EFFECT OF ORGANIC MANURE AND DIFFERENT DOSES OF CHEMICAL FERTILIZER ON YIELD AND SEED QUALITY OF OKRA

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EFFECT OF ORGANIC MANURE AND DIFFERENT DOSES OF CHEMICAL FERTILIZER ON YIELD AND SEED QUALITY OF OKRA

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CERTICERTIFICATE

This is to certify that the thesis entitled, ***"Effect of organic manure and different doses of chemical fertilizer on yield and seed quality of okra"*** *submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in SEED TECHNOLOGY****, embodies the result of a piece of original research work carried out by* ***Sumona Akhter****, Registration No.* ***12-05056*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Place: Dhaka, Bangladesh

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Dedicated to..

My parents,
The reason of what I become today,
I am grateful for your great support,
Inspiration and continuous love for me..

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Abstract

The pot experiment was conducted at the net house of agronomy research field in Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from April to July 2018 to study the effect of organic manure and different doses of chemical fertilizers on the yield and seed quality of okra. Two factors were considered for the present study such as three types of organic manures *viz.*, M_1= Cowdung (10 t ha^{-1}), M_2= ACI compost (8 t ha^{-1}) and M_3= Vermicompost (5 t ha^{-1}) and four levels of chemical fertilizers *viz.*, F_0= No fertilizer (NF), F_1= Recommended dose of fertilizer (RDF; where N, P and K was at 60-90-60 kg ha^{-1}, respectively), F_2= 25% less of RDF (45-67-45) and F_3= 50% less of RDF (30-45-30). The experiment was laid out in randomized complete block design (RCBD) with three replications. Result revealed that, most of the studied parameters *viz.*, plant height, pod diameter, pod length, green pod yield plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield plant^{-1} and germination percentage were significantly influenced by organic manures, inorganic fertilizers and their combination. The highest performances in terms of plant height at 20, 40 and 60 DAS (19.31, 82.28 and 104.96 cm, respectively), pod diameter (3.96 cm), pod length (11.59 cm), green pod plant^{-1} (6.75),green pod yield plant^{-1} (0.64 kg), seeds pod^{-1} (57.82), seed weight pod^{-1}(6.01 g), 100-seed weight (6.24 g), seed yield plant^{-1} (12.21 g) and shelling % (44.79)was found while vermicompost was used. On the contrary, the lowest value was observed while cowdung was applied. In terms of fertilizers doses, highest performances was observed at F_2= 25% less of RDF treatment considering the plant height at 20, 40 and 60 DAS (20.05, 79.15 and 100.39 cm, respectively), branches number plant^{-1} (4.54), pod diameter (3.75 cm), pod length (11.34 cm), green pod plant^{-1} (7.38), seeds pod^{-1} (59.06), 100-seed weight (6.08 g), seed yield plant^{-1} (9.79 g) and shelling % (41.05). In case of interaction effect of organic and inorganic fertilizer, the maximum growth and yield attributes were observed in M_3F_2 except the number of branches plant^{-1} (4.60) which was found in M_2F_2 treatment combination. However, in case of seed quality parameters *viz.*, germination percentage, root-shoot ratio, seedlings fresh weight (FW) and dry weight (DW), organic and inorganic fertilizers responded differently while in interaction the highest performances was found in M_3F_2 combination. Thus it could be concluded that, application of vermicompost along with 25% less of RDF accelerated growth, yield and seed quality of okra.

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	ELABORATION
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
CV %	Percent Coefficient of Variation
ANOVA	Analysis of Variance
DAS	Days After Sowing
et al.,	And others
e.g.	exempli gratia (L), for example
etc.	Etcetera
UNDP	United Nations Development Programs
FAO	Food and Agriculture Organization
g	Gram (s)
ppm	Parts per million
Kg	Kilogram (s)
LSD	Least Significant Difference
HRC	Horticultural Research Center
FYM	Farm Yard Manure
BARI	Bangladesh Agricultural Research Institute
BRRI	Bangladesh Rice Research Institute
SAU	Sher-e-Bangla Agricultural University
var.	Variety
RDF	Recommended Doses of Fertilizer
RCBD	Randomized Complete Block Design
N-P-K	Nitrogen-Phosphorus-Potassium
^{o}C	Degree Celsius
%	Percentage

CHAPTER I

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] belongs to the family Malvaceae which is popularly known as Lady's finger, Dherosh or Bhindi in different regions of the country. Okra is considered as one of the most important summer vegetables in Bangladesh. It is widely cultivated and can be found in almost every market all over the country (Gudugi, 2013, Iyagba *et al.*, 2012). Okra is a vegetable originated from Africa, cultivated under rainfed or irrigated conditions in a wide range of soils, and is one of the most important vegetables in the world, especially in tropical and subtropical climates (Vinícius-Marin *et al.,* 2017, Prakash *et al.,* 2014). This crop plays an important role in human diet due to the supply of carbohydrates, proteins, fats, minerals and vitamins (El-Kader *et al.,* 2010). Tender green pods of okra contains approximately 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fiber and 0.8% ash. The pods have some medicinal values in preparing mucilaginous substances which may use as plasma replacement or blood volume expander (Jahan *et al.,* 2020).Additionally, its seeds provide high-quality oil and the mucilage from its fruit can be used as a thickener in food industry (Alegbejo *et al.,* 2008).The significance of crop further enhances due to its multiple uses. The dry seed contains 13-22 % good quality edible oil and 20-24% protein. The oil is used in soap and cosmetic industry while protein is used for fortified feed preparation. The crushed seed is fed to cattle for higher milk production and the fiber is utilized in jute textile and paper industry (Muhammad *et al.,* 2019).

Vegetable production in Bangladesh has increased between 1980 and 2010. Current yields are 5.8 t ha^{-1}, as compared to 5.7 t ha^{-1} in 1980. However, domestic vegetable availability is still far from fulfilling domestic demand (Weinberger and Genova, 2005).In Bangladesh, supply of vegetables is plenty in winter season, but is low in summer season. Of the total vegetable production, around 30% is produced during Kharif season and around 70% in the Rabi season. Therefore, as vegetable okra can get an importance in kharif season as well as summer season in our country context(Firoz *et al.,* 2007).Total production of okra was 42,366 MT produced from 10,204 ha of land in the year 2009- 2010 and the average yield was 3.92 t ha^{-1} (BBS, 2011), which is very low compared to that of other developed countries where the yield was as high as 14.0-15.0 t ha^{-1} (Dash *et al.,* 2013, Anjali *et al.,* 2006).Daily requirements of vegetables for an adult person is approximately 285 g whereas in Bangladesh people hardly can intake only 35g of vegetable per day. Therefore, there is a big gap between the requirement and per capita vegetable consumption in Bangladesh. As a result, malnutrition is very much evident in our country. Successful okra production may contribute partially in solving this vegetable scarcity of summer season for the people of Bangladesh (Muqtadir *et al.,* 2019).

The sustainability of conventional agriculture in Bangladesh is under threat from the continuous degradation of land and water resources, as well as declining yield due to indiscriminate use of agro-chemicals. The low yield of okra in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons *viz.,* unavailability of quality seeds of high yielding varieties in appropriate time, fertilizer management, disease and insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices (Bhunia and Chakraborty, 2011).Organic farming practices are the potential way to decrease the negative environmental impact of excessive amounts of chemical fertilizers. Organic fertilizers are environmental friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density and they foster diverse population of beneficial soil microorganisms. Akhter *et al.* (2019) found the highest yield of okra from the combined effect of vermicompost and netting which was 56.74% higher compared to control treatment combination. Besides mineral fertilization, the application of organic fertilizers has been considered as important for vegetable production. The strategy is to use this input at doses that maximize yield, adding mineral fertilizers in complementary quantities, which would reduce production costs (Oliveira *et al.,* 2014).The inorganic chemical fertilizers cause environmental risks including heavy incidence of pests and diseases. Therefore, it is felt imperative to reduce the use of inorganic fertilizers by adopting suitable integrated nutrient management system (INMS) comprising farm yard manure (FYM), composts, vermicompost, Cowdung etc. It is noteworthy that application of organic manures not only produced the highest and sustainable crop yield, but also improved the soil fertility and productivity (Sanwal *et al.,* 2007). Although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, its growth promoting constituents like enzymes and hormones, besides plant nutrients make them useful for improvement of soil fertility and productivity. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields (Abou El Magd and Hoda, 2005).

In recent years, use of vermicompost has been advocated in integrated nutrient management (INM) system in vegetable crops. Vermicompost refers to a mixture of worm casting, organic materials, humus, living earthworms, their cocoons and other organisms. Vermicompost is a slow releasing organic manure which have most of the macro as well as micro nutrients in chelated form and full fill the nutrient requirement of plants for longer period. Vermicompost helps in reducing C: N ratio, increased humic acid content, cation exchange capacity and water soluble carbohydrates. It also contains biological active substance such as plant growth regulators (Makinde and Ayoola, 2008). Soil fertility of Bangladesh is reducing day by day due to applying excessive amount chemical fertilizers. Combination of organic and inorganic fertilizers can help to increase yields during hot, sunny periods of the year. It might be the opportunity to reduce the demand of inorganic fertilizers and improve the soil quality by incorporating organic fertilizers in the field.

Considering this, the present experiment has been undertaken with the following objectives-

I. To determine the effect of organic manures on green vegetable, seed yield and seed quality of okra,

II. To find out the performances of different levels of inorganic fertilizer on green vegetable, seed yield and seed quality of okra

III. To evaluate the interaction of organic and inorganic fertilizer on green vegetable, seed yield and seed quality of okra.

CHAPTER II

REVIEW OF LITERATURE

A brief review of literature on important aspects pertaining to the present study is presented in this chapter. An attempt has been made to cite all available literature on okra but due to paucity of adequate published information, research work on other crops has also been reviewed.

2.1 World scenario of okra production

According to FAOSTAT (2016), global production of okra is approximately 8.90 million tons per year. The major producing countries include India (5.50 million tons), Nigeria (1.97 million tons), Sudan (287,000 tons), Mali (241,033), Pakistan (117,961 tons), Cote d'Ivoire (112,966 tons), Ghana (66,360 tons), Egypt (55,166 tons), Iraq (123,583 tons), and Malaysia (55,856 tons). Nutritionally, tender green pods of okra are important sources of vitamins and minerals such as vitamins A, B1, B3, B6, C and K, folic acid, potassium, magnesium, calcium and trace elements such as copper, manganese, iron, zinc, nickel, and iodine (Lee *et al.,* 1990).

2.2 Soil fertility and vegetable production

Vegetable crop producers in the tropics are inflicted with the problem of maintaining soil fertility. This is because the native fertility of most agricultural soils in this region is low and cannot support suitable crop production over a long period without the use of fertilizers (Saidu *et al.,* 2011). This problem is further compounded by the scarcity and high cost of inorganic fertilizers which has forced farmers to make use of fertilizer rates that are lower than the optimum with its resultant reduction in yield. Tyagi *et al.* (2016) discovered that farmers applied less than half of the 120 kg N ha^{-1} recommended for Okra in the northern Guinea savannah due to the problem of scarcity and high cost of inorganic fertilizer. Prasad and Naik (2013) have described soil fertility degradation as the second most serious constraint to food scarcity in Asia.

2.3 Overview on vegetables growing patterns in Bangladesh

More than 60 types of vegetables of indigenous and exotic origin are grown in Bangladesh. Based on the growing season, vegetables are categorized as summer/rainy season vegetables, winter season vegetables, and all-season vegetables.

Of the summer vegetables, various cucurbits, vegetable cowpea, hyacinth bean, stem amaranth, several aroids and Indian spinach are predominant. Winter vegetables include tomato, cabbage, Chinese cabbage, cauliflower, eggplant, carrot, spinach, bottle gourd, bush bean and radish. Crops like okra, heat-tolerant tomato, eggplant, carrot, spinach, many leafy vegetables and small onion are grown all year round. Summer vegetables are cultivated during the monsoon season from May to October. On the other hand, winter vegetables are grown from November to April. The production of vegetables is higher during winter (60 to 70%) and most districts produce marketable surplus during that season. (Weinberger and Genova, 2005).

2.4 Effect of organic manure on crop growth and yield

Agricultural production is greatly influenced by the irrational use of inorganic fertilizers. Deterioration of soil nutrient content resulted in reduced crop yield is the common detrimental effect of inorganic fertilizers. On the other side, inorganic fertilizers have enormous harmful effect on the environment and the living entities of the environment. Reduced soil fertility and increased price of the fertilizers made organic manures as a suitable and eco-friendly replacement of the environment. The organic matter contents of soil vary from 0-5% and it depends on several factors like origin of soil, climatic conditions, vegetation, microbial activities etc. The physical, chemical and biological properties of soil are greatly influenced by organic matter (Cardoso and Berni, 2012). Oliveira *et al.* (2007) stated that manures are not sufficiently available with nutrients in organic arable farming; this is why it necessitates the rapid use of other sources of inorganic nutrients that can fulfill the nutrient requirements of high yielding cereals under organic farming in Northern Europe.

Abou El-Magd *et al.* (2006) reported that application of manures sustains cropping system through better nutrient recycling and provides all necessary nutrients, thereby improving the physical and biological properties of soil. Organic fertilizer released all type of micro and macro nutrients that helps to plant elongation. Although, organic matter contain all the essential plant nutrients, but after application of organic manures required time to convert its available form to the plant. That is why the response of crops to organic manure is low. But due to the beneficial effects on soil properties, applications of organic manures are encouraged. Some available information about the effects of organic manures on growth and yield of okra are reviewed here.

Adekiya *et al.* (2012) expressed that organic manures generally improve the soil physical, chemical and biological properties such as increased infiltration rate, reduced bulk density, aggregate stability, cation exchange capacity (CEC), and biological activities along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and productivity.

Muhammad *et al.* (2019) reported that organic manure serves as slow release reservoir for plant macronutrients, aids in plants micronutrient absorption, and facilitates water and air infiltration. It has however been argued that organic manures are usually late in nutrient mineralization. In spite of the numerous advantages of organic manure in soil productivity, not many works have been reported on their effects on yield of vegetables in the tropics.

Shahriazzaman *et al.* (2014) also stated the roles of manures influencing many physicochemical and biological properties of the soil as well as increasing high yield of vegetables that have yet not been given the necessary attention. Very recently, attention is focused on the global environmental problems; utilization of organic wastes, vermicompost and poultry manures as the most effective measure for the purpose. Application of vermicompost and poultry manure subsequently increase yield attributing characters and yield of okra.

Ali *et al.* (2008) stated that cowdung is an important organic manure in Bangladesh. It can be easily found in the village area and are frequently applied to the soil during the land preparation. The farmers of our country used it as a compulsory nutrient component for crop production. Cowdung manure may be bulky (nutrient contents are very low per unit volume) but it improve physical conditions of the soil and supplies N-P-K and other nutrients to plants. It also increases water-holding capacity of soil and balance the soil temperature. As it a good source of nitrogen, it supplemented nitrogen in the field thus reduce the pressure of applying extra amount of inorganic nitrogenous fertilizers. Cowdung helps to make the plant nutrients available in the soil solution and also make the good soil physical condition. Water holding capacity of the soil, root penetration capacity of the crop gets increased due to the application of the cowdung.

Muhammad *et al.* (2019) observed the effect of cowdung and poultry manure on yield of okra varieties and the results revealed that yield parameters such as number of pods per plant, mean pod weight, mean pod length, fresh pod weight per plant and pod yield were significantly increased when the nitrogen dose of 120 kg N ha^{-1} was applied using cowdung 6.6 t ha^{-1}. He also reported that cowdung manure application in addition to N and P fertilizers significantly increased yield by 14-41 % in comparison with plots that received the same amount of N and P but without manure.

Santos *et al.* (2019) reported that, organic fertilization like cowdung did not influence the vegetative growth of okra, but was beneficial to the production of fruits with higher vitamin C content, 52% higher than the contents found in fruits produced without such input. Mona *et al.* (2008) conducted a study to compare the impact of organic compost at 3 levels (6, 12 and 18 m^3/fed.) and mineral fertilization (150 kg ammonium sulphate, 150 kg ammonium sulphate, 150 kg calcium monophosphate and 50 kg potassium sulphate/fed), on growth and productivity of bitter fennel (*Foeniculum vulgare* var. vulgare Mill.) and Egyptian sage (*Salvia officinalis*). The results retrieved that all levels of compost significantly increased plant height, number of branches, fresh and dry weights of herb, oil (%) in fennel seeds and sage herb, as well as seed, herb and oil yield ml/plant and L/fed in fennel and sage, respectively, as compared to mineral fertilization.

Marschner (2012) observed that compost is the stable humus-like product resulting from the biological decomposition of organic matter under controlled conditions. It recycles nutrient elements such as nitrogen, sulfur, calcium, phosphorus, carbon, magnesium and trace minerals. These nutrients do not feed the plants directly, but sustain the natural life cycles of the soil by feeding the microorganisms that live there.

Chavan *et al.* (2015) showed that the highest plant height, number of leaves $plant^{-1}$ and pods yield of okra were higher with the application of compost, followed by chemical fertilizers and as compared with control field. Rady *et al.* (2016) showed that addition of compost at a rate of 20 t ha^{-1} improved the soil chemical and physical properties besides growth characteristics *viz.*, pods weight plant^{-1}, pod and seed yields of common bean. Abou El-Hassan *et al.* (2017) showed that all treatments of compost and vermicompost without mineral fertilizers decreased all vegetative characters, early and total yield of green beans plants and nitrate content of green bean pods.

Bucagu *et al.* (2017) found that application of organic fertilizers significantly increased leaf area, plant height, number of leaves, pods, weight of pods and total pod yield of snap bean. Chang *et al.* (2017) indicated that compost addition up to 20% had a positive influence on plant emergence and plant growth index (shoot height, stem diameter, leaf area, root dry weight and plant biomass) of green bean.

Fouda *et al.* (2017) showed that the best treatment that produced the highest values of vegetative growth parameter, pod length, pod diameter and yield of bean as well as quality parameters of bean plant was NPK 100 %+compost, compared to control. Alidadi *et al.* (2013) narrated that one of the best techniques for composting is vermicompost, by using a suitable earthworm species like *Eisenia fetida*. Vermicompost is the waste of worms feeding from solid waste, plant waste, and such additives as manures.

Sheela and Khimiya, (2013) observed that vermicompost is a nutrient-rich, microbiologically active organic amendment that results from the interactions between earthworms and microorganisms during the breakdown of the organic matter. It is a stabilized, finely divided peat-like material with a low C: N ratio, high porosity, and high water-holding capacity, in which most nutrients are present in forms that are readily taken up by plants. The most important benefit of vermicompost is its diverse and high microbial population. Its other benefits are as follows: good organic fertilizer, decreasing environmental pollution, and detoxifying some toxic chemicals. Recently, using vermicompost has increased because of these benefits and many researches are carried out to optimize them.

Chauhan *et al.* (2010) stated that waste of worms often contains nitrogen, phosphorus and potassium 5 to 11 times more than the bare soil. Islam *et al.* (2016) reported that bush bean (*Phaseolus vulgaris*) plants fertilized with vermicompost produced the highest fresh biomass, pod weight, pods number plant^{-1}, pod dry weight, pod length, green pod yield and protein content in pods.

2.5 Effect of organic manure on crop yield attributes and seed qualities

Yield of okra dramatically affected by the application of the cowdung. Different experiment shows the positive role of cowdung in increasing the yield and yield attributes of okra. Makinde and Ayoola (2008) reported that application of cowdung resulted in higher fruit yield as compared to poultry manure. At 10 t ha^{-1} poultry manure application gave the yield of 640 kg ha^{-1} while the highest of 1927 kg ha^{-1} of okra yield was observed with 15 t ha^{-1} application of cowdung.

Farhad *et al.* (2009) reported that the use of organic and mineral fertilizer for production of okra had a serious imperative effect. The consecutive study was performed for two year with 0, 10, 20, 30, and 40 ton cowdung ha^{-1} was applied with or without NPK fertilizer. A significant increase in yield with mineral fertilizer was observed during both years while the significant increase in yield was also obtained with increasing the dose of cowdung. Oliveira *et al.* (2007) conducted experiment and observed that the volume of curd in cabbage was significantly increased by application of cowdung and vermicompost (47 t ha^{-1}+27 t ha^{-1}) respectively in hybrid cabbage.

Attigah *et al.* (2013) conducted a study to explore the effect of poultry and cattle manures on the growth and yield of okra. Result showed that, the combined treatments of 175 kg NPK + 4t Poultry Manure ha^{-1} and 175 kg NPK + 6t Cowdung Manure ha^{-1} produced higher levels of the growth and yield parameters than the rest of the treatments.

Muhibbullah *et al.* (2005) observed that poultry manure alone increased the yield significantly when it was applied at the rate of 20 t ha^{-1}. Kondapa *et al.* (2009) observed the similar findings while experimented on cabbage and result showed that combination of poultry drops and inorganic fertilizer performed the best in sweet potato. Raguchander *et al.* (2005) found that the yield was higher over mineral fertilization while cowdung was used at a rate of 20 t ha^{-1}.

Alidadi *et al.* (2014) conducted an experiment on tomato to explore the comparison of vermicompost and cow-manure efficiency on the growth and yield. Results revealed that the effect of type and amount of organic fertilizers on tomato yield was significant at 1% level. The results of this study showed that using the vermicompost could significantly increase the tomato yield.

Different fruit and seed quality parameter are greatly influenced by the application cowdung as organic manure in okra. In different experiment alone or in combination with other treatments, imperative role of cowdung was observed by different scientists (Danso *et al.,* 2015). Akpa *et al.* (2019) conducted the experiment to observe the role of combine application of Cowdung and biochar on okra and therefore recommended that combination of cowdung and biochar at 12 t ha^{-1} and 8 t ha^{-1} respectively is necessary for effective growth and development of okra. It thus supplies three of the main nutrient elements needed by fruit plants.

Sameera *et al.* (2005) experimented with pigeon pea and treated with 4, 3 and 2 t ha^{-1}cowdung, vermicompost and poultry manure accordingly, which showed the highest protein content in seed with the application of cowdung (21.25 %) followed by vermicompost (20.90%) and poultry manure (20.87%).

Swift and Woomer (1993) proposed that composed prepared from cowdung has showed some positive results on different vegetable. For example, compost obtained from cowdung and municipal solid waste was used in broccoli to observe the effect on growth, yield and nutrient component. Interestingly, it showed better growth, yield and card nutrient content in broccoli.

Parthasarathi *et al.* (2008) conducted an experiment to develop a composite technique to produce quality okra pods for export purposes by using organic manures, biofertilizers and bio pesticides. The three highest pod yields (12.85, 12.54 and 12.51 t ha^{-1}) were recorded from 75 kg N ha^{-1} + biofertilizers + FYM, 50 kg N ha^{-1} + biofertilizers + FYM and 75 kg N ha^{-1} + FYM, respectively.

Premsekhar and Rajashree (2009) reported that the effect of farmyard manure (FYM; 12 t ha^{-1}) and *Azospirillum* Inoculation (1kg ha^{-1}), singly or in combination (1:1) with other organic amendments (neem cake, green leaf, and enriched compost), on the yield and quality of okra. In addition, green mulching is another effective way of increasing the plant productivity. Akanbi *et al.* (2005) found the highest number of fruits per plant (6.8) in case of okra was obtained with 4 t ha^{-1} of compost, split applied twice at planting and five weeks after planting.

Uwah *et al.* (2010) observed that the efficacy of poultry litter applications to enhance crop growth (yield and nutrient uptake) depends upon its nutrient availability. Kramany *et al.* (2007) suggested that the application of poultry litter to cropland can also increase soil organic matter; thereby improving soil quality and productivity. Jaja and Ibeawuch (2015) observed higher NPK content and uptake in both fruit as well as plant in tomato with application of 100% recommended dose of NPK as compared to 50 per cent.

Khan and Jaiswal (1988) reported that the application of nitrogen through urea and vermicompost significantly increased the nitrogen and protein content in okra fruit over control. Sharma *et al.* (2016) conducted experiment in two consecutive years with okra and observed that application of vermicompost (10 t ha^{-1}) with recommended NPK fertilizers showed the highest yield (9.83 and 14.67 t ha^{-1}). Bucagu *et al.* (2017) has reported that effect of vermicompost application was favorable than the effect of application of chemical fertilizers for potato crops.

Bano *et al.* (2018) conducted an experiment to estimate the efficacy of organic manures and biofertilizers on yield attributes and yield of okra var. Chameli with different types of organic and biofertilizers. Among which, the application of vermicompost at 8 t ha^{-1} and *Azotobacter* alone significantly increased the number of fruit $plant^{-1}$, fruit weight, fruit length, fruit yield $plant^{-1}$, fruit yield $plot^{-1}$ and fruit yield ha^{-1} as compared to control, FYM and poultry manure.

Akhter *et al.* (2019) found the highest yield of okra from the combined effect of vermicompost and netting which was 56.74% higher compared to control treatment combination. Shahriazzaman *et al.* (2014) found that, tallest plant, longest petiole and longest pod was observed with vermicompost application at 9.0 t ha^{-1}. Furthermore, integrated use of organic and inorganic sources of nutrients and biofertilizers increased the N, P and K concentrations in the plants (including fruits) of okra, pea and tomato.

Senjobi *et al.* (2010) suggested that integrated nutrient management also significantly increased shoot dry matter yield of tomato and fruit yields of okra. Kyriakopoulou *et al.* (2010) reported that the application of 100 per cent nitrogen as vermicompost registered the higher plant height and number of branches per plant of tomato and it was significantly superior over supplementation of 100 per cent N through urea and FYM. Abduli *et al.* (2013) found that growth of tomato plants significantly raised by increasing ratio of vermicompost combined with soil.

Sharma *et al.* (2010) recorded that application of 5 t ha^{-1} vermicompost significantly higher the values of yield attributes, fruit yield (69.2 t ha^{-1}) and protein content (18.0%) as well as B: C ratio (2.11) in okra crop. Yadav and Yadav (2010) conducted an experiment on okra and observed that the integrated application of 75% RDF with vermicompost gave significantly higher marketable fruit yield (86.40 g ha^{-1}).

2.6 Effect of inorganic fertilizer on crop growth and yield

Akanbi *et al.* (2010) conducted both pot and field experiments to determine okra response to organic and inorganic sources of nitrogen (N) fertilizer. In the pot experiment okra variety NHAe 47-4 was nourished with four N levels (0, 25, 50 and 75 kg N ha^{-1}) and five compost while in the field experiment the same variety of okra was fertilized with three N levels (0, 25 and 75 kg N ha^{-1}) and four compost rates. Application of 75 kg N ha^{-1} gave the highest okra fruit yield.

Uwah *et al.* (2010) conducted field experiments in 2007 and 2008 at Calabar in the south eastern rainforest zone of Nigeria to evaluate the response of okra due to the four rates of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and three rates of lime. Nitrogen had significant effects on plant height, number of leaves and branches plant^{-1}, number of pods plant^{-1}, fresh pod weight and total fresh pod yield. Nitrogen 80 kg ha^{-1} maximized all the growth and yield attributes.Vermicompost essentially improves the quality of the fruits and pods of different crops. Crop quality tends to increase with the increasing doses of vermicompost. Sood and Kaur (2019) observed that the maximum range of some plant parameters i.e. root length, shoot length, leaf length, fresh weight, number of cloves in garlic were increased with 15 t ha^{-1} vermicompost + 50 per cent NPK.

Liza *et al.* (2014) conducted a field experiment to evaluate the residual effects of organic manures and different level of recommended fertilizer dose (RFD) on the yield and nutrient uptake of BBRI dhan29. Results showed that, residual effects of organic manure with inorganic fertilizers significantly increased the yield attributes as well as grain and straw yields of rice. Treatment T6 (50% RFD + residual effect of CD 2.5 t ha^{-1}, PM 1.5 t ha^{-1}, and Com. 2.5 t ha^{-1}) produced the highest grain yield (6.87 t ha^{-1}) and straw yield (7.24 t ha^{-1}). The lowest grain yield (3.22 t ha^{-1}) and straw yield (4.55 t ha^{-1}) were found in T0 (Control) treatment. Arora *et al.* (1991) compared growth and yield of new okra cultivar, Punjab Padmini, with that of cv. Pusa-Sawani grown under variable N (0, 30, 60 and 90 kg ha^{-1}) and P (0, 30 and 60 kg ha^{-1}) fertilizer applications. They stated that plant height, number of fruits, fruit size and total green fruit yield were significantly improved by the application of 90 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}.

2.7 Effect of inorganic fertilizer on crop yield attributes and seed qualities

Das *et al.* (2007) reported that rabbit manure at 5 t ha^{-1} + 50% NPK (N:P:K kg 30:60:40 ha^{-1}) produced higher growth, yield attributes and seed yield (1767 Kg ha^{-1}) of black gram compared to the control (769 Kg ha^{-1})." This treatment was produced equivalent results to that of NPK + FYM or pig manure. All organic manures applied alone produced superior pod and seed yields compared to the control. The manures alone, or in combination with NPK, improved or maintained the NPK status of the soil.

Kramany *et al.* (2007) found that treatment of 25 percent recommended dose of NPK + 75 per cent FYM + biofertilizers (microbien) was best in improving the groundnut yield, yield components, oil yield (kg ha^{-1}), P (%), Fe and Zn (ppm) while number of seeds/pod and weight of straw (g $plant^{-1}$) was highest with 50 per cent NPK+ 50 per cent FYM + microbien.

Sharma *et al.* (2010) reported that the application of 100 per cent RDF along with vermicompost at 2.5 t ha^{-1} in green gram recorded significantly higher plant height (52.7 cm), number of pods $plant^{-1}$ (12.67), seeds pod^{-1} (12.00), 100-seed weight (4.6 g), seed yield (535 Kg ha^{-1}) over control and it was on par with the application of 75% or 50% RDF + vermicompost (2.5 t ha^{-1}) over control in green gram.

Abbas *et al.* (2019) narrated that excessive use of chemical fertilizers causes unforeseen environmental impacts and sensitivity to pests and diseases through the oversupply of nitrogen. Organic farming practices are the potential way to decrease the negative environmental impact of excessive amounts of chemical fertilizers. Organic fertilizers are environmental friendly and improve soil health, water-holding capacity, high cation exchange capacity and low bulk density and they foster diverse population of beneficial soil microorganisms.

Omidire *et al.* (2015) explained that the nutrients in mineral fertilizers are relatively high, and the release of these nutrients is quick because there is no need for decomposition.

Ojeniyi (2000) observed the use of inorganic fertilizer that cause the destruction of soil texture and structure, which often leads to soil erosion and acidity as a result of the leaching effect of nutrients. All these give rise to reduced crop yields as a result of soil degradation and nutrients imbalance.

Meerabai *et al.* (2006) studied that the effect of different organic amendments in bitter gourd which improved the physical conditions of the soil and supported better aeration to the plant roots, absorption of water, induction of N, P and K exchange thereby resulting better growth of the plants.

Chattopadhyay and Sahana (2000) studied the seed quality (SQ) and seed yield (SY) of okra cv. ParbhaniKranti during *kharif* seasons of 1998-99 in West Bengal, India. Five N rates (0, 60, 80, 100 and 120 kg ha^{-1}) were tested against 4 P rates (0, 40, 60 and 80 kg ha^{-1}). Urea (50% of the total N dose), single superphosphate and muriate of potash (50 kg K_2O) were applied basally. The remaining urea was applied 30 days after sowing. Most of the SQ and SY parameters improved significantly due to increasing rates of N and P, the optimum N and P rates, being 100 and 60 kg ha^{-1}, respectively. Germination percentage and 100-seed weight were not significantly affected by N or P, while P had no significant effect on fruit length.

2.8 Interaction effect of organic manure and inorganic fertilizer on crop growth and yield

The use of fertilizers is indispensable in alleviating nutrient constraints and is important in soil fertility management for improved crop production. Today, a wide range of fertilizers are required to maintain soil fertility and sustainable agricultural systems. Nitrogen and phosphorus fertilizers and their interaction effect are indispensable for the production system of okra and play a vital role to increase the yield and yield attributes, providing other factors are not limiting (Omotoso and Shittu, 2007).

Oliveira *et al.* (2007) conducted an experiment where along with recommended doses of fertilizer, 12 t ha^{-1} vermicompost was used that produced highest yield and thus as an organic source, vermicompost significantly reduced the cost of okra production.

Omidire *et al.* (2015) compared among the macronutrients and found that N and P are used largely by the okra plants. Physio-morphological and biological development of okra plants depends on the judicious application of N and P. An excess or deficiency of N and P cause remarkable effect on growth and yield of okra plant.

Gudugi (2013) investigated the effect of cow dung and inorganic fertilizer on the growth and yield of okra. Results revealed that, cowdung applied at 20 t ha^{-1} and inorganic fertilizer significantly produced taller plants, more leaves and more fruits. Non application of fertilizer significantly delayed flowering.

Nagar *et al.* (2016) reported that the favourable effects of phosphorus with vermicompost and biofertilizers, on soil properties may also be due to increased microbial activities which in turn release organic acids to bring down to soil pH to a range where the activities of plant nutrients are maximum.

The increase in microbial activity due to the addition of organic manure and biofertilizer, which enhance activity of enzymes that play a key role in transformation, recycling and availability of plant nutrients in soil. Similar results were reported by Mohammad *et al.* (2017) and Jangir *et al.* (2017).

Khan and Jaiswal (1988) was conducted a field experiment to determine the response of okra cultivars Arka, Anamika, Varshal to 3 NPK fertilizer rates. The highest dry matter production in (20.40 g), stems (35.17 g), fruits (31.11 g), and whole plants (104. 71 g) was recorded with 175: 125: 100 kgh^{-1} treatments. Varsha recorded significantly higher dry matter production in leaves (17.48 g), stems (31.44 g), roots (17.61 g), fruits (29.98 g), and whole plants (96.51 g) compared with the other cultivars. In the interaction effect, the highest total dry matter production (111.48 g $plant^{-1}$) was recorded in Varsha supplemented with 175:125:100 NPK kg ha^{-1}.

Smriti and Ram (2018) conducted an experiment in okra to observe the yield and yield Attributing characters in association with Organic, Inorganic, and Bio Fertilizers where 50% RDF+Vermicompost performed better followed by 75% RDF+ Phosphate solubilizing bacteria thus concluded that the application of 50% RDF+Vermicompost in ‘kashipragati’ increased the growth, yield and nutritional quality of okra under study area.

2.9 Interaction effect of organic manure and inorganic fertilizer on crop yield attributes and seed qualities

Crop yield, soil nutrient content, amount of agricultural production and their environmental effects are all influenced by fertilizer use. Decreased soil fertility and increased mineral fertilizer prices made application of combined fertilizer a popular option to reduce the coast. Organic fertilizers have an important role in improving soil fertility.

Askegaard and Eriksen (2008) reported that soil fertility is especially affected by soil organic matter, which depends on biomass input to compensate mineralization. Higher biomass return to the soil can increase soil organic carbon and soil total N. N is the most studied nutrient, but P and K levels are also important. They also observed that in organic farming, K deficiency may become a significant problem. Perennial legumes such as lucerne, with their deep root systems, import additional nutrients (P, K, and Ca) to the soil that are accessible to succeeding crops. Kondapa *et al.* (2009) reported that the fresh and dry weight and yield of cowpea were greatest in soil amended with vermicompost.

Smriti and Ram (2018) reported that vermicompost had a significant effect on root and fruit weight of tomatoes. In 100 per cent vermicompost treatment, fruit weight and shoot and root weight were three, five and nine times more than the control, respectively. Naidu *et al.* (2002) conducted a field experiment and reported that application of 5 t ha^{-1} vermicompost significantly increased the pods $plant^{-1}$, seeds pod^{-1}, harvest index and straw yield of cowpea over control. Sameera *et al.* (2005) performed an experiment on garden bean and found that while biofertilizers mixed with vermicompost and vermiwash it tend to give better yield.

Attigah *et al.* (2013) showed that okra produced highest number of fruits, fruit yield, fruit weight, length of fruits and thickness of fruits with the application of neem cake 0.66 t ha^{-1} + vermicompost 1 t ha^{-1} + Azotobacter + PSB + 60% recommended dose of NPK through inorganic fertilizers. Kondapa *et al.* (2009) supplemented the beneficial effect of integrated vermicompost application was also documented its effect in growth, yield and economics of chili. Inorganic fertilizers significantly increased the crop yield while reducing the soil fertility at a large scale. However, the applications of inorganic fertilizers retrieve the soil fertility considerably.

Bano *et al.* (2018) plotted a field experiment to study the ‘Efficacy of organic manures and biofertilizers on yield attributes and yield of okra. Result revealed that the combined application of vermicompost at 8 t ha^{-1} + Azotobacter as seed inoculation proved to be most superior treatment combination in terms of fruit weight $plant^{-1}$, fruit yield $plot^{-1}$ and fruit yield ha^{-1}.

Parthasarathi *et al.* (2008) observed that besides, FYM also maintains a congenial hydro-thermal regime for optimum crop production. Since vermicompost helps in enhancing the activity of microorganisms in soils which further enhances solubility of nutrients and their consequent availability to plants is known to be altered by microorganism by reducing soil pH at micro sites, chelating action of organic acids produced by them and mobility in the fungal filaments. In addition to nitrogen, which is fixed in the soil from the atmosphere, farmyard manure and vermicompost are another source of nutrients which enhance the nitrogen fixation capacity of the crop. In addition to biologically fixed nitrogen, crop also requires nitrogen through fertilization to meet its initial requirement.

CHAPTER III

MATERIALS AND METHODS

This chapter describes the materials and methods used to conduct the experiment during the period from April- July, 2018. A precise description on experimental design and layout, time and location of the experiment, climatic condition of experimental site, seed or planting materials, plant growing procedure, nutrient and treatment doses, data collection and statistical analysis of the experiment has been narrated throughout this chapter. The details of experimental material used and criteria adopted for the evaluation of treatment during the course of investigation are being presented in this chapter under following headings:

3.1 Location of the experimental site

The study was conducted at the Agronomy net house of Sher-e-Bangla Agricultural University. Geographically the experimental area is located at $23^{o}41'$/N latitude and $90^{o}22'$/E longitudes at the elevation of 8.6 m above the sea level. The map showing the experimental site in Appendix I is under Madhupur tract Agro-ecological zone (AEZ-28).

3. 2 Climatic condition of the experimental site

Experimental location is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. During summer, the temperature may go as high as 35^{0}C while in winters, it may fall as low as 15^{o} C. The average annual rainfall of this tract ranges between 400-500 mm, most of which is contributed by the South-West monsoon during the months of July and August. Since, climate influence the growth, yield and quality of agricultural produce, therefore the mean monthly weather parameters for the crop season, recorded at the meteorological observatory of Bangladesh Meteorological Department, Agargoan, Dhaka (Appendix II).

3.3 Soil characteristics of the experimental site

The experimental pots were filled with the soil which belongs to the Modhupur Tract under AEZ No. 28. The soil texture of the experimental soil was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analysed in the Soil Resources Development Institute (SRDI) Dhaka, and result have been presented in Appendix III.

3.4 Planting materials

The test crop used in the experiment was BARI Dherosh-2, developed by Olericulture Division, HRC, Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh. This variety was first released in 2015.Main characteristics of this variety are: green fruits, soft and tasty, about 30-38 fruits/plant. Single fruit weight is 13-16 g, produced fruit in every nodes. The total crop duration for this variety is 80-85 days. This variety is resistant to yellow mosaic virus (YMV). The best planting season and time is Kharif. Pods should be harvested 7-10 days after flowering. The average yield of this variety is 17-20 t ha^{-1}.

3.5 Collection of seeds

The seeds of okra “BARI Dherosh-2”was collected from Olericulture Division, HRC, Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh.

3.6 Treatment details and experimental design

3.6.1 Treatments

The experiment consisted of two factors-

Factor A: Organic manures- 03

I. M_1 = Cowdung (10 t ha^{-1})

II. M_2 = ACI Compost (8 t ha^{-1})

III. M_3 = Vermicompost (5 t ha^{-1})

Factor B: Chemical fertilizer- 04 levels

I. F_0= No fertilizer (control)

II. F_1= Recommended dose of fertilizer (RDF; 60-90-60 N-P-K Kg ha^{-1})

III. F_2= 25% less of RDF (45-67-45 N-P-K Kg ha^{-1})

IV. F_3= 50% less of RDF(30-45-30 N-P-K Kg ha^{-1})

There were 12 (3×4) treatments combination such as, M_1F_0, M_1F_1, M_1F_2, M_1F_3, M_2F_0, M_2F_1, M_2F_2, M_2F_3, M_3F_0, M_3F_1, M_3F_2 and M_3F_3.

3.6.2 Design and layout of the experiment

The two factors experiment was conducted in pots, where pots were arranged following randomized complete block design (RCBD) with three replications. The total number of pot was 36 where each replication contains 12 pots (Appendix IV). Proper distance from pot-pot and plant-plant were maintained accordingly.

3.7 Application of fertilizers and manure

The crop was fertilized with N, P and Kat 60-90-60 kg ha^{-1}, respectively (FRG, 2012). Full amount of fertilizers as per treatment were applied in the form of Urea, TSP and MoP during the final pot preparation except the Urea. Urea was applied in two installments. Half amount of urea was applied during final pot preparation. The rest amount of Urea was applied during the pod filling stage (45 DAS). Cowdung, ACI compost and vermicompost were applied in each pot at 10, 8 and 5 t ha^{-1}, respectively. All the organic manures was applied in the pot as per treatment during pot filling with soil. After 15 days of pot preparation, okra seeds were sown in each pot.

3.8 Raising of the experimental crop

The schedules of different pre and post-sowing operations carried out during the crop season and details of crop raising are described as following:

3.8.1 Pot preparation

Empty garden pot made of plastic with a size specification of 14, 12, 16 inch diameter on top, bottom and height accordingly; were used for carrying out this experiment. Pots were frequently washed and sundried for two days before filling with sundried soil.

3.8.2 Fertilizer management and plant growth substrate

Organic manure and inorganic fertilizers were incorporated with the soil as per treatment for plant growth and were considered as plant growth substrate for this experiment. Each pot was filled with 20kg of prepared soil and was ready for seed sowing.

3.8.3 Seed sowing

Healthy and mechanical injury free seeds were sorted manually prior to seed sterilization. Seeds were treated with Bavistinat 2 mlL^{-1} of water before sowing the seeds to control the seed borne diseases. Eight seeds were sown in each pot having a depth of 2-3 cm maintaining uniform distance in each successive hill. The okra seeds were sown in the pot on 15 April 2018.

3.9 Intercultural operations

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

3.9.1 Gap filling

Dead, injured and weak seedlings were replaced by new vigorous seedlings from the extra plants of the same treated pot.

3.9.2 Thinning, weeding and hoeing

To maintain the proper plant population thinning was done at 14 days after sowing, leaving 2plants per pot. The weeding was done by hand picking as and when necessary to keep the pots free from weeds.

3.9.3 Irrigation

Okra requires enough soil moisture for seed germination. It was maintained by pre-sowing irrigation. Light watering was given by a watering can at every afternoon and it was continued for a week for rapid and well establishment of the germinated seedlings. Further irrigations were given as per requirement of the crop.

3.9.4 Plant protection measure

Insect infestation was a serious problem during the period of establishment of seedlings in the field. To protect the crop from the attack of insect pests *viz.,* Jassids and whitefly, spray of Malathion 50 EC (0.05%) was done after 15 days of sowing thereafter, sprays of Endosulfan 35 EC (0.07%) were done before the flowering stage at 45 DAS to control fruit borers in okra crop. A net covering was used to protect plants from insects and over sunlight.

3.10 Harvesting of pods

Out of 2 plants in each pot, green pods (vegetable) were collected from one plant and rest one was kept for collecting seed. The first harvest of green pods were collected at 65 DAS. Later on, the fruits were picked manually at 10 day intervals when they were green tender and at marketable size. The picked pods were weighed and subjected to other observations immediately, after each picking. Mature pods from the rest plants were collected. Later on, seed were separated from the pods and dried, counted and weighted accordingly.

3.11 Data recording

Effect of different treatments on plants of the experimental pot were used to take growth parameters, yield attributes, green pod (vegetable) yield and seed yield data. The following parameters were recorded for further analysis.

A. Growth attributes

I. Plant height (cm) at 20, 40 and 60 DAS

II. Number of branches plant^{-1}at 45 DAS

B. Yield and other crop characters

I. Pod diameter (cm)

II. Pod length (cm)

III. Green pod plant^{-1} (no.)

IV. Green pod yield plant^{-1} (kg)

V. Seedspod^{-1} (no.)

VI. Seed weight pod^{-1} (g)

VII. 100-seed weight (g)

VIII. Seed yield plant^{-1} (g)

IX. Seed yield (t ha^{-1})

X. Shelling (%)

C. Seed quality attributes

Seeds collected from each pot were dried properly and kept separately followed by proper tagging. These seeds were used for taking seed quality attributes.

I. Germination percentage

II. Root-shoot ratio

III. Fresh weight (FW) seedling^{-1}(g)

IV. Dry weight (DW) seedling^{-1}(g)

V. Electric conductivity (EC)

3.12 Growth attributes

3.12.1 Plant height

Plant height was measured from 2 plants in centimeter, from the ground level to the tip of the stem. Plant height was recorded at 20 days interval starting from 20 days after sowing (DAS) up to 60. Average height of 2 plants was recorded as mean plant height (cm).

3.12.2 Number of branches plant^{-1}

Total number of branches emerging from main stem of the plant was counted in each pot from 2 plants at 45 DAS and the average was calculated to derive number of branches plant^{-1}.

3.13 Yield and other crop characters

3.13.1 Pod diameter

Pod diameter was measured from 5 sample pods in each pot with a digital calipers-515 (DC- 515) from the three different parts of the pod and mean value was calculated. Pod diameter was recorded while the green pod was at marketable size.

3.13.2 Pod length

The length of randomly selected 5 pods from each pot was measured from the base of the pod to the tip of the pod in cm. The average value was considered as pod length.

3.13.3 Green pods plant^{-1}

The number of green pods was counted from the sample plant for the whole growing period and expressed as green pods plant^{-1}.

3.13.4 Green pod yield plant^{-1}

Green pods harvested from each pot after each picking were weighed and was calculated to derive green pod yield plant^{-1}.

3.13.5 Seeds pod^{-1}

Mature and dried pods (5) from the sample plant in each pot were counted and averaged to derive the seeds pot^{-1}.

3.13.6 Seed weight pod^{-1}

Mature and dried pod (5) from the sample plant in each pot were peeled and seeds were weighed to derive the seed weight pod^{-1}.

3.13.7 100-seed weight

Seeds (100) were counted and weighed from each treatment. All weights were taken using electronic balance and averaged accordingly.

3.13.8 Seed yield plant^{-1}

All the mature and dried pods from the sample plant were peeled and seeds were weighed to derive the seed yield plant^{-1}.

3.13.9 Seed yield

Seed yield ha^{-1} was estimated by converting the weight of seed yield plant^{-1} in each pot into hectare and was expressed in t ha^{-1}.

3.13.10 Shelling percentage

Shelling percentage was calculated by dividing seed dry weight by dry pod weight and expressed in percentage:

$$\text{Shelling (\%)} = \frac{\text{Seed dry weight}}{\text{Pod dry weight}} \times 100$$

3.14 Quality attributes

3.14.1 Germination percentage (%)

Twenty five (25) seeds from each treatment were taken for germination. Seeds were sown in Petri-dishes contained soaked sand. After 10 days the total number of germinated seeds was counted and derived the germination percentage.

3.14.2 Root-shoot ratio

Length of root and shoot of 10 seedlings were measured 10 days after germination. Values were averaged and ratio was calculated.

3.14.3 Fresh weight (FW) seedling^{-1}

Fresh weight was taken when seedlings age was 10 days. 10 seedlings were taken, cleaned and weighted by a digital weighing machine and averaged to count fresh weight seedlings^{-1}.

3.14.4 Dry weight (DW) seedlings^{-1}

After taking the fresh weight, the same 10 seedlings were oven dried for three days and was again weighted with a digital balance. Mean of 10 seedlings dry weight was considered as dry weight seedlings^{-1}.

3.14.5 Electric conductivity

EC was determined in the seed soaked water in a glass according to the number of replicates, using a benchtop digital conductivity meter (model: DDB-303A) to estimate the content of electrolytes.

3.15 Statistical Analysis

Data accumulated for different parameters were subjected to analysis of variance (ANOVA) using the software Statistix 10. Mean separation was done by Fisher's LSD at 5% level of significance (Statistix, 2013).

CHAPTER IV

RESULTS AND DISCUSSION

The current experiment was plotted to investigate the effect of different organic manure (Cowdung, ACI compost and vermicompost) and inorganic fertilizers on the growth yield and seed quality of okra. A summary of the analysis of variance of all the characteristics studied with their sources of variance and corresponding degrees of freedom have been shown in Appendix V- VIII. 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 demonstrated and discussed with possible interpretations under the following headings.

4.1 Plant height

Plant height was observed at 20, 40 and 60 days after sowings (DAS). Organic source of nutrient exerted significant role in plant height at 20, 40 and 60 DAS. Different organic manures showed varying results at different days after sowing. However, the significant increase of plant height at 20, 40 and 60 DAS was observed in the pot treated with vermicompost *viz.*,19.31 cm, 82.28 cm and 104.96 cm, accordingly, whereas the lowest height (12.35, 54.86 and 74.90 cm) was observed with cowdung treatment in 20 DAS, 40 DAS and 60 DAS, respectively (Table 1). This findings was in agreement with the result of Shahriazzaman *et al.* (2014). They conducted a research on okra with vermicompost and poultry manure where increase of plant height was observed with the application of organic matter. However, the poultry manure performed the best there followed by vermicompost. Vermicompost and poultry manure subsequently increased yield attributing characters of okra supported by Prakash and Bhadoria (2004). The beneficial effect of vermicompost on plant growth might be attributed to the fact that the earthworms mineralized the macro and micronutrients during vermicomposting and made available to crop plants for longer period. In addition, they also improve soil structure, aeration and water holding capacity. The results were in close conformity with the findings of Adeleye *et al.* (2010).

It was observed that various level of inorganic fertilizers showed significant effect on the plant height of okra at 20, 40 and 60 DAS (Table 1). At 20 DAS, tallest plant

(20.05 cm) was found when 25% less of RDF was applied. Similarly, both at 40 and 60 DAS, the highest plant height (79.15 cm and 100.39 cm) was observed at pot while fertilizers applied 25% less of RDF. However, there was no statistically significant difference at height with F_1 and F_2fertilizers application treatments at 60 DAS. Similar result was also observed by Raguchander *et al.* (2005).

Table 1. Effect of organic manures and different levels of inorganic fertilizer on plant height of okra at 20, 40 and 60 DAS

Treatments		**Plant height (cm)**		
		20 DAS	**40 DAS**	**60 DAS**
Organic manures	**M_1**	12.35c	54.86c	74.90c
	M_2	16.62b	69.00b	87.48b
	M_3	19.31a	82.28a	104.96a
LSD (0.05)		**0.46**	**2.08**	**2.60**
CV (%)		8.89	4.87	5.58
Fertilizer levels	**F_0**	12.92c	60.08c	81.83b
	F_1	15.69b	68.98b	96.14a
	F_2	20.05a	79.15a	100.39a
	F_3	15.72b	66.64b	78.08b
LSD (0.05)		**0.53**	**2.40**	**3.01**
CV (%)		8.89	4.87	5.58

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF.

The biological role of nitrogen as an essential constitute of chlorophyll in harvesting solar energy, phosphorylated compound in energy transformation, nucleic acids in the transfer of genetic information and the regulation of cellular metabolism and of protein as structural units and biological catalysts is well known. Similarly, potassium role in stomatal opening and thereby governing the entry of CO_2 in widely known (Marschner 2012).

The plant height was significantly influenced by the treatment combinations at 20, 40 and 60 DAS due to combine effect of organic manure and chemical fertilizer (Table

2). At 20 DAS, the maximum plant height (24.85 cm) was obtained from M_3F_2 and the minimum height (9.59 cm) was obtained from M_1F_0 treatment. At 40 DAS, the maximum plant height (91.33 cm) was obtained from M_3F_2, while the minimum height (44.80 cm) was obtained from M_1F_0 treatment. At 60 DAS, the maximum plant height (122.58 cm) was obtained from M_3F_2 whereas the minimum height (63.00 cm) was obtained from M_1F_3 treatment. The result indicated that M_3F_2 combination was superior among other combinations in producing plant height of okra for all sampling dates.

Table 2. Interaction effect of organic and inorganic fertilizers on plant height of okra

Treatment combinations	Plant height (cm)		
	20 DAS	40 DAS	60 DAS
M_1F_0	9.59g	44.80f	68.92fg
M_1F_1	12.59f	52.07ef	79.42ef
M_1F_2	15.64e	67.27c	88.25c-e
M_1F_3	11.59f	55.30e	63.00g
M_2F_0	13.50f	57.68de	80.75de
M_2F_1	16.87de	73.33bc	98.08c
M_2F_2	19.68b	78.85b	90.33cd
M_2F_3	16.46de	66.15cd	80.75de
M_3F_0	15.66e	77.76b	95.83c
M_3F_1	17.62cd	81.54b	110.92b
M_3F_2	24.85a	91.33a	122.58a
M_3F_3	19.11 bc	78.49b	90.50cd
$LSD_{(0.05)}$	**1.93**	**8.63**	**10.81**
CV (%)	**7.09**	**7.42**	**7.17**

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at P≤0.05 applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF.

4.2 Number of branches plant^{-1}

Organic sources significantly affected the branches number in okra presented in Figure 1. Cowdung, ACI compost and vermicompost variedly effect on the branches number of okra plant. However, the highest number of braches (4.13) was observed with the application of ACI compost followed by 3.89 at vermicompost. The lowest number of branches (3.66) was observed with cowdung treatment.

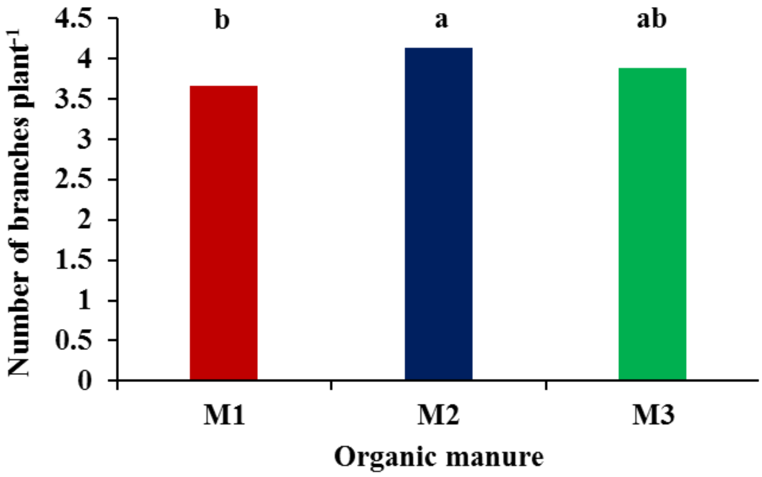

Figure 1. Effect of organic manures on branches number of okra. Mean ($LSD_{0.05}$ 0.37). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

Effect of inorganic fertilizers showed significant variation in case of branches number of plant of okra. The result depict that the highest branches number plant^{-1} (4.54) was found when 25% less of RDF was applied which was 37% higher than the F_0 (control). On the contrary, lowest number of branches plant^{-1} (3.32) was observed at pots while no fertilizers were applied. However, 18 and 14% branches were increased at RDF and 50% less of RDF accordingly compared to control (Figure 2).

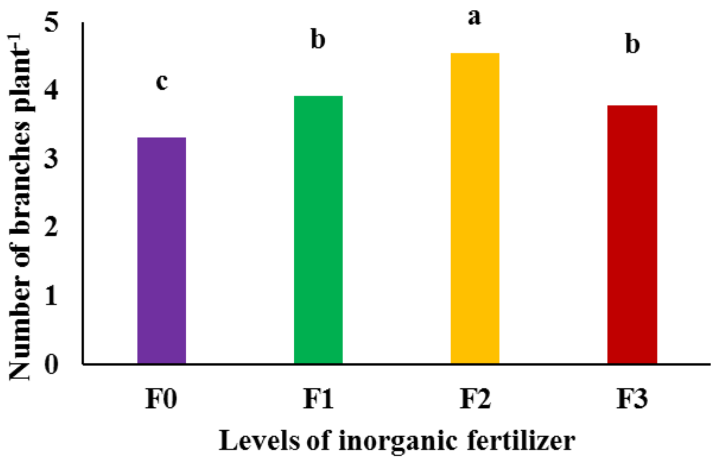

Figure 2. Effect of inorganic fertilizers on number of branches plant^{-1}increase front size of okra. Mean ($LSD_{0.05}$ 0.43). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

Interaction effect of organic and inorganic fertilizers showed significant variation in branches number plant^{-1} (Figure 3). The F_2 treatment showed superiority in producing number of branches plant^{-1} irrespective of organic manure treatments. The highest number of branches plant^{-1} (4.60) was observed at M_2F_2 treatment combination whereas the lowest (3.12) was observed at M_3F_0.

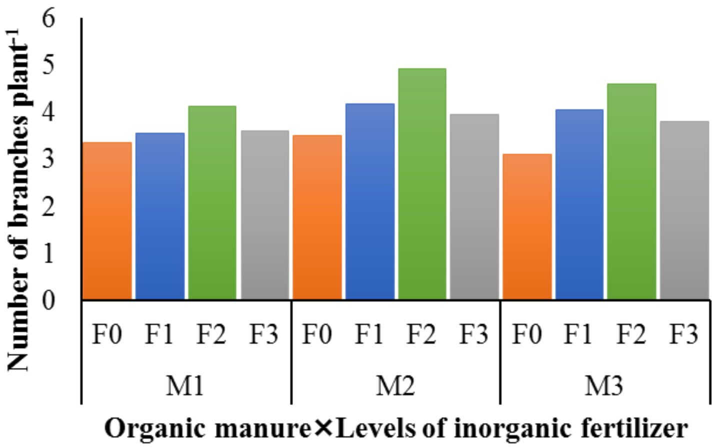

Figure 3. Interaction effect of organic and inorganic fertilizers on branches plant^{-1} (n). Mean ($LSD_{0.05}$ 0.74). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.3 Pod diameter

Pod diameter was highly influenced with the application of different types of organic manures. Application of vermicompost showed the best performances in terms of pod diameter (3.96 cm).The minimum pod diameter (3.05 cm) was found while cowdung was applied followed by ACI compost. However, all three treatments showed statistically significant result (Figure 4).

Increased pod diameter was recorded while vermicompost was used in an experiment of Shahriazzaman *et al.* (2014). Addition of vermicompost brought about improvement in soil chemical properties soil pH, total N, available P, organic matter, exchangeable cations and cation exchange capacity were improved (Ano and Agwu, 2006; Akande *et al.,* 2010). Vermicompost could be used for soil management as it improves soil nutrient status and could be used for sustainable production of crops.

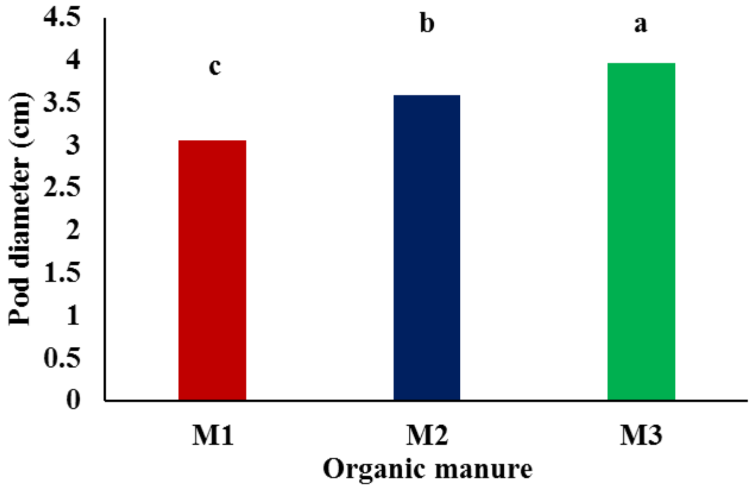

Figure 4. Effect of organic manures on pod diameter of okra. Mean ($LSD_{0.05}$ 0.30). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

Although the pod diameter was increased with the application of increased rate of inorganic fertilizers there was no significant differences among the treatments of RDF. The maximum pod diameter (3.75 cm) was observed at 25% less of RDF while the minimum (3.16 cm) was observed at F_0treatment (Figure 5).

In interaction effect, both organic and inorganic treatments bears significant effect on pod diameter of okra plant. Interaction effect of organic and inorganic fertilizers resulted that at M_3F_2 combination the highest pod diameter (4.57 cm) was observed while at M_1F_3 treatment combination lowest pod diameter (2.95 cm) was found (Figure 6).

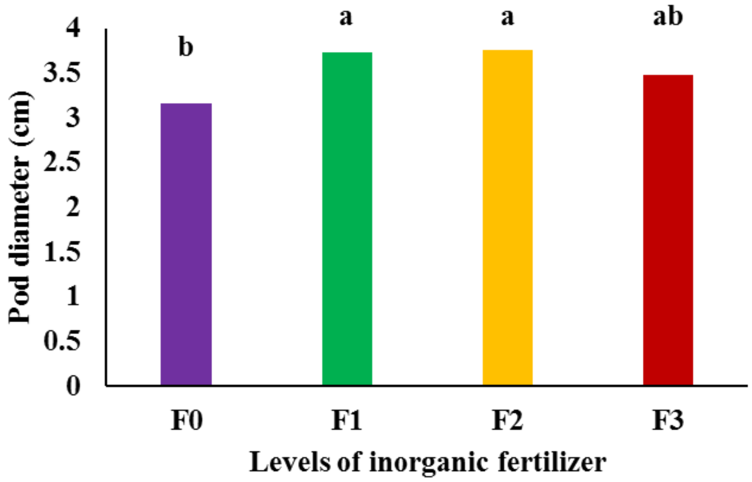

Figure 5. Effect of different levels of inorganic fertilizer on pod diameter of okra. Mean ($LSD_{0.05}$ 0.35). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

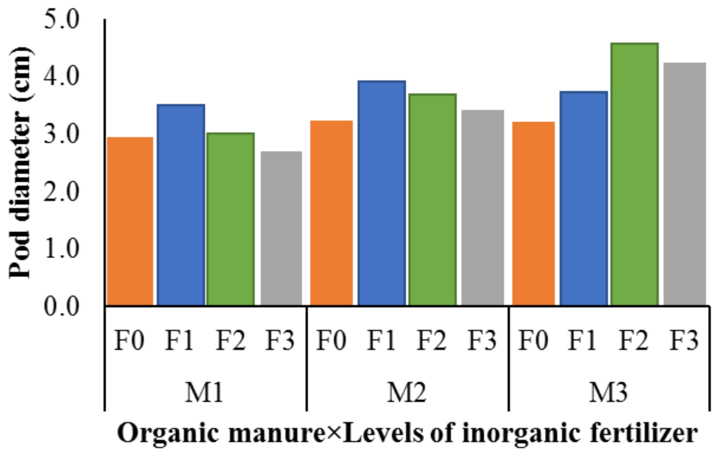

Figure 6. Interaction effect of organic and inorganic fertilizers on pod diameter of okra. Mean ($LSD_{0.05}$ 0.60). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.4 Pod length

Pod length is an important factor that determines the yield and quality of the okra (Figure 7). Organic manures highly effect on the pod length of okra. The maximum pod length (11.59 cm) was observed with the application of vermicompost. Whereas, the minimum pod length (7.59 cm) was observed with application of cowdung. However, all the three treatments showed significant variation. Similar increase of pod length was observed by Bano *et al.* (2018) while applied vermicompost compared to the control. The beneficial effect of vermicompost on yield and yield attributes might be attributed to its ability to sustain availability of nutrient throughout the growing season. The increased balanced C: N ratio might have increased the synthesis of carbohydrates with ultimate improvement in yield and yield attributes (Kondapa *et al.,* 2009, Sharma *et al.,* 2010).

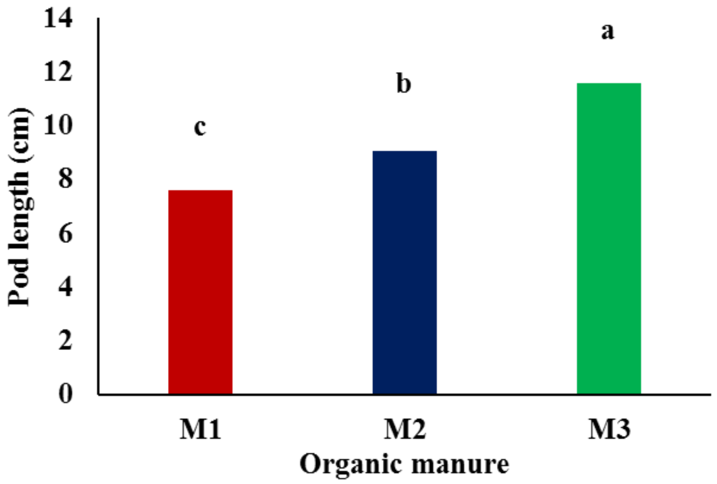

Figure 7. Effect of organic manures on pod length of okra. Mean ($LSD_{0.05}$ 1.21). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

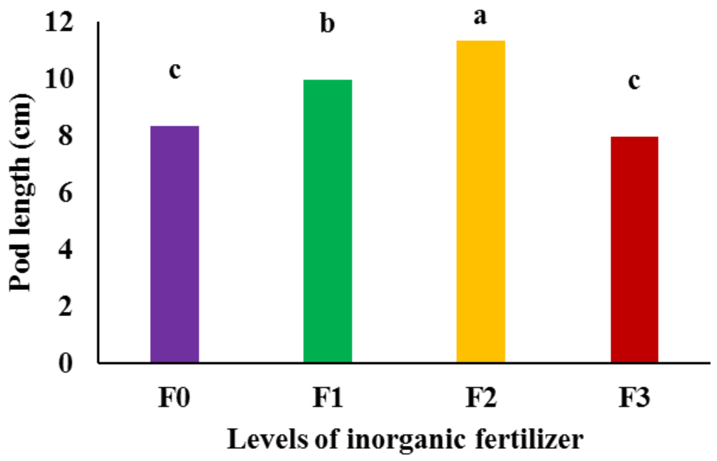

Figure 8. Effect of different levels of inorganic fertilizer on pod length of okra. Mean ($LSD_{0.05}$ 1.39). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

Pod length of okra was influenced by different doses of fertilizers. Different doses of inorganic fertilizer helped to increase the length of the okra pod (Figure 8). In the experiment, the highest pod length was observed at 25% less of RDF, which is 11.34 cm and the minimum pod length (8.35 cm) was found while no fertilizers was used.

Organic manures along with inorganic fertilizers showed the significant role in increasing the pod length of the okra (Table 3). The highest pod length (14.55 cm) was found at vermicompost in combination with 25% fertilizers less than the recommended doses. Meanwhile, the lowest result (6.42 cm) was found while cowdung was used without any fertilizers (F_0) which was statistically similar with M_1F_1, M_1F_3 and M_2F_3 interactions.

Table 3. Interaction effect of organic and inorganic fertilizers on yield contributing parameters of okra

Treatment combinations	Pod length (cm)	Green pods plant^{-1}(no.)	Green pod yield plant^{-1}(kg)	Seeds pod^{-1} (no.)
M_1F_0	6.42f	5.33fg	0.41de	38.13f
M_1F_1	7.43ef	5.83ef	0.56c	47.92de
M_1F_2	9.70cd	6.42 c-e	0.46d	53.17b-e
M_1F_3	6.82ef	4.92g	0.37e	45.43ef
M_2F_0	8.39de	4.08h	0.42de	49.03 c-e
M_2F_1	10.47bc	7.58b	0.52c	61.17ab
M_2F_2	9.78cd	7.00 b-d	0.47d	55.00 b-d
M_2F_3	7.57ef	5.25fg	0.37e	50.30 c-e
M_3F_0	10.25c	4.75gh	0.55c	51.38 c-e
M_3F_1	12.02b	7.17bc	0.64b	57.22bc
M_3F_2	14.55a	8.75a	0.77a	69.02a
M_3F_3	9.55cd	6.33de	0.62b	53.68b-e
LSD $_{(0.05)}$	**1.67**	**0.79**	**0.05**	**8.41**
CV%	**10.51**	**7.63**	**6.37**	**9.45**

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF.

4.5 Green pods plant^{-1}

Organic sources had significant effect on the green pod number in the plant. Cowdung, ACI compost and vermicompost variedly effect on the green pod number of okra plant^{-1}. However the highest number of green pod plant^{-1}(6.75) was observed with the application of vermicompost. Whereas the lowest number of green pod plant^{-1} (5.62) was observed with cowdung treatment (Figure 9). Hence, there was no significant difference between the mean of cowdung and ACI compost application. Similar increase of pod number was also observed by Bano *et al.* (2018) where the maximum number of fruits plant^{-1} (26.04) were recorded under vermicompost at8 ton h^{-1}, while minimum number of fruits plant^{-1} (16.55) were recorded under control. Number of pods in plants was also increased similarly while applied organic matter (poultry manure and vermicompost) in an experiment of Shahriazzaman *et al.* (2014). Vermicompost has long been recognized as the most desirable organic fertilizer that improves soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention (Farhad *et al.,* 2009) and that may responsible for the production of more number of pods in okra.

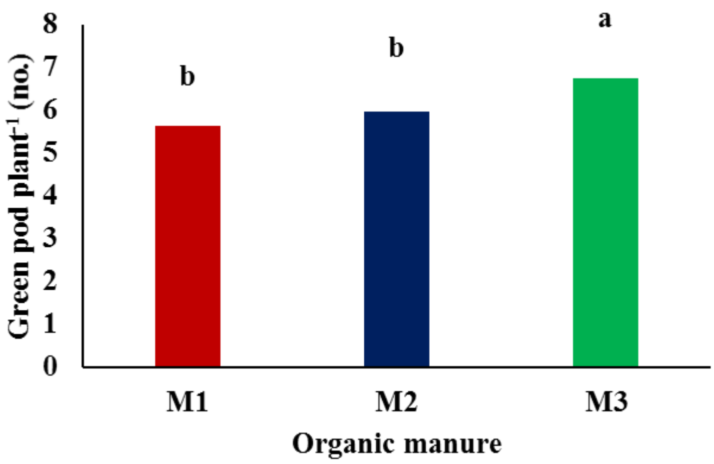

Figure 9. Effect of organic manures on number of green pod plant^{-1}. Mean ($LSD_{0.05}$ 1.00). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

Number of green pods plant^{-1} was observed to be increased significantly with the application of inorganic fertilizers. There observed,45% and 56% green pod was increased due to application of fertilizers at RDF and 25% less of RDF, respectively, compared to the control. The maximum green pod plant^{-1} (7.38) was observed at 25% less of RDF while the minimum (4.72) was observed at F_0 (Figure 10).

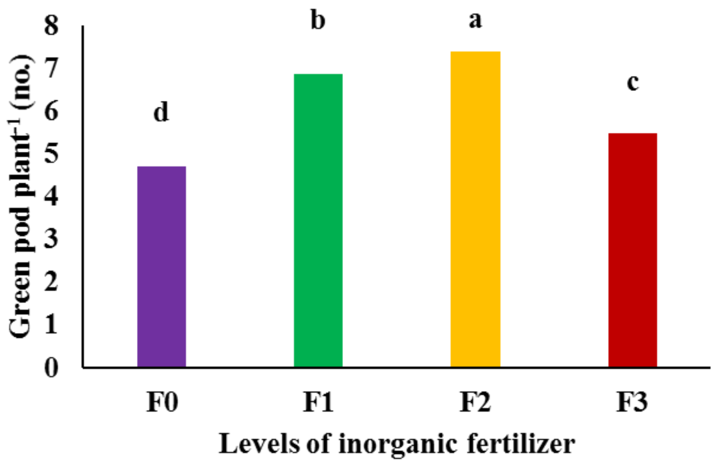

Figure 10. Effect of different levels of inorganic fertilizer on number of green pod plant^{-1} of okra. Mean ($LSD_{0.05}$ 1.15). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

In combination of both organic sources of nutrients and inorganic fertilizers showed the significant role in increasing the green pod number of okra plant^{-1} (Table 3). The highest number of green pod (8.75) was found at M_3F_2. Meanwhile, the lowest result (4.08) was found at M_2F_0 that similar to M_3F_0.

4.6 Green pod yield plant^{-1}

Green pod yield of okra plant^{-1}was influenced significantly by the application of different organic manures (Figure 11). The highest yield plant^{-1} (0.64 kg) was recorded with the application of vermicompost whereas the lowest result (0.45 kg) was found at applying cowdung. However, the application of cowdung and ACI compost were statistically similar. Experiment conducted by Bano *et al.* (2018) revealed that vermicompost was performed the most influential role in case of pod yield plant^{-1}, which was maximum compared to the control. The increased yield attributes and yield with vermicompost might be because of rapid availability and utilization of nitrogen for various internal plant processes for carbohydrates production (Omidire *et al.* 2015).

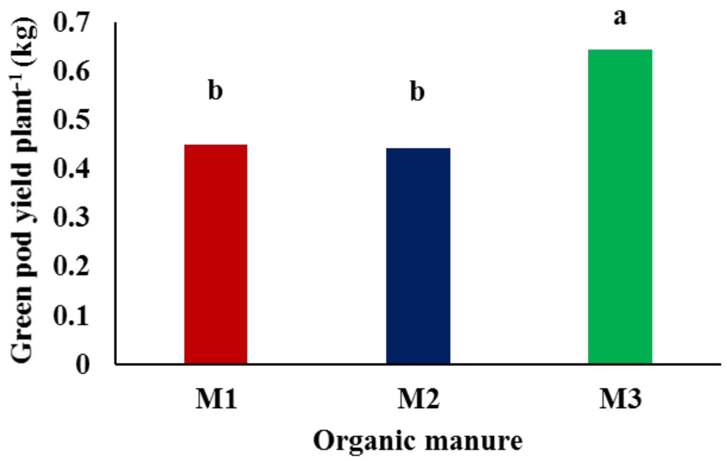

Figure 11. Effect of organic manures on green pod yield pot^{-1}. Mean ($LSD_{0.05}$ 0.027). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

Application of inorganic fertilizers at different levels significantly increased the green pod yield plant^{-1}. Application of RDF resulted in significantly higher green pod yield (0.57 kg) plant^{-1}, which was 24% higher over the control and statistically similar to 25% less of RDF (Figure 12). The reason for enhancement in yield attributes could again be ascribed to the role which might have been played by the nutrients supplied to the plants. The application of NPK favored the metabolic and auxin activities in plant and ultimately resulted in increased fruit size, number of fruits per plant, fruit weight and yield per hectare.

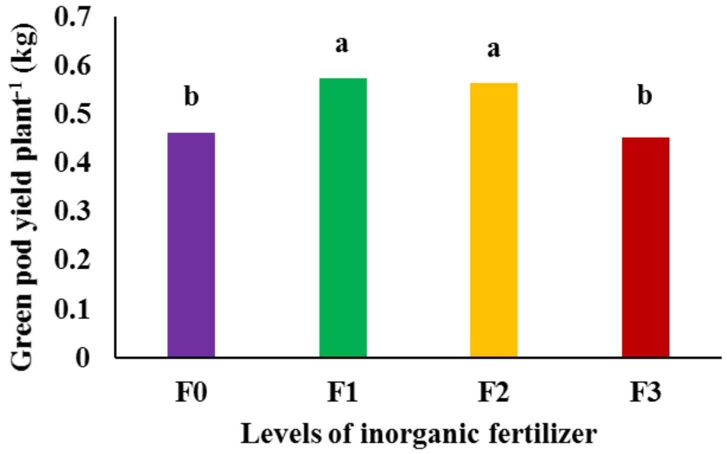

Figure 12. Effect of different levels of inorganic fertilizer on pod yield plant^{-1} of okra. Mean ($LSD_{0.05}$ 0.031). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

Interaction effect between different organic manures and inorganic fertilizer were found to be significant in respect to green pod yield plant^{-1} (Table 3). The application of vermicompost with 25% less of RDF (M_3F_2) recorded the maximum pod yield (0.77 kg) plant^{-1}. The minimum (0.37) was observed at M_1F_3 which is similar to M_2F_3.

4.7 Seeds pod^{-1}

Seeds pod^{-1} significantly influenced with the application of different types of organic manures. Among cowdung, ACI compost and vermicompost, the application of vermicompost showed the best performances in terms of seeds pod^{-1} (57.82). The minimum seeds pod^{-1} (46.16) was found while cowdung was applied followed by ACI compost. However, ACI compost and vermicompost showed statistically similar results (Figure 13).

Seeds pod^{-1} was increased significantly with the application of inorganic fertilizers at different doses. Effect of inorganic fertilizers revealed that around 20, 28 and 8% of seeds pod^{-1} was increased with the application of fertilizers at RDF, 25% less of RDF and 50% less of RDF accordingly, compared to the control. The maximum seeds pod^{-1}(59.06) was observed at 25% less of RDF while the minimum (46.18) was observed at F_0 (Figure 14) while there was no significant difference between the RDF and 25% less of RDF.

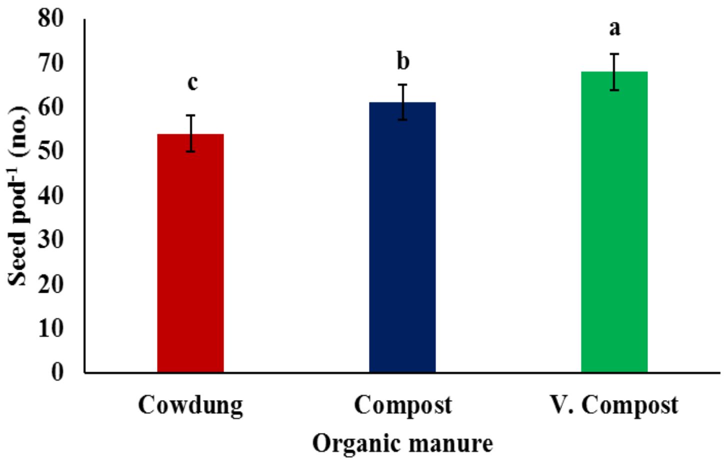

Figure 13. Effect of organic manures on number of seeds pod^{-1}. Mean ($LSD_{0.05}$ 2.96). Barrs with different letters are significantly different at $P \le 0.05$ applying the LSD test. Here cowdung, ACI compost and vermicompost indicate as M_1, M_2 and M_3, respectively.

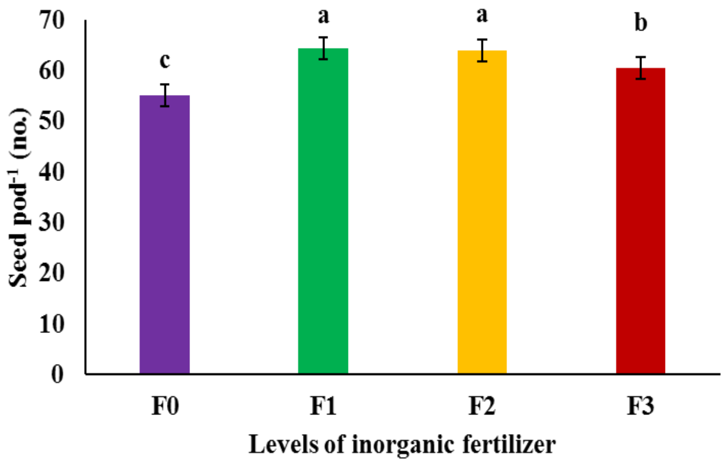

Figure 14. Effect of different levels of inorganic fertilizer on number of seeds pod^{-1} of okra. Mean ($LSD_{0.05}$ 3.41). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

Combination of both organic and inorganic fertilizer treatments bears significant effect on seeds pod^{-1} of okra plant. Interaction effect of organic and inorganic fertilizers resulted that at M_3F_2 combination gave the highest seeds pod^{-1} (69.02) while at M_1F_0 treatment combination lowest seeds pod^{-1} (38.13) was found (Table 3). Islam *et al.* (2016) also found the similar results in respect of seeds pod^{-1} of okra.

4.8 Seed weight pod^{-1}

Seed weight pod^{-1} is an important yield affecting factor that determines the amount of seed yield of okra (Table5). Organic manures highly effect on the seed weight of okra. In this experiment, maximum seed weight pod^{-1} (6.01 g) was observed with the application of vermicompost. Whereas, the minimum seed weight pod^{-1} (3.39 g) was observed with application of cowdung. All the three means were statistically significant from each other. Seed weight pod^{-1} of okra influenced by different doses of inorganic fertilizers. Here, the highest seed weight pod^{-1} was observed at 25% less of RDF. Which was 5.35 g and the minimum seed weight pod^{-1} (3.76 g) was found while no fertilizers was used. 35, 42 and 14% seed weight were increased at RDF, 25% less of RDF and 50% less of RDF, accordingly compared to control (Table5). The accumulation of higher protein content in the pod might be correlated with the increased activity of nitrate reductase which helped in synthesis of certain amino acids and proteins. These results are also corroborated by the findings of Yadav and Yadav (2010) in okra crop.

Table 4. Yield and other crop characters of okra as influenced by different organic manures and different levels of inorganic fertilizer

Treatments		Seed weight pod^{-1} (g)	100-seed weight (g)	Seed yield plant^{-1}(g)	Seed yield (t ha^{-1})	Shelling (%)
Organic manure	**M_1**	3.39 c	4.80 b	5.82 c	0.032 c	22.24 c
	M_2	4.44 b	5.21 b	6.86 b	0.038 b	29.76 b
	M_3	6.01 a	6.24 a	12.21 a	0.067 a	44.79 a
LSD $_{(0.05)}$		**0.25**	**0.25**	**0.43**	**0.83**	**1.11**
CV (%)		**15.16**	**25.56**	**14.05**	**6.45**	**9.42**
Fertilizer levels	**F_0**	3.76 b	4.74 b	6.23 c	0.034 c	21.61 c
	F_1	5.08 a	6.04 a	9.19 a	0.051 a	32.51 b
	F_2	5.35 a	6.09 a	9.79 a	0.054 a	41.05 a
	F_3	4.27 b	4.81 b	7.98 b	0.044 b	33.87 b
LSD $_{(0.05)}$		**0.29**	**0.29**	**0.43**	**1.24**	**1.28**
CV (%)		**15.16**	**25.56**	**14.05**	**6.45**	**9.42**

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF

Organic manures along with inorganic fertilizers showed the significant role in increasing the pod length of the okra (Figure 15). The highest seed weight pod^{-1} (7.15 g) was found at vermicompost in combination with 25% fertilizers less than the recommended doses. Meanwhile, the lowest (2.83 g) was found while cowdung was used with 50% less of RDF (M_1F_3). Means were statistically similar while vermicompost was combined with different doses of inorganic fertilizers except while no fertilizers were combined (Figure 15).

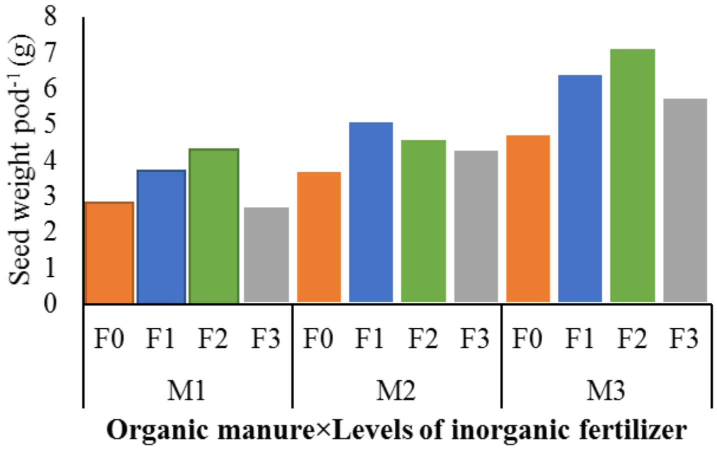

Figure 15. Interaction effect of organic and inorganic fertilizers on seed weight pod^{-1} of okra. Mean ($LSD_{0.05}$ 1.40). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.9 100-seed weight

100-seed weight exerted significant effect due to application of different types of organic materials. In the experiment, among cowdung, ACI compost and vermicompost, the application of vermicompost showed the best performances in terms of 100-seed weight (6.24 g). The minimum 100-seed weight (4.80 g) was found while cowdung was applied. However, both cowdung and ACI compost showed the statistically similar result (Table 4).

Although the 100-seed weight was increased with the application of inorganic fertilizers, there was not observed any significant differences between the treatments at RDF (F_1) and 25% less of RDF (F_2). The maximum 100-seed weight (6.09 g) was observed at 25% less of RDF while the minimum (4.74 g) was observed at control (Table5).

Interaction effect of organic and inorganic fertilizers bears significant effect on 100-seed weight of okra plant that presented in Figure 16. The figure revealed that irrespective of organic manure (except vermicompost) F_1 showed the highest 100-seed weight than other fertilizer doses, but in case of vermicompost F_2 (25% less of RDF) showed highest seed weight followed by F_1 (RDF). However, M_3F_2 combination showed the highest 100-seed weight (7.93 g) while at M_1F_3 treatment combination gave the lowest 100-seed weight (4.23 g) (Figure 18). Makinde and Ayoola (2008) also observed similar trend of 100-seed weight in okra.

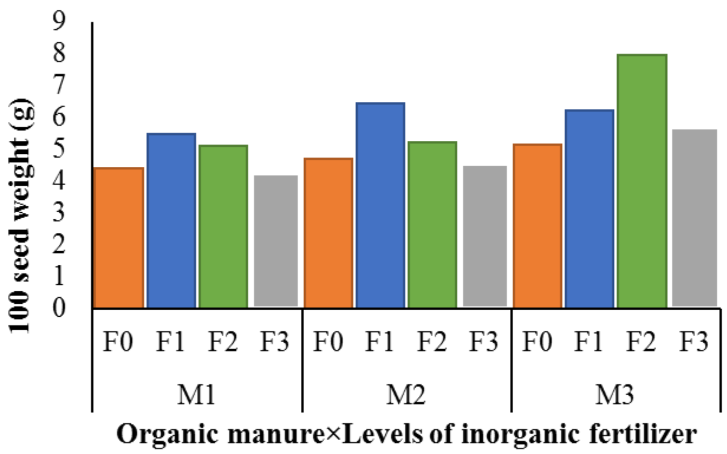

Figure 16. Interaction effect of organic and inorganic fertilizers on 100-seed weight of okra. Mean ($LSD_{0.05}$ 2.53). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.10 Seed yield plant^{-1}

Organic manures exerted significant effect on the seed yield of okra. Different organic manure effect on the seed yield by influencing the nutrient uptake ability. Among the three different organic manure, vermicompost showed best performance over the cowdung and ACI compost. The highest result (12.21 g) was observed while vermicompost was used where the minimum result was observed at cowdung (5.82 g) application. However, there observed a statistically significant difference among the three means (Table 4).

Fertilizers are the vital component for the plant productivity. Inorganic fertilizers at different levels showed significant yield variation in okra. The highest yield was found at 25% less of RDF with 9.79 g seed yield plant^{-1} which was 57% higher than the control (Table 4). Moreover 47% and 28% seed yield plant^{-1} was found at RDF and 50% less of RDF accordingly.

Interaction effect of organic manure and chemical fertilizer's effect has been presented in Figure 17. The figure indicated that irrespective of fertilizers except cowdung, F_2 (25% less of RDF) showed highest seed yield plant^{-1} over other treatment, but in case of cowdung, F_1 (RDF) was found superior. For all combinations with organic manure F_0 (control) treatment showed the lowest seed yield plant^{-1} in okra. However, the combination of M_3F_2 (vermicompost × 25% less of RDF) resulted in best result in terms of seed yield plant^{-1} (14.54 g). On the contrary the minimum seed yield (3.69 g) was found at M_2F_0treatment combination. Similar results was also stipulated by Lee *et al.* (1990) in case of seed yield in okra.

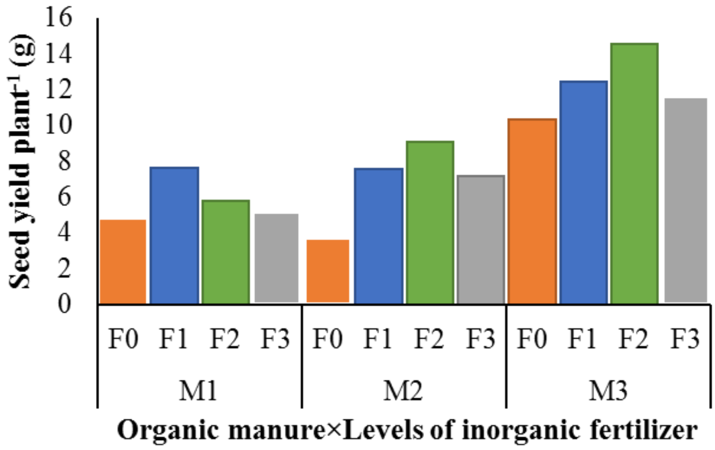

Figure 17. Interaction effect of organic and inorganic fertilizers on seed yield plant^{-1} of okra. Mean ($LSD_{0.05}$ 2.42). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.11 Seed yield

Seed yield ha^{-1} was influenced by different organic manures. Here, in this study vermicompost showed best performance over the cowdung and ACI compost (Table 4). The highest result (0.067 t ha^{-1}) was observed while vermicompost was used where the minimum result was observed at cowdung (0.032 t ha^{-1}) application. The result indicated that vermicompost out yielded over cowdung and ACI compost by producing 0.035 and 0.029 t ha^{-1} higher seed yield, respectively.

However, inorganic fertilizers at different levels showed significant yield variation in okra. The highest seed yield (0.054 t ha^{-1}) was found at 25% less of RDF where the lowest (0.034 t ha^{-1}) was observed when no fertilizer was used. Above that, F_1 and F_2 showed statistically similar results. Morris *et al.* (2007) also observed the similar findings.

Interaction effect of organic manure and different level of inorganic fertilizer signifies that, vermicompost × 25% less of RDF resulted in best result in terms of seed yield t ha^{-1} (0.080 t ha^{-1}). On the contrary the minimum seed yield (0.025t ha^{-1}) was found at M_2F_0 treatment combination (Figure 18).

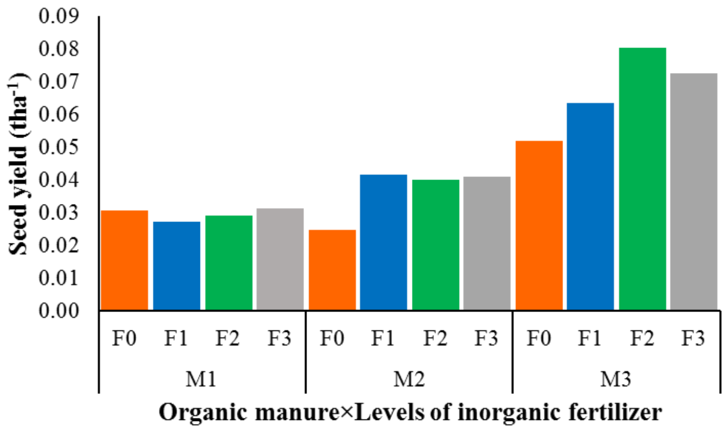

Figure 18. Interaction effect of organic and inorganic fertilizers on seed yield (t ha^{-1}) of okra. Mean ($LSD_{0.05}$ 1.29). Barrs with different letters are significantly different at P≤0.05 applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.12 Shelling percentage

Shelling percentage was highly influenced by the application of different types of organic materials. In the experiment, the application of vermicompost showed the best performances in terms of shelling percentage (44.79%). The minimum shelling (%) (22.24%) was found while cowdung was applied followed by ACI compost. However, all three means are significantly different from one another (Table 4).

Shelling (%) of okra is influenced by different doses of inorganic fertilizers. Different doses of chemical fertilizer helped to increase the shelling (%) of okra. In the experiment the highest shelling (%) was observed 25% less of RDF which is 41.05% and the minimum shelling (%) (21.61%) was found while no fertilizers were used (Table 4).

In combination of both Organic manures and inorganic fertilizers showed the significant role in increasing the shelling (%) of okra (Figure 19). The highest shelling (%) (57.67%) was found at vermicompost in combination with 25% fertilizers less than the recommended doses. Meanwhile, the lowest result (17.05%) was found while cowdung was used without any fertilizers (Figure 19). In chickpea, Namvar *et al.* (2011) observed the similar results.

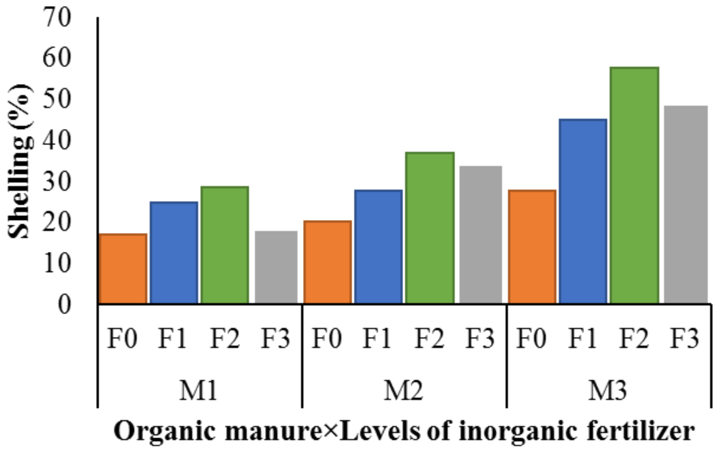

Figure 19. Interaction effect of organic and inorganic fertilizers on shelling (%) of okra. Mean ($LSD_{0.05}$ 5.44). Barrs with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= control; F_1= Recommended dose of fertilizer, F_2= 25% less of RDF and F_3= 50% less of RDF.

4.13 Seed germination percentage

Germination percentage is a vital indicator to estimate seed viability and vigor index. However, application of different organic manure exerted non-significant variation on seed germination (Table 5).The highest (86%) germination resulted in application of ACI compost where the lowest (84%) was due to both cowdung and vermicompost. Statistically similar result was observed due to application of cowdung, ACI compost and vermicompost in terms of seed germination.

Different doses of inorganic fertilizers effect on the germination percentage of okra. Statistically similar result was observed at RDF and 25% less of RDF. On the other hand, non-significant difference between control and 50% less of RDF was recorded. However, the highest germination (89%) was found at RDF and the lowest (80%) was at F_3 treatment (Table 5).

Table 5. Seed qualities of okra as influenced by different organic manures and levels of inorganic fertilizer

Treatments		Germination (%)	Root-Shoot ratio	Fresh weight of seedlings^{-1} (g)	Dry weight of seedlings^{-1} (g)
Organic manures	M_1	84 a	0.40c	0.161c	0.033b
	M_2	86 a	0.66b	0.180b	0.034b
	M_3	84 a	0.84a	0.253a	0.045a
LSD $_{(0.05)}$		**NS**	**0.02**	**6.35**	**2.48**
CV (%)		**3.12**	**6.07**	**8.55**	**13.35**
Fertilizer levels	F_0	83 b	0.49c	0.151c	0.030b
	F_1	89 a	0.67b	0.220a	0.042a
	F_2	87 a	0.74a	0.232a	0.042b
	F_3	80 b	0.62b	0.191b	0.035b
LSD $_{(0.05)}$		**0.01**	**0.02**	**7.33**	**2.87**
CV (%)		**3.12**	**6.07**	**8.55**	**13.35**

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF.

Interaction effect of organic manure and inorganic fertilizers showed statistically similar and higher germination percentage was resulted from the combination of M_3F_2, M_1F_1 and M_2F_1 which was 91%, 92% and 91%, respectively. The lowest germination (78%) in treatment combination was at M_1F_3 (Table 6). Najar and Khan (2013) also observed the similar results in tomato.

Table 6. Interaction effect of organic and inorganic fertilizers on seed quality parameters of okra

Treatment combination	Germination percentage	Root-Shoot ratio	Fresh weight of Seedlings^{-1} (g)	Dry weight of Seedlings^{-1} (g)
M_1F_0	83 b	0.38hi	0.026e	0.110h
M_1F_1	92 a	0.51ef	0.033 c-e	0.176fg
M_1F_2	85 b	0.41gh	0.040 b-d	0.193ef
M_1F_3	78 c	0.30i	0.033 c-e	0.166g
M_2F_0	85 b	0.49fg	0.026e	0.130h
M_2F_1	91 a	0.60de	0.046ab	0.220cd
M_2F_2	85 b	0.80c	0.033 c-e	0.196 d-f
M_2F_3	83 b	0.75c	0.030de	0.176fg
M_3F_0	81 bc	0.62d	0.036b-e	0.213 c-e
M_3F_1	84 b	0.90b	0.046ab	0.263b
M_3F_2	91 a	1.01a	0.053a	0.306a
M_3F_3	81 bc	0.82bc	0.043 a-c	0.230c
$LSD_{(0.05)}$	**0.050**	**0.096**	**0.010**	**0.026**
CV (%)	**3.51**	**8.96**	**16.25**	**7.84**

Mean was calculated from three replications for each treatment. Values with different letters are significantly different at $P \leq 0.05$ applying the LSD test. Here, M_1= Cowdung; M_2= ACI compost; M_3= Vermicompost and F_0= No fertilizers (control); F_1= Recommended dose of fertilizer (RDF); F_2= 25% less of RDF; F_3= 50% less of RDF.

4.14 Root-shoot ratio

Significant effect was observed in respect of root-shoot ratio in okra with application of different organic matter. Cowdung, ACI compost and vermicompost had significant effect on the root-shoot ration of the seedlings of okra. Due to vermicompost application, the highest root-shoot ratio was (0.84) found where the lowest (0.40) was found at cowdung application (Table 5).

Inorganic fertilizers similarly affect the root-shoot ratio of the okra seedlings. However, there was no significant difference between fertilizer applied at recommended dose and 25% less than recommended dose. The highest ratio (0.74) found at25% less of RDF and the lowest at F_0 (0.49). At highest treatment (25% less of RDF) 49% ratio was increased compared to the control (Table 5).

In combination of organic and inorganic fertilizers, significant difference was observed on root-shoot ratio of okra. Interaction effect documented that the best (1.01) performance found at M_3F_2 treatment combination (Table 6).

4.15 Fresh weight and dry weight seedlings^{-1}

Plant biomass both dry weight and fresh weight highly influenced due to the application of organic and inorganic fertilizers. Organic manures significantly influence the dry weight content of okra (Table6) except due to application of vermicompost. The dry weight content 0.033 g, 0.034 g, 0.045 g was calculated from cowdung, ACI compost and vermicompost, respectively. Fresh weight content showed maximum in vermicompost (0.253 g) and the minimum (0.161 g) at cowdung application (Table 5).

Inorganic fertilizers at different doses showed significant variation on plant dry and fresh weight content. Whereas, the maximum fresh and dry weight was found 0.232 g and 0.042 g both at F_2 and F_1, respectively (Table6). The lowest FW and DW (0.151 g and 0.030 g) was observed both at the treatment F_0. Sheela and Khimiya (2013) found the similar observation in cowpea.

The interaction effects of organic manure and inorganic fertilizers were significant in respect of fresh weight and dry weight (Table 6). The highest content (0.053, 0.306 g) was recorded at M_3F_2 and the lowest (0.110, 0.026 g) dry weight and fresh weight were measured from the treatment combination M_1F_0 (Table 6).

CHAPTER V

SUMMARY AND CONCLUSION

The pot experiment was conducted at agronomy net house of Sher-e-Bangla Agricultural University during April-August 2018 to find out the role of organic and inorganic fertilizers on growth, yield and seed quality of okra. The experiment comprised with two factors *viz.*, factor (A)3 organic manures *viz.*, cowdung (M_1), ACI compost(M_2) and vermicompost(M_3) and factor (B) 4 levels of inorganic fertilizer *viz.*, control (F_0), Recommended dose of fertilizer; RDF (F_1), 25% less of RDF (F_2) and 50% less of RDF (F_3). The experiment was conducted following randomized complete block design (RCBD) with three replications.

In this experiment, data were taken considering the growth, yield, and yield contributing characters and seed quality parameters. Following parameters *viz.*, plant height at 20,40, and 60 DAS, branches number plant^{-1}, pod diameter, pod length, green pod plant^{-1}, green pod yield plant^{-1}, seeds pod^{-1}, seed weight pod^{-1}, 100-seed weight, seed yield plant^{-1}, total seed yield, shelling %, seed germination, root-shoot ratio and fresh weight-dry weight were considered for overall justification.

Plant height was observed at three intervals *viz.*, 20, 40 and 60 DAS. Among three organic manures, vermicompost resulted with maximum plant height 19.31, 82.28, and 104.96 cm respectively. On the other hand, application of cowdung resulted in the lowest plant height 12.35, 54.86 and 74.90 cm at 20, 40 and 60 DAS, respectively. Among 4 levels of inorganic fertilizer, tallest plant (20.05 cm) at 20 DAS, (79.15) at 40 DAS and (100.39 cm) at 60 DAS was found while 25% less of RDF was applied. However, the minimum plant height 12.92, 60.08 and 81.83 cm was found when plant was treated with no fertilizer at 20, 40 and 60 DAS, respectively. Highest plant height due to manure and fertilizer interaction was obtained from M_3F_2 treatment combination. In comparison to the highest value 24.85, 91.33 and 122.58 cm, the lowest value 9.59, 44.80 and 68.92 cm was observed from M_1F_0 treatment combination at 20, 40 and 60 DAS, respectively.

Among three organic manure, ACI compost resulted with maximum (4.13) number of branches plant^{-1}. On the other hand, application of cowdung resulted in the minimum (3.66) number of branches plant^{-1}. Among 4 levels of inorganic fertilizer, highest number of branches plant^{-1} (4.54) was found while fertilizers was applied at recommended dose. However, the lowest number of branches plant^{-1} (3.32) was found when plant was treated with no fertilizer. Furthermore, manure and fertilizer interaction M_3F_2 showed highest number of branches plant^{-1} (4.60) where at M_3F_0, the lowest number of branches plant^{-1} (3.12) was found.

In case of pod diameter and pod length, vermicompost resulted with maximum results (3.96, 11.59 cm) while the minimum (3.05, 7.59 cm) was from cowdung, respectively. On the contrary, maximum (3.75 cm) and minimum (3.16 cm) pod diameter due to inorganic fertilizer application at 4 different levels was recorded from F_2 and F_0, respectively where the maximum (14.55 cm) and minimum (6.42 cm) pod length was also found at F_2, and F_0 respectively. The interaction effect signified that at M_3F_2 combination highest pod diameter and pod length (4.57 cm, 14.55 cm) was produced whereas the lowest (2.95 cm, 6.42 cm) was found while cowdung was used without any fertilizers (F_0), respectively.

Due to application of vermicompost, maximum green pod plant^{-1} (6.75) and green pod yield plant^{-1} (0.64 kg) was recorded where the minimum green pods plant^{-1} (5.62) and green pod yield plant^{-1} (0.45 kg) was resulted due to application of cowdung. The maximum green pods plant^{-1} (7.38) was observed at F_2 while the minimum (4.72) was observed at F_0. Conversely, application of RDF resulted in significantly higher green pod yield (0.57 kg) per pot while the lowest (0.45 kg) resulted due to the application of fertilizers 50% less of RDF. In combination, highest green pods plant^{-1} (8.75) and green pod yield plant^{-1} (0.77 kg) were found at M_3F_2. Meanwhile, the lowest result green pod plant^{-1} (4.08) was found at M_2F_0 while the minimum green pod yield plant^{-1} (0.37) was observed at M_2F_3.

Among the seed yield parameters *viz.*, seeds pod^{-1}, seed weight pod^{-1}, 100-seed weight, seed yield plant^{-1} and total seed yield significantly influenced by the application of organic manures. In above all parameters, vermicompost showed the highest result (57.82, 6.01 g, 6.24 g, 12.21 g, 0.067 t ha^{-1}), whereas the cowdung resulted with lower (46.16, 3.39 g, 4.80 g, 5.82 g, 0.032 t ha^{-1}) performances, accordingly. However, inorganic fertilizer played differential role in those above mentioned parameters. The maximum seeds pod^{-1} (59.06) was observed at F_2 while the minimum (46.18) was observed at F_0. Highest seed weight pod^{-1} (5.35 g) was observed at F_2 while the minimum (3.76 g) was found while no fertilizers was used.

The maximum 100-seed weight (6.08 g) was observed at 25% less of RDF while the minimum (4.73 g) was observed at control. The highest seed yield plant^{-1} (9.79 g) was found at F_2 while the lowest (6.23 g) was at F_0. The highest seed yield (0.054 t ha^{-1}) was found at 25% less of RDF (F_2) where the lowest (0.034 t ha^{-1}) was observed when no fertilizer was used. In combination effect, M_3F_2 resulted with highest values while the M_1F_0 showed the lowest results in terms of seed yield and yield parameter except seed yield plant^{-1} and total seed yield at M_2F_0 treatment combination.

Seed quality parameters *viz.,* seed germination percentage, root-shoot ratio and seedlings fresh weight-dry weight showed different responses due to application of cowdung, compost and vermicompost. The highest (86%) germination resulted with ACI compost where the lowest (84%) was due to both cowdung and vermicompost. Due to vermicompost application highest (0.84) root-shoot ratio were found where the lowest (0.40) was found at cowdung application. The highest dry weight content (0.45 g) was calculated from vermicompost, where fresh weight content showed maximum in vermicompost (0.253 g) and the minimum (0.161 g) at cowdung application. Due to application of inorganic fertilizer at different level the highest level of germination was found at F_1 and F_2 and the lowest at F_3 treatment. The highest root-shoot ratio (0.74) found at F_2 while the lowest was at F_0. The maximum fresh and dry weight was found at F_2 and F_1, while the lowest FW and DW was observed both at the treatment F_0.

Interaction effect represent that, at M_3F_2, M_1F_1 and M_2F_1 combination seed germination was highest while the lowest was at M_1F_3. Meanwhile, the best root-shoot ratio (1.01) was documented at M_3F_2 treatment. Furthermore, the highest fresh and dry weight (0.053, 0.306 g) was recorded at M_3F_2 and the lowest (0.110, 0.026 g) were measured at M_1F_0.

Organic manure and chemical fertilizers play essential role in growth and development of okra. For the better crop establishment plant required a balanced mixture of both inorganic and organic fertilizers. As food security and food quality both are the most pronounced agenda of sustainable agriculture and the agenda of sustainable development goal, we need to focus much on the use of the organic matter as the best alternative for soil and plant nutrition. This experiment revealed the essential role of organic matter in combination of inorganic fertilizers. Results conclude that, among the organic manures vermicompost performed best over rest other organic treatment whereas, in combination vermicompost along with 25% less of RDF inorganic fertilizer showed the best performances over rest other combinations. Hence, further research need to be conducted in assessing the nutrient content analysis and the reduction of the use of inorganic fertilizers where although the production will be maximized. In addition, for quality okra seed production more efficient and modern agricultural practices needs to be adopted.

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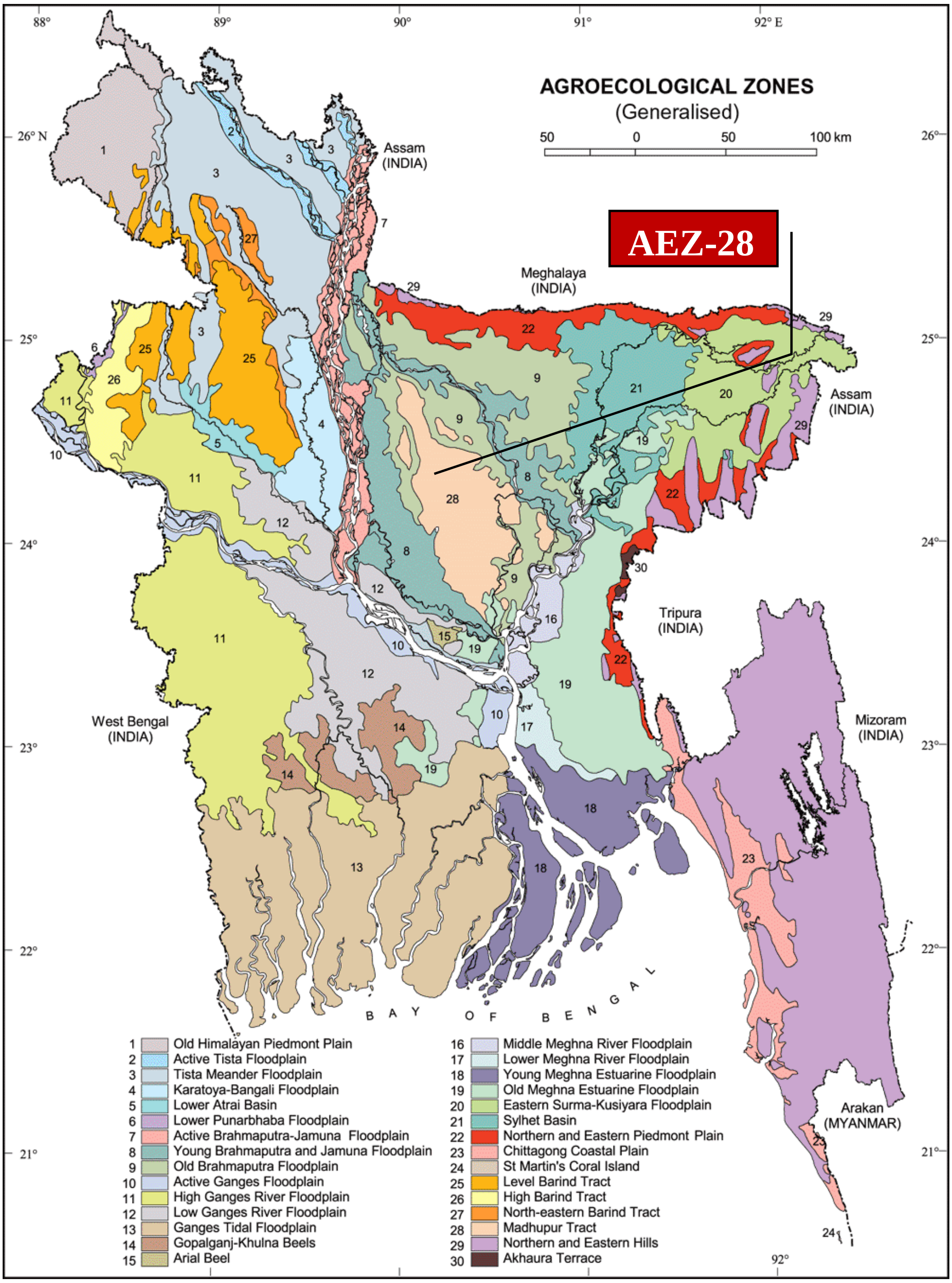
APPENDICES

Appendix I. Map showing the experimental site (AEZ-28)



Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from April 2018 to August 2018

Year	Month	**Air temperature (^0C)			**Relative humidity (%)	*Rainfall (mm)	**Sunshine Maximum Minimum Mean(Hours)
		Max.	Min.	Mean			
2018	April	30.11	26.32	28.215	82.53	43.16	235.0
	May	25.32	14.40	19.86	84.06	73.23	196.4
	June	21.77	10.17	15.97	83.65	88.56	165.6
	July	26.77	15.49	21.13	75.21	82.45	229.2
	August	28.79	18.54	23.665	76.34	55.45	234.3

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan, Dhaka-1212, Bangladesh

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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy 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

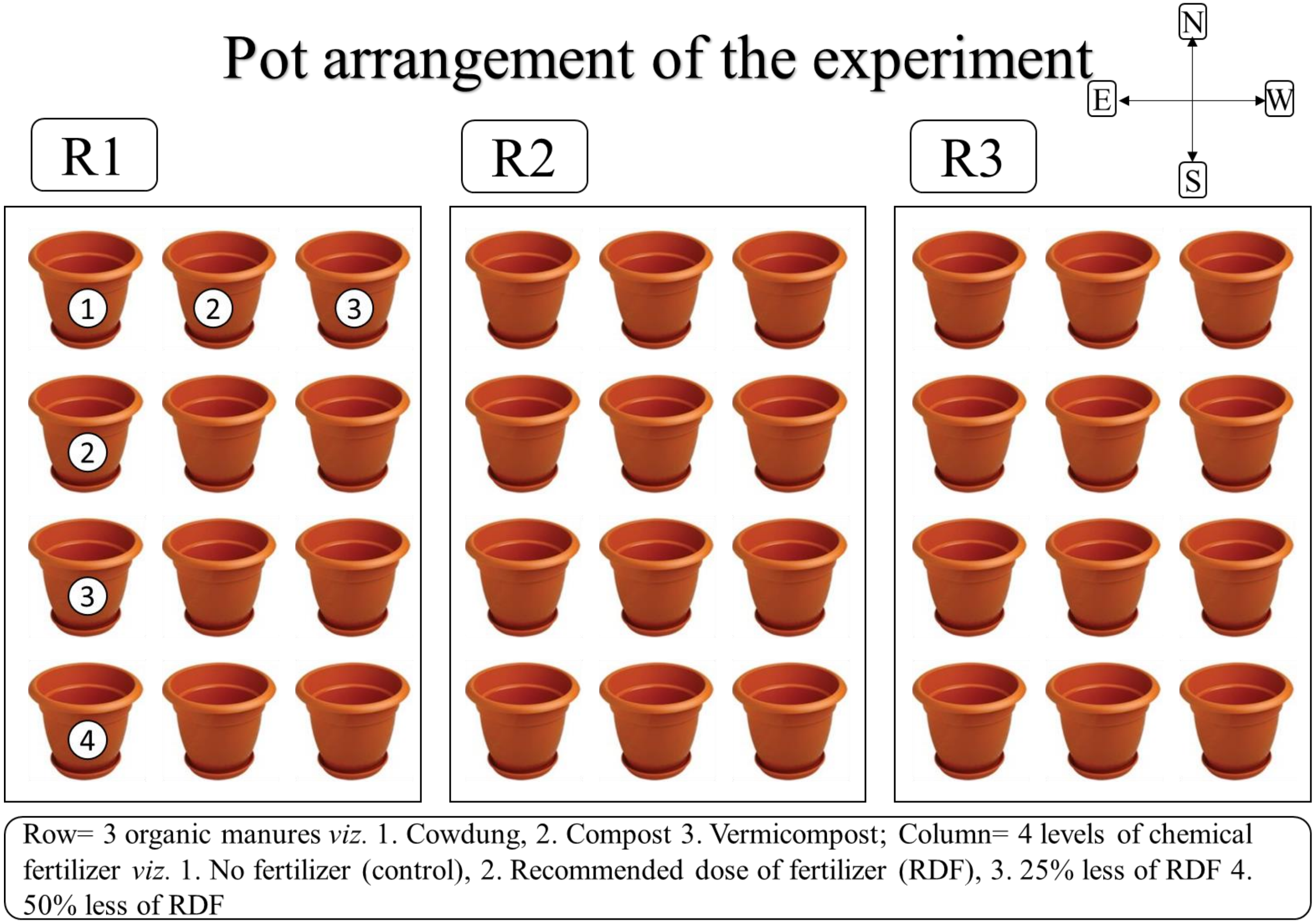
Source: Soil Resource Development Institute (SRDI)

B. Table representing the Soil tests results of the experimental field

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Ca	6.36 meq/100g soil
B	0.30 µg/g soil
Organic matter (%)	0.78
Total N (%)	0.071%
Available P	14.04 µg/g soil
Exchangeable K	0.31 meq/100g soil
Available S	15.16 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix IV. Figure showing the pot arrangement of the experiment



Appendix V. Mean square values and degrees of freedom (df) of plant height at 20, 40 and 60 DAS, number of branches plant^{-1}, pod diameter of okra as influenced by organic and inorganic fertilize

		Mean square value of				
Sources of variation	**df**	**Plant height 20 DAS**	**Plant height 40 DAS**	**Plant height 60 DAS**	**Branches plant^{-1}**	**Pod diameter**
Replication	2	1.33	1.47	17.36	0.029	0.15
OM	2	47.31	1002.36	1037.69	0.98	0.65
Fertilizers	3	12.29	225.30	485.91	0.22	0.13
Treatment	6	3.29	37.92	116.93	0.07	0.03
Error	22	2.27	12.24	28.17	0.19	0.12

Appendix VI. Mean square values and degrees of freedom (df) of pod length, green pod plant^{-1}, green pod yield plant^{-1}, seeds pod^{-1} of okra as influenced by organic and inorganic fertilizers

Sources of variation	**df**	**Pod length**	**Green pod plant^{-1}**	**Green pod yield plant^{-1}**	**Seeds pod^{-1}**
Replication	2	0.11	5.0122	0.00	17.7
OM	2	10.18	20.0747	0.14	580.79
Fertilizers	3	1.34	18.3490	0.03	167.15
Treatment	6	0.17	6.7344	0.01	40.85
Error	22	2.04	1.3985	0.00	12.23

Appendix VII. Mean square values and degrees of freedom (df) of seed weight pod^{-1}, 100-seed weight, seed yield plant^{-1}, seed yield, shelling percentage of okra as influenced by organic and inorganic fertilizers

Sources of variation	df	Mean square value of: Seed weight pod^{-1}	100-seed weight	Seed yield plant^{-1}	Seed yield	Shelling (%)
Replication	2	0.12	0.38	1.11	9.23	3.07
OM	2	69.05	11.55	366.37	205.2	2507.54
Fertilizers	3	12.89	9.08	32.04	21.25	874.12
Treatment	6	2.74	4.04	7.11	4.91	156.99
Error	22	0.68	2.24	2.05	3.70	10.36

Appendix VIII. Mean square values and degrees of freedom (df) of germination percentage, root-shoot ratio, fresh weight and dry weight of okra as influenced by organic and inorganic fertilizers

Sources of variation	df	Germination percentage	Root-shoot ratio	Fresh weight	Dry weight
Replication	2	0.00	0.00	0.00	0.12
OM	2	0.00	0.10	0.02	0.01
Fertilizers	3	0.01	0.06	0.01	0.05
Treatment	6	0.00	0.00	0.00	0.08
Error	22	0.00	0.00	0.00	0.10

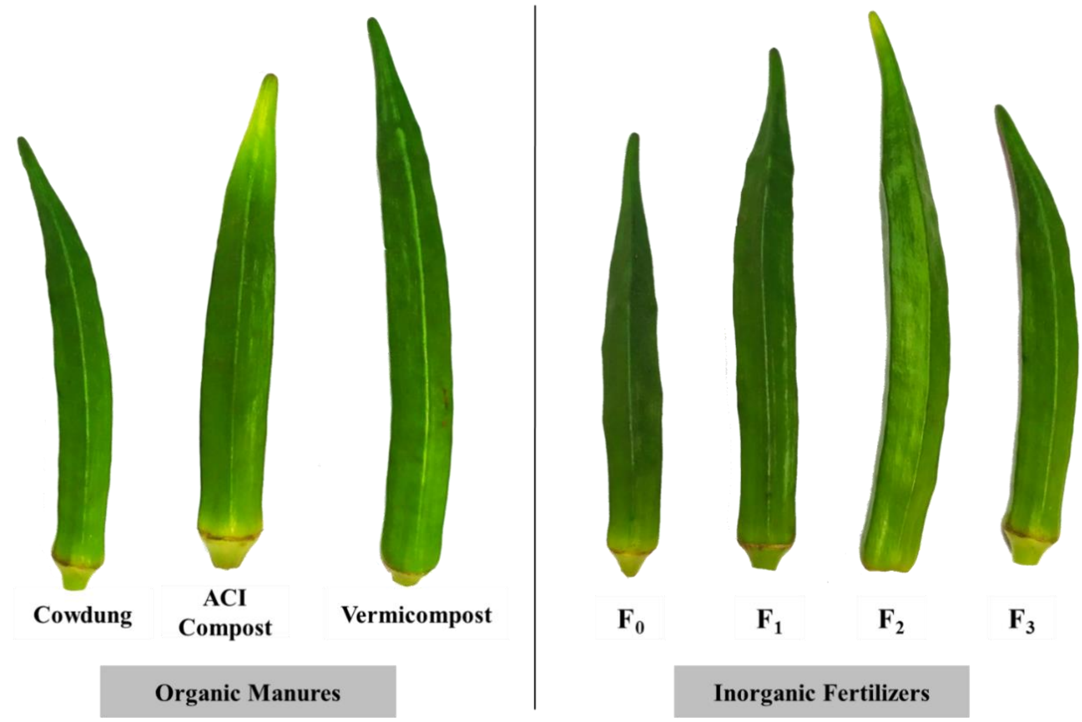


Plate 1. Effect of organic manure and inorganic fertilizer doses on pod length of okra

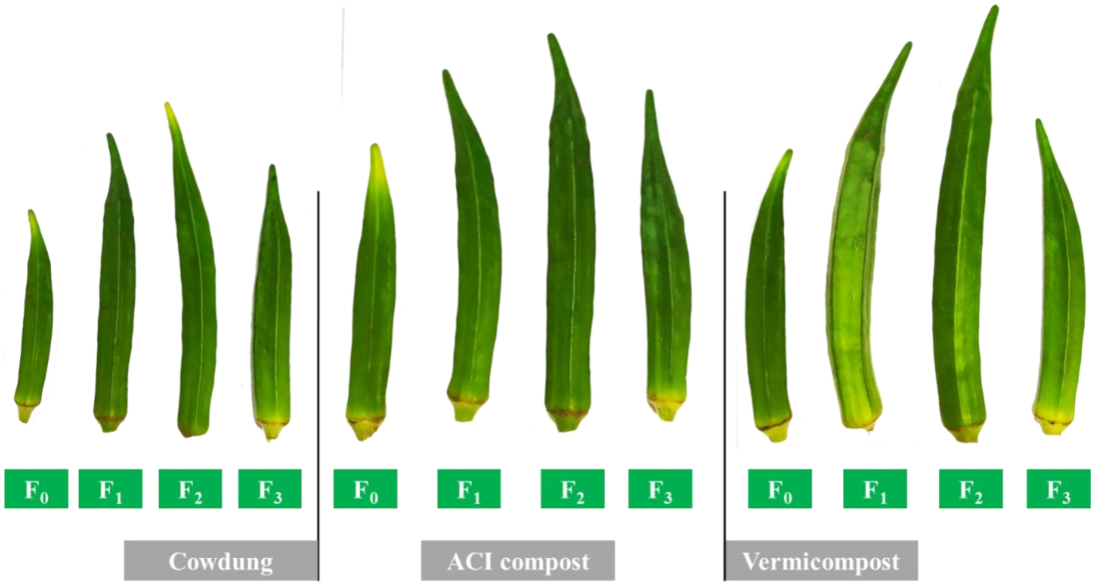


Plate 2. Interaction effect of organic sources and inorganic fertilizer doses on pod length of okra

Plate 3. Different stages of okra seed germination

Plate 4. Flower and pod formation stage of okra

Plate 5. Pod in the plant

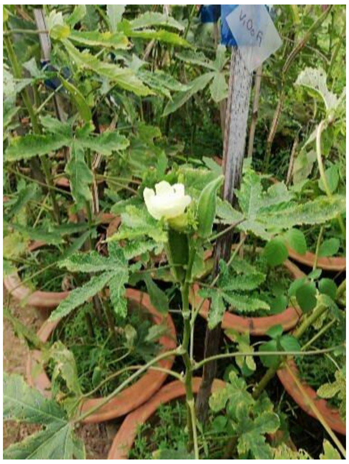


Plate 6. Flower in the plant