EFFECT OF VERMICOMPOST AND SPACING ON GROWTH AND YIELD OF SUMMER ONION

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF VERMICOMPOST AND SPACING ON GROWTH AND YIELD OF SUMMER 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 in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **SHARMIN SULTANA**, Registration No.: 09-03673 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information received during the course of this investigation has been duly acknowledged.

Dated: June, 2015
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Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was carried out at Horticultural Farm in Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh to study the effect of vermicompost and spacing on growth and yield of summer onion. The experiment was carried out during summer season (March -May 2014). Two factors were used in the experiment *viz*. three levels of spacing; S_1 = 10 cm× 25 cm, S_2 = 15cm × 25cm and S_3 = 20 cm × 25 cm and three levels of vermicompost; V_0 = Control , V_1 = 2 t ha^{-1} and V_2 = 4 t ha^{-1}. The experiment was laid out in Randomized Complete Block Design with three replications and all together with 9 treatment combinations were used. The findings of the experiment revealed that the tallest plant (49.6cm) was found in S_1V_2; the highest number of leaves plant^{-1} ,the highest dry weight of leaves plant^{-1} (12.9 g), the highest bulb diameter (5.3cm), the highest fresh weight of bulb plant^{-1} (44.6 g) and the highest dry weight of bulb plant^{-1} (12.6 g) was found in S_3V_2. But the highest length and diameter of bulb, highest fresh weight of bulb plant^{-1} and highest yield was found in. S_2V_2.In terms of economic return, results also revealed that gross return, net return and highest benefit cost ratio (BCR) was found from treatment combination of S_2V_2.

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BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) is a bulbous biennial herb of family Alliaceae. It is commonly called as “Queen of kitchen” for its unique usage throughout the year in the form of salads, condiments or for cooking with other vegetables. The pungency in onion is due to sulphur compound “ally propyl disulphide” in the volatile oil and the outer skin colour is due to the presence of “querctin”. Onion bulb is rich in minerals like phosphorus (50mg/100g), iron (0.7mg/100g), calcium (18mg/100g), carbohydrates (11.0g/100g), protein (1.2g/100g), vitamins ‘C’ (11mg/100g), fibers (0.6g/100g) and nicotinic acid (0.4mg/100g) (Aykroyd,1963).

Onion is one of the most important bulb crops of the globe. There are more than 500 species under the genus *Allium and* onion was first domesticated in Iran and Pakistan (Purseglove, 1972). At present, the crop is widely grown in both the tropical and temperate regions.

In Bangladesh, onion is mainly used as, spice and in many food preparations (Hossain and Islam, 1994). It is also used as condiment, curinary herb, vegetables (leaves of onion) and salad. It has medicinal value too. Among the spice crops grown in the country, it ranks second (36.842 ha) next to chilli (38,138 ha) in area but first (15,000 mt) in production during the year 2001-2002 (BBS, 2003). It is a winter crop and its cultivation is concentrated in the greater districts of Faridpur, Pabna, Rajshahi, Jessore, Dhaka, Mymensingh, Comilla and Rangpur (BBS, 2002) . The average yield of onion in the country is very low (4.07 t ha^{-1}) compared to the world average yield (17.46 t ha^{-1}).

Onion production is greatly influenced by cultivars and various agronomic practices (Mondal *et al.* 1986; Mondal, 1991). Onion bulbing is highly influenced by light duration.

To increase the yield of onion, emphasis must be given on adopting improved varieties, plant spacing, proper fertilization (organic and inorganic) and light duration . Several researchers in many countries have experienced those varieties

and plant spacing had profound effects on the growth and yield of onion (Kumar *et al.* 1998). Onion varieties grown in the probably European countries are photosensitive, enjoying long day length for production and maturation of bulbs.

Earthworms vermicompost is proving to be highly nutritive ‘organic fertilizer’ and more powerful ‘growth promoter’ over the conventional composts and a ‘protective’ farm input (increasing the physical, chemical and biological properties of soil, restoring and improving its natural fertility) against the ‘destructive’ chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NKP (nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, and beneficial soil microbes and also contain ‘plant growth hormones and enzymes’. It is scientifically proving as ‘miracle growth promoter and also plant protector’ from pests and diseases. Vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time, the vermicompost does (Arancon *et al*. 2004).

Vermicompost can be used as manure in crop production and as bio-fertilizer (Edwards and Lofty, 1972). It also plays a major role in improving growth and yield of different field crops, vegetables, and flower and fruit crops. The process of conversion of organic waste into bio-fertilizer with the help of traditional composting which can be used to minimize the environmental pollution and is a good alternative to restrict the use of chemical fertilizers for sustainable agriculture.(Kondappa *et al*., (2009) studied the effect of integrated nutrient management on growth, yield and economics of chili (cv. *Byadgidabbi*) in a vertisol and stated that the cost of vermicompost can be reduced by indigenous preparation by farmers themselves and then the integrated application of vermicompost with fertilizers in equal proportion was found to be beneficial.

Successful bulb production depends on plant spacing, which affects plant growth, bulb size, bulb yield and quality (Rahim *et al.* 1983). Planting at proper spacing increases thequality and size of the bulb (Nichols and Heydecker, 1964). Many workers reported that wider spacing caused higher bulb weight plant^{-1}, although the closer spacing gave higher yield per unit area due to increased plant density up to a certain limit (Nehra*et al.* 1988).

Although the demand of onion in Bangladesh is increasing day by day with the rising population, the area under cultivation in not expanding accordingly due to limitation of land. Total production can be boosted-up by increasing yield as found in the other onion producing countries of the world. But during the last few years it has been found that the area and total production of onion in Bangladesh remained almost same. The production per unit area can be increased by adopting improved methods of cultivation. Among the method, transplanting of onion seedling at proper spacing and growing under proper fertilizer management (organic and inorganic) could increase the optimum growth, bulbing and yield of the crop.

Considering the above stated situations, the present study was undertaken with the following objectives:

i) To study the growth and yield of onion utilizing different doses of vermicompost
ii) To find out the optimum spacing for growth and yield of summer onion
iii) To find out the combined effects of different doses of vermicompost and spacing on the growth and yield of onion.

CHAPTER II

REVIEW OF LITERATURE

Onion (*Allium cepa* L.) is one of the major bulbous crops of the world and one of the most important commercial vegetable crops grown in India. The production of onion bulb is influenced by many factors, such as spacing and light duration. Plant spacing and fertilizer are closely related to growth and yield of onion. Increased use of the fertilizer nitrogen is probably the most important single factor that has enabled the crop production to increase significantly in recent years.Vermicompost is a rich source of macro and micro nutrients, vitamins, enzymes, growth hormones and micro flora. This organic manure plays a significant role in improving the fertility of top soil and in boosting the productivity of the crop. There is a need to promote use of organics in addition to inorganic fertilizers for sustained maintenance of soil fertility.

2.1Effect of spacing on the growth and yield of onion

Optimum plant spacing is one of the most important and uncontroversial factors for maximizing the yield of any crop. In this connection the results of many studies related to spacing of onion are reviewed here:

Purewal and Dargan (1962) stated that the closer spacing (17.62 cm × 15.24 cm) resulted in higher yield than the wider spacing value. They also observed that closer spacing produced smaller bulbs. Similar result was also found by Verma*et al*. (1972) and their recommended spacing was 9cm × 15 cm.

An experiment on onion was observed by Bacvarov (1964) with different spacings. The plant spacing of 15 cm × 15 cm produced the best quality bulbs. Frappel and Cox (1973) conducted an experiment with plant population/m*2* and reported that the optimum density for maximum yield was 107.53 plants/m2.

Eunus*et al*. (1974) noted a trial in Bangladesh with onion seedling transplanted at the spacings of 5cm × 20 cm, 10 cm × 20 cm, 15 cm × 20 cm and 20 cm × 20 cm. They obtained the highest yield from the closest spacing without heavy irrigation.

Rashid and Rashid (1976) observed an experiment with onion in Bangladesh. They stated that the yield was increased with the closer spacing due to larger number of plants per unit area. Closer spacing also caused the plants to produce fewer and shorter leaves and smaller bulbs as well.

Badaruddin and Haque (1977) carried out an experiment with onion cv. White Glove in relation to the effect of time of planting and spacing. The spacing was 10.16, 15.24 and 20.32 cm with the fixed row distance of 30.48 cm. They found that wider spacing (20.32 cm x 30.48 cm) increased the height of plants, number of leaves and size of bulbs. The closer spacing of 10.16 cm x 30.48 cm produced the highest yield. However plants were shorter and the size and weight of bulbs were less in closer spacing as compared with that of wider spacing one.

Macro and Villamil (1981) observed a three year trial from 1974 to 1977 on the yield of onion. They found that the highest percentage of bulbs of 5 cm to 7.5 cm diameter and the highest percentage of bulbs weighing from 150 to 220 gm were produced from the seedlings planted at *6* to *8* cm apart in rows of 40 cm apart. They also noted that yield/ha varied from year to year.

Villagram and Escaf (1982) set an experiment with five levels of nitrogen from 0 to 120 kg/ha and five levels of plant density from 2, 66, 666to 800000 plants/ha. The highest marketable bulb was obtained from 5.71,428 plants/ha.

Wilson and Huttan (1983) studied the effect of plant spacing on onion yield. In a three- year trial, they obtained the best yield of large grade onion with the population of 45 to70 plants/m^2. Above these levels, the proportionof large bulbs (> 57 mm diameter) decreased although the total yield was also increased.

Nagre*et al*. (1985) set an experiment on onion with the spacing of 15 ×10, 15 × 15 and 15 cm ×20 cm and noticed that planting at 15 cm ×20cm gave the best yield, quality and storage losses through rotting were the lowest at the closest spacing.

Mondal (1986) carried out an experiment on onion at different densities of 100 plants/m^2 in two sowing seasons and observed that earlier sowing increased the leaf number/plant as well as specific leaf area (SLA). Mondal (1986) also observed that the number of leaves/plant decreased, but the SLA increased with increasing plant density.

An experiment was conducted by Mondal and Islam (1987) on four cultivars of onion grown in two seasons at densities of 25100 and 400 plants/nr with two sowing dates. Increase in plant density resulted in reduction of plant size and in particular the size and number of leaves and bulb diameter. The fresh and dry weights of leaves and bulbs were also decreased due to significantly increase in ratio of bulb length to bulbdiameter and that of bulb pesudostem length to bulb diameter.

Gruda (1987) carried out a three- year trial on onion where plants were grown at spacing ranging from 15 × 10 to 30cm × 15cm (control) giving densities of 66.6 to22.2 plants/m^2. The higher yields were obtained from 20 cm × 10 cm (50plants/m^2) and were 108.85 and 75 percent higher than the control on the trials at 1^{st}, 2^{nd} and 3^{rd} years, respectively.

Lopes (1987) investigate some short day onion varieties, and claimed that closer plant spacing gave the best yield of bulb.

Vishnu and Prabhakar (1989) observed an experiment with onion cv. Nasik Red spaced at 15 × 10, 15 × 15 and 15 cm × 25 cm applying nitrogen at 0, 75 and 150kg/ha and P205 at 0 or 60 kg/ha in a three- year trial. Results suggested that the yields were generally higher with the closest spacing and the highest N and P rates, but the benefit cost ratio was optimum at the closest spacing, coupled with N at 75 kg/ha.

Khushk *et al*. (1990) studied the effect of three inter (20, 30 and 40 cm) and the three intra (10, 15 and 20 cm) rows spacing and observed bulb yield and yield components. Results showed that wider inter and intra row spacing significantly increased number of leaves/plant, plant height and single bulb weight. The vertical diameter of bulb was significantly increased by wider intra row spacing.

Pandey *et al*. (1999) tested one month old seeding of onion cv. Phulkara which was planted at three inter (20, 30 and 40 cm) and intra (10, 15 and 20 cm) row spacing. Wider inter and intra row spacing resulted in significant increases in number of leaf/plant, plant height and single weight. The vertical diameter of the bulb was significantly increased by wider inter row spacing whereas the horizontal diameter of the bulbs was significantly increased by wider intra row-spacing. The highest bulb yield was obtained at an inter × intra row spacing of 20× 10 cm.

Riz *et al.* (1991) evaluated the effect of with plant spacing on the growth, yield, yield components and bulb quality of onion as well as on the growth of associated weeds. They reported that the increasing row spacing had no significant effect on root measurement (length, size, fresh weight and dry weight), number of leaves, bulb length (at 5, 9, 13 weeks after transplanting and harvest) and the yield at harvest. The increased plant spacing caused significant increases in the fresh weight and dry weight of bulb and bulb diameter at 9 and 13 weeks after transplanting. Marketable, non-marketable and total bulb yields were adversely affected by increased row spacing.

Rahim *et al.* (1992) from a trial with onion at plant spacing of 20 × 25, 20 × 20 or 20 cm × 15 cm stated that the highest yield was obtained from the closest spacing.

Mehla*et al*. (1993) noted an experiment with onion on row spacing and nitrogen levels. In their two years trial from 1991 to 1992 it was revealed that with the increase of spacing, bulb size and weight increased, but the total yield decreased. They also argued that there was a significant interaction between spacing and nitrogen rate.

Rajas *et al*. (1993) carried out a trail with onion using four rates of Sulphur (0, 40, 60 and 80 kg/ha.), three plant spacing (10×15, 15×15 and 20 cm ×15 cm) and three irrigation at intervals of 5, 10 and 15 days. They stated that the highest yield (28.11 t/ha) was obtained with 80 kg S/ha, a plant spacing of 10 cm x 15 cm and an irrigation at the interval of 5 days.

From 1989 to 1991,Pakyarek*et al.* (1994) determined the effects of sowing date (Sprig and Autumn), row spacing (25, 30 and 35 cm), planting density (2, 3 or 4 kg seeds/ha) and different cultivars on onion yield and quality. They reported that row spacing had no effect on yield, but the maximum sowing density produced a noticeable higher yield of good quality bulb.

Singh (1995) implemented two trials with onion at Ranchi with plant spacing, nitrogen rate and phosphorus rate to study the response of onion. He claimed that the closest spacing gave higher number of marketable bulbs and yields, whereas the widest spacing yielded lower number of marketable bulbs as well as yields. He also cited that the widest spacing gave the greatest size of bulbs.

From a study Galmarini*et al*. (1995) urged that increase in of plant density also increased bulb yield. The yield having 29,921 kg/ha was obtained from 156,000 plants/ha and 62,864 kg/ha was obtained from 830,000 plants/ha. They also recommended that onion seedlings of cv. Mendoza should be transplanted during early to mid September and at the densities of 300,000-451,000 plants/ha.

Farghali and Zeid (1995) observed a field experiment in Egypt to find out the effects of plant population and phosphorus fertilization on onion production. The results showed that both the average bulb weight and the diameter decreased as the plant population increased.

Stofella (1996) worked with two onion varieties in 2, 3 and 4 rows per bed at 7.6, 15.2 and 22.9 cm with row spacing resulting a plant population ranging from 41,000 to 246,000 plants/ha. The results demonstrated no interaction between numbers of rows per bed, but row spacing was significant. It was also observed that yield of marketable onion linearly increased and average bulb size (g/bulb) decreased with increasing number of rows per bed or decreased when row spacing was decreased. Percentage of small, medium and large sized bulbs were unaffected by the number of rows per bed, but percentage of small and medium bulbs increased and percentage of bulb decreased as in row spacing decreased.

Coelo *et al.* (1996) executed an experiment under three irrigation regimes and five spacing such as 8or10 cm between plants and rows 10 to 30cm apart. They found the highest yield of commercial bulbs at 20cm ×8cm spacing. This spacing resulted the proportion of large bulbs and the highest average bulb weight as well onion.

Rumpel and Felczynski (1997) conducted at experiment in 1991-93 at Skiemiewice, Poland with onion cultivars Hysam FI. Mercato and Sochaczewska. Which were sown to give densities of 20, 40, and 60, 80, 100 and 140 plants/m^2. The onions were planted in beds of 1.35 m wide with 4 rows/bed. The yield ol large bulbs decreased as plant density increased, whereas the yield of small bulbs was the highest at the plant density of 140 plants/m^2.

From an experiment Harun-or-Rashid (1998) narrated that the closest spacing (5.08 cm × 7.91 cm) produced the highest plant height and highest dry matter of bulb (15.5%) but the number of leaves and individual bulb weight were found to be highest at the widest spacing. The combination of NPKS and plant spacing had significant effects on bulb growth and bulb yield. The highest bulb yield (25 t/ha) was obtained from the closest spacing by Kumar *et al.* (1998).

After conducting an experiment Islam (1998) cited that the effect on spacing of root fresh weight of onion was statistically significant. The maximum root fresh weight was obtained at the spacing of 20 cm × 15 cm while the minimum at 20cm ×10cm.

In Brazil,Bofy *et al.* (1998) conducted a field trial to find out the response of onion cv. Crioula to plant densities. The three plant spacing studied was 10cm × 20cm. 8cm × 40cm and 10 cm × 50 cm. They came to conclusion that the plant spacing of 10cm ×20 cm produced bulbs with higher total weight.

Bosch *et al.* (2000) conducted an experiment with an onion cultivar Valenciana DE Grano in Spain under drip irrigated field. Seedlings were planted at densities of 30, 60 and 90 plants/m^2 as the main factor and N fertilizer at the rates of 240 and 420 kg/ha to asses the capability of the field reflectance measurements. Results showed that differences in the measures of crop growth characteristics, for example Leaf Area Index (LAI) and biomass were associated with crop densities.

Mostakin *et al.* (2000) carried out an experiment during the rabi season with 45 days old seedlings of onion cv. Agrifound Dark Red dipped for 30 minutes in 1.5, 2.5 and 5% *Azotobacter* solutions, or water (control) and planted in flat beds at 15 × 10 and 15 × 15 cm spacing in the second week of December 1992. N, P_2O_5 and K_2O were applied at 130, 80 and 60 kg/ha, respectively. Observations on growth and yield were recorded at 180 days after planting. The diameter and length of the bulbs were significantly higher in *Azotobacter*-inoculated plants than those of the control ones and were highest (7.35 and 4.35 cm. respectively) with the 5% treatment when planted at 15 × 15 cm spacing (4.15 and 6.74 cm, respectively). Amongst the *Azotobacter* treatments, the highest fresh (132.24 g) and dry (13.52 g) weight of the bulbs and yield (57.58 t/ha) were obtained with the 5% treatment. Closer spacing also gave higher plant height and yields than the wider spacing (52.99 and 48.94 t/ha, respectively).

Singh *et al.* (2000) studied the combined eflects of planting date (21 August and 1 and 11 September) and spacing (15 × 10 and 15 × 15cm) on growth and yield attributes of onion cv. N-53. The maximum neck thickness of the plant (2.5 and 2.29cm), fresh weight (59.54 and 65.33g) diameter of bulb (4.90 and 5.17cm) and weight of 'A' grade bulb (0.734 and 0.833g) were tound with combinations ot early planting date (21 August) and wider spacing (15 × 15 cm) compared to the other treatments combination during both the years. However, the highest recovery percentage of KB' grade bulbs (84.53-86.78%), weight of 'B' grade bulbs (4.08-4.34 kg), gross yield (34.33-36.46 t/ha) and the yield of marketable bulbs (30.35-34.93 t/ha) were obtained from the combination of early planting date (21 August) with closer spacing (15 × 10 cm).

Kumer *et al.* (2001) conducted an experiment with onion for plant spacing (20 × 20 cm and 20× 15 cm) and found that the higher bulb yields (27.92 t/ha) were obtained from 20 × 15 cm spacing. Higher growth parameters and bulb characters were obtained in the 20 × 20 cm spacing compared to the narrow plant density.

Ushakumari *et al.* (2001) worked with onion transplanted at 10 ×10cm, 15 × 10 cm and 20 × 10 cm, and found that the total bulb yield, dry matter. Leaf area index and crop growth rate significantly increased with the decrease in plant spacing.

2.2 Effect of vermicompost on the growth and yield of onion

Vermibiotechnology is the best method for application of earthworms in combating the solid waste disposal problem or reducing the pollution effect. It helps in cost effective and meticulous recycling of agricultural residues and industrial wastes using minimum energy. The process of conversion of organic waste into biofertilizer with the help of traditional composting which can be used to minimize the environmental pollution and is a good alternative to restrict the use of chemical fertilizers for sustainable agriculture.

Kitturmath *et al.,* (2007) studied the nutrient changes during earthworm *Eudriluseugeneiae*(Kinberg) mediated vermicomposting of the agroindustrial wastes such as pressmud, bagasse, coir waste, rice husk and groundnut shells.

Giraddi *et al.,* (2007) studied the vermitechnology for successful management of municipal waste. They have emphasized basically on the waste produced from the market and animal waste from slaughter house and produced useful vermicompost.

Bano et al., (1987) have studied the culturing of earthworm species *Eudriluseugeniae*for vermicast production and assessment of worm cast as biofertilizer. Vermicompost can be used as manure in crop production and as biofertilizer (Edwards and Lofty, 1972).

Desai *et al.,* (1999) studied a major role in improving growth and yield of different field crops, vegetables, and flower and fruit crops. The efficacy of vermicompost was evaluated in a field study by and highlighted the integrated nitrogen management in wheat and coriander cropping system.

Kondappa *et al.,* (2009) studied the effect of integrated nutrient management on growth,yield and economics of chilli (cv. Byadgidabbi) in a vertisol and stated that the cost of vermicompost can be reduced by indigenous preparation by farmers themselves and then the integrated application of vermicompost with fertilizers in equal proportion was found to be beneficial.

Vanessa *et al.,* (2008) studied the influence of vermicompost on the yield of *Sorghum bicolor.* In the present study an attempt has been made to see the growth and yield of onion plant (*Allium cepa*) due to application of vermicompost produced from the tendu leaf litter.

Yadav *et el.,* (2015) carried out an experiment to assess the effect of integrated nutrient management on growth and yield of onion cv. Pusa Madhvi during the year 2013-14. 10 treatments [RDF as control, FYM, Vermicompost, PSB, Azotobacter, Azosprillium, and combination with nitrogen, phosphorus and potash] were applied with three replications and laid out under Randomized Block Design. The results showed that the maximum plant height (74.32 cm), bulb diameter (4.60 cm), neck thickness (1.06 cm), bulb length (4.39 cm) and number of leaves (9.88) per plant were recorded under treatment T_{10}- RDF (50%) + Vermicompost (50%) at 90 (DAT).Whereas, the maximum leaf length (62.23 cm) was observed in the treatment T_5(Azotobacter @ 100%). Although, the treatment T_5 showed the maximum bulb weight (175.67 g) but the maximum yield (283 q ha^{-1}) and TSS (12.30^0B) were recorded in T_{10}.Thus, it can be concluded that treatment T_{10} i.e. application of RDF (50%) + Vermicompost (50%) was suitable for better growth and higher production of onion cv. PusaMadhvi.

Meena *et al.,* (2015) conducted an experiment during kharif, 2012 with eighteen treatment combinations including six levels of organic manures (Control, FYM @ 10 t ha^{-1}, vermicompost @ 5 t ha^{-1}, poultry manure @ 5 t ha^{-1}, FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}, FYM @ 5 t ha^{-1} + poultry manure @ 2.5 t ha^{-1}) and three bio-fertilizer treatments (without inoculation, Azospirillium, Azospirillium + PSB). Results indicated 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.

Kumar *et al.,* (2015) conducted an experiment to evaluate the performance of different onion varieties in response to organic condition during the Rabi season of the year 2014-15.The soil was prepared with recommended doses of vermicompost as soil nutrient. The Pre harvest effect of the commercial Bio based product namely; Trichoderma viridae, Neem, Panchgavya and Water were studied. It was revealed from the Data, Maximum vegetative growth (Plant height, Number of leaves,) and Bulb growth (Bulb diameter, Bulb weight) was observed in case of Panchgavya treatments. A similar observation was made in the case of neem and Trichoderma viridae application as compared to control.

Adhikary *et al.,* (2012) carried out an experiment to catch imagination of philosophers like Pascal and Thoreau. Yet its role in the nutrition of agricultural fields has attracted at- tention of researchers worldwide only in recent decades. Waste management is considered as an integral part of a sustainable society, thereby necessitating diversion of biodegradable frac- tions of the societal waste from landfill into al- ternative management processes such as ver- micomposting. Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycets and growth hormones auxins, gibberlins&cytokinins. Both vermicompost& its body liquid (vermiwash) are proven as both growth promoters & protectors for crop plants. We discuss about the worms composting technology, its importance, use and some salient results obtained in the globe so far in this review update of vermicompost research.

Ngullie *et al.,* (2009) Studied a combined applications of manures, fertilizers, and microbial biofertilizers with reference to onion bulb yield and soil nutrient balances. Given the good supply of quality manures, observations favored the combined application of inorganic fertilizers and manures over sole application of either nutrient source. Application of 50 to 75% of the fertilizer recommendation plus any microbial inoculants treatment failed to achieve a viable alternative.

Patil *et al.,* (2013) Modern farming practices affect our world, by the way of land degradation, nutrient runoff, soil erosion, water pollution, soil compaction, loss of cultivated biodiversity, habitat destruction, contaminated food and destruction of traditional knowledge systems.

These all result into changing climatic conditions of the earth. Farmers are directly getting affected due to these climate changes as it affects the crop production. Sudden change in normal weather conditions sometimes results into the total crop failure. These ill effects of modern agriculture and climate change can be delineated by adopting organic farming.

This paper summarizes use of biofertilizers and organic fertilizers by the farmers in Sangamner region of Maharashtra as low input Sustainable agricultural technology (LISA). Though the use of chemicals in agriculture is inevitable to meet the growing demand for food in world, there are opportunities in some areas where organic production can be encouraged to tape the domestic export market. Farmers are now using the biofertilizer, Vermicompost, Poultry manure, Jeevamrit as source of organic manures in their fields in Sangamner.

There are actually a wide variety of biofertilizer that have been evolved through universities and independent research labs, but these are not disseminated upto the 100 % farmers. Sustainable use and conservation of natural resources are the key components to face the problem of soil degradation and climate change.Mohanty *et al.,* (2015) conducted an experiment at KrishiVigyan Kendra, Jajpur, OUAT, Bhubaneswer during winter 2010-2011 to study the response of organic and inorganic fertilizer in various proportion on growth and yield of onion

(*Allium cepa* L.)variety Agri found light red. The experiment was laid out in randomized block design (RBD) using three replications. Significant variations were observed for plant height, number of leaves, polar and equatorial bulb diameter, bulb weight and estimated yield per hectare. Naik and Hosamani (2003) conducted an experiment to investigate the effect of spacing (15 ×10 cm, 15 × 15 cm and 15 × 20 cm) and N levels (0.50. 100 and 150 kg/ha) on the growth and yield of kharif onion under rainfed condition. Narrow spacing of 15 ×10 cm with an application of 150kg N/ha was found optimum for enhancing yield (16.90 t/ha) and other growth and quality parameters including plant height, leaf number per plant, bulb length, bulb diameter and bulb total soluble solid content.

As far as fertilizer treatments were concerned, T4 (50% vermicompost +50% NPK) were proved to be best fertilizer treatment for most of the traits. It recorded maximum plant height, bulb polar and equatorial diameter and bulb weight. The same treatment also produced highest bulb yield (353.80 q/ha). Applications of organic inputs in combination with chemical fertilizer were found better option than application of organic manure or chemical fertilizer alone. This will not only help to improve the economic return and revenue generation of the farmers but also lower the growing onion market prices in the country.

Hanumannaik *et al.,* (2013) carried out an experiment for three years to produce onion organically using farm yard manure, vermicompost, neem cake and sheep manure in comparison with chemical fertilizer at RDF. Plant height, bulb weight and yield per ha were significantly influenced by different treatments.

RDF produced tallest plants, while neem cake produced shortest plants. Diameter of bulb was maximum with vermicompost, while it was least with sheep manure.

Vermicompost application resulted in highest bulb weight and bulb yield. The yield was least with sheep manure. RDF was at third in position in yield. However, the cost : benefit ratio was highest with RDF and least with sheep manure indicating organic farming in onion was not cheaper than farming with RDF. Suresh *et al*. (2007) conducted the field cum laboratory experiments to study the effect of organics and their combination on seed production in onion cv. N-53 at Agricultural Research Station, Bagalkot. The first season, experiment consisting of RDF (control) @ 125:50:125 kg NPK/ha; RDF @ 125:50:125 kg NPK/ha + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha; FYM@ 25 t/ha (100%); vermicompost @ 4.2 t/ha (100%); poultry manure @ 4.2 t/ha (100%); FYM @ 12.5 t/ha (50%) + vermicompost @ 2.1 t/ha (50%); vermicompost @ 2.1 t/ha (50%) + poultry manure @ 2.1 t/ha (50%); FYM @ 12.5 t/ha (50%) + poultry manure @ 2.1 t/ha (50%); FYM @ 25 t/ha (100%) + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha; vermicompost @ 4.2 t/ha (100%) + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha and poultry manure @ 4.2 t/ha (100%) + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha.

Maximum number of leaves per plant at 30 DAT (7.4), higher bulb length (8.6 cm), higher bulb diameter (22.0 cm), higher bulb weight (133.6 g) and also numerically higher bulb yield (40.01 q/ha) was observed with application of vermicompost @ 4.2 t/ha (100%) alone and vermicompost @ 4.2 t/ha (100%) + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha.

Whereas, lowest bulb yield was obtained in poultry manure @ 4.2 t/ha (22.58 q/ha). Organic onion bulb produced in previous season is used for seed production using same treatments as taken in first experiment. Significantly, maximum number of leaves per plant at 60 DAT in seed crop (13.4), umbel diameter (15.10 cm), seed weight per umbel (5.3 g), seed weight per plant (15.43

g), seed yield per plot and per hectare (16.14 q/ha) respectively and also 1000-seed weight higher (15.43 g) was observed in vermicompost @ 4.2 t/ha (100%) + PSB @ 5 kg/ha + Azospirillum @ 5 kg/ha followed by vermicompost @ 4.2 t/ha (100%). While, minimum seed yield (10.77 q/ha) was obtained with poultry manure 4.2 t/ha (100%) + PSB + Azospirillum. Seed quality parameters did not varied significantly except root length, germination (94.30%), seedling vigour index (1675) was observed in RDF + PSB @ 5 kg/ha + Azospirillum @ 50 kg/ha. The gross returns net returns and B:C ratio were greatly influenced by organics and other combination. However, higher gross returns (Rs. 1, 29,213/ha) and net returns (Rs. 1, 06,543/ha) were recorded in vermicompost @ 4.2 t per ha (100%) + PSB + Azospirillum followed by VC alone and lowest gross returns was seen in FYM @ 12.5 t/ha (50%) + poultry manure @ 2.1 t/ha (50%) (Rs.90,511/ha).

CHAPTER III

MATERIALS AND METHODOLOGY

This chapter deals with the materials and methods including a brief' description of the location of experimental site, soil, climate and materials used for the experiment.

3.1 Experimental site

The experiment was conducted at Horticultural Farm in Sher-e-Bangla Agricultural University, Dhaka-1207, and Bangladesh. The experiment was carried out during summer season (March-May,2014). The experimental fields was located at 90^0 33′ E longitude and 23^0 71′ N latitude at a height of 9 m above the sea level.

3.2 Weather and climate

The climate of the experimental field was sub-tropical and was characterized by high temperature, heavy rainfall during Kharif-1 season (March-May) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature .The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the cropping season are presented in Appendix 1.

3.3 Soil

The land belongs to the Agro-ecological zone “Madhupur tract” (AEZ-28) having the red brown traces soils and acid basin clay of Nodda soil series. The soil of the experimental site were well drained and medium high. The physical and chemical properties of soil of the experimental site sandy loam in texture and having soil p^H varied from 5.45-5.61. Organic matter content ware very low (0.83). The physical and chemical characteristics of the experimental field soil are furnished in Appendix 2.

3.4Planting material

BARI onion-3 variety was used for the experiment and collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

3.5 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design with three replications all together with 9 treatment combinations. First of all, the entire experimental plot was divided into three blocks, each of which as then divided into 27 unit plots. The treatment combinations were assigned randomly to the unit plots of one block. The size of unit plot was 1 m × 1 m. Two adjacent unit plots and blocks were separated by 50 cm. Then statistical analysis was done and different treatments were compared. The layout of the experiment was shown in fig.1.

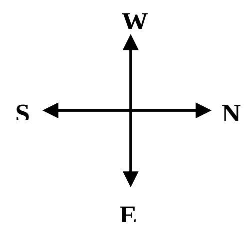
3.6 Land preparation

The land of the experimental plot was first opened on 20, October, 2013 with a power tiller and it was exposed to the sun for few days prior to next ploughing. It was then thoroughly prepared by ploughing and cross ploughing with a power tiller followed by laddering to obtain a good tilth. The subsequent operations were done with harrow, spade, hammer, basket etc. The clods were broken into fine soil particles and the surface was leveled until the desired tilth was obtained. The weeds and stubbles were removed and the plots were prepared after applying the basal dose of manure and fertilizers. Irrigation and drainage channels were prepared around the plot. The soil was treated with insecticides (Furadan 5G @ 10).Seedling was planed on March 2014.

Layout of the experiment

B1	B2	B3
V_0S_1	V_1S_1	V_0S_3
V_2S_1	V_0S_1	V_2S_2
V_0S_2	V_1S_1	V_2S_1
V_1S_1	V_1S_2	V_0S_1
V_0S_2	V_2S_2	V_1S_2
V_1S_2	V_2S_1	V_0S_2
V_0S_3	V_2S_3	V_1S_3
V_1S_3	V_2S_2	V_2S_3
V_2S_3	V_0S_3	V_1S_3

Legend



Treatments

Vermicompost

V_0 = Control

$V_1 = 2$ t ha^{-1}

$V_2 = 4$ t ha^{-1}

Spacing

$S_1 = 10 \times 25$ cm^2

$S_2 = 15 \times 25$ cm^2

Figure1: Layout of the experiment

3.7 Treatments

Two factors were used in the experiment viz. three levels of vermicompost (V) and three levels of spacing (S).

3.7.1 Factor- A: Three levels of spacing

$S_1 = 10 \times 25\ cm^2$

$S_2 = 15 \times 25\ cm^2$

$S_3 = 20 \times 25\ cm^2$

2.7.2 Factor –B: Three levels of vermicompost

V_0 = Control

$V_1 = 2\ t\ ha^{-1}$

$V_2 = 4\ t\ ha^{-1}$

2.7.3 Treatment Combinations

S_1V_0, S_1V_1, S_1V_2, S_2V_0, S_2V_1, S_2V_2, S_3V_0, S_3V_1, S_3V_2

3.8 Fertilizer and manure

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. But in the present study no chemical fertilizer was used. Only vermicompost was used as for proper nutrient supply. In addition vermicompost was used regarding different doses as per treatment.

3.9Intercultural operations

3.9.1 Weeding and mulching

Manual weeding was done as and when necessary to keep the plots free from weeds. The soil was mulched by breaking the crust of the soil for easy aeration and to conserve soil moisture as and when needed. Mulching also helped to disturb the emergence of Bathua plants (*Chenopodium album*) and other weeds. These two operations were done carefully without hampering the luxurious crop health.

3.9.2 Gap filling

Gap filling was done within 7 days after transplanting of the seedlings using the plants from the border rows

3.9.3 Irrigation

Irrigation was applied after top dressing of fertilizer and also when needed with water can. A constant moisture supply was maintained to obtain a good growth of the plant. Irrigation was stopped before one month of harvesting.

3.9.4 Plant protection

Except cutworm, no other insects were found harmful for potato in growing season. To protect the soil borne insects Furadan 5G was applied @10kg ha-1 during the final land preparation. Dursban was applied @2ml L-1 after 20 DAP to control the cutworm. Dithane M-45 was applied @2g L-1 at 10 days interval as a preventive measure against late blight *(Phytophthora infestans*) of potato. Poison bait was used in some plots for protecting the tuber from the rat.

3.10 Harvesting

The maturity of the crop was determined by the appearance of the yellowish color of the leaves, falling of the stems on the ground and finally drying of leaves. Ten sample plants were harvested at first from each plot and then the whole plot was harvested.Care was taken to avoid injury of onion bulb during harvesting. Harvesting was done on 27 May, 2014.

3.11 Curing

The bulbs were dried in shade for one day with tops uncut and in the following day tops were separated with knife keeping 2 cm neck. Curing of bulbs was done in a room at ambient temperature (22.6 ± 2.5 °C) for 5 days.

3.12 Collection of data

a) Plant height (cm)
b) Number of leaves plant^{-1}
c) Dry weight of leaves plant^{-1} (g)
d) Bulb diameter (cm)
e) Length of bulb (cm)
f) Fresh weight of bulb plant^{-1} (g)
g) Dry weight of bulb plant^{-1} (g)
h) Yield ha^{-1} (ton)

3.13Procedure of recording data

Data were recorded on different morphological, yield components and yield from 5 randomly selected sample plants. Data on different parameters were recorded as per the following parameters:

3.13.1 Plant height (cm)

The height was measured from 10 randomly selected plants of each plot. After 30 days of planting, data recording was started at 20 days interval up to 90 days of planting. The height was measured in centimeter (cm) from the ground level to the tip of the longest leaf and the average height of ten plants was taken to observe the rate of grow. Plant height was recorded at 30, 50, 70 and 90 days after planting.

3.13.2Number of leaves plant^{-1}

Number of leaves from ten selected plants was counted separately alter 30 days of transplanting and the average number of leaves was calculated at an interval of 20 days up to 90 days of planting. Number of leaves plant^{-1} was recorded at 30, 50, 70 and 90 days after planting.

3.13.3 Dry weight of leaves plant^{-1} (g)

Dry weight of leaves was taken from the randomly selected 10 plants of each plot after it was dried at 70 °C for 72 hrs in an oven and their average was calculated prior to this sun drying for two days.

3.13.4 Bulb diameter (cm)

The diameter at the middle part of the bulb was taken from ten randomly selected plants after harvest with a slide calipers and their mean was recorded in cm.

3.13.5 Fresh weight of bulb plant^{-1}(g)

Fresh bulb of 10 individual plants were taken and weighed after harvest and their average weight was calculated and expressed in gram (g)

3.13.6 Dry weight of bulb plant^{-1} (g)

Dry weight of fresh bulb was taken from the randomly selected 10 plants of each plot after it was dried at 70°C for 72 hrs in an oven and their average was calculated prior to this sun drying for two days.

3.13.7 Length of bulb (cm)

Bulb height was measured from ten plants in centimeter (cm) from the ground level to the end of the bulb formation at harvest. The mean was calculated.

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

When all onion bulbs were reached to at harvest, then selected 1 m^2 harvested onion bulb was weighed after drying and cleaning from each plot. The average weight from three replications for each treatment was calculated and converted to t ha^{-1}.

3.14 Statistical analysis

The data obtained for yield contributing characters and yield were statistically analyzed to find out the significance of the differences among the treatments. The collected data from the experimental plot on morphology, yield and yield contributing characters were compiled and analyzed using the Statistical, Mathematical Calculation and Data Management (MSTATC) package program. Morphological variation and yield performance among the treatments were studied by Analysis of Variance (ANOVA) by F-test. The significance of the difference between pairs of treatment means was evaluated by least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

An experiment was conducted to find out the growth and yield of BARI onion-3 as influenced by spacing and vermicompost. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendices III-VIII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following sub-headings:

4.1 Plant height

4.1.1 Effect of spacing

The studied experiment showed that significant variation was found in terms of different spacing on plant height of BARI onion-3 at different days after planting (DAP) (Fig.2 and Appendix 3).It was observed that plant height was significantly influenced by different treatments at 30, 50, 70 and 90 DAP. Results revealed that the highest plant height (22.2, 47.2, 50.5 and 45.5 cm at 30, 45, 60 and 75 DAP respectively) was achieved from $S_1 = 10 \times 25$ cm^2. Again, the lowest plant height (19.5, 44.7, 48.6 and 44.0 cm at 30, 50, 70 and 90 DAP respectively) was recorded from $S_3 = 20 \times 25$ cm^2 followed by $S_2 = 15 \times 25$ cm^2.

Similar result was found from Harun-or-Rashid (1998), he narrated that the closest spacing (5.08 cm × 7.91 cm) produced the highest plant height which was supported by Mostakin*et al.* (2000). But Khushk*et al.* (1990) observed that wider inter and intra row spacing significantly increased plant height which was also confirmed by Pandey *et al.* (1999).

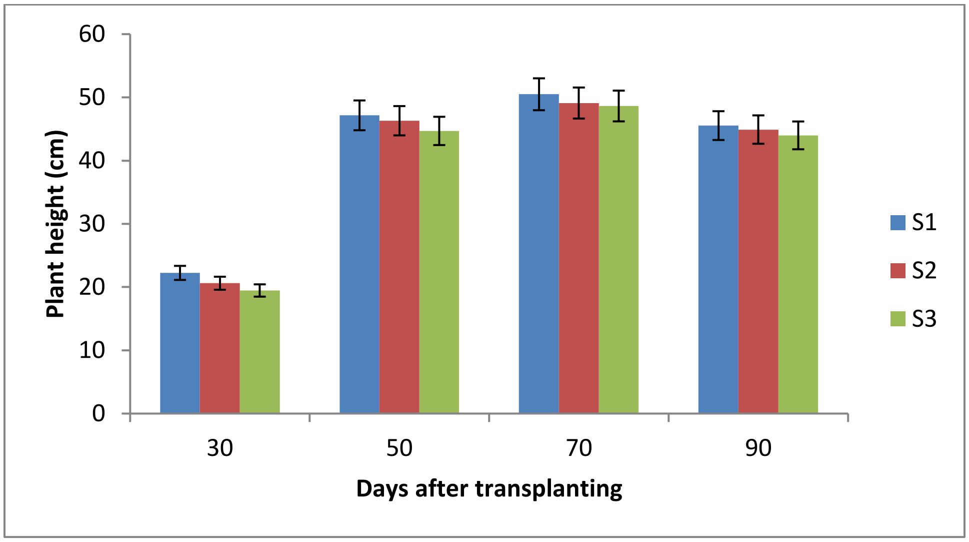


Fig. 2.Effect of spacing on plant height of summer onion

$S_1 = 10 \times 25\ cm^2$	V_0 = Control
$S_2 = 15 \times 25\ cm^2$	$V_1 = 2\ t\ ha^{-1}$
$S_3 = 20 \times 25\ cm^2$	$V_2 = 4\ t\ ha^{-1}$

4.1.2 Effect of vermicompost

The experiment was significantly influence for the variation of different rates of vermicompost on plant height of BARI onion-3 at different days after planting (DAP) (Fig.3 and Appendix 3). It was found that there were significant effect on plant height among the treatments at 30, 50, 70 and 90 DAP.Results showed that the tallest plant (22.3, 48.5, 52.1 and 47.0 cm at 30, 50, 70 and 90 DAP respectively) were achieved from V_2 = 4 t vermicompost ha^{-1} followed by V_1 = 2 t vermicompost ha^{-1}where the shortest plants (18.7, 42.5, 45.9 and 41.3 cm at 30, 50, 70 and 90 DAP respectively) were observed from V_0 = Control. The results obtained from the present study was conformity with the findings of Yadav *et al.* (2015) and they showed that the maximum plant height (74.32 cm), was recorded under treatment T_{10} - RDF (50%) + 10 Vermicompost (50%).

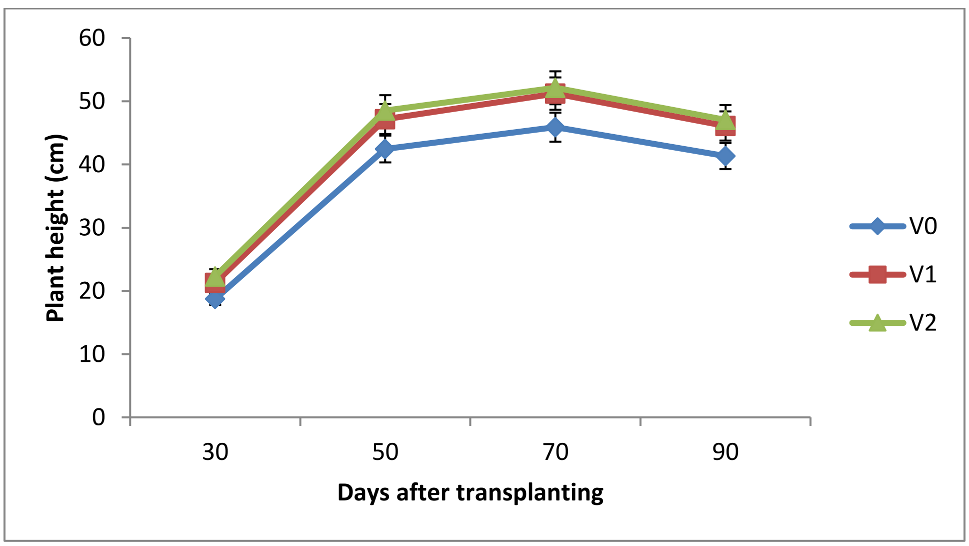


Fig. 3. Effect of vermicompost on plant height of summer onion

$S_1 = 10 \times 25$ cm^2	V_0 = Control
$S_2 = 15 \times 25$ cm^2	V_1 = 2 t ha^{-1}
$S_3 = 20 \times 25$ cm^2	V_2 = 4 t ha^{-1}

4.1.3 Combined effect of spacing and vermicompost

It was observed that at 30, 50, 70 and 90 DAP plant height was significantly influenced by different combinations of plant spacing and vermicompost.Results revealed that the tallest plant (25.3, 52.2, 54.5 and 49.6 cm at 30, 50, 70 and 90 DAP respectively) were found in S_1V_2 followed by $S_1V_1$and S_2V_2.On the contrary the shortest plant (18.2, 40.5 44.7 and 39.7 cm at 30, 50, 70 and 90 DAP respectively) were recorded from S_1V_0followed by S_2V_0 and S_3V_0.

Table.1 Combined effect of vermicompost and spacing on plant height of summer onion

Treatments	Plant height (cm)			
	30 DAP	50 DAP	70 DAP	90A DAP
S_1V_0	18.2h	40.5f	44.7e	39.7 h
S_1V_1	23.2b	48.7 b	52.3 b	47.3 b
S_1V_2	25.3a	52.2 a	54.5 a	49.6 a
S_2V_0	19.0 g	43.2 e	46.3 d	41.5 g
S_2V_1	21.0 d	47.8 c	51.9 b	46.4 d
S_2V_2	21.9 c	48.0 c	52.1 b	42.7 f
S_3V_0	19.0 g	43.6 e	46.7 d	46.8c
S_3V_1	19.6 f	45.1 d	49.4 c	44.5 e
S_3V_2	19.7e	45.4d	49.8 c	44.7 e
$LSD_{0.05}$	0.58	0.72	0.71	0.31
CV (%)	8.37	7.26	10.2	12.5

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

$S_1 = 10 \times 25\ cm^2$ V_0 = Control
$S_2 = 15 \times 25\ cm^2$ $V_1 = 2\ t\ ha^{-1}$
$S_3 = 20 \times 25\ cm^2$ $V_2 = 4\ t\ ha^{-1}$

4.2 Number of leaves plant^{-1}

4.2.1 Effect of spacing

Significant variation was found in terms of different spacing on number of leaves plant^{-1} of BARI onion-3 at different days after planting (DAP) (Fig. 4 and Appendix 4).It was found that number of leaves plant^{-1} was significantly influenced by different treatments at 30, 50, 70 and 90 DAP. Results revealed that the number of leaves plant^{-1}(4.2, 6.8, 9.6 and 8.8 at 30, 45, 60 and 75 DAP respectively) was achieved from $S_3 = 20 \times 25$ cm^2.Again, the lowest number of leaves plant^{-1}(3.5,6.0, 8.5 and 8.6 at 30, 50, 70 and 90 DAP respectively) was observed from $S_1 = 10 \times 25$ cm^{2}followed by $S_2 = 15 \times 25$ cm^2. Pandey *et al.* (1999) found that wider inter and intra row spacing resulted in significant increases in number of leaf/plant but Ushakumari *et al.* (2001) found that leaf area index and crop growth rate significantly increased with the decrease in plant spacing.

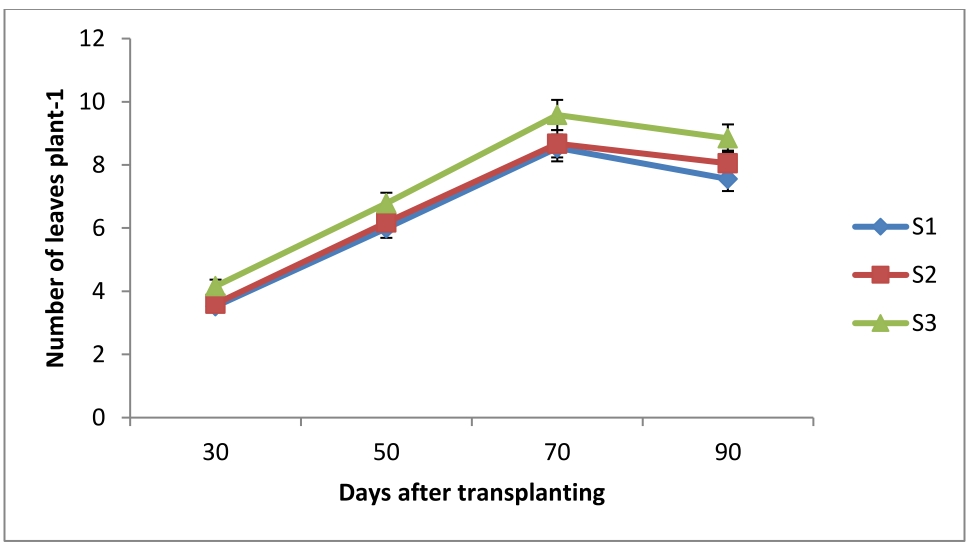


Fig. 4. Effect of spacing on number of leaves plant^{-1} of summer onion

$S_1 = 10 \times 25$ cm^2	V_0 = Control
$S_2 = 15 \times 25$ cm^2	V_1 = 2 t ha^{-1}
$S_3 = 20 \times 25$ cm^2	V_2 = 4 t ha^{-1}

4.2.2 Effect of vermicompost

Significant variation was found for different rates ofvermicompost on number of leaves plant^{-1} of BARI onion-3 at different days after planting (DAP) showed significant variation (Fig. 5 and Appendix 4). It was observed that there was significant effect on number of leaves plant^{-1} among the treatments at 30, 50, 70 and 90 DAP. Results revealed that the number of leaves plant^{-1} (4.3, 7.2, 10.1 and 9.8 at 30, 50, 70 and 90 DAP respectively) was achieved from V_2 = 4 t ha^{-1} followed by V_1 = 2 t ha^{-1} where the lowest number of leaves plant^{-1}(3.2, 5.3, 8.0 and 6.0 at 30, 50, 70 and 90 DAP respectively) was received from V_0 = Control. Yadav *et el.*, (2015) showed that the maximum number of leaves (9.88) per plant was recorded under treatment T_{10} - RDF (50%) + 10 Vermicompost (50%).

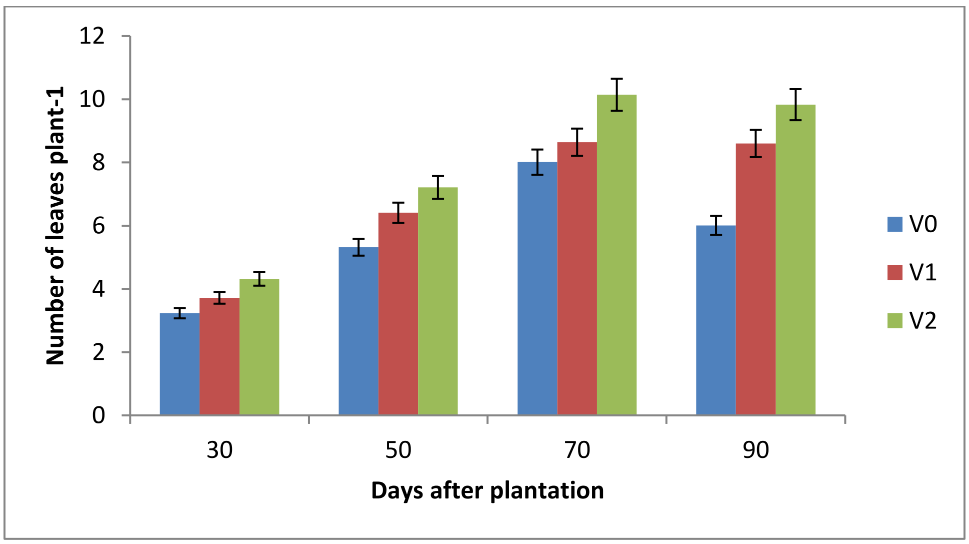


Fig. 5. Effect of vermicompost on number of leaves plant^{-1} of summer onion

$S_1 = 10 \times 25$ cm^2 V_0 = Control
$S_2 = 15 \times 25$ cm^2 V_1 = 2 t ha^{-1}
$S_3 = 20 \times 25$ cm^2 V_2 = 4 t ha^{-1}

4.2.3 Combined effect of spacing and vermicompost

There was highly significant variation of different spacing and vermicompost on number of leaves plant^{-1} of BARI onion-3 at different days after planting (DAP) (Table 2 and Appendix 4). It was observed that at 30, 50, 70 and 90 DAPnumber of leaves plant^{-1} was significantly influenced by different plant spacing and vermicompost.The findings showed that the highest number of leaves plant^{-1}(5.0, 7.8, 11.0 and 10.3 at 30, 50, 70 and 90 DAP respectively) was found in S_3 V_2 followed by S_3V_1 andS_2 V_2. On the other handthe lowest number of leaves plant^{-1} (3.2, 5.1, 7.3 and 7.2 cm at 30, 50, 70 and 90 DAP respectively) was recorded from S_1V_0 followed by S_2 V_0, S_3 V_0, S_1 V_1 and S_2 V_2.

Table 2.Interaction effect of vermicompost and spacing on number of leaves plant^{-1} of summer onion

Treatments	Number of leaves plant^{-1}			
	30 DAP	50 DAP	70 DAP	90A DAP
S_1V_0	3.2 e	5.1 f	7.2 e	5.2 f
S_1V_1	3.5 d	6.0 d	8.5 cd	7.9 c
S_1V_2	3.9 c	6.9 c	8.9 cd	10.6 b
S_2V_0	3.2 e	5.4 e	7.8 de	6.3 e
S_2V_1	3.5 d	6.1 d	8.7 cd	8.2 c
S_2V_2	4.1 bc	7.0bc	9.5 bc	9.7 b
S_3V_0	3.3 e	5.5 e	9.0 bc	6.6 d
S_3V_1	4.2 b	7.1 b	9.9b	9.6 b
S_3V_2	5.0 a	7.8 a	11.0a	10.3 a
$LSD_{0.05}$	0.13	0.20	1.02	0.31
CV (%)	9.22	6.37	7.26	8.36

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

$S_1 = 10 \times 25$ cm^2 V_0 = Control
$S_2 = 15 \times 25$ cm^2 $V_1 = 2$ t ha^{-1}
$S_3 = 20 \times 25$ cm^2 $V_2 = 4$ t ha^{-1}

4.3 Dry weight of leaves plant^{-1}

4.3.1.1Effect of spacing

The findings showed highly significant variation for different spacing on dry weight of leaves plant^{-1}at harvest of BARI onion-3 (Table 3 and Appendix 5).Results explained that the highest dry weight of leaves plant^{-1}(11.5 g) was recorded from $S_3 = 20 \times 25$ cm^{2}where the lowest dry weight of leaves plant^{-1}(9.9 g)was observed from $S_1 = 10 \times 25$ cm^2 where the intermediate result (9.92 g) was found in $S_2 = 15 \times 25$ cm^2. Mondal and Islam (1987) found that fresh and dry weights of leaves and bulbs were also decreased due to significantly increase in ratio of bulb length to bulb diameter which was significantly influence by spacing.

4.3.1.2 Effect of vermicompost

Significant variation was influenced significantly for different rates of vermicompost on dry weight of leaves plant^{-1}ofBARI onion-3 (Table 3 and Appendix 5). Results explained that the highest dry weight of leaves plant^{-1}(11.9 g) was recorded from $V_2 = 4$ t ha^{-1}where the intermediate result (10.4 g) was found in $V_1 = 2$ t ha^{-1}. Otherwise the lowest dry weight of leaves plant^{-1}(9.9 g) was observed from V_0 = Control.

4.3.1.3 Combined effect of spacing and vermicompost

The studied parameter showed highly significant variation in spacing and vermicompost of BARI onion-3 (Table 3 and Appendix 5).The findings showed that the highest dry weight of leaves plant^{-1}(12.9 g) was found in S_3V_2 closely followed by S_3V_1, S_2V_2 and S_1V_2. On the other hand, the lowest dry weight of leaves plant $^{-1}$(9.15 g) was recorded from S_1V_0 which was statistically similar with S_1V_1, S_2V_1, S_2V_0 and S_3V_0.

4.4 Bulb diameter

4.4.1 Effect of spacing

There was significant variation for different spacing on bulb diameter of BARI onion-3 (Table 3 and Appendix 5).Results signified that the highest bulb diameter (4.4 cm) was recorded from $S_3 = 20 \times 25$ cm^2 otherwise the lowest bulb diameter (3.0cm) was observed from $S_1 = 10 \times 25$ cm^2 where the intermediate result (3.6 cm) was found in $S_2 = 15 \times 25$ cm^2. The result obtained from the present findings was similar with Mondal and Islam (1987), they observed that increase in plant density resulted in reduction of plant size and in particular the size and number of leaves and bulb diameter which was also supported by Khushk *et al.* (1990) and Pandey *et al.* (1999). Riz *et al.* (1991) evaluated the increased plant spacing caused significant increases in the fresh weight and dry weight of bulb and bulb diameter.

4.4.2 Effect of vermicompost

Significant variation was found for different rates of vermicompost on bulb diameter of BARI onion-3 (Table 3 and Appendix 5).Results explained that the highest bulb diameter (4.9 cm) was recorded from V_2 = 4 t ha^{-1}followed by V_1 = 2 t ha^{-1} where the lowest bulb diameter (2.49 cm) was recorded from V_0 = Control. Yadav *et al.,* (2015) observed that highest bulb diameter (4.60 cm), was recorded under treatment T_{10} - RDF (50%) + Vermicompost (50%). Similar result was found from Yadav *et el.,* (2015) and they showed that the maximum bulb diameter (4.60 cm), was recorded under treatment T_{10} - RDF (50%) + Vermicompost (50).

4.4.3 Combined effect of spacing and vermicompost

Significantly influenced variation was found in terms of different spacing and vermicompost on bulb diameter of BARI onion-3 (Table 3 and Appendix 5).The findings showed that the highest bulb diameter (5.31cm) was found in S_3V_2 which statistically identical with S_3V_1, and S_2V_2 and closely followed by S_1V_2.

Similarly,the lowest bulb V_2diameter (2.2 cm) was recorded from S_1V_0 which was statistically same with S_2V_1.

4.5 Length of bulb (cm)

4.5.1 Effect of Spacing

The experiment showed significant variation for different spacing on length of bulb of BARI onion-3 (Table 3 and Appendix 5). Results revealed that the highest length of bulb (4.6 cm) was recorded from $S_2 = 15 \times 25$ cm^2 where the lowest length of bulb (3.8cm) was observed from $S_3 = 20 \times 25$ cm^2 followed by (4.3 cm) was found in $S_1 = 10 \times 25$ cm^2. Such results obtained from the present findings might be due to cause of nutrient unavailability and decreased bulb diameter with closer spacing and resulted higher bulb height with closer spacing.

4.5. 2 Effect of vermicompost

The experiment showed significant variation for different rates of vermicompost on length of bulb (cm) of BARI onion-3 (Table 3 and Appendix 5). Results explained that the highest length of bulb (4.7 cm) was recorded from $V_2 = 4$ t ha^{-1} followed by $V_1 = 2$ t ha^{-1} (4.63) where the lowest length of bulb (3.3 cm) was recorded from V_0 = Control.

4.5.3 Combined effect of spacing and vermicompost

Significant variation was found in terms of different spacing and vermicompost on height of bulb (cm) of BARI onion-3 (Table 3 and Appendix 5). The findings showed that the highest length of bulb (5.4cm) was found in S_2V_2 followed by S_2V_1 and S_1V_2. Again, the lowest length of bulb (3.2 cm) was recorded from S_1V_0 followed by S_2V_0.

Table.3 Effect of vermicompost and spacing on dry weight of leaves per plant,bulb diameter and length of bulb of summer onion

Treatments	Dry weight of leaves plant^{-1} (g)	Bulb diameter (cm)	Length of bulb (cm)
Effect of Spacing			
S_1	9.9c	3.0c	4.3b
S_2	10.4 b	3.6 b	4.6a
S_3	11.5 a	4.4 a	3.8 c
$LSD_{0.05}$	1.02	0.4	0.1
Effect of Vermicompost			
V_0	9.9 c	2.5 c	3.3 b
V_1	10.4b	4.2 b	4.6 a
V_2	11.9a	4.9 a	4.7 a
$LSD_{0.05}$	1.02	0.4	0.13

Table.4 Combined effect of vermicompost and spacing on dry weight of leaves per plant,bulb diameter and length of bulb of summer onion

Treatments	Dry weight of leaves plant^{-1} (g)	Bulb diameter (cm)	Length of bulb (cm)
S_1V_0	9.2 c	2.2 e	3.2 e
S_1V_1	10.1bc	3.8 c	5.3 a
S_1V_2	11.5 ab	4.6 ab	4.4 b
S_2V_0	10.2 bc	4.0 bc	3.3 de
S_2V_1	10.2bc	2.2 e	4.7 b
S_2V_2	11.3 ab	4.7 a	5.4a
S_3V_0	10.3 bc	3.1 d	3.5 d
S_3V_1	11.3 ab	4.8 a	3.9 c
S_3V_2	12.9 a	5.3 a	4.1 c
$LSD_{0.05}$	1.77	0.7	0.24
CV (%)	8.36	7.91	6.47

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

$S_1 = 10 \times 25$ cm^2 V_0 = Control
$S_2 = 15 \times 25$ cm^2 $V_1 = 2$ t ha^{-1}
$S_3 = 20 \times 25$ cm^2 $V_2 = 4$ t ha^{-1}

4.6 Fresh weight of bulb plant^{-1}

4.6.1 Effect of spacing

The findings showed the significant variation for different spacing on fresh weight of bulb plant^{-1} of BARI onion-3 (Table 5 and Appendix 6). Results revealed that the highest fresh weight of bulb plant^{-1}(38.4 g) was recorded from S_3 = 20 × 25 cm^2 otherwise the lowest fresh weight of bulb plant^{-1}(32.83 g) was observed from S_1 = 10 × 25 cm^2 followed by 34.3g fresh weight of bulb plant^{-1} was found in S_2 = 15 × 25 cm^2. The result obtained from the present findings was similar with that of Riz *et al.* (1991), they evaluated the increased plant spacing caused significant increases in the fresh weight of bulb.

4.6.2 Effect of vermicompost

In the experiment, parameter showed significant variation for different rates of vermicompost on fresh weight of bulb plant^{-1} of BARI onion-3 (Table 5 and Appendix 6). Results explained that the highest fresh weight of bulb plant^{-1}(40.88 g) was recorded from V_2 = 4 t ha^{-1} followed by V_1 = 2 t ha^{-1} where the lowest fresh weight of bulb plant^{-1}(28.6 g) was recorded from V_0 = Control. Similar result was also observed by Hanumannaik *et al.*, (2013) and they observed that vermicompost application resulted in highest bulb weight and bulb yield.

4.6.3 Combined effect of spacing and vermicompost

The studied experiment had a significant variation of different spacing and vermicompost on fresh weight of bulb plant^{-1}of BARI onion-3 (Table 5 and Appendix 6).The findings showed that the highest fresh weight of bulb per plant(44.6 g) was found in S_3V_2 followed by S_3V_1. Conversely the lowest fresh weight of bulb plant^{-1} (27.5 g) was recorded from S_1V_0 followed by S_2 V_0 and S_3V_0.

4.7 Dry weight of bulb (g)

4.7.1 Effect of spacing

Significant influence was found for different spacing on dry weight of bulb of BARI onion-3 (Table 5 and Appendix 6). Results revealed that the highest dry weight of bulb (10.1 g) was recorded from $S_3 = 20 \times 25$ cm^2 where the lowest dry weight of bulb (8.4 g) was observed from $S_1 = 10 \times 25$ cm^2 followed by (8.6g) was found in $S_2 = 15 \times 25$ cm^2. The result obtained from the present findings was similar with that of Riz *et al.* (1991), they evaluated the increased plant spacing caused significant increases dry weight of bulb.

4.7.2 Effect of vermicompost

Result showed that the varied influence was significant for different rates of vermicompost on dry weight of bulb (g) of BARI onion-3 (Table 5 and Appendix 6). Results explained that the highest dry weight of bulb (10.64 g) was recorded from V_2 = 4 t ha^{-1} followed by V_1 = 2 t ha^{-1} where the lowest dry weight of bulb (7.4 g) was recorded from V_0 = Control. Similar result was also observed by Hanumannaik *et al.*, (2013) and Yadav *et el.*, (2015).

4.7.3 Combined effect of spacing and vermicompost

Significant variation was found in terms of different spacing and vermicompost on dry weight of bulb (g) of BARI onion-3 (Table 4 and Appendix 3).The findings showed that the highest dry weight of bulb (12.6 g) was found in S_3V_2 followed by S_3V_1. Alternatively the lowest dry weight of bulb (7.2 g) was recorded from S_1V_0 followed by S_2 V_0 and S_3V_0.

4.8 Yield (ton/ha)

4. 8.1 Effect of spacing

Different spacing on yield (ton/ha) of BARI onion-3 had a high significant variation (Table and Appendix 3).Results revealed that the highest yield (13.7 ton) was recorded from $S_2 = 15 \times 25$ cm^{2}where the lowest yield (12.5 t ha^{-1}) was observed from $S_3 = 20 \times 25$ cm^{2}followed by 12.7 t ha^{-1} was found in $S_1 = 10 \times 25$ cm^2.Riz*et al.* (1991) evaluated that marketable, non-marketable and total bulb yields were adversely affected by increased row spacing. Mehla *et al.* (1993) noted that with the increase of spacing, bulb size and weight increased, but the total yield decreased.

4. 8. 2 Effect of vermicompost

Significantly influence in variationof vermicompost was found on yield (t ha^{-1}) of BARI onion-3 (Table 5 and Appendix 6).Results explained that the highest yield (14.5 t ha^{-1}) was recorded from V_2 = 4 t ha^{-1} followed by V_1 = 2 t ha^{-1}where the lowest yield (11.4 t ha^{-1}) was recorded from V_0 = Control. Similar result was also observed by Hanumannaik *et al.,* (2013) and they observed that vermicompost application resulted in highest bulb weight and bulb yield. Supported result was also found by Yadav *et al.,* (2015).

4. 8.3 Combined effect of spacing and vermicompost

The studied findings showed the high significant variation of different spacing and vermicompost on yield (ton/ha) of BARI onion-3 (Table 6 and Appendix 3). The findings showed that the highest yield(15.9 t ha^{-1}) was found in S_2V_2 followed by S_1V_2 and S_1V_1. Then again, the lowest yield (9.4 ton) was recorded from S_1V_0 followed by S_2V_0 and S_3V_1.

Table 5. Effect of spacing and vermicompost on yield and yield contributing parameters showing fresh weight of bulb plant^{-1}, dry weight of bulb plant^{-1} and yield of summer onion

Treatment	Fresh weight of bulb plant^{-1}	Dry weight of bulb plant^{-1} (g)	Yield (t ha^{-1})
Effect of Spacing			
S_1	32.8c	8.4 c	12.7b
S_2	34.3 b	8.6 b	13.7 a
S_3	38.4 a	10.1a	12.5c
$LSD_{0.05}$	0.25	0.15	0.43
Effect of Vermicompost			
V_0	28.6c	7.4 c	11.4 c
V_1	36.0 b	9.1 b	13.3 b
V_2	40.9 a	10.6a	14.5 a
$LSD_{0.05}$	0.82	0.52	0.43

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

$S_1 = 10 \times 25\ cm^2$　　V_0 = Control
$S_2 = 15 \times 25\ cm^2$　　$V_1 = 2\ t\ ha^{-1}$
$S_3 = 20 \times 25\ cm^2$　　$V_2 = 4\ t\ ha^{-1}$

Table 6. Interaction effect of spacing and vermicompost on yield and yield contributing parameters showing fresh weight of bulb plant^{-1}, dry weight of bulb plant^{-1} and yield of summer onion

Treatment	Fresh weight of bulb plant^{-1}	Dry weight of bulb plant^{-1} (g)	Yield (t ha^{-1})
S_1V_0	27.5i	7.2 h	9.4 f
S_1V_1	32.7 f	8.2 f	14.1b
S_1V_2	38.4 d	9.5 d	14.9 b
S_2V_0	28.7 h	7.5 g	11.9 d
S_2V_1	34.6 e	8.7 e	13.2 c
S_2V_2	39.6 c	9.9 c	15.9 a
S_3V_0	29.6 g	7.7 gh	11.0 e
S_3V_1	40.9b	10.3b	12.6 cd
S_3V_2	44.6 a	12.6 a	13.0 c
$LSD_{0.05}$	0.45	0.3	0.72
CV (%)	11.4	9.5	12.8

In a column same lettering indicate non-significant difference and different lettering indicate significant difference among the treatments

$S_1 = 10 \times 25$ cm^2 V_0 = Control
$S_2 = 15 \times 25$ cm^2 $V_1 = 2$ t ha^{-1}
$S_3 = 20 \times 25$ cm^2 $V_2 = 4$ t ha^{-1}

4.9 Economic performances

Cost of production, gross and net return and BCR were done and have been presented in Table 6. Material cost, non-material and overhead cost were recorded for all the treatments of unit plot and calculated on per hectare basis (yield ha^{-1}), the price of onion at the local market rates were considered.The total cost of production ranges between Tk. 65,880 ha^{-1} and Tk88,204 ha^{-1} among the different treatment combination. The variation was due to different cost of number of seedlings $plot^{-1}$ and different doses of vermicompost.

The highest cost of production Tk88,204 ha^{-1} was involved in the treatment combination of S_1V_2 followed by $S_1V_1$and S_2V_2while the lowest cost of production Tk65,880 ha^{-1} was involved in the combination of S_3V_0 followed by $S_2V_0$and S_3V_1 (Table 5 and Appendix 8).

Gross return from maximum treatment combination was promising, it was ranged between Tk112800 ha^{-1} and Tk190800 ha^{-1}.

The highest gross return Tk190800 ha^{-1} was obtained from the treatment combination of S_2V_2followed by S_1V_2 and $S_1V_1$where the lowest gross return Tk112800 ha^{-1} was found from the treatment combination of S_1V_0.

Among the different treatment combinations S_2V_2 gave the highest net return (Tk109,293 ha^{-1}) while the lowest net return (Tk35,758 ha^{-1}) was obtained from the treatment combination of S_1V_0.

The benefit cost ratio (BCR) was found to be the highest (2.34) in the treatment combination of S_2V_2. The lowest BCR (1.46) was recorded from the treatment combination of S_1V_0. The treatment combination of $S_3V_1$and S_2V_1 also gave hopeful BCR compared to other treatment combinations.

Thus it was evident that the Spacing (15 × 25 cm^2) + Vermicompost(4 t ha^{-1}) gave the highest onion yield (15.90 t ha^{-1}) with highest net return (Tk109293).

Therefore, it may be suggested that though S_2V_2 gave the highest onion yield, further studies in this relation should be conducted in other regions of the country before final recommendation.

Table 6. Economic analysis regarding cost of production, gross return, net return and benefit cost ration in respect of onion cultivation

Treatment combinations	Cost of production (Tk. ha^{-1})	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})*	Net return (Tk. ha^{-1})	BCR
S_1V_0	77,042	9.40	112800	35,758	1.46
S_1V_1	82,623	14.07	168840	86,217	2.04
S_1V_2	88,204	14.48	173760	85,556	1.97
S_2V_0	70,345	11.94	143280	72,935	2.04
S_2V_1	75,926	13.18	158160	82,234	2.08
S_2V_2	81,507	15.90	190800	109,293	2.34
S_3V_0	65,880	10.96	131520	65,640	2.00
S_3V_1	71,461	12.60	151200	79,739	2.12
S_3V_2	77,042	12.98	155760	78,718	2.02

* selling cost = Tk 12.00 kg^{-1}

S_1 = 10 × 25 cm^2 V_0 = Control
S_2 = 15 × 25 cm^2 V_1 = 2 t ha^{-1}
S_3 = 20 × 25 cm^2 V_2 = 4 t ha^{-1}

CHAPTER V

SUMMERY AND CONCLUSION

An experiment was conducted at Horticultural Farm in Sher-e-Bangla Agricultural University, Dhaka-1207 Bangladesh to study the effect of vermicompost and spacing on growth and yield of summer onion. The experiment was carried out during summer season (March 2014 May 2014). Two factors were used in the experiment *viz.* three levels of spacing; S_1 = 10 × 25 cm^2, S_2 = 15 × 25 cm^2 and S_3 = 20 × 25 cm^2 and three levels of vermicompost; V_0 = Control , V_1 = 2 t ha^{-1} andV_2 = 4 t ha^{-1}.

The experiment was laid out in Randomized Complete Block Design with three replications all together with 9 treatment combinations was used. First of all, the entire experimental plot was divided into three blocks, each of which as then divided into 36 unit plots. The treatment combinations were assigned randomly to the unit plots of one block. The size of unit plot was 1 m × 1 m. Two adjacent unit plots and blocks were separated by 50 cm. The crop was harvested at the sign of full maturity. Data were statistically analyzed for evaluation of the treatment effect and different treatments were compared.

Different parameters showed significant variation for different distance of planting spacing. That's effectively influenced the growth and yield of BARI onion-3. Where the highest plant height (22.2, 47.2, 50.5 and 4.5 cm at 30, 45, 60 and 75 DAP respectively) was achieved from S_1(10 × 25 cm^2); the highest number of leaves $plant^{-1}$ (4.1, 6.8, 9.6 and 8.8 at 30, 45, 60 and 75 DAP respectively), the highest dry weight of leaves $plant^{-1}$(11.5 g),the highest bulb diameter (4.4 cm),the highest fresh weight of bulb $plant^{-1}$ (38.4 g)and the highest dry weight of bulb (10.1 g) was recorded from S_3 (20 × 25 cm^2)but the highest height of bulb (4.6 cm)and the highest yield (13.7 ton) was recorded from S_2 (15 × 25 cm^2). By the study, the result revealed that the lowest distance of plant spacing influenced plant height progressively increase but medium status of distance for plant spacing increase height of bulb and highest yield of BARI onion-3 while the lowest number of leaves plant^{-1} (3.5, 6.0, 8.5 and 7.55 at 30, 50, 70 and 90 DAP respectively), the lowest dry weight of leaves plant^{-1}(9.9 g), the lowest bulb diameter (3.0 cm),the lowest fresh weight of bulb plant^{-1} (32.8 g)and the lowest dry weight of bulb (8.4 g) was recorded from S_1 (10 × 25 cm^2)but the lowest height of bulb (3.8cm),the lowest plant height (19.5, 44.7, 48.6 and 44 cm at 30, 50, 70 and 90 DAP respectively) and the lowest yield (12.50 ton) was observed from S_3 (20 × 25 cm^2).

On the other hand, the finding showed significantly variation by comparing of different levels of vermicompost. It influenced directly growth and yield of BARI onion-3. In the experiment, the tallest plant(22.3, 48.5, 52.1 and 47.0 cm at 30, 50, 70 and 90 DAP respectively), the highest number of leaves plant^{-1} (4.3, 7.2, 10.1 and 9.8 at 30, 50, 70 and 90 DAP respectively), the highest dry weight of leaves plant^{-1}(11.90 g),the highest bulb diameter (4.9cm), the highest fresh weight of bulb plant^{-1} (40.88 g),the highest dry weight of bulb (10.6 g)and the highest yield (14.5 ton) was recorded from V_2(4 t ha^{-1}vermicompost). All the vegetative and yield parameter of BARI onion-3 were influenced by the vermicompost level of 4 t ha^{-1}where the shortest plant(18.7, 42.5, 45.9 and 41.3 cm at 30, 50, 70 and 90 DAP respectively), the lowest number of leaves plant^{-1} (3.2, 5.3, 8.0 and 6.0 at 30, 50, 70 and 90 DAP respectively), the lowest dry weight of leaves plant^{-1}(9.8 g),the lowest bulb diameter (2.5 cm),the lowest fresh weight of bulb plant^{-1} (28.6 g),the lowest dry weight of bulb (7.3 g),the lowest length of bulb (3.3 cm) and the lowest yield (11.4 ton) was recorded from V_0(Control). Observing the findings it was showed that without vermicompost all parameters of BARI onion-3 negatively influenced.

The combinations of plant spacing and vermicompost directly showed significant variation on growth and yield parameter of BARI onion-3.The findings of the experiment revealed that the tallest plant (25.3, 52.2, 54.5 and 49.6 cm at 30, 50, 70 and 90 DAP respectively) was found in S_1V_2; the highest number of leaves plant^{-1} (5.0, 7.7, 11and 10.3 cm at 30, 50, 70 and 90 DAP respectively), the highest dry weight of leaves plant^{-1} (13.0 g), the highest bulb diameter (5.3cm), the highest fresh weight of bulb plant^{-1} (44.6 g) and the highest dry weight of bulb plant^{-1}(12.6 g) was found in S_3V_2. The combinations of highest level of spacing and medium status of vermicompost influenced positively of maximum vegetative growth but combination of maximum level of vermicompost and medium level of spacing influenced positively bulb yield of BARI onion-3 and the highest height of bulb (5.4 cm) and the highest yield (15.9tha^{-1}) was found with this combination(S_2V_2).On the contrary, the lowest plant height (18.2, 40.5 44.7 and 39.7 cm at 30, 50, 70 and 90 DAP respectively), the lowest number of leaves plant^{-1} (3.2, 5.1 7.2 and 5.2 cm at 30, 50, 70 and 90 DAP respectively), the lowest dry weight of leaves plant $^{-1}$(9.2 g), the lowest bulb diameter (2.2 cm), the lowest fresh weight of bulb plant^{-1} (27.5 g), the lowest dry weight of bulb (7.2 g), the lowest height of bulb (3.20 cm) and the lowest yield (9.40 ton) was recorded from S_1V_0. The negative result was shown with the combination of zero level of vermicompost and highest spacing on growth and yield of BARI onion-3.

In terms of economic return, results revealed that the highest cost of production (Tk88,204 ha^{-1}) was found from the treatment combination of S_1V_2 while the lowest cost of production (Tk65,880 ha^{-1}) was found from the combination of S_3V_0. The highest gross return (Tk190800 ha^{-1}) was obtained from the treatment combination of S_2V_2 where the lowest gross return (Tk112800 ha^{-1})was found from the treatment combination of S_1V_0. Among the different treatment combinations S_2V_2 gave the highest net return (Tk109,293 ha^{-1}) while the lowest net return (Tk35,758 ha^{-1}) was obtained from the treatment combination of S_1V_0.

The benefit cost ratio (BCR) was found to be highest (2.34) in the treatment combination of S_2V_2 and the lowest BCR (1.46) was recorded from the treatment combination of S_1V_0.

From the above findings, it can be concluded that among all the treatment combinations, the S_2V_2 (Spacing of 15 × 25 cm^2 and Vermicompost of 4 t ha^{-1}) gave the highest onion yield (15.90 t ha^{-1}) with highest net return (Tk 109293) and highest BCR (2.34) and it was evident that this result was considered as best compared to other treatment combinations. Further experiment can be conducted with this respect with more option for justification of the present study.

REFFERENCES

Adhikary, S. 2012. Vermicompost, the story of organic gold. Agriculture & Ecological Research Unit, Biological Sciences Division, Indian Statistical Institute, Kolkata, India.,**3**(7): 905-917.

Agarwal, Sunita, 1999. Study of Vermicomposting of Domestic Waste and the Effects of Vermicompost on Growth of Some Vegetable Crops.Ph. D Thesis Awarded by University of Rajasthan, Jaipur, India.

Ahmad, K.I.J. and Shahjahan M., 1991. Homestead vegetable production training manual. 1 irst Edition.On-Farm Research Division.Bangladesh Agricultural Research Institute, Joydehpur, Gazipur. pp. 106-108.

Alam, M. N., Jahan M. S., Ali, M. K., Ashraf, M. A. and Islam, M. K., 2007b, Effect of vermicompost and chemical fertilizers on growth, yield and yield components of potato in Barind soils of Bangladesh. *J. Appl. Sci. Res.*,**3**:1879-1888.

Alam, M. N., Jahan, M. S., Ali, M. K., Islam, M. S. and Khandaker, S. M., 2007, Effect of vermicompost and NPKS fertilizers on growth, yield and yield components of red amaranth. *Aust. J. Basic Appl. Sci.*, **1**:706-716.

Alam, M.N.,. Jahan M.S.,, Ali M.K.,, Ashraf, M.A., and. Islam M.K., 2007.Effect of Vermicompost and Chemical Fertilizers on Growth, Yield and Yield Components of Potato in Barind Soils of Bangladesh.*J. Appl. Sci. Res.*,**3**(12): 1879-1888.

Al-Dahmani, J.H., Abbasi P.A., Miller S.A. and. Hoitink,H.A.J., (2003). Suppression of bacterial spot of tomato with foliar sprays of compost extracts under greenhouse and field conditions. Plant Disease, **87**: 913-919.

Anderson, N.C., (1983). Nitrogen Turnover by Earthworms in Arable Plots Treated With Farmyard Manure and Slurry; J.E. Satchell (Ed.) Earthworm Ecology: from Darwin to Vermiculture; Chapman and Hall, London, pp. 139-150.

Anita Mohanty, A. Behera, P. and Harichandan, S. (2015) Effect of nutrient management on the growth and productivity of onion.*Agric. Sci. Digest.*, **35**(3): 241-243.

Anonymous, (1980).Report and Recommendations on Organic Farming-Case Studies of 69 Organic Farmers in USA; Pub.of US Board of Agriculture, USA.

Anonymous, (1998). Sustainable Agriculture; People and the Planet; Vol: 7(1). Anonymous, 2001.Vermicompost as Insect Repellent; Biocycle, Jan. 01: 19.

Ansari, Abdullah A., (2008). Effect of Vermicompost on the Productivity of Potato (Solanum tuberosum).Spinach (Spinaciaoleracea) and Turnip (Brassica campestris). World Journal of Agricultural Sciences, 4 (3): 333-336.

Aoba, T. (1964). Studies on bulb formation and dormancy in the onion VIII.1he effect ol duration ol short day treatment before bulb formation and ol long day treatment before harvest on bulb formation and sprouting of onions. J. Hort. Assoc. Jpn.33-46.

Appelhof, Mary, (1997). Worms Eat My Garbage; 2nd (Ed.). Flower Press, Kalamazoo, Michigan, U.S.

Appelhof, Mary,(2003). Notable Bits; In WormEzine, Vol: 2 (5).

Arancon, N.Q., Edwards, C.A., Babenko,A., Cannon,J., Galvis,P. and Metzger G., (2008). Influences of vermicomposts, produced by earthworms and microorganisms from cattle manure, food waste and paper waste, on the germination, growth and flowering of petunias in the greenhouse; Applied Soil Ecology, 39: 91-99.

Arancon, N.Q., Edwards,C.A., Bierman,P., Welch,C. and Metzger,J.D., (2004). Influences of vermicomposts on field strawberries-1: Effects on growth and yields; Bioresource Technology, 93: 145-153.

Ayres, Mathew, (2007). Supression of Soil-Borne Plant Diseases Using Compost; Paper Presented at 3rd National Compost Research and Development Forum; Organized by COMPOST Australia, Murdoch University, Perth.

Bacvarov, S. (1964). The effect of spacing of seed onion on the commercial quality of bulbs.Grad.Lozar.Nauka.,**l**(5):53-60.

Badaruddin, M. and Haque.M.A., (1977). Effect of time of planting and spacing on the Yield of onion (Allium ccpa L.). Bangladesh Hort., **5**(2):23-29.

Bailey, N. J. J., (1965), Statistical Methods in Biology. ELBS English University Press, London.

Bano, K., Kale, R. D. and Gajanan, G. N., (1987), Culturing of earthworms Eudriluseugenaie for cast production and assessment of 'worm cast' as biofertilizer. *J. Soil Biol. Ecol.*,**7**: 98-104.

BBS. (2002). Monthly (February) Statistical Bullrtinol Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka.

BBS. (2003). Monthly (February) Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the Peoples Republic of Bangladesh, Dhaka.

Bhonden.S., Ram.I.J., Pandy,B. and Tiwari.H.N. (1995). Effect of micronutrients on growth, yield and quality of onion. Newsletter National llort. Res. Dept. Foundation, **14-15** (1): 16-20.

BolT. P., Stuker.H., and. Gongalves. P.A.S., (1998). Effect of plant density on leal diseases and bulb production in onion. Fitopatologia, Brasileira. **23**(4):448-452.

Bongkyoon, K., (2004), Effect of vermicompost on growth of fall - cropping potato in volcanic ash soil. *Korean J. Crop. Sci.*,**49**: 305-308.

Bosch-Serra, A., Casanova.H., Challa,H., Monteira. A.A., Heuvelink.E., and Aguiar, P.A., (2000). Estimation of onion biomass and light interception from reflectance measurements at field level.

Bose, T.K. and Som.A.G., (1986).Vegetable Crops in Indian.First Edition.NayaPrakash , Calcutta. India, pp. 358-601.

Coelo, E.F., Souza-de, V.A.B. , Conceicao, M.A.F., and. De-Souza. V.A.B.,(1996). Performance of onion crops under three irrigation regimes and five spacing. Pesiquisa-Agropccuaria-Brasileria, **31**(8).545-591 [Cited from Hort., Abst.,**67**(10):1075, 19971.

Decampose, A.R., Comango, L.D.S. and Abramides.E, (1968). The effect of bulb spacing on onion seed production. Bragantia, 27.79-82.

Desai, V. R., Sabale, R. N. and Raundal, P. V., (1999), Integrated nitrogen management in heat- coriander cropping system. *J. Maharashtra Agric. Univ.*,**24**(3): 273-275.

Edwards, C. A. and Lofty, J. R.,(1972), Biology of Earthworms: Chapman and Hall, London, p.1-333.

Flapped, B.D. and Cox.K.I. (1973). Plant spacing for onion production. *Tasmanian J. Agric.*,**44**(1):31 -34.

Galmarini, C.R (1995). Effect of transplanting dates and plant density on yield response to onion. *I lort.-Argentina*, **14**(37):23-29.

Hanold.P. (1990).Taxonomy, evolution and history. In: Rabinowitch, H.D. and J.L. Brewster (eds), onions and Allied crops, CRC press. *Boca Raton, Florida*. **1**:1-26.

Hanumannaik,M., Srihari,G. and Gopala rao, B. (2013).Organic production of onion.*Crop Res*. **45** (1, 2 & 3): 218-220.

Harun-or-Rashid.A.R.M. (1998).Effects of NPKS on growth and yield of onion at different plant spacing. M.S. Thesis, Dept, of Hort., BAU, Mymensingh.

Heath.O.V.S. and Holdsworth.M, (1994). Morphogenic factors as exemplitied by the onion plant, in Growth. Relation to Differentiation and Morpho genesis, Symposis of the Society for experimental Botany II, Danielli, J.F. and Brown, R., Eds., Cambridge University Press, London, 326.Hort., 25(3-4): 139-141.

Hossain, A.K.M.A. and Islam J. (1994). Status of Allium production in Bangladesh. Acta I lort., 358:33-36.

Islam, M.K. (1998). Effects of set size, plant spacing and nitrogen levels on the growth and yield of onion cv. I aherpuri. M.S. Thesis, Dept, of Hort., BAU, Mymensingh.

Jambhekar, H. A., (1992), Use of earthworm as a potential source of decomposed organic wastes. In : Proc. Nation. Sem.OrganicFrmg : Mahatma PhuleKrishiVidyapeth, Pune, p.52-53.

Jones.H.A. and Mann.L.K., (1963). Onion and there Allies. Leonard Hill (Book) Ltd., London, 286p.

Kato, I. (1964). Physiological studies on hulh formation and dormancy in the onion plant. Ill Effect of internal factors on bulb formation and development. J. Hort. Assoc. Jpn., 33, 53.

Kondappa, D., Radder, Patil.B.M., Hebsur,P.L.,. and Alagundagi, S. C., (2009), Effect of integrated nutrient management on growth, yield and economics of chilli (Cv. Byadgidabbi) in a vertisol. Karnataka J. Agric. Sci., 22: 438-440.

Kumar, D., Singh.P.V.,. Ajay.K. Kumar,I. and Kumar,A., (2001). Effects of different levels of spacing on growth and yield of onion (Allium cepaL.). Indian Agril. Sci. Digst., 21:2, 139-140.

Kumar, V. and Neeraj, (2015).Evaluation of the performance of onion varieties in response to organic cultivation.In. J. of Advanced Res.Volume 3, Issue 9, 1558- 1562.

Kumar. H., Singh,J.V., Kumar,A. and Singh,M., (1986). Studied on the effect of spacing on growth and yield of onion cv. Indian J. Agril. Res., 32(2): 134-138.

Lopes J. F. (1987).Effects of planting dates and spacing on several characteristics of short day onion varieties grown in South I exas.Disst.Abst. Int., 48(6): 1564.

Macro, C.R. and Villmil,J. (1981). Effect of planting distance within rows on bulb size in Valencianatype onions. Investgacionesagronomicas., 2(l):82-85 (Cited from Hort. Abst. 53(5): 323, 19831.

Manivannan, S., Balamurugan, Parthasarathi, G., Gunasekharan and Ranganathan, R., (2009), Effect of vermicompost on soil fertility and crop productivity - beans (Phaseolus vulgaris) J. Environ. Biol., 30: 275-281.

Meena, A.K. Paliwal, R. and Meena, K. K.(2015). Effect of organic manures and bio-fertilisers on growth and quality attributes of kharif onion (Allium cepa L.) in semi-arid region Indian Res. J. Genet. & Biotech 7(1): 73 – 76.

Mehla, C.P., Baswana,K.S.,. Saharan,B.S., and Taya,J.S., (1993). Effects of row spacing and nitrogen levels on growth and yield of onion. Prog.

Mondal, M. F. (1986). Leal growth ol onion as intluenced by sowing date, plant density and irrigation. Bangladesh llort..14(2):41-43.

Mondal, M. F. (1991). Factors contributing the process of bulbing in onion a review .Bangladesh J. Agril. Sci., 18(1): 65-70.

Mondal, M.f. and Islam,N. (1987). Plant and bulb growth of onion as influenced by sowing date and plant density. Bangladesh Hort., 15(l):30-35.

Nagre, P.K., Kulwal,L.V. and Kale,P.B.(1985). Effect of different dates of transplanting and spacing on growth and yield ot onion cv. Local Ehite. PKV Res. J., 9(2):77-80.

Naik, B.H. and Hosamani,R.M.(2003). Effect of spacing and nitrogen levels on growth and yield olkharil onion. Karnataka J. Agril. Sci.,16(1):98-102.

Nehra, B.K., Pandita,L.M., and Singh,K. (1988). Cultural and nutritional studies in relation to seed production in onion. II. Eflectol bulb size. spacing and nitrogen on plant growth and seed yield. Haryana.J. Hort. Sci., Nichols, M.A. and Heydecker,W.(1964). Onion sets at four by six gave the highest returns. Grower, 61:1089.

Ngullie, E. Singh, Singh, V.B.and Singh, H. (2009) Fertilizing for Sustainable Onion Production Systems Am-Euras. J. Agric. & Environ. Sci., 5 (S): 01-55.

Pakyarck, Y., Abak,K., Sari,N., Guler,H.Y., Babik,I. and Rumpel,J. (1994). Effects ot sowing dates and plant densities on the yield and quality of some onion varities in Southest Anatolia. Acta Hort., 371:209-214.

Panday, IJ.B., Singh,L., Kumar,R. and Chaudhury,R.(1991). Response of different level of N, P, K on the yield and quality of Karif onion. Recent Advan.inMedi. Arom.and spice crops, 1:231-234.

Pandey, Y.B., Lallan,S. Raj,K., Singh,L. and Kumar,R.(1999). Studies on the effect of dates on transplanting and levels of nitrogen on the yield and quality of onion. Newsl. Assoc. Agril. Dev. f oundation, 10(3): 10-12.

Panse, G. V. G. and Sukhatme, R. V. (1989).Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Patil, M. P., Hulamani, N. C., Athani, S. I. and Patil, M. G., (1997), Response of Potato Solanum tuberosumkufrichandramukhi to integrated nutrient management. Adv. Agric. Res. India., 8:135-139.

Patil1, P. Ghag, P. and Patil, S. (2013). Use of Bio-fertilizers and Organic Inputs - as LISA technology by farmers of Sangamner. In. J. of Advancements in Res. & Tech. Volume 2, Issue 7..

Purewal.S.S. and Dargan,K.S.(1962).Fertilizer and spacing experiments with onion crop. Indian J. Agron., 7:46-53.

Purseglove, J.W.(1972). Tropical crops: Monocotyledons 1 and 2, Longman Group Ltd. London, pp. 32-50.

Rahim, M.A., Hussain,A. and Siddique,M.A. (1983). Production of bulbs and storage ability of three eultivars on onion. Punj. Veg. Grower, 17/18. 13-20.

Rajas.R.N., Cihulaxe S.N. and Tayde,S.R. (1993). Effects of vary ing levels of sulpher and spacing compared with frequencies of nitrogen on yield of onion grown in Vidardha. J. Soils. Crops. 3(l):37-40.

Rashid.M.A. and Rashid,M.M.(1976). Effect of spacing on the yields of onion. Bangladesh 1lort., 4(2): 18-22.KML

Saritha, D. (2005). Integrated nutrient management with nitrogenous fertilizers and caster cake in onion cv. Nasik Red (N-53). M. Sc. (Hort.) thesis submitted to Acharya N. G. Ranga Agricultural University, Hyderabad.

Singh, S. and Rathore,S.V.S. (1977). Effect of bulb spacing on seed production of onion (Allium cepa L.) Punjab Hort., 17:75-77.

Singh.A.K., Vijai,S. and Singh,V. (2000). Interaction effect of agronomical practices on kharif onion. Indian New-Botanist, 27:1-4. 115-118.

Singh.R.V. (1995).Response of onion to plant spacing and nitrogen, phosphorus fertilization. Res. J. Birsa. Agril. Univ., 17:75-77.

Stocer, B.T.(1980). The bulbing response to day length and temperature of some Australasian cultivars of onion (Allium cepa L), Aust. J. Agril.Res., 31, 54.

Stoffela.P.J.1(996). Planting arrangement and density ol transplants influences sweet Spanish onion yields and bulb size. Hort. Sc.31 (7): 1129-1130.

Suresh, C. and Bendegumbal.(2007). Studies on effect of organics on seed yield and quality in onion (Allium cepa L.) Department of Seed Science and Technology. cv. N-53.

Tarakanov. E. (1993). Response of photoperiod on growth of onion (Allium cepa L.). J. Natl. Inst. Agril. Bot. (G.B.), 45:20-29

Thomson, N.C. and. Kelly, W.C. (1957). Vegetable crops. Mac draw Mill Book Co. Inc., New York. pp. 353-362.

Tomati, V., Grapelli,A., Galli, E. and Rossi, W. (1983). Fertilizer from vermiculture as an option for organic waste recovery. Agrochem., 27:244-251. Vanessa and RajeshwariAnand, 2008, Influence of vermicompost on the yield of Sorghum bicolor. Uttar Pradesh J. Zool., 28: 259-265.

Ushakumari. K., Reddy, I.P.,. Reddy, M.D. and Neeraja,G. (2001). Effect of spacing and weed control methods on growth and yield of onion. Indian J. Weed Sci., 33:3-4,222-224.

Verma, J.P., Rathore, S.V.S and Ram,V.(1972). Effect of nitrogen and spactng on the performance of bulb crop of onion. Prog.Hort., 4(l):52-68.

Villagram, C.M. and Escaf, G.M.(1982). Effect of plant density and nitrogen fertilization on the yield and quality of onion bulbs. Agril.Iccnica, 42(3):215 [Cited from Hort. Abst., 53(7):488,1983J.

Vishnu.S. and Parbhakar ,B.S. (1989). Response of onion to spacing and phosphorus levels. Indian J. Hort., 46(3):379-381.

Wilson, G.J. and Hutton,R.C. (1983). Onion spacing. New Zealand Commercial Grower, 38(3):20.

Yadav, R. Dwivedi, Govind,D.H. and Majid, S. (2015) Department of Applied Plant Science, Babasaheb Bhimrao Ambedka University, Lucknow-226025.

APPENDICES

Appendix I.Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from March 2015 to June 2015

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2015	March	33.60	29.50	31.60	72.70	3.00	227.00
2015	April	33.50	25.90	299.20	68.50	1.00	194.10
2015	May	34.90	27.00	30.95	61.00	2.00	221.50
2015	June	35.60	29.30	32.45	72.65	2.50	229.40

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

Appendix II. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (µ gm/gm)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

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

Appendix III. Effect of vermicompost and spacing on plant height of summer onion

Treatments	Degrees of Freedom	Mean square of plant height (cm)			
		30 DAP	50 DAP	70 DAP	90A DAP
Replication	2	0.154	0.015*	0.944	0.627
Factor A	2	7.588*	4.058*	8.618*	5.500*
Factor B	2	13.54*	9.797*	10.89**	8.675*
AB	4	8.473**	2.340*	9.439*	12.96*
Error	16	0.111	1.170	1.167	2.039

Appendix IV. Effect of vermicompost and spacing on number of leaves plant^{-1} of summer onion

Treatments	Degrees of Freedom	Mean square of number of leaves plant^{-1}			
		30 DAP	50 DAP	70 DAP	90A DAP
Replication	2	0.009	0.099	0.203	0.087
Factor A	2	1.090*	1.514**	2.887*	3.794 *
Factor B	2	2.706**	8.103*	10.71*	4.245*
AB	4	0.213*	0.184**	0.694*	0.405*
Error	16	0.003	0.013	0.394	0.039

Appendix V.Effect of vermicompost and spacing on plant height of summer onion

Source of variation	Degrees of Freedom	Mean square of		
		Dry weight of leaves plant^{-1} (g)	Bulb diameter (cm)	Height of bulb (cm)
Replication	2	0.291	0.027	0.040
Factor A	2	4.144*	2.085*	1.404*
Factor B	2	6.048*	3.623*	5.610*
AB	4	0.685**	0.025**	0.644**
Error	16	1.047	0.165	0.016

Appendix VI. Effect of spacing and vermicompost on yield and yield contributing parameters showing fresh weight of bulb plant^{-1}, dry weight of bulb plant^{-1} and yield of summer onion

Treatments	Degrees of Freedom	Mean square of		
		Fresh weight of bulb plant^{-1} (g)	Dry weight of bulb plant^{-1} (g)	Yield (t ha^{-1})
Replication	2	0.003	0.023	0.294
Factor A	2	4.345*	8.220*	2.642*
Factor B	2	13.83*	23.77*	9.900*
AB	4	8.742*	2.208**	7.742*
Error	16	0.061	0.022	2.823

Appendix VII. Production cost of onion per hectare

A. Input cost

Treatment combination	Labour cost	Ploughing cost	Seedling cost	Water for plant establishment	Cost of Vermicompost	Insecticide/ Pesticides cost	Sub-total (A)
S_1V_0	16,000	8,000	20,000	6,000	0	2,000	52,000
S_1V_1	15,000	8,000	20,000	6,000	6,000	2,000	57,000
S_1V_2	14,000	8,000	20,000	6,000	12,000	2,000	62,000
S_2V_0	16,000	8,000	14,000	6,000	0	2,000	46,000
S_2V_1	15,000	8,000	14,000	6,000	6,000	2,000	51,000
S_2V_2	14,000	8,000	14,000	6,000	12,000	2,000	56,000
S_3V_0	16,000	8,000	10,000	6,000	0	2,000	42,000
S_3V_1	15,000	8,000	10,000	6,000	6,000	2,000	47,000
S_3V_2	14,000	8,000	10,000	6,000	12,000	2,000	52,000

Unit cost:

Labor = Tk 300 day^{-1}, Vermicompost = Tk 3000 ton^{-1}, Seedling cost = Tk 15 kg^{-1}, Selling cost = Tk 12.00 kg^{-1}

B. Overhead cost (Tk./ha)

Treatment combination	Cost of lease of land (Tk.8% of value of land cost/4 months)	Miscellaneous cost (Tk. 7% of the input cost	Interest on running capital for 4 months (Tk. 14% of cost/year)	Sub-total (Tk.) (B)	Total cost of production (Tk./ha) [Input cost (A) + overhead cost (B)]	Yield/ha	Gross return	Net return	BCR
S_1V_0	19,000	3,640	2,402	25,042	77,042	9.4	112800	35,758	1.46
S_1V_1	19,000	3,990	2,633	25,623	82,623	14.07	168840	86,217	2.04
S_1V_2	19,000	4,340	2,864	26,204	88,204	14.48	173760	85,556	1.97
S_2V_0	19,000	3,220	2,125	24,345	70,345	11.94	143280	72,935	2.04
S_2V_1	19,000	3,570	2,356	24,926	75,926	13.18	158160	82,234	2.08
S_2V_2	19,000	3,920	2,587	25,507	81,507	15.9	190800	109,293	2.34
S_3V_0	19,000	2,940	1,940	23,880	65,880	10.96	131520	65,640	2.00
S_3V_1	19,000	3,290	2,171	24,461	71,461	12.6	151200	79,739	2.12
S_3V_2	19,000	3,640	2,402	25,042	77,042	12.98	155760	78,718	2.02

Unit cost:

Labor = Tk 300 day^{-1}, Vermicompost = Tk 3000 ton^{-1}, Seedling cost = Tk 15 kg^{-1}, Selling cost = Tk 12.00 kg^{-1}