAS and at harvest, respectively) and number of grain pod^{-1} (1.93) were found from the treatment combination of V_1P_1 but the lowest number of branches plant^{-1} (2.30, 3.10 and 3.60 at 40 DAS, 60 DAS and at harvest, respectively), number of pods plant^{-1} (30.13), weight of 1000-grain (116.67 g), and grain yield ha^{-1} (1.53 t) was found from the treatment combination of V_1P_1.

V_3P_3 combination showed better performance o yield attributing characters i.e. produced highest number of pod plant^{-1}, pod length, grain pod^{-1}, highest seed yield, stover yield and biological yield as compared with other treatment combination.

Considering the above results, it may be concluded that growth parameters, seed yield and yield contributing parameters of soybean are positively influence with variety and seed priming treatments. Therefore, the present experimental results suggest that the combined use of variety along with seed priming treatments would be beneficial to increase the seed yield of soybean under the climatic and edaphic condition of Hajee Mohammad Danesh Science and Technology University, Dinajpur.

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

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

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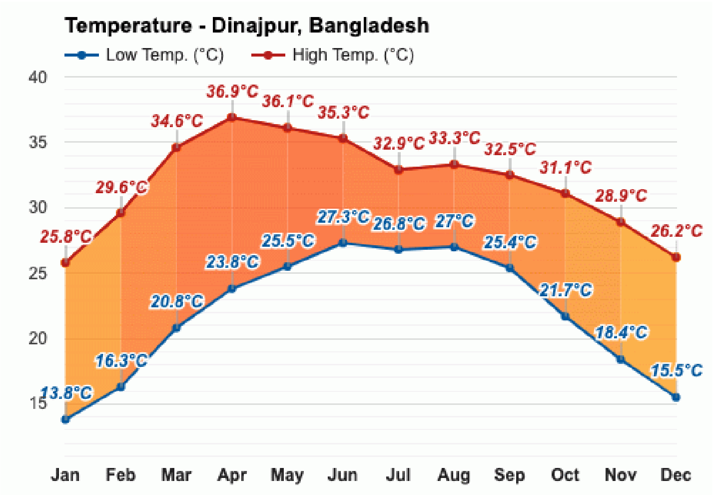
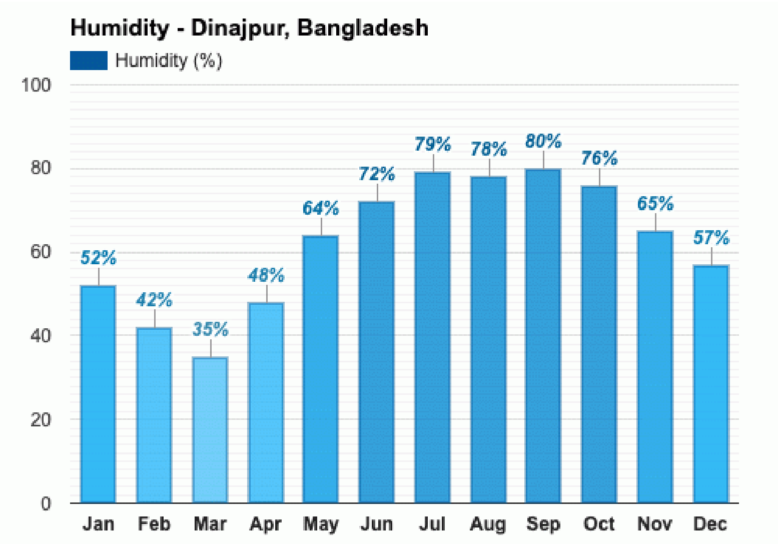
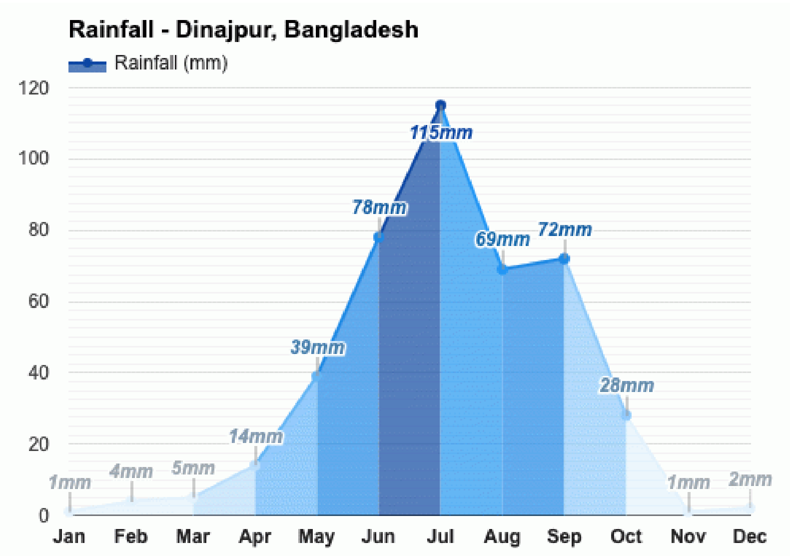
APPENDICES

Appendix I. Map showing the experimental site under study

Appendix II. Weather data 2023, Dinajpur, Bangladesh







Appendix III: Morpho-physio-chemical properties of soil (collected before sowing of seeds) of the experimental field.

A. Morphological characteristics of the soil

Constituents	Characteristics
Location	Agronomy shade house, Department of Agronomy ,Hajee Mohammad Danesh Science and Technology University, Dinajpur
Agro-ecological zone	Old Himalayan Piedmont Plain (AEZ-1)
Geographical position	$25^0$38N latitude and $88^0$41E longitude
General Soil type	Non-calcareous dark grey floodplain
Parent materials	Old Brahmaputra River borne deposit
Land type	Medium high land
Elevation	37 meter above the mean sea level
Drainage	Well drained
Topography	Fairly level
Soil texture	Sandy loam
Soil Color	Dark grey
Flood level	Above flood level

B. Physical properties of the initial soil (0-15 cm depth)

Constituents	Results
Particle size analysis	
Sand (%) (0.2-0.002 mm)	58
Silt (%) (0.02-0.002 mm)	28
Clay (%) (<0.002 mm)	14
Soil textural class	Sandy loam

Source: Results obtained from the mechanical analysis of the initial soil sample.

C. Chemical composition of the initial soil (0-15 cm depth)

Characteristics	Value (%)
pH (Soil: water = 1: 1.25	5.41
Organic matter	1.48
Organic carbon	0.72
Total N	0.08
Available P (ppm)	11.20
Exchangeable P (meq)	0.10
Exchangeable Ca (meq)	2.48
Exchangeable Mg (meq)	2.29
Available S (ppm)	17.29
Available B (ppm)	0.13
Available Zn (ppm)	0.90
Available Fe (ppm)	51.90
Available Mn (ppm)	12.13

Source: Results obtained from the chemical analysis of the initial soil sample (SRDI, Dinajpur).

Appendix IV. Mean square values for plant height at different days after sowing

Source of variation	**df**	**PH (cm)**			
		20 DAS	**40 DAS**	**60 DAS**	**At harvest**
Replication	2	20.7993^{NS}	311.567^{NS}	893.72^{NS}	284.06^{NS}
Factor A	2	21.7005**	74.458**	278.28**	1027.72**
Factor B	3	4.3261^{NS}	23.251**	163.64**	196.97**
Factor AB	6	2.8424*	21.836*	4.13*	4.94*
Error	22	13.0800	31.816	107.74	115.94

Df= degrees of freedom, Factor A=Variety, Factor B= Seed Priming, Factor AB = Variety and Seed Priming

Appendix V. Mean square values for number of branches plant^{-1} at different days after sowing

Source of variation	df	BN (number)		
		40 DAS	60 DAS	At harvest
Replication	2	3.3517^{NS}	5.6439^{NS}	5.6439^{NS}
Factor A	2	3.8079**	2.2706**	2.2706**
Factor B	3	5.2911**	5.9608**	5.9608**
Factor AB	6	0.2026*	0.1050*	0.1050*
Error	22	1.6317	3.5361	3.5361

Df= degrees of freedom, Factor A=Variety, Factor B= Seed Priming, Factor AB = Variety and Seed Priming

Appendix VI. Mean square values for pod length, number of pod plant^{-1}, grains pod^{-1} and 1000-grain weight

Source of variation	df	Mean squire values			
		Pod Length (cm)	Number of Pod Plant^{-1}	Number of Grain Pod^{-1}	1000-grain Weight (g)
Replication	2	0.221^{NS}	502.780^{NS}	0.880^{NS}	812.260^{NS}
Factor A	2	0.570**	382.310**	0.389**	2290.210**
Factor B	3	0.374**	130.300**	0.441**	804.140**
Factor AB	6	0.037*	4.040*	0.040*	15.320*
Error	22	0.230	118.400	0.614	381.450

Df= degrees of freedom, Factor A=Variety, Factor B= Seed Priming, Factor AB = Variety and Seed Priming

Appendix VII. Mean square values for Seed yield, stover yield, biological yield, harvest index of soybean

Source of variation	df	Mean squire values			
		Grain Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Harvest Index (%)
Replication	2	1.033^{NS}	1.121^{NS}	3.633^{NS}	61.912^{NS}
Factor A	2	2.115**	1.611**	7.348**	80.784**
Factor B	3	0.884**	0.341^{NS}	2.322**	49.880*
Factor AB	6	0.030*	0.021*	0.080*	3.064*
Error	22	0.789	1.013	2.564	84.709

Df= degrees of freedom, Factor A=Variety, Factor B= Seed Priming, Factor AB = Variety and Seed Priming

Appendix VIII: Some photographs of my research works