SALT STRESS MITIGATION BY SEED PRIMING IN FABA BEAN (*Vicia faba* L.)

AYESHA SIDDIKA

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA -1207

JUNE, 2018

SALT STRESS MITIGATION BY SEED PRIMING IN FABA BEAN

(*Vicia faba* L.)

BY

AYESHA SIDDIKA

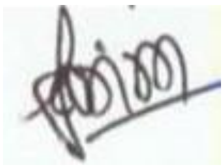
REG. NO. 12-04843

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2018

Approved by:



Prof. Md. Ruhul Amin
Department of Horticulture
SAU, Dhaka
Supervisor

Associate Prof. Dr. Jasim Uddain
Department of Horticulture
SAU, Dhaka
Co-supervisor

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **"SALT STRESS MITIGATION BY SEED PRIMING IN FABA BEAN (*Vicia faba* L.)"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **AYESHA SIDDIKA**, Registration No. **12-04843** 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, 2018
Dhaka, Bangladesh

Prof. Md. Ruhul Amin
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

*All praises to the **"Almighty Allah"** Who enable me to complete a piece of research work and prepare this thesis for the degree of Master of Science (M.S.) in Horticulture.*

*The author wishes to express her gratitude and best regards to her respected Supervisor, **Professor Md. Ruhul Amin**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of the thesis.*

*The author wishes to express her earnest respect, sincere appreciation and enormous indebtedness to her reverend Co-supervisor, **Dr. Jasim Uddain**, Associate Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.*

*The author feels to express her heartfelt thanks to the honorable Chairman, **Prof. Dr. Md. Humayun Kabir,** Department of Horticulture, Sher-e- Bangla Agricultural University, Dhaka-1207 for his encouragement and co-operation in various stages towards completion of this research work.*

*The Author wishes to express her gratitude and heartfelt thanks to her **honorable teachers** of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207 for their valuable teaching, indirect advice and enormous inspiration throughout the research work.*

*The author deeply acknowledges the profound dedication to her beloved **Father, Mother and Brother** for their moral support, steadfast encouragement and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.*

Finally, the author is deeply indebted to her friends and well-wishers and Jahan Ara High school family for their kind help, constant inspiration, co-operation and moral support which can never be forgotten.

The Author

SALT STRESS MITIGATION BY SEED PRIMING IN FABA BEAN (*Vicia faba* L.)

BY

AYESHA SIDDIKA

ABSTRACT

A pot experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to April 2018. The experiment consisted of two factors: Factor A: Different level of saline in soil with NaCl solution such as, S_1: Control (0 mM NaCl), S_2: 40 mM NaCl, S_3: 80 mM NaCl, S_4: 120 mM NaCl and Factor B: Different type of seed priming , viz. P_1: Non primed , P_2: Hydroprimed and P_3: Ascorbic acid priming (100 mg/L). The experiment was laid out in completely randomized design with 3 replications. Salinity level and different type of seed priming showed significant variation with most of the parameters. In case of salinity the total pod weight per plant was recorded highest (90.19 g) from S_1 while the lowest from S_4 (17.34 g). For priming total pod weight per plant was recorded highest (66.29 g) from P_3 while the lowest from P_1 (37.99 g). For combined effect total pod weight per plant was recorded highest (107.09 g) from P_3S_1 while the lowest from P_2S_4 (16.41 g). So, the use of ascorbic acid priming (100 mg/L) in lowest level of salinity S_1 (0 mM NaCl) was the best for growth and yield of faba bean.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF TABLES (Contd.)

LIST OF PLATES

LIST OF APPENDICES

LIST OF APPENDICES (Contd.)

LIST OF ABBREVIATIONS

@	=	At the rate of
AEZ	=	Agro-ecological Zone
Agric.	=	Agriculture
Agril.	=	Agricultural
ANOVA	=	Analysis of variance
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
^0C	=	Degree Centigrade
DAS	=	Days after Sowing
DMRT	=	Duncan's Multiple Range Test
et al.	=	and others
Kg	=	Kilogram
Kg ha^{-1}	=	Kilogram per hectare
g	=	Gram
SE	=	Standard Error
m	=	Meter
pH	=	Hydrogen ion concentration
RCBD	=	Randomized Complete Block Design
%	=	Percent

CHAPTER I

INTRODUCTION

Faba bean (*Vicia faba* L.) belongs to the Fabaceae family and has many common names. It is native to northern Africa and south-west Asia, where it is extensively cultivated. The species spread from the Mediterranean region to Europe and then through Eurasia and to parts of the New World. Extensive cultivation occurs in in China. It is one of the most globally important legume crops. Its global acreage declined from 3.7 to 2.1 million ha between 1980 and 2014, and yields are highly variable within specific countries (FAO, 2017). Despite the decreasing acreage, however, productivity per area has tended to increase, due to a reduced susceptibility to abiotic and biotic stresses (Singh *et al.*, 2012). The plant is rigid and erect, growing to 0.5 to 1.7 m tall, leaves are 10–25 cm long, pinnate with 2-7 leaflets and have a distinct grey-green colour. The pods are green, broad and leathery. When mature they are blackish-brown with a dense, downy surface. The different nutritional parameters were also found to be in variable concentration viz. total soluble protein ≈ 20–32 %, free amino acids ≈ 188–348 mg/100 g, starch ≈ 27–33 %, reducing sugars ≈ 85–188 mg/100 g, non reducing sugars ≈ 0.7–1.7 % and total soluble sugars ≈ 0.8–1.9 %.

In Bangladesh the total area of 147,570 km^2. The coastal area covers about 20% of it and over 30% of the total cultivable lands. The cultivable areas in coastal districts are affected with varying degrees of soil salinity.Excess soil salinity affects both growth and nitrogen fixation in faba bean plant, which are considered moderately tolerant of soil salinity (Bulul *et al*., 2011).Katerji *et al.*, 2011 report a yield reduction in faba bean at soil salinity levels of $\geq$ 6.5 dSm^{-1}. According to FAO (2013) daily consumption rate of pulse should be 80 g/day, but in Bangladesh only 14.2 g/day (BBS, 2017b). At present, total pulse grown area is 0.373 million hectare and production 0.387 million tons, where faba bean is grown only in a negligeable area with poor production (BBS, 2017a) which is insufficient to meet up national demand for low productivity.

Seed priming is a practice by which seeds are partially hydrated to a point where germination processes begin but radical emergence does not occur. Seed priming can be found effective for legumes i.e., yields of mung bean and chickpea were increased substantially by priming (hydropriming) seeds for 8 h before sowing mostly under irrigated conditions (Harris *et al.,* 1999; Musa *et al.*, 1999). Priming is a technique applied before planting and can improve seed characteristics especially under abiotic stress conditions. It has been found a promising technology to improve rapid and uniform emergence, high vigor, and better yields for vegetable and field crops (Janmohammadi *et al.,* 2009; Rouhi *et al.,* 2011). Abiotic stresses such as salt stress is more destructive to crop production at different crop growth stages. Janmohammadi *et al.* (2008) reported that poor seed germination and crop stand are major problems in saline areas. A lot of strategies are established to escape the adverse effects of salt. Priming can be an alternative to overcome salt stress.Seed can be primed by either uncontrolled hydration - hydropriming (Casenave and Tosselli, 2007; Ghassemi-Golezani *et al.,* 2010a) or controlled hydration methods which include osmotic priming and hormonal priming (Basra *et al.,* 2006; Foti *et al.,* 2008).

Hydropriming significantly improved germination, seedling growth percentage, germination index, seedling vigour index and length of seedling under both stress and non-stress conditions. Hydropriming could alleviate the effects of salinity and drought stress on germination and growth.It could be suitable seed invigoration treatment under saline condition. Ascorbic acid is an abundant antioxidant small molecule in plants. It affects many physiological processes including the regulation of growth and metabolism of plants under saline conditions and increasing physiological availability of water and nutrient (Barakat, 2003). Its application was effective to mitigate the adverse effect of salt stress on plant growth due to increased leaf area, improved chlorophyll and carotenoids contents (Azzedine *et al.,* 2011). The role of vitamins in modifying the salt-stress induced changes in osmoprotectant contents was also investigated by some investigators (Fercha *et al.,* 2011).

In Bangladesh a little research work is known about hydro priming and osmopriming induced salt tolerant capacity in faba bean is not widely used. Therefore, the present study on seed priming of faba bean was conducted with following objectives:

Objective of my research work:

1. To evaluate the performance of primed seed in different level of saline soil.
2. To identify the suitable seed priming agent in varying degrees of soil salinity; and
3. To evaluate the combined effect of seed priming agent and different level of saline soil modulating salinity stress.

CHAPTER II

REVIEW OF LITERATURE

Salinity becomes severe problem in the coastal region of Bangladesh now-a-days. The scientists of Bangladesh are conducting different experiments to adopt different crops in the saline area. An attempt has been made to find out the performance of faba bean at different levels of salinity as well as to find out the performance of primed seed in different level of saline soil, to identify the suitable seed priming agent in varying degrees of soil salinity and to evaluate the combined effect of seed priming agent and different level of saline soil modulating salinity stress. Some of the important and informative works and research findings related to the salt stress and also the mitigation of salt stress in vegetable crops as well as bean, so far been done at home and abroad, have been reviewed in this chapter under the following heads-

2.1 Seed priming

The history of seed priming dates back to 60 A.D. Attempts to improve seed germination have been reported since Ancient Greeks. Theophrastus (372-287 BC) recommended presoaking of cucumber seeds in milk or water to make them germinate earlier and vigorously (Evanari, 1984).Osmo-priming conditions by soaking the seeds of *Lepidium sativum* and lettuce in seawater and noticed improved germination.

Parmoon *et al*. (2013) stated that priming allowed to begin the biochemical processes and metabolism of sugars and hydrolysis inhibitors during the first and the second stages of germination before the emergence of the radical.

Conrath *et al*. (2002) reported that various advantages are in seed priming to eliminate physiological and pathological stresses that results in utilization, activation and enhancement of various cellular defense responses and resistance priming effects are related with the fixing and building-up of nucleic acids, improved synthesis of proteins and repairing of the cell membranes.

2.2 Priming effect on germination parameters

2.2.1 Germination percentage

Farooq *et al*. (2008) stated that good germination ensures better establishment of crop and it is a big sign for maximum crop yield. For that sometime seed treatment are necessary before sowing. In the field conditions, primed seeds resulted earlier germination as it restored deteriorated seeder parts and quickened germination because of speedier developing life

Laghari *et al*. (2016) reported that seed priming is a controlled hydration method in which seeds are soaked in water or low osmotic potential solution for a point where germination related metabolic exercises start in the seeds, however radical development does not happen. During seed priming, it was found effective for legumes that is, yields of legume harvest were increased impressively by priming seeds before sowing. The maximum mean seed germination (86.78%) was recorded at Hydro-priming period 4 hours, whereas the lower seed germination (68.88%) no priming in mungbean.

According to Posmyk and Janas (2007), at low temperature hydropriming along with proline can be practiced as a harmless priming process for betterment of seed germination and growth of *Vigna radiata*. Stress injuries also repaired fast through hydroming. Germination and emergence were found in primed seeds on canola (*Brassica compestris*), wheat (*Triticum aestivum*), and rice (*Oryza sativa*) who defined hydropriming for 24 hr betterment hardening, germination rate and percentage in seeds.

Kumar *et al.* (2017) reviewed that, osmo-priming treated seed showed significantly higher germination percentage in PEG at 20% followed by mannitol 4% in chick pea. It was informed by Kaya *et al*. (2006) that seed priming had an important result on increasing of germination percent; germination speed and seedling dry weight of sunflower. Priming also decreased abnormal seedling in drought stress.

Saha *et al*. (2006) found the positive effects of priming might be more obvious under unfavorable rather than favorable conditions. In mungbean, 4 hr and 8 hr primed seeds presented substantial variation in germination and seed moisture percentage over un-primed seeds

Lee and Kim (2000) reported that increasing germination rate by 10-15% was through hardening (150 gm seeds soaked in 500 mL water for 18 and 24 hr) of older rice seeds, as the process of increase total sugar content and α-amylase activity

Afzal *et al*. (2011a) found that seed priming hasten germination percentage, lessened emergence time and enhanced yields are reviewed in many crops Judicious doses of PEG (Polyethylene Glycol) showed better tolerance at drought stress condition than hydro-priming, while more doses of PEG had negative effects on germination.

Vishwas *et al*. (2017) investigated an experiment where seed treated with Rhizobium + Pseudomanas @ 10% for 12 hr recorded higher germination percentage (87%). It may due to completion of peregrination metabolic activities, increased rate of cell division, apical dominance in shoot and root apex. During seed priming, all those attributes making the seed ready for soon germination after planting and the highest germination percentage

Mahajan *et al*. (2011) stated that natural priming has been shown to increase germination synchrony, rate and final percentage in many species. Seed priming treatments not only improved germination rate and time, but it also enhanced seedling vigour by longer roots, shoots and seedling dry weight.

2.2.2 Mean germination time (days)

Mean germination time reflects germination speed that cannot be measured by germination percentage. Speed of germination may because of the accelerated germination of primed seeds might be due to increased rate of cell division (Bose and Mishra, 1992).

Basra *et al*. (2005) found that priming promoted to reduce mean germination time over the un-primed one. The MGT is also dependent on the duration of imbibitions and/or internal metabolic activities after imbibitions (the second stage of germination). Priming activates internal metabolism required for furthering the germination process.

Elkoca *et al*. (2007) determined that hydro priming treatment in chickpea induced faster and more synchronous germination compared with the unprimed seeds. Besides, in terms of priming duration, priming treatment for 24 hr generally reduced the germination synchrony compared with the treatment for 12 hr. This result indicated that longer priming duration may overcome effect of decreased water potential in osmo-priming treatments of lentil seeds.

Hassanpouraghdam *et al.* (2009) reported that at the time of different phases of seedling establishment priming plays very significant role to reduce the time between planting and emergence and safe the seeds from environmental stress. Uniform stands and improved yield could be maintained through earlier and synchronized emergence. Priming creates stimulatory effects on the early phases of emergence by occurrence of cell 8 division in germinating seeds.

Ashraf and Foolad (2005) stated that improved seed priming methods were recognized to lessen emergence time, achieve even emergence and ensure good crop stand in several horticultural and field crops .

Rashid *et al.* (2006) reported that “On-farm” hydropriming was very efficient in speed germination, good crop establishment and increased yields for many crops in various environmental condition.

Yucel (2012) found that priming treatment influenced the MGT compared with control seeds at all of the germination temperatures. In generally, seeds primed for 24 hr reduced hours required reaching 50 % germination compared with the seeds primed for 12 hr, but there was no significant difference between priming durations.

Ghassemi-Golezani *et al.* (2008a) reported that lentil seeds priming with KNO_3, PEG and water showed the highest germination percentage. Seeds primed for 24 hr increased the germination percentage and decreased mean germination time compared with seeds primed for 12 hr. This result indicated that longer priming time may overcome adverse effects of decreased water potential in osmo-priming treatments than control seeds.

According to Basra *et al*. (1989) priming with polyethylene glycol or potassium salt (K_2HPO_4 or KNO_3) resulted in quicker emergence in corn seed. When salinity and drought stress cause the reduction of germination speed, hydro priming perform as a decent, economical and simple seed stimulating treatment for inbreed lines of maize .

Yamauchi and Winn (1996) showed that seed treating may help to overcome dormancy through embryo advancement and leaching of emergence inhibitors that lead to an earlier start of emergence.

According to Harris *et al*., (1999) early emergence and maturity in seed priming treatment could be due to advancement in metabolic state and also concluded that priming improve plant stand and provide benefits in term of maturity. Seed priming resulted in earlier emergence of seedlings by 1-3 days and significantly increased plant stand and initial growth vigour.

Singh *et al.* (2012) found that a steady decrease in number of days taken for seed emergence from control or non-treated seeds to 16 hr of hydropriming. i.e., average number of days taken by control or non-treated seeds for 50% seed emergence was 5.00 which was highest, and average number of days taken by 12 hr of hydropriming was 2.78 days which was lowest.

Ghassemi-Golezani *et al*. (2010c) reported that ydropriming of seeds could have achieved earlier and more uniform germination than the unprimed seeds. These positive effects are probably due to stimulatory effects of priming on early stage of germination process by mediation of cell division in germination.

Kaya *et al.* (2006) reported that seed priming enhanced germination which may be attributed to repair processes, a buildup of germination metabolites or osmotic adjustments during priming treatment and also reported that osmotic seed priming of maize caryopses in coper sulphate, zinc sulphate, manganese sulphate, or boric acid induced high levels of seed germination.

Sun *et al*. (2010) also concluded that PEG priming with moderate concentration resulted in higher tolerance to drought stress than hydropriming, while higher concentrations of PEG had negative effects on seed germination.

Hosseein *et al.* (2011) reported that seed priming resulted in anti-oxidant 10 increment as glutathione and ascorbate in seed. These enzymes led to higher germination speed via reduction of lipid peroxidation activity. Hydropriming could have advances the germination rate, speed (germination index) and uniformity even under less optimum field condition.

Singh *et al.* (2017) done a critical analysis on different hydropriming and osmo-priming treatments on pea have significant effect on germination index, 20% Polyethylene glycol (PEG) for 24 hr (9.11) shows significant effect on rest of the treatments except 20% Polyethylene glycol (PEG) for 12 hr (8.92).

Elangbam *et al.* (2017) experimented that, the speed of germination in chickpea as influenced by various seed treatment: Lemon juice, Panchgavya, GA_3 and IAA. The maximum speed of germination with GA_3 might be due to its influence in early germination and increased percent germination.

Rashid *et al.* (2006) stated that priming boosted speed of germination, better crop stand and amplified yields in varied situations for a lot of crops (Khan *et al.,* 2008).

Kaur *et al.* (2003) conducted study to determine the effect of seed priming with mannitol (4%), water and potassium nitrate on chickpea. The response of chickpea seedlings to salt stress was also studied. In general priming with water and mannitol resulted in early germination under salt stress. Priming with 4%

mannitol was also as effective as mannitol and water in the enhancement of root and shoot growth. Osmo-priming methods, Mannitol primed seed gave higher germination index than that of NaCl primed.

Nyarko *et al.* (2006) also reported that cabbage seeds primed and expose to vernalization temperature (0°- 5° C) for 8 weeks had a higher CV than non-primed seeds. In primed leek seeds, the significant benefit in germination performance was accompanied by marked increases in protein, DNA and nucleotide biosynthesis.

2.2.4 Energy of emergence (%)

Khan *et al.* (2005) said that primed seed can quickly uptake and revive the seed metabolism, subsequently advanced germination rate and lessening the internal physiological heterogeneity in germination. The consequential improved crop stand can apparently enhance the drought tolerance, decrease pest damage and hasten crop yield in cereals and legumes

Cramer (2002) stated that many metabolic processes are related in the early stages of germination and those are stimulated by priming. It is well-known that seedlings from primed seeds germinate faster, grow more rapidly and perform better in negative conditions.

Roy and Srivastava (1999) found that soaking wheat kernels in water improved their germination rate under saline conditions. It improved the field stand and plant growth both at vegetative and maturity of maize. Hydro-priming plays an important role in the seed germination, radical and plumule emergence in different crop species under saline and non-saline conditions and also have beneficial effect on enzyme activity required for rapid germination.

Sun *et al.* (2010) reported that PEG priming with moderate concentration resulted in higher tolerance to drought stress than hydro-priming, while higher concentrations of PEG had negative effects on seed germination.It was reported seed priming had significant effect on increment of germination percent;

germination speed and seedling dry weight of sunflower vice versa of producing abnormal seedling decrement in drought condition.

Korkmaz and Pill (2003) reported that priming with KH_2PO_4 improved the germination synchrony of low vigour cultivar in lettuce and seed primed with KH_2PO_4 and water treatments enhanced germination in wheat under normal condition compared to untreated seed.

Tavili *et al*. (2011) described osmopriming with PEG was as a good technique for improving seed germination of Bromus seeds under salt and drought stress and for increasing the germination percentage and seedling vigor of bersim (*Trifolium alexandrinum*) seeds. In soybean too, seed priming with PEG was successfully carried out.Osmopriming with PEG results in strengthening the antioxidant system and increasing the seed germination potential.

Rashid *et al*. (2006) reported that priming decreased the temperature optimum and ceiling temperature for germination and also helped in advancing the germination time and did not decrease the final percentage emergence.‘‘On-farm’’ seed priming (soaking seeds in water prior to sowing) has been shown to be effective in producing early germination, better establishment and increased yields in a wide range of crops in diverse environments .

2.2.5 Coefficient of velocity

Bose and Mishra (1992) cited that primed seed improve germination and coefficient of velocity in treated fenugreek seeds may be explained by an increase of cell division in the seeds kept at 15° C had accelerated emergence and gave increased plant fresh weight.

Farooq *et al*. 2006 found that seed priming had a double technology to enhance rapid and uniform emergence, and to achieve high vigor and better yields in vegetables and floriculture and some field crops.The enhanced phenology in mungbean due to primed seed is associated with faster emergence and reduced germination imbibition periods. It has been declared that priming had been resulted in more germination speed especially in drought stress, saline stress and low temperatures.

Mwale *et al*. (2003) reported early germination of primed seeds but not recorded any improvement in the growth of seedlings in muskmelon (*Cucumis melo*) seeds under laboratory conditions. Confounding results, where priming did not show any beneficial results, also reported by different research workers.

2.3 Effect on growth parameters

2.3.1 Shoot length

Kaur *et al*. (2005) reported that osmo and hydropriming of chickpea seeds with mannitol and water alleviated the adverse effects of water deficiency and salt stress on seedling growth. The treatment of seeds with water and 4 % mannitol increased the length and biomass of roots and shoots of chickpea seedlings as compared to non-primed controls under salt stressed conditions.Priming of chickpea seeds with mannitol and water improved seedling growth under salt stressed conditions.

Harris *et al*. (2004) reported that increased shoot and root length may be due to early emergence induced by priming treatment as compared to unprimed seeds and osmo-priming boosted plumule dry weight.

Kumar *et al.,* (2017) experimented on chickpea that shoot length has recorded high in case of osmo-primed seeds than that of unprimed seeds. Among different osmo-priming treatments 20% PEG showed the highest shoot length followed by 4% mannitol and control showed the lowest shoot length.

Singh *et al.* (2012 experimented on faba bean and reported that hydropriming and osmo-priming treatments on shoot length provide significant variation. 20% Polyethylene glycol (PEG) for 24 hr (13.14cm) shows better effect on rest of the treatments except at 100 ml distilled water for 12 hr (12.11 cm) and 20% Polyethylene glycol (PEG) for 12 hr (12.77 cm)

Gupta and Singh (2012) conducted a field experiment in inceptisols to find out the effects of seed priming on chickpea. The treatments consisted of seed priming (seed soaking in water for 8 hr). The results revealed that the growth parameters of chickpea were significantly affected by seed priming. Soaking chickpea seeds in water for about 8 hr significantly influenced plant height and nodule dry weight in comparison to un-soaked seeds.

Shehzad *et al.* (2012) conducted an experiment to study the influence of priming techniques on emergence and seedling growth of forage sorghum. Therefore, this study was designed with different seed priming techniques, un-soaked seed (control), Hydro-priming (soaked with distill water), Halo-priming with KNO_3 and $CaCl_2$ (1% solution). Experiment was conducted in wire house under natural climatic conditions during 2008. All the priming treatments significantly affected the fresh weight, shoot length, number of roots, root length, vigour index, and time to start emergence, time to 50% emergence and energy of emergence of forage sorghum. It is concluded that seed priming may serve as an appropriate treatment for accelerating the emergence of sorghum genotypes studied.

Singh *et al.* (2014) conducted an experiment to study the effect of osmo-priming duration on germination, emergence and early growth of cowpea in Nigeria. Treatment consisted three osmo-priming duration (soaking in 1 % KNO_3 salt for 6, 8 and 10 hr) and one hydro-primed control (10 hr). The results showed that osmo-priming with KNO_3 for different durations were superior to unprimed treatment in seed germination, emergence, plant height and dry matter accumulation in cowpea. Primed seed increased performance of cowpea. However, osmo-priming with in 1 % KNO_3 salt solution could result in greater seed germination and seedling height than hydro-priming.

It was stated by Kaur *et al.* (2002, 2005) that osmo and hydro priming of chickpea seeds with mannitol and water lightened the negative effects of water deficiency and salt stress on seedling development. The treatment of seeds with water, 2% and 4 % mannitol improved the length and biomass of roots and shoots of chickpea seedlings as compared to non-primed controls under salt stressed conditions. Similarly, seed priming with P solutions significantly improved fresh and dry weight and plant height of mungbean seedlings 21 days after sowing in the field experiment (Shah *et al.*, 2012).

2.3.2 Vigour index

Farnia and Shafie (2015) stated that the probable reason for the highest vigour index might be due to photosynthetic capacity treated with bio fertilizers increases due to increased supply of nutrition

Safiatou (2012) experimented on seedling vigour and said that seedling vigour increased by using seed priming methods in sorghum and Bambara groundnut. Also, highest seedling vigour was achieved by osmo-priming (Mannitol priming) in Bambara groundnut and by hydro-priming in sorghum.

Harris *et al.* (1999) confirmed that on-farm seeds soaking overnight in water noticeably improved establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. Also, vigorous growth is often connected with higher yields.

Hanen *et al.* (2012) conducted an experiment to study the effect of 100 μM salicylic acid (SA) priming on *Hedysarum coronarium* and *Hedysarum carnosum* subjected to 200 mM of NaCl at germination and seedling growth stages was analyzed. SA priming had a beneficial effect on germination, since the dry biomass of cotyledons was unchanged by salt stress and SA priming. The results showed that SA priming at the seedling growth stage alleviated salt-induced oxidative stress by reducing malondialdehyde and H_2O_2 content. In addition, the two species demonstrated differential H_2O_2 detoxification with the stimulation of catalase activity in both species, but guaiacol peroxidase stimulation was found to only occur in *H. coronarium*. Surprisingly, *H. coronarium* seedlings proved to be more tolerant to NaCl stress than *H. carnosum* seedlings. SA priming reinforced the salt tolerance of *H. coronarium* at germination and seedling growth stages.

Ruiz *et al*. (2015) conducted a study to characterize the effects of salinity on tomato fruit skin texture. Tomato plants were irrigated with fresh water (control, ED=1.01 dSm−1) and saline water (up to 12.61 dSm−1). Results showed that saline water improves fruit taste and reduces yields. Salinity additionally leads to toughening of tomato fruit skin, though the causative mechanism for which is unknown. The tougher tomato skin obtained under salinity conditions is attributed to increased hypodermal cell layers rather than to changes in cell wall composition. Results stated that due to salinity strengthening tomato skin and increasing of its thickness happens, which results in increasing firmness and shelf life of tomato fruits under salt stress.

Shalaby *et al.* (2015) conducted a Field experiment to investigate growth parameters and fruit yield of tomato response to salt stress at irrigation water levels during different growth stages under drip and gated-pipe irrigation systems in arid environmental conditions. Each irrigation system is comprised 9 irrigation treatments combined between salt stress using well water of 9.15 dSm-1 and irrigation water levels of 100, 75, and 50 % from crop evapotranspiration subjected during development, flowering and harvesting stages as control treatment. The results showed that the plant height, dry weight, leaf water potential and fruit yield of tomato plants at the harvesting stage were subjected to studied salt stress.

Jogendra *et al.* (2011) studied ten genetically diverse genotypes along with their 45F_1 (generated by di-allel mating) under normal and salt stress conditions and reported that germination rate, speed of germination, dry weight ratio and Na^+/K^+ ratio in root and shoot, were the parameters assayed on three salinity levels; control, 1.0 % NaCl and 3.0 % NaCl with Hoagland's solution. Salt stress negatively affected growth and development of tomato. Germination of tomato seed was reduced, root/shoot dry weight ratio was higher and Na^+ content increased but K^+ content decreased under higher saline level. Result showed that plants which were tolerant at seedling stage also show improved salinity tolerance at adult stage.

Humayun *et al.* (2010) conducted an experiment to evaluate the adverse effects of NaCl induced salt stress on growth attributes and endogenous levels of gibberellins (GA), abscisic acid (ABA), jasmonic acid (JA) and salicylic acid (SA) soybean cv. Hwangkeumkong by He reported that 70 mM and 140 mM concentrations of NaCl decreased 1000 seed weight and yield significantly.

Farzin *et al* (2012) estimated the effect of priming on seed germination and seedling growth of canola (cv OKP) under salinity conditions, laboratory experiment was performed as a factorial experiment basis of a completely randomized design with four replications. Experimental factors were included 3 priming treatment (NaCl 1%, KNO_3 3% and non-priming as control) and five salinity solution using 2:1 molar ratio of NaCl and $CaCl_2$ included 0, 50, 100, 150 and 200 mM (EC equal to 0, 3.1, 7.9, 12.3 and 19.4 dSm-1, respectively). Seed priming increased final germination percentage (FGP), germination index (GI) and seedling fresh and dry weight (SFW and SDW) over the non-primed treatment. Although KNO_3 3% and NaCl 1% had the similar effect on these traits, but seed priming with KNO_3 resulted maximum FGP (68%), GI (41.3), SFW (18.6 mg) and SDW (3.5 mg). At the lowest levels of salinity, there were no notable differences between primed and nonprime seeds for the FGP and GI, but with increasing salinity levels, primed seeds showed the better performance than non-primed seeds. Priming of the canola seeds significantly improved root length and radicle to primary shoot ratio (R/S ratio) in salinity conditions when compared to control. The study also showed that salt stress inhibits shoot growth more than root growth. This inhibitory effect increased R/S ratio. In saline conditions KNO_3 3% increased R/S ratio more than NaCl 1%. This may in turn have the advantage of increased ratio of water up take by seedlings, which is useful for saline conditions. The results indicated that priming treatments significantly improved seed performance under salinity conditions.

2.3.3 Root length

Kulkarni and Eshanna (1988) said that seed treated prior at sowing with 10 ppm IAA increased root length, germination percentage and seedling vigour.

Kumar *et al.* (2017) conducted an experiment on effect of osmo-priming on seed germination behavior and vigour of chickpea (*Cicer arietinum*) and found that 20% PEG and 4% mannitol produce maximum (22.07 cm) root length. Smallest root length was recorded by (15.38cm) with control. Laghari *et al.* (2016) also stated that maximum mean root length cm (5.324) was recorded at Hydro-priming period 4 hours whereas the lower (3.093) found at no priming or check in case of mungbean.

Singh *et al.* (2017) reported that a significant effect of different hydropriming and osmo-priming on root length of pea. 20% polyethylene glycol for 24 hr (14.11 cm) priming showed better performance over untreated (11.98 cm), 3% mannitol for 12 hr (12.37 cm), 3% mannitol for 24 hr (12.67 cm) and 5% glycerol for 12 hr (12.99 cm) priming. Ashraf and Rauf (2001) found that GA_3 treatment enhanced the vegetative growth of two wheat cultivars. It enhanced the deposition of Na^+ and Cl^- in both root and shoots of wheat plant. It also caused a significant increase in photosynthetic at the vegetative stage.

Farahbakhsh (2012) reported that the concentration of 0.25 and 0.5 mM of salicylic acid on germination, germination rate, seed stamina index, hypocotyl length, radical length, seedling fresh and dry weight of fennel (*Foeniculum vulgare*) was more effective as compared to other levels (0 and 0.75 mM). Therefore, seed priming with salicylic acid could be a suitable tool for improving germination characteristics of fennel.

Sarika *et al.* (2013) conducted a lab experiment to study various physiological and biochemical changes by priming in French bean at Bangalore. They reported that chemo priming with GA_3 and Ethrel improved the seed quality and showed improved seedling length, seedling dry weight which in turn improved higher seedling vigour index, germination speed and mean germination time. Significant increase in initial (6.02 cm) and final (11.5 cm) root length, initial and final shoot length, seedling vigour index and dry seedling weight with GA_3 is observed in the crop.

Zhou *et al*. (2002) conducted an experiment where seed soaked with chitosan increased the energy of germination, germination percentage, lipase activity, GA_3 and indole acetic acid (IAA) levels in peanut. The results showed that the chitosan priming increased the chilling tolerance of seedlings demonstrated by improving germination speed and shoot and root growth.The 0.50% chitosan seems to be a suitable concentration for seed priming it significantly increased seedling growth, root dry weight and root length as compared to control.

2.3.4 Seedling dry weight

Increase of the synthesis of the hormone gibberellin, which Trigg the activity of α-amylase and other germination specific enzymes like protease and nuclease involved in hydrolysis and assimilation of the starch (Gholami *et al.,* 2009) enhance dry weight of the shoot and dry weight.

Harris *et al.* (2004) reported that higher plant dry weight and seed yield following seed priming. The increase in the dry weight and grain yield of mungbean was due to better emergence and better performance per plant (Parera and Cantliffe, 1994).

Kumar *et al.* (2017) experimented on chickpea and found that in case of seedling dry weight it was higher (1.02 mg to 1.59 mg) in PEG 20% seeds followed by mannitol 4% when compared with control.

Laghari *et al.* (2016) found that, shoot dry weight (g) has affected by temperature regimes, hydro-priming periods showed highly significant where as their interaction was significant for shoot dry weight (mg). The maximum mean shoots dry weight mg (54.74) was recorded at hydro-priming period 4 hours whereas the lower shoot dry weight mg (38.56) found at no priming or check. The maximum mean root dry weight mg (7.898) was observed at hydropriming period 4 hours whereas the lower root dry weight mg (5.496) found at no priming or check.

At Varanasi, Srivastava and Bose (2012) conducted an experiment on seed priming of rice varieties with or without nitrate salts (Mg(NO_3) and KNO_3). Results showed the beneficial effect of priming treatments which was clearly exhibited in plant height, leaf area and number of leaf and yield attribute characteristics i.e. fertile tillers, panicle and grain quality, with nitrate treated varieties. Seed priming treatment resulted in increased crop growth rate in treated sets which encouraged deposition of more photo-assimilates in key plant parts, greatly affecting the dry weight and final yield.

Singh *et al.* (2016) cited on different hydropriming and osmo-priming treatments on dry weight. Polyethylene glycol (PEG) @ 20% for 24 hr (0.54) shows significant effect on Untreated (0.40), Menitol @ 3% for 12 hr (0.44), Menitol @ 3% for 24 hr (0.43), Glycerol @ 5% for 12 hr (0.46) and Glycerol @ 5% for 24 hr (0.48) on dry weight parameters.

2.4 Effect of hydropriming against salt stress

Janmohammadi *et al.* (2008) reported that poor seed germination and crop stand are major problems in saline areas. However, seed vigour enhancement treatments might be able to alleviate the negative effects of salinity. Hydropriming significantly improved germination and seedling growth presented as final germination percentage, germination index, seedling vigour index and length of seedling under both stress and non-stress conditions. Hydropriming could alleviate the effects of salinity stress on germination and seedling early growth. This study indicated that hydropriming could be suitable seed invigoration treatment under saline and drought-prone environments.

Kaur *et al.* (2002) shown that hydropriming of seeds have many advantages as compared to non-primed seeds. Hydropriming has resulted in 3 to 4-fold increases in root and shoot length in comparison with seedlings obtained from non-primed seeds in drought condition.

Harris *et al.* (1999) also found that hydropriming enhanced seedling establishment and early vigour of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields.

Mwale *et al.* (2003) reported early germination of primed seeds but not recorded any improvement in the growth of seedlings in muskmelon seeds under laboratory conditions.Confounding results, where priming did not show any beneficial results, also reported by different research workers.

Ghassemi-Golezani *et al*. (2008a) conducted Laboratory tests to evaluate the effects of hydro and osmo - priming (PEG: Polyethylene glycol 6000 at -0.8MPa) on seed germination and field emergence of lentil. Analysis of variance for laboratory data showed that hydropriming significantly improved germination rate and root weights, compared to other seed treatments. However germination percentage for seeds primed with water and PEG were statistically similar, but higher than those for unprimed seeds. Over all, hydropriming treatment was comparatively superior in laboratory tests. Invigoration of lentil seeds by hydropriming resulted in higher seedling emergence in the field, compared to control and seed priming with PEG. Seedling emergence rate was also enhanced by priming seed with water. Thus,hydropriming could be used as a simple method for improving seed germination and seedling emergence of lentil in the field.

Ghassemi-Golezani *et al.* (2008b) mentioned that early emergence and stand establishment of lentil (*Lens culinaris* Medik) are considered to be the most important yield contributing factors in rainfed areas. Analysis of variance of laboratory data showed that hydropriming significantly improved imbibition rate, germination rate, seed vigor index, shoot, root and seedling dry weights and reduced electrical conductivity of seed leachates, compared to other seed treatments. However, germination percentage for seeds primed with KNO_3, water and PEG were statistically similar, but higher than those for unprimed and NaCl priming. Overall, hydropriming treatment was comparatively superior in the laboratory tests. Invigoration of lentil seeds by hydropriming and NaCl priming resulted in higher seedling emergence and establishment in the field, compared to control and seed priming with KNO_3 and PEG. Seedling emergence rate was also enhanced by priming seeds with water, NaCl and KNO_3 . It was, therefore, concluded that hydropriming is a simple, low cost and environmentally friendly technique for improving seed and seedling vigor of lentil.

Yağmur and Kaydan (2008) conducted an experiment to find out the effects of seed priming treatments with 0.5% KH_2PO_4 (w/v) solution and water on germination and seedling characters of hexaploid triticale in different osmotic potential of NaCl and PEG solutions. Germination percentage and seedling growth and also relative water content (RWC) decreased with the decrease in osmotic potential of PEG 6000 and NaCl. But root-to-shoot length ratios increased with the effects of osmotic stress of PEG 6000 and NaCl. Despite the negative effects of two stress conditions, the two priming treatments were effective in improving germination percentage and seedling growth in Presto. But seed primed treatment was effective at the lowest osmotic potentials; therefore, seedling growth survived at the highest concentrations. Consequently, the effect of hydropriming is very pronounced particularly in improving germination and seedling growth in low stress.

Lee *et al*. (1998) mentioned that germination and emergence rates, plumule height, and radicle length of primed seeds were higher than those of untreated seeds at any soil moisture and temperature examined. The time from planting to 50% germination of primed seeds was less than that of untreated seeds by 0.9～3.7 days. Germination rate, emergence rate, plumule height, and radicle length were highest at the soil moisture of 80% field capacity among the soil moistures. Priming effects of rice seeds on germination and emergence rates were more prominent under the unfavorable soil moistures (60, 100, 120, and 140% field capacity) than those under the optimum soil moisture condition (80% field capacity). However, priming effects on seedling growth were greater at near optimum soil moisture compared with too lower or higher soil moistures. Therefore, these findings suggest that priming of rice seeds may be a useful way for better seedling establishment under the adverse soil conditions.

2.5 Effect of Ascorbic acid priming against salt stress

Zhou *et al*. (2009) stated that ascorbic acid is an important vitamin is also used for priming due to its antioxidant nature. It has already been proved that a high level of endogenous acrobat is essential to maintain the antioxidant capacity that protects plants from oxidative stress. Ascorbic acid pretreatment results in improved germination properties of under salt stress condition.

Mohamed *et al* (2013) reported that eed priming with vitamins is an efficient method for increasing seedlings growth and productivity under stressful conditions and aimed to investigate the priming of broad bean (*Vicia faba* L.) seeds using 100 mg L-1 ascorbic acid and nicotinamide and to study their interactions on growth and some physiological parameters of plant under salt stress (150 mM NaCl) for 4 weeks. Salinity treatment significantly reduced growth parameters, water status, photosynthetic pigments, soluble proteins, K^+, and Mg^{+2} ions contents. However, application of the two vitamins individually or in interaction increased the photosynthetic pigments, soluble carbohydrates and proteins, proline and free amino acids content, while transpiration and ion leakage were decreased. In addition, K^+/Na^+ ratio was increased, whereas Na^+, Cl^- and Na^+/K^+ratio were decreased. Application of vitamins induced the synthesis of additional protein bands with molecular weights of 28 and 17 KDa such as those appeared after treatment with vitamins C; and 56, 40 and 28 KDa under vitamin PP treatment. Moreover, three protein bands which disappeared under salinity stress were reappeared in response to vitamin treatments. The stimulatory effects of vitamin PP on the growth and other related metabolic activities were greater than that of vitamin C. However, these stimulatory effects were higher when they were applied in combination. The above results pave the way to gain the insight into the potential role of these vitamins to improve the salt tolerance of broad bean plant.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2017 to March 2018 to study the salt stress mitigation in faba bean by seed priming. This chapter deals with the materials and methods that were used in execution of the experiment.

3.1 Experimental site

This experiment was carried out in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The location of the experimental site is 23°74′N latitude and 90°35′E longitude at an altitude of 8.6 meter above the sea level.

3.2 Characteristics of soil that used in pot

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28. The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil science Department, SAU, Dhaka and details of soil characteristics have been presented in Appendix I. The soil of the pot remained fallow during the previous season. The soil texture of the experiment was sandy loam.

3.3 Climatic condition of the experimental site

The experimental field was under subtropical climate characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The monthly means of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours received at the experimental site during the cropping season November 2017 to March 2018 have been presented in Appendix II.

3.4 Planting materials

Diseased free, healthy faba bean variety was collected from Bangladesh Agricultural Research Institute (BARI) which were used for this experiment.

3.5 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Different type of seed priming , viz.

P_1: Non Primed

P_2: Hydroprimed

P_3: Ascorbic acid Priming (100 mg/L)

Factor B: Different level of saline in soil with NaCl solution such as,

S_1: Control (0 mM NaCl),

S_2: 40 mM NaCl,

S_3: 80 mM NaCl,

S_4: 120 mM NaCl

There are 12 treatment combinations such as P_1S_1, P_1S_2, P_1S_3, P_1S_4, P_2S_1, P_2S_2, P_2S_3, P_2S_4, P_3S_1, P_3S_2, P_3S_3 and P_3S_4

3.6 Experimental design and layout

The two factor experiment was laid out in Completely Randomized Design (CRD) with three replications. There were 36 pot all together. The total area was 12 m × 3 m. The experimental area was divided into 3 equal blocks.

3.7 Pot preparation

A ratio of 1:3 well rotten cow dung and soil were mixed. 36 pots were filled 20 days before seed sowing . Those pots were filled on 15 November 2017. Weeds and stubbles were completely removed from the soil and brought into desirable fine tilth by hand mixing. The soil was treated with insecticides. Sevin was applied as precautionary measure against ants and worm around the seedbed.

3.8 Application of the treatments

3.8.1 Surface treatment of seeds

Seeds were treated with 75% alcohol for 5 minutes then were rinsed 2 minutes with distilled water for 3 times to reduce the effect of alcohol from the seed surface. At last seeds were dried in room temperature to regain the normal condition.

3.8.2 Preparation of priming solutions

a) Distilled water

Distilled water was collected from the Soil Science laboratory of Sher-e-Bangla Agricultural University (SAU).

b) Ascorbic acid 20 mg/L and 200 ml distilled water were used to make a solution as priming agents. Ascorbic acid was collected from Biochamestry laboratory of Sher-e-Bangla Agricultural University (SAU).

3.8.3 Priming technique

Two priming techniques viz., osmopriming and hydropriming were applied on the faba bean varieties.The surface sterilized seeds were sub-sampled into three parts. One of the sub-samples was considered as control (unprimed) and the other two sub-samples were primed with priming chemicals. For hydropriming seeds of a sub-sample were soaked in distilled water for 16 hours and for osmopriming seeds were pretreated with ascorbic acid solution for 10 hours. Priming was done in different plastic containers covered with lids to prevent evaporation loss. All seeds were removed from the priming solution at the same time. The primed seeds were rinsed thoroughly with distilled water for three times and dried lightly using blotting paper and finally air dried near to original weight (Umair *et al.*, 2010) in room temperature for 24 hours back to the original moisture level.

3.8.4 Preparation of irrgation water

3.8.4.1 Treatments

This experiment was comprises of hydropriming and osmopriming with three salt stress levels (40 mM, 80 mM and 120 mM). Salt stress was simulated by highly osmotic substance NaCl (molecular weight (MW) 58.5 g/L) supplied through irrigation water.

3.8.4.2 Preparation of stress solutions

Salt (NaCl) solutions (40mM, 80 mM and 120 mM)

23.4 g of sodium chloride was dissolved in 10 L of water to prepare 40 mM salt (NaCl) solution. Similarly, 46.8 g, 70.2 g sodium chloride was dissolved in 10 L of water to prepare 80 mM and 120 mM salt solution respectively.

3.8.5 Irrigation

3.8.5.1 Application of salt with irrigation water

Light watering was provided with water cane immediately after sowing the seedlings and this technique of irrigation was at early morning and sometimes also in evening throughout the growing period when necessaries . But the frequency of irrigation became less in harvesting stage. The amount of irrigation water was limited up to that quantity which does not leached out through the bottom. The salinity status was maintained in the desired level.

3.9 Raising the seedling

Faba bean Seedlings were raised in pot .The pot soil was well prepared and made into loose friable and dried mass to obtain fine tilth. The seeds were sown in pot at 5 December, 2017. Four seeds were sown in each pot. After sowing, seeds were covered with light soil to a depth of about 1cm. Seedlings emergence was visible within 8 to 9 days after sowing . Weeding, mulching and irrigation were provided when necessary and required.

3.10 Uprooting extra seedlings

In 5 January, 2018 keeping healthy and uniform seedlings, extra seedlings were uprooted separately from the pot and each pot containing only one seedling. The pot was irrigated before uprooting from the seedbed, which helps to minimize damage to main plant roots.

3.11 Intercultural operations:

After raising seedlings, various intercultural operations such as weeding, earthing-up, irrigation, pest and disease control etc. were accomplished for better growth and development of the faba bean seedlings.

3.11.1 Staking

When the plants were well established, staking was given to each plant by bamboo sticks. This is done to give support to keep the plant erect.

311.2 Weeding

Weeding was done whenever it was necessary, mostly in vegetative stage.

3.11.3 Earthing-up

Earthing up was done at 25 and 45 days after sowing by taking the soil from the boundary side of pots by hand at the basement of plant.

3.11.4 Plant protection measures

Spraying Dithane M-45 fortnightly @ 2 gm per L of water at the early vegetative stage was done as precautionary measure against disease attack of faba bean during foggy weather .Ridomil gold was also applied @ 2 gm per L of water against blight disease of faba bean.

3.11.5 Harvesting

Pods were harvested when it is near to mature and feel smooth skin. Harvesting was started from 7 March and was continued up to last week of March 2018.

3.12. Data recording

Experimental data were recorded from 30 days after sowing and continued until harvest. The following data were recorded during the experimental period.

- **Morphological characters**

  01. Plant height (at different days after sowing)
  02. Number branches per plant (at different days after sowing)
  03. Number of leaf per plant (at different days after sowing)
  04. Number of leaflet per plant (at different days after sowing)
  05. Leaf length (cm)
  06. Leaf breadth (cm)
  07. Leaflet length (cm)
  08. Leaflet breadth (cm)
  09. Root length (cm)

- **Physiological and Yield contributing characters**

  10. No. of inflorescence per plant
  11. No. of flowers per inflorescence
  12. Total number of flower per plant

- **Yield related characters**

  13. No. of pods per plant
  14. Length of pod
  15. Breadth of pod
  16. Weight of individual pod
  17. Total Pod Weight per plant (g)

Detailed Procedures of Data Recording

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

3.12.1 Plant height

Plant height was measured at 30, 45 DAS and at harvest. The height of the plant was determined in centimeter by measuring the distance from the soil surface to the tip of the highest leaf.

3.12.2 Number of branches per plant

The total number of branches per plant was counted from each plant at 30, 45 DAS at harvest. There is no option to make average value from collected value due to only one plant was maintained per pot.

3.12.3 Number of leaves per plant

Leaf number was counted at 30, 45 DAS and at harvest. The number of leaves per plant was counted from each plant.

3.12.4 Number of leaflet per plant

Leaflet number was counted at 30, 45 and DAS at harvest. The number of leaflet per plant was counted from each plant.

3.12.5 Leaf length

Leaf length was measured by a scale from the apex of the main leaflet to the collar of the branch. The length of leaves were measured from each plant and their average was taken and expressed in cm.

3.12.6 Leaf breadth

Leaf breadth was measured by distance between the apex of the side leaflet with a scale. The breadth of leaves were measured from each plant and their average was taken and expressed in cm.

3.12.7 Leaflet length

Leaflet length was measured by a scale from the apex of the main leaflet to the pedicel. The length of leaflets were measured from each plant and their average was taken and expressed in cm.

3.12.8 Leaflet breadth

Leaflet breadth was measured at middle portion of the leaflet. The breadth of leaflets were measured from each plant and their average was taken and expressed in cm.

3.12.9 Root length

Individual root length were measued from each plant and expressed in (cm) after plant harvest.

3.12.10 Number of inflorescence per plant

The number of produced inflorescence per plant was counted and recorded in each plant.

3.12.11 Number of flowers per inflorescence

The number of flowers per inflorescence was counted and recorded.

3.12.12 Total number of flower per plant

Total number of flower per plant was counted and recorded in each plant.

3.12.13 Length of pod

The length of pods were measured with a scale from each plant and their average was taken and expressed in cm.

3.12.14 Breadth of pod

Breadth of pods were measured at middle portion of pods from each plant with a slide calipers. Their average was taken and expressed in cm.

3.12.15 Weight of individual pod

Individual pod weight was recorded from the plant. Their average was taken and expressed in (g).

3.12.16 Total number pod per plant

Total pod number of faba bean per plant was calculated from the whole plant.

3.12.17 Total pod weight per plant

Total pod weight of faba bean per plant was calculated from the whole pods per plant and was expressed in gram (g).

3.13 Statistical analysis

The data obtained from different parameters were statistically analyzed following the analysis of variance (ANOVA) technique by using SPSS computer package program. The significance of the difference among the treatment combinations of means was estimated by DMRT method.

Plate 1. Ascorbic acid 20 mg for priming

Plate 2. Preparation of priming solution

Plate 3. Seed view after Ascorbic acid priming

Plate 4. Seed view after Hydropriming

CHAPTER IV

RESULTS AND DISCUSSION

This experiment was aimed to study the salt stress mitigation in faba bean with primed seed (hydro primed and osmoprimed seed). Growth and yield contributing characters of faba bean greatly influenced by priming in salt stress condition. Different characters of faba bean were analyzed and the analysis of variance (ANOVA) is given in the appendices. The results of the study were presented in both tables and figures; and discussed below:

4.1 Plant height:

Naturally plant height increased with the increasing age, but due to salinity decreased gradually in faba bean.Table 1shows that plant height of faba bean was reduced significantly at different DAS with the increase of salinity. Plant height of faba bean varied significantly for different levels of salt stress at 30, 45 DAS and at harvest. Table1 revealed that, at 30, 45 and at harvest (Appendix III-V), the height of faba bean plant was recorded highest (26.55, 43.22 and 47.81 cm) from S_1, followed by S_2 (26.33, 41.11 and 44.63 cm) and S_3 (19.33, 34.44 and 36.53 cm) respectively. The lowest value (14.88, 27.88 and 28.94 cm) was observed from S_4 at 30, 45 and at harvest respectively. Shalaby *et al.* (2015) have reported the same i.e morphological traits like plant height reduced due to increasing salinity. Jamal *et al.* (2014) and Siddiky *et al.* (2012) concluded that increased salinity decrease plant hight of tomato.

Hydropriming and ascorbic acid priming as mitigation agent had significant effect on height of faba bean plant at 30, 45 and at harvest (Appendix III-V). Table 2 revealed that, at 30, 45 and at harvest, the height of faba bean plant was recorded highest (23.41, 38.16 and 41.65 cm) from P_3, followed by P_2(22.5 , 38.08 and 40.83 cm) and P_1 (19.41, 33.75 and 35.95 cm) respectively. The lowest value was observed from P_1 at 30, 45 and at harvest respectively.

Combined effect of salinity and mitigation agent showed different significant variation on height of faba plant at 30, 45 and at harvest (Appendix III-V).

From table 3, it showed that highest result was recorded from P_2S_1 (28.00, 45.33 and 49.66 cm) at 30, 45 DAS and at harvest respectively. Whereas the lowest value was observed from P_1S_4 (13.66, 24.33 and 25.33 cm) at 30, 45 DAS and at harvest respectively.

Table 1. Effect of salinity levels on plant height of faba bean at different days after sowing

Treatment	Plant height (cm) at		
	30 DAS	45 DAS	At Harvest
S_1	26.55 a	43.22 a	47.81 a
S_2	26.33 a	41.11 a	44.63 b
S_3	19.33 b	34.44 b	36.53 c
S_4	14.88 c	27.88 c	28.94 d
Standard Error	0.90	1.10	1.33
Significance level	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 2. Effect of seed priming on plant hight of faba bean at different DAS

Treatment	Plant height (cm) at		
	30 DAS	45 DAS	At Harvest
P_1	19.41 a	33.75 a	35.95 a
P_2	22.50 a	38.08 a	40.83 a
P_3	23.41 a	38.16 a	41.65 a
Standard Error	0.900	1.108	1.339
Significance level	0.16	0.17	0.17

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , P_2: Hydroprimed , P_3: Ascorbic acid 100 mg/L Priming

Table 3. Combined effect of salinity and different type of priming as mitigation agent on plant height of faba bean at different days after sowing

Treatment combination	Plant height (cm) at		
	30 DAS	45 DAS	At Harvest
P_1S_1	24.33 b	40.33 cd	43.93 bc
P_1S_2	23.66 bc	39.00 de	41.66 cd
P_1S_3	16.00 e	31.33 g	32.86 f
P_1S_4	13.66 f	24.33 h	25.33 g
P_2S_1	28.00 a	45.33 a	49.66 a
P_2S_2	28.00 a	43.00 abc	46.66 a
P_2S_3	19.66 d	35.00 f	37.33 e
P_2S_4	14.33 f	29.00 g	29.66 f
P_3S_1	27.33 a	44.00 ab	49.83 a
P_3S_2	27.33 a	41.33 bcd	45.56 b
P_3S_3	22.33 c	37.00 ef	39.40 de
P_3S_4	16.66 e	30.33 g	31.83 f
Standard Error	0.900	1.108	1.339
Significance level	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3:** Ascorbic acid 100 mg/L Priming

S_4: 120 mM NaCl

4.2. Number of branches per plant

Number of branches of faba bean varied significantly for different levels of salt stress at 30, 45 DAS and at harvest (Appendix VI-VIII). Table 4. revealed that, the total number of branches of faba bean plant was recorded highest (1.55, 3.55 and 4.00) from S_1 as control at 30, 45 DAS and at harvest respectively; followed by S_2 (1.55 , 3.5 and 3.88) and S_3 (1.44 , 3.22 and 3.44) respectively. On the contrary, the lowest value was observed from S_4 (1.11 , 2.55 and 2.55) at 30, 45 DAS and at harvest respectively.

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on number of branch in faba bean plant at 30, 45 DAS and at harvest (Appendix VI-VIII). Table.5 revealed that, at 30, 45 DAS and at harvest, the height of faba bean plant was recorded highest (1.75 , 3.33 and 3.83) from P_3, followed by P_2(1.41, 3.41 and 3.58) and P1(1.08, 2.50 and 3.00) respectively. The lowest value was observed from P_1 at 30, 45 DAS and at harvest respectively.

Combined effect of salinity and mitigation agent showed different significant variation on total number of branches of faba bean plant at 30, 45 and at harvest (Appendix VI-VIII). Table 6 showed that highest result was recorded from P_3S_1 (2.00, 3.00 and 4.33) 30, 45 DAS and at harvest respectively. Where as the lowest value was observed from P_1S_4 (1.00, 2.00 and 2.00) at 30, 45 DAS and at harvest respectively.

Table 4. Effect of salinity levels on number of branches of faba bean at different DAS

Treatment	Number of Branch		
	30 DAS	45 DAS	At Harvest
S_1	1.55 a	3.55 a	4.00 a
S_2	1.55 a	3.35 ab	3.88 ab
S_3	1.44 a	3.22 ab	3.44 b
S_4	1.11 a	2.55 b	2.55 c
Standard Error	0.083	0.128	0.12901
Significance level	0.190	0.038	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 5. Effect of seed priming on number of branch of faba bean at different DAS

Treatment	Number of Branch		
	30 DAS	45 DAS	At Harvest
P_1	1.08 b	2.50 b	3.00 b
P_2	1.41 ab	3.41 a	3.58 ab
P_3	1.75 a	3.33 a	3.83 a
Standard Error	0.083	0.128	0.129
Significance level	0.002	0.003	0.021

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , P_2: Hydroprimed , P_3: Ascorbic acid 100 mg/L Priming

Table 6. Combined effect of salinity and different type of priming as mitigation agent on number of branch at different days after sowing (DAS)

Treatment combination	Number of branch		
	30 DAS	45 DAS	At Harvest
P_1S_1	1.00 c	2.66 cd	3.66 abc
P_1S_2	1.00 c	3.00 bcd	3.33 bcd
P_1S_3	1.33 bc	2.33 cd	3.00 cd
P_1S_4	1.00 c	2.00 d	2.00 e
P_2S_1	1.66 ab	3.33 bc	4.00 ab
P_2S_2	2.00 a	4.33 a	4.33 a
P_2S_3	1.00 c	3.33 bc	3.33 bcd
P_2S_4	1.00 c	2.66 cd	2.66 de
P_3S_1	2.00 a	3.00 bcd	4.33 a
P_3S_2	1.66 ab	3.33 bc	4.00 ab
P_3S_3	2.00 a	4.00 ab	4.00 ab
P_3S_4	1.33 bc	3.00 bcd	3.00 cd
Standard Error	0.083	0.128	0.129
Significance level	0.00	0.01	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100 mg/L Priming

S_4: 120 mM NaCl

4.3 **Number of leaves per plant**

The total number of leaves per faba bean plant varied significantly for different levels of salt stress at 30, 45 and at harvest (Appendix IX-XI). Table 7. Revealed that, the total number of leaves per faba bean plant was recorded highest (4.88 , 8.33 and 10.11) from S_1 as control at 30, 45 DAS and at harvest respectively; followed by (4.88 , 8.11 and 9.33) and S_2 (4.88 , 8.11 and 9.33) respectively. On the contrary, the lowest value was observed from S_4 (3.11 , 6.55 and 6.88) at 30, 45 DAS and at harvest respectively. Similar result was found from Jogendra *et al.*, (2011), Ahmet *et al.*, (2009) and Sixto *et al.* (2005).

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on number of leaves in faba bean plant at 30, 45 DAS and at harvest (Appendix IX-XI). Table 8. Revealed that, at 30, 45 DAS and at harvest, the height of faba bean plant was recorded highest (5.25, 7.75 and 9.33) from P_3, followed by P_2 (4.16, 7.58 and 8.75) and P_1(3.66, 7.08 and 8.00) respectively. The lowest value was observed from P_1 at 30, 45 and at harvest respectively.Similar result was found from Mohsen Kazemi *et al.* (2014). Eman *et al.* (2018) states the same.

Combined effect of salinity and mitigation agent showed different significant variation on total number of branches of faba bean plant 30, 45 DAS and at harvest (Appendix IX-XI). Table 9 showed that highest result was recorded from P_3S_1 (5.33, 7.33 and 10.66) 30, 45 and at harvest respectively. Where as the lowest value was observed from P_1S_4 (2.00, 6.00 and 6.00) 30, 45 and at harvest respectively.

Table 7. Effect of salinity levels on number of leaves of faba bean at different DAS

Treatment	Number of Leaf		
	30 DAS	45 DAS	At Harvest
S_1	4.88 a	8.33 b	10.11 a
S_2	4.88 a	8.11 a	9.33 b
S_3	4.55 a	7.88 ab	8.44 c
S_4	3.11 b	6.55 c	6.88 d
Standard Error	0.199	0.146	0.235
Significance level	0.001	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 8. Effect of seed priming on number of leaf of faba bean at different DAS

Treatment	Number of Leaf at		
	30 DAS	45 DAS	At Harvest
P_1	3.66 b	7.08 a	8.00 b
P_2	4.16 b	7.58 a	8.75 ab
P_3	5.25 a	7.75 a	9.33 a
Standard Error	.199	0.146	0.235
Significance level	0.002	0.154	0.063

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table 9 Combined effect of salinity and different type of priming as mitigation agent on number of leaf of faba bean at different days after sowing(DAS)

Treatment combination	Number of Leaf		
	30 DAS	45 DAS	At Harvest
P_1S_1	4.66 bcd	7.33 abc	9.33 bc
P_1S_2	4.33 bcd	8.00 ab	8.66 cd
P_1S_3	3.66 d	7.00 bc	8.00 d
P_1S_4	2.00 e	6.00 d	6.00 e
P_2S_1	4.66 bcd	7.33 abc	10.33 a
P_2S_2	5.33 ab	8.33 a	9.33 bc
P_2S_3	4.00 cd	8.33 a	8.66 cd
P_2S_4	2.66 e	6.33 cd	6.66 e
P_3S_1	5.33 ab	7.33 abc	10.66 a
P_3S_2	5.00 abc	8.00 ab	10.00 ab
P_3S_3	6.00 a	8.33 a	8.66 cd
P_3S_4	4.66 bcd	7.33 abc	8.00 d
Standard Error	0.199	0.146	0.235
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100 mg/L Priming

S_4: 120 mM NaCl

Number of leaflet per plant

The total number of leaflet per faba bean plant varied significantly for different levels of salt stress at 30, 45 DAS and at harvest (Appendix XII-XIV).Table. 10 revealed that, the total number of leaflet per faba bean plant was recorded highest (15.11 , 23.88 and 30.11) from S_1 as control at 30, 45 DAS and at harvest respectively; followed by (15.33 , 25.55 and 28.44) and S_2 (14.11 , 24.33 and 25.33) respectively. On the contrary, the lowest value was observed from S_4 (9.88 , 20.22 and 21.22) at 30, 45 DAS and at harvest respectively.

Hydropriming and ascorbic acid priming as mitigation agent had significant effect on number of leaflet in faba bean plant at 30, 45 DAS and at harvest (Appendix XII-XIV).Table 11 revealed that, at 30, 45 and at harvest, the height of faba bean plant was recorded highest (16.00 , 16.00 and 28.25) from P_3, followed by P_2 (13.08 , 13.08 and 26.58) and P_1 (11.75 , 11.75 and 24.00) respectively. The lowest value was observed from P_1 at 30, 45 and at harvest respectively.

Combined effect of salinity and mitigation agent showed different significant variation on total number of leaflet of faba bean plant at 30, 45 and at harvest (Appendix XII-XIV). Table 12 showed that highest result was recorded from P_3S_3 (18.33) followed by P_2S_2 (16.00) at 30 DAS respectively.At 45 DAS highest value from P_2S_2 followed by P_3S_3 and highest value from P_3S_1 (32.00) followed by P_3S_2 (30.66) . Where as the lowest value was observed from P_1S_4 (6.33, 17.66 and 18.33) at 30, 45 and at harvest respectively.

Table 10. Effect of salinity levels on number of leaflet of faba bean at different DAS

Treatment	Number of leaflet		
	30 DAS	45 DAS	At Harvest
S_1	15.11a	23.88 a	30.11 a
S_2	15.33 a	25.55 a	28.44 a
S_3	14.11 a	24.33 a	25.33 b
S_4	9.88 b	20.22 b	21.22 c
Standard Error	0.551	0.488	0.695
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 11. Effect of seed priming on number of leaflet of faba bean at different DAS

Treatment	Number of Leaflet at		
	30 DAS	45 DAS	At Harvest
P_1	11.75 b	11.75 a	24.00 b
P_2	13.08 b	13.08 a	26.58 ab
P_3	16.00 a	16.00 a	28.25 a
Standard Error	0.551	0.488	0.695
Significance level	0.003	0.155	0.037

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table No:12 Combined effect of salinity and different type of priming as mitigation agent on number of leaflet of faba bean at different days after sowing (DAS)

Treatment combination	Number of Leaflet		
	30 DAS	45 DAS	At Harvest
P_1S_1	14.66 b	24.00 abc	28.00 bc
P_1S_2	14.33 b	25.33 ab	26.33 cd
P_1S_3	11.66 c	21.66 cd	23.33 de
P_1S_4	6.33 e	17.66 e	18.33 f
P_2S_1	15.00 b	24.33 abc	30.33 ab
P_2S_2	16.00 b	26.66 a	28.33 bc
P_2S_3	12.33 c	25.33 ab	26.00 cd
P_2S_4	9.00 d	20.00 de	21.66 e
P_3S_1	15.66 b	23.33 abc	32.00 a
P_3S_2	15.66 b	24.66 abc	30.66 ab
P_3S_3	18.33 a	26.00 ab	26.66 cd
P_3S_4	14.33 b	23.00 bcd	23.66 de
Standard Error	0.551	0.488	0.695
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl),

S_2: 40 mM NaCl,

S_3: 80 mM NaCl,

S_4: 120 mM NaCl

P_1: Non Primed

P_2: Hydroprimed

P_3: Ascorbic acid 100 mg/L Priming

4.5 Leaf length

The leaf length of faba bean varied significantly for different levels of salt stress (Appendix XV-XVII). Table 13 reveals that, leaf length of faba bean was recorded highest (32.00, 32.61 and 32.86 cm) from S_1 as control at 30, 45 DAS and at harvest followed by S_2 (29.11, 29.33 and 29.53 cm) and S_3 (22.66, 22.88 and 23.11 cm) respectively. On the contrary, the lowest value was observed from S_4 (13.72, 14.00 and 14.16 cm) at harvest. Jamal *et al*. (2014) also showed that total leaf area of tomato (*Lycopersicon esculentum* Mill.) decreased with increasing salinity .

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on leaf length in faba bean plant at 30, 45 DAS and at harvest (Appendix XV-XVII). Table 14 revealed that, at 30, 45 and at harvest, the height of faba bean plant was recorded highest (28.04, 28.66 and 28.83 cm) from P_3, followed by P_2(25.0 , 25.29 and 26.58 cm) and P_1(20.00 , 20.16 and 20.41 cm) respectively. The lowest value was observed from P_1 at 30, 45 DAS and at harvest respectively.

Combined effect of salinity and mitigation agent showed different significant variation on leaf length of faba bean plant at 30, 45 DAS and at harvest (Appendix XV-XVII). Table 15 showed that highest result was recorded from P_3S_1 (36.00, 37.66 and 37.88 cm) at 30, 45 DAS and at harvest respectively. Where as the lowest value was observed from P_3S_4 (10.00, 10.33 and 10.50 cm) at 30, 45 and at harvest respectively.

4.6. Leaf breadth

The leaf breadth in faba bean plant varied significantly for different levels of salt stress at 30, 45 DAS and at harvest (Appendix XVIII-XX). Table 13 revealed that, the total number of leaves per faba bean plant was recorded highest (23.01, 23.36 and 23.76 cm) from S_1 as control at 30, 45 DAS and at harvest respectively; followed by (20.82, 20.97 and 21.26 cm) and S_2 (16.72, 17.35 and 17.48) respectively. On the contrary, the lowest value was observed from S_4(10.94, 10.96 and 11.06 cm) at 30, 45 DAS and at harvest respectively.

Hydropriming and ascorbic acid priming had significant effect on leaf breadth at 30, 45 DAS and at harvest (Appendix XVIII-XX). Table 14 revealed that, at 30, 45 DAS and at harvest, leaf breadth of faba bean plant was recorded highest (20.08, 20.33 and 20.68 cm) from P_3, followed by P_2(18.37, 18.44 and 18.60 cm) and P_1(15.16, 15.72 and 15.90 cm) respectively. The lowest value was observed from P_1 at 30, 45 DAS and at harvest respectively.

Combined effect of salinity and mitigation agent showed significant effect on leaf breadth of faba bean plant at 30, 45 DAS and at harvest (Appendix XVIII-XX). Table 15 showed that highest result was recorded from P_3S_1 (25.60, 26.10 and 26.56 cm) at 30, 45 DAS and at harvest respectively. Where as the lowest value was observed from P_1S_4 (8.50, 8.50 and 8.53 cm) at 30, 45 DAS and at harvest respectively.

Table 13. Effect of salinity levels on leaf length and leaf breadth of faba bean at different DAS

Treatment	Leaf Length at (cm)			Leaf breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
S_1	32.00 a	32.61 a	32.86 a	23.01 a	23.36 a	23.76 a
S_2	29.11 a	29.33 a	29.53 a	20.82 a	20.97 a	21.26 b
S_3	22.66 b	22.88 b	23.11 b	16.72 b	17.35 b	17.48 c
S_4	13.72 c	14.00 c	14.16 c	10.94 c	10.96 c	11.06 d
Standard Error	1.35	1.38	1.38	0.87	0.88	0.90
Significance level	0.00	0.00	0.00	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 14. Effect of seed priming on leaf length and leaf breadth of faba bean at different DAS

Treatment	Leaf length at (cm)			Leaf breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
P_1	20.00 b	20.16 b	20.41 b	15.16 b	15.72 b	15.90 b
P_2	25.08 ab	25.29 ab	25.50 ab	18.37ab	18.44 ab	18.60 ab
P_3	28.04 a	28.66 a	28.83 a	20.08 a	20.33 a	20.68 a
Standard Error	1.35	1.385	1.389	0.874	0.885	0.906
Significance level	0.044	0.036	0.040	0.062	0.100	0.094

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table 15. Combined effect of salinity and different type of priming as mitigation agent on leaf length and leaf breadth of faba bean at different days after sowing

Treatment combination	Leaf length at (cm)			Leaf breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
P_1S_1	27.00 c	27.16 c	27.50 c	19.66 c	20.16 cd	20.46 cd
P_1S_2	23.33 cde	23.33 cd	23.60 cd	17.66cd	17.67 de	17.93 e
P_1S_3	19.66 ef	19.83 dc	20.06 de	14.83 e	16.56 e	16.66 e
P_1S_4	10.00 g	10.33 f	10.50 f	8.50 f	8.50 g	8.53 g
P_2S_1	33.00 ab	33.00 b	33.26 b	23.76 ab	23.83 ab	24.26 ab
P_2S_2	31.00 b	31.50 b	31.66 b	22.06 b	22.26 bc	22.50 bc
P_2S_3	23.00 de	23.16 cd	23.43 cd	17.16 d	17.16 e	17.16 e
P_2S_4	13.33 g	13.50 f	13.66 f	10.50 f	10.50 g	10.50 g
P_3S_1	36.00 a	37.66 a	37.83 a	25.60 a	26.10 a	26.56 a
P_3S_2	33.00 ab	33.16 b	33.33 b	22.73 b	23.00 b	23.36 b
P_3S_3	25.33 cd	25.66 c	25.83 c	18.16 cd	18.33d e	18.63 de
P_3S_4	17.83 f	18.16 e	18.33 e	13.83 e	13.90 f	14.16 f
Standard Error	1.353	1.385	1.389	0.874	0.885	0.906
Significance level	0.00	0.00	0.00	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100 mg/L Priming

S_4: 120 mM NaCl

4.7. Leaflet length

The leafet length of faba bean varied significantly for different levels of salt stress(Appendix XXI-XXIII). Table 16 reveals that, leaflet length of faba bean was recorded highest (11.86, 12.25 and 12.31 cm) from S_1 as control at harvest ; followed by S_2 (10.66, 10.80 and 10.91 cm) and S_3 (8.72, 8.87 and 8.96 cm) respectively. On the contrary, the lowest value was observed from S_4 (5.88, 6.02 and 6.04 cm) at harvest. Jamal *et al.* (2014) showed that total leaf area of tomato (*Lycopersicon esculentum* Mill.) decreased with increasing salinity.

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on leaflet length in faba bean plant at 30, 45 DAS and at harvest (Appendix XXI-XXIII). Table.17 revealed that, at 30, 45 DAS and at harvest, the height of faba bean plant was recorded highest (10.52 cm , 10.84 cm and 10.90 cm) from P_3, followed by P_2(9.54 cm , 9.69 cm and 9.77cm) and P_1(7.79 cm , 7.93 and 7.99 cm) respectively. The lowest value was observed from P_1 at 30, 45 DAS and at harvest respectively.

Combined effect of salinity and mitigation agent showed significant variation on leaflet length of faba bean plant at 30, 45 DAS and at harvest (Appendix XXI-XXIII). Table 18 showed that highest result was recorded from P_3S_1 (13.10, 13.50 and 13.60 cm) at 30, 45 DAS and at harvest respectively. Where as the lowest value was observed from P_1S_4 (4.50, 4.56 and 4.56 cm) at 30, 45 DAS and at harvest respectively.

4.8 Leaflet breadth

The leaflet breadth of faba bean varied significantly for different levels of salt stress (Appendix XXIV-XXVI). Table 16 reveals that, leaflet breadth of faba bean was recorded highest (7.05, 7.22 and 7.36 cm) from S_1 as control at harvest ; followed by S_2 (5.36, 5.51 and 5.57 cm) and S_3 (4.44, 4.44 and 4.44 cm) respectively. On the contrary, the lowest value was observed from S_4 (3.72, 3.72 and 3.74 cm) at harvest . Jamal *et al.* (2014) showed that total leaf area of tomato decreased with increasing salinity.

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on leaflet breadth in faba bean plant at 30, 45 DAS and at harvest (Appendix XXIV-XXVI). Table 17 revealed that, at 30, 45 DAS and at harvest, leaflet breadth of faba bean plant was recorded highest (6.16, 6.33 and 6.40 cm) from P_3, followed by P_2 (5.25, 5.28 and 5.34 cm) and P_1 (4.02, 4.05 and 4.10 cm) respectively. The lowest value was observed from P_1 at 30, 45 DAS and at harvest respectively.

Combined effect of salinity and priming on leaflet breadth of faba bean plant at 30, 45 DAS and at harvest showed in (Appendix XXIV-XXVI). Table 18 showed that highest result was recorded from P_3S_1 (8.00, 8.33 and 8.50 cm) at 30, 45 DAS and at harvest respectively. Where as the lowest value was observed from P_1S_4 (2.66, 2.66 and 2.66 cm) at 30, 45 DAS and at harvest respectively.

Table 16. Effect of salinity levels on leaflet length and leaflet breadth of faba bean at different DAS

Treatment	Leaflet length at (cm)			Leaflet breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
S_1	11.86 a	12.25 a	12.31 a	7.05 a	7.22 a	7.36 a
S_2	10.66 a	10.80 b	10.91 b	5.36 b	5.51 b	5.57 b
S_3	8.72 b	8.87 c	8.96 c	4.44bc	4.44 c	4.44 c
S_4	5.88 c	6.02 d	6.04 d	3.72 c	3.72 c	3.74 c
Standard Error	0.438	0.456	0.458	0.263	0.277	0.286
Significance level	0.000	0.000	0.000	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 17. Effect of seed priming on leaflet length and leaflet breadth of faba bean at different DAS

Treatment	Leaflet Length at (cm)			Leaflet Breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
P_1	7.79 b	7.93 b	7.99 b	4.02 b	4.05 b	4.10 b
P_2	9.54 ab	9.69 ab	9.77 ab	5.25 a	5.28 a	5.34 a
P_3	10.52 a	10.84 a	10.90 a	6.16 a	6.33 a	6.40 a
Standard Error	0.438	0.456	0.458	0.263	0. 277	0.286
Significance level	0.031	0.027	0.028	0.002	0.002	0.002

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table 18. Combined effect of salinity and different type of priming as mitigation agent on leaflet length and breadth of faba bean at different days after sowing(DAS)

Treatment combination	Leaflet length at (cm)			Leaflet breadth at (cm)		
	30 DAS	45 DAS	Harvest	30 DAS	45 DAS	Harvest
P_1S_1	10.16 c	10.50de	10.53 de	6.00 c	6.10 cd	6.23 cd
P_1S_2	8.83 d	9.00 fg	9.16 f	4.26 d	4.30 ef	4.33 e
P_1S_3	7.66 e	7.66 h	7.70 g	3.16 ef	3.16gh	3.16 fg
P_1S_4	4.50 g	4.56 i	4.56 h	2.66 f	2.66 h	2.66 g
P_2S_1	12.33ab	12.76 ab	12.80 ab	7.16 b	7.23 b	7.36 b
P_2S_2	11.33 b	11.40 c	11.40 cd	5.66 c	5.73 d	5.83 d
P_2S_3	8.83 d	8.93 fg	9.16 f	4.50 d	4.50 e	4.50 e
P_2S_4	5.66 f	5.66 i	5.73 h	3.66 e	3.66 fg	3.66 f
P_3S_1	13.10 a	13.50 a	13.60 a	8.00 a	8.33 a	8.50 a
P_3S_2	11.83 b	12.00 bc	12.16 bc	6.16 c	6.50 c	6.56 c
P_3S_3	9.66 cd	10.03 ef	10.03 ef	5.66 c	5.66 d	5.66 d
P_3S_4	7.50 e	7.83 gh	7.83 g	4.83 d	4.83 e	4.90 e
Standard Error	0.438	0.456	0.458	0.263	0.277	0.286
Significance level	0.00	0.00	0.00	0.00	0.00	0.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100 mg/L Priming

S_4: 120 mM NaCl

4.9 Root Length

The roots of faba bean varied significantly for different levels of salt stress (Appendix XXXV). Table 19 reveals that, root length of faba bean was recorded highest (7.61 cm) from S_1 as control at harvest followed by S_3 (7.17 cm) and S_4 (7.01 cm) respectively. On the contrary, the lowest value was observed from S_2 (6.7 cm) at harvest.

Hydropriming and Ascorbic acid priming as mitigation agent had significant effect on root length in faba bean plant (Appendix XXXV). Table 20 revealed that, roots of faba bean plant was recorded highest (8.42 cm) from P_3, followed by P_2(6.71cm) and P_1(6.22 cm) respectively. The lowest value was observed from P_1. Present results confirm the findings of Stofella *et al*. (1992), who reported that priming of pepper seeds significantly improved radicle length.

Combined effect of salinity and mitigation agent on root length of faba bean showed in (Appendix XXXV). Table 21 showed that highest result was recorded from P_3S_3 (9.33 cm) at harvest. Where as the lowest value was observed from P_1S_4 (5.33 cm) at harvest.

Table 19. Effect of salinity levels on root length of faba bean

Treatment	Root length (cm)
S_1	7.61 a
S_2	6.70 a
S_3	7.17 a
S_4	7.01 a
Standard Error	0.228
Significance level	0.576

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 20. Effect of seed priming on root length of faba bean

Treatment	Root length (cm)
P_1	6.23 b
P_2	6.71 b
P_3	8.42 a
Standard Error	0.228
Significance level	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table No: 21 Combined effect of salinity and different type of priming as mitigation agent on root length of faba bean

Treatment	Root length (cm)
P_1S_1	6.66 cd
P_1S_2	6.66 cd
P_1S_3	6.26 cd
P_1S_4	5.33 d
P_2S_1	7.50 bc
P_2S_2	6.43 cd
P_2S_3	5.93 cd
P_2S_4	7.00 c
P_3S_1	8.66 ab
P_3S_2	7.00 c
P_3S_3	9.33 a
P_3S_4	8.70 ab
Standard Error	0.228
Significance level	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100mg/L Priming

S_4: 120 mM NaCl

4.10 Number of inflorescence per plant

Number of inflorescence per faba bean plant varied significantly for different levels of salt stress (Appendix XXVII). Table 22 reveals that, total number of inflorescence per faba bean plant was recorded highest (4.00) from S_1; followed by S_2 (3.44) and S_3 (2.22) respectively. On the contrary, the lowest value was observed from S_4 (1.44).

Priming as mitigation agent had significant effect on total number of inflorescence per faba bean plant (Appendix XXVII). Table 23 reveals that, total number of inflorescences per faba bean plant was recorded highest (3.08) from P_3; followed by P_2 (2.66) and P_1 (2.58) respectively. The lowest value was observed from P_1.

Combined effect of salinity and mitigation agent showed non-significant variation on total number of inflorescences per faba bean plant (Appendix XXVII). Table 24 shows that highest result was recorded from P_3L_1 (4.00), which was statistically similar to P_2S_1 (4.00) and P_1S_1 (4.00). Whereas the lowest value was observed from P_3S_4 (1.33).

4.11 Number of flowers per inflorescence per plant

Number of flowers per inflorescence varied significantly for different levels of salt stress (Appendix XXVIII). Table.22 reveals that, total number of flowers per inflorescence was recorded highest (3.44) from S_1; followed by S_2 (2.88) , S_3 (2.55) and S_4 (2.55). The lowest value was observed from S_3 and S_4 where both were statistically similar to each other.

Priming as mitigation agent had significant effect on total number of flower per inflorescence (Appendix XXVIII). Table 23 reveals that, total number of flower per inflorescence was recorded highest (3.25) from P_3 ; followed by P_2 (2.91) and P_1 (2.41) respectively. The lowest value was observed from P_1.

Combined effect of salinity and mitigation agent showed significant variation on total number of flower per inflorescence (Appendix XXVIII). Table 24 shows that highest result was recorded from P_3S_1 (4.00) and the lowest value was observed from P_1S_2 (2.00) which was statistically similar to P_1S_3 (2.00) .

4.12 Total Number of flower per plant

Total Number of flower per faba bean plant varied significantly for different levels of salt stress (Appendix XXIX). Table 22 reveals that, total number of flower per faba bean plant was recorded highest (13.77) from S_1; followed by S_2 (10.11) and S_3 (5.77) respectively. On the contrary, the lowest value was observed from S_4 (3.44).

Hydropriming and Ascorbic acid priming had significant effect on total number of flower per plant (Appendix XXIX). Table.23 reveals that, total number of flower per plant was recorded highest (10.50) from P_3; followed by P_2 (8.00) and P_1 (6.33) respectively. The lowest value was observed from P_1.

Combined effect of salinity and mitigation agent showed significant variation on total number of flower per plant (Appendix XXIX). Table 24 shows that highest result was recorded from P_3S_1 (16.00). Whereas the lowest value was observed from P_1S_4 (3.33) which was statistically similar to P_2S_4 (3.33).

Table 22. Effect of salinity levels on number of inflorescence/plant, number of flower/inflorescence and total number of flower of faba bean

Treatment	No. of inflorescence/plant	No. of flower/Inflorescence	Total flower/Plant
S_1	4.00 a	3.44 a	13.77 a
S_2	3.44 b	2.88 ab	10.11 b
S_3	2.22 c	2.55 b	5.77 c
S_4	1.44 d	2.55 b	3.44 c
Standard Error	0.187	0.113	0.776
Significance level	0.000	0.011	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 23. Effect of seed priming on number of inflorescence/plant, number of flower/inflorescence and total number of flower of faba bean

Treatment	No. of inflorescence/Plant	No. of flower/Inflorescence	Total flower/plant
P_1	2.58 a	2.41 b	6.33 b
P_2	2.66 a	2.91 ab	8.00 ab
P_3	3.08 a	3.25 a	10.50 a
Standard Error	0.187	0.113	0.776
Significance level	0.519	0.007	0.085

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming

Table 24. Combined effect of Salinity and Different type of priming as mitigation agent on number of inflorescence/plant, number of flower/inflorescence and total number of flower of faba bean

Treatment	No. of inflorescence/Plant	No. of flower/Inflorescence	Total No. of flower
P_1S_1	4.00 a	3.00 bcd	12.00 bc
P_1S_2	3.00 b	2.00 e	6.00 e
P_1S_3	2.00 c	2.00 e	4.00 ef
P_1S_4	1.33 c	2.66 cde	3.33 f
P_2S_1	4.00 a	3.33 abc	13.33 b
P_2S_2	3.66 ab	3.00 bcd	11.00 cd
P_2S_3	1.66 c	2.66 cde	4.33 ef
P_2S_4	1.33 c	2.66 cde	3.33 f
P_3S_1	4.00 a	4.00 a	16.00 a
P_3S_2	3.66 ab	3.66 ab	13.33 b
P_3S_3	3.00 b	3.00 bcd	9.00 d
P_3S_4	1.66 c	2.33 de	3.66 f
Standard Error	0.187	0.113	0.776
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100mg/L Priming

S_4: 120 mM NaCl

4.13 Pod length

Length of fruits varied significantly for different levels of salt stress (Appendix XXX).Table 25 reveals that, the volume of fruits was recorded highest (18.63) from S_1; followed by S_2 (17.27 cm) and S_3 (13.47 cm) respectively (Appendix VI). On the contrary, the lowest value was observed from S_4 (12.17 cm).

Priming as mitigation agent had significant effect on length of fruits (Appendix XXX). Table 26 reveals that, the length of fruits was recorded highest (16.88 cm) from P_3; followed by P_2 (15.72 cm) and P_1 (13.52 cm), the lowest value was observed from P_1 (13.52 cm).

Combined effect of salinity and mitigation agent showed significant variation on pod length (Appendix XXX). Table 27 shows that highest result was recorded from P_3S_1 (19.73 cm) and the lowest value from P_1S_4 (8.83 cm).

4.14. Pod breadth

Breadth of fruits varied significantly for different levels of salt stress (Appendix XXXI). Table 25 reveals that, the volume of fruits was recorded highest (1.06) from S_1; followed by S_2 (0.92 cm) and S_3 (0.81 cm) respectively (Appendix XXXI). On the contrary, the lowest value from S_4 (0.71 cm).

Hydro priming and Ascorbic acid priming as mitigation agent had significant effect on pod breadth (Appendix XXXI). Table.26 reveals that, the breadth of fruits was recorded highest (0.94 cm) from P_3; followed by P_2 (0.86 cm) and P_1 (0.82 cm), the lowest value was observed from P_1 (13.52 cm).

Combined effect of salinity and mitigation agent showed significant variation on pod breadth (Appendix XXXI).Table. 27 shows that highest result was recorded from P_3S_1 (1.12 cm).Whereas the lowest value was observed from P_2S_4 (0.62 cm).

Table 25. Effect of salinity levels on pod length and pod breadth of faba bean

Treatment	Pod length (cm)	Pod breadth (cm)
S_1	18.63 a	1.06 a
S_2	17.27 a	.92 b
S_3	13.47 b	.81 c
S_4	12.17 b	.71 d
Standard Error	0.549	0.02680
Significance level	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT..

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 26. Effect of seed priming on pod length and pod breadth of faba bean

Treatment	Pod length (cm)	Pod breadth (cm)
P_1	13.52 b	0.82 a
P_2	15.77 ab	0.86 a
P_3	16.88 a	0.94 a
Standard Error	0.549	0.026
Significance level	0.034	0.185

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100mg/L Priming

Table 27. Combined effect of salinity and different type of priming as mitigation agent on pod length and pod breadth of faba bean

Treatment	Pod length (cm)	Pod breadth (cm)
P_1S_1	17.81 b	1.01 abc
P_1S_2	17.27 bc	0.86 cd
P_1S_3	10.15 e	0.71 ef
P_1S_4	8.83 e	0.70 ef
P_2S_1	18.35 ab	1.04 ab
P_2S_2	17.07 bc	0.93 bcd
P_2S_3	14.34 d	0.85 de
P_2S_4	13.32 d	0.62 f
P_3S_1	19.73 a	1.12 a
P_3S_2	17.47 b	0.96 bcd
P_3S_3	15.93 c	0.86 cd
P_3S_4	14.37 d	0.81 de
Standard Error	0.549	0.026
Significance level	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100mg/L Priming

S_4: 120 mM NaCl

17.81 17.27 10.15 8.83 18.35 17.07 14.34 13.32 19.73 17.47 15.93 14.37

P_1S_1 P_1S_2 P_1S_3 P_1S_4 P_2S_1 P_2S_2 P_2S_3 P_2S_4 P_3S_1 P_3S_2 P_3S_3 P_3S_4

Plate 5. Effect of salinity and different type of priming on pod length of faba bean

4.15. Weight of individual pod

Weight of individual faba bean pod varied significantly for different levels of salt stress(Appendix XXXII and Figure 3). Table 28 reveals that, weight of individual faba bean fruits was recorded highest (7.49 g) from S_1; followed by S_2 (6.96 g) and S_3 (6.14 g) respectively. On the contrary, the lowest value was observed from S_4 (5.57 g). The result was consistent with Humayun *et al.* (2010) and Jamal *et al.* (2014) in tomato.

Hydro priming and Ascorbic acid priming as mitigation agent had significant effect on weight of fruits (Appendix XXXII). Table.29 reveals that, the breadth of fruits was recorded highest (6.82 g) from P_3; followed by P_2 (6.46 g) and P_1 (6.35 g), the lowest value was observed from P_1 (6.35 g).

Combined effect of salinity and mitigation agent showed significant variation on pod breadth (Appendix XXXII).Table 30 shows that highest result was recorded from P_3S_1 (7.84 g) and the lowest value observed from P_2S_4 (5.47 g).

4.16 Total Number of pods per plant

Total Number of fruits per faba bean plant varied significantly for different levels of salt stress (Appendix XXXIII). Table 28 reveals that, total number of fruits per faba bean plant was recorded highest (12.00) from S_1 followed by S_2 (9.44) and S_3 (4.88) respectively. On the contrary, the lowest value was observed from S_4 (3.11).

Priming as mitigation agent had significant effect on total number of fruits per faba bean plant (Appendix XXXIII and Figure 2). Table 29 reveals that, total number of fruits per faba bean plant was recorded highest (9.25) from P_3; followed by P_2 (7.16). On the contrary, the lowest value from P_1 (5.66).

Combined effect of salinity and mitigation agent showed significant variation on pod breadth (Appendix XXXIII). Table 30 shows that highest result was recorded from P_3S_1 (13.66).Whereas the lowest value was observed from P_1S_4 (3.00) which was statistically similar to P_1S_3 (3.00) and P_2S_4 (3.00).

4.17. Total pod weight per plant

Total pods weight per faba bean plant varied significantly for different levels of salt stress (Appendix XXXIV). Table 27 reveals that, total fruit weight per faba bean plant was recorded highest (90.19 g) from S_1; followed by S_2 (66.53 g) and S_3 (30.28 g) and the lowest value observed from S_4 (17.34 g).

Priming as mitigation agent had significant effect on total weight of pods per plant (Appendix XXXIV and Figure 4). Table 29 reveals that, the breadth of fruits was recorded highest (66.29 g) from P_3; followed by P_2 (48.98 g) and P_1 (37.99 g), the lowest value was observed from P_1 (37.99 g).

Combined effect of salinity and mitigation agent showed significant variation on total weight of pods per plant (Appendix XXXIV).Table 30 shows that highest result was recorded from P_3S_1 (107.09 gm).Whereas the lowest value was observed from P_2S_1 (16.41 gm).

Table 28. Effect of salinity levels on weight/pod, total pod/plant and total pod weight/pod of faba bean

Treatment	Weight(g)/pod	Total pod/plant	Total pod Weight (g) /plant
S_1	7.49 a	12.00 a	90.19 a
S_2	6.96 b	9.44 b	66.53 b
S_3	6.14 c	4.88 c	30.28 c
S_4	5.57 d	3.11 c	17.34 c
Standard Error	0.137	0.672	05.439
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **S_2:** 40 mM NaCl, **S_3:** 80 mM NaCl, **S_4:** 120 mM NaCl

Table 29. Effect of seed priming on weight/pod, total pod/plant and total pod weight/pod of faba bean

Treatment	Weight(g)/pod	Total pod/plant	Total pod Weight (g) /plant
P_1	6.35 a	5.66 b	37.99 b
P_2	6.46 a	7.166 ab	48.98 ab
P_3	6.82 a	9.25 a	66.29 a
Standard Error	0.137	0.672	5.43
Significance level	0.036	0.089	0.099

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

P_1: Non Primed , **P_2:** Hydroprimed , **P_3**: Ascorbic acid 100 mg/L Priming.

Table 30. Combined effect of salinity and different type of priming as mitigation agent on weight/pod, total pod/plant and total pod weight/pod of faba bean

Treatment	Weight(g)/pod	Total pod/plant	Total pod Weight (g) /plant
P_1S_1	7.31 ab	10.66 c	77.94 c
P_1S_2	6.59 cd	6.00 e	39.53 f
P_1S_3	6.023 def	3.00 f	18.06 gh
P_1S_4	5.47 f	3.00 f	16.43 h
P_2S_1	7.33 ab	11.66 b	85.54 b
P_2S_2	7.01 bc	10.00 c	70.11 d
P_2S_3	6.04 def	4.00 f	23.85 g
P_2S_4	5.47 f	3.00 f	16.41 h
P_3S_1	7.84 a	13.66 a	107.09 a
P_3S_2	7.30 ab	12.33 b	89.95 b
P_3S_3	6.36 de	7.66 d	48.93 e
P_3S_4	5.77 ef	3.33 f	19.19 h
Standard Error	0.137	0.672	5.439
Significance level	0.000	0.000	0.000

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability analysed by DMRT.

S_1: Control (0 mM NaCl), **P_1:** Non Primed

S_2: 40 mM NaCl, **P_2:** Hydroprimed

S_3: 80 mM NaCl, **P_3**: Ascorbic acid 100mg/L Priming

S_4: 120 mM NaCl

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted to observe the effect of salt stress and hydroprimed and ascorbic acid primed seed as mitigation agent in faba bean. This study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2017 to April 2018. The experiment consisted of two factors: Factor A: Different type of seed priming chemical, viz. P_1: Non Primed, P_2: Hydroprimed and P_3: Ascorbic acid 100mg/L priming , Factor B: Different level of saline in soil with different level of NaCl solution such as, S_1: Control (0 mM NaCl), S_2: 40 mM NaCl, S_3: 80 mM NaCl, S_4: 120 mM NaCl.

The experiment was laid out in Randomized Complete Block Design with 3 replications. Various morphological, physiological and yield contributing characters varies due to increasing salinity, and application of hydropriming and ascorbic acid priming have significantly mitigate this effect. Data on plant height, number branches per plant , number of leaf per plant , number of leaflet per plant , leaf length, leaf breadth, leaflet length, leaflet breadth, root length (cm), number. of inflorescence per plant , number of flowers per inflorescence, total number of flower per plant, number of pods per plant , length of pod , breadth of pod , weight of individual pod and total pod weight per plant was recorded and highest was recorded in ,while lowest was in P_1S_4 combination.

Results revealed that different parameters were significantly influence by different levels of salinity level in soil. It was found that the height of faba bean plant was recorded highest (26.55, 43.22and 47.81 cm) from S_1 as control at 30, 45 DAS and at harvest, while the lowest value was observed from S_4 (14.88, 27.88 and 28.94 cm). At 30, 45 DAS and at harvest, the total number of branches of faba bean plant was recorded highest (1.55, 3.56 and 4.00) from S_1 as control, while the lowest value was observed from S_4 (1.11 , 2.55 and 2.55). The total number of leaves per faba bean plant was recorded highest (4.88 , 8.33 and 10.11) from S_1 as control at 30, 45 DAS and at harvest, while the lowest value was observed from S_4 (3.11 , 6.55 and 6.88) . The total number of leaflet per faba bean plant was recorded highest (15.11 , 23.88 and 30.11) from S_1 as control at 30, 45 DAS and at harvest, while the lowest value was observed from S_4 (9.88 , 20.22 and 21.22) . Data of leaf length of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (32.00 cm, 32.61 cm and, 32.86 cm) from S_1 (no salt), while the lowest value was observed from S_4 (13.72 cm, 14.00 cm and 14.16 cm). Data of leaf breadth of faba bean was recorded at 30, 45 and at harvest and observed highest (23.01 cm , 23.36 cm and 23.76 cm) from S_1 (no salt), while the lowest value was observed from S_4 (10.94 cm, 10.96 cm and 11.06 cm). Data of leaflet length of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (11.86 cm, 12.25 cm and, 12.31 cm) from S_1 (no salt), while the lowest value was observed from S_4 (5.88 cm, 6.02 cm and 6.04 cm). Data of leaflet breadth of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (7.05 cm , 7.22 cm and 7.36 cm) from S_1 (no salt), while the lowest value was observed from S_4 (3.72 cm, 3.72 cm and 3.74 cm). Length of faba bean roots was recorded highest (7.61 cm) from S_1, while the lowest value was observed from S_4 (7.01 cm). Total number of inflorescences per faba bean plant and total number of flowers per inflorescence per faba bean plant was recorded highest (4.00 and 3.44) respectively from S_1, while the lowest value was observed from S_4 (1.44 and 2.55) respectively. Total Number of flower per plant was recorded highest (13.77) from S_1, while the lowest value was observed from S3 (3.44).Total number of pods per faba bean plant was recorded highest (12.00) from S_1, while the lowest value was observed from S_4 (3.11). Length of faba bean pods was recorded highest (18.63 cm) from S_1 while the lowest value was observed from S_4 (12.17 cm). Breadth of faba bean pods was recorded highest (1.06 cm) from S_1, while the lowest value was observed from S_4 (0.71 cm). Weight of individual faba bean pods was recorded highest (7.49 g) from S_1 while the lowest value was observed from S_4 (5.57 g). Total pod weight per faba bean plant was recorded highest (90.19 g) from S_1 while the lowest value was observed from S_4 (17.34 g). Hydropriming and ascorbic acid priming can mitigate the effect of salinity.

Different type of priming applied on the faba bean pots had significant effect on different parameters. Results exposed that the height of faba bean plant was recorded highest (23.41 cm, 38.16 cm, 41.65 cm) from P_3 at 30, 45 DAS and at harvest, while the lowest value was observed from P_1 (19.41 cm, 33.75 cm, 35.95 cm). At 30, 45 DAS and at harvest, the total number of branches of faba bean plant was recorded highest (1.75, 3.33 and 3.83) from P_3, while the lowest value was observed from P_1 (1.08, 2.50 and 3.00). The total number of leaves per faba bean plant was recorded highest (5.25, 7.75 and 9.33) from P_3 as control at 30, 45 DAS and at harvest, while the lowest value was observed from P_1 (3.66, 7.08 and 8.00). The total number of leaflet per faba bean plant was recorded highest (16.00, 16.00 and 28.25) from P_3 as control at 30, 45 DAS and at harvest, while the lowest value was observed from P_1 (11.75, 11.75 and 24.00). Data of leaf length of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (28,04 cm, 28.66 cm and, 28.83 cm) from P_3, while the lowest value was observed from P_1 (20.00 cm, 120.16 cm and 20.41 cm). Data of leaf breadth of faba bean was recorded at 30, 45 and at harvest and observed highest (28.08 cm, 20.33 cm and 20.68 cm) from $P_{3,}$ while the lowest value was observed from P_1 (15.16 cm, 15.72 cm and 15.90 cm). Data of leaflet length of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (10.52 cm, 10.84 cm and, 10.90 cm) from P_1, while the lowest value was observed from P_1 (7.79 cm, 7.93 cm and 7.99 cm). Data of leaflet breadth of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (6.61 cm, 6.33 cm and 6.40 cm) from P_3, while the lowest value was observed from P_1 (4.02 cm, 4.05 cm and 4.10 cm). Length of faba bean roots was recorded highest (8.42 cm) from P_3, while the lowest value was observed from P_1 (6.23cm). Total number of inflorescences per faba bean plant and total number of flowers per inflorescence per faba bean plant was recorded highest (3.08 and 3.25) respectively from P_3, while the lowest value was observed from P_1 (2.58 and 2.41) respectively. Total number of flower per plant was recorded highest (10.50) from P_3, while the lowest value was observed from P_1 (6.33).Total number of pods per faba bean plant was recorded highest (9.25) from P_3, while the lowest value was observed from P_1 (5.66). Length of faba bean pods was recorded highest (16.88 cm) from P_3 while the lowest value was observed from P_1 (13.52 cm). Breadth of faba bean pods was recorded highest (0.94 cm) from P_3, while the lowest value was observed from P_1 (0.82 cm). Weight of individual faba bean pods was recorded highest (6.82 g) from P_3 while the lowest value was observed from P_1 (6.35 g). Total pod weight per faba bean plant was recorded highest (66.29 g) from P_3 while the lowest value was observed from P_1 (37.99 g).

Combined effect of salinity with hydropriming and ascorbic acid priming had significant effect on faba bean. Results demonstrated that at 30, 45 DAS and at harvest the plant height was recorded highest from (27.33 cm, 44.00 cm, 49.83 cm) Whereas the lowest value was observed from P_1S_4 (13.66 cm, 24.33 cm, 25.33 cm). Total number of branches of faba bean plant was recorded highest from P_3S_1 (2.00 cm, 3.00 cm, 4.33 cm) whereas the lowest value was observed from P_1S_4 (1.00 cm, 2.00 cm, 2.00 cm) at 30, 45 DAS and at harvest. The total number of leaves per faba bean plant at 35, 55 and 75 was recorded highest from (5.33, 7.33 and 10.66) Whereas the lowest value was observed from P_1S_4 (2.00, 6.00 and 6.00. The total number of leaflet per faba bean plant was recorded highest (18.33 , 26.00 and 26.66) from P_3S_3 as control at 30, 45 DAS and at harvest, while the lowest value was observed from P_1S_4 (6.33 , 17.66 and 18.33) . Data of leaf length of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (36.00 cm, 37.66 cm and, 37.83 cm) from P_1S_4 (no salt), while the lowest value was observed from P_1S_4 (10.00 cm, 10.33 cm and 10.50 cm). Data of leaf breadth of faba bean was recorded at 30, 45 DAS and at harvest and observed highest (25.60 cm , 26.01 cm and 26.56 cm) from P_3S_1 (no salt), while the lowest value was observed from P_1S_4 (8.50 cm, 8.50 cm and 8.53 cm). Data of leaflet length of faba bean was recorded at 30, 45 and at harvest and observed highest (13.10 cm, 13.50 cm and, 13.60 cm) from P_1S_4 (no salt), while the lowest value was observed from P_1S_4 (5.88 cm, 6.02 cm and

6.04 cm). Data of leaflet breadth of faba bean was recorded at 30, 45 and at harvest and observed highest (8.00 cm , 8.33 cm and 8.50 cm) from P_3S_1 (no salt), while the lowest value was observed from P_1S_4 (2.66 cm, 2.66 cm and 2.66 cm).Total number of inflorescences per faba bean plant and total number of flowers per inflorescence per faba bean plant was recorded highest (4.00 and 4.00) respectively from P_3S_1, while the lowest value was observed from P_1S_4 (1.33 and 2.66) respectively. Total number of flower per plant was recorded highest (16.00) from P_3S_1, while the lowest value was observed from P_1S_4 (3.33). Length of faba bean root was recorded highest (9.33 cm) from P_3S_3, while the lowest value was observed from P_1S_4 (5.33cm). Total number of pods per faba bean plant was recorded highest (13.66) from P_3S_1, while the lowest value was observed from P_2S_4 (3.00). Length of faba bean pods was recorded highest (19.73 cm) from P_3S_1, while the lowest value was observed from P_1S_4 (8.83cm). Breadth of faba bean pods was recorded highest (1.12 cm) from P_3S_1, while the lowest value was observed from P_1S_4 (0.70 cm). Weight of individual faba bean pods was recorded highest (7.84 g) from P_3S_1 while the lowest value was observed from P_2S_4 (5.47 g). Total pod weight per faba bean plant was recorded highest (107.09 g) from P_3S_1 while the lowest value was observed from P_2S_4 (16.41 g).

Conclusion and suggestion:

From the results of the study it was revealed that the reduction in growth parameters and yield was more profound in control seeds than primed seeds under salt stress condition. Thus, the priming may be an effective method to meet the demands of farmers during the installation of the culture in the field and especially in conditions of salt stress. Considering the discussions, we can be concluded that:

i. In the experiment, faba bean plant was more sensitive in higher level of salinity (S_4: 120 mM NaCl with irrigation water) than lower salinity level (S_1: 0 mM NaCl with irrigation water).

ii. The performance of hydroprimed and ascorbic acid primed faba bean was better in respect of growth and yield parameters. Priming with ascorbic acid (20 mg/200ml distilled water for 16 hr) was better in respect of growth and yield parameters than hydro-priming for 16hr.

iii. During the investigation, the treatment combination of P_3S_1 (Ascorbic acid priming (20 mg/200 ml distilled water for 16 hr) with S_1: 0 mM NaCl with irrigation water) was the best due to highest yield.

iv. More experiment can be carried out with various levels of salt stress.

v. Various techniques of hydropriming and ascorbic acid priming can be used as mitigation agent for further study.

vi. Considering the findings of the present experiment, further studies might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances of priming.

REFFERENCE

Afzal, I., Basra and Ahmad, N. 2011. Hormonal priming induces salt tolerance in wheat through enhanced antioxidant defence system. *Cereal Res. Comm*. **39**: 334-342.

Amjad, M., Ziaf, K., Iqbal, Q., Ahmad, I. and Saqib, Z.A. 2007. Effect of seed priming on seed vigour and salt tolerance in hot pepper. *Pak. J. Agri. Sci*; **44**: 408-416.

Ashraf, M. and Foolad, R.M. 2005. Pre-sowing seed treatment—a shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions. *Adv. Agron*. **88**: 223–271. 94

Azzedine, F., Gherroucha, H and Baka, M. 2011. Improvement of salt tolerance in durum wheat by ascorbic acid application. *J Stress Physiol Biochem* **7**:27–37

Barakat, H. 2003. Interactive effects of salinity and certain vitamins on gene expression and cell division.*Inte.r J. Agric. Biol.* **5**(3):219–225

BARI. 2008. Mungbean cultivation in Bangladesh. Joydebpur, Gazipur.p 63

Basra, A.S., Dhillon, R. and Malik, C. P. 1989. Influence of seed pretreatment on metabolic alterations of germinating maize embryos under stressing temperature regimes. *Ann. Bot.*, **64**: 37-41.

Basra, S. M. A., Farooq, M. and Tabassum, R. 2005. Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice (*Oryza sativa* L.). *Seed Sci. Technol.*, **33**: 623-628.

Basra, S. M. A., Farooq, M., Wahid, A. and Khan, M. B. 2006. Rice seed invigoration by hormonal and vitamin priming. *Seed Sci. Technol*., **34**: 775-780.

BBS. 2017a. Yearbook of Agricultural Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. P 36

BBS. 2017 b. Statistical year book of Bangladesh. Statistics Division. Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka. P 51

Bose, B. and Mishra, T. 1992. Response of wheat seed to pre-sowing seed treatments with $Mg(NO_3)$. *Ann. Agril. Res*., **13**: 132-136.

Bulut, F., Akinci, S., and Eroglu, A. 2011. Growth and uptake of sodium and potassium in broad bean (*Vicia faba* L.) under salinity stress. *Commun. Soil Sci. Plant Anal.*, **42**: 945–961.

Casenave, E. C. and Toselli, M. E. 2007. Hydropriming as a pre-treatment for cotton germination under thermal and water stress conditions. *Seed Sci. Technol*. **35**: 88-98.

Conrath, U., Thulke, O. and Katz, V. 2002. Priming as a mechanism in induced systemic resistance of plants. *Eur. J. Plant Patho*. **107**: 113–119.

Cramer, G. R. 2002. Sodium-calcium interactions under salinity stress in Lauchli A, Lüttge salinity. *Envirn. Plant*., **4**: 205-227.

Dezfuli, P. M., Sharif-zadeh, F. and Janmohammad, M. (2008). Influence of priming techniques on seed germination behaviour of maize inbred lines (*Zea mays* L.). *ARPN J. Agril. Biol. Sci*. **3**(3): 22-25.

Elangbam, M., Rai, P. K., Lal, G. M., Singh, S. and Vishwas, S. (2017). Effect of growth regulators on germination and vigour of Chickpea (*Cicer arietinum* L.) seed. *J. Pharmacogn. Phytochem.* **6**(4): 31-34.

Elkoca E., Haliloğlu, K., Eşitken, A. and Ercişli, S. (2007). Hydro- and osmopriming improve chickpea germination. *Acta. Agric. Scand. B. Soil Plant Sci.* **57**: 193-200.

Evanari, M. (1984). Seed Physiology: Its History from antiquity to the beginning of the 20th century. *Bot. Rev*. **50**: 119-142.

FAO . 2017. Yearbook Production. p.53.

Farahbakhsh, H. (2012). Germiantion and seedling growth in primed and primed seeds of fennel as affected by reduced water potential induced by NaCl. *Inter. Res. J. Applied Basic Sci*. **3**: 737-744.

Farnia, A. and Shafie, M. (2015). Effect of bio-priming on yield and yield components of maize (*Zea mays* L.) under drought stress. *Bull. Env. Pharmacol. Life Sci*. **4** (4): 68-74.

Farooq, M., Aziz, T., Basra, S. M. A., Cheema, M. A. and Rehman, H. (2008). Chilling tolerance in hybrid maize induced by seed priming with salicylic acid. *J. Agron. Crop Sci.* **194**(2): 161-168.

Farooq, M., Basra, S. M. A. and Wahid, A. (2006). Priming of field- sown rice seed enhances germination, seedling establishment, allometry and yield. *Plant Growth Regul.* **49**: 285-294.

Farzin, Abdollahi And Jafari, l. 2012. Effect of nacl and kno3 priming on seed germination of canola (*brassica napus* L.) Under salinity conditions. *Inter. J. Agric. Res*. **Vol., 2**(5), 573-579.

Fercha, A., Gherroucha, H and Baka, M. 2011. Improvement of salt tolerance in wheat by vitamin C application. *J. Stress Physiol. Biochem.* **7**: 27-37.

Foti, R., Abureni, K., Tigere, A., Gotosa, J. and Gere, J. (2008). The efficacy of different seed priming osmotica on the establishment of maize (*Zea mays* L.) caryopses. *J. Arid Environ.* **72**: 1127-1130.

Ghassemi-Golezani, K., Aliloo, A. A., Valizadeh, M. and Moghaddam, M. (2008). Effects of different priming techniques on seed invigoration and seedling establishment of lentil. *J. Food. Agric. & Environ.* **6**: 222-226.

Ghassemi-Golezani, K., Chadordooz-Jeddi, A., Nasrollahzadeh, S. and Moghaddam, M. 2010 a. Effects of hydro-priming duration on seedling vigour and grain yield of pinto bean (*Phaseolus vulgaris* L.) cultivars. *Nat. Bot. Hort. Agrobot.* **38**(1): 109-113.

Ghassemi-Golezani, K., Chadordooz-Jeddi, A., Nasrullahzadeh, S. and Mohammad, M. 2010 b. Influence of hydro-priming duration on field performance of pinto bean (*Phaseolus vulgaris* L.) cultivars. *Afr. J. Agril. Res.* **5**(9): 893-897.

Ghassemi-Golezani, K., Sheikhzadeh-Mosaddegh, and Valizadeh, M. (2008b). Effects of hydropriming duration and limited irrigation on filed performance of chickpea. *Res. J. Seed Sci.* **1**(1): 34-40.

Gholami, A., Shahsavani, S. and Nezarat, S. (2009). The effect of plant growth promoting rhizobacteria (PGPR) on germination, seedling growth and yield of maize. *World Aca. Sci. Engineer. Technol*. **25**: 19-24.

Gupta and Singh, M. (2012). Effect of seed priming and fungicide treatment on *Cicer arietinum* sown at different sowing depths in kandi belt of low altitude sub-tropical zone of Jammu. *Applied Biol. Res.* **14**: 187-192.

Hanen, D., Elhem M. M., Néziha, G. B., Rabia, H. 2012.Salicylic acid priming in *Hedysarum carnosum* and *Hedysarum coronarium* reinforces NaCl tolerance at germination and seedling growth stage. *AJCS*. **6**(3):407-414.

Harris, D., Joshi, A., Khan, P.A., Gothkar, P. and Sodhi, P.S. (1999). On-farm seed priming in semi-arid agriculture: Development and evaluation in corn, rice and chickpea in India using participatory methods. *Expt. Agric.* **35**: 52-91.

Harris, D., Joshi, A., Khan, P.A., Gothkar, P. and Sodhi, P.S. (2004). On-farm seed priming in semi-arid agriculture: development and evoluation in maize, rice and chickpea in India using participatory methods. *Expt. Agric.* **35**: 15-29.

Hassanpouraghdam, M. B., Emarat, P. J. and Farsad, A. N. (2009). The effect of osmo-priming on germination and seedling growth of (*Brassica napus* L.) under salinity conditions. *J. Food Agric. Environ.* **7**(2): 620–622.

Hosseein, A., Farahani and Karsa, M. (2011). Effect of hydro-priming on seedling vigour in Basil (*Ocimum basilicum* L.) under salinity conditions. *Adv. Environ. Biol.* **5**(5): 828-833.

Humayun, M. (2010). Effect of salt stress on growth attributes and endogenous growth hormones of soybean cultivar. *Pak. J. Bot.*, **42**(5): 3103-3112.

Iqbal, M., Ashraf, M., Jamil, A. and Rehmaan, S. (2006). Does seed priming induce changes in the level of some endogenous plant hormones in hexaploid wheat plant under salt stress? *J. Inter. Plant Biol.* **48**: 181-189.

Jamal, A. F. M., Shimul, M. A. H., Shin- ichi, Sadia, S. and Roni, M. Z. K. (2014). Response of tomato *(Lycopersicon esculentum*) to salinity on hydroponic study. *Bangladesh res. Pub. J.* **10**(3): 249-254.

Janmohammadi, M., Moradi, P.D., Dezfuli, P. and Sharifzadeh, F. 2009. Seed invigouration techniques to improve germination and early growth of inbred lines of maize under salinity and drought stress. *Plant. Physiol.* **343**(4): 215-226.

Jogendra, S. E. V., Sastry, D. and Singh, V. 2012. Effect of salinity on tomato (*Lycopersicon esculentum* Mill.) during seed germination stage. *Physiol Mol. Biol. Plants.* **18** (1):45–50.

Katerji, N., Mastrorilli, M., Lahmer, F. Z., Maalouf, F., and Oweis, T. 2011. Faba bean productivity in saline-drought conditions. *Eur. J. Agron.* **35**: 2–12.

Kaur, S., Cupta, A.K. and Kaur, N. (2002). Effect of osmo and hydropriming of chickpea seeds on the performance of crop in the field. *Inter. Chickpea Pigeonpea Newsl.* **9**: 15-17.

Kaur, S., Gupta, A.K. and Kaur, N. (2003). Priming of chickpea seeds with water and mannitol the effect of salt stress on seedling growth. *Inter. Chickpea Pigeonpea Newsl.* **10:** 18-20.

Kaur, S., Gupta, A.K. and Kaur, N. (2005). Seed priming increases crop yield possibly by modulating enzymes of sucrose metabolism in chickpea. *J. Agron. Crop Sci.***191**: 81-87.

Kaya M.D., Okçub, G., Ataka, M., Çıkılıc, Y. and Kolsarıcıa, Ö. (2006). Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.). *Eur. J. Agron.* **24**: 291–295.

Kazem, G. G., Saeid, H. B., Ali, B. H., Salar F. A. (2014). Seed hydro-priming, a simple way for improving mung-bean performance under water stress. *Int. J. Bio. sci.* **4**(12):12-18.

Khan, H. A., Ayub, C. M., Pervez, M. A., Billal, R. M., Shahid, M.A. and Ziaf, K. 2005. Effect of seed priming with NaCl on salinity tolerance of hot pepper (*Capsicum annuum* L.) at seedling stage. *Soil and Environ.* **28**: 81-87.

Korkrmaz, A. and Pill, W.G. (2003). The effect of different priming treatments and storage conditions on germination performance of lettuce seeds. *Europ. J. Hort. Sci.* **68**(6): 260-265.

Kulkarni, G.N., and Eshanna, M.R. (1988). Effect of presoaking of corn seed on seed quality. *Seed Sci. Res.* **16**: 37-40.

Kumar, P. M., Chaurasia, A.K. and Michael Bara, B.M. (2017). Effect of osmo-priming on seed germination behaviour and vigour of chickpea (*Cicer arietinum* L.). *Inter. J. Sci. Nat.* **8**(2): 330-335.

Laghari, G.M., Laghari, M.R. Soomro, A.A., Leghari, S.J., Solangi, M. and Soomro, A. (2016). Response of mungbean to different hydro-priming periods and temperature regimes. *Sci. Inter. Res.* **28**(2): 1269-1273.

Lee, S. S. and Kim, J. H. (2000). Total sugars, α-amylase activity and germination after priming of normal and aged rice seeds. *Korean J. Crop Sci.* **45**: 108-111.

Mahajan, G., Sarlach, R.S., Japinder, S. and Gill, M.S. (2011). Seed priming effects on germination, growth and yield of dry direct-seeded rice. *J. Crop Improvement.* **25**: 409–417.

Mirza, H., Kamrun, N., and Masayuki, F. 2013. Plant response to salt stress an role of exogenous protectants to mitigate salt-induced damages laboratory of plant stress responses, *Dept. Applied Biol. Sci*. Faculty of Agriculture , Kagawa University , Kita-gun , Kagawa .761-0795

Mohamed, M., Abdullah, M. and Magdy, M. 2013.The potential role of seed priming with ascorbic acid and nicotinamide and their interactions to enhance salt tolerance in bean (*Vicia faba* L.). *AJCS*. **7**(13):2091-2100

Musa, A.M., Johansen C., Kumar, J. and Harris, D. (1999). Response of chickpea to seed priming in the High Barind Tract of Bangladesh. *Intl. Chickpea Pigeonpea Newsl.* **6**: 20-22.

Mwale, S., Hamusimbi, S. and Mwansa, K. (2003). Germination, emergence and growth of sunflower (*Helianthus annus* L). in response to osmotic seed priming. *Seed Sci. Technol.* **31**: 199-206.

Nyarko, G., Alderson, P. G. and Craigon, J. (2006). Towards cabbage seed production in the tropics. *Ghana J. Hort.* **5**: 120-124

Parmoon, G., Ebadi, A., Johanbakhsh, S. and Davari, M. (2013). The effect of seed priming and accelerated aging on germination and physiochemical changes in milk thistle (*Silybum marianum*). *Nat. Sci. Biol*. **5**: 204-211.

Posmyk, M.M. and Janas, K.M. (2007). Effects of seed hydropriming in presence of exogenous proline on chilling injury limitation in *Vigna radiata* L. seedlings. *Acta. Physiol. Plant.* **29:** 509–517.

Rashid, A., Harris, D., Hollington, P. and Khan, P. (2006). On-farm seed priming for barley on normal, saline and saline-sodic soils in NWFP, Pakistan. *Europ. J. Agron.* **24**: 276-281. 106

Rouhi, H.R., Aboutalebian, M.A. and Sharif-Zadeh, F. (2011). Effects of hydro and osmopriming on drought stress tolerance during germination in four grass species. *Inter. J. Agril. Sci*. **1**: 701–774.

Rowse, H.R. (1995). Drum Priming- A non-osmotic method of priming seeds. *Seed Sci. Technol*. **24**: 281-294.

Roy, N. K. and Srivastava, A. K. (1999). Effect of presoaking seed treatment on germination and amylase activity of wheat (*Triticum aestivum* L.) under salt stress conditions. **18**: 46-51.

Ruiz, M. S., Yasuor, H., Bengal, A., Yermiyahu, U., Saranga, Y. and Elbaum R. 2015. Salinity induced fruit hypodermis thickening alters the texture of tomato (*Solanum lycopersicum* Mill) fruit. *Sci Hort*. **192**: 244–249.

Safiatou, S. S. 2012. Effect of different seed priming methods on germination, seedling establishment and vigour in sorghum and bambara groundnut (*Vigna subterrenea* L.) Verdc. M.S. thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ashanti, Ghana. P.107

Saha, R.R., Hamid, A. and Haq, M.M. 2006. Seasonal variation in seed quality of two improved mungbean varieties. Proc. Final workshop and planing meeting. Punjab Agricultural University, Ludhiana. *AVRDC***.** **6**. p. 35-43.

Sarika, G., Basavaraju, G. V., Bhanuprakash, K., Chaanakeshava, V. and Radha, B. N. 2013. Investigation on seed viability and vigour of aged seed by priming in French bean. *Veg. Sci.* **40**: 169-173.

Shah, H., Jalwat, T., Arif, M. and Miraj, G. 2012. Seed priming improves early seedling growth and nutrient uptake in mungbean. *J. Plant Nutrition*. **35**(6): 805-816.

Shalaby, A. A., Saad A. F. and Mokhta A. M. A. 2015. Tomato yield response to salt stress during different growth stages under arid environmental conditions. *J. Soil Sci. and Agric. Eng.***6** (7): 863-880.

Shehzad, M., Ayub, M., Ahmad, A. H. U. and Yaseen, M. 2012. Influence of priming techniques on emergence and seedling growth of forage sorghum (*Sorghum bicolor* l.). *J. Plant Sci.* **22**: 154-58.

Singh, A. K., Bhatt, B. P., Upadhyaya, A., Kumar, S., Sundaram, P. K. and Singh, B. K. 2012. Improvement of faba bean (*Vicia faba* L.) yield and quality through biotechnological approach: a review. *Afr. J. Biotechnol.* **11**: 15264–15271

Singh, A., Dahiru, R., Musa, M. and Haliru, B. S. 2014. Effects of osmo-priming duration on germination, emergence and early growth of cowpea (*Vigna unguiculata* (L.) in the Sudan savanna Nigeria. *Inter. J. Agron.* **12**: 25-30.

Singh, V. P., Nath, S., Patra, S. S., Sahoo, S. and S. Rout, S. 2016. Effects of hydropriming and different sowing dates on growth and yield attributes of Lentil (*Lens culinaris* M.). *Res. Environ. Life Sci.* **9(**12): 1461-1466.

Singh, S., Bara, B. M. and Mishra, S. N. 2017. Effect of hydropriming and osmopriming on seed vigour and germination of pea (*Pisum sativum* L.) seeds. *J. Pharmacognosy and Phytochem*. **6**(3): 820-824.

Srivastava, A. K. and Bose, B. 2012. Effect of nitrate seed priming on phenology, growth rate and yield attributes in rice (*Oryza sativa* L.). *Vegetos*. **25**: 174-181. 109

Stofella, P. J., Lipucci, D. P., Pardossi, A. and Tognoni, F. (1992). Seedling root morphology and shoot growth after seed priming or pregermination of bell pepper. *Hort Sci*. **27**: 214–215.

Sun, Y. Y., Sun, Y. J., Wang, M. T. and Jun, M.A. (2010). Effects of seed priming on germination and seedling growth under water stress in rice. *Acta. Agron. Sin.* **36**(11): 1931-1940.

Tavili A., Zare, S. Moosavi, S. A. and Enayati, A. (2011). Effects of seed priming on germination characteristics of bromus species under salt and drought conditions. *American-Eurasian J. Agril. Environ. Sci.* **10**(2): 163-168.

Umair, A., Ali, S. and Hussain, S. (2010). Evaluation of different seed priming techniques in mungbean (*Vigna radiata*). *S. Envir.* **29**: 181-186.

Vishwas, V., Chaurasia, A. K., Bara, B. M., Debnath, A., Parihar, N. N., Brunda, K. and Saxena, R. 2017. Effect of priming on germination and seedling establishment of chickpea (*Cicer arietinum* L.) seeds. *J. Pharmacogn. Phytochem.* **6**(4): 72-74. 110

Yagmur, M. and Kaydan, D. (2008). Alleviation of osmotic stress of water and salt in germination and seedling growth of triticale with seed priming treatments. *Afr. J. Biotechnol*. **7**(13): 2156-2162.

Yamauchi and Winn, T. 1996. Rice seed vigor and seedling establishment in anaerobic soil. *Crop Sci.* **36**: 680-686.

Yucel, D. O. 2012. The effect of different priming treatments and germination temperatures on germination performance of lentil (*Lens culinaris* Medik) seeds. *ARPN J. Agril. Biol. Sci*. **7**(12): 122-125.

Zheng, G. H., Wilen, R. W., Slinkard, A. E. and Gusta, L. V. (1994). Enhancement of canola seed germination and seedling emergence at low temperature by priming, *Crop Sci.* **34**: 1589-1593.

Zhou, Y. G., Yang, Y. D., Zhang, Z. M., Wang, X. J. and Hu, X. J. (2002). Effects of chitosan on some physiological activity in germinating seed of peanut. *J. Peanut Sci*. **31**: 22-25.

APPENDICES

Appendix I. Characteristics of Horticulture Farm soil as analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

Morphological features	Characteristics
Location	Horticulture Garden ,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly level
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fallow – Kohlrabi

Appendix II. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from October 2017 to April 2018.

Month	Air temperature (°c)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2017	31.6	23.8	78	172.3	5.2
November, 2017	29.6	19.2	77	34.4	5.7
December, 2017	26.4	14.1	69	12.8	5.5
January, 2018	25.4	12.7	68	7.7	5.6
February, 2018	28.1	15.5	68	28.9	5.5
March, 2018	32.5	20.4	64	65.8	5.2
April, 2018	33.7	23.6	69	165.3	4.9

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

Appendix III. Analysis of Variance on Plant height at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	105.389	2	52.694	1.897	.166
Salinity	873.111	3	291.037	62.458	.000
Priming × Salinity	1004.222	11	91.293	121.724	.000

Appendix IV. Analysis of Variance on Plant height at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	153.167	2	76.583	1.812	.179
Salinity	1302.444	3	434.148	56.577	.000
Priming × Salinity	1476.000	11	134.182	44.727	.000

Appendix V. Analysis of Variance on Plant height at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	228.451	2	114.225	1.854	.173
Salinity	1940.805	3	646.935	64.454	.000
Priming × Salinity	2182.563	11	198.415	59.949	.000

Appendix VI. Analysis of Variance on Number of Branch at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	2.667	2	1.333	7.233	.002
Salinity	1.194	3	.398	1.686	.190
Priming × Salinity	6.083	11	.553	4.977	.000

Appendix VII. Analysis of Variance on Number of Branch at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	6.167	2	3.083	6.977	.003
Salinity	4.750	3	1.583	3.167	.038
Priming × Salinity	14.083	11	1.280	4.609	.001

Appendix VIII. Analysis of Variance on Number of Branch at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	4.389	2	2.194	4.367	.021
Salinity	11.639	3	3.880	13.302	.000
Priming × Salinity	16.972	11	1.543	9.258	.000

Appendix XI. Analysis of Variance on Number of Leaf at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	15.722	2	7.861	7.501	.002
Salinity	19.417	3	6.472	6.705	.001
Priming × Salinity	42.972	11	3.907	12.785	.000

Appendix X. Analysis of Variance on Number of Leaf at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	2.889	2	1.444	1.979	.154
Salinity	12.972	3	4.324	9.884	.000
Priming × Salinity	19.639	11	1.785	5.843	.000

Appendix XI. Analysis of Variance on Number of Leaf at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	10.722	2	5.361	3.003	.063
Salinity	51.639	3	17.213	30.601	.000
Priming × Salinity	64.306	11	5.846	26.307	.000

Appendix XII. Analysis of Variance on Number of Leaflet at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	113.389	2	56.694	6.951	.003
Salinity	173.889	3	57.963	8.889	.000
Priming × Salinity	360.556	11	32.778	35.758	.000

Appendix XIII. Analysis of Variance on Number of Leaflet at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	32.167	2	16.083	1.974	.155
Salinity	142.333	3	47.444	9.569	.000
Priming × Salinity	225.667	11	20.515	6.536	.000

Appendix XIV Analysis of Variance on Number of Leaflet at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	110.056	2	55.028	3.638	.037
Salinity	412.556	3	137.519	22.376	.000
Priming × Salinity	527.222	11	47.929	14.028	.000

Appendix XV Analysis of Variance on Leaf Length at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	397.042	2	198.521	3.427	.044
Salinity	1772.743	3	590.914	35.282	.000
Priming × Salinity	2196.354	11	199.669	42.659	.000

Appendix XVI. Analysis of Variance on Leaf Length at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	439.625	2	219.813	3.668	.036
Salinity	1816.410	3	605.470	32.250	.000
Priming × Salinity	2293.187	11	208.472	40.349	.000

Appendix XVII. Analysis of Variance on Leaf Length at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	431.284	2	215.642	3.553	.040
Salinity	1830.048	3	610.016	32.318	.000
Priming × Salinity	2297.036	11	208.821	36.577	.000

Appendix XVIII. Analysis of Variance on Leaf Breadth at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	149.542	2	74.771	3.032	.062
Salinity	759.845	3	253.282	39.847	.000
Priming × Salinity	921.808	11	83.801	48.533	.000

Appendix XIX. Analysis of Variance on Leaf Breadth at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	128.782	2	64.391	2.472	.100
Salinity	786.962	3	262.321	41.659	.000
Priming × Salinity	940.453	11	85.496	42.742	.000

Appendix XX. Analysis of Variance on Leaf Breadth at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	138.084	2	69.042	2.540	.094
Salinity	824.641	3	274.880	41.793	.000
Priming × Salinity	988.023	11	89.820	45.781	.000

Appendix XXI. Analysis of Variance on Leaflet Length at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	46.002	2	23.001	3.868	.031
Salinity	183.819	3	61.273	33.560	.000
Priming × Salinity	232.983	11	21.180	54.895	.000

Appendix XXII. Analysis of Variance on Leaflet Length at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	51.491	2	25.745	4.024	.027
Salinity	195.882	3	65.294	31.310	.000
Priming × Salinity	250.669	11	22.788	45.780	.000

Appendix XXIII. Analysis of Variance on Leaflet Length at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	51.887	2	25.943	4.014	.028
Salinity	198.947	3	66.316	32.046	.000
Priming × Salinity	253.494	11	23.045	47.380	.000

Appendix XXIV. Analysis of Variance on Leaflet Breadth at 30 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	27.711	2	13.855	7.685	.002
Salinity	55.930	3	18.643	19.072	.000
Priming × Salinity	84.250	11	7.659	62.101	.000

Appendix XXV. Analysis of Variance on Leaflet Breadth at 45 DAS of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	31.115	2	15.558	7.758	.002
Salinity	62.445	3	20.815	19.117	.000
Priming × Salinity	93.854	11	8.532	59.643	.000

Appendix XXVI. Analysis of Variance on Leaflet Breadth at Harvest of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	32.032	2	16.016	7.392	.002
Salinity	67.490	3	22.497	19.975	.000
Priming × Salinity	99.870	11	9.079	59.535	.000

Appendix XXVII. Analysis of Variance on Number of Inflorescence/Plant of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	1.722	2	.861	.669	.519
Salinity	36.222	3	12.074	48.296	.000
Priming × Salinity	40.222	11	3.657	21.939	.000

Appendix XXVIII. Analysis of Variance on Number of Flower/Inflorescence of faba bean influenced by salinity and seed priming

Source of Variance	SS	Df	MS	F-Value	Significance Level
Priming	4.222	2	2.111	5.766	.007
Salinity	4.750	3	1.583	4.385	.011
Priming × Salinity	12.306	11	1.119	6.712	.000

Appendix XXIX. Analysis of Variance on Total Number of Flower/Plant of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	105.556	2	52.778	2.664	.085
Salinity	569.000	3	189.667	31.907	.000
Priming × Salinity	725.222	11	65.929	46.538	.000

Appendix XXX. Analysis of Variance on Pod Length of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	70.390	2	35.195	3.741	.034
Salinity	252.510	3	84.170	20.989	.000
Priming × Salinity	364.068	11	33.097	47.366	.000

Appendix XXXI. Analysis of Variance on Pod Breadth of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	.088	2	.044	1.778	.185
Salinity	.604	3	.201	21.388	.000
Priming × Salinity	.738	11	.067	9.633	.000

Appendix XXXII. Analysis of Variance on Weight/Pod of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	1.439	2	.720	1.053	.360
Salinity	19.704	3	6.568	49.013	.000
Priming × Salinity	21.407	11	1.946	18.070	.000

Appendix XXXIII. Analysis of Variance on Total Pod /Plant of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	77.722	2	38.861	2.603	.089
Salinity	450.306	3	150.102	40.027	.000
Priming × Salinity	562.306	11	51.119	153.356	.000

Appendix XXXIV. Analysis of Variance on Total Pod Weight/Plant of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	4884.743	2	2442.372	2.487	.099
Salinity	30050.260	3	10016.753	44.291	.000
Priming × Salinity	36923.548	11	3356.686	221.434	.000

Appendix XXXV. Analysis of Variance on Root Length of faba bean influenced by salinity and seed priming

Source of Variance	SS	df	MS	F-Value	Significance Level
Priming	31.822	2	15.911	15.468	.000
Salinity	3.894	3	1.298	.671	.576
Priming × Salinity	48.514	11	4.410	6.135	.000