# RESPONSE OF SEED PRIMING AND VERMICOMPOST ON GERMINATION, GROWTH AND YIELD OF OKRA


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# *CERTIFICATE*

This is to certify that the thesis entitled **“RESPONSE OF SEED PRIMING AND VERMICOMPOST ON GERMINATION, GROWTH AND YIELD OF OKRA”** 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 **MASTERS OF SCIENCE (M.S.)** in **HORTICULTURE,** embodies the result of a piece of bonafide research work carried out by **RABEYA AKTER RABU**, Registration No.**17-08250** 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: December, 2018**
**Dhaka, Bangladesh**

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# Dedicated to
# My
# Beloved Parents

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***The Author***

# RESPONSE OF SEED PRIMING AND VERMICOMPOST ON GERMINATION, GROWTH AND YIELD OF OKRA

## ABSTRACT

The experiment was carried out at the Horticultue farm of Sher-e-Bangla Agricultural University during the period of march to July, 2018. The experiment was carried out to evaluate the response of seed priming and vermicompost on germination, growth and yield of okra .The experiment consists of two factors such as three levels of seed priming treatments *viz*, $P_0$ No priming (with water), $P_1$ (Halopriming; $CaCl_2$ - 1 ppm) and $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** and four levels of vermicompost *viz*, $V_0$ (control; no vermicompost), $V_1$ (5 t $ha^{-1}$ vermicompost), $V_2$ (7.5 t $ha^{-1}$ vermicompost) and $V_3$ (10 t $ha^{-1}$ vermicompost) was laid out in Randomized Complete Block Design with the three replications. Results showed that the highest percent of (%) seed germination (95.75%) was found from $P_2V_3$ whereas the lowest percent of (%) seed germination (73.00%) was found in $P_0V_0$. Regarding growth parameters, the highest plant height (152.40 cm) and number of leaves $plant^{-1}$ (45.40) were achieved from $P_2V_3$. In case of yield contributing parameters and yield, the highest number of flowers $plant^{-1}$ (32.62), number of fruits $plant^{-1}$ (23.72), fruit length (18.80 cm), fruit diameter (2.16 cm), single fruit weight (15.34 cm), fruit yield $plot^{-1}$ (4.36 kg) and fruit yield $ha^{-1}$ (15.15 t) were achieved from the treatment combination of $P_2V_3$ whereas the lowest was recorded from the treatment combination of $P_0V_0$. In terms of economic analysis, the highest gross return, net return and BCR (1.70) were obtained from the treatment combination of $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t $ha^{-1}$ vermicompost) whereas the lowest gross return, net return and BCR (1.17) were obtained from $P_0V_0$. So, treatment combination $P_2V_2$ was found promising for okra production.

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**ABBREVIATIONS AND ACRONYMS**

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| cm | = | Centimeter |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan’s Multiple Range Test |
| *et al.,* | = | And others |
| e.g. | = | exempli gratia (L), for example |
| etc. | = | Etcetera |
| FAO | = | Food and Agricultural Organization |
| g | = | Gram (s) |
| i.e. | = | id est (L), that is |
| Kg | = | Kilogram (s) |
| LSD | = | Least Significant Difference |
| $m^2$ | = | Meter squares |
| ml | = | MiliLitre |
| M.S. | = | Master of Science |
| No. | = | Number |
| SAU | = | Sher-e-Bangla Agricultural University |
| var. | = | Variety |
| $^oC$ | = | Degree Celceous |
| % | = | Percentage |
| NaOH | = | Sodium hydroxide |
| GM | = | Geometric mean |
| mg | = | Miligram |
| P | = | Phosphorus |
| K | = | Potassium |
| Ca | = | Calcium |
| L | = | Litre |
| µg | = | Microgram |
| USA | = | United States of America |
| WHO | = | World Health Organization |

# CHAPTER I

# INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a member of Malvaceae family and is also known as Lady's finger. It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Thakur and Arora, 1986).). It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1990). Its tender green fruits are popular as vegetable among all classes of people in Bangladesh and elsewhere in the world.

Okra is a nutritious and delicious vegetable, fairly rich in vitamins and minerals. Per 100 gm of edible portion of pod has moderate levels of vitamin A (0.01 mg) and C (18 g), calcium (90 mg), phosphorus and potassium. The content of thiamine (0.07 mg), riboflavin (0.08 mg) and niacin (0.08 mg) per 100 g edible portion of pod is higher than that of many vegetables (Rashid, 1990). Tender pods have high mucilage content and are used in soups and gravies. The pods also have some medicinal value and a mucilaginous preparation from the pod can be used as a plasma replacement or blood volume expander.

In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during kharif season and around 70% in the rabi season (Anon., 1993). Therefore, as vegetable okra can get importance in kharif season in our country context. The consumption of vegetables in Bangladesh is 62 g/day/person, which is far below the standard requirement of 220 g/day/person (BBS, 2015). Therefore, there is a big gap between the requirement and per capita vegetable consumption in Bangladesh. Successful okra production may contribute partially in solving vegetable scarcity of summer season in our country. In Bangladesh the total production of okra is about 246 thousand tons which was produced from 7287.5 hectares of land in the year 2010 with average yieldabout 3.38 t/ha which is very low (BBS, 2011) compared to that of other developedcountries.

Germination and seedling establishment are critical stages in the plant life cycle and can contribute in increasing total crop production. Once sown, seeds spend a great deal of time just absorbing water from the soil. If this time is minimzed by soaking seeds in water before sowing (seed priming), seed germination and seedling emergence is more rapid. It also causes higher seedling establishment. The three early phases of germination are: (i) imbibition, (ii) lag phase, and (iii) protrusion of the radical through the testa (Simon, 1984).Priming is a procedure that partially hydrates seed, followed by drying of seed, so that germination processes begin, but radicle emergence does not occur. Methods of seed priming have been described in detail by Bradford (1986) and Khan (1992) and include soaking seed in water or osmotic solution, and intermixture with porous matrix material.

Organic farming has the twice objectives of the system being sustainable and environment friendly (Magar, 2004). Organic fertilizers depend on soil organisms which break them down to release nutrients; therefore, most are effective only when soil is moist and warm enough for the microorganisms to be active. The continued use of organic fertilizers increased soil organic matter, better water infiltration and aeration, higher soil biological activity as the materials decompose in soil and increase yields after the year of application (Ceglarek *et al.*, 2002). The effectiveness of such materials can be improved by combining them with chemical fertilizers.

Vermicompost can play a vital role in sustaining soil fertility and crop production more than the use of chemical fertilizers. Nutrient level of the vermicompost is about two times higher than that of ordinary poultry manure. Vermicompost is an excellent product because it tends to hold more nutrients over a longer period without adversely affecting the environment. Among the sources of available organic manures, vermicompost is a potential source due to the presence of readily available plant nutrient and number of beneficial micro-organisms such as N fixing, P solubilizing and cellulose decomposing organisms (Sultan, 1997). It increases macropore space resulting in improved air-water relationship in the soil which favorably affects plant growth (Marinari *et al.,* 2000). The application of organic matter including vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al.,* 1999). It also reduces water- soluble chemical species, which cause possible environmental contamination. Vermicompost contains more organic matter, N, P, S, Ca and Mg. Warm-worked composts have shown better texture and soil enhancing properties, contained typically higher percentages of N, P and K (Zahid, 2001).

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

1. To evaluate the effect of priming treatments on the germination, growth and yield of okra
2. To estimate the effect of different doses of vermicompost on growth and yield of okra
3. To find out the combined effect of seed priming and different doses of vermicompost on germination response, growth and yield of okra

# CHAPTER II

# REVIEW OF LITERATURE

Seed priming can reduce the water requirement and increase germination percentage, adaptability to adverse situation which contribute to increase total production of crops. The following review is presented regarding quality improvement of some vegetable seedlings as influenced by seed priming.

## 2.1 Effect of seed priming

Farooq *et al*. (2019) observed that seed priming is a presowing technique in which seeds are moderately hydrated to the point where pregermination metabolic processes begin without actual germination. Seeds are then redried to near their actual weight for normal handling. Seeds can be soaked in tap water (hydropriming), aerated low-water potential solutions of polyethylene glycol or salt solutions ($KNO_3$, $KH_2PO_4$, KCl, NaCl, $CaCl_2$ or $MgSO_4$; osmopriming), plant growth regulators, polyamines (hormonal priming), plant growth-promoting bacteria (biopriming), macro or micronutrients (nutripriming) or some plant-based natural extracts.

Tizazu *et al*. (2019) conducted a laboratory test with the objective of evaluating of seed priming, pesticide dressing and coating on germination of sesame (*Sesamum indicum* L.). Twelve treatments, untreated seed ($T_1$), hydro-primed seed ($T_2$), seed primed with $CaCl_2$ ($T_3$), seed treated with dynamic ($T_4$), hydro-primed seed + treated with dynamic ($T_5$), seed primed with $CaCl_2$+ treated with dynamic ($T_6$), seed treated with dynamic + disco ($T_7$), hydro-primed seed + treated with dynamic + disco ($T_8$), seed primed with $CaCl_2$ + treated with dynamic + disco ($T_9$), seed treated with dynamic + disco +genius coating($T_{10}$), hydro-primed seed + treated with dynamic +disco + genius coating($T_{11}$) and seed primed with $CaCl_2$ + treated with dynamic + disco + genius coating ($T_{12}$) were tested. Physiological quality data like germination percentage, root length, shoot length and vigor index were taken. The study revealed that germination percentage, root length, shoot length and vigor index of sesame were significantly ($p < 0.01$) affected by seed priming and coating treatments. From this experiment, higher germination percentage (91.50%) was recorded by primed seeds with water. However, the root length (4.78 cm), shoot length (6.33 cm) and vigor index (928.48) of sesame was higher for seeds coated with dynamic + disco.

Chan-Su-Yi (2018) carried out an experiment to study the effect of various priming treatments to overcome germination hindrance of fresh or stored seeds of okra. There were five treatments with five replications. The experiment was laid out in a Completely Randomized Design (CRD). Seeds were germinated using between paper method. The treatments were $T_1$: control; $T_2$: soaking in water for 24 hours; $T_3$: soaking in 80% $H_2SO_4$ solution for 3 minutes; $T_4$: soaking in 60°C hot water for 40 minutes; and T5: soaking in 0.3% $KNO_3$ solution for 1 hour. Germination of okra seeds were carried out under alternating temperature regimes of 30/20°C with 8 hours light and 16 hours darkness. Analysis of the data revealed that accession and treatment significantly affected germination percentage of okra while the interaction of accession x treatment did not. $T_3$ marked the highest germination percentage for both accessions. For germination index, the interactions of accession × treatment, main effect of both accession and treatment showed significant differences. Both accessions showed interesting different germination index results. The results obtained indicated that different accessions showed different trend in the germination rate of okra seeds.

Bhattacharya and Bose (2017) carried an experiment to study effects of seed priming with $MgSO_4$, Salicyclic Acid and Jasmonic acid on the response of two Chick pea varieties *viz*. Pusa 362 ($V_1$) and Avrodhi ($V_2$), keeping non primed seeds and hydroprimed seeds as controls. Priming response was evaluated at different time intervals of germination in the laboratory. It was found that germination percentage, dry and fresh weight of plumule, radical and cotyledon, amylase activity, proline, protein, soluble sugar and insoluble sugar contents increased in both osmopriming with $MgSO_4$ and priming with phytohormones like salicyclic acid and jasmonic acid. The effect of salicyclic acid in respect of germination percentage showed considerable improvement over hydro priming. jasmonic acid as priming agent was not so prominent in comparison to other treatments when germination percentage is considered but it showed a significant increase in respect of root and shoot length and dry weight of plumule.

Kamra *et al*. (2017) conducted a study to examine the effect of seed priming with different chemicals on germination and nursery raising of Ridge Gourd (*Luffa acutangula*) and Summer Squash (*Cucurbita pepo*). The seeds of both ridge gourd and summer squash were treated with $GA_3$ (0.1% and 0.2%) and $KNO_3$ (0.3% and 0.4%) for 24 hrs at room temperature on $14^{th}$ Feb, 2017. Untreated seeds of both ridge gourd and summer squash were used as control. After 24 hrs of priming, the seeds were surface washed with distilled water. 10 treated seeds of each treatment were then sown in germination tray filled with growing media (cocopeat) and 10 control seeds of both vegetables were sown in plastic cups containing cocopeat. Both treated and untreated (control) seeds were then allowed to grow in laboratory for 30 days. Priming with 0.2% $GA_3$ solution enhanced the germination initiation, percentage of germination, mean germination time and vigour index of ridge gourd and summer squash than unprimed seeds. Average seedling length was higher in 0.3% $KNO_3$ primed seeds than the other seeds.

Soubhagyabehera, (2016) reported when tomato seeds were primed with $GA_3$ in Utkal Kumari germination was increased by 30.56%. Venkatasubramanian and Umarani (2010) conducted storage studies to compare four different methods of priming *viz.*, hydropriming, halopriming, sand matrix priming and osmopriming accomplished for two durations. The results revealed that viability of primed seeds were dependent on the method as well as duration of priming. Among the protocols studied, hydropriming (48 hours) for tomato and sand matrix priming (80% water holding capacity, 3 days) for eggplant and chilli were established as best methods of seed priming.

Khan *et al*. (2015) conducted a field trial to assess the role of seed priming techniques and planting methods for improving drought resistance in maize. Maize seeds were soaked in an aerated solution of $CaCl_2$ (osmopriming –1.25 MPa) and distilled water (hydropriming), while untreated dry seeds were taken as controls. Primed and untreated seeds were sown on either ridges or a flat seedbed and were subjected to drought at vegetative and tasseling stages. Seed priming, osmopriming with CaCl2, mitigated the damaging effects of drought on the root system, yield, and related traits. Interestingly, under vegetative drought, hydropriming performed better than osmopriming for 1000-grain weight; however, the supremacy of osmopriming over hydropriming was evident in all other yield-related attributes under vegetative and terminal drought stress. Net returns and benefit cost ratio (BCR) declined under drought conditions; nevertheless, priming techniques over control and ridge sowing over flat sowing were helpful in improving the net returns and BCR. Combination of ridge sowing and osmopriming with CaCl2 can play a vital role in mitigating the adverse effects, increasing the production of maize and net returns under normal and deficit water conditions.

Tiwari *et al*. (2016) carried out a field experiment, one year old seeds of two late sown wheat varieties *viz*., HUW 234 and WR544 were primed with tap water and inorganic salts including $KNO_3$ and $Mg(SO_4)_2$ singly (in 0.2% solutions) for 12 hours. After priming, the seeds were taken out and allowed for shade drying till returning to their original moisture content. One set of unprimed control was also kept simultaneously. The data showed that seed priming with tap water and inorganic salts including $KNO_3$ and $Mg(SO_4)_2$ singly in 0.2 percent solution for 12 h significantly enhanced seed germination, shoot/root length, seedling dry weight, vigour index and finally the total biomass and grain yield in both the varieties evaluated over unprimed control. Among the treatment, $KNO_3$ priming displayed maximum values in respect of all characters studied followed by $Mg(SO_4)_2$ and tap water. Varieties differed significantly in respect of shoot/root length, seedling dry weight, spike length, number of spikelets/spike, number of grains and test weight.

Hegazi and Amal (2014) initiated a study to determine the seed yield and quality of a local genotype okra var. Sabahia in relation to seed priming and water stress. The main plots represented two irrigation regimes either normal or stress 20 days or 30 days intervals respectively, whereas the priming treatments represented the subplots. For priming treatments, seeds were soaked for 24 hours either in water (hydropriming) or in a 3% solution of $Na_2HPO_4$, $MgSO_4$, or KCl (osmopriming), whereas dry seeds represented the control. Results indicated that all plant traits determined were reduced under water stress while this reduction was improved in the primed seeds. Using $Na_2HPO_4$ or $MgSO_4$ seed priming treatments under both water regimes applied gave the highest and best results regarding plant growth, seed yield and quality. Obtained results also showed that seed priming with KCl gave lower positive effects in this concern and such results seemed to be higher than those obtained by hydropriming treatments. In addition, results clearly showed that okra plants could resist the applied water stresses treatments as a result of seed priming processes used which were found to cause accumulation of some osmolytes as proline.

Sikhondze and Ossom (2011) conducted an experiment to determine how long okra seeds should be primed in order to influence seedling growth and development. Four time durations (6, 12, 24, or 36 hours) were taken for hydro priming okra seeds. The results showed that seedlings grown from seeds that are primed for 24 hours had the greatest mean stem length and diameter, as compared to other durations and control. Tajbakhsh *et al.,* (2004) conduct experiment on onion carried different treating methods. The results indicated that hydro-priming in high humidity leads to shortening the average germination time. Kaur *et al.,* (2002) found that priming of pea by water and mannitol (4%) for 12 hours at 25°C increased the number and biomass of plants knots. The positive effect of hydro priming may be due to the maintenance of tissue water content, increase in antioxidant activities and carbohydrate metabolism (Farooq *et al.,* 2008). Hydro-priming of bean seeds in water for 7-14 hours can improve the plant performance (Ghassemi-Golezani *et al.,* 2010).

Sharma *et al.,* (2013) reported that he has taken four different priming methods like hydro-priming, osmopriming, halo-priming and solid matrix along with control. The hydro-priming technique for 12 hour duration and SM priming with calcium aluminum silicate for 24 hour significantly increased the seed germination, seedling vigour, mean germination time and marketable fruit yield. Priming in seed improve seed germination, seedling vigour and fruit yield in okra.

Saleem *et al.* (2014) set an experiment to study the effect of seed soaking on seed germination and growth of bitter gourd cultivars. Three cultivars of bitter gourd Faisalabad Long, Jaunpuri and Palee were soaked in water for various soaking durations (4, 8, 12 and 16 hours) along with control to determine the optimal soaking duration and find out the best growing cultivar. The highest germination percentage (85.18%), number of branches plant-1 (8.64), fruits plant$^{-1}$ (20.70) were obtained when the bitter gourd seeds soaked for 12 hours. Earlier emergence (6.28) and earlier flowering (39.40) were recorded in plants where seeds soaked for 16 hours. Seed soaking in water for 12 hours has the potential to improve germination, seedling growth of bitter gourd cultivars.

Mehta *et al.* (2014) reported that pre-sowing seed priming helps to improve germination and stand establishment. Seeds of bitter gourd cultivar Solan Hara were hydro-primed at 20 C between wet germination papers for different durations keeping unprimed seeds as control. The plateau phase (Phase-II) with little change in water content from 53.3 to 57.3% (after 24 hours to 72 hours of seed priming) found as seed priming regime for bitter gourd. Significantly higher speed of germination, total% germination, seedling length, seedling dry weight, vigour index-I and II were recorded in hydro-priming for 72 hours as compared to other durations and control. Based on seed priming regime i.e. phase-II of seed germination and performance with respect to seed quality parameters it was found that 72 hours of seed priming is optimum in bitter gourd.

Abdoli (2014) set an experiment to evaluate the effects of seed priming on certain important seedling characteristic and seed vigor of fennel *(Foeniculum vulgare L.)* at Department of Agronomy and Plant Breading, Faculty of Agriculture, Maragheh University in Maragheh state, Iran. Treatment included untreated seeds (control) and those primed in water ($H_2O$), sodium chloride (NaCl, 100 mM) and polyethylene glycol 6000 (PEG-6000,water potential-1.6 MPa), in darkness for 18 hrs. Among them unsoaked seed (control) and hydropriming treatments had the lowest plumule, radicle and seedling length, seedling dry weight and seedling vigor index. PEG and NaCl in all of traits were better than the water priming treatments, respectively. PEG-6000 (1.6 MPa) is the best treatment for breaking of fennel seed dormancy.

Rastin *et al.* (2013) conducted an experiment in 2011 in Arak, Iran, to evaluate the effect of seed priming treatments on the seed quality of red bean. The experiment was conducted in split plot in the form of a randomized complete block design with three replications and two factors. The first factor was primary seed priming, in which seeds were or were not treated with water, for 14 hours. The second factor was complementary seed priming which was conducted after drying the seeds treated in the first step and water, 100 ppm KCl, 0.5% $CaCl_2.2H_2O$, 50 ppm $KH_2PO_4$ and 20 ppm $GA_3$ were used to treat seeds for 14 hours. They found that Primary seed priming had no significant effect on none of the measured traits but complementary seed priming significantly affected plant dry matter, grain yield, 100 grain weight and the number of pods. The highest plant dry matter (53.06 g) and the highest grain yield (5.98 t/ha) were achieved when seeds were first treated with water (as the primary seed priming) and after drying were treated with GA3 (as the complementary seed priming).

Meena *et al.* (2013) conducted an experiment for two consecutive years 2010-11 and 2011-12 to evaluate the influence of hydropriming on the water use efficiency and grain yield of wheat *(Triticum aestivum* L.) under moisture stress. The hydroprimed and pregerminated seeds established earlier than dry seeds leading to better crop establishment under optimum, sub optimum soil moisture as well as dry soil conditions leading to higher tillering and grain yield.

Ajirlo *et al.* (2013) reported that germination and early growth under prevailing environmental conditions improves by seed priming technique. Their result showed that all the priming treatments significantly affect the fresh weight, shoot length, number of roots, root length, vigor index, time to start emergence, time to 50% emergence and energy of emergence of forage maize. The interactive effect of varieties and priming techniques were not significant for mean emergence time and coefficient of uniformity of emergence.

Aymen and Cherif (2013) reported that with increasing salinity, emergence traits (total emergence, mean emergence time), growth parameters (plant height, shoot fresh and dry weight) and mineral contents ($K^+$ and $Ca^{2+)}$ decreased, but to a less degree in primed seeds. At different salinity levels, primed seeds possessed higher emergence and growth rate than control.

Dastanpoor *et al.* (2013) carried out an experiment to find out the influence of hydro priming treatments on seed parameters of *Salvia officinalis* L. (sage). Seeds of sage were treated by hydro priming at three temperatures 10, 20, 30°C for 0, 12, 24 and 48 h. Hydro priming clearly improved the final germination percentage (FGP), mean germination time (MGT) and synchronized the germination of seeds at each three temperature. All the treatments resulted in germination enhancement except hydro primed seeds for 48 h at temperature 30°C. Hydro priming (12 h at 30°C) was most effective in improving seed germination that FGP was increased by 25.5% as compared to that of non-primed seeds.

Kisetu *et al.* (2013) conducted a field study to assess the effects of priming okra *(Abelmoschus esculentus* L.) seeds var. clemson spineless in tap-water, di ammonium phosphate (DAP) and Minjingu (M) Mazao fertilizers at varying hours from non-primed (absolute control) to 48 h at an interval of 12 h. The priming materials used contained 0.115 g $L^{-1}$ DAP, 1 g $L^{-1}$ M-Mazao, and 1 L tap-water. Seeds primed with DAP for 36 h gave the highest number of pods (6) as compared with the absolute control (3), tap-water (5) at 36 h and M-Mazao (5) at 12 h. The highest yield (4.52 t/ha) was obtained for DAP at 36 h compared with M-Mazao (3.32 t $ha^{-1}$) at 12 h, tap-water (3.16 t $ha^{-1}$) at 36 h and absolute control (1.88 t $ha^{-1}$).

Ogbuehi *et al.* (2013) carried out a field experiment in 2012 at Teaching and Research Farm of faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri to assess the effect of hydro priming duration on performance of morphological indices of Bambara groundnut *(Vigna subterranean* (L.) Verdc). The treatments were 12hrs, 24 hrs, 36 hrs, 48 hrs and 0 hrs which served as control (untreated seeds). Among the treatments 24hours hydro priming duration found to improve the performance of growth indices measured whereas the 36 hours was the least effective.

Ali *et al.* (2013) reported that seed priming improves irrigation water use efficiency, yield, and yield components of late-sown wheat under limited water condition. Seed priming treatments reduced the mean emergence time and promoted germination, early canopy development, and tillering in comparison to the untreated control. The number of fertile tillers, plant height, 1000-grain weight, and grain and biological yield were also increased by different priming techniques. On-farm priming and hydropriming for 12 h gave higher grain and biological yields and higher harvest index than other priming treatments. Seed priming increased the irrigation water use efficiency (IWUE) of all irrigation regimes. Grain yields were linearly increased at 100% ETo while maximum IWUE was achieved at 80% ETo.

Amoghein *et al*. (2013) conducted an experiment on the effect of osmopriming and hydropriming on the different index of germination & early growth of wheat under salty stress. They reported that the simple effect of priming for all the characteristics under study, except of shoot dry weight and simple effect of salinity for all the characteristics under study in the experiment at 1% level was significantly simple effect of seed soaking time (4 hours) only on hypocotyle length was significantly. Interaction of salinity on seed priming for root dry weight, longest root on the 5% level showed a statistical significant difference. Also shoot dry weight had a positive and significant correlation with the first and second leaf length, root number and root longest at the %1 level.

Azadi *et al.* (2013) set an experiment on seed germination, seedling growth and enzyme activity of wheat seed primed under drought and different temperature conditions. They found that the highest germination percentage (GP) (94.33%), normal seedling percentage (NSP) (92%), germination index (GI) (44.85) and seedling length (11.03 cm) were attained from osmopriming in control conditions. Seed priming with PEG 6000 significantly increased germination characteristics as compared to the unprimed seeds under drought stress. Osmopriming also increased catalase (CAT) and ascorbate peroxidase (APX) as compared to the unprimed.

Abbasdokhta *et al.* (2013) studied the effect of priming and salinity on physiological and chemical characteristics of wheat *(Triticum aestivum* L.). They showed that primed plants significantly reduced its gas exchanges by accelerating senescence under a series of salt stress, which became more serious along with the increasing of salt concentrations, especially at 21 d after anthesis. Under each level of salt stress, dry matter accumulation of primed plants was always higher than the non-primed plants. Primed plants had higher potassium selectivity against sodium than non-primed plants. Salt stresses caused significant declines in growth period of wheat by accelerating leaf senescence at reproductive stage. Primed plants of wheat successfully preserved normal growth by maintaining *Pn*, K+/Na+, leaf area duration (LAD) and dry matter accumulation (DMA), while non-primed plants decreased considerably in those parameters.

Dey *et al.* (2013) carried out an experiment at the Seed Laboratory of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period from January to April 2012 to study the effect of hydropriming on field establishment of seedlings obtained from primed seeds of *Boro* rice cv. BRRI dhan29. Seeds were soaked in water for 0, 24, 30, 36, 42, 48, 54 and 60 hours. They found that priming treatments had significant effect on germination and other growth parameters of rice seedlings. The highest germination, vigor index, population $m\text{-}^2$, length of shoot and root and their weights were found at 15 and 30 DAS. The lowest mean germination time was observed from hydropriming of seeds with 30 hours soaking. On the contrary, no priming treatment showed the lowest germination, vigor index, population $m\text{-}^2$, and the highest mean germination time.

Tilahun-Tadesse *et al.* (2013) carried out a field experiment in 2010 and 2011 at Fogera plains, Ethiopia to study the effect of hydro-priming and pre-germinating rice seed on the yield and response of the crop to terminal moisture stress. They found that planting pre-germinated seeds as well as seeds soaked and dried for 24 hrs at the local (farmers') sowing time resulted in significantly earlier seedling emergence, heading, and maturity. Higher numbers of productive tillers, filled spikeletes, leaf area index, crop growth rate, net assimilation rate, grain yield, biomass yield, and harvest index were recorded in response to planting pre germinated seeds followed by seeds soaked and dried for 24 hrs at farmers' sowing time.

Shirinzadeh *et al.* (2013) set an experiment to evaluate the effects of seed priming with Plant Growth Promoting Rhizobacteria (PGPR) on grain yield and agronomic traits of barley cultivars in 2009. Seed priming with Plant Growth Promoting Rhizobacteria affected plant height, spike length, number of spike per area, grains per spike, 1000-grain weight and grain yield, significantly. Maximum of these traits were obtained by the plots in which seeds were inoculated with *Azospirillium* bacteria. The highest grain yield (3063.4kg.ha$^{-1}$) was obtained in cultivar of Makori. Application of PGPR bacteria (especially Azospirillum) had an appropriate performance and could increase grain yield to an acceptable level and could be considered as a suitable substitute for chemical fertilizer in organic agricultural systems

Hoseini *et al.* (2013) examines the effect of priming on laboratory experiments and field studies. They found that the influence of various treatments on germination percentage and rate were significant. The length of plumule and radicle in magnetic field in comparision with others were the highest. Some treated seeds were stored and reduction of germination percentage were observed. Considering physiological characters, the most Leaf Area Index and Leaf Area Ratio were seen in magnetic field treatment. The effects of priming on plant height, biomass dry weight and essential oil were significant. Different durations of magnetic field had the most positive effect on essential oil.

Dastanpoor *et al.* (2013) carried out an experiment to find out the influence of hydro priming treatments on seed parameters of *Salvia officinalis* L. (sage). Seeds of sage were treated by hydro priming at three temperatures 10, 20, 30°C for 0, 12, 24 and 48 h. Hydro priming clearly improved the final germination percentage (FGP), mean germination time (MGT) and synchronized the germination of seeds at each three temperature. All the treatments resulted in germination enhancement except hydro primed seeds for 48 h at temperature 30°C. Hydro priming (12 h at 30°C) was most effective in improving seed germination that FGP was increased by 25.5% as compared to that of non-primed seeds.

Sarkar (2012) noted that seed priming improved seedling establishment under flooding. Acceleration of growth occurred due to seed pretreatment, which resulted longer seedling and greater accumulation of biomass. Seed priming greatly hastened the activities of total amylase and alcohol dehydrogenase in variety Swarna-Sub 1 than Swarna. Priming had positive effects on yield and yield attributing parameters both under non-flooding and early flooding conditions.

Moghanibashi *et al.* (2012) conducted a laboratory experiment to evaluate the effect of aerated hydropriming (24h) on two cultivar of sunflower (Urfloar and Blazar) seed germination under a range of drought stress and salt stress. They found that hydropriming for 24 h increased germination percentage, germination rate, germination index, root and shoot length, root and shoot weight of seed sunflower as compared with the control. Primed seeds produced higher germination rate and percentage, D50 and GI under all salinity and drought levels as compared with non-primed seeds. There was interaction between cultivar and priming on the germination rate and D50 as hydropriming was more effective in cultivar Urfloar.

Mirshekari (2012) studied the effects of seed priming with solutions of Fe and B, each at concentrations of 0.5%, 1%, 1.5%, and 2%, and 1.5% Fe + 1% B, on the germination and yield of dill *(Anethumgraveolens)* in both field and laboratory condition .He found that in laboratory the effect of the studied treatments on the final germination percentage was significant. The seedling vigor index of dill was restricted when the Fe and B concentrations increased beyond 1.5% and 1%, respectively. The highest seed yield was recorded for the concentration of 1.5% Fe + 1% B in solution, which produced nearly 20% greater yield than the control. The essential oil concentration of the seeds ranged from 2.60% for 0.5% Fe to 2.81% for 1.5% B for the priming solutions. There was a positive response to seed priming with Fe and B regarding the essential oil yield. Priming dill seeds in the 1.5% Fe + 1% B solution resulted in a further increase in dill yield

Elouaer and Hannachi (2012) reported that in a study to the effect of seed priming with 5 g/L NaCl and KCl on germination and seedlings growth of safflower *(Carthamustinctorius)* exposed to five levels of salinity (0, 5, 10, 15 and 20 g/L). NaCl and KCl priming have improved germination parameters (germination percentage, mean germination time, germination index and coefficient of velocity) and growth parameters (radicle and seedling length, seedling fresh and dry weight and Vigour Index) of safflower under saline condition.

Lemrasky and Hosseini (2012) conducted an experiment on the effect of seed priming on the germination behavior of wheat. They found that Maximum seed germination percentage was observed when seed primed by PEG 10% for 45 h. The most stem and radical length were obtained for seeds with KCl 2% and KCl 4% for 45 h. Rate of germination was improved when the seed soaked water and PEG 10%. There was interaction between seed priming media priming duration showed the beneficial effects on germination percentage and stem length.

Yousaf *et al.* (2011) noted that in an experiment of effects of seed priming with 30 mM NaCl on various growth and biochemical characters of 6 wheat varieties (Tatara-96, Ghaznavi-98, Fakhri Sarhad, Bakhtawar-92, Pirsabaq-2004 and Auqab- 2000) under 4 salinity levels (0, 40, 80 and 120 mM), the effects of varieties and salinity were significant ($P < 0.05$) and of seed priming was non significant ($P > 0.05$) on plant height (cm), root length (cm) and shoot chlorophyll- a contents.

Sharifi *et al.* (2011) set an experiment to evaluate the effects of seed priming with Plant Growth Promoting Rhizobacteria (PGPR) on dry matter accumulation and yield of maize *(Zea mays* L.) hybrids in 2009 at the Research

Farm of the Faculty of Agriculture University of MohagheghArdabili. They showed that seed priming with Plant Growth Promoting Rhizobacteria affected grain yield, plant height, number of kernel per ear, number of grains per ear significantly. Maximum of these characteristics were obtained by the plots which seeds were inoculated with *Azotobacter* bacteria. Mean comparison of treatment compound corn hybrids xvarious levels of priming with PGPR showed that maximum grain yield and number of kernel per ear were obtained by the plots which was applied SC-434 hybrid with *Azotobacter* bacteria and minimum of it was obtained in SC-404 hybrid without of seed priming.

Yari *et al.* (2011) set an experiment on the effect of seed priming on grain yield and yield components of bread wheat. They found that osmotic priming with PEG10% had positive significant effects on emergence percentage, straw, grain and biological yield compared to other seed priming treatments (KCl 2%, KH2 $PO_4$ 0.5% and distilled water). It was recognized that the maximum straw, biological yield, kernel weight, number of spikes per $m^2$ was obtained from Sardari-101 meanwhile the highest number of kernels per spike was achieved from Azar-2.

Arif *et al.* (2010) carried out an experimen to study the effect of seed priming on growth parameters of soybean *(Glycine max* L.) cv. William-82. Three seed priming durations (6, 12 and 18 h) and five Polyethylene glycol (PEG 8000) concentrations (0, 100, 200, 300 and 400 g $L^{-1}$ water) along with dry seed (non primed) as control treatment were included in the experiment. They found that primed seed plots recorded higher AGR and CGR as compared with non-primed seed plots at $I_1$ during 2004 and RGR showed the same trend at $I_1$ and $I_2$ during 2003.

Tzortzakis (2009) noted that halopriming ($KNO_3$) or growth regulators (gibberelic acid; $GA_3$) improved the rate of germination of endive and chicory and reduced the mean germination time needed. 30 min pre-sowing treatment with $NaHClO_3$, methyl jasmonate and dictamus essential oil decreased seed germination as well as seed radicle length *in vitro*. 6 benzylaminopurine (BAP) or $NaHClO_3$ treatment reduced plant growth. He suggested that $KNO_3$ and secondly $GA_3$ treatments may improve rapid and uniform seedling emergence and plant development in nurseries and/or in greenhouses, which is easily applicable by nursery workers with economic profits.

Farahbakhsha *et al.* (2009) studied the effects of seed priming on agronomic traits in maize using NaCl solutions containing different salt concentrations. Salinity treatments were 0, 4, 8 and 12 $dS.m^{-1}$ and salt solutions for priming were 0.0, 0.5 and 1.0 molar NaCl. Seed characteristics like shoot dry weight, stem length, number of leaves, leaf area, chlorophyll and ion leakage were measured. They found that the effects of salinity and seed priming on shoot dry weight, stem length, number of leaves, leaf area, chlorophyll and ion leakage were significant at the probability level of 1% ($P< 0.01$). The increase in salinity up to 12 dS.m-1 negatively influenced all traits except ion leakage and the amounts of reduction for the mentioned traits were 75.67, 52.25, 25, 69.97 and 21.17%, respectively, as compared with the control. In the case of ion leakage, the difference was 3.03 times less than that of control. Seed priming compensated the negative effects of salinity on plant traits and all the traits positively responded to the treatment of seed priming.

Pushpalatha (2008) conducted a laboratory experiment where seeds were soaked in water from two to 2 to 24 h and observations on seed quality were recorded at two hours interval. Seeds soaked for 12 h recorded maximum germination (88.67%), seedling dry weight (28.33 mg) and vigour index (2961) as compared to control and other durations of seed soaking. This experiment was conducted with two different quality seeds viz., high quality seeds with germination above 85 percent and low quality seeds with germination below 70 percent as first factor and six priming treatments *viz.*, water, $KH_2PO_4$ (5000 ppm), $GA_3$ (100 ppm), $CaCl_2$ (1%), $KNO_3$ (2%) and control as second factor and laid out in randomized block design with factorial concept. High quality seeds recorded less days to 50 percent emergence, higher field emergence, plant height, less days to 50 percent flowering and harvest maturity. Highest yield and yield components as compared to low quality seeds. The seeds primed with $GA_3$ (100 ppm) taken less days to attain 50 percent emergence (8.00 days), higher total field emergence (81.60%), plant height (22.79 cm),less days to 50 percent flowering (41.28) along with higher number of fruits/plant (12.87), number of seeds/fruit (51.60), seed yield/plant (36.52 g), individual fruit weight (13.12 g) and yield per hectare (1292.90 kg) over unprimed seeds (10.83, 74.25%, 18.08 cm, 44.45, 9.07, 45.67, 27.58 g and 868 kg respectively). The seeds primed with $KNO_3$ (2%) maintained higher germination, seedling dry weight, vigour index, field emergence with minimum electrical conductivity even at the end of 8 months of storage.

Amjad *et al.* (2007) set an experiment to evaluate the influence of seed priming using different priming agents (distilled water, NaCl, salicylic acid, acetyl salicylic acid, ascorbic acid, PEG-8000 and $KNO_3$) on seed vigour of hot pepper cv. They found that all priming treatments significantly improved seed performance over the control. $KNO_3$ primed seeds excelled over all other treatments; decreased time taken to 50% germination, increased root and shoot length, seedling fresh weight and vigour over all other priming agents. Seeds were primed in water (hydropriming) and NaCl (1% solution) (halopriming) and sown in pots at different salinity levels [1.17 (control), 3, 5 and 7 dS m-1], along with unprimed seeds. Emergence rate (ER), final emergence percentage (FEP), reduction percentage of emergence (RPE), shoots length, number of secondary roots, seedling fresh weight and vigour were significantly improved by both priming treatments over the control; halopriming was more effective than hydropriming. Number of secondary roots was maximum in haloprimed and unprimed seeds. Seed priming treatment did not significantly affect root length, fresh and dry weight of seedlings.

## 2.2 Effect of vermicompost

Sarma and Gogoi (2015) designed a study was designed to understand the effects of different soil organic amendments on germination and seedling vigour of Okra (Abelmoschus esculentus L.). Five treatments with organic amendments (farmyard manure, vermicompost and biochar) and mineral fertilizers were designed in randomized block design with three replications. Results showed that organic amendments significantly enhanced per cent seed germination and emergence speed index compared to inorganic fertilizer. Highest homogeneity of seed germination was observed in vermicompost. Plant height, root length and leaf area were higher in vermicompost and biochar than farmyard manure. Both allocation of biomass to above ground parts and Dickson quality index were highest in seedlings from the plots amended with vermicompost. The study revealed that compared to biochar, vermicompost and farmyard manure significantly enhanced the germination and growth of Okra seedling, but the stimulation was best in vermicompost-amended plots.

Ansari and Kumar (2010) revealed that combination organic fertilizers vermicompost and vermiwash combination compared with control and chemical fertilizers had great influence on plant growth parameters. The average yield of okra *(A. esculentus)* during trial showed a significantly greater response in comparison with the control by 64.27%. Fruits were found to have a greater percentage of fats and protein contentwhen compared with those grown with chemical fertilizers by 23.86 and 19.86%, respectively.

Meenatchi *et al.* (2010) conducted a field experiment at the University of Agricultural Sciences, Dharwad, Karnataka, during *kharif* 2007 to study the effect of vermicompost and vermiwash on the activity of defoliator pests, pod borer and yield attributes of soybean. The results indicated that application of vermicompost @ (2 t $ha^{-1}$ ) and split application of vermicompost (2 t $ha^{-1}$) + four vermiwash (1:3) sprays were effective in reducing the incidence of defoliators and pod borer, being comparable to RPP. Significantly highest seed yield was registered in the treatments receiving vermicompost @ 3 t ha$^{-1}$ + four sprays of vermiwash (1:5) (30.00 q ha$^{-1}$ ) and vermicompost @ 1 t ha$^{-1}$ + four sprays of vermiwash (1:1) (25.83 q ha$^{-1}$) which were on par with each other, were comparable to RPP (30.80 q ha$^{-1}$). Untreated crop yielded significantly lowest yield at 10.58 q ha$^{-1}$.

A field experiment was performed to determine the effects of cow manure and vermicompost on plant growth, metabolite contents and antioxidant activities of chinese cabbage were investigated in pot cultures. Five treatments were designed by mixing vermicompost and soil at ratio of 0:7, 1:7, 2:7, 4:7 and 7:0 (w/w). Marketable weight of chinese cabbage was significantly ($p<0.05$) higher in the 2:1 treatment than in the other treatments, while plants grown in the full soil treatment (0:7) showed the lowest marketable weight. Vermicompost application significantly increased the nutrient content of Chinese cabbage leaves ($p<0.05$), especially in the 4:7 treatment, with increases in the contents of soluble sugar, soluble protein, vitamin C, total phenols and total flavonoids by 62, 18, 200, 25 and 17% compared to the full soil treatment, respectively (Wang *et al.,* 2010).

Bairwa *et al.* (2009) reported that application of 60% recommended dose of NPK through inorganic fertilizers + neem *(Azadirctaindica)* cake at 0.6 t ha$^{-1}$ + vermicompost at 1 t ha$^{-1}$ + Azobacter + phosphate solubilizing bacteria resulted in significantly maximum plant height at 30, 60 and 90 days after sowing (38.80, 57.65 and 77.48 cm, respectively), stem base diameter (2.25 cm), number of primary branches (5.49), number of flowers plant$^{-1}$ (33.72), total fruit bearing nodes plant$^{-1}$ (19.18), total chlorophyll content in the leaves at 30 and 60 days after sowing (0.311 and 0.390 mg g$^{-1}$ fresh weight respectively), NPK content in the leaves after final harvesting (2.275, 1.060 and 1.443 respectively), number of fruits (18.36 plant$^{-1}$), fruit yield (182.50 g plant$^{-1}$ and 13.51 t ha$^{-1}$), fruit weight (17.65 g), length of fruits (12.26 cm), thickness of fruits (1.898 cm) and protein content 1.86 g 100 g$^{-1}$fresh weight of fruits. The fruit yield was increased 29.30% along with highest benefit: cost ratio (3.19) for this treatment.

A field experiment was conducted in 2005-06 in Mashhad, Iran, to study the effects of organic amendments, synthetic fertilizers and compost extrats on crop health, productivity and storability of tomato. The treatments included different fertilizers of cattle, sheep and poultry manures, green-waste and household composts and chemical fertilizers of urea and superphosphate and five aqueous extrats from cattle manure, poultry manures, green-waste and household composts plus water as control. The results revealed that the application of poultry manure showed lower disease incidence, as shown by 80% healthy tomato, compared with the other fertilizers. However, the organic fertilizers used did not give higher yields compared with chemical fertilizers. Sheep manure and chemical fertilizers led to the highest total yield of tomato. Marketable yield was highest in poultry manures of 16 t $ha^{-1}$ and lowest in chemical fertilizer of 7 t $ha^{-1}$, 6 weeks after storage. The effects of aqueous extrats were not significant on either crop health or tomato yield and the results were inconsistent. The compost made of poultry manure, therefore, appears to be a promising ecological alternative to classical fertilizers (Ghorbani *et al.*, 2008).

Ullah *et al.* (2008) conducted a field experiment at the Horticultural Farm of Bangladesh Agricultural University (BAU), Mymensingh during the period from December 2004 to April 2005 to evaluate the effect of organic manures and fertilizers on the yield of brinjal. There were five treatments consisting of organic, inorganic and combined sources of nutrient, of which the combined treatment (60% organic + 40% inorganic) showed the best performances. The maximum branching (20.1) with the highest number fruits $plant^{-1}$(15.2), fruit length (14.1 cm) and fruit diameter (4.3 cm) were found combined application of organic and inorganic sources of nutrients. Application of mustard oil cake or vermicompost or poultry manure alone gave better performance compared to only chemical fertilizers. The organic matter content and availability of N, P, K and S in soil were increased by organic matter application.

Johann (2007) studied an experiment to assess the peat by vermicompost in potting substrate for the emergence and biomass allocation of tomato seedlings (*Lycopersiconesculentum* Mill.) under greenhouse conditions and whether VC amendments in seedling substrate affect tomato yields and fruit quality after plants were transplanted into equally fertilized field soil. Amended VC was produced of food and cotton waste in a window system by *Eisenia fetida* Sav. Vermicompost amendments significantly influenced, specifically for each tomato variety, emergence and biomass allocation (root: shoot ratio) of seedlings.

Addition of vermicompost increased plant heights, yields and fruit quality of tomatoes significantly compared to those harvested from plants cultivated in un-amended soil (Gutierrez-Miceli *et al.,* 2007).

Machado *et al.* (2006) carried out an experiment to evaluate microbiological quality of horticultural crops which were grown organically. Three species of vegetables, lettuce (*Lactuca sativa*), radish *(Raphanus sativus*) and spinach (*Tetragoniaexpansa*) were grown organically in fertile soil. Six different treatments consisted of mineral fertilizer, chicken, cow and pig manure were applied. These crops were handled according to correct agronomic practices for growing crops organically for commercial purposes.

Wang *et al.* (2006) performed a pot experiment to study the effects of organic and inorganic fertilizers on spinach growth and soil nitrogen supplying characteristics. The mineral nitrogen contents in the soil added with inorganic fertilizers alone were much higher than those with organic fertilizers in early growth stage, while a steady increase of mineral nitrogen content was found in soil in which combined application of organic and inorganic nitrogen fertilizer was added during the whole growth of spinach.

The vermicompost applications increased plant heights and yields of peppers significantly including increased leaf areas, plant shoot biomass and marketable fruit weights (Arancon *et al.*, 2005).

Anwar *et al.* (2005) conducted an experiment to study the effect of organic manure and inorganic fertilizer on growth, herb and oil yield, nutrient accumulation and oil quality of French basil. A field trial was performed with six different combinations of organic manure (FYM and vermicompost) and inorganic fertilizers (NPK) to study their effect on yield and oil quality in basil *basilicum* L. cv. Vikas Sudha. Results from the experiment revealed that among six treatments compared, the combination of vermicompost at 5 t $ha^{-1}$, and 21 p fertilizers NPK 50:25:25 kg $ha^{-1}$ performed the best with respect to growth, herb, dry matter, oil content and oil yield.

Mahtoj and Yadav (2005) arranged a pot culture experiment during winter season of 2001-2002 to investigate the effect of vermicompost on growth and productivity in vegetables peas. The dry weight in vegetable peas was significantly influenced by vermicompost.

Ahmed (2004) carried out an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh, with four levels of cowdung (0, 7.5, 15 and 22.5 t $ha^{-1}$) two levels of boron (0 and 10 kg $ha^{-1}$) and two levels of sulphur (0 and 90 kg gypsum $ha^{-1}$) on growth and yield of potato. The result showed that growth parameters of potatoes were gradually increased rate of cowdung, boron and sulphur. The yield of potato tubers was increased up to 15 t cowdung $ha^{-1}$ and then declined with further increase in the dose of cowdung. When the main effects were considered the maximum yield of tubers were recorded to be 25.67, 20.77 and 20.40 t $ha^{-1}$ in the plants receiving 15 t of cowdung, 10 kg borax and 90 kg gypsum, respectively. The combination of 15 t cowdung ha$^{-1}$ and 10 kg borax ha$^{-1}$ gave better yield (26.76 t ha$^{-1}$). The yield of tuber was maximum (26.47 t ha$^{-1}$) in the combination of 15 t cowdung ha$^{-1}$ and 90 kg gypsum ha$^{-1}$.

Bahadur *et al.* (2004) arranged a field experiment to find out the effects of the use of organic manures and biofertilizers on the growth and yield of cabbage. There were 13 treatments consisting of 4 organic manures (farmyard manure, pressmud, digested sludge and vermicompost) in combination with 3 biofertilizers *Azospirillum*, Vesicular Arbuscular

Mycorrhiza (VAM) and phosphate solubilizing microorganisms (PSM) plus the control (recommended NPK only). The farmyard manure (FYM), digested sludge and pressmud were applied at 10 t ha$^{-1}$, whereas vermicompost was given at 5 t ha$^{-1}$.

*Azospirillum* and PSM were inoculated into 5 week old seedlings, whereas VAM was inoculated onto the soil near seedling roots. All treatments received the recommended doses of NPK (120:60:80 kg ha$^{-1}$). Pressmud + VAM recorded the highest values for all parameters studied, namely number of outer leaves (13.3), fresh weight of outer leaves (476.67 g), number of inner leaves (31.7), head weight (1616.67 g), head length (16.8 cm),head diameter (15.5 cm) and head yield (602.67 q ha$^{-1}$).

Dademal and Dongale (2004) reported that the growth (plant height and dry matter production), yield contributing characters (number of green pod plant$^{-1}$, length of green pod, diameter of greed pod and number of seeds pod$^{-1}$) and fruit yield of okra and tomato were significantly increased with the application of vermicompost at 7.5 t ha$^{-1}$ as compared to chemical fertilizers and application of FYM at 1.5 t ha$^{-1}$.

Jingxue *et al.* (2004) conducted a field experiment in China to study the effects of the combined application of organic manures and chemical fertilizers on the yield and quality of chinese cabbage. The combined application of organic manure and fertilizer improved the yield and quality of chinese cabbage.

Effects of inorganic and organic fertilizers on the fruit yield and quality of tomato (cv. Parbhani, Yashshri) were studied in Parbhani, Maharashtra, India, during *rabi* 2000-01. The treatments consisted of 100% recommended fertilizer rate (RFR: 100:50:50 kg NPK/ha), 75% RFR + 25% Celrich, Teracare, farmyard manure (FYM) or vermicompost; 50% RFR + 50% Celrich, Teracare, vermicompost; 25% RFR + 75% Celrich, Teracare, vermicompost and 100% organic fertilizer (25% each of FYM, Teracare, Celrich and vermicompost). Celrich (2.0 t $ha^{-1}$),

Teracare (2.5 t $ha^{-1}$), FYM (25.0 t $ha^{-1}$) and vermicompost (25.0 t $ha^{-1}$) were applied at 10 days before transplanting. Plant height, number of primary branches and number of leaves were evaluated from 30 to 105 days after transplanting. The application of 50% RFR + 50% FYM resulted in the highest plant height (120.70 cm), number of primary branches per plant (8.53), number of fruits per plant (52.0), average fruit weight (45.06 g), yield per plant (2.34 kg) and total soluble solid content (6.08%). The highest number of leaves per plant was obtained with 50% RFR + 50% FYM (118.10) and 50% RFR + 50% vermicompost (116.63). Ascorbic acid content (26.76, 26.53 and 25 97 mg 100 $g^{-1}$) and shelf life (6.91, 7.00 and 6.22 days) were highest with 50% RFR + 50% FYM, 50% RFR + 50% vermicompost and 100% organic fertilizers (Patil *et al.,* 2004).

Uddin *et al*. (2004) performed two-year field experiment at the Regional Agricultural Research Station, BARI, Hathazari, Bangladesh, in the year 2001-02 on the fertilizer requirement of carrot as influenced by different levels of NPKS (N: P: K: S at 120: 45: 120: 30, 90: 30: 60: 20 and 60: 15: 30: 10 kg $ha^{-1}$) and cowdung (0 and 5 t $ha^{-1}$) were used in the investigation. Different combinations of NPKS and cowdung showed significant influence on the yield of carrot. The combination of fertilizer 120: 45: 120: 30 kg $ha^{-1}$ of NPKS and 5 t cowdung $ha^{-1}$ produced root yield of 27.22 t $ha^{-1}$ which was 303% higher over control treatment.

Lattiff and Maraikar (2003) performed an experiment on reddish brown latsolic soil in Srilanka, to study the performance of different vegetable crops when they were grown as a monocrop under organic farming system. Cattle and poultry manure (PM) applied at rates of 20, 30, 40 and 10, 20, 30 t $ha^{-1}$ respectively, as source of nutrients for the crops. For comparison, a chemical fertilizer treatment, using recommended rates of NPK was included in the experiment. In the monocrop experiments, brinjal, cabbage and tomato gave comparable or sometimes higher yields when treated with organic manures such as cowdung, vermicompost and FYM than NPK.

## CHAPTER III

# MATERIALS AND METHODS

The experiment was carried out at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to July2018 to study the response of seed priming and vermicompost on germination, growth and yield of okra (*Abelmoschus esculentus*). The details of the materials and methods have been presented below:

### 3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level.

### 3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix I.

### 3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment wascollected from the Wether Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

### 3.4 Planting material

BARI dherosh 1 variety of okra was considered for the present study collected from BARI, Joydebpur, Gazipur.

### 3.5 Experimental details

#### 3.5.1 Treatments

The experiment comprised of two factors.

**Factor A: Seed priming - 3 types**

1. $P_0$ = No priming (with water)
2. $P_1$ = Halopriming ($CaCl_2$) - 1 ppm
3. $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

**Factor B: Vermicompost - 4 levels**

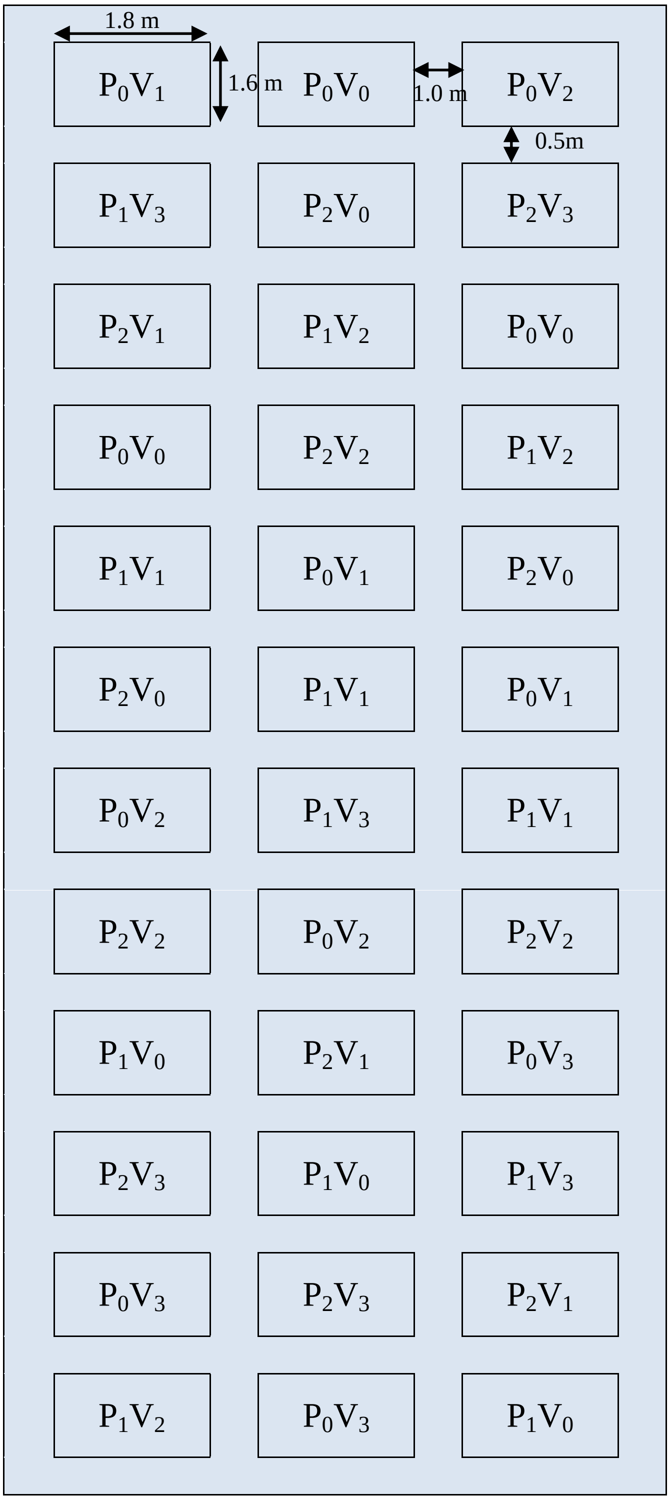
1. $V_0$ = Control (0 t $ha^{-1}$)
2. $V_1$ = 5 t $ha^{-1}$ vermicompost
3. $V_2$ = 7.5 t $ha^{-1}$ vermicompost
4. $V_3$ = 10 t $ha^{-1}$ vermicompost

**Treatment combinations–** Twelve treatment combinations were as follows:

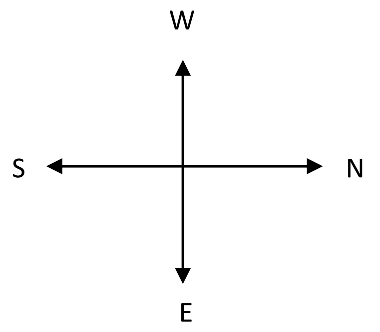
$P_0V_0$, $P_0V_1$, $P_0V_2$, $P_0V_3$, $P_1V_0$, $P_1V_1$, $P_1V_2$, $P_1V_3$, $P_2V_0$, $P_2V_1$, $P_2V_2$ and $P_2V_3$.

#### 3.5.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of seed priming and different vermicompost levels. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 1.8 m × 1.6 m. The distance between blocks and plots were 1.0 m and 0.5 m respectively.




**LEGEND**




Plot Size: 1.8 m × 1.6 m
Block to block distance = 1 m
Plot to plot distance = 0.5 m
Plant spacing = 60 cm × 40 cm

**Treatments:**
**Factor A: Seed priming**

1. $P_0$ = No priming (with water)
2. $P_1$ = Halopriming ($CaCl_2$) - 1 ppm
3. $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

**Factor B: Vermicompost**

1. $V_0$ = Control (0 t $ha^{-1}$)
2. $V_1$ = 5 t $ha^{-1}$ vermicompost
3. $V_2$ = 7.5 t $ha^{-1}$ vermicompost
4. $V_3$ = 10 t $ha^{-1}$ vermicompost

**Fig. 1. Layout of the experiment field**

### 3.6 Preparation of the main field

The plot selected for the experiment was opened in the first week of 6 March, 2018 with a power tiller and was exposed to the sun for a few days, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for sowing. The individual plots were made by raising soil (20 cm high) from the ground level.

### 3.7 Fertilizers and manure application

The N, P, K fertilizer were applied according to BARI recommended doses, 2016 as urea, TSP, MoP respectively. Vermicompost also used as organic manure as per treatment. Nutrient doses used through fertilizers under the present study are presented as follows:

| Nutrients | Manures/fertilizers | BARI recommended dose $ha^{-1}$ |
|---|---|---|
| N | Urea | 150 kg |
| P | TSP | 100 kg |
| K | MoP | 150 kg |

Full amount of TSP, MoP, and vermicompost were applied at the time of final land preparation. Urea was applied in two equal installments at 20 and 35 days after transplanting (DAS) respectively.

### 3.8 Methods of seed priming techniques

Procedures of pre-sowing seed treatments

1. One hundred gram of okra seeds was taken.
2. The seeds were soaked in different priming agent for 24 hours separately at room temperature as per treatments.

3. Primed seeds were sown on each plot for seed germination, growth and yield.

### 3.9 Sowing of seeds

The okra Seeds (BARI Dheros-1) were sown on 21 March, 2018 in rows of the raised beds. Plant to plant distance was 40 cm and row to row distance was 60cm. Three seeds were sown in each hole. Then the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

### 3.10 Intercultural Operation

Necessary intercultural operations were done through the cropping season for obtain in proper growth and development of the plants. The seedlings were always kept under close observation.

#### 3.10.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

#### 3.10.2 Irrigation

Light irrigation was given immediately after sowing around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition.

#### 3.10.3 Plant protection

The crop was sprayed with Ripcord 50 EC, Bavistin, Admire and Malathion 60EC to prevent infestation of insects and vectors of virus. Some discolored leaves were also collected from the plant and removed from the field.

### 3.11 Harvesting and cleaning

Fruits were harvested at 3 days interval based on eating quality at soft and green (edible stage) condition. Harvesting was started from 3 May, 2018 and was continued up to July, 2018.

### 3.12 Data collection

The data were collected on the following parameters

1. Percent germination
2. Plant height (cm) at 30, 60 and 90 DAS
3. Number of leaves plant$^{-1}$ at 30, 60 and 90 DAS
4. Number of flowers plant$^{-1}$
5. Number of fruits plant$^{-1}$
6. Fruit length (cm)
7. Fruit diameter (cm)
8. Single fruit weight (g)
9. Fruit yield plot$^{-1}$
10. Fruit yield ha$^{-1}$
11. Cost of production
12. Benefit cost ratio (BCR)

### 3.13 Procedure of recording data

#### 3.13.1 Percent (%) seed germination

The number of germinated seeds were counted daily commencing. Germination was recorded at 24 hrs interval and continued up to 12$^{th}$ day. More than 2 mm long plumule and radicle was considered as germinated seed. The germination rate was calculated using the following formula:

$$\text{Rate of germination (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total seeds placed for germination}} \times 100$$

### 3.13.2 Plant height

The height was recorded in centimeter (cm) at different days after sowing of crop duration with a meter scale. Data were recorded from each plot. The length was measured from the ground level to the top of the stem using meter scale. Data were taken at 30, 60 and 90 days after sowing (DAS).

### 3.13.3 Number of leaves plant$^{-1}$

Number of leaves per plant was counted at different days after sowing of crop. Leaves number per plant was recorded from each selected plants of each plot and mean was calculated. Data was taken at 30, 60 and 90 days after sowing (DAS).

### 3.13.4Number of flowers per plant

The number of flower buds per plant was counted from the sample plants and the average numbers of flower buds produced per plant were recorded.

### 3.13.6 Number of fruits per plant

The number of fruits per plant was counted from the sample plants for the whole growing period and the average number of fruits produced per plant was recorded and expressed in fruits per plant.

### 3.13.7 Fruit length per plant (cm)

Fruits were collected from the selected plants of each plot as per-treatment and length was measured with the help of a scale in centimeter (cm).

### 3.13.8 Fruit diameter (cm)

Mean diameter of collected green pods from each plots as per treatment were measured in centimeter (cm) with the help of a slide calipers**.**

### 3.13.9 Single fruit weight

From first harvest to last harvest total fruit number was counted and total fruit weight was measured from each plant of each plot to determine single fruit weight. Single fruit weight was calculated from total fruit weight dividing by total number of fruits.

### 3.13.10 Fruit yield plot$^{-1}$

Total fruit was collected from 1st harvest to last harvest from each plot and weighed. The total weight was considered as fresh fruit yield per plot and expressed in kilogram (kg).

### 3.13.11Fruit weight ha$^{-1}$

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ \text{m}^2}{\text{Plot size (m}^2\text{)} \times 1\,000\ \text{kg}}$$

### 3.14 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

### 3.15 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of mulching and nitrogen in cost and return were done in details according to the procedure of Alam *et al*. (1989).

### 3.15.1 Analysis of total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix IX.

### 3.15.2 Gross income

Gross income was calculated on the basis of mature fruit sale. The price of okra was assumed to be Tk. 25/kg basis of current market value of farmer level at the time of harvesting.

### 3.15.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

### 3.15.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per hectare}}$$

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted to observe the response of seed priming and vermicompost on germination, growth and yield of okra (*Abelmoschus esculentus*). Data on different parameters were analyzed statistically and the result has been presented in tables, graphs and figures. The results of the present study have been presented and discussed and possible interpretations have been made under the following headings.

## 4.1 Germination of seed (%)

Significant variation was observed on seed germination at different days after sowing (DAS) as influenced by different seed priming treatments (Fig2 and Appendix III). Results showed that the highest seed germination in percentage (62.15, 90.74 and 92.27% at 4, 8 and 12 DAS, respectively) was recorded in $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm) whereas the lowest percent (%) seed germination (48.94, 75.96 and 76.63% at 4, 8 and 12 DAS, respectively) was found in control treatment $P_0$ No priming (with water). Generally, it is known that seed priming is a presowing technique in which seeds are moderately hydrated to the point where pregermination metabolic processes begin without actual germination. Seeds can be soaked in tap water (hydropriming), aerated low-water potential solutions such as $KNO_3$, $KH_2PO_4$, KCl, NaCl, $CaCl_2$ or $MgSO_4$; osmopriming, plant growth regulators, hormonal priming etc. (Farooq *et al*., 2019). Seed priming as a simple and effective approach for improving stand establishment, economic yields and tolerance to biotic and abiotic stresses in various crops by inducing a series of biochemical, physiological, molecular and subcellular changes in plants (Farooq *et al*., 2019). Under the present study, the treatment $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm) showed the best performance on seed germination which was supported the findings of Tiwari *et al*. (2016).

Different rate of vermicompost application showed significant variation on percent (%) seed germination at different days after sowing (Fig 3 and Appendix III). The highest percent (%) seed germination (59.58, 87.47 and 88.22% at 4, 8 and 12 DAS, respectively) was recorded in $V_3$ (10 t $ha^{-1}$ vermicompost) treatment which was statistically identical with $V_2$ (7.5 t $ha^{-1}$ vermicompost). The lowest percent (%) seed germination (52.95, 81.40 and 82.00% at 4, 8 and 12 DAP, respectively) was found in control treatment $P_0$ (No priming with water). Application of organic amendment is an environmentally, economically and agronomically sound practice which helps to seed germination and also higher yield (Carson and Peterson, 1990). Sarma and Gogoi (2015) also found similar result with the present study who found that highest homogeneity of seed germination was observed in vermicompost compared to inorganic manure.

Seed priming and vermicompost combination showed significant variation on seed germination at different days after sowing (Table 1 and Appendix III). The highest percent (%) seed germination (64.30, 92.67 and 95.75% at 4, 8 and 12 DAS, respectively) was found from the treatment combination of $P_2V_3$whereas the lowest percent (%) seed germination (45.72, 72.67 and 73.00% at 4, 8 and 12 DAP, respectively) was found from the treatment combination of $P_0V_0$.

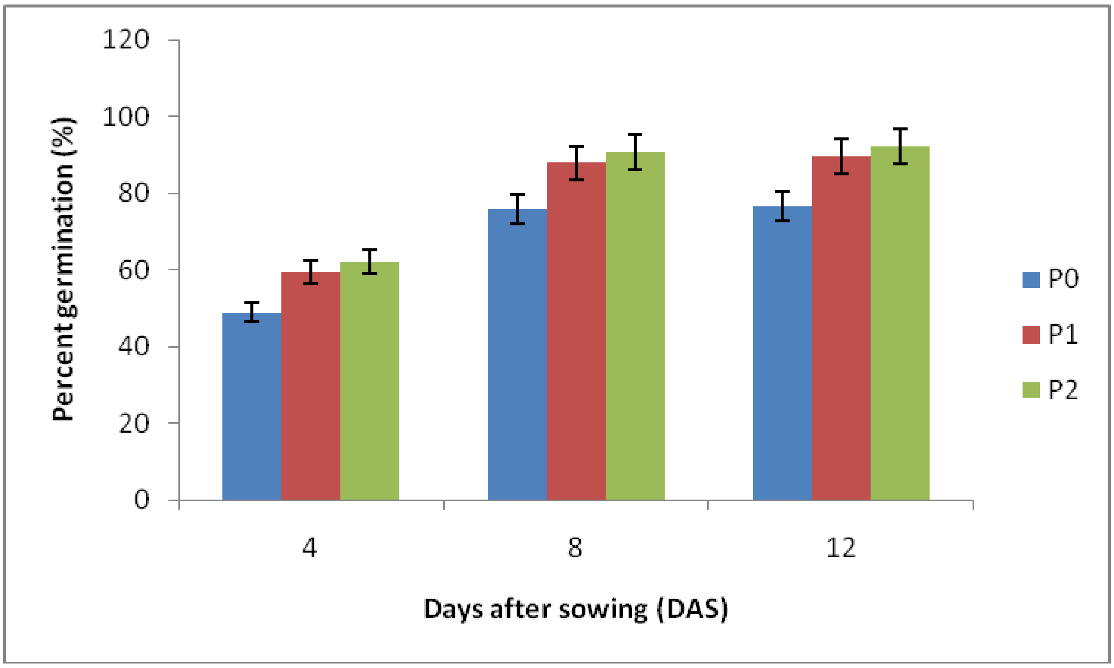



Fig 2. Percent seed germination of okra as influenced by seed priming (Vertical bars represented error bar with percentage)

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

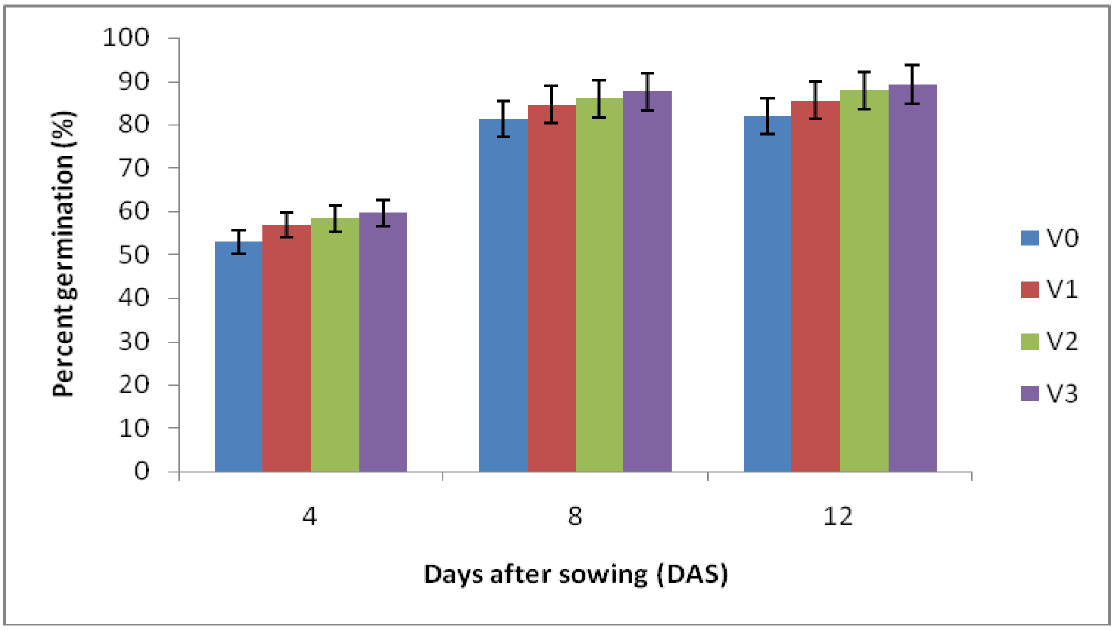



Fig 3. Percent seed germination of okra as influenced by Vermicompost (Vertical bars represented error bar with percentage)

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost

Table 1. Percent seed germination of okra as influenced by seed priming and vermicompost

| Treatment | Percent seed germination | | |
|---|---|---|---|
| | 4 DAS | 8 DAS | 12 DAS |
| $P_0V_0$ | 45.72 f | 72.67 f | 73.00 f |
| $P_0V_1$ | 48.48 ef | 75.67 e | 76.00 ef |
| $P_0V_2$ | 50.36 e | 77.23 e | 78.00 e |
| $P_0V_3$ | 51.20 e | 78.27 e | 79.50 e |
| $P_1V_0$ | 55.45 d | 84.87 d | 86.00 d |
| $P_1V_1$ | 58.94 c | 86.95 cd | 88.60 bcd |
| $P_1V_2$ | 60.70 bc | 88.31 bc | 91.28 abc |
| $P_1V_3$ | 63.24 ab | 91.47 a | 92.40 ab |
| $P_2V_0$ | 57.67 cd | 86.67 cd | 87.00 cd |
| $P_2V_1$ | 62.87 ab | 91.17 ab | 92.00 ab |
| $P_2V_2$ | 63.78 ab | 92.45 a | 94.33 a |
| $P_2V_3$ | 64.30 a | 92.67 a | 95.75 a |
| LSD0.05 | 3.49 | 2.93 | 4.78 |
| CV(%) | 4.39 | 6.04 | 6.23 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost

## 4.2 Growth parameters

### 4.2.1 Plant height (cm)

Significant variation was recorded on plant height of okra at different growth stages due to different seed priming treatments (Fig 4 and Appendix IV). The highest plant height (63.28, 115.9 and 133.10 cm at 30, 60 and 90 DAS, respectively) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically different from others. The lowest plant height (56.96, 108.70, 127.10 cm at 30, 60 and 90 DAS, respectively) was recorded from control treatment $P_0$ No priming (with water). This result indicates that seed priming is also contributed to plant growth. Pushpalatha (2008) found that seed priming helps to produce high quality seeds and high quality seeds recorded higher field emergence, plant height and harvest maturity.

Different rate of vermicompost application showed significant difference among the treatments regarding plant height of okra at different growth stages (Fig 5 and Appendix IV). The highest plant height (74.75, 129.10 and 148.00 cm at 30, 60 and 90 DAS, respectively) was recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) which was statistically different from others. The lowest plant height (44.60, 91.77 and 112.90 cm at 30, 60 and 90 DAS, respectively) was recorded from the treatment $V_0$ (control; no vermicompost). Gutierrez-Miceli *et al.,* 2007 found that vermicompost applications increased plant heights which supported the present study. Similar result was also observed by Dademal and Dongale (2004) who found vermicompost at 7.5 t $ha^{-1}$ showed highest plant height compared to lower doses.

Combined effect of seed priming and vermicompost exhibited significant variation on plant height of okra at different growth stages among the treatment combinations (Table 2 and Appendix IV). The highest plant height (78.64, 132.90 and 152.40 cm at 30, 60 and 90 DAS, respectively) was achieved from the treatment combination of $P_2V_3$whereas $_t$he lowest plant height (43.28, 90.36 and 111.40 cm at 30, 60 and 90 DAS, respectively) was recorded from the treatment combination of $P_0V_0$.

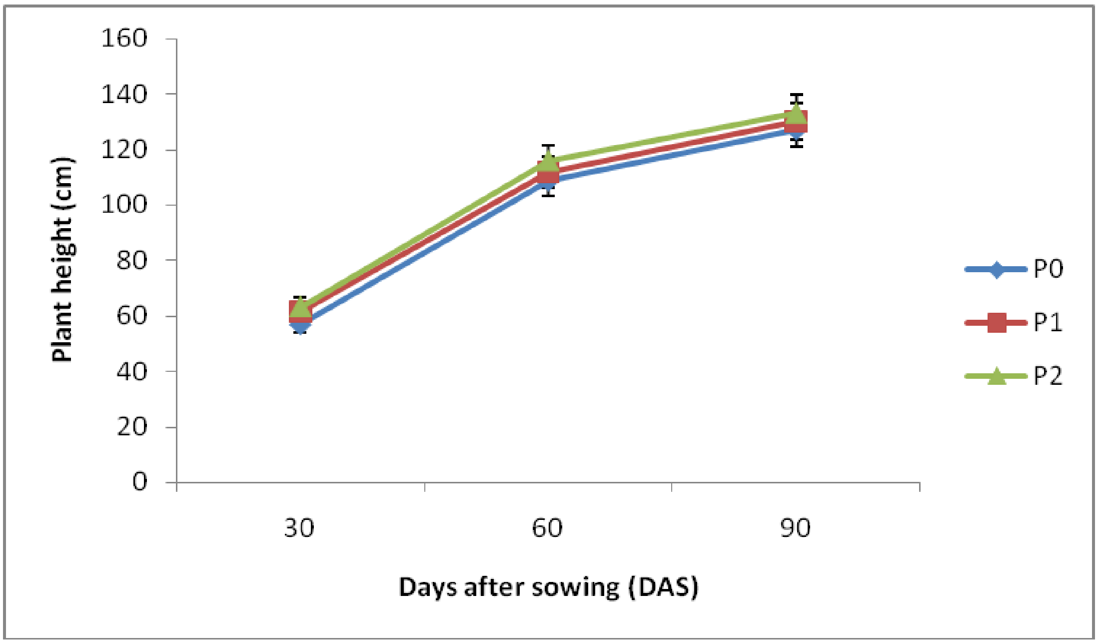



Fig 4. Plant height of okra as influenced by seed priming (Vertical bars represented error bar with percentage)

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

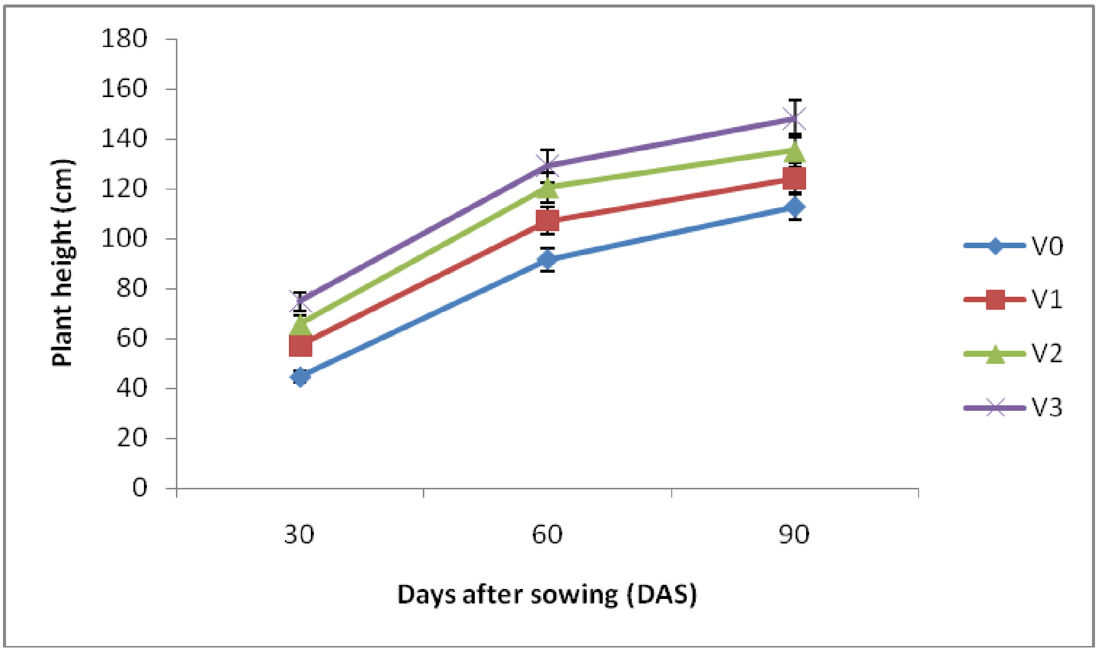



Fig 5. Plant height of okra as influenced by vermicompost (Vertical bars represented error bar with percentage)

$V_0$ = Control (0 t ha$^{-1}$), $V_1$ = 5 t ha$^{-1}$ vermicompost, $V_2$ = 7.5 t ha$^{-1}$ vermicompost, $V_3$ = 10 t ha$^{-1}$ vermicompost

Table 2. Plant height of okra as influenced by seed priming and vermicompost

| Treatment | Plant height (cm) | | |
|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS |
| $P_0V_0$ | 43.28 h | 90.36 f | 111.4 f |
| $P_0V_1$ | 52.47 g | 102.6 e | 120.4 e |
| $P_0V_2$ | 61.84 e | 116.8 cd | 133.7 c |
| $P_0V_3$ | 70.24 c | 124.8 b | 142.8 b |
| $P_1V_0$ | 44.78 h | 91.48 f | 112.8 f |
| $P_1V_1$ | 58.44 f | 104.9 e | 122.8 e |
| $P_1V_2$ | 67.11 d | 121.2 bc | 135.8 c |
| $P_1V_3$ | 75.36 b | 129.7 a | 148.7 a |
| $P_2V_0$ | 45.74 h | 93.48 f | 114.5 f |
| $P_2V_1$ | 60.37 ef | 113.8 d | 128.8 d |
| $P_2V_2$ | 68.36 cd | 123.6 b | 136.5 c |
| $P_2V_3$ | 78.64 a | 132.9 a | 152.4 a |
| LSD0.05 | 3.014 | 4.688 | 4.436 |
| CV(%) | 8.94 | 10.60 | 9.51 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost

### 4.2.2 Number of leaves plant$^{-1}$

Non-significant variation was found on number of leaves plant$^{-1}$ of okra at different growth stages due to different seed priming treatments (Table 3 and Appendix V). However, the highest number of leaves plant$^{-1}$ (15.34, 31.73 and 39.65 at 30, 60 and 90 DAS, respectively) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** whereas the lowest number of leaves plant$^{-1}$ (14.28, 30.39 and 37.90 at 30, 60 and 90 DAS, respectively) was recorded from control treatment $P_0$ No priming (with water). Results indicated that higher germinated seeds through seed priming showed better performance on growth and yield of crops compared to non primed seeds. Under the present study, $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** gave best result which might be due to cause of higher germination percentage from the same treatment.

Table 3. Number of leaves plant$^{-1}$ of okra as influenced by seed priming

| Treatment | Number of leaves plant$^{-1}$ | | |
|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS |
| $P_0$ | 14.28 | 30.39 | 37.90 |
| $P_1$ | 14.96 | 31.19 | 38.96 |
| $P_2$ | 15.34 | 31.73 | 39.65 |
| LSD0.05 | 1.249$^{NS}$ | 1.385$^{NS}$ | 0.916$^{NS}$ |
| CV(%) | 7.82 | 6.16 | 8.80 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

Different rate of vermicompost application showed significant difference among the treatments regarding number of leaves plant$^{-1}$ of okra at different growth stages (Table 4 and Appendix V). The highest number of leaves plant$^{-1}$ (17.64, 35.32 and 44.23 at 30, 60 and 90 DAS, respectively) was recorded from the treatment $V_3$ (10 t ha$^{-1}$ vermicompost) whereas the lowest number of leaves plant$^{-1}$ (11.89, 25.77 and 32.75 at 30, 60 and 90 DAS, respectively) was recorded from the treatment $V_0$ (control; no vermicompost). The result obtained from the present study was similar with the findings of Wang *et al. (*2010).

Table 4. Number of leaves plant$^{-1}$ of okra as influenced by vermicompost

| Treatment | Number of leaves plant$^{-1}$ | | |
|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS |
| $V_0$ | 11.89 d | 25.77 d | 32.75 d |
| $V_1$ | 14.45 c | 30.16 c | 38.10 c |
| $V_2$ | 15.45 b | 33.15 b | 40.26 b |
| $V_3$ | 17.64 a | 35.32 a | 44.23 a |
| LSD0.05 | 0.6738 | 1.266 | 1.441 |
| CV(%) | 7.82 | 6.16 | 8.80 |

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

$V_0$ = Control (0 t ha$^{-1}$), $V_1$ = 5 t ha$^{-1}$ vermicompost, $V_2$ = 7.5 t ha$^{-1}$ vermicompost, $V_3$ = 10 t ha$^{-1}$ vermicompost

Combined effect of seed priming and vermicompost exhibited significant variation on number of leaves plant$^{-1}$ of okra at different growth stages among the treatment combinations (Table 5 and Appendix V). Results showed that the highest number of leaves plant$^{-1}$ (18.50, 36.20 and 45.40 at 30, 60 and 90 DAS, respectively) was achieved from the treatment combination of $P_2V_3$ which was statistically different from others whereas the lowest number of leaves plant$^{-1}$ (11.60, 25.48 and 32.48 at 30, 60 and 90 DAS, respectively) was recorded from the treatment combination of $P_0V_0$.

Table 5. Number of leaves plant$^{-1}$ of okra as influenced by seed priming and vermicompost

| Treatment | Number of leaves plant$^{-1}$ | | |
|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS |
| $P_0V_0$ | 11.60 g | 25.48 f | 32.48 f |
| $P_0V_1$ | 14.12 f | 29.47 e | 37.50 e |
| $P_0V_2$ | 15.06 de | 32.76 cd | 38.94 de |
| $P_0V_3$ | 16.33 b | 33.83 bc | 42.67 bc |
| $P_1V_0$ | 11.86 g | 25.78 f | 32.62 f |
| $P_1V_1$ | 14.48 ef | 29.88 e | 38.33 de |
| $P_1V_2$ | 15.40 cd | 33.18 cd | 40.28 cd |
| $P_1V_3$ | 18.10 a | 35.92 ab | 44.62 ab |
| $P_2V_0$ | 12.20 g | 26.06 f | 33.14 f |
| $P_2V_1$ | 14.76 def | 31.14 de | 38.48 de |
| $P_2V_2$ | 15.88 bc | 33.52 c | 41.56 c |
| $P_2V_3$ | 18.50 a | 36.20 a | 45.40 a |
| LSD0.05 | 0.7084 | 2.193 | 2.496 |
| CV(%) | 7.82 | 6.16 | 8.80 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t ha$^{-1}$), $V_1$ = 5 t ha$^{-1}$ vermicompost, $V_2$ = 7.5 t ha$^{-1}$ vermicompost, $V_3$ = 10 t ha$^{-1}$ vermicompost

### 4.3 Yield contributing parameters

Table 6. Yield contributing parameters of okra as influenced by seed priming and vermicompost

| Treatment | Yield contributing parameters | | | |
|---|---|---|---|---|
| | Number of flowers plant$^{-1}$ | Number of fruits plant$^{-1}$ | Fruit length (cm) | Fruit diameter (cm) |
| Effect of seed priming | | | | |
| $P_0$ | 24.82 c | 18.86 c | 15.18 b | 1.62 b |
| $P_1$ | 26.69 b | 19.67 b | 16.10 a | 1.75 a |
| $P_2$ | 27.51 a | 20.37 a | 16.44 a | 1.81 a |
| LSD0.05 | 0.6904 | 0.6773 | 0.5878 | 0.1136 |
| CV(%) | 10.73 | 7.08 | 6.36 | 4.87 |
| Effect of vermicompost | | | | |
| $V_0$ | 20.56 d | 14.79 c | 12.77 d | 1.44 b |
| $V_1$ | 25.76 c | 18.97 b | 15.55 c | 1.60 b |
| $V_2$ | 28.28 b | 21.96 a | 17.27 b | 1.84 a |
| $V_3$ | 30.76 a | 22.81 a | 18.04 a | 2.02 a |
| LSD0.05 | 1.256 | 1.044 | 0.6787 | 0.2027 |
| CV(%) | 10.73 | 7.08 | 6.36 | 4.87 |
| Combined effect of seed priming and vermicompost | | | | |
| $P_0V_0$ | 19.42 g | 14.24 e | 12.56 g | 1.42 e |
| $P_0V_1$ | 24.67 e | 18.44 d | 15.10 f | 1.58 de |
| $P_0V_2$ | 27.40 bc | 21.27 c | 16.28 de | 1.70 cd |
| $P_0V_3$ | 27.78 bc | 21.48 c | 16.77 cd | 1.78 bcd |
| $P_1V_0$ | 20.85 fg | 14.88 e | 12.80 g | 1.45 e |
| $P_1V_1$ | 25.50 de | 18.80 d | 15.62 ef | 1.60 de |
| $P_1V_2$ | 28.55 bc | 21.76 bc | 17.42 bc | 1.83 bc |
| $P_1V_3$ | 31.88 a | 23.24 a | 18.56 a | 2.11 a |
| $P_2V_0$ | 21.40 f | 15.24 e | 12.95 g | 1.46 e |
| $P_2V_1$ | 27.12 cd | 19.67 d | 15.92 def | 1.62 cde |
| $P_2V_2$ | 28.90 b | 22.85 ab | 18.10 ab | 1.98 ab |
| $P_2V_3$ | 32.62 a | 23.72 a | 18.80 a | 2.16 a |
| LSD0.05 | 1.663 | 1.355 | 1.047 | 0.2208 |
| CV(%) | 10.73 | 7.08 | 6.36 | 4.87 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t ha$^{-1}$), $V_1$ = 5 t ha$^{-1}$ vermicompost, $V_2$ = 7.5 t ha$^{-1}$ vermicompost, $V_3$ = 10 t ha$^{-1}$ vermicompost

### 4.3.1 Number of flowers plant$^{-1}$

Significant variation was recorded on number of flowers plant$^{-1}$ of okra at different growth stages due to different seed priming treatments (Table 4 and Appendix VI). The highest number of flowers plant$^{-1}$ (27.51) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** whereas the lowest number of flowers plant$^{-1}$ (24.82) was recorded from control treatment $P_0$ No priming (with water). The result on number of flowers plant$^{-1}$ obtained from the present study was similar with the findings of Pushpalatha (2008).

Different rate of vermicompost application showed significant difference among the treatments regarding number of flowers plant$^{-1}$ of okra at different growth stages (Table 6 and Appendix VI). The highest number of flowers plant$^{-1}$ (30.76) was recorded from the treatment $V_3$ (10 t ha$^{-1}$ vermicompost) which was statistically different from others whereas the lowest number of flowers plant$^{-1}$ (20.56) was recorded from the treatment $V_0$ (control; no vermicompost).Similar result was also observed by Bairwa *et al.* (2009).

Combined effect of seed priming and vermicompost exhibited significant variation on number of flowers plant$^{-1}$ of okra at different growth stages among the treatment combinations (Table 6 and Appendix VI). Results indicated that the highest number of flowers plant$^{-1}$ (32.62) was achieved from the treatment combination of $P_2V_3$which was statistically identical with $P_1V_3$ whereas the lowest number of flowers plant$^{-1}$ (19.42) was recorded from the treatment combination of $P_0V_0$.

### 4.3.2 Number of fruits plant$^{-1}$

Significant variation was recorded on number of fruits plant$^{-1}$ of okra at different growth stages due to different seed priming treatments (Table 6 and Appendix VI). The highest number of fruits plant$^{-1}$ (20.37) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** and the lowest number of fruits plant$^{-1}$ (18.86) was recorded from control treatment $P_0$ No priming (with water). It is well known that seed priming is a technique that improves seed performance in the field and hence ameliorates subsequent germination, growth and seed yield. Moreover, seed priming is often implicated in improving the stress-tolerance of germinating seeds. So, it can be stated that higher yield contributing parameters can be achieved with this technique. Pushpalatha (2008) also found similar result which supported the present study.

Different rate of vermicompost application showed significant difference among the treatments regarding number of fruits plant$^{-1}$ of okra at different growth stages (Table 6 and Appendix VI).The highest number of fruits plant$^{-1}$ (22.81) was recorded from the treatment $V_3$ (10 t ha$^{-1}$ vermicompost) which was statistically identical with $V_2$ (7.5 t ha$^{-1}$ vermicompost) whereas the lowest number of fruits plant$^{-1}$ (14.79) was recorded from the treatment $V_0$ (control; no vermicompost). The result obtained from the present study was conformity with the findings of Ansari and Kumar (2010), Bairwa *et al.* (2009) and Ullah *et al.* (2008) which supported the present study.

Combined effect of seed priming and vermicompost exhibited significant variation on number of fruits plant$^{-1}$ of okra at different growth stages among the treatment combinations (Table 6 and Appendix VI). The highest number of fruits plant$^{-1}$ (23.72) was achieved from the treatment combination of $P_2V_3$which was statistically similar with $P_2V_2$. The lowest number of fruits plant$^{-1}$ (14.24) was recorded from the treatment combination of $P_0V_0$.

### 4.3.3 Fruit length (cm)

Significant variation was recorded on fruit length of okra at different growth stages due to different seed priming treatments (Table 6 and Appendix VI). The highest fruit length (16.44 cm) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically identical with $P_1$ (Halopriming; $CaCl_2$ - 1 ppm). The lowest fruit length (15.18 cm) was recorded from control treatment $P_0$ No priming (with water).

Different rate of vermicompost application showed significant difference among the treatments regarding fruit length of okra at different growth stages (Table 6 and Appendix VI). The highest fruit length (18.04 cm) was recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) whereas the lowest fruit length (12.77 cm) was recorded from the treatment $V_0$ (control; no vermicompost). Ullah *et al.* (2008) also found supported result with the present study.

Combined effect of seed priming and vermicompost exhibited significant variation on fruit length of okra at different growth stages among the treatment combinations (Table 6 and Appendix VI).The highest fruit length (18.80 cm) was achieved from the treatment combination of $P_2V_3$which was statistically identical with $P_1V_{3.}$ The lowest fruit length (12.56 cm) was recorded from the treatment combination of $P_0V_{0.}$

### 4.3.4 Fruit diameter (cm)

Significant variation was recorded on fruit diameter of okra at different growth stages due to different seed priming treatments (Table 6 and Appendix VI). The highest fruit diameter (1.81 cm) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically identical with $P_1$ (Halopriming; $CaCl_2$ - 1 ppm). The lowest fruit diameter (1.62 cm) was recorded from control treatment $P_0$ No priming (with water).

Different rate of vermicompost application showed significant difference among the treatments regarding fruit diameter of okra at different growth stages (Table 6 and Appendix VI).The highest fruit diameter (2.02 cm) was recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) which was statistically identical with $V_2$ (7.5 t $ha^{-1}$ vermicompost). The lowest fruit diameter (1.44 cm) was recorded from the treatment $V_0$ (control; no vermicompost). Supported result was also observed by Ullah *et al.* (2008).

Combined effect of seed priming and vermicompost exhibited significant variation on fruit diameter of okra at different growth stages among the treatment combinations (Table 6 and Appendix VI). The highest fruit diameter

(2.16 cm) was achieved from the treatment combination of $P_2V_3$which was statistically similar with $P_2V_2$. The lowest fruit diameter (1.42 cm) was recorded from the treatment combination of $P_0V_0$.

### 4.4 Yield parameters

Table 7. Yield parameters of okra as influenced by seed priming and vermicompost

| Treatment | Yield parameters | | |
|---|---|---|---|
| | Single fruit weight (g) | Fruit yield plot$^{-1}$ (kg) | Fruit yield ha$^{-1}$ (t) |
| Effect of seed priming | | | |
| $P_0$ | 11.73 b | 2.71 b | 9.41 b |
| $P_1$ | 12.40 a | 3.01 a | 10.45 a |
| $P_2$ | 12.66 a | 3.16 a | 10.98 a |
| LSD0.05 | 0.4676 | 0.1816 | 0.7371 |
| CV(%) | 5.82 | 7.91 | 9.90 |
| Effect of vermicompost | | | |
| $V_0$ | 8.850 c | 1.57 d | 5.45 d |
| $V_1$ | 12.93 b | 2.93 c | 10.19 c |
| $V_2$ | 12.87 b | 3.39 b | 11.77 b |
| $V_3$ | 14.40 a | 3.95 a | 13.71 a |
| LSD0.05 | 1.117 | 0.3736 | 1.296 |
| CV(%) | 5.82 | 7.91 | 9.90 |
| Combined effect of seed priming and vermicompost | | | |
| $P_0V_0$ | 8.543 d | 1.46 e | 5.06 e |
| $P_0V_1$ | 12.88 bc | 2.85 d | 9.90 d |
| $P_0V_2$ | 12.24 c | 3.12 cd | 10.83 cd |
| $P_0V_3$ | 13.27 b | 3.42 bc | 11.87 cd |
| $P_1V_0$ | 8.767 d | 1.58 e | 5.48 e |
| $P_1V_1$ | 12.92 bc | 2.92 d | 10.13 d |
| $P_1V_2$ | 13.32 b | 3.47 bc | 12.06 bcd |
| $P_1V_3$ | 14.58 a | 4.07 a | 14.12 ab |
| $P_2V_0$ | 9.240 d | 1.67 e | 5.81 e |
| $P_2V_1$ | 13.00 bc | 3.03 d | 10.53 cd |
| $P_2V_2$ | 13.06 bc | 3.58 b | 12.43 bc |
| $P_2V_3$ | 15.34 a | 4.36 a | 15.15 a |
| LSD0.05 | 0.9352 | 0.363 | 2.245 |
| CV(%) | 5.82 | 7.91 | 9.90 |

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

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t ha$^{-1}$), $V_1$ = 5 t ha$^{-1}$ vermicompost, $V_2$ = 7.5 t ha$^{-1}$ vermicompost, $V_3$ = 10 t ha$^{-1}$ vermicompost

### 4.4.1 Single fruit weight (g)

Significant variation was recorded on single fruit weight of okra at different growth stages due to different seed priming treatments (Table 7 and Appendix VII). The highest single fruit weight (12.66 cm) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically identical with $P_1$ (Halopriming; $CaCl_2$ - 1 ppm). The lowest single fruit weight (11.73 cm) was recorded from control treatment $P_0$ (No priming with water). Similar result was also observed by Pushpalatha (2008) which supported the present study.

Different rate of vermicompost application showed significant difference among the treatments regarding single fruit weight of okra at different growth stages (Table 7 and Appendix VII). The highest single fruit weight (14.40 cm) was recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) whereas the lowest single fruit weight (8.85 cm) was recorded from the treatment $V_0$ (control; novermicompost). Wang *et al.* (2006) Ullah *et al.* (2008) also observed supported result with the present study.

Combined effect of seed priming and vermicompost exhibited significant variation on single fruit weight of okra at different growth stages among the treatment combinations (Table 7 and Appendix VII). The highest single fruit weight (15.34 cm) was achieved from the treatment combination of $P_2V_3$which was statistically similar with $P_2V_2$. The lowest single fruit weight (8.54 cm) was recorded from the treatment combination of $P_0V_0$.

### 4.4.2 Fruit yield plot$^{-1}$

Significant variation was recorded on fruit yield plot$^{-1}$ of okra at different growth stages due to different seed priming treatments (Table 7 and Appendix VII). The highest fruit yield plot$^{-1}$ (3.16 kg) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically identical with $P_1$ (Halopriming; $CaCl_2$ - 1 ppm) whereas the lowest fruit yield plot$^{-1}$ (2.71 kg) was recorded from control treatment $P_0$ No priming (with water). Pushpalatha (2008) also observed similar result with the present study.

Different rate of vermicompost application showed significant difference among the treatments regarding fruit yield plot$^{-1}$ of okra at different growth stages (Table 7 and Appendix VII). The highest fruit yield plot$^{-1}$ (3.95 kg) was recorded from the treatment $V_3$ (10 t ha$^{-1}$ vermicompost) which was statistically different fromothers. The lowest fruit yield plot$^{-1}$ (1.57 kg) was recorded from the treatment $V_0$ (control; novermicompost). Similar result was also observed by Wang *et al.* (2006).

Combined effect of seed priming and vermicompost exhibited significant variation on fruit yield plot$^{-1}$ of okra at different growth stages among the treatment combinations (Table 7 and Appendix VII). The highest fruit yield plot$^{-1}$ (4.36 kg) was achieved from the treatment combination of $P_2V_3$ which was statistically different from others. The lowest fruit yield plot$^{-1}$ (1.46 kg) was recorded from the treatment combination of $P_0V_0$.

### 4.4.3 Fruit yield ha$^{-1}$

Significant variation was recorded on fruit yield ha$^{-1}$ of okra at different growth stages due to different seed priming treatments (Table 2 and Appendix VII). The highest fruit yield ha$^{-1}$ (10.98 t) was recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** which was statistically identical with $P_1$ (Halopriming; $CaCl_2$ **-** 1 ppm). The lowest fruit yield ha$^{-1}$ (9.41 t) was recorded from control treatment $P_0$ (No priming with water). Pushpalatha (2008) also observed similar result which supported the present study. Results indicated that $P_2$ (Osmopriming; $MgSO_4$ **-** 3 ppm**)** showed maximum fruit yield ha$^{-1}$ which might be due to cause of maximum number of fruits plant$^{-1}$, fruit length, fruit diameter and single fruit weight were from the same treatment. Moreover, seed priming from this treatment showed highest seed germination and also might be healthy and vigorous plant also found from the same treatment. Similar result was also observed by Pushpalatha (2008).

Different rate of vermicompost application showed significant difference among the treatments regarding fruit yield $ha^{-1}$ of okra at different growth stages (Table 5and Appendix VII). The highest fruit yield $ha^{-1}$ (13.71 t) was recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) which was statistically different from others. The lowest fruit yield $ha^{-1}$ (5.45 t) was recorded from the treatment $V_0$ (control; novermicompost). Yield contributing parameters like number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ and single fruit weight were also recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) which might be resulted maximum fruit yield $ha^{-1}$. Again, $V_3$ (10 t $ha^{-1}$ vermicompost) application to okra might be considered as optimum nutrient supplier for plant growth and yield compared to other doses. Wang *et al.* (2010), Meenatchi *et al.* (2010) and Ghorbani *et al.* (2008) also found similar result which supported the present study.

Combined effect of seed priming and vermicompost exhibited significant variation on fruit yield $ha^{-1}$ of okra at different growth stages among the treatment combinations (Table 5 and Appendix VII). The highest fruit yield $ha^{-1}$ (15.15 t) was achieved from the treatment combination of $P_2V_3$ which was statistically similar with $P_1V_2$ whereas the lowest fruit yield $ha^{-1}$ (5.06) was recorded from the treatment combination of $P_0V_0$.

### 4.5 Economic analysis

Different material and non-material input cost like land preparation, seed, seed sowing, vermicompost, irrigation and, interest on fixed capital land (Leased land by ban loan basis) and miscellaneous cost were considered for calculating the total cost of production in per hectare basis (Table 8 and Appendix VIII). Price of okra was considered at market rate. The economic analysis is presented under the following headlines:

Table 8. Cost of production of okra per hectare as influenced by seed priming and vermicompost combination

| | Okra yield $ha^{-1}$ (t) | Total cost of production Tk. $ha^{-1}$) | Gross return (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
|---|---|---|---|---|---|
| $P_0V_0$ | 5.06 | 129946 | 151800 | 21854 | 1.17 |
| $P_0V_1$ | 9.90 | 197041 | 297000 | 99959 | 1.51 |
| $P_0V_2$ | 10.83 | 230588 | 324900 | 94312 | 1.41 |
| $P_0V_3$ | 11.87 | 264136 | 356100 | 91964 | 1.35 |
| $P_1V_0$ | 5.48 | 132182 | 164400 | 32218 | 1.24 |
| $P_1V_1$ | 10.13 | 199277 | 303900 | 104623 | 1.53 |
| $P_1V_2$ | 12.06 | 232825 | 361800 | 128975 | 1.55 |
| $P_1V_3$ | 14.12 | 266372 | 423600 | 157228 | 1.59 |
| $P_2V_0$ | 5.81 | 133301 | 174300 | 40999 | 1.31 |
| $P_2V_1$ | 10.53 | 200396 | 315900 | 115504 | 1.58 |
| $P_2V_2$ | 12.43 | 233943 | 372900 | 138957 | 1.59 |
| $P_2V_3$ | 15.15 | 267491 | 454500 | 187009 | 1.70 |

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost

### 4.3.1 Gross return

The combination of different seed priming treatments and vermicompost levels showed different gross return (Table 8). Gross return was calculated on the basis of sale of okra. The highest gross return (Tk. 454500) obtained from $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t $ha^{-1}$ vermicompost) treatment combination and lowest gross return (Tk. 21854) obtained from the treatment combination of $P_0V_0$ (no priming with water and no vermicompost).

### 4.3.2 Net return

Treatment combinations of priming treatment and different macro nutrient management showed net returns variation (Table 8). The highest net return (Tk. 187009) was obtained from the treatment combination of $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t $ha^{-1}$ vermicompost) and lowest net return (Tk. 21854) was obtained from the treatment combination of $P_0V_0$ no priming (with water) and no vermicompost.

### 4.3.3 Benefit cost ratio (BCR)

Among different treatment combinations of priming treatment and macro nutrient management, difference on benefit cost ration (BCR) was observed among the treatment combinations (Table 8). The highest BCR (1.70) was obtained from the treatment combination of $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t $ha^{-1}$ vermicompost) and lowest BCR (1.17) was obtained from $P_0V_0$ (no priming with water and no vermicompost) treatment combination. From economic point of view, it was noticeable from the above results, the treatment combination of $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppmwith 10 t $ha^{-1}$ vermicompost), $P_2V_3$ was more profitable than rest of the treatment combinations.

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University during the period of March to July, 2018. The experiment was carried out to evaluate the response of seed priming and vermicompost on germination, growth and yield of okra *(Abelmoschus esculentus*). The experiment consists of two factors such as three levels of seed priming treatments *viz*, $P_0$ (no priming with water), $P_1$ (Halopriming; $CaCl_2$ - 1 ppm) and $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)** and four levels of vermicompost *viz*, $V_0$ (control; no vermicompost), $V_1$ (5 t $ha^{-1}$ vermicompost), $V_2$ (7.5 t $ha^{-1}$ vermicompost) and $V_3$ (10 t $ha^{-1}$ vermicompost). Two factors experiment was laid out in Randomized Complete Block Design (RCBD) with the three replications.

Application of seed priming exhibited a significant influence on studied parameters except number of leaves $plant^{-1}$.Results revealed that the highest % seed germination (92.27%) was recorded in $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm) whereas the lowest percent (%) seed germination (76.63%) was found in control treatment $P_0$ (No priming with water). Regarding growth parameters, the highest plant height (133.10 cm) and number of leaves $plant^{-1}$ (39.65) were recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm**)**whereas the lowest plant height (127.10 cm) and number of leaves $plant^{-1}$ (37.90) were recorded from control treatment $P_0$ (No priming with water). Again, the highest number of flowers $plant^{-1}$ (27.51), number of fruits $plant^{-1}$ (20.37), fruit length (16.44 cm), fruit diameter (1.81 cm), single fruit weight (12.66 cm), fruit yield $plot^{-1}$ (3.16 kg) and fruit yield $ha^{-1}$ (10.98 t) were recorded from $P_2$ (Osmopriming; $MgSO_4$ - 3 ppm). Similarly, the lowest number of flowers $plant^{-1}$ (24.82), number of fruits $plant^{-1}$ (18.86), fruit length (15.18 cm), fruit diameter (1.62 cm), single fruit weight (11.73 cm), fruit yield $plot^{-1}$ (2.71 kg) and fruit yield $ha^{-1}$ (9.41 t) was recorded from control treatment $P_0$ No priming (with water).

Application of vermicompostshowed significant variation on different studied parameters.Results revealed that the highest percent (%) seed germination (88.22%) was recorded in $V_3$ (10 t $ha^{-1}$ vermicompost) treatment whereas the lowest percent (%) seed germination (82.00%) was found in control treatment $P_0$ (No priming with water). Regarding growth parameters, the highest plant height (148.00 cm) and number of leaves $plant^{-1}$ (44.23) were recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) whereas the lowest plant height (112.90 cm) and number of leaves $plant^{-1}$ (32.75) were recorded from $V_0$ (control; novermicompost).In terms of yield contributing parameters and yield, the highest number of flowers $plant^{-1}$ (30.76) number of fruits $plant^{-1}$ (22.81), fruit length (18.04 cm), fruit diameter (2.02 cm), single fruit weight (14.40 cm), fruit yield $plot^{-1}$ (3.95 kg) and fruit yield $ha^{-1}$ (13.71 t) were recorded from the treatment $V_3$ (10 t $ha^{-1}$ vermicompost) whereas the lowest number of flowers $plant^{-1}$ (20.56), number of fruits $plant^{-1}$ (14.79), fruit length (12.77 cm), fruit diameter (1.44 cm), single fruit weight (8.85 cm), fruit yield $plot^{-1}$ (1.57 kg) and fruit yield $ha^{-1}$ (5.45 t) were recorded from $V_0$ (control; no vermicompost).

Different treatment combination showed significant variation on different growth and yield parameters. Results showed that the highest percent (%) seed germination (95.75%) was found from $P_2V_3$whereas the lowest percent (%) seed germination (73.00%) was found in $P_0V_0$.Regarding growth parameters, the highest plant height (152.40 cm) and number of leaves $plant^{-1}$ (45.40) were achieved from $P_2V_3$but the lowest plant height (111.40 cm) and number of leaves $plant^{-1}$ (32.48) were recorded from $P_0V_0$.Again, regarding yield contributing parameters and yield, the highest number of flowers $plant^{-1}$ (32.62), number of fruits $plant^{-1}$ (23.72), fruit length (18.80 cm), fruit diameter (2.16 cm), single fruit weight (15.34 cm), fruit yield $plot^{-1}$ (4.36 kg) and fruit yield $ha^{-1}$ (15.15 t) were achieved from the treatment combination of $P_2V_3$. The lowest number of flowers $plant^{-1}$ (19.42), number of fruits $plant^{-1}$ (14.24), fruit length (12.56 cm), fruit diameter (1.42 cm), single fruit weight (8.54 cm), fruit yield plot$^{-1}$ (1.46 kg) and fruit yield ha$^{-1}$ (5.06) was recorded from the treatment combination of $P_0V_0$.

In terms of economic analysis, the highest gross return (Tk. 454500), net return (Tk. 187009) and BCR (1.70) were obtained from the treatment combination of $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t ha$^{-1}$ vermicompost) whereas the lowest gross return (Tk. 151800), net return (Tk. 21854) and BCR (1.17) were obtained from $P_0V_0$ no priming (with water) and no vermicompost.

From the above discussion it can be concluded that among the three priming treatments, $P_2$ (Osmopriming; $MgSO_4$ **-** 3 ppm**)** showed the best performance in respect of yield and economic performance. In terms of vermicompost application, among the 4 rates, $V_3$ (10 t ha$^{-1}$ vermicompost) gave the best result. Again, Interaction effect of seed priming and vermicompost, $P_2V_3$ (Osmopriming; $MgSO_4$ - 3 ppm with 10 t ha$^{-1}$ vermicompost) provided the higher return in terms of yield compared to other combination.

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## APPENDICES

Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from Marchto July 2018.

| Year | Month | Air temperature (°C) | | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | *Max* | *Min* | *Mean* | | |
| 2018 | March | 35.20 | 21.00 | 28.10 | 52.44 | 20.4 |
| 2018 | April | 34.70 | 24.60 | 29.65 | 65.40 | 165.0 |
| 2018 | May | 32.64 | 23.85 | 28.25 | 68.30 | 182.2 |
| 2018 | June | 27.40 | 23.44 | 25.42 | 71.28 | 190 |
| 2018 | July | 30.52 | 24.80 | 27.66 | 78.00 | 536 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Horticulture Farm, SAU, Dhaka |
| *AEZ* | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Not Applicable |

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam (ISSS) |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

Appendix III. Percent seed germination of okra as influenced by seed priming and vermicompost

| Sources | DF | Mean square of percent seed germination | | |
|---|---|---|---|---|
| | | 4 DAS | 8 DAS | 12 DAS |
| Replication | 2 | 13.317 | 21.175 | 96.285 |
| Factor A | 2 | 589.03* | 738.15* | 839.224* |
| Factor B | 3 | 74.202* | 60.365* | 89.885* |
| AB | 6 | 1.743** | 1.943* | 1.305* |
| Error | 22 | 6.243 | 3.000 | 12.970 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Plant height of okra as influenced by seed priming and vermicompost

| Sources | DF | Mean square of plant height (cm) | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS |
| Replication | 2 | 40.869 | 17.572 | 8.982 |
| Factor A | 2 | 126.639* | 160.507* | 107.111* |
| Factor B | 3 | 1485.43* | 2400.47* | 2038.84* |
| AB | 6 | 6.183** | 12.290* | 10.934* |
| Error | 22 | 3.168 | 7.666 | 3.862 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Number of leaves plant$^{-1}$ of okra as influenced by seed priming and vermicompost

| Sources | DF | Mean square of number of leaves plant$^{-1}$ | | |
|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS |
| Replication | 2 | 17.138 | 17.887 | 13.003 |
| Factor A | 2 | 3.449NS | 5.497NS | 9.308NS |
| Factor B | 3 | 51.292* | 153.742* | 206.219* |
| AB | 6 | 0.547** | 0.831** | 0.991** |
| Error | 22 | 0.175 | 1.677 | 2.172 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield contributing parameters of okra as influenced by seed priming and vermicompost

| Sources | DF | Mean square of yield contributing parameters | | | |
|---|---|---|---|---|---|
| | | Number of flowers plant$^{-1}$ | Number of fruits plant$^{-1}$ | Fruit length (cm) | Fruit diameter (cm) |
| Replication | 2 | 21.870 | 0.191 | 0.332 | 0.059 |
| Factor A | 2 | 22.878* | 6.876* | 5.132* | 0.108** |
| Factor B | 3 | 171.27* | 118.36* | 49.17* | 0.577** |
| AB | 6 | 2.384 | 0.410 | 0.576** | 0.027** |
| Error | 22 | 0.965 | 0.640 | 0.482 | 0.014 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Yield parameters of okra as influenced by seed priming and vermicompost

| Sources | DF | Mean square of yield parameters | | |
|---|---|---|---|---|
| | | Single fruit weight (g) | Fruit yield plot$^{-1}$ (kg) | Fruit yield ha$^{-1}$ (t) |
| Replication | 2 | 5.460 | 0.323 | 3.862 |
| Factor A | 2 | 2.737** | 0.631 | 7.598* |
| Factor B | 3 | 51.07* | 9.308* | 112.06* |
| AB | 6 | 0.625** | 0.101** | 1.226* |
| Error | 22 | 3.305 | 0.146 | 1.758 |

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII: Cost of production of okra per hectare

A. Input cost (Tk. $ha^{-1}$)

| Treatments | Labor cost | Ploughing cost | Seed cost | Sowing cost | Irrigation | Vermicompost | Fertilizer cost (Tk/ha) | | | Seed priming cost | Subtotal (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Urea | TSP | MoP | | |
| $P_0V_0$ | 12000 | 8000 | 10000 | 13000 | 4000 | 0 | 2400 | 2500 | 2400 | 0 | 54300 |
| $P_0V_1$ | 12000 | 8000 | 10000 | 13000 | 4000 | 60000 | 2400 | 2500 | 2400 | 0 | 114300 |
| $P_0V_2$ | 12000 | 8000 | 10000 | 13000 | 4000 | 90000 | 2400 | 2500 | 2400 | 0 | 144300 |
| $P_0V_3$ | 12000 | 8000 | 10000 | 13000 | 4000 | 120000 | 2400 | 2500 | 2400 | 0 | 174300 |
| $P_1V_0$ | 12000 | 8000 | 10000 | 13000 | 4000 | 0 | 2400 | 2500 | 2400 | 2000 | 56300 |
| $P_1V_1$ | 12000 | 8000 | 10000 | 13000 | 4000 | 60000 | 2400 | 2500 | 2400 | 2000 | 116300 |
| $P_1V_2$ | 12000 | 8000 | 10000 | 13000 | 4000 | 90000 | 2400 | 2500 | 2400 | 2000 | 146300 |
| $P_1V_3$ | 12000 | 8000 | 10000 | 13000 | 4000 | 120000 | 2400 | 2500 | 2400 | 2000 | 176300 |
| $P_2V_0$ | 12000 | 8000 | 10000 | 13000 | 4000 | 0 | 2400 | 2500 | 2400 | 3000 | 57300 |
| $P_2V_1$ | 12000 | 8000 | 10000 | 13000 | 4000 | 60000 | 2400 | 2500 | 2400 | 3000 | 117300 |
| $P_2V_2$ | 12000 | 8000 | 10000 | 13000 | 4000 | 90000 | 2400 | 2500 | 2400 | 3000 | 147300 |
| $P_2V_3$ | 12000 | 8000 | 10000 | 13000 | 4000 | 120000 | 2400 | 2500 | 2400 | 3000 | 177300 |

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost

B. Overhead cost (Tk. $ha^{-1}$), Cost of production (Tk. $ha^{-1}$), Gross return (Tk. $ha^{-1}$), Net return (Tk. $ha^{-1}$) and BCR

| Treatments | Overhead cost (Tk. $ha^{-1}$) | | | | Subtotal (A) | Total cost of production ( A+B) | Okra yield $ha^{-1}$ (t) | Gross return (Tk. $ha^{-1}$) | Net return (Tk. $ha^{-1}$) | BCR |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cost of leased land for 6 months (13% of value of land Tk. 10,00,000/- | Miscellaneous cost ( Tk. 5% of the input cost) | Interest on running capital for 6 month (13% of cost $year^{-1}$) | Subtotal (B) | | | | | | |
| $P_0V_0$ | 65000 | 2715 | 7931 | 75645.98 | 54300 | 129946 | 5.06 | 151800 | 21854 | 1.17 |
| $P_0V_1$ | 65000 | 5715 | 12026 | 82740.98 | 114300 | 197041 | 9.90 | 297000 | 99959 | 1.51 |
| $P_0V_2$ | 65000 | 7215 | 14073 | 86288.48 | 144300 | 230588 | 10.83 | 324900 | 94312 | 1.41 |
| $P_0V_3$ | 65000 | 8715 | 16121 | 89835.98 | 174300 | 264136 | 11.87 | 356100 | 91964 | 1.35 |
| $P_1V_0$ | 65000 | 2815 | 8067 | 75882.48 | 56300 | 132182 | 5.48 | 164400 | 32218 | 1.24 |
| $P_1V_1$ | 65000 | 5815 | 12162 | 82977.48 | 116300 | 199277 | 10.13 | 303900 | 104623 | 1.53 |
| $P_1V_2$ | 65000 | 7315 | 14210 | 86524.98 | 146300 | 232825 | 12.06 | 361800 | 128975 | 1.55 |
| $P_1V_3$ | 65000 | 8815 | 16257 | 90072.48 | 176300 | 266372 | 14.12 | 423600 | 157228 | 1.59 |
| $P_2V_0$ | 65000 | 2865 | 8136 | 76000.73 | 57300 | 133301 | 5.81 | 174300 | 40999 | 1.31 |
| $P_2V_1$ | 65000 | 5865 | 12231 | 83095.73 | 117300 | 200396 | 10.53 | 315900 | 115504 | 1.58 |
| $P_2V_2$ | 65000 | 7365 | 14278 | 86643.23 | 147300 | 233943 | 12.43 | 372900 | 138957 | 1.59 |
| $P_2V_3$ | 65000 | 8865 | 16326 | 90190.73 | 177300 | 267491 | 15.15 | 454500 | 187009 | 1.70 |

Selling cost of Okra = Tk. 30/kg

$P_0$ = No priming (with water), $P_1$ = Halopriming ($CaCl_2$) - 1 ppm, $P_2$ = Osmopriming ($MgSO_4$) – 3 ppm

$V_0$ = Control (0 t $ha^{-1}$), $V_1$ = 5 t $ha^{-1}$ vermicompost, $V_2$ = 7.5 t $ha^{-1}$ vermicompost, $V_3$ = 10 t $ha^{-1}$ vermicompost