INFLUENCE OF NUTRIENT SOURCES ON GROWTH AND BULB YIELD OF ONION CULTIVARS

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DHAKA-1207

JUNE, 2020

INFLUENCE OF NUTRIENT SOURCES ON GROWTH AND BULB YIELD OF ONION CULTIVARS

By

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REG. NO. 13-05548

A Thesis

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

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2020

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CERTIFICATE

*This is to certify that the thesis entitled "**INFLUENCE OF NUTRIENT SOURCES ON GROWTH AND BULB YIELD OF ONION CULTIVARS**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **PULAK KUMER SARKER**, Registration. No. **13-05548** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:
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Dedicated
to
My Beloved Parents

ACKNOWLEDGEMENTS

With immense pleasure, the author wishes to express his heartfelt respect and gratitude to his beloved father ***Prollad Chandra Sarker*** *and mother* ***Monju Rani Sarker*** *whose everlasting love, unfading faith, incessant inspiration, moral and blessings kept him enthusiastic throughout his life and molded him to the present position and without which this work could not be completed.*

The author humbly takes this opportunity to place his profound debt of gratitude to his Supervisor ***Prof. Dr. Jashim Uddain****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his valuable suggestions, encouragement, affection, personal guidance, keen interest, immeasurable help and constructive criticism given throughout his work and making it possible to bring out this thesis. The author equally and deeply indebted to his Co-supervisor* ***Dr. Md. Noor Alam Chowdhury****, Senior Scientific Officer, Spices Research Centre, Shibganj, Bogura, for his cordial suggestions, constructive criticisms and valuable advice to complete the thesis.*

The author expresses his sincere gratitude to all of the respected teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their valuable counsel, note-worthy guidance, and cordial co-operation during the course of the investigation. The author acknowledges Sher-e-Bangla Agricultural University for providing excellent milieu and facilities in the completion of his post-graduation.

Not forgetting the kindness and punctuality of farm staff of Sher-e-Bangla Agricultural University Horticultural Farm, Dhaka, who have helped him during the period of study working in his experimental field.

*The author is really indebted to his beloved friends **Md. Jahedul Alam Forhad** and **Asif Noor** for their great support, help and encouragement.*

Above all, the author is grateful to 'Almighty God' for giving him enough strength and fortitude to his various challenges.

Needless to say, omissions and errors are entirely to the author.

The Author

INFLUENCE OF NUTRIENT SOURCES ON GROWTH AND BULB YIELD OF ONION CULTIVARS

ABSTRACT

The present research was undertaken with the aims to investigate the influence of nutrient sources and onion cultivars on growth and yield of onion in the field condition. The experiment was conducted during the period from October 2018 to March 2019 at Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment was performed with Randomized Complete Block Design which consists of two factors *viz.* Factor A: Nutrient sources- 4 Kinds *viz.* F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK) and F_3 = Vermicompost and Factor B: Cultivars of Onions- 3 Kinds viz. V_1 = BARI Piaz-1, V_2 = BARI Piaz-4 and V_3 = BARI Piaz-5. The results demonstrated that growth parameters, reproductive components, and yield were significantly different among the different treatments. The highest plant height (52.66 cm) and number of leaves plant^{-1} (6.61) were obtained from treatment combination V_1F_2 and V_2F_3, respectively. Though the highest straw yield (5.80 t) ha^{-1} was obtained from treatment combination V_1F_2 but the highest bulb length (4.15 cm), bulb diameter (4.46 cm), fresh weight of bulb (46.88 g), yield plot^{-1} (1125.28 g) and yield ha^{-1} (12.09 t) were obtained from treatment combination V_3F_2 while the lowest was recorded from V_2F_0. The highest yield was recorded in Onion cultivar BARI Piaz-5 with application of inorganic fertilizer (NPK) compared to other treatments.

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ABBREVIATIONS AND ACRONYMS

%	-	Percentage
AEZ	-	Agro-Ecological Zone
BBS	-	Bangladesh Bureau of Statistics
cm	-	Centimeter
DAT	-	Days After transplanting
DMRT	-	Duncan's Multiple Range Test
e.g.	-	exempli gratia (L), for example
et al.,	-	And others
etc.	-	Et cetera
FAO	-	Food and Agricultural Organization
g	-	Gram (s)
i.e.	-	id est (L), that is
K	-	Potassium
Kg	-	Kilogram (s)
L	-	Litre
M.S.	-	Master of Science
m^2	-	Meter squares
mg	-	Miligram
N	-	Nitrogen
no.	-	Number
^oC	-	Degree Celsius
P	-	Phosphorus
PSB	-	Phosphate Solubilizing Bacteria
RCBD	-	Randomized Completely Block Design
RDF	-	Recommended doses of Fertilizer
SAU	-	Sher-e-Bangla Agricultural University
TSS	-	Total soluble solids
var.	-	Variety
VC	-	Vermicompost

Chapter I
INTRODUCTION

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the Alliaceae family and is one of the most important spices as well as vegetable crops (Hanelt, 1990). In nature, it is semi-perishable and can be transported without much injury over a long distance. As a condiment and vegetable, onion is an indispensable item in every kitchen. The onion is therefore commonly referred to as the "Queen of the Kitchen." Onion, due to the presence of a volatile oil 'allyl propyl disulfide' - an organic compound rich in sulfur, is liked for its flavor and pungency.

The primary center of its origin is Central Asia and the second center for large onion types is the Mediterranean (McCullum, 1976). Now, it is growing across the globe. The world's leading onion-growing countries are China, Holland, Korea, Israel, Japan, Turkey, Syria, Iran, Egypt, the United States, Lebanon, Austria, and India (FAO, 2012). It is commercially cultivated in the greater Dhaka, Mymensingh, Rajshahi, Rangpur, Rajbari, Khustia, Khulna, Barishal, and Pabna districts in Bangladesh (BBS, 2015). Among Bangladesh grown spice crops, onion ranks top in terms of production and area (BBS, 2018). The total production of onion in Bangladesh is about 1866502 metric tons under the total cultivated area of 458969 acres (BBS, 2018). The total production of onion in Bangladesh is about 23.31 lakh metric tons under the total cultivated area of 2.08 lakh ha (AIS, DAE, 2020). It is most widely grown and popular vegetable crop among the *alliums* as well as cash crops.

The onion bulb is a rich source of minerals such as phosphorus, calcium, and carbohydrate. Also, it contains vitamin C and protein. It is utilized as fresh, frozen, dehydrated bulbs and green bunching types in several ways. It has good medicinal value. It contains several anti-cancer agents that have shown to prevent animals from developing cancer. A strong antioxidant, is a beneficial compound called 'quercetin' present in onions.

To a greater extent, onion has recently been used by the processing industry to prepare dehydrated forms such as powder and flakes (Singh, 2015).

Onion contains carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamins such as vitamin A (0.012 mg), vitamin C (11 mg), thiamin (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) as well as some minerals such as phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) per 100 g (Rahman *et al*., 2013).

In recent years, it has been realized that the proper use of nutrients is essential for higher yields and improved quality of onion. Under appropriate agro-climatic conditions, nutrient management is the main factor that significantly influences the growth and yield of onion. In modern agriculture, fertilizer is a major part of the cost of the production of onion. Higher yields of good quality bulbs can be produced by careful use of nutrients.

Onion is generally grown during the Rabi season in Bangladesh. The growth and yield of this crop is remarkably influenced by the management of different nutrients. There are two types of fertilizer, one is organic and the other is inorganic. It is established that the use of inorganic fertilizer for crops is not so beneficial to health due to residual effects, but that such problems do not arise in the case of organic fertilizers and, on the other hand, increased soil productivity as well as crop quality and yield (Tindall, 2000). However, excessive amounts of inorganic fertilizers are applied to onion for higher bulb yields (Shedeed, *et al.*, 2014).

Though, an increased nitrogen level increased the bulb's weight; the bulb's weight was reduced by white potassium at an increased level. In their study, 67.21 kg ha^{-1} nitrogen and 22.48 kg ha^{-1} potassium was found to give the highest yield of the local onion variety (Satter and Haque, 1975).

Foliar application of nutrients at proper growth phases is essential for their consumption and improved crop performance (Anadhakrishnaveni *et al.*, 2004).

Vermicompost is documented as a rich source of vital macronutrients (N, P, K, Ca, and Mg) and micronutrients (Fe, Mo, Zn, and Cu). Chemical analysis of vermicompost shows that N, P, and K contents were respectively 0.8, 1.1, and 0.5 percent (Giraddi, 1993). It is scientifically proven to be a miracle growth promoter and also a plant protector against pests and diseases. Vermicompost retains nutrients for a long time and vermicompost does not deliver the required quantity of macro and micronutrients, including vital NKP, to plants in a shorter time (Arancon *et al*., 2004). The process of converting organic waste into a bio-fertilizer with the help of traditional composting, which can be used to minimize environmental pollution and is a good alternative to limiting the use of chemical fertilizers for sustainable agriculture.

Allium is the onion genus, with 600-920 species, making it one of the largest plant genera in the world. BARI developed 6 onion varieties named as BARI Piaz-1, 2, 3, 4, 5 and 6. Among them 3 are summer and the rest are winter varieties.

Considering the above facts the present study was undertaken with three onion cultivars viz. BARI Piaz-1, BARI Piaz-4 and BARI Piaz-5 to assess their growth and yield potential when grown with different nutrient sources.

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

- To study the effect of different nutrient sources on growth and yield of onion ;
- To investigate the productivity of three onion cultivars ; and
- To determine the combined effect of nutrient sources and cultivars based on growth and yield of onion.

Chapter II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Onion (*Allium cepa* L.) is one of the world's main bulbous crops and one of Bangladesh's most important commercial vegetable crops. Onions are important crop of photo and thermo-sensitive bulbs. The production and storage of bulbs are influenced by various factors. Onion bulb production and storage are greatly influenced by environmental factors, agronomic practices, and cultivars (Mondal *et al.*, 1986; Mondal, 1991). Different kinds of nutrient play an important role in the growth and production of onions. Onion varieties may also vary in their sensitivity to temperature, nutrient sources, and photoperiod. Such sensitive varieties are cultivated in specific regions of the world and, in particular, in local seasons when the desired environment prevails. This chapter reviewed some relevant findings on cultivar performance and the nutritional effect of onion bulb production.

2.1 EFFECT OF NPK & S

Onion is sensitive to nutritional imbalance which has shallow roots with a high demand for nutrients and a long growing season. (Yaso *et al.*, 2007)

To produce high yields with good storage quality, the NPK fertilizers applied in the required amounts are crucial. Nitrogen is related to the content of chlorophyll and is essential for amino acids, proteins, and enzymes to be synthesized. In multiple physiological processes such as photosynthesis, plant metabolism, and improving the translocation of photo assimilates, phosphorus and potassium are important. El-Desuki, *et al*. (2006 a & b) and Marschner (1995).

Yadav *et al*. (2003) conducted an experiment to determine the optimum rate of potassium to obtain maximum and good quality of onion bulb. Four cultivars (Puna Red, White Marglobe, Nasik Red, and Rasidpura Local) were given three potassium rates (50, 100 and 150 kg ha^{-1}). The highest K rate recorded the highest plant height, leaf number per plant, leaf fresh weight, leaf dry weight, neck thickness, bulb equatorial diameter, bulb polar diameter, bulb fresh weight and bulb yield. The lowest K rate recorded the lowest neck thickness.

Islam (1999) conducted an experiment to find out the effects of different sources of potassium and different application methods on yield, yield attributes of onion, and potassium uptake by plants at Bangladesh Agricultural Research Institute, Gazipur during the winter of 1994-1995. Three sources of potassium (Muriate of potash. potassium nitrate, and potassium sulfate) and three application methods viz, basal, 1/2 basal + 1/2 at 20 days after transplanting (DAT) and 1/3 basal + 1/3 at 20 DAT + 1/3 at 40 DAT were used in the study. Maximum (35 kg ha^{-1}) and minimum (26 kg ha^{-1}) K accumulation were recorded in two split applications and a single basal application, respectively.

Rodriguez *et al.* (1999) carried out an experiments during 1993-94 and 1994-95 on onion to find out the effect of nitrogen, phosphorus and potassium rates, sources and forms upon onion (*Allium cepa* L.) bulb yield and quality. Yield, plant height, leaf number, and polar and equatorial diameters were measured in treatments with different rates, sources and forms of NPK. Significant effects of P and K rates (applied tip to 98.2 and 200 kg ha^{-1}, respectively) could not be detected, nor significant interactions between N and P.

Anwer *et al.* (1998) observed that the application of nitrogen, phosphorus, potassium, sulphur and zinc increased number of leaves $plant^{-1}$ along with higher bulb yield of onion with the increasing rates up to 150 kg N ha^{-1}, 120 kg P_2O_5 ha^{-1}, 120 kg K_2O ha^{-1}, 20 kg S $ha^{-1}$and 5 kg Zn ha^{-1} at Jashore area.

Harun-or-Rashid (1998) carried out a field experiment at the Bangladesh Agricultural University, Mymensingh on the effect of NPKS on growth and yield of onion at different plant spacing. He reported that the maximum bulb weight (40.50 g) and bulb yield (20.75 t ha^{-1}) were found from the combination of 125-150-150-30 kg N, P_2O_5, K_2O, S ha^{-1}. Whereas the minimum bulb yield (16.75 t ha^{-1}) was recorded from the control treatment. Application of NPKS increased the plant height, leaf number, length of bulb, bulb diameter, and bulb weight as well as the bulb yield. He recommended 100-150-200-30 kg N, P_2O_5, K_2O, S ha^{-1} for the cultivation of BARI peaj-1 at BAU Farm conditions.

Islam (1998) found that nitrogen at 120 kg ha^{-1} produced the maximum bulb weight and bulb yield (25.5 t ha^{-1}).

An experiment to investigate the effect of plant density and NPK fertilizers on the productivity of onions was carried out by Rizk (1997). A higher number of leaves per plant, higher fresh and dry weight, higher leaf areas, higher average bulb weights, and higher nitrogen uptake resulted in lower planting density. With dense planting, total bulb yield and yield of marketable bulbs were the highest. Increasing the NPK rate increased all the measured parameters of vegetative growth and increased the bulb yield. Two equal doses applied at 30 and 60 days after transplantation was the best application method for NPK.

Katwale and Saraf (1994) reported that the maximum bulb yield was obtained with the application of NPK at the rate of 125:60:100 kg ha^{-1}, respectively. The rate also gave the highest economic return.

Nasiruddin *et al.* (1993) reported the individual and combined effect of potassium and sulphur on growth and yield of onion and found an increase in plant height, leaf production ability, bulb diameter, bulb weight, and the bulb yield. They recommended 100 kg potash and 30 kg sulphur ha^{-1} for cultivation of onion.

Sangakkara and Piyadasa (1993) observed the effect on the growth and yields of shallot (onion) under uniform nitrogen and phosphorus levels of six levels of potassium supplied as KCl, when applied as either basal or split (basal and topdressing). Tinder, both rainfed and irrigated conditions were tested for these treatments. Potassium, along with dry weights, has increased bulb size, bulb numbers, and yields per shallot plant. The optimum yield was obtained at 100 kg K_2O per hectare when potassium was applied as basal. Split applications decreased the potassium requirement to 75 kg K_2O per hectare for optimal yields.

Vachhani and Patel (1993) studied the effect of different levels of nitrogen (50, 100 or 150 kg ha^{-1}), Phosphorus (25, 50 or 75 kg P_2O_5 ha^{-1}) and potash (50, 100 or 150 kg K_2O ha^{-1}) on the growth and yield of onion. They found that plant height, number of leaves $plant^{-1}$, bulb weight and yield were the highest with 150 kg N ha^{-1}, although bulb weight and yield with 100 kg N ha^{-1} were not significantly different. Increasing phosphorus application increased the number of leaves $plant^{-1}$ and weight, size and yield of bulbs. Application of K increased only the number of leaves per plants.

Rahim *et al.*(1992) conducted fertilizer trial with onion planted on 6^{th} November at a spacing of 25 X 15 cm and supplied with 0-160 kg ha^{-1} N and potassium 0-100 kg ha^{-1}, where half fertilizers were applied before planting and half 30 days after planting. The combined application of higher rate of N and K gave the maximum yield of 11.11 t/ha compared with 4.5 t/ha from control.

Sharma (1992) reported that at the rate of 40 kg ha^{-1}, the application of K through K_2O gave a significantly higher bulb compared to the control. There was no beneficial effect on further increases in the level of K. He also found that 81 kg of nitrogen and 59 kg of K_2O ha^{-1} were economically optimal doses. The optimum level of N and K response was up to 43.3 t/ha.

Baloch *et al.* (1991) obtained maximum bulb yield (22.66 t/ha) with the application of 125 kg N, 75 kg K_2O per ha. The highest plant height (38.5 cm), number of leaves per plant (17.0), single bulb weight (82 g), vertical bulb diameter (4.80 cm) and horizontal bulb diameter (5.78 cm) were obtained with 125 kg N + 100 kg K_2O per ha.

Pandey *et al.* (1990) studied the effect of four levels of nitrogen (0, 50, 100, and 150 kg ha^{-1}), three levels of phosphorus (0, 40, or 80 kg ha^{-1}) and two levels of potash (0 and 50 kg ha^{-1}), on the yield and quality of kharif onion. They found maximum yield and net return with N: P: K @ 130: 40: 50 kg ha^{-1}.

Duque *et al.* (1989) studied the growth and nitrogen, phosphorus and potassium uptake of onion. The results indicated that the plants demand for N and K was higher during early growth stages, whereas demand for P was continuous throughout the development. Uptake levels were 38.8, 38.6 and 71.3 kg N, P_2O_5 and K_2O, respectively, for the yield of 2.5 t/ha.

Saimhhi *et al.* (1987) reported that applying NPK at the highest rate gave the greatest bulb size, maximum yield (33.89 t/ha) and best quality of dehydrated onions. The highest NPK combination was 100 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare.

Amin (1985) reported that nitrogen at 60 kg ha^{-1} coupled with potash at 100 kg ha^{-1} gave the best performance in respect of bulb diameter (5.86 cm), bulb weight (64.70 g) and yield of onion (27.47 t/ha).

Madan and Sandhu (1985) noticed that effective plant growth and maximum bulb yield and dry matter yield were obtained with the application of N: P_2O_5: K_2O at 120: 60: 60 kg ha^{-1}.

Deshmukh *et al.* (1984) also reported beneficial effect of K on bulb yield of onion up to 40 kg K_2O ha^{-1}.

Satyanarayana and Arora (1984) reported that onion bulb yield increased with direct application of nitrogen up to 60 kg ha^{-1}, and potash up to 40 kg as K_2O Kg ha^{-1}.

Rashid (1983) recommended 10 tons cowdung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation in Bangladesh.

Agarwal *et al.* (1981) studied the yield of onion with N, P_2O_5, and K_2O at 80-160:40-80:40-80 kg ha^{-1}, respectively. The highest yield was obtained from plots receiving 160:40:40 or 80:40:80 kg ha^{-1}.

The effect of various row spacing tinder combinations of nitrogen, phosphorus, and potassium on the growth and yield of onions was studied by Gupta and Gaffar (1981). The application of NPK had a significant effect on the characteristics contributing to the yield and yield of the onion. From the NPK application @ 46: 36: 36 kg ha^{-1}, the economic yield was obtained.

The effects of FYM, ammonium sulphate, super phosphate and potassium sulphate were studied by Katyal (1977). He suggested to use 20 tons FYM, 100 kg ammonium sulphate, 175 kg super phosphate and 130 kg potassium sulphate per hectare before transplanting and a top dressing of another 150 kg ammonium sulphate in early stage of growth of onion crop.

Satter and Haque (1975) found that an increased nitrogen level increased the bulb's weight; the bulb's weight was reduced by white potassium at an increased level. In their study, 67.21 kg ha^{-1} nitrogen and 22.48 kg ha^{-1} potassium was found to give the highest yield of the local onion variety.

After one week of onion transplantation, the application of half nitrogen and potash and the remaining half after one week of the first application was reported to produce a higher yield than the application after one week of transplantation of full amount of nitrogen and potash (Tseng, 1972).

2.2 Effect of vermicompost

Kiros *et al.* (2018) studied on the NP fertilizer or organic resources alone may not provide sufficient amounts or may be unsuitable for alleviating specific constraints to crop production. Therefore, a field experiment was conducted at Maitsebri Research Station of Shire-Maitsebri Agricultural Research Center (SMARC) to study the effect of inorganic NP fertilizers and vermicompost on growth, seed yield and yield components of red onion (*Allium cepa* L.) variety during 2016-17 dry season under irrigation. The numbers of umbels per plant, umbel diameter, number of seeds per umbel and seed weight per umbel were significantly affected by the main effect of NP fertilizer rates and vermicompost. The highest seed yield per hectare (1462.5 kg ha^{-1}) was obtained from the combined application of 75% of RDF with vermicompost at 2.5 t ha^{-1}. It can improves growth, seed yield and yield components of Bombay red onion variety in the study area.

Dhaker *et al.* (2017), a field experiment was conducted during Rabi season 2016-17 to find out the effect of FYM and Vermicompost with or without PSB and Azotobacter and rates of organic manures (50% and 100% RND) on yield, quality and economics of onion (Agri Found Dark Red) on clay loam soil. Results revealed that the application of organic manure significantly influenced the diameter of the bulb (cm), bulb weight (g), bulb yield (q/ha), total soluble solid (^{0}B) and allylpropyl content (ppm) with 100% RDF through Vermicompost + PSB + Azotobacter.

Rao *et al.* (2017), conducted an experiment on the growth and yield of onion as affected by the application of vermicompost produced from tendu (*Diospyros melanoxylon*) leaf litter was studied in Maharashtra, India, during 2007. The treatments consisted of: 100% N through chemical fertilizer + 50 kg P/ha + 50 kg K/ha (T_1); 100% N through vermicompost produced by *Eudrilus eugeniae* + 50 kg ha^{-1} P + 50 kg K/ha (T_2); 50% N through vermicompost produced by *E. eugeniae* + 50% N through chemical fertilizer + 50 kg P/ha + 50 kg K/ha (T_3);

and control (T_4). T_1 increased the total yield by up to 7.25 t/ha after 120 days of treatment (DOT) and plant height by up 30.00% after 30 DOT compared to the control. After 60 DOT, leaf length increased by up to 2.60%. After 90 and 120 DOT, leaf size increased by 23.6 and 15.20%, respectively. T_2 enhanced plant height and increased the yield by up to 8.75 t/ha. Leaf length after 30 DOT increased by up to 50.00%. After 60 DOT, leaf length increased by up to 11.30%. After 90 and 120 DOT, leaf size increased by 36.45 and 53.64%, respectively. T_3 increased the total yield after 120 DOT by up to 9.75 t/ha. Plant height after 30 DOT increased by up to 51.60%. After 60 DOT, leaf length increased by up to 52.6%. After 90 and 120 DOT, leaf size increased by up to 71.4 and 56.65%, respectively.

Vedpathak and Chavan (2016) carried out a study about the effects of organic and chemical fertilizers on growth and yield characteristics of onion (*Allium Cepa* L.) at the outdoor nursery of Solapur University, an agricultural farm in the district of Solapur, Maharashtra State, India. The outcomes of field study showed that the highest length of leaves (cm/plant), single bulb weight (g/plant), bulb yield (kg/plot) were maximum with the application of a recommended dose of chemical fertilizer as compared to other fertilizer treatments. The application of vermicompost also gave the maximum plant biomass per plant of onion.

Kumar and Neeraj (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 a soil nutrient. The pre-harvest effect of the commercial bio-based product namely; *Trichoderma virid*e, 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 in the case of neem and *Trichoderma viride* application as compared to control.

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 the 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.

Yadav *et al.* (2015) carried out an experiment to assess the effect of integrated nutrient management on growth and yield of onion cv. Pusa Madhvi at Horticultural Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow, India during the year 2013-14. Ten 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 ^{0}B) 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. Pusa Madhvi under Lucknow condition having high soil pH of 8.2.

Indira and Singh (2014), a field experiment was conducted during the rabi season of 2008-2009 to study the effect of vermicompost and biofertilizer on yield and quality of rabi onion. The experiment was laid out in the split-plot design with four replications. There were twenty-four treatment combinations comprising of four levels of vermicompost viz. 5, 10, 15, 20 q ha^{-1} , three treatments of Azotobacter (A_1) i.e. Seedling dipping (A_1S_1), seed treatment (A_1S_2) and soil application (A_1S_3) and three treatments of Azospirillum (A_2) i.e. seedling dipping (A_2S_1), seed treatment (A_2S_2) and soil application (A_2S_3). The data revealed that among vermicompost application of 20 q/ha recorded significantly higher high fresh weight of bulb (43.04 g), bulb yield (251.20 q/ha), N content (0.918 %), TSS (11.07%) and pungency (6.63 mg/l00g) as compared to control. Among the biofertilizer levels, A_1S_2 recorded significantly maximum bulb yield (23.51 q/ha) fresh weight of bulb (42.13 q/ha) TSS (10.06 %) and it was similar with A_2S_2. Among the interactions the treatment 04, A_1S_2 recorded comparatively maximum fresh weight of the bulb (49.14 g) and bulb yield (269.52 q/ha) followed by 04 A_2S_2, 03 A_1S_2 and 03 A_2S_2 which were similar with each other.

In comparison to chemical fertilizer at RDF, Hanumannaik *et al.* (2013) conducted a three-year experiment to produce onions organically using farmyard manure, vermicompost, neem cake, and sheep manure. Plant height, bulb weight, and yield per ha were significantly influenced by different treatments. RDF produced the tallest plants while the shortest plants were produced by neem cake. With vermicompost, the diameter of the bulb was the maximum, while with sheep manure it was the least. The application of vermicompost resulted in the 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 the highest with RDF and least with sheep manure indicating organic farming in onion was not cheaper than farming with RDF.

Mandal *et al.* (2013) noted that maximum plant height, neck diameter, bulb polar and equatorial diameter, whole plant weight, and average bulb weight were recorded by the application of 50 % VC + 50 % NPK. A better option than the application of organic manure or chemical fertilizer alone was found to be the application of organic inputs in combination with chemical fertilizer. For 100% VC treated parcels, the maximum (15.01%) total soluble solids were recorded.

Naik and Hosamani (2013) 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^{-1}) on the growth and yield of kharif onion under rainfed condition. Narrow spacing of 15 ×10 cm with an application of 150kg N ha^{-1} was found optimum for enhancing yield (16.90 t ha^{-1}) another growth and quality parameters including plant height, leaf number $plant^{-1}$, bulb length, bulb diameter, and bulb total soluble solid content. As far as fertilizer treatments were concerned, T_4 (50% vermicompost +50% NPK) was proved to be the best fertilizer treatment for most of the traits. It recorded maximum plant height, bulb diameter and bulb weight. The same treatment also produced the highest bulb yield (353.80 q/ha). Applications of organic inputs in combination with chemical fertilizer were found a better option than the 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.

Patil *et al.* (2013) reported that, through land degradation, nutrient runoff, soil erosion, water pollution, soil compaction, loss of cultivated biodiversity, habitat destruction, contaminated food, and the destruction of traditional knowledge systems, modern agricultural practices affect our world. All of these result in the earth's changing climatic conditions. Owing to these climate changes, farmers are directly affected as it affects crop production. Sometimes, sudden changes in weather conditions lead to total crop failure. Through adopting organic farming, these ill effects of modern agriculture and climate change can be delineated.

This paper summarizes the use of biofertilizers and organic fertilizers by the farmers in Sangamner region of Maharashtra as low input Sustainable agricultural technology (LISA). Farmers are now using the biofertilizer, vermicompost, Poultry manure, jeevamrit as a source of organic manures in their fields in Sangamner.

Adhikary (2012) carried out an experiment to catch the imagination of philosophers like Pascal and Thoreau. Yet its role in the nutrition of agricultural fields has attracted the attention of researchers worldwide only in recent decades. Waste management is considered as an integral part of a sustainable society, thereby necessitating diversion of biodegradable fractions of the societal waste from landfill into alternative management processes such as vermicomposting. Earthworms excreta (vermicast) is a nutritive organic fertilizer rich in humus, NPK, micronutrients, beneficial soil microbes; nitrogen-fixing, phosphate solubilizing bacteria, actinomycetes and growth hormones auxins, gibberellins & cytokinins. Both vermicompost& its body liquid (vermiwash) are proven as both growth promoters & protectors for crop plants.

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

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

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

Reddy *et al.* (2010) conducted a field experiment on a sandy loam soil during kharif (onion) and rabi (radish) seasons of 2007-08 with a view to studying the effect of integrated use of vermicompost (0, 5 and 10 t ha^{-1}) and nitrogen fertilizers (0, 60, 90 and 120 kg N ha^{-1}) on soil dehydrogenase enzyme activity and yield of onion-radish cropping system. Application of 10 t vermicompost ha^{-1} + 120 kg N ha^{-1} recorded significantly highest fresh onion bulb yields (24.45 t ha^{-1}) at harvest.

Sinha *et al*. (2010) carried out an experiment on earthworms and its excreta (vermicast) promises to usher in the 'Second Green Revolution' by completely replacing the destructive agro- chemicals which did more harm than good to both the farmers and their farmland. Earth-worms restore & improve soil fertility and significantly boost crop productivity. Both earthworms and its vermicast & body liquid (vermiwash) are scientifically proving as both 'growth promoters & protectors' for crop plants. However, with application of vermicompost the 'organic nitrogen' tends to be released much faster from the excreted 'humus' by worms and those mineralised by them and the net overall efficiency of nitrogen (N) is considerably greater than that of chemical fertilizers. Availability of phosphorus (P) is sometimes much greater. It showed that earthworms and vermicompost can promote growth from 50 to 100% over conventional compost & 30 to 40% over chemical fertilizers besides protecting the soil and the agro-ecosystem.

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

Sharma *et al.* (2009) conducted an experiment of applying organic manures (vermicompost and farmyard manure) and inorganic fertilizers on yield and nutrient uptake by okra (*Abelmoschus esculentus*) - onion (*Allium cepa*) and nutrient build up in the soil were studied under field conditions. The highest yield of okra was recorded in the treatment comprising 100% recommended NPK + vermicompost @ 10 t ha^{-1}, 11.10 and 11.63 t ha^{-1} during 2003 and 2004, respectively. Similarly, the maximum yield of onion was observed in plots receiving 100% recommended NPK + 25 t vermicompost ha^{-1} during both the years i.e. 9.83 and 14.67 t ha^{-1} during 2003-04 and 2004-05, respectively. After completion of the experiment, the highest available NPK content were recorded in case of the treatment consisting of 10 t vermicompost ha^{-1} to okra and 25 t vermicompost ha^{-1} to the onion along with 100% NPK to these crops. A similar effect was observed on mineral composition and nutrient uptake.

Bybordi and Malakouti (2007) conducted an experiment in Khosrowshahr and Bonab, Iran, during the growing seasons of 2003 and 2004 to evaluate the effects of different sources of organic fertilizers on the yield and quality of the Azarshahr red onion variety. The highest yield (71.1 t/ha) was obtained when vermicompost @ 6 t/ha was applied.

Suresh and Bendegumbal (2007) conducted 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 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^{-1} + Azospirillum @ 5 kg ha^{-1}. Whereas, lowest bulb yield was obtained in poultry manure @ 4.2 t/ha (22.58 q/ha).

Reddy and Reddy (2005) conducted an experiment in Andhra Pradesh, India during 1996-98 to determine the effects of different levels of vermicompost (0, 10, 20 and 30 t/ha) and nitrogen fertilizer (0, 50, 100, 150 and 200 kg ha^{-1}) on the growth and yield of onion (cv. N53) and their residual effect on succeeding radish in an onion-radish (cv. Sel-7) cropping system. Furthermore, the yield of okra obtained at 5 t vermicompost ha^{-1} plus 100% NPK (9.73 and 10.83 t ha^{-1} during 2003 and 2004) was similar with that under 10 t farmyard manure + 100% NPK (10.03 and 10.46 t ha^{-1} during 2003 and 2004). Similarly, the yield of onion obtained at 12.5 t vermicompost ha^{-1} plus 100% NPK (8.38 and 12.56 t ha^{-1} during 2003-04 and 2004-05) was similar with that under 25 t farmyard manure ha^{-1} plus 100% NPK (8.86 and 12.08 t ha^{-1} during 200304 and 2004-05). This demonstrated the superiority of vermicompost over farmyard manure in okra-onion sequence.

2.3 Effect of Foliar Spraying

It was found that supplementary foliar fertilization increased the mineral status of plants and increased crop yields during crop growth (Rahman *et al*., 2014).

The nutrients have one of the chief importance in improving quality and productivity of vegetables which require mineral nutrients in large amount. Due to continuous inorganic fertilizers consumption results in micronutrients deficiency, disproportion in physiochemical properties of soil and low production of crops. For that reason these minerals are applied as affliction foliar form (Jeyathilake *et al.*, 2006).

Foliar application of nutrients at proper growth phases is essential for their consumption and improved crop performance (Anadhakrishnaveni *et al.*, 2004).

The assimilation rate of mineral nutrients by aerial components of plants differed not only among plant species but also among many different varieties of the same plant species (Wojcik, 2004).

Fertilizer is an important source of crop yield growth in agricultural practices. Foliar nutrition is one of the most important methods of application among fertilizer application techniques because foliar nutrients facilitate easy and quick nutrient consumption by penetrating the stomata or leaf cuticle and entering the cells (Latha and Nadanassababady, 2003).

Potassium nitrate, Calcium nitrate + Potassium chloride foliar spraying results in the highest vegetative growth and a significant reduction in the flaking rate during storage, increasing the percentage of exportable bulbs.

Foliar spray of micronutrients was performed with a reasonable success in Egypt on several crops in the Nile Valley, the Nile Delta and the adjacent reclaimed soils. (Abu Garb *et al*., 1993).

2.4 Effect of Cultivars

In Bangladesh, multiple onion cultivars are grown. There are large differences in size, shape, color, pungency, premature bolting, splitting, dry matter content, yield, and storage among the cultivars. In general, an ideal cultivar, resistant to insect pests & diseases, non-splitting type, free of premature bolting, high yielding, and capable of good storage, should be attractive, i.e. uniform in size, shape, and colour.

Rops (1996) reported that the application of split N did not affect the yield of the Jumbo, Hyfield and Hyskin onion cultivars, but an increased in the total amount of application of N led to higher yields.

Singh *et al.* (1996) carried out a field trial in Agra, India to observe the effects of N (0, 60, 120 or 180 kg ha^{-1}) and S (0, 20, 40 or 80 kg ha^{-1}) on the growth of onions (cv. Pusa Red). The yield and plant's N contents were significantly increased with N application. The yield and plant's S content also increased significantly with increasing rate of S to 40 kg ha^{-1}. Combined addition of N and S significantly increased its yield.

In the performance trials of the BARI exotic cultivars during the period 1981-93, it was concluded that although the exotic cultivars produced higher yields of up to 20 t ha^{-1}, their storage performance compared to our local cultivars was very poor. Many of the exotic cultivars yielded like the indigenous cultivars (Anonymous, 1993).

In trials conducted from 1984 to 1987, the onion cultivars Hybrid No. 1, Pusa Red, N-53, Anka Kalyan and Arka Niketan were planted on 3 dates (15 Jan., 30 Jan., and 15 Feb.). Bulb size and yield were the greatest with planting on 15 January. Pusa Red gave the highest yield of 184.6 q/ha and N-53 gave the lowest yield of 142.62 q/ha (Singh *et al.*, 1989).

An experiment was conducted at BAU, Mymensingh by Rabbani *et al.* (1986) with six exotic and a local cultivars of onion namely Red Creole, Polar, Hysol, Texas Yellow Grano, RS 2603, Tropical Red and Faridpuri Bhati. They reported that the highest number of leaves per plant was found in cultivar Faridpuri Bhati (13.3). The plant height of cv. Faridpuri Bhati was found to be 51.4 cm. Faridpuri Bhati also produced the maximum number of splitted bulbs (48.0%) while Red Creol had small quantity of splitted bulbs (14.0%). The bulb of Faridpuri Bhati had average diameter of 4.10 cm and average weight of 37.7 g. Faridpuri Bhati had dark green leaf and red coloured bulb and was highly pungent.

To study their maintenance quality, an experiment was conducted with sixteen exotic and one local onion cultivars at Central Research Station, BARI, Joydebpur. There was a marked varietal difference between them from this study. Within a month of storage, the bulbs of the exotic cultivars were found to begin to rot, and the progress of rotting causal by bacteria continued until all the bulbs were spoiled. It was further noted that at the end of the rainy season, the bulbs of only two cultivars, Faridpuri Bhati (local) and Red Tropicana, remained unaffected, at 97% and 35% of the total number of bulbs stored (Anonymous, 1983).

Rahim *et al.* (1983) studied the performance and keeping quality of two exotic and one local cultivars viz., Hissar-2, N-53 and Faridpuri local at the Bangladesh Agricultural University, Mymensingh. They reported that the plant height and leaf number observed in the cultivar Faridpuri local were 64.34 cm, and 14.48 cm respectively. The plants of Faridpuri local cultivar showed more premature bolting while the cultivar Hissar-2 did not show premature bolting. The variety Faridpuri local produced maximum number of splitted bulbs (26.30%) followed by the cultivars Hissar-2 (1.6%) and N-53 (1.04%). The bulb of Faridpuri local had minimum diameter (5.40 cm) and weight (73.59 g). Faridpuri local was red in bulb skin colour and highly pungent. Among three cultivars tested, N-53, an Indian cultivar eas found to be the best bulb yielder (13.23 tons/ha) and Hissar-2, another Indian cultivar was the second highest yielder (9.13 tons/ha) and the cultivar Faridpuri local was found to be the poorest yielder (7.65 tons/ha).

Rahman *et al.* (1976) who studied the effect on the local onion cv. Faridpuri Bhati. In both of the previous studies. MP was used as the source of potash while in another study conducted by Raza and Shaikh (1972) potassium sulfate was the source of potash. In the later work, 86% increased yield over control was obtained with a balanced mixuture at the rate $N_{60}P_{60}K_{60}$.

Rahman and Faruque (1975) studied the effect of NPK on onion cv. White Creole and found that potash had significant effect on the yield of onion in combination with nitrogen and phosphorus. The application of P_2O_5 and K_2O both at the rate of 22.45 kg ha^{-1} was found to be adequate.

Rashid (1976) recommended 10 tons cowdung, 175 kg urea, 125 kg TSP and 150 kg MP per hectare for successful onion cultivation. He also recommended that the ideal temperature and relative humidity for the storage of onion bulbs are 0°C and 70-75%, respectively.

Choudhury (1967) noted that onion is a cool season crop of India, but the crop can be grown in kharif season in the regions of mild climate. The cultivar N-53, transplanted in August produced good bulb in December-January under North-Indian conditions. The maximum cultivar yielded 23 tons of bulb per hectare. The yield of kharif crop was comparatively lower than that of the cool season.

Chapter III

MATERIALS AND METHODS

Chapter III
MATERIALS AND METHODS

Current research activities were carried out during the period from October 2018 to March 2019 at the Horticulture Farm at Sher-e-Bangla Agricultural University, Dhaka 1207. This chapter provided brief explanations of the soil, environment, materials, and methods used to conduct the experiment.

3.1 Experimental site

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka 1207, Bangladesh. It is situated at 8.6 meters above sea level at 90°32′ E longitude and 23°31′ N latitude. The land is within the Modhupur Tract, AEZ-28. The experimental site has been presented in Appendix I.

3.2 Climatic condition

The experimental area is characterized by less rainfall during the rabi season (October-March) and high temperature, high humidity, and heavy rainfall during the Kharif season (April-September) with occasional rainy winds. Details of the weather data such as temperature (^{0}C), precipitation (mm) and relative humidity (%) for the study period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1207 (Appendix II).

3.3 Soil condition

The soil of experimental area located under AEZ no. 28 and Tejgoan soil series (FAO 2012) at the Modhupur (UNDP 1988). Soil of tested area with a pH of 5.47 to 5.63 was sandy loam. The physical and chemical properties of the soil have been presented in Appendix III.

3.4 Planting material used for the experiment

The experiment was conducted using onion seeds, namely "BARI Piaz-1, BARI Piaz-4 and BARI Piaz-5." The seeds were collected from the Spices Research Center, Shibganj, Bogura.

3.5 Treatments of the experiment

The experiment consists of two factors which are given below:

Factor A: Nutrient sources- 4 Kinds

1. F_0 = Control
2. F_1 = Foliar spray (NPKS)
3. F_2 = Inorganic fertilizer (NPK)
4. F_3 = Organic (Vermicompost)

Factor B: Cultivars of Onions– 3 Kinds

1. V_1 = BARI Piaz-1
2. V_2 = BARI Piaz-4
3. V_3 = BARI Piaz-5

There are 12 treatment combinations are given bellow:

V_1F_0, V_1F_1, V_1F_2, V_1F_3, V_2F_0, V_2F_1, V_2F_2, V_2F_3, V_3F_0, V_3F_1, V_3F_2, V_3F_3.

3.6 Design of the experiments

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

3.7 Layout of the field experiment

First, the experimental field was divided into three blocks. For the treatment combinations, each block was divided into 12 plots. There were 36 plots in total. Each block was subsequently assigned to 12 treatment combinations according to the experimental design. The plot size was 1 m × 0.9 m. In each unit plot, a distance of 25 cm was maintained between the rows and 15 cm between the plants. The distance between the two plots was 0.5 m with blocks being 0.75 m. The field layout is shown in Figure 1.

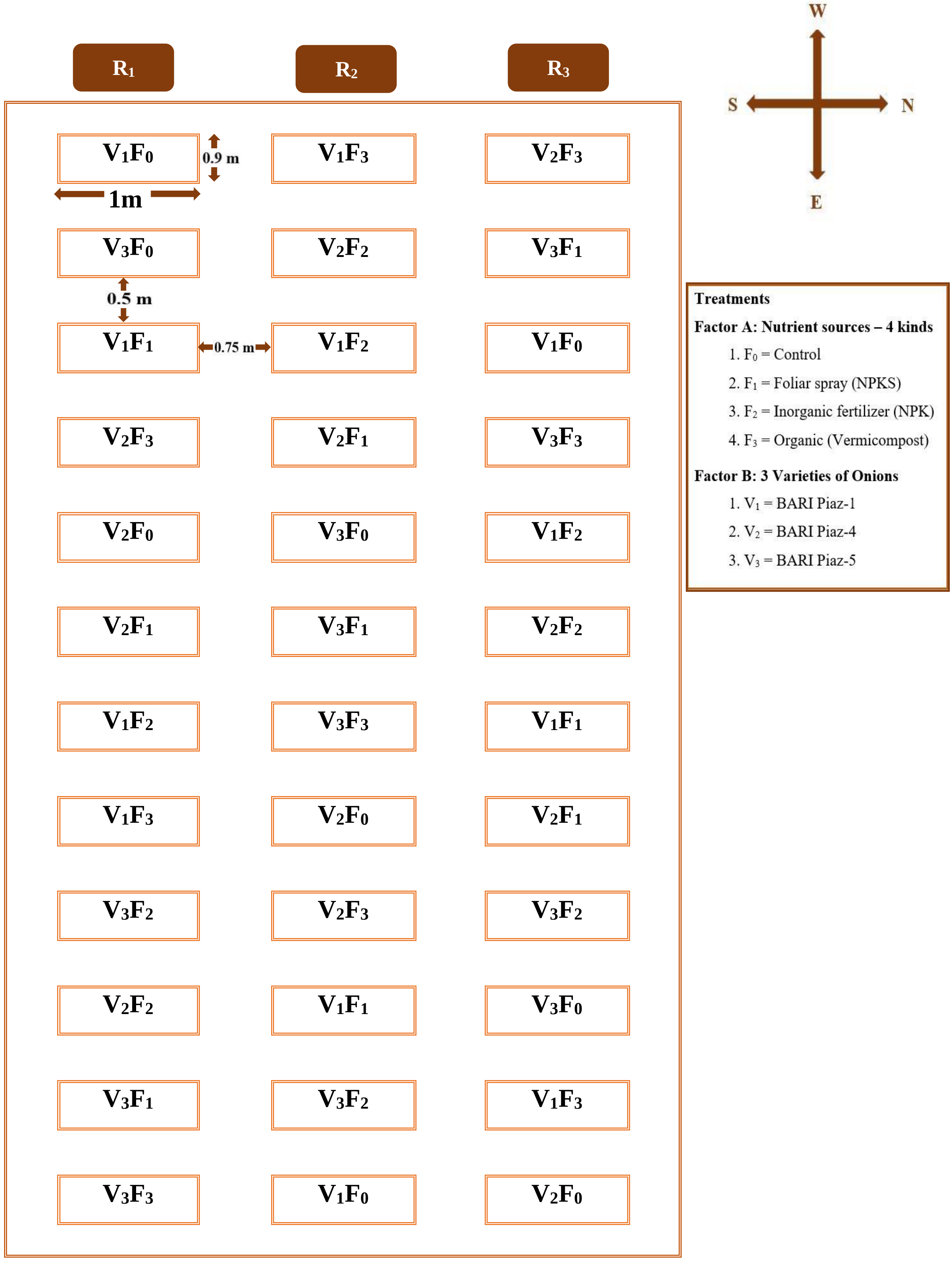

Figure 1. Layout of the field experiment

3.8 Details of the field operations

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

3.8.1 Seedbed preparation

The land selected to raise seedlings was nicely textured and well-drained. The land had been opened up and dried for 10 days. Seedbed was made for the raising of seedlings on 28 October 2018 and the seedbed size was 3 m^2 with a height of about 20 cm. The soil was well ploughed and converted to loose friable and dried masses to get good tilth for making seedbed. The seedbed had removed weeds, stubbles, and dead roots. Cowdung, @ 10 t ha^{-1}, was applied to the prepared seedbed. The application of Furadan 3G @ 20 kg ha^{-1} for two days was covered by polythene. Onion seeds were soaked overnight (12 hours) in water and allowed to sprout in a piece of moist cloth keeping in the sun shade for one day.

3.8.2 Seed treatment and sowing

Seeds were treated by Vitavax-200 @ 5g/kg seeds to protect some seed-borne diseases. The seed sowing date was November 8, 2018. Seeds were sown in the seedbed to produce seedlings that were 35 days old. The seeds were seeded at a depth of 0.6 cm and covered with a thin layer of soil, followed by a light watering. The young seedlings were exposed to morning and evening dew by night and mild sunshine. Shade was given to retain soil moisture over the seedbed and saved the seedlings from direct sun and rain.

3.8.3 Raising of seedlings

Light watering and weeding were done in several times. No chemical fertilizer was used to raise the seedlings. When seedlings reached about 10 cm in height, the thinning operation was done. On 11 December 2018, healthy, 35 days old seedlings were transplanted into the main field.

3.8.4 Land preparation

The experimental area was first opened by a disc plough in direct sunshine to kill soil-borne pathogens and soil-inhabitant insects on 03 December 2018. Then the land was prepared to bring a good tilth by ploughing several times and cross-ploughing with a power tiller followed by laddering. The land had been leveled, the corners had been formed, and the clods had been broken to pieces. The weeds, residues of crops, and stables were taken out of the field. At final ploughing, the basal dose of manures and fertilizers was applied. The plots were prepared according to the design and layout. The soil was treated by Sevin 50 WP @ 5 kg ha^{-1} to protect young plants from the attacks of mole crickets, ants, and cutworms.

3.8.5 Manures and fertilizers

The BARI recommended doses for onion production of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) according to soil analysis interpretation. However, the recommended doses of chemical fertilizer as in the experimental field for low land (Urea- 17.6 g, TSP- 20.25 g and MP- 18 g per plot), vermicompost (0.9 kg $plot^{-1}$) and foliar spray (NPKS) @ 15 ml solution in L^{-1} water (at 10, 20, 30, and 40 DAT) was applied according to the treatment assigned in the present study.

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

Soil analysis interpretation	N	P	K	Cowdung (t/ha)
Optimum	0-30	0-15	0-40	
Medium	31-60	16-30	41-80	5
Low	**61-90**	**31-45**	**81-120**	
Very Low	91-120	46-60	121-160	

Source: Fertilizer recommendation guide 2012.

3.8.6 Transplanting of seedlings

On 11 December 2018, healthy and disease-free uniform 35 days old seedlings were removed from the seedbeds and transplanted to the main field as per treatment after a slight trimming of healthy seedlings' leaves and roots and maintaining a spacing of 25 cm × 15 cm. Before uprooting the seedlings, the seedbed was watered to minimize root damage. Following transplantation, the seedlings were watered immediately. There were also some seedlings transplanted adjacent to the experimental area to be used for gap fillings.

3.8.7 Intercultural operations

Whenever necessary, intercultural operations were carried out after seedlings were transplanted to achieve better plant growth and development. So, under careful observation, the crop was always kept.

3.8.7.1 Gap filling

Required gap filling was carried out within a week with the use of healthy plants of excess plants. Dead or damaged seedlings were removed.

3.8.7.2 Weeding

After the transplant, weeding was done three to four times to keep the crop free of weeds.

3.8.7.3 Earthing up

Earthing up has been provided through breakage of a soil crust, piling of soil at the base of a plant for ease of aeration, soil moisture and temperature preservation, improvement of germination and emergence, high yields, and quality, prolonged seasonal higher product nutritional benefits, improved storability, etc. This would also improved the onion seed quality**.**

3.8.7.4 Irrigation and drainage

Watering cane and hose pipe were used for irrigation when required. Immediately after transplantation, the first irrigation was given. During that time, care was taken to prevent irrigation water from passing between plots. Mulching was also done by breaking the soil crust after irrigation. The soil was saturated with water during the irrigation process. Excess water was drained if necessary after rainfall.

3.8.7.5 Plant protection

Preventive measures against soil-borne insects were taken. For preventing cutworm invasion, Furadan 3G @ 20 kg ha^{-1} was applied. No insect infestation was found in the field after the application of the pesticide. Some plants were attacked by purple blotch disease caused by *Alternaria porri* a few days after transplantation. It is controlled by spraying Rovral 50 WP @ 2 g/L of water at 7-day interval.

3.8.8 Harvesting

The crop was harvested on 28 March, 2019 to their completion of maturity showing the sign of drying up most of the leaves and collapsing of neck. With the help of a hand, onions were lifted and care was taken so that no bulb was injured during lifting. The tops were removed after harvesting by cutting off the pseudostem and holding with the bulb for 2.5 cm.

3.8.9 Storage of bulbs

The bulbs of each harvest had been dried in the field in shade for one day with the tops. The following day after harvesting, the tops were separated leaving 2 cm of the neck. Bulb curing was performed for 7 days in a room at ambient temperature (29.6 ± 2.6^{0}C) and then stored in a well-ventilated room.

3.9 Collection of data

Data were collected on the following parameters:

1) Plant height (cm)

2) Number of leaves plant^{-1}

3) Onion stem diameter (cm)

4) Bulb length (cm)

5) Bulb diameter (cm)

6) Neck diameter (cm)

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

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

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

10) Straw (Onion leaf) yield plot^{-1} (g)

11) Straw (Onion leaf) yield ha^{-1} (t)

3.10 Procedure of recording data

3.10.1 Plant height (cm)

After 30 days of transplantation, the height of the randomly selected six plants was measured from each plot to 60 DAT with an interval of 15 days. The height was measured by centimeter (cm) from the ground level to the tip of the longest leaf and the average height of six plants was calculated in centimeter.

3.10.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} was calculated from the randomly selected six plants of each plot and the mean was recorded. After 30 to 60 DAT with 15 days of interval, the number of leaves plant^{-1} of each unit plot was measured.

3.10.3 Stem diameter (cm)

The onion stem diameter of 6 randomly selected plants from each plot was measured at the time of harvest. The length was measured in centimeter (cm) and the average diameter of the stem was calculated in centimeter.

3.10.4 Bulb length (cm)

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

3.10.5 Bulb diameter (cm)

Following harvesting, the bulb diameter was measured in the middle portion of six randomly selected plants using slide calipers from each plot and their mean value was taken in centimeter.

3.10.6 Neck diameter (cm)

After harvesting, the neck diameter of six randomly selected plants were measured with a slide calipers and the average mean was calculated and expressed in centimeter.

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

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

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

From each replication of each treatment combination, all the bulbs have been collected. Bulb weight per plot was measured by an electric balance and then expressed as bulb yield gram (g) per plot average.

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

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

3.10.10 Straw (Onion leaf) yield plot^{-1} (g)

From each replication of each treatment combination, all the straw of bulbs were collected. Bulb weight per plot was measured by an electric balance and then expressed as bulb yield gram (g) per plot average.

3.10.11 Straw (Onion leaf) yield ha^{-1} (t)

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

3.11 Statistical analysis

To determine the statistical significance of the treatment effect, the data collected on different parameters were statistically analyzed using SPSS software (Version 20.00). The mean values of all the treatments were calculated, and the F-test carried out variance analyzes for all the characters. DMRT (Duncan's Multiple Range Test) estimated the significance of the difference between the treatments and mean combinations at a 5% significance level (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the effect of different sources of nutrients and cultivars on the growth and yield of onion. The results of the study were presented, discussed, and compared in this chapter through tables, figures, and appendices. The analysis of variance (ANOVA) data for all parameters was shown in Appendix IV- VII. The results were presented and discussed with the help of tables, graphs, and possible interpretations under the following subheadings.

4.1 Plant height (cm)

4.1.1 Effect of nutrient sources

Plant height at different growth stages was significantly influenced by different types of nutrient sources (Figure 2 and Appendix IV). At 30 DAT the highest plant height (22.91 cm) at was found from the F_2 (Inorganic fertilizer) treatment where the lowest plant height (18.33 cm) was found from the treatment F_0 (Control). Finally, at 60 DAT the highest plant height (48.74 cm) at was found from the F_2 (Inorganic fertilizer- NPK) treatment where the lowest plant height (45.16 cm) was found from the treatment F_1 (Foliar). Rizk (1997) found that increasing the NPK rate increased all the measured parameters of vegetative growth and increased the bulb yield.

At harvest, the highest plant height (41.64 cm) was found from the treatment F_3 (Vermicompost) which was numerically higher than all other treatments and the lowest plant height (41.02 cm) was found from the treatment F_2 (Inorganic-NPK) though all the treatments are statistically similar.

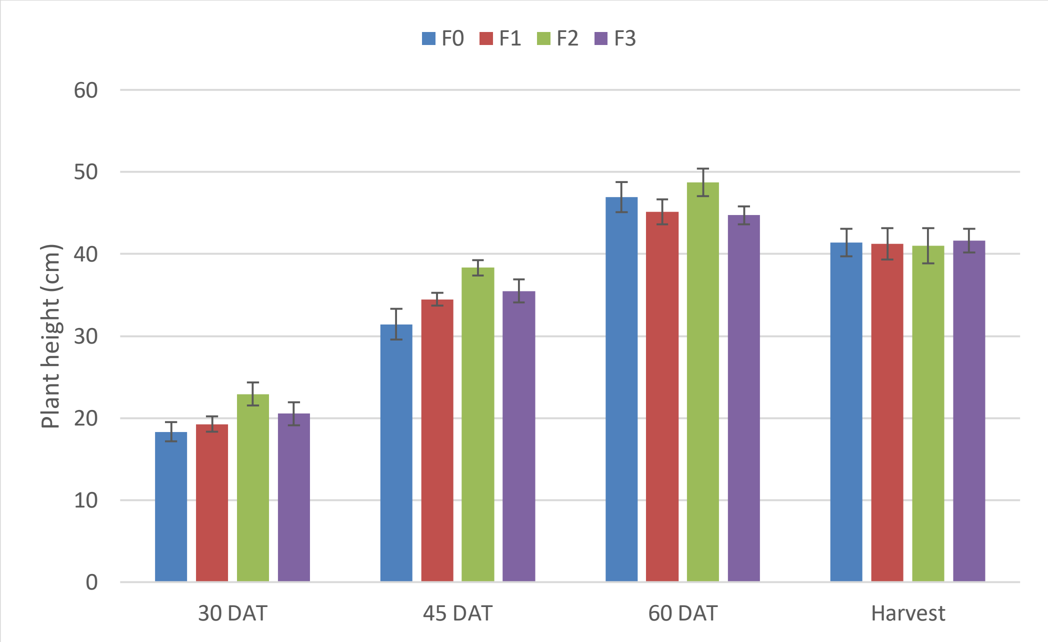

Figure 2. Effect of Nutrient sources on plant height (cm) at different days after transplanting of onion

DAT: Days after transplanting; Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.1.2 Effect of cultivar

There was a significant variation on plant height of onion influenced by different levels of nutrients application at different growth stages (Figure 3 and Appendix IV). At 30 DAT the highest plant height (22.46 cm) at was found from the V_2 (BARI Piaz-4) treatment where the lowest plant height (19.02 cm) was found from the treatment V_3 (BARI Piaz-5). Finally, results revealed that the highest plant height (47.84 cm) at 60 DAT was found from the treatment V_1 (BARI Piaz-1) which was significantly different from all other treatments followed by V_3 (BARI Piaz-5) treatment. The lowest plant height (44.41 cm) at 60 DAT was found from the treatment V_2 (BARI Piaz-4). At harvest, the highest plant height (44.69 cm) was found from the treatment V_1 (BARI Piaz-1) which was significantly different from the lowest plant height (35.86 cm) was found from the treatment V_2 (BARI Piaz-4).

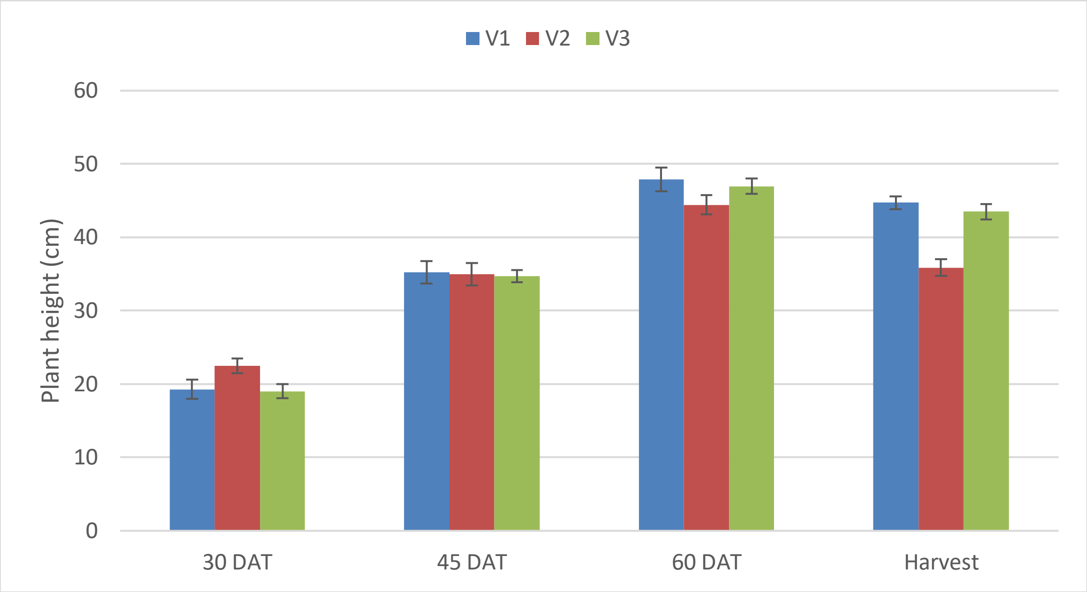

Figure 3. Effect of cultivar on plant height at different days after transplanting of onion

DAT: Days after transplanting; Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.1.3 Combined effect of nutrient sources and cultivar

The combined effect of different cultivar and nutrient sources showed positively significant variation in plant height on all dates of observation (Table 2 and Appendix IV). At 30 DAT, the tallest plant (25.05 cm) was measured from V_2F_2 combination which was statistically similar to eight more treatment combination except the shortest (16.19 cm) was recorded from V_1F_1 combination which was statistically similar to V_1F_0, V_3F_3. At 45 DAT, the tallest plant height (40.16 cm) was recorded from V_1F_2 combination which was statistically similar to V_2F_3 and the shortest (28.11 cm) was measured from V_2F_0 combination. At 60 DAT, the tallest plant height (52.66 cm) was recorded from V_1F_2 and the shortest (40.28 cm) was recorded from V_2F_1 combination, those were statistically non-significant. At harvest, the highest plant height (47.22 cm) was found from the treatment combination V_1F_2, which was statistically similar to all other treatment combinations except the lowest plant height (33.89 cm) was found from the V_2F_2 treatment combination, which was statistically similar to V_2F_1, V_2F_0, V_2F_3 treatment combinations (35.28 cm).

Table 2. Combined effect of nutrient sources and cultivar on plant height (cm) at different days after transplanting of onion

Treatment	Plant height (cm) at			
	30 DAT	45 DAT	60 DAT	Harvest
V_1F_0	16.55 ± 2.09^{b}	31.80 ± 4.57^{cd}	48.25 ± 4.20^{a-c}	42.89 ± 0.83^{ab}
V_1F_1	16.19 ± 0.29^{b}	32.94 ± 0.91^{b-d}	46.67 ± 1.78^{a-c}	45.00 ± 2.38^{ab}
V_1F_2	24.05 ± 2.12^{a}	40.16 ± 2.10^{a}	52.66 ± 3.74^{a}	47.22 ± 1.36^{a}
V_1F_3	20.33 ± 2.58^{ab}	35.94 ± 2.54^{a-c}	43.77 ±1.55^{bc}	43.66 ± 2.12^{ab}
V_2F_0	19.40 ± 2.92^{ab}	28.11 ± 3.14^{d}	43.33 ± 3.00^{bc}	35.55 ± 1.56^{cd}
V_2F_1	21.50 ± 0.53^{ab}	34.27 ± 1.23^{a-d}	40.28 ± 2.21^{bc}	35.28 ± 1.90^{d}
V_2F_2	25.05 ± 0.80^{a}	38.22 ± 1.20^{a-c}	46.72 ± 1.89^{a-c}	33.89 ± 2.09^{d}
V_2F_3	23.91 ± 1.29^{a}	39.27 ± 0.36^{ab}	47.33 ± 2.11^{a-c}	38.72 ± 3.27^{b-d}
V_3F_0	19.02 ± 0.74^{ab}	34.41 ± 0.77^{a-d}	49.27 ± 1.84^{ab}	45.83 ± 1.83^{a}
V_3F_1	20.08 ± 1.61^{ab}	36.27 ± 1.44^{a-c}	48.55 ± 0.47^{ab}	43.55 ± 2.60^{ab}
V_3F_2	19.62 ± 3.26^{ab}	36.64 ± 1.39^{a-c}	46.83 ± 2.45^{a-c}	41.94 ± 2.07^{a-c}
V_3F_3	17.36 ± 2.13^{b}	31.30 ± 1.27^{cd}	43.11 ± 1.54^{bc}	42.55 ± 2.05^{ab}
Significance level	**	**	NS	***

** Significant at >0.01- <0.05 level of probability; *** Significant at 0-0.01 level of probability and ^{NS}Non-significant

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
DAT: Days after transplanting; Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.2 Number of leaves plant^{-1}

4.2.1 Effect of nutrient sources

For the variation of different nutrient sources the number of leaves plant^{-1} of onion was influenced at different days after transplanting (DAT) (Figure 4 and Appendix V). At 30 DAT, the maximum number of leaves plant^{-1} of onion (3.50) was measured from F_2 (Inorganic fertilizer) which was statistically similar to that of F_3 (Vermicompost) and the minimum number of leaves plant^{-1} of onion (2.94) was recorded from F_0 (Control). At 45 DAT, the maximum number of leaves plant^{-1} of onion (4.68) was recorded from F_3 (Vermicompost) which was statistically similar to that of F_1 (Foliar spray) and the minimum number of leaves plant^{-1} of onion (4.38) was measured from F_0 (Control).

At 60 DAT, the maximum number of leaves plant^{-1} of onion (6.23) was recorded from F_2 (Inorganic fertilizer) which was statistically similar to that of F_3 (Vermicompost) and the minimum number of leaves plant^{-1} of onion (5.86) was recorded from F_0 (Control) and F_1 (Foliar spray) treatment. The variation in a number of leaves plant^{-1} as influenced by nutrient sources was perhaps due to proper availability and utilization of nutrients. Gurjar *et al.* (2017) found that better growth of leaves plant^{-1} as an effective nutrient sink of the bulb, which eventually translated into higher yield.

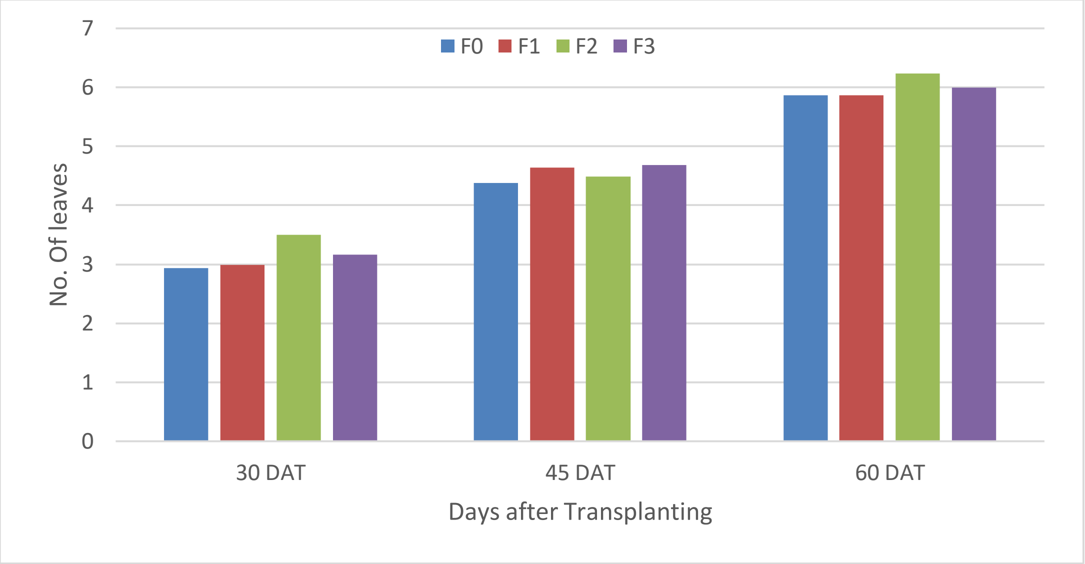

Figure 4. Effect of nutrient sources on no. of leaves at different days after transplanting of onion

DAT: Days after transplanting; Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.2.2 Effect of cultivar

Good foliage indicates higher growth, development, and productivity of the plant. In the present study, the number of leaves per plant was found to be significantly influenced by cultivar (Figure 5 and Appendix V). At 30 DAT, the maximum number of leaves plant^{-1} of onion (3.45) was measured from V_1 (BARI Piaz-1) which was statistically similar to that of V_2 (BARI Piaz-4) and the minimum number of leaves plant^{-1} of onion (2.84) was recorded from the V_3 (BARI Piaz-5) treatment.

At 45 DAT, the maximum number of leaves plant^{-1} of onion (4.79) was recorded from V_1 (BARI Piaz-1) which was statistically similar to that of V_2 (BARI Piaz-4) and the minimum number of leaves plant^{-1} of onion (4.38) was measured from V_3 (BARI Piaz-5). At 60 DAT, the maximum number of leaves plant^{-1} of onion (6.36) was recorded from V_2 (BARI Piaz-4) which was statistically similar to that of V_1 (BARI Piaz-1) and the minimum number of leaves plant^{-1} of onion (5.7) was recorded from V_3 (BARI Piaz-5) treatment.

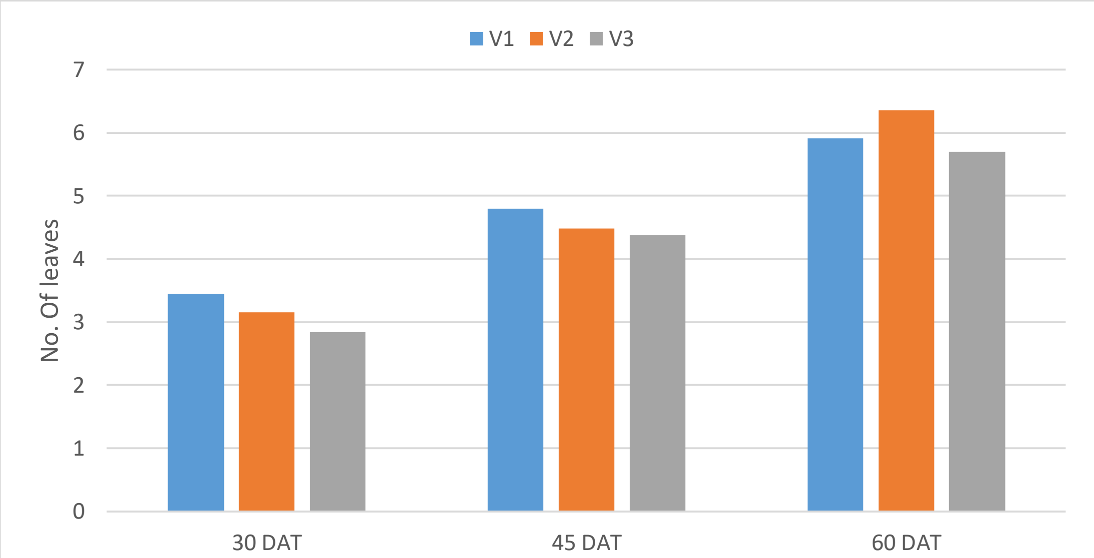

Figure 5. Effect of cultivars on no. of leaves at different days after transplanting of onion

DAT: Days after transplanting; Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.2.3 Combined effect of nutrient sources and cultivar

The combined effect of different nutrient source and cultivar showed positively significant variation at early dates (30 DAT) of observation (Table 3 and Appendix V). At 30 DAT, the maximum number of leaves plant^{-1} of onion (4.0) was found from V_1F_2 combination which was statistically similar to V_1F_3 and the minimum number of leaves plant^{-1} of onion (2.55) was recorded from V_3F_1 combination. At 45 DAT, the maximum number of leaves plant^{-1} of onion (4.83) was recorded from V_1F_1 combination which was statistically similar to rest treatments. The minimum number of leaves plant^{-1} of onion (3.99) was measured from V_2F_0 combination.

At 60 DAT, the maximum number of leaves plant^{-1} of onion (6.61) was recorded from V_2F_3 which was statistically similar to all other treatments and the minimum number of leaves plant^{-1} of onion (5.50) was recorded from V_3F_3 combination.

Table 3. Combined effect of cultivar and nutrient sources on no. of leaves at different days after transplanting of onion

Treatment	No. of leaves at		
	30 DAT	45 DAT	60 DAT
V_1F_0	$3.11 \pm 0.30^{b\text{-}d}$	4.66 ± 0.25	5.83 ± 0.19
V_1F_1	$3.11 \pm 0.22^{b\text{-}d}$	4.83 ± 0.17	5.55 ± 0.36
V_1F_2	4.00 ± 0.33^{a}	4.72 ± 0.22	6.39 ± 0.45
V_1F_3	3.61 ± 0.15^{ab}	4.94 ± 0.15	5.89 ± 0.31
V_2F_0	2.83 ± 0.25^{cd}	3.99 ± 0.25	6.11 ± 0.39
V_2F_1	3.33 ± 0.17^{bc}	4.72 ± 0.05	6.39 ± 0.20
V_2F_2	$3.22 \pm 0.15^{b\text{-}d}$	4.49 ± 0.17	6.33 ± 0.34
V_2F_3	$3.22 \pm 0.15^{b\text{-}d}$	4.72 ± 0.11	6.61 ± 0.14
V_3F_0	2.88 ± 0.05^{cd}	4.50 ± 0.09	5.66 ± 0.19
V_3F_1	2.55 ± 0.15^{d}	4.38 ± 0.33	5.66 ± 0.33
V_3F_2	3.28 ± 0.11^{bc}	4.27 ± 0.05	5.99 ±0.25
V_3F_3	2.66 ± 0.25^{cd}	4.39 ± 0.39	5.50 ± 0.28
Significance level	***	NS	NS

*** Significant at 0-0.01 level of probability and ^{NS} Non-significant

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.3 Stem Diameter (cm)

4.3.1 Effect of nutrient sources

With the application of different nutrient, stem diameter showed non-significant variation (Figure 6 and Appendix VI). AT 30 DAT, the highest stem diameter (0.43 cm) of onion was recorded in the treatment F_2 (Inorganic Fertilizer) which was statistically similar to F_1 (Foliar spray) and the lowest stem diameter (0.37 cm) of onion was recorded in the treatment F_0 (Control). AT 45 DAT, the highest stem diameter (0.67 cm) of onion was recorded in the treatment F_2 (Inorganic fertilizer) which was statistically similar to F_1 (Foliar spray) and F_3 (Vermicompost). The lowest bulb length of onion was recorded in the treatment F_0 (0.59 cm). AT 60 DAT, the highest (1.34 cm) stem diameter of onion was recorded in the treatment F_2 (Inorganic fertilizer) which was statistically similar to F_1 (Foliar spray) and the lowest (1.18 cm) bulb length of onion was recorded in the treatment F_3 (Vermicompost). The result might be due to the fact that different types of nutrients enhances the development of onion.

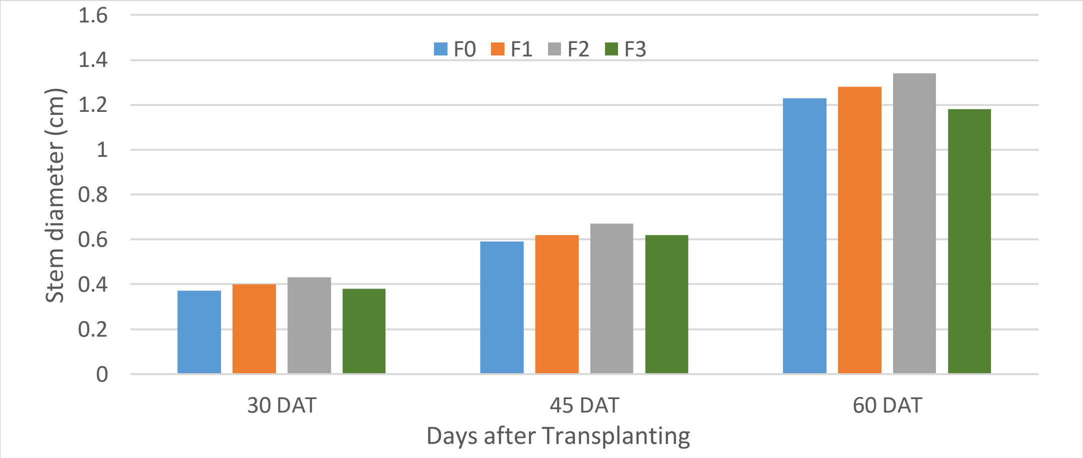

Figure 6. Effect of nutrient sources on stem diameter of onion at different days after transplanting of onion

DAT: Days after transplanting; Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.3.2 Effect of cultivar

Stem diameter was insignificantly influenced by cultivar (Figure 7 and Appendix VI). At 30 DAT, the highest stem diameter of bulb (0.41 cm) was produced from V_1 (BARI Piaz-1) treatment, which was statistically similar to V_2 (BARI Piaz-4) treatment and the lowest stem diameter (0.38 cm) was recorded from V_3 (BARI Piaz-5) treatment. At 45 DAT, the highest stem diameter of bulb (0.65 cm) was produced from V_1 (BARI Piaz-1) treatment, which was statistically similar to V_2 (BARI Piaz-4) treatment and the lowest stem diameter (0.59 cm) was recorded from V_3 (BARI Piaz-5) treatment. At 60 DAT, the highest stem diameter of bulb (1.34 cm) was produced from V_1 (BARI Piaz-1) treatment, which was statistically similar to V_2 (BARI Piaz-4) treatment and the lowest stem diameter (1.18 cm) was recorded from V_3 (BARI Piaz-5) treatment.

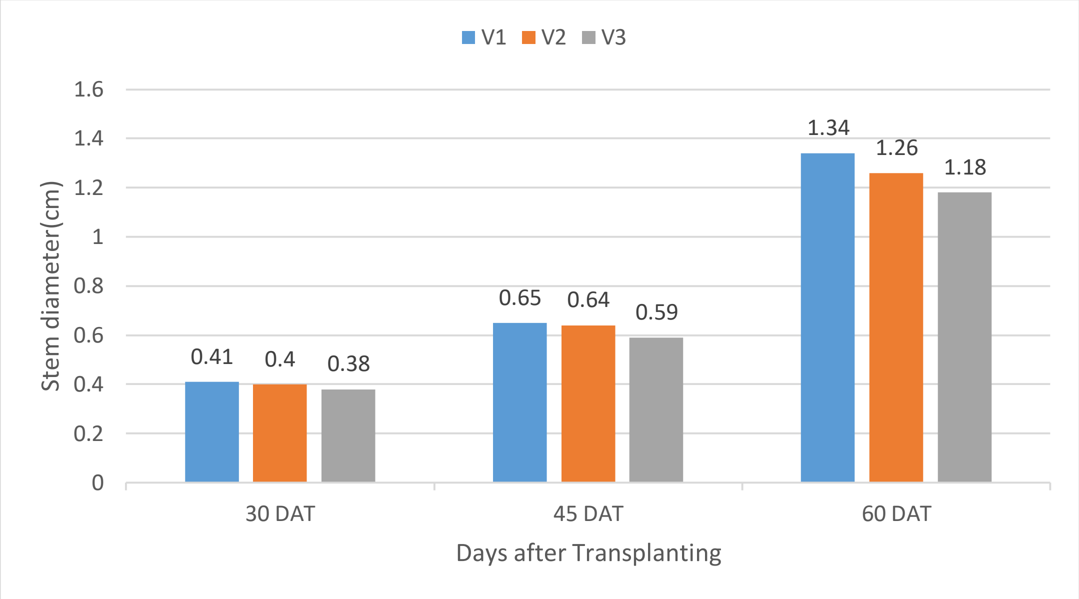

Figure 7. Effect of cultivars on stem diameter (cm) of onion at different days after transplanting of onion

DAT: Days after transplanting; Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.3.3 Combined effect of nutrient sources and cultivar

The combined effect of different nutrient source and cultivar showed positively non-significant variation at all dates of observation (Table 4 and Appendix VI). At 30 DAT, the maximum stem diameter of bulb (0.47 cm) was found from V_1F_2 combination which was statistically similar to all other treatments. At 45 DAT, the maximum stem diameter of onion (0.74 cm) was recorded from V_1F_2 combination which was statistically similar to all other treatments. At 60 DAT, the maximum stem diameter of onion (1.49 cm) was recorded from V_1F_2 and the minimum stem diameter plant^{-1} of onion (0.98 cm) was recorded from V_3F_3 combination.

Mandal *et al.* (2013) noted that maximum plant height, neck diameter, bulb polar and equatorial diameter, whole plant weight, and average bulb weight were recorded by the application of 50 % VC + 50 % NPK.

Table 4. Combined effect of cultivar and nutrient sources on stem diameter (cm) of bulb at different days after transplanting of onion

Treatment	Stem Diameter (cm) at		
	30 DAT	45 DAT	60 DAT
V_1F_0	0.39 ± 0.03	0.58 ± 0.05	1.24 ± 0.09
V_1F_1	0.38 ± 0.02	0.63 ± 0.05	1.32 ± 0.14
V_1F_2	0.47 ± 0.04	0.74 ± 0.05	1.49 ± 0.09
V_1F_3	0.38 ± 0.01	0.64 ± 0.06	1.32 ± 0.11
V_2F_0	0.38 ± 0.05	0.58 ± 0.09	1.16 ± 0.13
V_2F_1	0.42 ± 0.03	0.64 ± 0.03	1.30 ± 0.64
V_2F_2	0.43 ± 0.02	0.69 ± 0.03	1.31 ± 0.03
V_2F_3	0.38 ± 0.01	0.64 ± 0.01	1.25 ± 0.09
V_3F_0	0.36 ± 0.02	0.60 ± 0.01	1.30 ± 0.05
V_3F_1	0.40 ± 0.03	0.61 ± 0.05	1.22 ± 0.02
V_3F_2	0.39 ± 0.02	0.59 ± 0.01	1.22 ± 0.04
V_3F_3	0.38 ± 0.05	0.58 ± 0.08	0.98 ± 0.02
Significance level	NS	NS	NS

^{NS} Non-significant

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.4 Neck diameter (cm)

4.4.1 Effect of nutrient sources

Insignificant variation was observed in neck diameter among the nutrient source treatments (Figure 8 and Appendix VII). At harvesting, the maximum neck diameter (1.28 cm) was obtained from F_2 (Inorganic fertilizer) treatment, whereas the minimum neck diameter (1.1 cm) was recorded from control F_0 (Control) treatment. These results indicate that nutrient sources supplied plant nutrients and provide better growing conditions, which helped for getting proper vegetative growth as well as maximum neck diameter of onion.

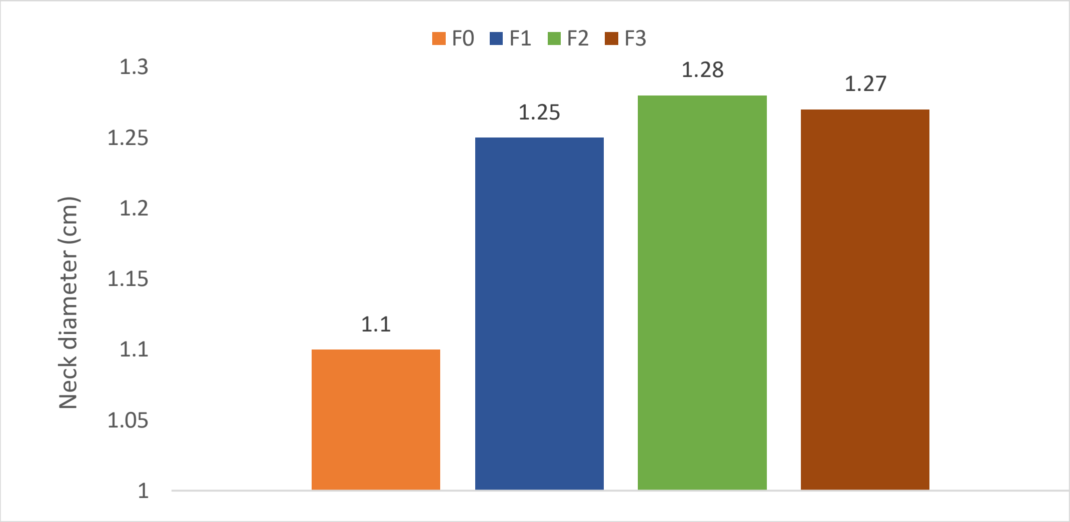

Figure 8. Effect of nutrient sources on neck diameter (cm) of onion at the time of harvesting of onion

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.4.2 Effect of cultivar

Varietal difference had a significant effect on neck diameter of onion (Figure 9 and Appendix VII). At harvesting, the maximum neck diameter (1.42 cm) was obtained from V_1 (BARI Piaz-1) treatment whereas the minimum neck diameter (1.04 cm) was recorded from V_2 (BARI Piaz-4) treatment.

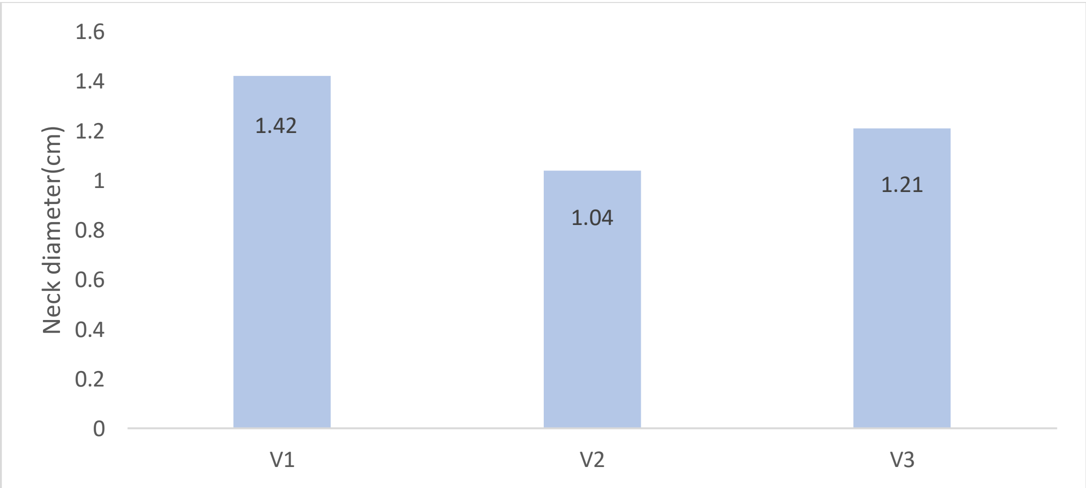

Figure 9. Effect of cultivar on neck diameter (cm) of onion at the time of harvesting of onion

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.4.3 Combined effect of nutrient sources and cultivar

The neck diameter was significantly influenced by the combinations of cultivar and nutrient sources (Table 5 and Appendix VII). The maximum neck diameter (1.52 cm) was obtained from V_1F_2 treatment combination, whereas the minimum neck diameter (0.87 cm) was recorded from V_2F_0 treatment combination compared to other combination.

Table 5. Combined effect of cultivar and nutrient sources on neck diameter (cm) of bulb at the time of harvest of onion

Treatment	Neck diameter (cm) at harvest
V_1F_0	1.25 ± 0.05^{a-c}
V_1F_1	1.45 ± 0.04^{ab}
V_1F_2	1.52 ± 0.10^{a}
V_1F_3	1.45 ± 0.04^{ab}
V_2F_0	0.87 ± 0.05^{d}
V_2F_1	1.06 ± 0.06^{cd}
V_2F_2	1.13 ± 0.11^{b-d}
V_2F_3	1.12 ± 0.18^{b-d}
V_3F_0	1.17 ± 0.04^{a-d}
V_3F_1	1.23 ± 0.3^{a-c}
V_3F_2	1.20 ± 0.6^{a-d}
V_3F_3	1.23 ± 0.23^{a-c}
Significance level	**

** Significant at >0.01 - <0.05 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
DAT: Days after transplanting; Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.5 Bulb length (cm)

4.5.1 Effect of nutrient sources

Bulb length of onion was affected by different types of nutrient sources (Figure 10 and Appendix VII). The highest bulb length (3.55 cm) was found from the treatment F_2 (Inorganic fertilizer) which was numerically higher than all other treatments and the lowest bulb length (3.35 cm) was found from the treatment F_0 (Control).

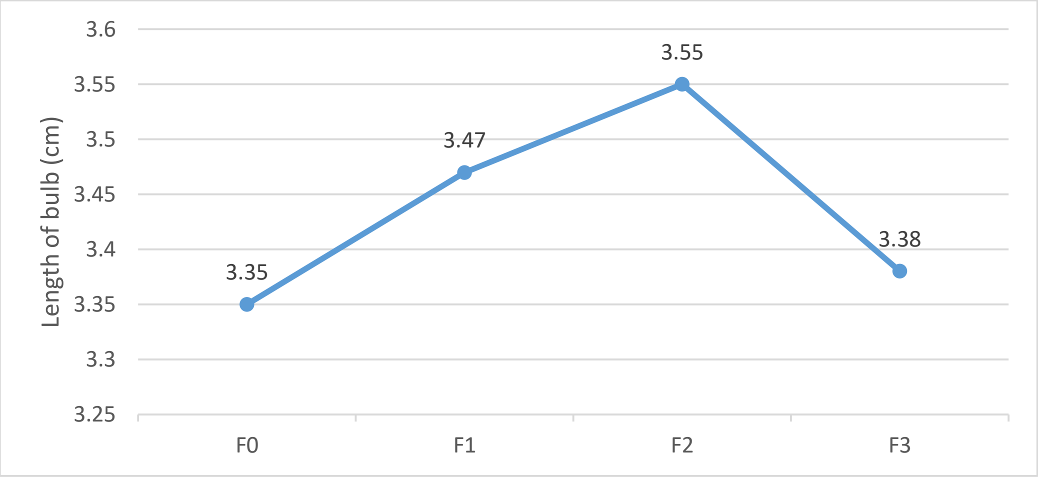

Figure 10. Effect of nutrient sources on length of bulb (cm) of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.5.2 Effect of cultivar

Different cultivar of onion significantly influenced the bulb length (Figure 11 and Appendix VII). The highest bulb length (3.98 cm) was found from the treatment V_3 (BARI Piaz- 5) which was significantly different from all other treatments. The lowest bulb length (2.99 cm) was found from the treatment V_2 (BARI Piaz-4) which was also significantly different from all other treatments. The result obtained from the present study was similar with the findings of Zedan (2011), Gopakkali and Sharanappa (2014).

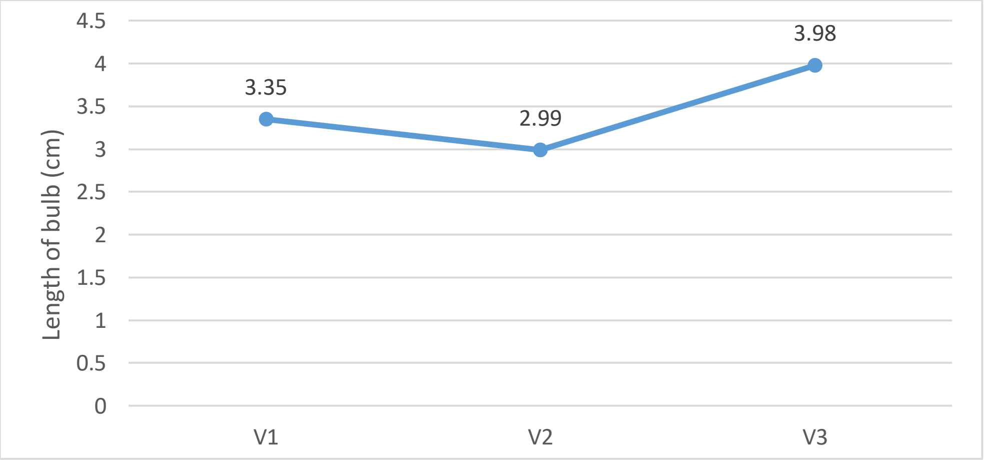

Figure 11. Effect of cultivar on length of bulb (cm) of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.5.3 Combined effect of nutrient sources and cultivar

The recorded data on bulb length (cm) was significantly influenced by combined effect of cultivar and nutrient sources of onion (Table 6 and Appendix VII). The highest bulb length (4.15 cm) was found from the V_3F_2, which was significantly different from all other treatment combinations expect V_3F_1, V_3F_0, V_3F_3 &V_1F_2. The lowest bulb length (2.87 cm) was found from the V_2F_0 treatment combination.

Table 6. Combined effect of cultivar and nutrient sources on length of bulb (cm) during harvesting of onion

Treatment	Length of bulb (cm) at harvest
V_1F_0	$3.27 \pm 0.19^{b-d}$
V_1F_1	3.33 ± 0.11^{bc}
V_1F_2	3.58 ± 0.25^{ab}
V_1F_3	$3.21 \pm 0.05^{b-d}$
V_2F_0	2.87 ± 0.05^{d}
V_2F_1	3.08 ± 0.07^{cd}
V_2F_2	2.94 ± 0.13^{cd}
V_2F_3	3.08 ± 0.00^{cd}
V_3F_0	3.93 ± 0.11^{a}
V_3F_1	4.01 ± 0.14^{a}
V_3F_2	4.15 ± 0.18^{a}
V_3F_3	3.86 ± 0.10^{a}
Significance level	***

*** Significant at 0 - 0.01 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.6 Bulb diameter (cm)

4.6.1 Effect of nutrient sources

Nutrient sources had an insignificant effect on bulb diameter of onion (Figure 12 and Appendix VII). At harvesting, the maximum bulb diameter (4.15 cm) was obtained from F_2 (Inorganic fertilizer) treatment which was statistically similar to F_3 (Vermicompost), whereas the minimum neck diameter (3.70 cm) was recorded from F_0 (Control) treatment.

The result obtained from the present study was similar with the findings of Dhaker *et al.* (2017). It showed that the application of organic manure significantly influenced the diameter of the bulb (cm), bulb weight (g), bulb yield (q/ha).

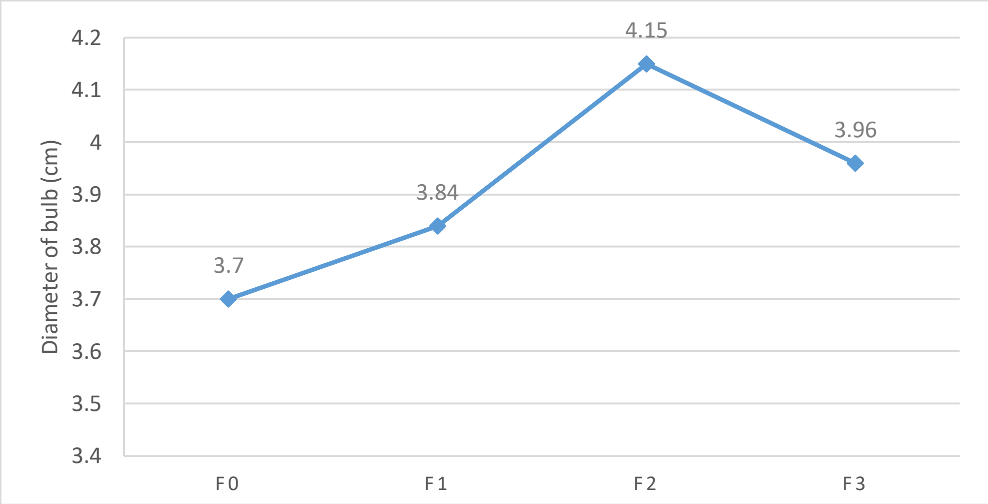

Figure 12. Effect of nutrient sources on diameter (cm) of bulb of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.6.2 Effect of cultivar

Significant variation was observed in bulb diameter of onion among the varietal treatments (Figure 13 and Appendix VII). At harvesting, the maximum bulb diameter (4.24 cm) was obtained from V_3 (BARI Piaz-5) treatment, whereas the minimum bulb diameter (3.7 cm) was recorded from V_2 (BARI Piaz-4) treatment. These results indicated that varietal variation played a role on getting proper vegetative growth as well as maximum bulb diameter of onion.

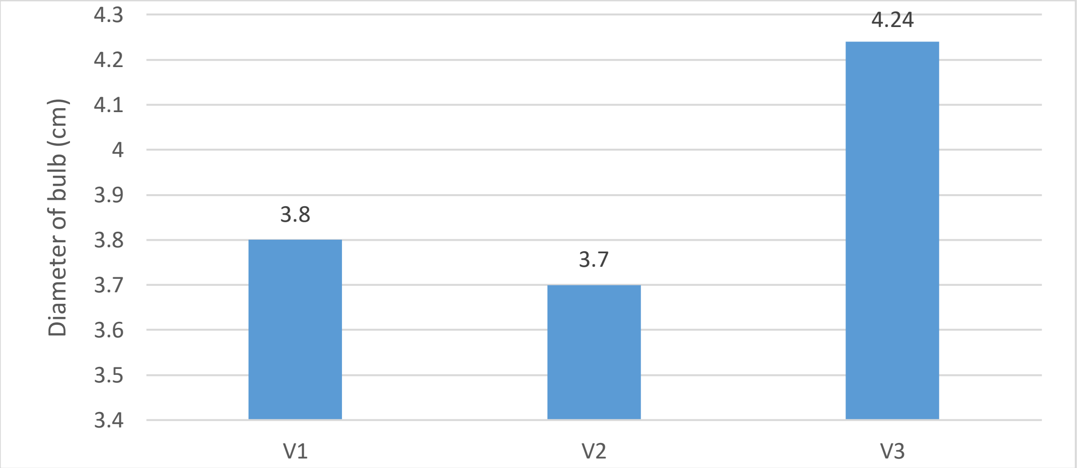

Figure 13. Effect of cultivar on diameter of bulb (cm) at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.6.3 Combined effect of nutrient sources and cultivar

The bulb diameter was significantly influenced by the combinations of cultivar and nutrient sources (Table 7. and Appendix VII). The maximum bulb diameter (4.46 cm) was obtained from V_3F_2 treatment combination, whereas the minimum bulb diameter (3.41 cm) was recorded from V_2F_0 treatment combination compared to other treatment combination.

Table 7. Combined effect of cultivar and nutrient sources on diameter of bulb (cm) at the time of harvest of onion

Treatment	Diameter of bulb (cm) at harvest
V_1F_0	3.44 ± 0.21^{c}
V_1F_1	3.55 ± 0.22^{c}
V_1F_2	4.32 ± 0.29^{ab}
V_1F_3	$3.91 \pm 0.45^{a-c}$
V_2F_0	3.41 ± 0.08^{c}
V_2F_1	3.73 ± 0.04^{bc}
V_2F_2	3.68 ± 0.22^{bc}
V_2F_3	$3.97 \pm 0.02^{a-c}$
V_3F_0	4.25 ± 0.08^{ab}
V_3F_1	4.25 ± 0.10^{ab}
V_3F_2	4.46 ± 0.08^{a}
V_3F_3	$3.98 \pm 0.02^{a-c}$
Significance level	***

*** Significant at 0 - 0.01 level of probability

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

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

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

4.7.1 Effect of nutrient sources

Fresh weight of bulb showed significant variation for different nutrient source (Figure 14 and Appendix VII). The maximum fresh weight bulb^{-1} (39.37g) was recorded from F_2 (Inorganic fertilizer) treatment, whereas the minimum bulb weight (27.70 g) was recorded from control F_0 (Control) treatment. Similar result was also observed by Vedpathak and Chavan (2016). It showed that the highest length of leaves (cm/plant), single bulb weight (g/plant), bulb yield (Kg/plot) were maximum with the application of a recommended dose of chemical fertilizer as compared to other fertilizer treatments.

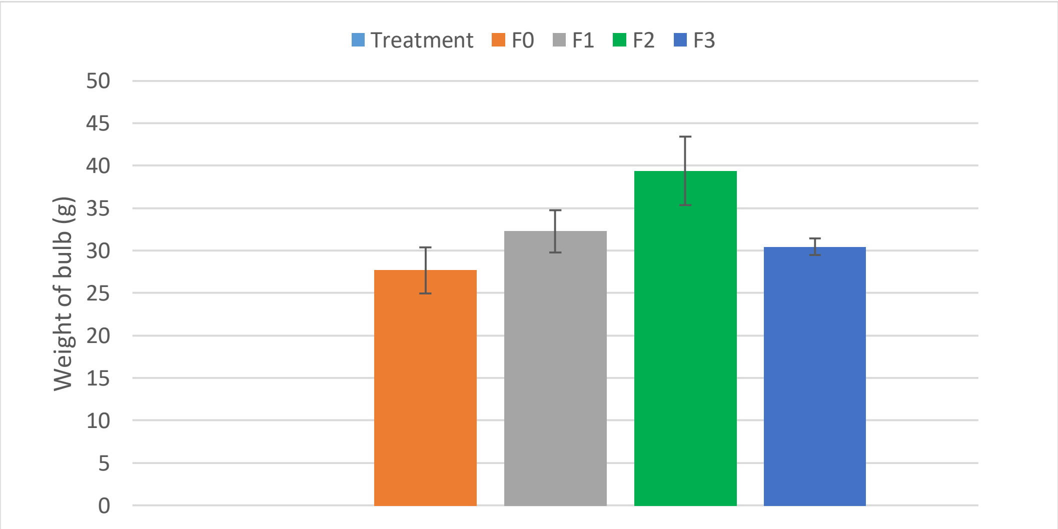

Figure 14. Effect of nutrient sources on weight of bulb (g) of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.7.2 Effect of cultivar

The findings showed the significant variation on fresh weight of bulb^{-1} for different cultivar (Figure 15 and Appendix VII). Data showed that the maximum fresh bulb weight (38.99 g) was recorded from V_3 (BARI Piaz-5) treatment, whereas the minimum bulb weight (26.55 g) was recorded from V_2 (BARI Piaz-4) treatment.

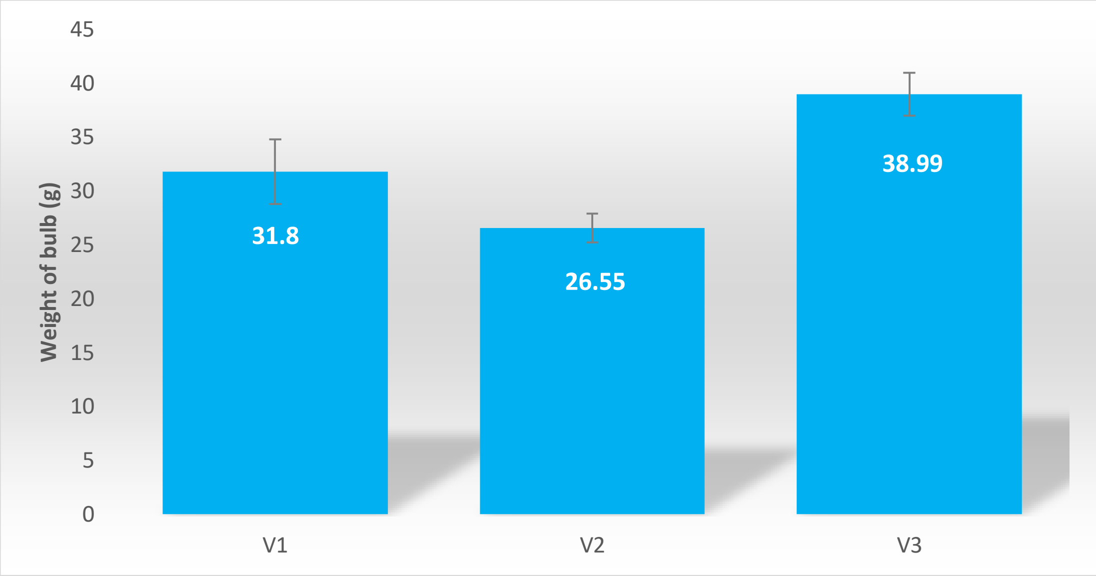

Figure 15. Effect of cultivar on fresh weight (g) of bulb^{-1} of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.7.3 Combined effect of nutrient sources and cultivar

There was a significant variation due to different nutrient source and cultivar on fresh weight of bulb^{-1} (Table 8 and Appendix VII). The findings showed that the highest fresh weight of bulb per plant (46.88 g) was found in V_3F_2 followed by V_1F_2. The lowest fresh weight of bulb per plant (21.22 g) was recorded from V_2F_0 treatment.

Table 8. Combined effect of cultivar and nutrient sources on fresh weight (g) of bulb^{-1} at the time of harvest of onion

Treatment	Fresh weight of bulb^{-1} (g) at harvest
V_1F_0	25.33 ± 3.33^{cd}
V_1F_1	28.66 ± 3.37^{cd}
V_1F_2	44.22 ± 7.86^{a}
V_1F_3	29.00 ± 2.77^{cd}
V_2F_0	21.22 ± 0.95^{d}
V_2F_1	27.66 ± 2.03^{cd}
V_2F_2	27.00 ± 3.37^{cd}
V_2F_3	30.33 ± 0.88^{b-d}
V_3F_0	36.55 ± 3.76^{a-c}
V_3F_1	40.55 ± 2.69^{ab}
V_3F_2	46.88 ± 2.32^{a}
V_3F_3	32.00 ± 1.01^{b-d}
Significance level	***

*** Significant at 0 - 0.01 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

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

4.8.1 Effect of nutrient sources

Yield plot^{-1} varied significantly due to different nutrient sources (Figure 16 and Appendix VIII). The highest yield plot^{-1} (948.51 g) was found from the treatment F_2 (Inorganic fertilizer), which was significantly different from all other treatments. The lowest yield plot^{-1} (664.85 g) was found from the treatment F_0 (Control).

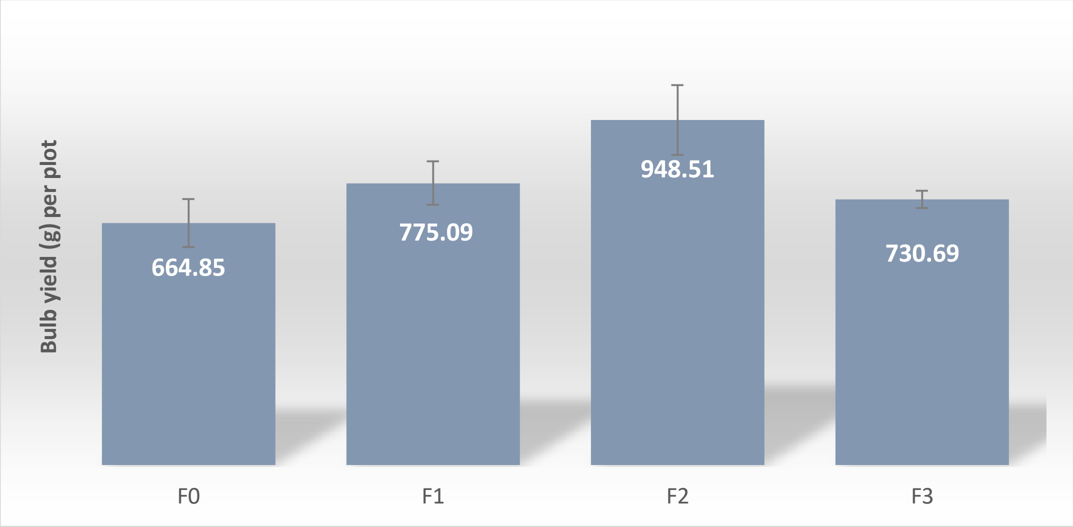

Figure 16. Effect of nutrient sources on bulb yield (g) per plot of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.8.2 Effect of cultivar

Significant variation was remarked on yield plot^{-1} as influenced by different cultivar of onion (Figure. 17 and Appendix VIII). The highest yield plot^{-1} (935.96 g) was found from the treatment V_3 (BARI Piaz-5) which was significantly different from all other treatments. The lowest yield plot^{-1} (640.06 g) was found from the Treatment V_2 (BARI Piaz-4).

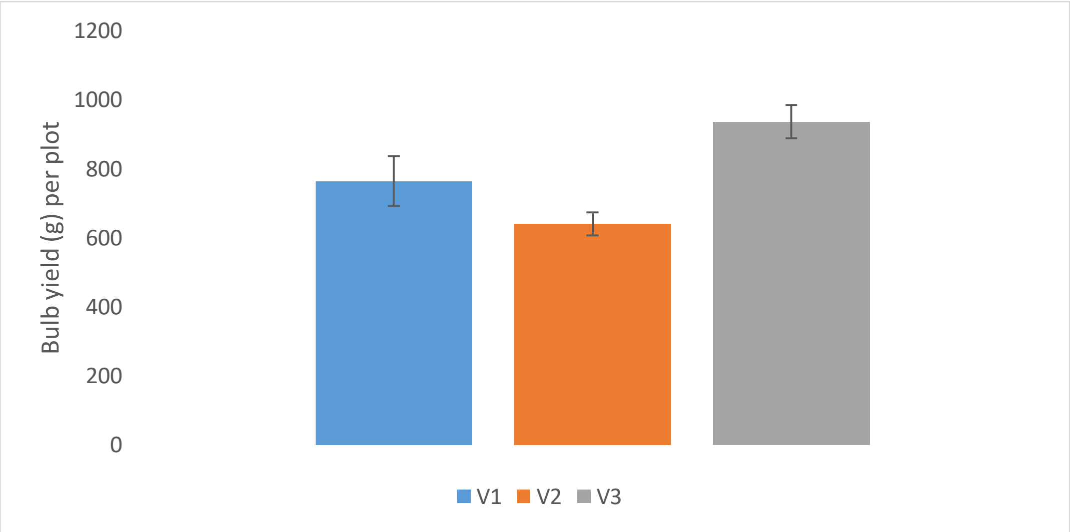

Figure 17. Effect of cultivar on bulb yield (g) per plot of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.8.3 Combined effect of nutrient sources and cultivar

Combined effect of nutrient sources and cultivars of onion was significantly influenced on yield plot^{-1} (Table 9 and Appendix VIII). The highest yield plot^{-1} (1125.28 g) was found from the treatment combination V_3F_2, which was statistically similar to V_1F_2, V_3F_0 and V_3F_1 treatment combinations. The lowest yield plot^{-1} (509.28 g) was found from the treatment combination V_2F_0 which was statistically similar to rest treatment combinations.

Table 9. Combined effect of cultivar and nutrient sources on bulb yield (g) plot^{-1} at the time of harvest of onion

Treatment	Bulb yield (g) plot^{-1} at harvest
V_1F_0	608.00 ± 80.09^{cd}
V_1F_1	688.00 ± 80.95^{cd}
V_1F_2	1061.36 ± 188.68^{a}
V_1F_3	696.00 ± 66.58^{cd}
V_2F_0	509.28 ± 22.79^{d}
V_2F_1	664.00 ± 48.91^{cd}
V_2F_2	658.89 ± 90.29^{cd}
V_2F_3	728.08 ± 21.16^{b-d}
V_3F_0	877.28 ± 90.33^{a-c}
V_3F_1	973.28 ± 64.69^{ab}
V_3F_2	1125.28 ± 55.89^{a}
V_3F_3	768.00 ± 24.43^{b-d}
Significance level	***

*** Significant at 0 - 0.01 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

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

4.9.1 Effect of nutrient sources

Variation on yield ha^{-1} was significant influenced by different sources of nutrient sources (Figure 18 and Appendix VIII). Results showed that the highest yield ha^{-1} (10.54 t) was found from the treatment F_2 (Inorganic fertilizer) which was significantly different from all other treatments. The lowest yield ha^{-1} (7.39 t) was found from the treatment F_0 (control) which was also significantly different from all other treatments. Similar result was also observed by Vedpathak and Chavan (2016).

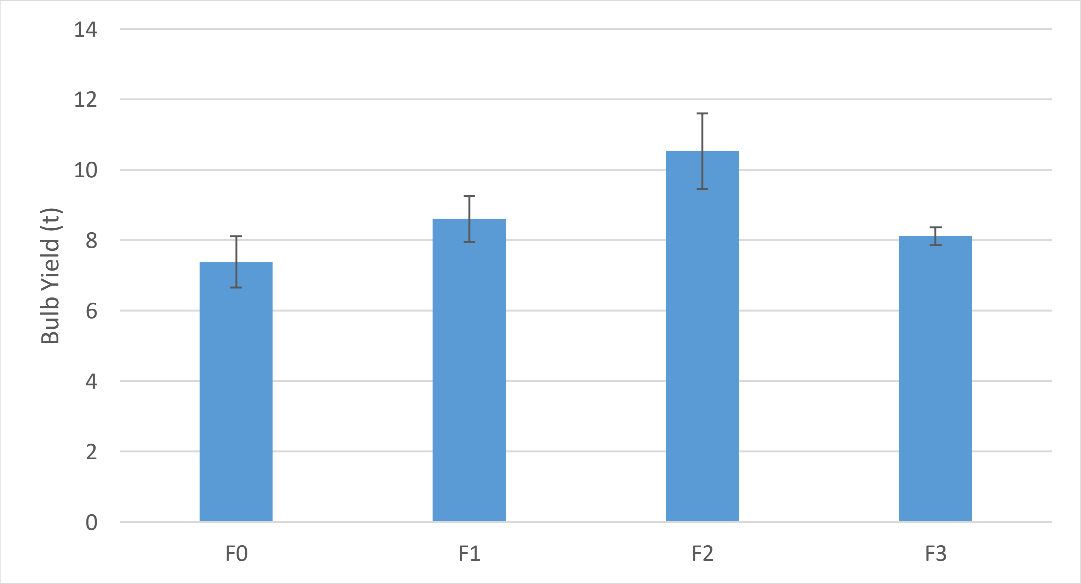

Figure 18. Effect of nutrient sources on bulb yield (t) ha^{-1} of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.9.2 Effect of cultivar

Yield ha^{-1} was significantly influenced by different cultivar of onion (Figure 19 and Appendix VIII). The highest yield ha^{-1} (10.39 t) was found from the treatment V_3 (BARI Piaz-5) treatment which was significantly different from all other treatments where the lowest yield ha^{-1} (7.11 t) was found from the V_2 (BARI Piaz-4) treatment.

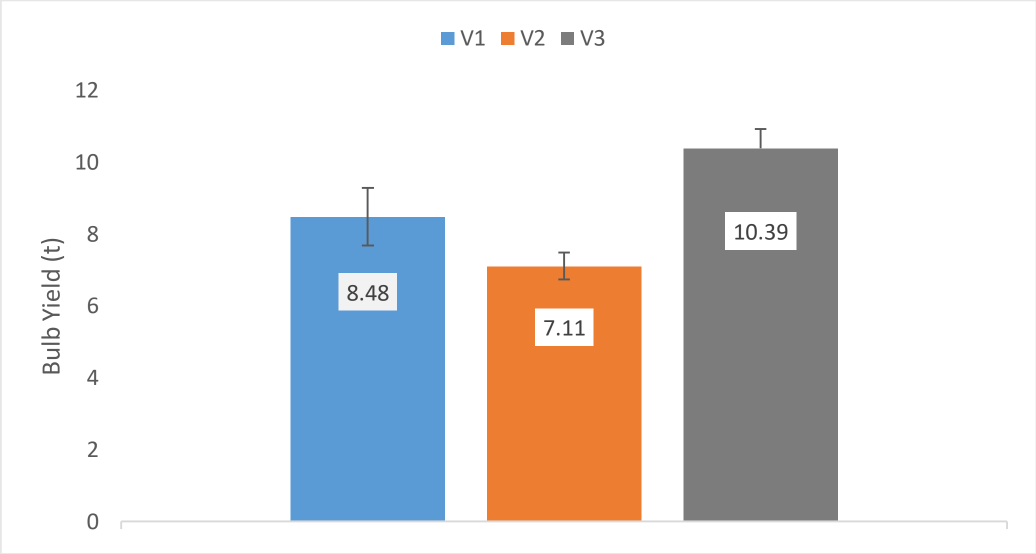

Figure 19. Effect of cultivar on bulb yield (t) ha^{-1} of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.9.3 Combined effect of nutrient sources and cultivar

The recorded data on yield ha^{-1} was significantly influenced by the combined effect of cultivar and nutrient sources (Table 10 and Appendix VIII). The highest yield ha^{-1} (12.09 t) was found from the treatment combination V_3F_2. The lowest yield ha^{-1} (5.66 t) was found from the treatment combination V_2F_0.

Table 10. Combined effect of cultivar and nutrient sources on bulb yield (t) ha^{-1} at the time of harvest of onion

Treatment	Bulb yield (t) ha^{-1} at harvest
V_1F_0	$8.40 \pm 1.76^{a-d}$
V_1F_1	7.64 ± 0.90^{cd}
V_1F_2	11.79 ± 2.09^{ab}
V_1F_3	7.73 ± 0.74^{cd}
V_2F_0	5.66 ± 0.25^{d}
V_2F_1	7.38 ± 0.54^{cd}
V_2F_2	7.32 ± 1.00^{cd}
V_2F_3	$8.09 \pm 0.23^{b-d}$
V_3F_0	$9.75 \pm 1.00^{a-c}$
V_3F_1	$10.81 \pm 0.72^{a-c}$
V_3F_2	12.09 ± 0.80^{a}
V_3F_3	$8.53 \pm 0.27^{a-d}$
Significance level	**

** Significant at > 0.01 - < 0.05 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.10 Straw (Onion leaf) yield plot^{-1} (g)

4.10.1 Effect of nutrient sources

Straw yield plot^{-1} varied due to different nutrient sources (Figure 20 and Appendix VIII). The highest yield plot^{-1} (329.11 g) was found from the treatment F_2 (Inorganic fertilizer), which was numerically higher than all other treatments. The lowest yield plot^{-1} (273.11 g) was found from the treatment F_1 (Foliar spray).

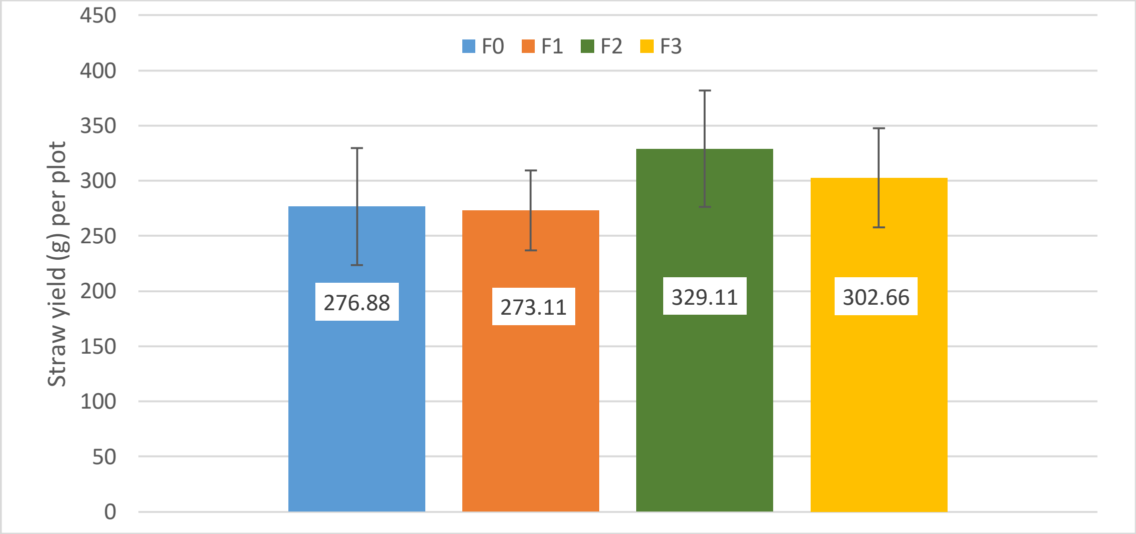

Figure 20. Effect of nutrient sources on straw yield (g) plot^{-1} of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.10.2 Effect of cultivar

Straw yield plot^{-1} varied significantly due to different cultivars of onion (Figure 21 and Appendix VIII). The highest yield plot^{-1} (456.0 g) was found from the treatment V_1 (BARI Piaz-1), which was significantly different from all other treatments. The lowest yield plot^{-1} (176.83 g) was found from the treatment V_2 (BARI Piaz-4).

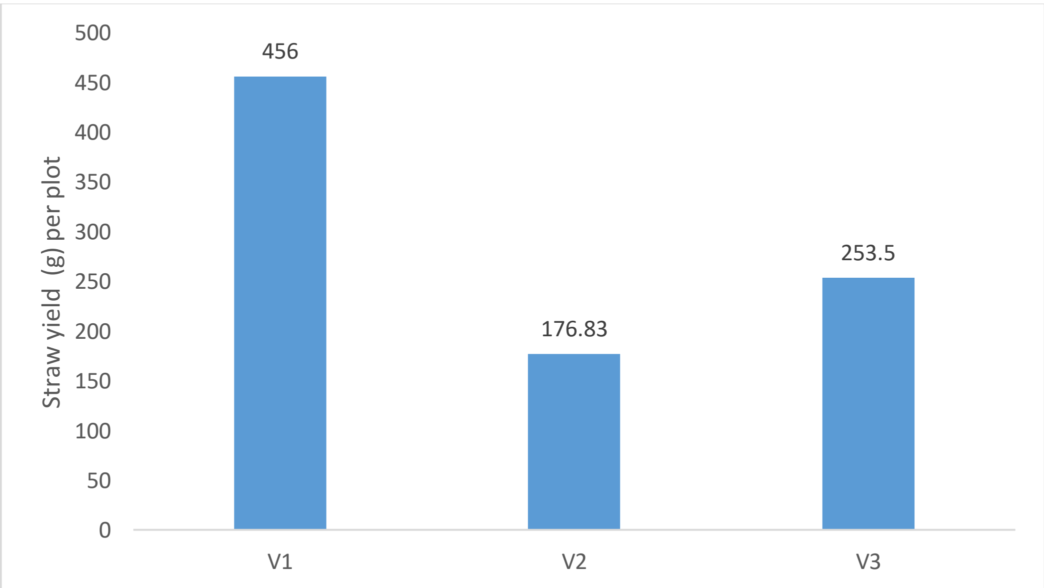

Figure 21. Effect of cultivar on straw yield (g) plot^{-1} of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.10.3 Combined effect of nutrient sources and cultivar

The recorded data on straw yield plot^{-1} was significantly affected by the combined effect of cultivar and nutrient sources (Table 11 and Appendix VIII). The highest yield ha^{-1} (522 g) was found from the treatment combination V_1F_2, which was statistically similar to V_1F_0 (470 g) and V_1F_3 (452 g). The lowest yield ha^{-1} was found from the treatment combination V_2F_0 (135.33 g).

Table 11. Combined effect of cultivar and nutrient sources on straw yield (g) plot^{-1} at the time of harvest of onion

Treatment	Straw yield (g) plot^{-1} at harvest
V_1F_0	470.00 ± 53.30^{ab}
V_1F_1	380.00 ± 45.82^{bc}
V_1F_2	522.00 ± 26.00^{a}
V_1F_3	452.00 ± 37.00^{ab}
V_2F_0	135.33 ± 18.98^{e}
V_2F_1	159.33 ± 11.68^{c-e}
V_2F_2	199.33 ± 47.41^{c-e}
V_2F_3	213.33 ± 60.67^{c-e}
V_3F_0	225.33 ± 22.69^{c-e}
V_3F_1	280.00 ± 33.54^{cd}
V_3F_2	266.00 ± 40.26^{c-e}
V_3F_3	242.66 ± 45.20^{c-e}
Significance level	***

*** Significant at 0 - 0.01 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.11 Straw (Onion leaf) yield ha^{-1} (t)

4.11.1 Effect of Nutrient sources

Straw yield plot^{-1} varied due to different nutrient sources (Figure. 22 and Appendix VIII). The highest yield plot^{-1} (3.66 t) was found from the treatment F_2 (Inorganic fertilizer), which was numerically higher than all other treatments. The lowest yield plot^{-1} (3.04 t) was found from the treatment F_1 (Foliar spray).

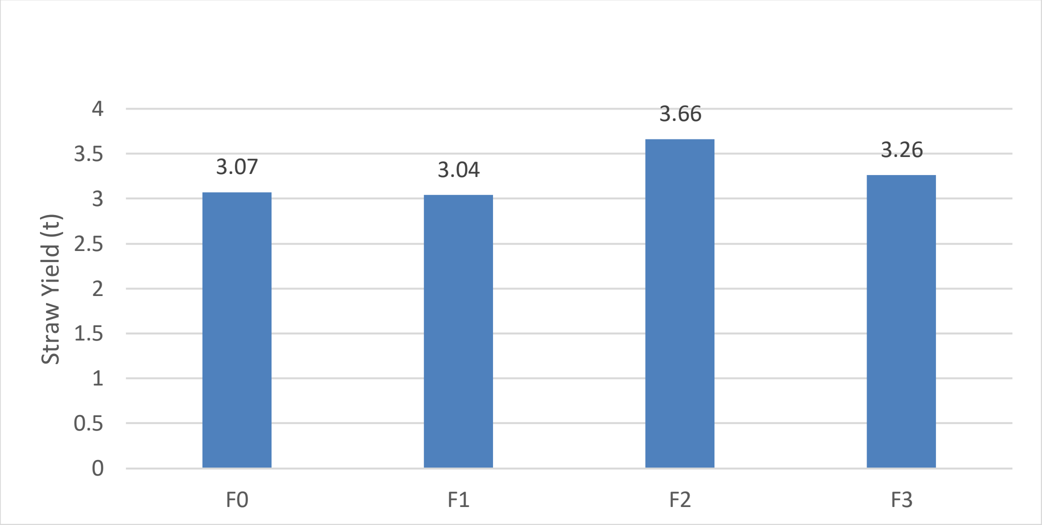

Figure 22. Effect of nutrient sources on straw yield (t) ha^{-1} of onion at the time of harvesting

Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

4.11.2 Effect of cultivar

Straw yield ha^{-1} varied significantly due to different cultivars of onion (Figure 23 and Appendix VIII). The highest yield ha^{-1} (5.06 t) was found from the treatment V_1 (BARI Piaz-1), which was significantly different from all other treatments. The lowest yield ha^{-1} (1.96 g) was found from the treatment V_2 (BARI Piaz-4).

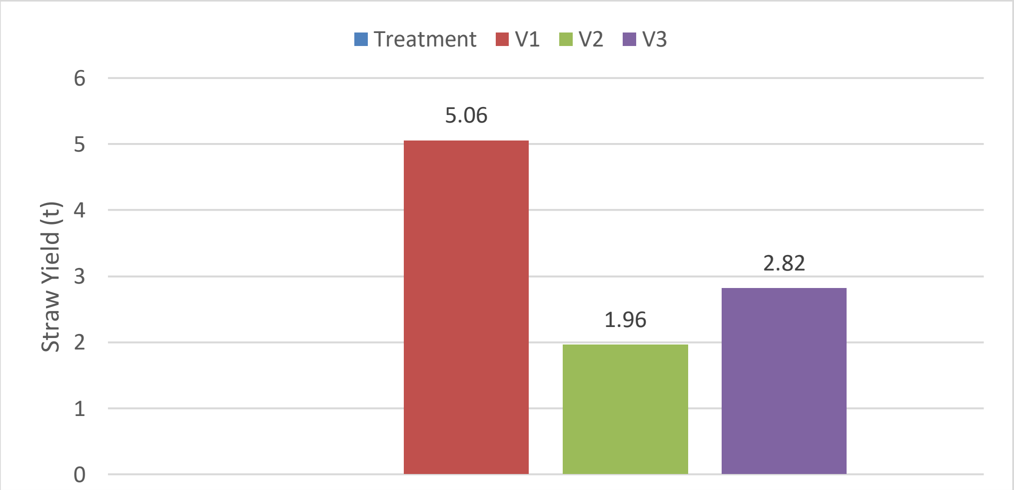

Figure 23. Effect of cultivar on straw yield (t) ha^{-1} of onion at the time of harvesting

Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5

4.11.3 Combined effect of nutrient sources and cultivar

The recorded data on straw yield ha^{-1} was significantly affected by the combined effect of cultivar and nutrient sources (Table 12 and Appendix VIII). The highest yield ha^{-1} (5.80 t) was found from the treatment combination V_1F_2, which was statistically similar to V_1F_3, V_1F_0 and V_1F_1. The lowest yield ha^{-1} was found from the treatment combination V_2F_0 (1.50 t), which was statistically similar to rest others.

Table 12. Combined effect of cultivar and nutrient sources on straw yield (t) ha^{-1} at the time of harvest of onion

Treatment	Straw yield (t) ha^{-1} at harvest
V_1F_0	4.52 ± 0.81^{ab}
V_1F_1	$4.22 \pm 0.51^{a-c}$
V_1F_2	5.80 ± 0.29^{a}
V_1F_3	5.02 ± 0.41^{a}
V_2F_0	1.50 ± 0.21^{d}
V_2F_1	1.77 ± 0.13^{d}
V_2F_2	2.22 ± 0.53^{d}
V_2F_3	2.37 ± 0.67^{d}
V_3F_0	2.50 ± 0.25^{d}
V_3F_1	$3.11 \pm 0.37^{b-d}$
V_3F_2	$3.22 \pm 0.62^{b-d}$
V_3F_3	2.70 ± 0.50^{cd}
Significance level	***

*** Significant at 0 - 0.01 level of probability

In a column having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability analyzed by DMRT.
Here, V_1 = BARI Piaz-1, V_2 = BARI Piaz-4, V_3 = BARI Piaz-5, Here, F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK), F_3 = Vermicompost

Chapter V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October 2018 to March 2019 to study the effect of nutrient sources and cultivar on growth and yield of onion. The experiment consists of two factors; Factor A: Nutrient sources- 4 Kinds viz. F_0 = Control, F_1 = Foliar spray (NPKS), F_2 = Inorganic fertilizer (NPK) and F_3 = Vermicompost and Factor B: Cultivars of Onions– 3 Kinds viz. V_1 = BARI Piaz-1, V_2 = BARI Piaz-4 and V_3 = BARI Piaz-5. There were 12 (4×3) treatment combinations and the experiment was laid out in RCBD with three replications. The size of the unit plot was 1.0 m × 0.90 m following the spacing 25 cm × 15 cm. Data were collected on different growth and yield parameters. The collected data were statistically analyzed by SPSS package programme. Different types of nutrient sources, cultivar of onions and their combination showed significant variation among the treatments on different growth and yield parameters.

Considerable influence in terms of growth parameters was found due to variation on fertilizer application. The highest plant height (22.91 cm, 38.34 cm and 48.74 cm at 30, 45 and 60 DAT, respectively) was found from the treatment F_2 (Inorganic fertilizer-NPK) and the highest number of leaves plant^{-1} (3.50, 4.68 and 6.23 at 30, 45 and 60 DAT, respectively) was recorded from the treatments F_2, F_3 and F_2, respectively (F_2 = Inorganic fertilizer-NPK, F_3 = Vermicompost) where the lowest plant height (18.33 cm, 31.44 cm and 44.73 cm at 30, 45 and 60 DAT, respectively) was found from the treatments F_0, F_0 and F_3, respectively (F_0 = Control, F_3 = Vermicompost) and the lowest number of leaves plant^{-1} (2.94, 4.38 and 5.86 and at 30, 45 and 60 DAT, respectively) was found from the treatment F_0 (control).

In terms of yield and yield contributing parameters, the highest neck diameter (1.28 cm), bulb length (3.55 cm), bulb diameter (4.15 cm), fresh weight bulb^{-1} (39.37 g), yield plot^{-1} (948.51 g) , bulb yield ha^{-1} (10.54 t) and straw yield plot^{-1} (329.11 g) was found from the treatment F_2 (Inorganic fertilizer-NPK) and the lowest neck diameter (1.10 cm), bulb length (3.35 cm), bulb diameter (3.70 cm), fresh weight bulb^{-1} (22.70 g), bulb yield plot^{-1} (664.85 kg), and yield ha^{-1} (7.39 t) were obtained from the treatment F_0 (control).

Significant influence was found due to different cultivar treatments. Results showed that in terms of growth parameters, the highest plant height (22.46 cm, 35.22 cm and 47.84 cm at 30, 45 and 60 DAT, respectively) were found from the varietal treatment V_2 (BARI Piaz-4), V_1 (BARI Piaz-1) and V_1, respectively, and number of leaves plant^{-1} (3.45, 4.79 and 6.36 at 30, 45 and 60 DAT, respectively) were found from the treatment V_1, V_1 and V_2, respectively whereas the lowest plant height (19.02 cm, 34.65 cm and 44.41 cm at 30, 45 and 60 DAT, respectively) were found from the treatment V_3 (BARI Piaz-5), V_3 and V_2, respectively. The highest number of leaves plant^{-1} (2.84, 4.38 and 5.70 at 30, 45 and 60 DAT, respectively) were found from the treatment V_3 (BARI Piaz-5). The highest stem diameter (0.41 cm, 0.65 cm and 1.34 cm at 30, 45 and 60 DAT, respectively) was found from the treatment V_1 and lowest stem diameter (0.38 cm, 0.59 cm and 1.18 cm at 30, 45 and 60 DAT, respectively) was found from the treatment V_3. In terms of yield and yield contributing parameters, the highest neck diameter (1.42cm), bulb length (3.98 cm), bulb diameter (4.24 cm), fresh weight bulb^{-1} (38.99 g), yield plot^{-1} (935.96 g), and bulb yield ha^{-1} (10.39 t) was found from the treatment V_3 (BARI Piaz-5) and the lowest neck diameter (1.04 cm), bulb length (2.99 cm), bulb diameter (3.70 cm), fresh weight bulb^{-1} (26.55 g), bulb yield plot^{-1} (640.06 kg), and yield ha^{-1} (7.11 t) were obtained from the treatment V_2 (BARI Piaz-4).

Substantial influence was also observed due to combined effect of different nutrient sources and cultivar. Results revealed that in terms of growth parameters, the highest plant height (25.05 cm, 40.16 cm and 52.66 cm at 30, 45 and 60 DAT, respectively) was found from the treatment combination V_2F_2, V_1F_2 and V_1F_2, respectively. The highest number of leaves plant^{-1} (4.00, 4.94 and 6.61 at 30, 45 and 60 DAT, respectively) was found from the treatment combination of V_1F_2, V_1F_3 and V_2F_3, respectively. Whereas the lowest plant height (16.19 cm, 28.11 cm and 40.28 cm at 30, 45 and 60 DAT, respectively) were found from treatment combinationV_1F_1, V_2F_0 and V_2F_1, respectively and the lowest number of leaves plant^{-1} (2.55, 3.99 and 5.50 at 30, 45 and 60 DAT, respectively) was found from the treatment combination of V_3F_1,V_2F_0 and V_1F_1, respectively. Finally, in terms of yield and yield contributing parameters, the highest neck diameter (1.52 cm) was found from treatment combination V_1F_2 and the highest bulb length (4.15 cm), bulb diameter (4.46 cm), fresh weight bulb^{-1} (46.88 g), bulb yield plot^{-1} (1125.28 g) and bulb yield ha^{-1} (12.09 t) were found from the treatment combination of V_3F_2. The highest straw yield (5.82 t) ha^{-1} was found from treatment combination V_1F_2. On the other hand, the lowest neck diameter (0.87 cm), bulb length (2.87 cm), bulb diameter (3.41 cm), fresh weight bulb^{-1} (21.22 g), bulb yield plot^{-1} (509.28 g) and bulb yield ha^{-1} (5.66 t) were found from the treatment combination of V_2F_0. So, onion production with treatment combination V_3F_2 (BARI Piaz-5 with Inorganic fertilizer-NPK) may be recommended for proper growth and development though treatment combination V_1F_2 showed better vegetative growth till the final period of cultivation at the condition of Sher-e-Bangla Agricultural University research field.

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

1. Application of inorganic fertilizer-NPK gave the highest growth and yield of onion bulbs.
2. BARI Piaz-5 also gave highest yield of onion bulb and BARI Piaz-1 showed a better vegetative growth at the early stage of cultivation.
3. Application of inorganic fertilizer-NPK with BARI Piaz-5 cultivar gave the highest growth and yield of onion bulb.

So, it can be stated that the cultivar BARI Piaz-5 with application of inorganic fertilizer-NPK showed the highest performance on growth and yield of onion.

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

Chapter VI

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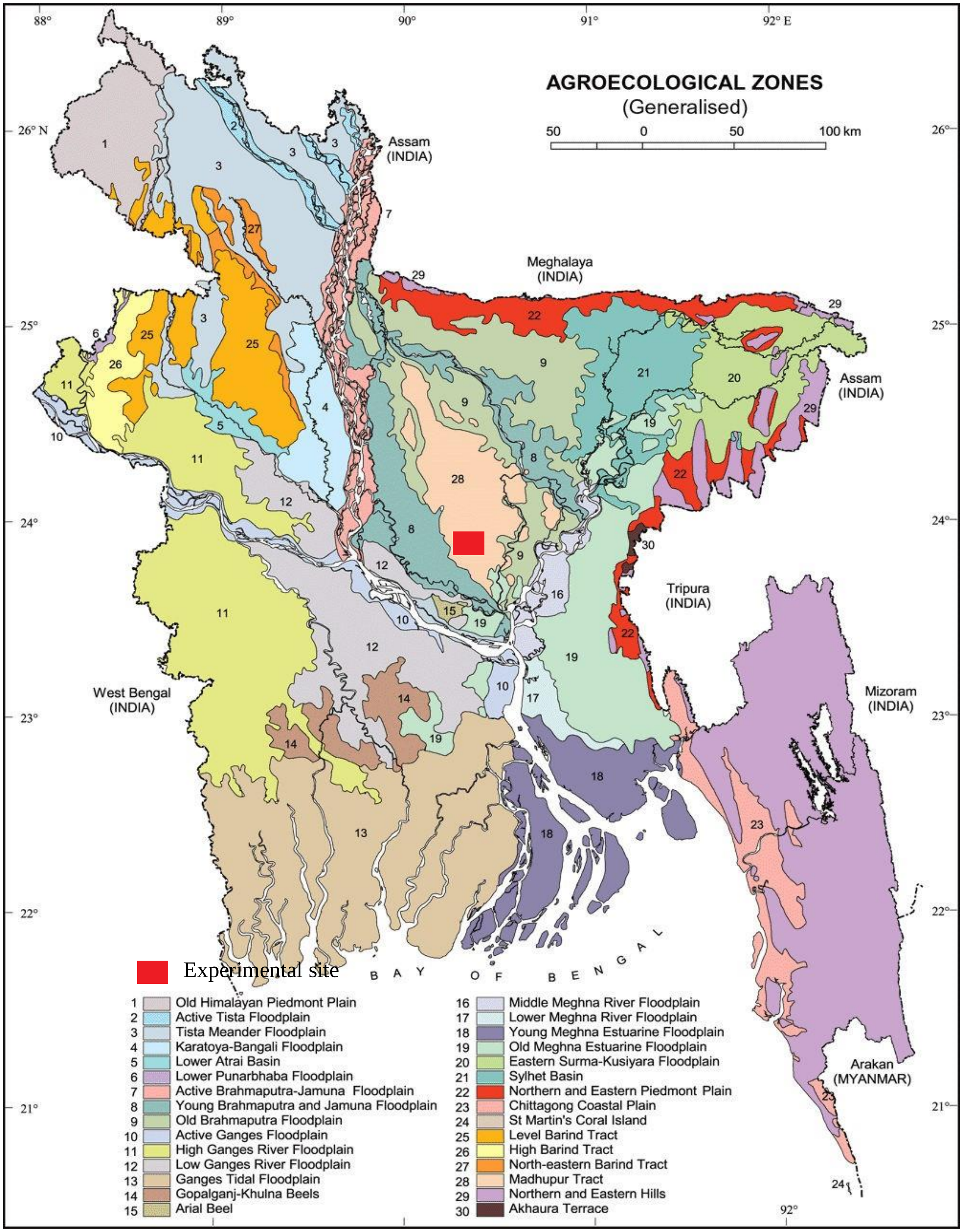
Chapter VII

APPENDICES

APPENDICES

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



Appendix II. **Monthly records of air temperature, relative humidity and rainfall during the period from October 2018 to March 2019.**

Year	Month	Air Temperature (^oC)			Relative humidity (%)	Rainfall (mm)
		Max	Min	Mean		
2018	October	28.60	8.52	18.56	56.75	14.40
2018	November	25.50	6.70	16.10	54.80	0.0
2018	December	23.80	11.70	17.75	46.20	0.0
2019	January	22.75	14.26	18.51	37.90	0.0
2019	February	35.20	21.00	28.10	52.44	20.4
2019	March	34.70	24.60	29.65	65.40	165.0

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

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

A. Morphological characteristics of the experimental field

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

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

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

Source: Soil Resource Development Institute (SRDI)

Appendix IV. **Plant height (cm) of onion influenced by nutrient sources and cultivars at different days after transplanting**

Source of variation	Degrees of freedom (df)	Mean square of plant height (cm)			
		30 DAT	45 DAT	60 DAT	At harvest
Factor A (Nutrient source)	3	35.48^{NS}	72.91***	30.19^{NS}	0.63^{NS}
Factor B (Cultivar)	2	44.16^{NS}	0.93^{NS}	37.80^{NS}	274.83***
A x B	11	25.53**	37.35**	33.11^{NS}	58.71***

** Significant at >0.01- <0.05 level of probability; *** Significant at 0- 0.01 level of probability and ^{NS} Non-significant

Appendix V. **Number of leaves plant^{-1} of onion influenced by nutrient sources and cultivars at different days after transplanting**

Source of variation	Degrees of freedom (df)	Mean square of number of leaves plant^{-1}		
		30 DAT	45 DAT	60 DAT
Factor A (Nutrient source)	3	0.57^{NS}	0.17^{NS}	0.27^{NS}
Factor B (Cultivar)	2	1.12***	0.54**	1.34**
A x B	11	0.48***	0.21^{NS}	0.41^{NS}

** Significant at >0.01- <0.05 level of probability; *** Significant at 0- 0.01 level of probability and ^{NS} Non-significant

Appendix VI. **Stem diameter plant^{-1} of onion influenced by nutrient sources and cultivars at different days after transplanting**

Source of variation	Degrees of freedom (df)	Mean square of Stem diameter (cm)		
		30 DAT	45 DAT	60 DAT
Factor A (Nutrient source)	3	0.01^{NS}	0.01^{NS}	0.04^{NS}
Factor B (Cultivar)	2	0.002^{NS}	0.01^{NS}	0.80^{NS}
A x B	11	0.003^{NS}	0.007^{NS}	0.04^{NS}

^{NS} Non-significant

Appendix VII. **Yield contributing parameters of onion influenced by nutrient sources and cultivars**

Source of variation	Degrees of freedom (df)	Mean square of number of leaves plant^{-1}			
		Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Fresh weight bulb^{-1} (g)
Factor A (Nutrient source)	3	0.07^{NS}	0.33^{NS}	0.07^{NS}	223.40**
Factor B (Cultivar)	2	3.04***	0.98***	0.42***	468.22***
A x B	11	0.57***	0.38***	0.01**	188.12***

** Significant at >0.01- <0.05 level of probability; *** Significant at 0- 0.01 level of probability and ^{NS} Non-significant

Appendix VIII. **Yield parameters of onion influenced by nutrient sources and cultivars**

Source of variation	Degrees of freedom (df)	Mean square of yield parameters			
		Bulb yield plot^{-1} (g)	Bulb yield ha^{-1} (t)	Straw yield plot^{-1} (g)	Straw yield ha^{-1} (t)
Factor A (Nutrient source)	3	132328.25**	16.36**	6086.07^{NS}	0.75^{NS}
Factor B (Cultivar)	2	530201.35***	32.65***	249636.11***	30.76***
A x B	11	107606.83***	10.43**	49746.63***	5.64***

** Significant at >0.01- <0.05 level of probability; *** Significant at 0- 0.01 level of probability and ^{NS} Non-significan

PLATES

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

Plate 2. Photograph showing final land preparation and transplanting of onion seedlings

Plate 3. Photographs showing foliar spraying and data collection

Plate 4. Photographs showing harvesting of onion

V_3F_2

V_1F_1

V_2F_0

Plate 5. Photographs showing different treatment combination of harvested onion