EFFECT OF VERMICOMPOST AND EARTHING UP ON THE GROWTH AND YIELD OF ONION

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EFFECT OF VERMICOMPOST AND EARTHING UP ON THE GROWTH AND YIELD OF ONION

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CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF VERMICOMPOST AND EARTHING UP ON THE GROWTH AND YIELD OF ONION**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **SHIRAJUM MONIRA** Registration. No. **12-04768** under my supervision and guidance. No part of this 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: June '18

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Dedicated to

My

Beloved Parents

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The Author

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ABSTRACT

A field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2017 to March 2018. The experiment consists of two factors. Factor-A vermicompost V_0 (control), V_1 (6 t ha^{-1} vermicompost), V_2 (10 t ha^{-1} vermicompost) and V_3 (14 t ha^{-1} vermicompost) and Factor-B earthing up E_0 (control), E_1 (two times earthing up) and E_2 (three times earthing up). The two factor experiment was laid out in Randomized Complete Block Design with three replications. The collected data were statistically analyzed. Results revealed that in terms of vermicompost application, the highest fresh weight bulb^{-1} (40.07g), yield plot^{-1} (527.89 g) and yield ha^{-1} (5.39 t) were found from the application of vermicompost at 14 t ha^{-1} compared to no application of vermicompost. Again, in terms of different earthing up treatments, the highest fresh weight bulb^{-1} (32.48g), yield plot^{-1} (431.67g) and yield ha^{-1} (4.41 t) were found from the treatment E_2 (three times earthing up) compared to E_0 (no earthing up) treatment. Both vermicompost and earthing up and their combination showed significant variation on different growth and yield parameters of onion. The highest fresh weight bulb^{-1} (42.73g), yield plot^{-1} (567.33g) and yield ha^{-1} (5.79 t) were found from the treatment combination of V_3E_2 compared to control V_0E_0 (control) treatment combination. And it may be summarized that 14 t/ha vermicompost with three times earthing up performed the maximum yield of onion compared to other treatments.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAT	=	Days After transplanting
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
mg	=	Miligram
N	=	Nitrogen
P	=	Phosphorus
K	=	Potassium
L	=	Litre
USA	=	United States of America

CHAPTER I

INTRODUCTION

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INTRODUCTION

Onion (*Allium cepa* L.) is an important herbaceous bulb and spice crop in the world which belongs to the family *Alliaceae*. It is also considered as the most important vegetable crops commercially grown in the world. It probably originated from Central Asia between Turkmenistan and Afghanistan where some of its relatives still grow in the wild. Onion is mainly used as spices but it is also used as condiments for flavoring food and also as delicious vegetables and salad crop. Onion is popularly referred as "Queen of Kitchen." Onion is liked for its flavour and pungency which is due to the presence of a volatile oil 'allyl propyl disulphide'- organic compound rich in sulphur. It is being used in several ways as fresh, frozen, dehydrated bulbs and green bunching types. Onion has got good medicinal value. Recently onion is being used by processing industry to greater extent for preparing dehydrated forms like powder and flakes. Onion contains carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamin like vitamin A (0.012 mg), vitamin C (11 mg), thiamin (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and also some minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) per 100 g (Rahman *et al*. 2013). In Bangladesh it is commercially cultivated in the greater districts of Dhaka, Mymensingh, Rajshahi, Rangpur, Rajbari, Khustia, Khulna, Barisal and Pabna (BBS, 2015). Among the spice crops grown in Bangladesh, onion ranks top in respect of production and second in respect of area (BBS, 2012).

Onion is generally grown in Rabi season in Bangladesh. Growth and yield of this crop is remarkably influenced by different nutrients management. There are two types of fertilizer one is Organic and another is Inorganic. Chemical fertilizers generate several deleterious effects on the environment and human health. The synthetic fertilizers are rapidly lost by leaching in drainage water; this causes dangerous environmental pollution (Aisha *et al*., 2007; Hernandez *et al.,* 2010). It is an established fact that use of inorganic fertilizer for the crops is not so good for health because of residual effect but in the case of organic fertilizer such problem does not arise and on the other hand, it increased the productivity of soil as well as crop quality and yield (Tindall, (2000). However, overall, excessive amounts of inorganic fertilizers are applied to onion in order to achieve a higher bulb yield (Shedeed, *et al*., 2014). Organic manure contains nutrient elements that can support crop production and enhance chemical and physical properties of soil. Application of organic fertilizers to the soils promoted nutrients availability, plant uptake, increased crop yield and quality (Shaheen *et al*., 2007; Shedeed *et al*., 2014). Organic manure is a two way practice of saving the environment by transforming waste materials into a valuable resource that can be used to supplement soil nutrients (Anon., 2009). Organic manure also helps to conservation of soil moisture. Available soil moisture also helps taking other nutrients for the plants. In this way organic manure helps up taking of different plant nutrients and to increase fertility and productivity of soil (Anon., 1992).

Manure like cowdung, poultry manure, mustard oil cake, vermicompost is becoming popular and they are also available locally. Vermicompost is organic manure which is important as a product of interactions between earthworm and microorganisms by degradation of organic waste (Arancon *et al*., 2005).Vermicompost is very important to increase Onion quality and yield. Several researchers have reported that vermicompost contains substaces which helps in building soil structure, stimulation of plant growth, particularly that of roots, drilling mud and emulsiliers. It is documented that vermicompost is a rich source of vital macronutrients (N, P, K, Ca and Mg) and micronutrients (Fe, Mo, Zn, and Cu). The chemical analysis of vermicompost reveals that N, P, K content was 0.8, 1.1 and 0.5 percent respectively (Giraddi, 1993). It is scientifically proving as ‘miracle growth promoter and also plants protector’ from pests and diseases. Vermicompost retains nutrients for a long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in a shorter time, the vermicompost does (Arancon *et al*., 2004).

There are different types of intercultural operation are doing on onion cultivation such as irrigation, weeding, thining, mulching, earthing up and so on. In which earthing up plays vital role in growth and yield of onion. Earthing up is the technique in agriculture and horticulture of piling soil up around the base of a plant. Earthing up provided maximum number of tuber with large size (Tesfaye *et al.,* 2013). Mukherjee *et al.* (2012) reported that earthing up is an economically viable weed control practice. The well known benefits that earthing up provided are regulating soil moisture and temperature, improving germination and emergence etc. High yield and quality, prolonged growing season higher nutritive value of the produce, improved storability etc. are also well described advantages of earthing up, therefore, aids in reducing cost involved in crop production with irrigation.

In consideration with the aforesaid idea, the present experiment was undertaken to assess the effect of vermicompost and earthing up on growth and yield of onion. Keeping above facts in view, the present study was undertaken with the following objectives:

1. To know the optimum dose of vermicompost on growth and yield of onion.
2. To determine the influence of earthing up on growth and yield of onion.
3. To evaluate the yield and yield contributing characters of onion influenced by the combined effect of vermicompost and earthing up.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Onion is an important spice and/or vegetable crop in Bangladesh. The production of onion bulb is influenced by many factors such as nutrient management and earthing up. Organic manure as vermicompost plays an important role on the growth and yield of onion. Many research works on vermicompost application in onion has been conducted in different parts of the worlds but their findings have little relevance to the agro-ecological situation of Bangladesh. But very few works has been initiated on earthing up of onion. The present study has been undertaken to investigate the effect of vermicompost and earthing up on growth and yield of onion. The relevant literatures available have been reviewed in this chapter.

2.1 Effect of vermicompost

Dhaker *et al*. (2017) conducted a field experiment during Rabi season 2016-17 to find out the effect of FYM and Vermicompost with or without PSB and Azotobactor and rates of organic manures (50% and 100% RND) on yield, quality and economics of onion (Agri Found Dark Red) on clay loam soil. The treatments comprised of organic, inorganic fertilizer and biofertilizers with ten treatments 100% RDF through inorganic, 100% RDF through FYM (N Basis), 100% RDF through vermicompost,50% RDF through Inorganic Fertilizers + 50 % through FYM, 50% RDF through Inorganic Fertilizers + 50 % through vermicompost, 5 0% RDF through Inorganic Fertilizers + 50 % through FYM + PSB, 50% RDF through Inorganic Fertilizers + 50 % through vermicompost + PSB, 50% RDF through Inorganic Fertilizers + 25 % vermicompost + PSB, 100% RDF through FYM (N Basis) + PSB +Azotobactor and 100% RDF through vermicompost + PSB + Azotobactor. Results revealed that the application of organic manure significantly influenced the diameter of bulb (cm), bulb weight (g), bulb yield (q ha^{-1}), total soluble solid (0B) and allyl propyl content (ppm) with 100% RDF through Vermicompost + PSB + Azotobactor). Application of 100% RDF applied through vermicompost + PSB + Azotobactor (T10) recorded maximum gross returns, net return and cost benefit ratio of onion crop.

Degwale (2016) conducted a field experiment to study the effect of vermicompost on growth, yield and quality of garlic *(Allium sativum* L.) during 2013 main rainy season. A locally grown garlic cultivar called Tsedey 92 (G-493) was used for the study. The treatment consisted of three levels of vermicompost (0, 2.5 and 5 t ha^{-1}). Data were collected on phenology, plant growth, bulb yield, and quality of the crop. The results revealed that increasing rate of vermicompost significantly ($P < 0.05$) affected days to emergence. The effect of vermicompost also significantly ($P < 0.05$) influenced days to maturity, leaf number, leaf area index, mean clove weight, mean bulb weight, fresh biomass yield, total bulb yield, dry matter percent and total soluble solid. The highest bulb dry matter percent (51.05) and total bulb yield (7.78 t ha^{-1}) was recorded at 5 t vermicompost ha^{-1}. Increasing level of vermicompost also significantly ($P < 0.05$) affected marketable and unmarketable bulb yield, and mean clove number. The highest marketable and the lowest unmarketable yield was obtained at 5 t ha^{-1} vermicompost. Marketable yield of garlic was increased by 9.96% and unmarketable bulb yield was decreased by 12.83% at an application rate of 5 t vermicompost ha^{-1} over the control. Total soluble solid was also increased from 5.13 to 5.69% Brix by applying 5 t vermicompost ha^{-1} over the control. Harvest index was also significantly affected by the increased application of vermicompost. The maximum harvest index 68.36% was also recorded at application of 5 t vermicompost ha^{-1}. It can, thus be concluded that, application of 5 t ha^{-1} vermicompost led to the maximum growth, yield and quality of the garlic crop.

Abou-El-Hassan *et al*. (2018) conducted a field experiment at Giza Agriculture Research Station, Giza Govemorate, Egypt, aims to evaluate the effect of compost, vermicompost and plant growth promoting rhizobacteria (PGPR) on growth, yield, quality and storage of some onion cultivars. Compost, vermicompost and PGPR as individual or combined treatments and recommended mineral fertilizers (RMF) were applied on three onion cultivars (Giza 20, Giza Red and Giza 6 Mohassan). The results showed that "Giza 20" cultivar was superior in most vegetative growth and total yield than the other two cultivars. "Giza 20" and "Giza red" recorded the highest values of bulb quality (TSS, dry matter and firmness) compared to "Giza 6 mohassan" at harvesting and during storage periods. "Giza 6 mohassan" gave the highest weight loss of bulbs at the end of storage period. Vermicompost + PGPR treatment gave the highest values of all growth properties and yield of bulbs without significant differences with RMF. Using RMF decreased bulb quality at harvesting and at the end of storage period, as well as increased total weight loss of bulbs at the end of the storage period. Application of RMF or 100% V+PGPR with "Giza 20" achieved the highest total gross return, total net return and benefit cost ratio. This study suggested possibility for using vermicompost + PGPR with "Giza 20" to produce good yield of onion similar to use RMF and higher bulb quality at harvesting and during storage, as well as to obtain the highest total net return and benefit cost ratio.

Reddy and Reddy (2005) studied the effect of different levels of vermicompost (0, 10, 20 and 30 t ha^{-1}) on growth of onion (cv. N-53). The plant height, number of leaves per plant and leaf area increased significantly with increasing levels of vermicompost from 10 to 30 t ha^{-1}.

Patil *et al.* (2005) studied the effect of flyash and FYM on nutrient uptake and yield of onion at Department of Horticulture, MAU, Parbhani. The results indicated that with increasing levels of FYM (0, 5, 15 and 30 t ha^{-1}), there was corresponding increase in uptake of N (ranging from 0.08 to 0.13 g/plant), P (ranging from 0.12 to 0.15 g/plant) and K (ranging from 0.61 to 0.92 g/plant) by onion bulb besides increasing onion yield.

Jayathilake *et al.* (2006) reported that the application of vermicompost alone has produced significantly higher bulb yield (18.8 t ha^{-1}) than the sole application of FYM or combined application of FYM and vermicompost in a study conducted at N G Ranga university, Hyderabad.

Dimri and Singh (2006) reported that application of FYM @ 15 t ha^{-1} produced the highest bulb weight, *i.e.* 74.45 g with the total onion yield of 291.02 q ha^{-1}.

Mamatha (2006) observed the highest bulb diameter with the application of FYM and vermicompost in onion.

Mehla *et al.* (2006) observed that the application of inorganic fertilizer supplemented with vermicompost increased the bulb yield significantly than over the fertilizers alone.

An experiment was conducted by Bybordi and Malakouti (2007) in Khosrowshahr and Bonab, Iran, during growing seasons of 2003 and 2004 to evaluate the effects of various sources of organic fertilizers on the yield and quality of Azarshahr variety of red onion. The highest yield (71.1 t ha^{-1}) was obtained with the application of vermicompost @ 6 t ha^{-1}.

Lal and Khurana (2007) reported that application of FYM @ 20 t ha^{-1} increased the onion bulb yield significantly than RDF in potato-onion-guar sequence rotation.

An experiment was carried out by Magdi *et al.* (2009) at Assiut University, Egypt in 2004-05 and 2005-06 to evaluate yield performance of onion (cv. Giza 6) fertilized with animal manure, chicken manures and mineral fertilizer. The highest yield of onion bulbs (7.26 and 8.82 t ha^{-1} for 2004-05 and 2005-06, respectively) was obtained by the application of chicken manure in both seasons as compared with animal manure and mineral fertilizers.

Yassen and Khalid (2009) observed that the combination of farm yard manure and chick manure significantly improved the bulb yield and other essential characters over the RDF.

Among the organic manures, poultry manure application at 3.28 t ha^{-1} recorded significantly higher onion yield as compared to vermicompost and FYM (Mandloi *et al.* 2008)

Ansari (2008) carried out the investigation to study the effect of vermicompost and vermiwash in reclaimed sodic soils on the productivity of onion during 1998-2000 in Lucknow, India. The yield of onion was significantly higher in plots treated with vermiwash (1:10 v/v in water), whereas the average weight of onion bulbs was significantly greater in plots amended with vermicompost and vermiwash (1:5 v/v in water).

Anburani and Gayathiri (2009) reported that the onion growth parameters were significantly influenced by the application of soil and foliar application of organic nutrients. The maximum plant height (54.43 cm), number of tillers (5.12), number of leaves per plant (17.77), leaf area (145.79 cm) and dry matter production (9.43 g plant) were recorded in the treatment that received AM @ 10 g pot^{-1} combined with humic acid @ 0.2 % followed by the treatment tested with vermicompost @ 1 kg pot^{-1} combined with panchagavya @ 3 % when compared to other treatments.

The application of 43 t ha^{-1} of organic compost (Swine compost) is enough to obtain onion bulbs with great quality and yield (Vidigal *et al.* 2010).

Zedan (2011) advocated that application of sheep manure @15 q ha^{-1} increased plant height, vegetative growth weight, and bulb length significantly.

Prabhakar *et al.* (2012) evaluated the trial, consisting of four levels of organic manure treatment and two inorganic nutrient supply treatments. The treatment which received 100 % recommended N, equivalent through organics produced the highest yield of 21.06 t ha^{-1}, plant height and leaf area index.

Bagali *et al.* (2012) studied that significantly higher bulb yield of 40.56, 41.65 and 40.88 t ha^{-1} was recorded with FYM @ 30 t ha^{-1}, vermicompost @ 6 t ha^{-1} and poultry manure @ 3 t ha^{-1} respectively, compared to their respective lower levels.

Dhotre and Allolli (2012) reported that the application of FYM resulted in earlier maturity and vermicompost increased the bulb yield.

Lee (2012) found that the application of cattle manure compost improved yield of intermediate-day onion and soil fertility under reduced rates of chemical fertilizer. However, CMC (cattle manure compost) application over 40 Mg ha^{-1} (1 Mg ha^{-1} = 0.4461 t acre^{-1}) did not increase onion bulb yield but accumulated soil nutrients.

Gami *et al.* (2012) found that the application of FYM applied @ 20 and 10 t ha^{-1} increased the bulb yield (36.64 and 22.27 per cent respectively) over no FYM application.

Kaswan *et al.* (2013) reported that the number of leaves per plant, plant height, fresh weight of bulb, diameter of bulb, volume of bulb, bulb yield, TSS and pungency were found maximum with the application of FYM @ 40 t ha^{-1}.

In the field trial, Gopakkali and Sharanappa (2014) found that the application of enriched bio-digested liquid manure (EBDLM) @ 100 kg N equivalent/ha + 3 sprays of panchagavya (3 %) recorded the highest plant height (42.3 cm), leaves/plant (8.1), leaf diameter (1.46 cm), fresh weight of bulb (143.7 g), bulb yield (42.8 t ha^{-1}), neck diameter (1.42 cm), bulb diameter (6.02 cm), bulb length (5.36 cm), total soluble solids (14.4 °B).

A field experiment was conducted by Meena *et al.* (2015) during summer season of 2004 and 2005 to find out the effect of various sources (FYM, VC and PM) and rates of inorganic manures (100 %, 125 %, 150 % RND) on yield, quality and economics of onion (Pusa Red) on a sandy clay-loam soil low in available N and medium in available phosphorus and potassium. Pooled data analysis revealed that the application of organic manure significantly influenced the yield attributes and bulb yield of onion over 100 % RND as urea (control). Progressive increase in dose of all the organic manures significantly increased the bulb yield, haulm yield, pungency and nutrient uptake (NPK). The application of 150 % RND as poultry manure gave higher bulb (270.84 q ha^{-1}) and haulm yields (35.13 q ha^{-1}) than other sources and levels of organic manures.

Indira and Singh (2014) recorded significantly high fresh weight of bulb (43.04 g), bulb yield (251.20 q ha^{-1}), N content (0.92 %) and TSS (11.07 °B) as compared to control with the application of vermicompost 20 q ha^{-1}.

Latha and Sharanappa (2014) reported higher bulb yield with the application of enriched bio-digested liquid manure (EBDLM) at 125 kg N equivalent/ha + 3 sprays of panchagavya (3 %).

Gwari *et al.* (2014) found that application of poultry manure @ 15 t ha^{-1} improved the onion bulb yield significantly than other manures.

Naik *et al.* (2014) revealed that leaf length and average bulb weight as well as bulb yield of onion were significantly higher when FYM, bio-compost and vermicompost were applied in combination with castor cake than their individual application. After three years of experiment at fixed site, decrease in pH and EC and improvement in soil fertility and finer and coarser fraction of water stable aggregates was recorded in all the treatments which received organic sources of nutrients as compared to the plots which received the INM treatment.

Rizk *et al.* (2014) reported that application of Nile compost (manufactured from recycling agricultural residues only) @ 7.5 t ha^{-1} increased the onion bulb yield than other treatments.

Moradi (2015) reported that the application of sheep manure (5 t ha^{-1}) increased fresh weight, dry weight, plant volume, bulb diameter, bulb height and plant height as compared to control in an experiment carried out at Payame Noor University, Iran.

Jayathilake *et al.* (2006) reported that application of Azospirillum in combination with vermicompost and chemical fertilizers recorded significantly higher bulb yield (42.0 t ha^{-1}) which was at par with the bulb yield (40.7 t ha^{-1}) recorded with Azotobacter in the same combination of fertilizers. The available N in soil was increased with integrated use of organic, inorganic and biofertilizers. Maximum yield (267.86 kg ha^{-1}) was obtained with the application of Azospirillum in combination with vermicompost and chemical fertilizers which was at par with Azotobacter in the same combination.

Singh and Pandey (2006) indicated that combined use of FYM, fertilizers and bio fertilizers (75 % NPK + 10 t FYM ha^{-1} + Azotobactor) would be the optimum INM practice for nutrient uptake.

A field experiment was conducted by Singh *et al.* (2008) in Uttar Pradesh, India, during 1998-99 and 1999-2000 winter seasons to determine the effect of integration of different doses of chemical fertilizers with organic manure (FYM) on bulb production of onion cv. N-53. The highest bulb yield (34.70 t ha^{-1}) and dry matter yield (5.46 t ha^{-1}) were obtained with 100 % NPK + 10 t FYM ha^{-1}. The uptake of N, P and K was highest under 100 % NPK + FYM @10 t ha^{-1}. The available N, P, K, S and Zn status of the soil decreased significantly in the control.

An experiment was carried out by Nandal and Bedi (2010) on onion *(Allium cepa* L.) var. N-53 at CSK HPKV, HAREC, Dhaulakuan in the years 2007 and 2008.

There were eight treatments consisting of FYM + recommended fertilizers, vermicompost + recommended fertilizer, recommended FYM, recommended vermicompost, recommended fertilizers, FYM + 50 % NPK, vermicompost + 50 % NPK and control where neither FYM nor fertilizer was applied. The highest mean bulb yield of two years (108.1 q ha^{-1}) was recorded with vermicompost + fertilizers (recommended) and the mean splitting and bolting in onion bulbs were recorded 1.2 % and 2.6 % respectively, in recommended vermicompost.

Khang *et al.* (2011) observed that application of 100 per cent organic nutrient source through FYM, vermicompost, neem seed cake, Azotobacter, PSB and trap crop gave the maximum yield of onion and also improved the fertility status of soil more than control and 100 per cent NPK recommended dose.

Application of 10 t vermicompost ha^{-1} + 120 kg N ha^{-1} recorded significantly higher fresh bulb yield (24.45 t ha^{-1}) at harvest and also the highest total N content in soil at the end of onion- radish cropping sequence (Reddy *et al.* 2011).

A field experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka by Sultana *et al.* (2012) during the kharif season of 2007 in which urea, cowdung (CD) and vermicompost (VC) were combined in a way to supply N @ 120 kg ha^{-1}. The results indicated that maximum bulb yield (12.16 t ha^{-1}) and stover yield (5.46 t ha^{-1}) of summer onion were obtained in treatment receiving 80 kg N ha^{-1} from urea with 40 kg N ha^{-1} substituted by cowdung followed by the treatment receiving 80 kg N ha^{-1} from urea with 40 kg N ha^{-1} substituted by VC.

Mandal *et al.* (2013) observed that application of 50 % VC + 50 % NPK recorded maximum plant height, neck diameter, bulb polar and equatorial diameter, whole plant weight and average bulb weight. Application of organic inputs in combination with chemical fertilizer were found better option than application of organic manure or chemical fertilizer alone. Maximum (15.01 °B) total soluble solids was registered for 100 % VC treated plots.

Shinde *et al.* (2013) noted that the application of NPK S (110:40:60:40) + FYM (7.5 t) + Poultry manure (2.5 t) + Vermicompost (2.5 t) + Biofertilizer (5 kg each of Azospirillum + Phosphobacteria) ha^{-1} progressively increased the bulb yield as well as total nutrient uptake in onion.

Brinjh *et al.* (2014) reported that maximum plant height (73.33 cm) was recorded under the RDF 75 % + Vermicompost 25 % while length of leaves (64 cm), number of leaves (13.33), neck thickness (1.69 cm) and number of scales were found in RDF 75 % + Azotobacter 25 %. Whereas, diameter of bulb (7. 67 cm), bulb length (6. 80 cm) and yield (42.33 t ha^{-1}) were observed in RDF 75 % + Phosphobacteria 25 % and all the growth and yield parameters were recorded minimum under control. The quality parameters in respect of TSS (14°B) and dry weight of leaves (2.17 g) were found maximum under the RDF 75 % + Azotobacter 25 % and minimum under control and Azotobacter 100 % for better quality parameters, respectively.

Rabari *et al.* (2014) revealed that maximum plant height, leaf length, number of leaves per plant, leaf dry weight and yield attributes like bulb weight, bulb volume and bulb yield were obtained under combination of 75 % RDF + Vermicompost @ 1.25 t ha^{-1}. Higher phosphorous and potassium content was obtained in treatment combination of 50 % RDF + vermicompost 2.5 t ha^{-1}.

Meena *et al.* (2015) showed that growth attributes, TSS and nitrogen content in bulb increased significantly with the combined application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}. While phosphorus and sulphur content of bulb significantly increased with application of FYM @ 5 t ha^{-1} + poultry manure @ 2.5 t ha^{-1}. Bulb inoculation with Azospirillium + PSB significantly increased both growth and quality attributes over other treatments.

2.2 Effect of earthing up

Ali *et al*. (2007) conducted a field experiment during the period from October 2001 to April 2002 to study the effect of earthing up and level of irrigation on yield and quality seed production of onion (cv. Taherpuri) at Rajshahi University campus, Rajshahi, Bangladesh. Two different factors were considered, factor (A): Earthing up (E1), without earthing up (E_0) and factor (B): irrigation level (5 levels) *viz*. irrigation start at 1st time and when required (I_4), irrigation start at 40 DAP and when required (I_3), irrigation start at 60 DAP and when required (I_2), irrigation start at 80 DAP and when required (I_1), no irrigation or control (I_0). The result revealed that bulb emergence, plant height, number of leaves, length of scape, tillers, bulb yield, seeded fruits, fruits set, days to blooming, seed yield, 1000-seed weight and germination percentage were significantly influenced by different treatments. The highest seed yield (405.97 kg/ha) was found from earthing up with irrigation start at first time and when required (E_1I_4) followed by E_1I_3 (347.37 kg/ha), E_0I_4 (330.73 kg/ha) compared with other treatments. The results suggested that earthing up with 3-4 times irrigation is more effective for onion seed production in Bangladesh.

Faisal *et al*. (2009) carried out an investigation at Agricultural Research Station, Pahartali, Chittagong during February to August 2002 to select suitable size of planting material and proper time of earthing-up to obtain higher yield of Mukhi Kachu. Three planting materials, primary corm (40g), half cut corm (20g), and secondary corm (10g) and four times of earthing-up, 1 month, 2 months, 3 months, and 4 months after planting were used. Different planting materials showed significant difference on weight of total corms/plot, weight of total cormels/plot and cormel yield. Different times of earthing-up showed significant effects on the parameters studied except no. of cormels/hill and weight of cormels/hill. The highest (3.71 t/ha) corm yield was obtained when primary corms were planted and earthing-up was done three months after planting. The combination of P1E (primary corm × 3 months after planting) gave the highest (8.37 t/ha) cormel yield.

Gutema (2016) conducted the experiment for three consecutive years with the objective of determining the effects of the tuber seed size and hilling up frequencies on yield and yield traits of Potato. Two seed forms (half and full seed size) and four level of hilling up including the control were combined in factorial arrangements and conducted using split plot design, tuber form was considered as main plot while hilling up frequency as sub-plot. The result of the study revealed that the highest total tuber yield was obtained from three times hilling up frequency followed by two times, but both means are statistically similar. Three and two times hilling up frequency had significantly increased total tuber yield by 24.7% and 15.5% over the control, respectively. On the other hand, the yield increase of marketable and total tuber yield were 20% and 33%, respectively when full sized seed form was used as compared to half sized one. Interaction effect also indicated that, planting of full sized tuber seed with three times hilling showed the highest marketable and total tuber yield and followed by use of full sized with two times earthing up practices, but both are at par. From economic point of view, uses of full sized seed with three times hilling up frequencies resulted in the highest net benefit and marginal rate of return followed by the two times hilling up frequencies. Thus, farmers can get more income when they practice three times hilling up in combination with uses of full sized tuber seed though they invest more extra cost as compared to two times hilling up. However, full sized seed planting and with two times hilling up of potato could also be profitable in areas where the soil is less compacted or more loamy types and/or for some farmers who may not afford extra investment cost for three times hilling up frequency.

CHAPTER III

MATERIALS AND METHODS

Chapter III

MATERIALS AND METHODS

The present research work was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October, 2017 to March, 2018. Brief descriptions of soil, climate, materials and methods that are used in carrying out the experiment have been presented in this chapter.

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at $90^{o}22'$ E longitude and $23°41'$ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28.The experimental site is presented in (Appendix I).

3.2 Climatic condition

The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September). Details of weather data in respect of temperature (^{0}C), rainfall (mm) and relative humidity (%) for the study period was collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 (Appendix II).

3.3 Soil condition

The soil of experimental area situated to the Modhupur (UNDP, 1988) Tract under the AEZ no. 28 and Tejgoan soil series (FAO, 2012). The soil was sandy loam in texture with pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in (Appendix III).

3.4 Planting material used for the experiment

Seeds of onion cultivar namely "Taherpuri" was used for the experiment. The seeds were collected from Sidique Bazar, Dhaka.

3.5 Treatments of the experiment

The experiment consists of two factors which are given bellow:

Factor A: Vermicompost – 4 levels

1) V_0 = No application of vermicompost (Control)
2) V_1 = 6 t ha^{-1} vermicompost
3) V_2 = 10 t ha^{-1} vermicompost
4) V_3 = 14 t ha^{-1} vermicompost

Factor B: Earthing up – 3 levels

1) E_0 = No earthing up
2) E_1 = Two times earthing up (25 & 50 DAT)
3) E_2 = Three times earthing up (25, 50 & 75 DAT)

Therefore the treatment combinations were given below:

V_0E_0, V_0E_1, V_0E_2, V_1E_0, V_1E_1, V_1E_2, V_2E_0, V_2E_1, V_2E_2, V_3E_0, V_3E_1, V_3E_2.

3.6 Design of the experiments

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

3.7 Layout of the field experiment

The experimental area was first divided into three blocks. Each block was divided into 12 plots for the treatment combinations. The total number of plots was 36. Thereafter, 12 treatment combinations were assigned to each block as per design of the experiment. The size of the unit plot was 1.2 m ×0 .9 m. A distance of 20 cm between the rows and 15 cm between the plants were kept in each unit plot.

The distance maintained between two plots was 0.5 m and between blocks was 0.75 m. The layout of experiment field is presented in Fig. 1.

3.8 Details of the field operations

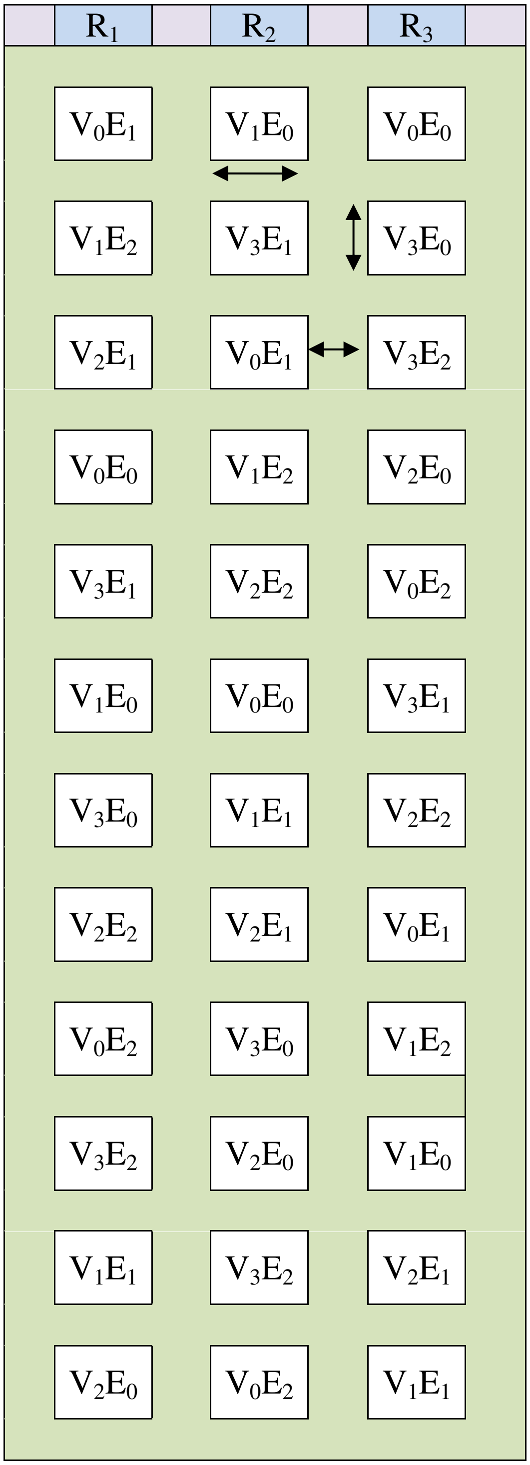
The particulars of the cultural operations carried out during the experiment are presented below:

3.8.1 Seedbed preparation

The land which was selected for raising seedlings was fine textured and well drained. The land was opened and drying for 10 days. Seedbed was made on 10 October, 2017 for raising seedlings and the size of the seedbed was 3 m with a height of about 20 cm. For making seedbed, the soil was well ploughed and converted into loose friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Applying Furadan 3G @ 20 kg/ha was covered by polythene for two days. Onion seeds were soaked overnight (12 hours) in water and allowed to sprout in a piece of moist cloth keeping in the sun shade for one day.

3.8.2 Seed treatment and sowing

Seeds were treated by Vitavax-200 @ 5g/1kg seeds to protect some seed borne diseases. The date of the seed sowing was 20 October, 2017. Seeds were sown on in the seedbed to get 35 days old seedlings. Seeds was sown at a depth of 0.6 cm and covered with a fine layer of soil followed by light watering by water can. The young seedlings were exposed to dew by night and mild sunshine in the morning and evening. Shade was given over the seedbed to retain soil moisture and to save the seedlings from direct sun and rain.



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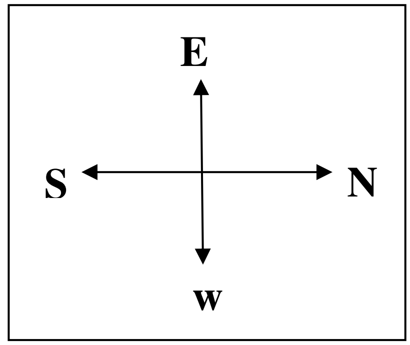

Treatments

Factor A: Vermicompost – 4 levels

1) V_0 = Control
2) V_1 = 6 t ha^{-1} vermicompost
3) V_2 = 10 t ha^{-1} vermicompost
4) V_3 = 14 t ha^{-1} vermicompost

Factor B: Earthing up – 3 levels

1) E_0 = Control
2) E_1 = Two times earthing up
3) E_2 = Three times earthing up

Fig. 1. Layout of the experiment field

3.8.3 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. When the seedlings of the seedbeds attained a height of about 10 cm, thinning operation was done. Healthy and 35 days old seedlings were transplanted into the main field on 25 November, 2017.

3.8.4 Land preparation

The experimental area was first opened on 18 November, 2017 by a disc plough in direct sunshine to kill soil borne pathogens and soil inhabitant insects. Then the land was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crops residues and stables were removed from the field. The basal dose of manures and fertilizers was applied at the finally ploughing. According to design and layout the plots was prepared. The soil was treated by Sevin 50 WP @ 5 kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm.

3.8.5 Manures and fertilizers

BARI recommendation doses of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) are 200 Kg ha-1, 125Kg ha-1, and MP-180 Kg ha-1 respectively for onion production. But in the present study, no chemical fertilizer was used. Only vermicompost were applied in experiment field according to the treatment assigned under the present study. vermicompost with available amount of nutrient: N (1.5-2%), P_2O_5 (0.5-1.5%), K_2O (0.5-1%).

Table 1. Nutrient recommendation (kg/ha) for onion.

<table>
<tr><th>Soil analysis interpretation</th><th>N</th><th>P</th><th>K</th><th>Cow dung (t/ha)</th></tr>
<tr><td>Optimum</td><td>0-30</td><td>0-15</td><td>0-40</td><td rowspan="4">5</td></tr>
<tr><td>Medium</td><td>31-60</td><td>16-30</td><td>11-20</td></tr>
<tr><td>Low</td><td>61-90</td><td>31-45</td><td>21-30</td></tr>
<tr><td>Very low</td><td>91-120</td><td>46-60</td><td>31-40</td></tr>
</table>

Source: Fertilizer recommendation guide 2012 (BARI).

3.8.6 Transplanting of seedlings

Healthy and disease free uniform sized 35 days old seedlings was uprooted from the seedbeds and transplanted to the main field on 25 November, 2017 as per treatment after a slight trimming of leaves and roots of healthy seedlings and maintaining a spacing of 30 cm × 15 cm. The seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting. Some seedlings were also transplanted adjacent to the experimental area to be used for gap fillings.

3.8.7 Intercultural operations

After transplanting of seedlings, intercultural operations were done whenever required for getting better growth and development of the plants. So, the crop was always kept under careful observation.

3.8.7.1 Gap filling

Required gap filling were done by using healthy plants from the excess plants within one week. Damaged/ dead seedlings were removed.

3.8.7.2 Weeding

Weeding was done three to four times after transplanting to keep the crop free from weeds.

3.8.7.3 Earthing up

Earthing up was provided by breaking the crust of the soil and piling soil up around the base of a plant for easy aeration, to conserve soil moisture and temperature, improving germination and emergence, high yield and quality, prolonged growing season higher nutritive value of the produce, improved storability etc. are also well described advantages of earthing up, therefore, aids in reducing cost involved in crop production with irrigation. This would also improve the seed quality of onion.

3.8.7.4 Irrigation and drainage

Irrigation was given by a watering cane and or hose pump when needed. First irrigation was given just after transplanting. During this time, care was taken so that irrigated water could not pass from one plot to another. Mulching was also done after irrigation at appropriate time by breaking the soil crust. During irrigation, the soil was made saturated with water. After rainfall excess water was drained out when necessary.

3.8.7.5 Plant protection

Preventive measure was taken against soil borne insects. Furadan 3G @ 20 kg/ha was applied for the prevention of cutworm. After pesticide application no insect infestation was found in the field. Few days after transplanting some plants were attacked by purple blotch disease caused by Alternaria porri. It is controlled by spraying Ruvral 50 WP @ 2 g/ L of water at 7 days interval.

3.8.8 Harvesting

The crop was harvested on 28 March, 2018 to their completion of maturity showing the sign of drying up most of the leaves and collapsing of neck. Onions were lifted with the help of hand and care was taken so that no bulb was injured during lifting. After harvesting the tops were removed by cutting off the pseudo stem and keeping 2.5 cm with the bulb.

3.8.9 Storage of bulbs

The bulbs of each harvest were dried in shade in the field for one day with tops. After harvesting tops were separated in the following day leaving 2 cm neck. Curing of bulbs was done in a room at ambient temperature (29.6 ±2.60C) for 7 days and then stored in a well-ventilated room.

3.9 Collection of data

Data were collected on the following parameters

A. Growth parameters

1) Plant height (cm)
2) Number of leaves plant^{-1}

B. Yield contributing parameters

1) Root length (cm)
2) Bulb length (cm)
3) Bulb diameter (cm)
4) Neck diameter (cm)
5) Fresh weight bulb^{-1} (g)
6) Dry matter of bulb (%)

C. Yield parameters

1) Yield plot^{-1} (g)
2) Yield ha^{-1} (t)

3.10 Procedure of recording data

3.10.1 Plant height (cm)

The height of the randomly selected ten plants was measured of each plot after 30 days of transplanting to at 60 DAT with 15 days interval. The height was measured in centimeter (cm) from the ground level to the tip of the longest leaf and average height of ten plants was calculated in centimeter.

3.10.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} was calculated from randomly selected ten plants from each replication and mean was recorded. Number of leaves plant^{-1} was measured from each unit plot after 30 to 60 DAT with 15 days interval.

3.10.3 Root length (cm)

The length of root was measured from each plot of 10 randomly selected plants at the time of harvest. The length was measured in centimeter (cm) and average root length was calculated in centimeter.

3.10.4 Bulb length (cm)

After harvesting the length of bulb was measured with a scale from the neck to the bottom of the bulb of ten randomly selected plants from each plot and their average was taken in centimeter.

3.10.5 Bulb diameter (cm)

After harvesting the diameter of bulb was measured at the middle portion of ten randomly selected plants with the help of slide caliper from each plot and their mean value was taken in centimeter.

3.10.6 Neck diameter (cm)

Neck diameter was measured at the neck of ten randomly selected plants with a slide caliper after harvesting and average mean was calculated and expressed in centimeter.

3.10.7 Fresh weight bulb^{-1} (g)

To determine the weight of individual bulb from ten randomly selected plants by an electric balance. After removing the top portion of the bulb keeping only 2.5 cm with neck, the bulb weight of plants was taken and means value was calculated.

3.10.8 Dry matter of bulb (%)

To determine the dry matter content of bulbs, 100 g of bulb was randomly collected from harvested bulb of each plot. The bulbs were sliced with a sharp knife. The fresh sample was dried under sunlight scorching and kept in an oven at 70°C for 72 hours until constant weight. Finally dry matter of bulb was taken with an electric balance and dry matter percentage was calculated by the following formula.

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of bulb}}{\text{Fresh weight of bulb}} \times 100$$

3.10.9 Bulb yield plot^{-1} (g)

All bulbs were collected from each replication of each treatment combination. Bulb weight per plot was measured by an electric balance and then average was expressed as bulb yield per plot in kilogram (kg).

3.10.10 Bulb yield ha^{-1} (t)

Plot yield of harvested fresh bulb was converted to per hectare yield and it was expressed in ton (t).

3.11 Statistical analysis

The collected data on various parameters under study were statistically analyzed using MSTAT-C computer package programme. The means for all the treatments were calculated and analysis of variance for all the characters was performed by the F- variance test (Gomez and Gomez, 1984). Significance of difference between means was evaluated by Least Significance Difference (LSD) and the probability level 5% and 1% for the interpretation of results.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results of the effect of vermicompost and earthing up of onion and their combined effects on the growth and yield of onion have been presented and discussed in this chapter. The analysis of variance of data on different characteristics obtained from the present investigations has been presented in Appendix IV - VII. The results and possible interpretations of the results have been given under the following headlines.

4.1 Growth parameters

4.1.1 Plant height (cm)

There was a significant variation on plant height of onion influenced by different levels of vermicompost application at different growth stages (Fig. 2 and Appendix IV). Results revealed that the highest plant height (53.80 cm) at 60 DAT was found from the treatment V_3 (14 t ha^{-1} vermicompost) which was significantly different from all other treatments followed by V_2 (10 t ha^{-1} vermicompost) treatment. The lowest plant height (43.60 cm) at 60 DAT was found from the treatment V_0 (control). Similar result was also observed by Reddy and Reddy (2005), Anburani and Gayathiri (2009) and Kaswan *et al.* (2013). Reddy and Reddy (2005) found that the plant height increased significantly with increasing levels of vermicompost from 10 to 30 t ha^{-1}.

Plant height at different growth stages was significantly influenced by earthing up of onion (Fig. 3 and Appendix IV). At 60 DAT the highest plant height (50.52 cm) at was found from the E_2 (three times earthing up) treatment which was statistically identical with E_1 (two times earthing up) treatment where the lowest plant height (47.0 cm) was found from the treatment E_0 (control). Similar result was also observed by Ali *et al.* (2007) which supported the present study.

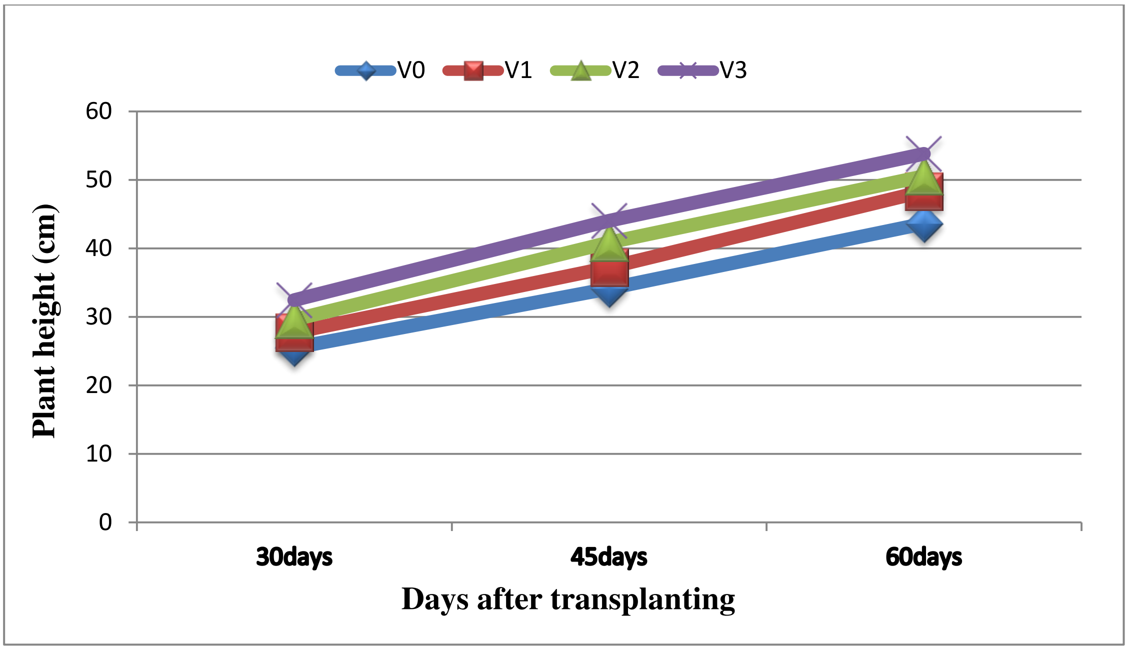

Fig. 2. Effect of vermicompost on plant height at different days after transplanting of onion

Here, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

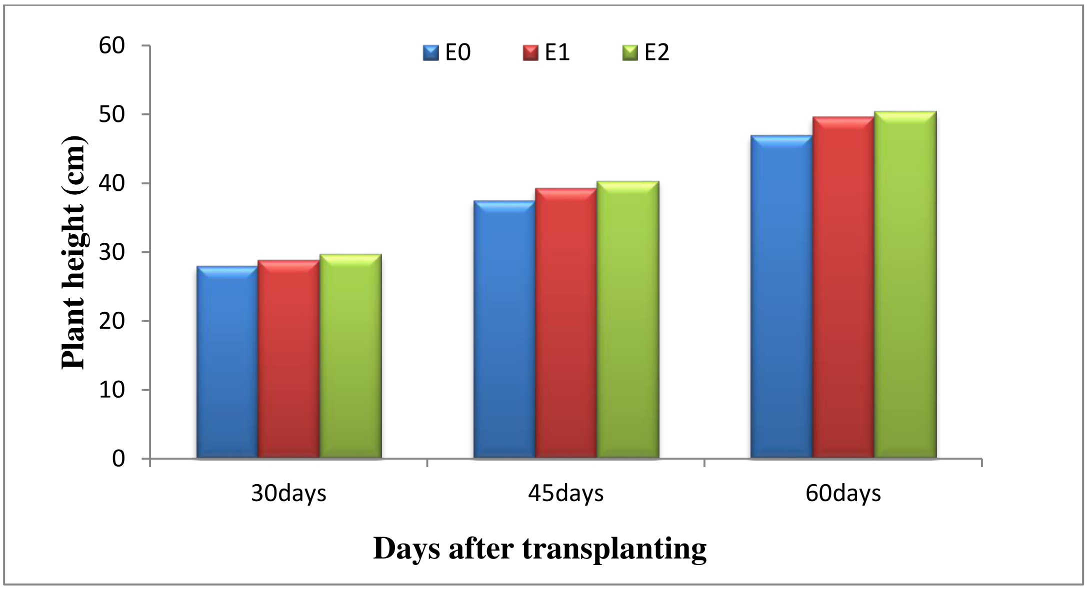

Fig. 3. Effect of earthing up on plant height at different days after transplanting of onion

Here, E_0 = Control, E_1 = two times earthing up, E_2 = three times earthing up.

Table 2. Combined effect of vermicompost and earthing up on plant height at different days after transplanting of onion

Treatments	Plant height (cm)		
	30 DAT	45 DAT	60 DAT
V_0E_0	24.20 j	32.33 i	39.00 g
V_0E_1	25.67 i	34.73 h	45.60 f
V_0E_2	26.67 hi	35.33 h	46.20 ef
V_1E_0	27.40 gh	36.07 gh	47.27 d-f
V_1E_1	27.73 gh	37.33 fg	48.67 c-f
V_1E_2	28.13 fg	38.20 ef	49.00 c-f
V_2E_0	28.93 ef	39.33 de	49.73 c-e
V_2E_1	29.67 de	41.20 cd	50.27 b-d
V_2E_2	30.27 cd	42.07 bc	51.53 a-c
V_3E_0	31.27 bc	42.40 bc	52.00 a-c
V_3E_1	32.33 b	43.87 b	54.07 ab
V_3E_2	33.80 a	45.87 a	55.33 a
CV %	8.62	7.54	5.67
$LSD_{(0.05)}$	1.08	1.00	3.96

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

E_0 = Control, E_1 = two times earthing up, E_2 = three times earthing up

Significant variation was observed on plant height at different growth stages influenced by combined effect of vermicompost and earthing up of onion (Table 1 and Appendix IV) at the 60 DAT highest plant height (55.33 cm) was found from the V_3E_2 (treatment combination) which was statistically similar to V_2E_2, V_3E_0 and V_3E_1 treatment combination and the lowest plant height (39.00 cm) was found from the V_0E_0 (control) treatment combination.

4.1.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} at different growth stages was significantly varied due to different levels of vermicompost application (Fig. 4 and Appendix V). At 60 DAT the highest number of leaves plant^{-1} (7.09) was found from the treatment V_3 (14 t ha^{-1} vermicompost) and the lowest number of leaves plant^{-1} (5.56) was found from the V_0 (control) treatment. Similar result was also observed by Reddy and Reddy (2005) and Kaswan *et al.* (2013). Reddy and Reddy (2005) found that number of leaves per plant increased significantly with increasing levels of vermicompost from 10 to 30 t ha^{-1}.

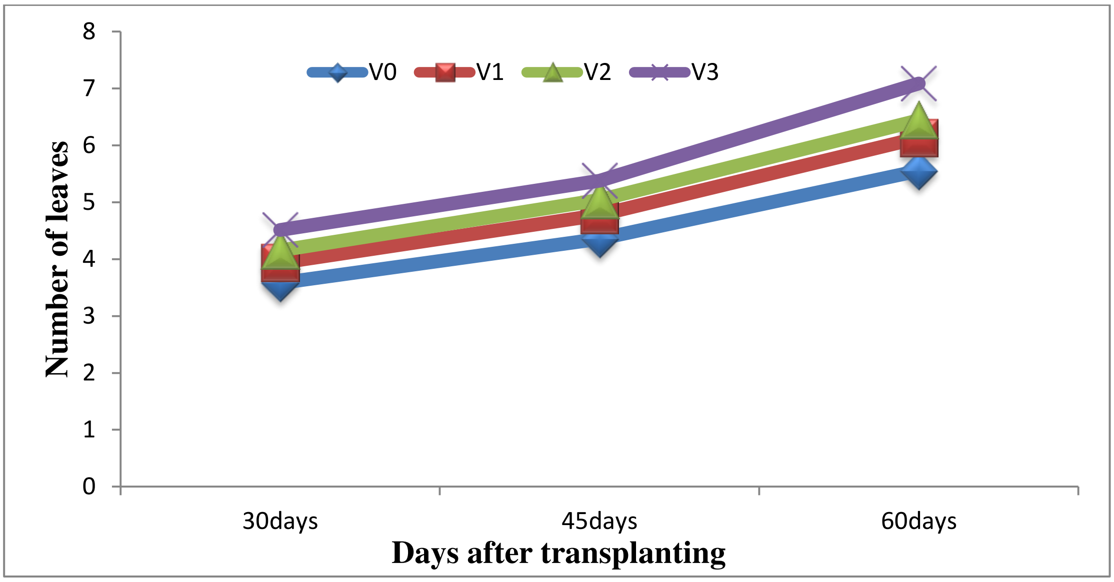

Fig. 4. Effect of vermicompost on number of leaves $plant^{-1}$ at different days after transplanting of onion

Here, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

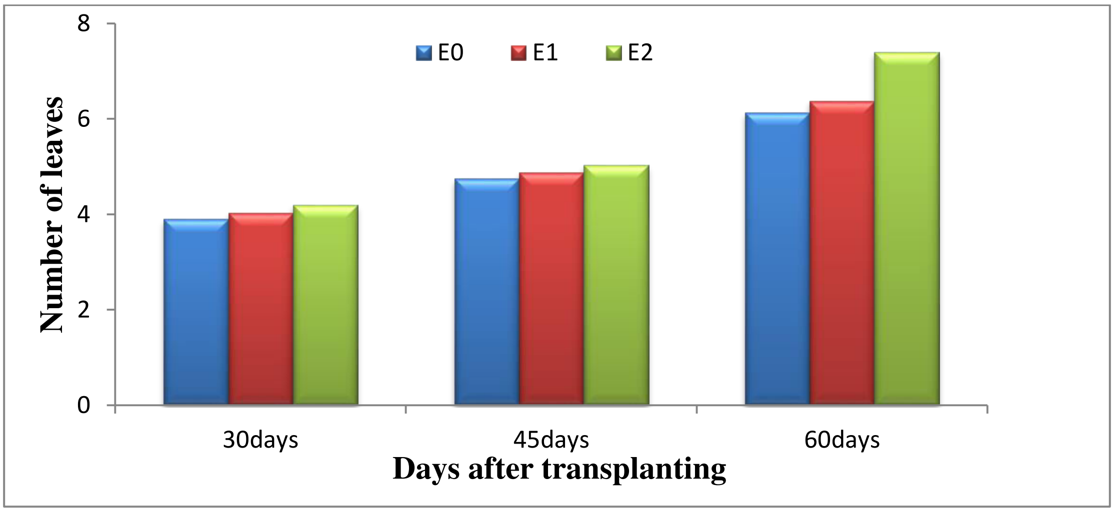

Fig. 5. Effect of earthing up on number of leaves $plant^{-1}$ at different days after transplanting of onion

Here, E_0 = Control, E_1 = two times earthing up, E_2 = three times earthing up

Remarkable variation was observed on number of leaves plant^{-1} at different growth stages influenced by earthing up of onion (Fig. 5 and Appendix V). At the 60 DAT the highest number of leaves plant^{-1} (7.40) was found from the treatment E_2 (Three times earthing up) treatment and the lowest number of leaves plant^{-1} (6.13) was found from the E_0 (control) treatment which was statistically identical with E_1 (Two times earthing up) treatment at all growth stages. The result obtained from the present study was similar with the findings of Ali *et al*. (2007).

Table 3. Combined effect of vermicompost and earthing up on number of leaves plant^{-1} at different days after transplanting of onion.

Treatments	30 DAT	45 DAT	60 DAT
V_0E_0	3.33 e	4.13 h	5.27 f
V_0E_1	3.67 de	4.40 g	5.60 ef
V_0E_2	3.73 c-e	4.53 fg	5.80 d-f
V_1E_0	3.80 b-e	4.67 ef	5.93 de
V_1E_1	3.93 b-e	4.80 de	6.20 c-e
V_1E_2	4.07 b-d	4.87 de	6.27 cd
V_2E_0	4.13 b-d	4.93 d	6.40 b-d
V_2E_1	4.13 b-d	5.00 cd	6.67 a-c
V_2E_2	4.20 a-d	5.20 bc	6.27 cd
V_3E_0	4.33 a-c	5.27 b	6.93 ab
V_3E_1	4.40 ab	5.33 ab	7.07 a
V_3E_2	4.80 a	5.53 a	7.27 a
CV %	7.45	8.62	9.97
$LSD_{(0.05)}$	0.61	0.22	0.63

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up

Significant influence was noted on number of leaves plant^{-1} affected by combined effect of vermicompost and earthing up of onion (Table 2 and Appendix V). At the 60 DAT highest number of leaves plant^{-1} (7.27) was found from the V_3E_2 (application of 14 t ha^{-1} vermicompost and three times earthing up) which was statistically identical to V_3E_1 and statistically similar with V_3E_0

and V_2E_1 (Treatment combination).The lowest number of leaves plant^{-1} (5.27) at 60 DAT was found from the V_0E_0 (combination of control) which was statistically similar with the treatment combination of V_0E_1 at 60 DAT.

4.2 Yield contributing parameters

4.2.1 Root length (cm)

Root length of onion varied significantly due to different levels of vermicompost application (Table 4 and Appendix VI). It was found that the highest root length (7.59 cm) was found from the V_3 (14 t ha^{-1} vermicompost) treatment while the lowest root length (5.04 cm) was found from the treatment V_0 (control) treatment.

Significant variation was remarked as influenced by earthing up of onion (Table 4 and Appendix VI). Results indicated that the highest root length (6.32cm) was found from the E_2 (Three times earthing up) treatment, which was statistically similar with E_1 (Two times earthing up) treatment where the lowest root length (5.86 cm) was found from the E_0 (control) treatment, which was statistically similar to E_1 treatment.

Root length was significantly influenced by combined effect of vermicompost and earthing up of onion (Table 5 and Appendix VI). The highest root length (7.97 cm) was found from the V_3E_2 (treatment combination) which was statistically similar with the V_3E_1 (treatment combination). The lowest root length (4.89 cm) was found from the V_0E_0 (control) treatment combination, which was statistically identical with the treatment combination of V_0E_1 and statistically similar with V_0E_2, V_1E_0 and V_1E_1.

4.2.2 Bulb length (cm)

Variation on bulb length was significantly influenced by different levels of vermicompost application (Table 4 and Appendix VI). The highest bulb length (3.15 cm) was found from the treatment V_3 (14 t ha^{-1} vermicompost) which was significantly different from all other treatments. The lowest bulb length (2.51 cm) was found from the treatment V_0 (control; 0 t ha^{-1} vermicompost) which was also significantly different from all other treatments. The result obtained from the present study was similar with the findings of Zedan (2011) and Gopakkali and Sharanappa (2014).

Bulb length was significantly affected by earthing up of onion (Table 4 and Appendix VI). The highest bulb length (2.95 cm) was found from the treatment E_2 (Three times earthing up) which was significantly different from all other treatments and the lowest bulb length (2.76 cm) was found from the treatment E_0 (control) which was statistically identical with the treatment E_1 (Two times earthing up).

The recorded data on bulb length was significantly influenced by combined effect of vermicompost and earthing up of onion (Table 5 and Appendix VI). The highest bulb length (3.35 cm) was found from the V_3E_2 (treatment combination), which was significantly different from all other treatment combinations followed by V_3E_1. The lowest bulb length (2.46 cm) was found from the V_0E_0 (control) treatment combination, which was statistically similar with the treatment combination of V_0E_1 and $V_0E_{2.}$

4.2.3 Bulb diameter (cm)

Considerable influenced was observed on bulb diameter persuaded by different levels of vermicompost application (Table 4 and Appendix VI). The highest bulb diameter (4.38 cm) was found from the treatment V_3 (8 t ha^{-1}

vermicompost) which was significantly different from all other treatments. The lowest bulb diameter (3.42 cm) was found from the treatment V_0 (control; 0 t ha^{-1} vermicompost). Similar result was also observed by Kaswan *et al.* (2013) and Moradi (2015).

Remarkable variation was identified on bulb diameter due to the effect of earthing up of onion (Table 4 and Appendix VI). The highest bulb diameter (4.04 cm) was found from the treatment E_2 (Three times earthing up), which was statistically similar with the treatment E_1 (Two times earthing up). The lowest bulb diameter (3.79 cm) was found from the treatment E_0 (control).

Bulb diameter was significantly influenced by combined effect of vermicompost and earthing up of onion (Table 5 and Appendix VI). The highest bulb diameter (4.55 cm) was found from the treatment combination V_3E_2 which was statistically similar with the treatment combination V_3E_1. The lowest bulb diameter (3.22 cm) was found from the V_0E_0 (control) treatment combination, which was statistically identical with the treatment combination of V_0E_1(3.35cm).

4.2.4 Neck diameter (cm)

Neck diameter was varied significantly due to different levels of vermicompost application (Table 4 and Appendix VI). The highest neck diameter (1.26 cm) was found from the treatment V_3 (14 t ha^{-1} vermicompost) treatment which was significantly different from all other treatments. The lowest neck diameter (0.89 cm) was found from the treatment V_0 (control) which was also significantly different from all other treatments followed by V_1 (6 t ha^{-1} vermicompost). The result obtained from the present study was similar with the findings of Mandal *et al.* (2013).

Significant variation was remarked on neck diameter as influenced by earthing up of onion (Table 4 and Appendix VI). The highest neck diameter (1.13 cm) was found from the treatment E_2 (three times earthing up) which was significantly different from all other treatments where the lowest neck diameter (0.99 cm) was found from the treatment E_0 (control) which was statistically identical with treatment E_1 (two times earthing up).

Neck diameter of onion was significantly influenced by combined effect of vermicompost and earthing up (Table 5 and Appendix VI). The highest neck diameter (1.45 cm) was found from the treatment combination V_3E_2, which was significantly different from all other treatment combinations. The lowest neck diameter (0.83 cm) was found from the V_0E_0 (control) treatment combination ,which was statistically similar to V_0E_1 treatment combination (0.91 cm).

4.2.5 Fresh weight bulb^{-1} (g)

Variation on fresh weight bulb^{-1} was significantly influenced by different levels of vermicompost application (Table 4 and Appendix VI). The highest fresh weight bulb^{-1} (40.07 g) was found from the treatment where 14 t vermicompost was applied ha^{-1} V_3. The lowest fresh weight bulb^{-1} (22.07 g) was found from the treatment V_0 (control) which was significantly different from all other treatments. Similar result was also observed by Dhaker *et al*. (2017) and Ansari (2008) which supported the present study.

Fresh weight bulb^{-1} was affected significantly by earthing up of onion (Table 4 and Appendix VI). The highest fresh weight bulb^{-1} (32.48 g) was found from the treatment E_2 (three times earthing up), which was statistically similar with treatment E_1 (two times earthing up) treatment. The lowest fresh weight bulb^{-1}

(28.47 g) was found from the tretment E_0 (control) which was statistically similar to E_1 (Two times earthing up) treatment. Similar result was also observed by Ali *et al*. (2007) which supported the present study.

The recorded data on neck diameter was significantly influenced by the combined effect of vermicompost and earthing up of onion (Table 5 and Appendix VI). The highest fresh weight bulb^{-1} (42.73 g) was found from the treatment combination V_3E_2, which was statistically similar with V_3E_1 where the lowest fresh weight bulb^{-1} (19.07 g) was found from the treatment combination of V_0E_0 (control) which was statistically similar to V_0E_1 treatment combination.

Table 4. Effect of vermicompost and earthing up on yield contributing parameters of onion

Treatments	Yield contributing parameters					
	Root length (cm)	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Fresh weight bulb^{-1} (g)	Dry matter of bulb (%)
Effect of vermicompost						
V_0	5.04 d	2.51 d	3.42 d	0.89 d	22.07 d	12.32 d
V_1	5.54 c	2.74 c	3.83 c	0.99 c	28.58 c	16.07 c
V_2	6.24 b	2.94 b	4.03 b	1.08 b	31.84 b	18.73 b
V_3	7.59 a	3.15 a	4.38 a	1.26 a	40.07 a	19.39 a
CV %	10.42	11.68	10.58	9.37	10.66	9.56
LSD $_{(0.05)}$	0.35	0.09	0.15	0.06	2.88	0.43
Effect of earthing up						
E_0	5.86 b	2.76 b	3.79 b	0.99 b	28.47 b	15.97 c
E_1	6.12 ab	2.81 b	3.91 ab	1.04 b	30.97 ab	16.59 b
E_2	6.32 a	2.95 a	4.04 a	1.13 a	32.48 a	17.32 a
CV %	10.42	11.68	10.58	9.37	10.66	9.56
LSD $_{(0.05)}$	0.30	0.08	0.13	0.05	2.50	0.37

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost; E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up

4.2.6 Dry matter of bulb (%)

Considerable influenced was observed on dry matter (%) of bulb persuaded by different levels of vermicompost application (Table 4 and Appendix VI). The highest dry matter (%) of bulb (19.39 %) was found from the treatment V_3 (14 t ha^{-1} vermicompost), which was significantly different from all other treatments. The lowest dry matter (%) of bulb (12.32 %) was found from the V_0 (control) treatment. Similar result was also found by Degwale (2016) which supported the present study.

Table 5. Combined effect of vermicompost and earthing up on yield contributing parameters of onion

Treatments	Yield contributing parameters					
	Root length (cm)	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Fresh weight $bulb^{-1}$ (g)	Dry matter of bulb (%)
V_0E_0	4.89 g	2.46 i	3.22 g	0.83 h	19.07 h	11.50 g
V_0E_1	5.01 g	2.50 hi	3.35 g	0.91 gh	22.27 gh	12.37 f
V_0E_2	5.21 fg	2.57 ghi	3.69 f	0.95 fg	24.87 fg	13.08 f
V_1E_0	5.39 fg	2.67 fgh	3.77 ef	0.96 efg	27.53 ef	14.71 e
V_1E_1	5.50 efg	2.73 efg	3.86 def	0.99 defg	28.80 def	15.99 d
V_1E_2	5.73 def	2.83 def	3.87 def	1.03 cdef	29.40 def	17.50 c
V_2E_0	6.08 cde	2.88 cde	3.97 cde	1.07 cde	30.93 de	18.70 b
V_2E_1	6.26 cd	2.92 bcd	4.05 cd	1.08 bcd	31.67 cde	18.71 b
V_2E_2	6.39 c	3.02 bc	4.06 cd	1.10 bcd	32.93 cd	18.78 b
V_3E_0	7.09 b	3.03 bc	4.18 bc	1.13 bc	36.33 bc	18.97 b
V_3E_1	7.70 ab	3.07 b	4.40 ab	1.19 b	41.13 ab	19.28 ab
V_3E_2	7.97a	3.35 a	4.55 a	1.45 a	42.73 a	19.92 a
CV %	10.42	11.68	10.58	9.37	10.66	9.56
$LSD_{(0.05)}$	0.61	0.17	0.26	0.11	4.98	0.75

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up

Remarkable variation was identified on dry matter (%) of bulb due to the effect of earthing up of onion (Table 4 and Appendix VI). The highest dry matter (%) of bulb (17.32 %) was found from the treatment E_2 (three times earthing up), which was significantly different from all other treatments on the other hand the lowest dry matter (%) of bulb (15.97 %) was found from the treatment E_0 (control).

Variation on dry matter (%) of bulb was significantly influenced by the combined effect of vermicompost and earthing up (Table 5 and Appendix VI). The highest dry matter (%) of bulb (19.92%) was found from the combined treatment V_3E_2, which was statistically similar to V_3E_1 (19.28%). The lowest dry matter (%) of bulb (11.50%) was found from the treatment combination V_0E_0 (control), which was significantly different from all other treatment combinations.

4.3 Yield parameters

4.3.1 Yield plot^{-1} (g)

Yield plot^{-1} varied significantly due to different levels of vermicompost application (Table 6 and Appendix VII). The highest yield plot^{-1} (527.89 g) was found from the treatment V_3 (14 t ha^{-1} vermicompost), which was significantly different from all other treatments. The lowest yield plot^{-1} (324.11 g) was found from the treatment V_0 (control) which was also significantly different from all other treatments.

Significant variation was remarked on yield plot^{-1} as influenced by earthing up of onion (Table 7 and Appendix VII). The highest yield plot^{-1} (431.67 g) was found from the treatment E_2 (three times earthing up), which was significantly different from all other treatments. The lowest yield plot^{-1} (388.0 g) was found from the Treatment E_0 (control).

Combined effect of vermicompost and earthing up of onion was significantly influenced by yield plot^{-1} (Table 7 and Appendix VII). The highest yield plot^{-1} (567.33 g) was found from the treatment combination V_3E_2, which was significantly different from all other treatment combinations. The lowest yield plot^{-1} (312.67 g) was found from the treatment combination V_0E_0 (control), which was statistically identical to V_0E_1 followed by the treatment combination V_0E_2 and V_1E_0.

4.3.2 Yield ha^{-1} (t)

Variation on yield ha^{-1} was significant influenced by different levels of vermicompost application (Table 6 and Appendix VII). Results showed that the highest yield ha^{-1} (5.39 t) was found from the treatment V_3 (14 t ha^{-1} vermicompost) which was significantly different from all other treatments. The lowest yield ha^{-1} (3.31 t) was found from the treatment V_0 (control) which was also significantly different from all other treatments. The result obtained from the present study was similar with the findings of Dhaker *et al*. (2017), Degwale (2016).

Yield ha^{-1} was significantly influenced by earthing up of onion (Table 6 and Appendix VII). The highest yield ha^{-1} (4.41 t) was found from the treatment E_2 (three times earthing up) treatment which was significantly different from all other treatments where the lowest yield ha^{-1} (3.96 t) was found from the E_0 (control) treatment. The result obtained from the present study was similar with the findings of Ali *et al*. (2007).

Table 6. Effect of vermicompost and earthing up on yield of onion

Treatments	Yield
	Yield plot^{-1} (g)
Effect of vermicompost	
V_0	324.11 d
V_1	363.67 c
V_2	424.33 b
V_3	527.89 a
CV %	12.87
LSD (0.05)	21.92
Effect of earthing up	
E_0	388.00 c
E_1	410.33 b
E_2	431.67 a
CV %	12.87
LSD (0.05)	18.98

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up

The recorded data on yield ha^{-1} was significantly affected by the combined effect of vermicompost and earthing up (Table 7 and Appendix VII). The highest yield ha^{-1} (5.39 t) was found from the treatment combination V_3E_2, which was significantly different from all other treatment combinations. The lowest yield ha^{-1} (3.19 t) was found from the treatment combination V_0E_0 (control), which was statistically identical to V_0E_1 (3.31 t) and statistically similar to V_0E_2 (3.42 t) and V_1E_0 (3.46 t) treatment combination.

Table 7. Combined effect of vermicompost and earthing up on yield of onion

Treatments	Yield	
	Yield plot^{-1} (g)	Yield ha^{-1} (t)
V_0E_0	312.67 f	3.19 f
V_0E_1	324.33 f	3.31 f
V_0E_2	335.33 ef	3.42 ef
V_1E_0	338.67 ef	3.46 ef
V_1E_1	368.67 de	3.76 de
V_1E_2	383.67 d	3.91 d
V_2E_0	406.00 cd	4.14 cd
V_2E_1	426.67 c	4.35 c
V_2E_2	440.33 c	4.49 c
V_3E_0	494.67 b	5.05 b
V_3E_1	521.67 b	5.32 b
V_3E_2	567.33 a	5.79 a
CV %	12.87	11.43
$LSD_{(0.05)}$	37.97	0.38

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

Where, V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost, V_3 = 14 t ha^{-1} vermicompost

E_0 = Control, E_1 = Two times earthing up, E_2 = Three times earthing up

CHAPTER V

SUMMERY AND CONCLUSION

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A field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2017 to March 2018 to study the effect of vermicompost and earthing up on growth and yield of onion. The experiment consists of two factors; Factor A: Vermicompost – 4 levels *viz*. V_0 = Control, V_1 = 6 t ha^{-1} vermicompost, V_2 = 10 t ha^{-1} vermicompost and V_3 = 14 t ha^{-1} vermicompost and Factor B: Earthing up – 3 levels *viz*. E_0 = Control, E_1 = Two times earthing up and E_2 = Three times earthing up. There were 12 (4×3) treatment combinations and the experiment was laid out in RCBD with three replications. The size of the unit plot was 1.2 m × 0.90 m following the spacing 30 cm ×15 cm. Data were collected on different growth and yield parameters. The collected data were statistically analyzed by MSTAT-C package programme. Different levels of vermicompost and earthing up of onion and their combination showed significant variation among the treatments on different growth and yield parameters.

Considerable influence was found due to variation on vermicompost application. Results revealed that in terms of growth parameters, the highest plant height (32.47, 44.04 and 53.80 cm at 30, 45 and 60 DAS, respectively) and number of leaves $plant^{-1}$ (4.51, 5.38 and 7.09 at 30, 45 and 60 DAT, respectively) were found from the treatment V_3 (14 t ha^{-1} vermicompost) where the lowest plant height (25.51, 34.13 and 43.60 cm at 30, 45 and 60 DAT, respectively) and number of leaves $plant^{-1}$ (3.58, 4.36 and 5.56 and at 30, 45 and 60 DAT, respectively) were found from the treatment V_0 (control). Likewise, in terms of yield contributing parameters and yield the highest root length (7.59 cm), bulb length (3.15 cm), bulb diameter (4.38 cm), neck diameter (1.26 cm), fresh weight $bulb^{-1}$ (40.07 g), dry weight of 100 g bulb (19.39 g), yield plot^{-1} (527.89 kg) and yield ha^{-1} (5.39 t) was found from the treatment V_3 (14 t ha^{-1} vermicompost) and the lowest root length (5.04 cm), bulb length (2.95 cm), bulb diameter (3.42 cm), neck diameter (0.89 cm), fresh weight bulb^{-1} (22.07 g), dry weight of 100 g bulb (12.32 g), yield plot^{-1} (324.11 kg) and yield ha^{-1} (3.31 t) were obtained from the treatment V_0 (control).

Significant influence was found due to different earthing up treatments. Results showed that in terms of growth parameters, the highest plant height (29.72, 40.37 and 50.52 cm at 30, 45 and 60 DAT, respectively) and number of leaves plant^{-1} (4.20, 5.03 and 7.40 at 30, 45 and 60 DAT, respectively) were found from the earthing up treatment E_2 (Three times earthing up) whereas the lowest plant height (27.95, 37.53 and 47.00 cmat 30, 45 and 60 DAT, respectively) and number of leaves plant^{-1} (3.90, 4.75 and 6.13 at 30, 45 and 60 DAT, respectively) were found from the earthing up treatment E_0 (control). Similarly, in terms of yield contributing parameters and yield, the highest root length (6.32 cm), bulb length (2.95 cm), bulb diameter (4.04 cm), neck diameter (1.13 cm), fresh weight bulb^{-1} (32.48 g), dry weight of 100 g bulb (17.32 g), yield plot^{-1} (431.67 kg) and yield ha^{-1} (4.41 t) were found from the earthing up treatment E_2 (Three times earthing up) whereas the lowest root length (5.86 cm), bulb length (2.76 cm), bulb diameter (3.79 cm), neck diameter (0.99 cm), fresh weight bulb^{-1} (28.47 g), dry weight of 100 g bulb (15.97 g), yield plot^{-1} (388.00 kg) and yield ha^{-1} (3.96 t) was found from the earthing up treatment E_0 (control).

Substantial influence was also observed due to combined effect of different vermicompost and earthing up. Results revealed that in terms of growth parameters, the highest plant height (33.80, 45.87 and 55.33 cm at 30, 45 and 60 DAT, respectively) and number of leaves plant^{-1} (4.80, 5.53 and 7.27 at 30, 45 and 60 DAT, respectively) were found from the treatment combination of V_3E_2 whereas the lowest plant height (24.20, 32.33 and 39.00 cm at 30, 45 and 60 DAT, respectively) and number of leaves plant^{-1} (3.33, 4.13 and 5.27 at 30, 45 and 60

DAT, respectively) were found from the treatment combination of V_0E_0. Likewise, in terms of yield contributing parameters and yield, the highest root length (7.97 cm), bulb length (3.35 cm), bulb diameter (4.55 cm), neck diameter (1.45 cm), fresh weight bulb^{-1} (42.73 g), dry matter of bulb (19.92%), yield plot^{-1} (367.33 kg) and yield ha^{-1} (5.79 t) were found from the treatment combination of V_3E_2. Again, the lowest root length (4.89 cm), bulb length (2.46 cm), bulb diameter (3.22 cm), neck diameter (0.83 cm), fresh weight bulb^{-1} (19.07 g), dry matter of bulb (11.50%) ,yield plot^{-1} (312.67 kg) and yield ha^{-1} (3.19) were found from the treatment combination of V_0E_0. So, onion production with V_3E_2 the application of 14 t vermicompost ha^{-1} and three times earthing up may be recommended for proper growth and development at the condition of Sher-e-Bangla Agricultural University research field.

In considering the above results of this experiment, the following conclusion and can be drawn

1. Application of Vermicompost at 14 t ha^{-1} gave the highest growth and yield of onion bulbs.
2. Three times earthing up also gave highest growth and yield of onion bulb.
3. Application of 14 t ha^{-1} vermicompost and three times earthing up gave the highest growth and yield of onion bulb.

So, it can be stated that application of 14 t vermicompost ha^{-1} with three times earthing up showed the highest performance on growth and yield of onion.

However, this is one year findings, more researches on this aspect are necessary to conduct at different agro-ecological zones for making at a definite conclusion and recommendations.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

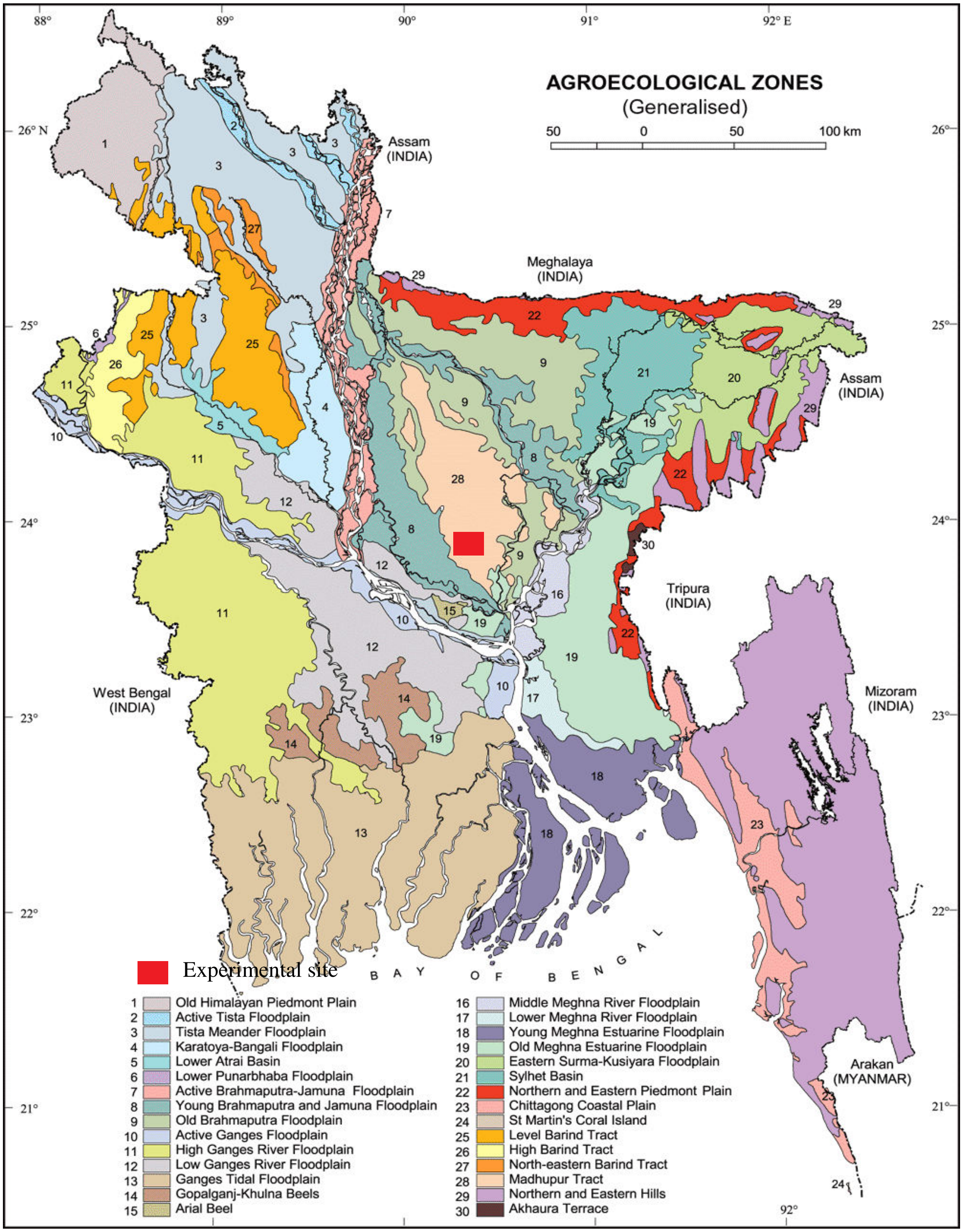

Fig. 6. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from October 2017 to March 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2017	October	28.60	8.52	18.56	56.75	14.40
2017	November	25.50	6.70	16.10	54.80	0.0
2017	December	23.80	11.70	17.75	46.20	0.0
2018	January	22.75	14.26	18.51	37.90	0.0
2018	February	35.20	21.00	28.10	52.44	20.4
2018	March	34.70	24.60	29.65	65.40	165.0

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

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. Physical and chemical properties of the initial soil

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

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of onion influenced by vermicompost and earthing up at different days after transplanting

Source of variation	Degrees of freedom (df)	**Mean square of p**lant height (cm)		
		30 DAT	45 DAT	60 DAT
Replication	2	5.533	66.809	0.353
Factor A (Vermicom)	3	57.377**	88.242**	7.767**
Factor B (Earthing)	2	39.576 *	95.986**	4.098*
A x B	6	31.049*	67.771*	4.026*
Error	22	11.566	21.538	1.152

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix V. Number of leaves plant^{-1} of onion influenced by of vermicompost and earthing up at different days after transplanting

Source of variation	Degrees of freedom (df)	**Mean square of number of leaves plant^{-1}**		
		30 DAT	45 DAT	60 DAT
Replication	2	0.486	3.021	0.787
Factor A (Vermicom)	3	13.380**	26.481*	44.896 **
Factor B (Earthing)	2	7.015NS	29.095*	20.280*
A x B	6	12.704*	22.282*	19.005*
Error	22	4.713	7.458	6.046

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix VI. Yield contributing parameters of onion influenced by vermicompost and earthing up

Source of variation	Degrees of freedom (df)	**Mean square of yield contributing parameters**					
		Root length (cm)	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Fresh weight $bulb^{-1}$ (g)	Dry weight of 100 g bulb (g)
Replication	2	5.472	8.90	20.70	0.04	249.51	2.29
Factor A (Vermicom)	3	101.37^{**}	87.87^{**}	124.12^{**}	1.26^{*}	1406.03^{**}	29.63^{**}
Factor B (Earthing)	2	125.43^{**}	85.62^{**}	94.00^{*}	4.093^{**}	5201.4^{**}	22.808^{*}
A x B	6	61.42^{*}	55.51^{*}	88.951^{*}	1.406^{*}	411.14^{*}	19.771^{*}
Error	22	21.98	17.93	31.05	0.643	132.67	7.142

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix VII. Yield parameters of onion influenced by vermicompost and earthing up

Source of variation	Degrees of freedom (df)	**Mean square of yield parameters**	
		Yield $plot^{-1}$ (kg)	Yield ha^{-1} (t)
Replication	2	2.108	0.021
Factor A (Vermicom)	3	64.250^{**}	6.195^{**}
Factor B (Earthing)	2	75.811^{**}	9.876^{**}
A x B	6	35.811^{*}	3.697^{*}
Error	22	23.237	1.005

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

PLATES

Plate 1. Photograph showing the raising of seedling in the seed bed.

Plate 2. Photograph showing the final land Preparation.

Plate 3. Photograph showing the earthing up treatment.

Plate 4. Photograph showing the harvesting of onion.

Plate 5. Photograph showing the harvested onion from different treatment combinations.