INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF TUBEROSE

ZANNATUL FIRDAUS BINTE HABIB

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2015

INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF TUBEROSE

BY

ZANNATUL FIRDAUS BINTE HABIB

Reg. No. 09-03620

A Thesis Submitted to
The Department of Horticulture, Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka-1207
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY– JUNE, 2015

Approved by:

Prof. Dr. Md. Ismail Hossain Dept. of Horticulture SAU, Dhaka **Supervisor**	**Dr. Kabita Anzu-Man-Ara** PSO, Floriculture Division HRC, BARI, Gazipur **Co- supervisor**

Dr. Tahmina Mostarin
Associate Professor and Chairman
Examination Committee

Department of Horticulture

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref :..... Date:.....

CERTIFICATE

This is to certify that thesis entitled, ***"INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF TUBEROSE"*** *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****, embodies the result of a piece of bona-fide research work carried out by* ***ZANNATUL FIRDAUS BINTE HABIB****, Registration No.* ***09-03620*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2015
Place: Dhaka, Bangladesh

……..……..……..……

Prof. Dr. Md. Ismail Hossain
Dept. of Horticulture
SAU, Dhaka
Supervisor

INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF TUBEROSE[1]

By

ZANNATUL FIRDAUS BINTE HABIB[2]

ABSTRACT

The present investigation was carried out to study the effect of integrated nutrient management on growth, flowering, yield and quality of tuberose at the Floriculture Research Field, Bangladesh Agricultural Research Institute, Gazipur from March, 2014 to May 2015. The experiment consisted of nine treatments namely: T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7:Bokashi (3 t/ha) + ½ RDF, T_8: Bokashi (5 t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1 kg/ha). The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Application of integrated nutrient management showed significant variations on most of the parameters. The highest spike length (80.0 cm), maximum rachis length (34.0 cm), Maximum florate number (45), bulb weight (40.0 g), yield of bulb (10.0 t/ha), yield of bulblet (12.0 t/ha), flower spike yield 425000 and maximum flower durability (15 days) were obtained from T_6 treatment. It has also maximized the spike weight, bulb number, bulblet number, bulb diameter and reduces the flowering time of tuberose. It may be concluded that the use of 10 tonvermicompostper hectare along with 50 percent recommended dose of fertilizer (RDF) in tuberose field gives the maximum production.

---

[1]The thesis title presented at MS defense on 26 September, 2016 in the Department of Horticulture of SAU for the partial fulfillment of MS degree.

[2]MS Student, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207.

INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND QUALITY OF TUBEROSE

ABSTRACT

The present investigation was carried out to study the effect of integrated nutrient management on growth, flowering, yield and flower durability of tuberose at the Floriculture Research Field, Bangladesh Agricultural Research Institute, Gazipur during March, 2014 to May 2015. The experiment consisted of nine treatments namely: T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3 t/ha) + ½ RDF, T_8: Bokashi (5 t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1 kg/ha). The experiment was conducted in Randomized Complete Block Design with three replications. Application of integrated nutrient management showed significant variations on most of the parameters. The highest spike length (80.0 cm), maximum rachis length (34.0 cm), maximum florate number (45), bulb weight (40.0 g), yield of bulb (10.0 t/ha), yield of bulblet (12.0 t/ha), flower spike yield (425000) and maximum flower durability (15 days) were obtained from T_6 treatment. It has also maximized the spike weight, bulb number, bulblet number, bulb diameter and reduces the flowering time of tuberose. It may be concluded that the use of 10 ton vermicompost per hectare along with 50 percent Recommended Dose of Fertilizer in tuberose field gives the maximum production.

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, Who enabled the author to complete this thesis.

It is a proud privilege of the author to express her deep sense of gratitude and sincere appreciation to her respected Supervisor **Dr. Md. Ismail Hossain**, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic direction, support, encouragement, valuable suggestions and constructive appreciation throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript.

The author sincerely expresses her wholehearted gratitude and indebtedness to her respected Co-Supervisor **Dr. Kabita Anzu-Man-Ara**, Principal Scientific Officer, Floriculture Division, Horticulture Research Centre, BARI, Joydebpur, Gazipur for her scholastic guidance, helpful comments and constant inspiration, immeasurable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses her sincere gratitude towards the sincerity of the Chairman, **Dr. Tahmina Mostarin**, Associate Professor, Department of Horticulture, SAU, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all teachers of the Department of Horticulture, SAU for their valuable suggestions, instructions, cordial help and encouragement during the study period.

The author expresses her sincere appreciation to her father, mother, brother relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ABBREVIATIONS		FULL WORD
%	:	Percent
@	:	At the rate
AEZ	:	Agro-Ecological Zone
ANOVA	:	Analysis of variance
B	:	Boron
BARI	:	Bangladesh Agricultural Research Institute
CV%	:	Percentage of Coefficient of Variation
cv.	:	Cultivar (s)
$0^{O}C$	:	Degree Celsius
df	:	Degrees of Freedom
DMRT	:	Duncan's Multiple Range Test
et al.	:	And others
etc.	:	Etcetera
HRC	:	Horticulture Research Centre
Kg	:	Kilogram
L	:	Litre
m^2	:	Square meter
Max.	:	Maximum
Min.	:	Minimum
MoP	:	Muriate of Potash
NS	:	Non Significant
OM	:	Organic manure
PSB	:	Phosphate Solubilizing Bacteria
q	:	Quintal
RCBD	:	Randomized Complete Block Design
RDF	:	Recommended Dose of Fertilizer
RDN	:	Recommended Dose of Nitrogen
RFR	:	Recommended Fertilizer Rate
RH	:	Relative Humidity
S	:	Sulphur
SAU	:	Sher-e-Bangla Agricultural University
TSP	:	Triple Super Phosphate
t/ha	:	Tons per hectare
VC	:	Vermicompost
Viz.	:	Namely

DEDICATED

TO MY

BELOVED PARENTS

CHAPTER I
INTRODUCTION

Tuberose (*Polianthestuberosa*L.), which occupies place in ornamental horticulture belongs to Amaryllidaceae family.It was originated in Mexico and grown on large scale in Asia. Tuberose is a half hardy, bulbous perennial multiplying itself through bulb-bulblets, roots are mainly adventitious and shallow, the leaves are long narrow, linear, grass like, green and arise in rosette. It is an important cut flower crop from aesthetic as well as commercial point of view. From Mexico, it spreaded out to the different parts of the world during the 16th century (Patel *et al*., 2006). In Bangladesh, it's commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgachathana under Jessore district near the Benapol border (Halder*et al*., 2007). In the orient, where 'white' goes for virtue and purity, tuberose is much adored for its colour, elegance and fragrance. Tuberose occupies a very selective and special position to flower loving people. It has a great economic potential for cut flower trade and essential oil industry. Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhoea, rheumatism and allied pains (Kusuma, 2000).

The spikes are useful as cut flowers in vase decoration and bouquets while individual floret is used for making veni, garland, button-holes or crown. Tuberose is planted in beds and borders and can also be grown as potted plants. It has a delightful fragrance and is the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive raw materials for perfume (Reshma*et al*.,2013). In Bangladesh, for the last few years, tuberose has become a popular cut flower of its attractive fragrance and beautiful display in

the vase. Now it has high demand in the market and its production is highly profitable (Mazed*et al.*, 2015).

To obtaining good growth and quality flower of tuberose depends on various factors such as genotype, environment, spacing, growth regulator, manuring, fertilization etc. (Bose *et al*., 2003). In conventional agriculture, chemical fertilizer and pesticides are usually applied to increase the yield and quality of flower crops. However, the frequent and excessive use of these chemicals is harmful for soil health, adversely affects environment and making plants even more susceptible to pests and diseases in tuberose (Shankar *et al.*,2010). It has been investigated earlier that organic materials are the safer sources of plant nutrients which have no detrimental effect to crops and soil (Reena*et al.*, 2014).

The growing period of tuberose is normally one year or more. Therefore, a high amount of organic and inorganic fertilizers are needed to maintain sustainable growth and flowering over a long period. There are many factors which affect plant growth and economic cultivation of tuberose. Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers (Amarjeet and Godara, 1998). Fertilizers have great influence on growth, building and flower production in tuberose. Effect of manures and chemical fertilizers on tuberose production has been reported by several authors for different geographical region (Yadav*et al*., 1985 and Singh *et al*., 2008).

Nitrogen, phosphorus and potassium have a significant effect on spike production and floret quality. Duration of flower in the field was improved through using organic fertilizer (Kabir, 2009). Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients (Mamtaand Ajit, 2014).Vermicompost has been shown to

have high levels of total and available nitrogen, phosphorus, potassium, micronutrients, microbial and enzyme activities and growth regulators (Chauhan*et al.*,2005). Mustard oil cake is an excellent source of organic amendment can replace not only the use of chemical fertilizers but also replace the use of pesticides by suppressing pathogens and insects (Naznin*et al*., 2015). Research works have shown that compost and other organic manures like farmyard manure, cocodust, vermicompost,bokashi, water hyacinth, mustard oil cake etc. can serve as soil amendments to improve soil nutrient status, water holding capacity as well as increase vase life (Hadwini*et al.*, 2013). They also stabilize soil pH, increase soil organic matter and ultimately improve plant growth, yield and quality.

But in Bangladesh, a little work has been done in respect of using organic manure withfertilizerfor tuberose cultivation. Considering the facts, such research is very important for the greater interest of the scientist as well as the growers of our country.

The present study was therefore undertaken with the following objectives:

- To determine the appropriate dose and combination of organic manure and fertilizer for better growth and yield of tuberose
- To find out the suitable nutrients for extending flower durability of tuberose

CHAPTER II
REVIEW OF LITERATURE

Tuberose is one of the important cut flower all over the world including Bangladesh. Its elegant spikes, attractive fragrance with long vase life are the reason for its ever-increasing demand. A very few studies on related to growth, flower and bulb production due to standard level of organic manure and fertilizers have been carried out in our country as well as many other countries of the world. So, the research work so far done in Bangladesh is not adequate and conclusive. The relevant information available on this area generated from different studies has been reviewed in this chapter.

2.1 Literatures on organic manures and fertilizers:

Mazed *et al.* (2015) investigated the effect of manures and fertilizer on growth and flower and bulb production of tuberose at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted five levels of nutrient sources, viz.: F_0 : Control, F_1: Cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MoP/ha, F_2: Poultry litter 5 t + 250 kg Urea + 190 kg TSP + 190 kg MoP/ha, F_3: Cowdung: 15 t/ha and F_4: Poultry litter: 10 t/ha. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Application of manures and fertilizer showed significant variations on most of the parameters. The highest yield of spike (4, 57, 650 /ha), bulb (26.64 ton) and bulblet per hectare (23.63 ton) was recorded from F_1 (Cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MoP per hectare).

An experiment was conducted by Naznin *et al.* (2015) to determine the appropriate dose and combination of organic and chemical fertilizers and to assess the effect of bio-control agent (*Trichoderma*) on qualitative and quantitative characteristics of tuberose (*Polianthes tuberosa* L. cv. Single), including stem

length, rachis length, spike length, floret number, flower yield, flower durability, number of bulb, bulb yield etc. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications having eight treatments as follows: T_1: Farmyard manure (5 t/ha) + ¼ RDF, T_2: Poultry refuse (5 t/ha) + ¼ RDF, T_3: Bokashi (3 t/ha) + ¼ RDF, T_4: Mustard oil cake (500 kg/ha) + ¼ RDF, T_5: Vermicompost (5 t/ha) + ¼ RDF, T_6: Tricho-compost (3 t/ha) + ¼ RDF, T_7: Tricho-leachate (3000 L/ha) + ¼ RDF and T_8: Control (Recommended doses of fertilizer) (N_{150} P_{45} K_{88} S_{10} B_1 Zn_1 kg/ha). Maximum growth, yield and yield contributing characters were recorded in T_6: Tricho-compost (3 t/ha) + ¼ RDF which were statistically superior to other treatments. Maximum plants emergence (93.3%) also recorded in T_6 (Tricho-compost + ¼ RDF). In case of plant height, number of leaves per plant, plant spread, days to flowering, number of florets, flower yield, bulb production, T_6: Tricho-compost (3 t/ha) + ¼ RDF gave superior results over control .

A research work was carried by Hussain *et al.* (2014) to find out the effect of planting depths, potassium levels and their interaction on tuberose. The bulbs of tuberose were planted at a depth of 5, 10, and 15 cm and were fertilized with four levels of potassium 0, 50, 100 and 150 Kg of K_2O per hectare using K_2SO_4 as a source of K_2O. Result of the study revealed that planting depth of 15 cm significantly increased length of spike (56.9 cm), number of florets spike^{-1} (54.84), and plant height (103.13 cm). Planting depth of 5 cm decreased number of days to last floret opening (180.08). Potassium level of 150 kg of K_2O ha^{-1} increased length of spike (55.24 cm), number of florets spike^{-1} (49.2) and plant height (100.29 cm). Planting depth of 15 cm and fertilizer application of 150 kg of K_2O ha^{-1} proved superior regarding spike length (64.4 cm), number of florets spike^{-1} (62.2) and plant height (106.20 cm).

Reena *et al.* (2014) studied the effect of bio-fertilizers (*Azotobacter*, PSB) along with the chemical fertilizers (N, P and K) on the growth of tuberose. The experiment was laid out in randomized block design with basal dose of FYM @ 5 kg/m^2 and 16 treatment combinations replicated thrice. The growth parameters (Plant height, number of leaves per plant, days taken for emergence of bulbs) increased significantly with the increasing levels of chemical fertilizers along with bio-fertilizers applications. Chemical fertilizers N, P and K application @ 15, 11.2 and 9.3 g/m^2, respectively along with bio-fertilizers was optimum for the growth parameters in tuberose.

An investigation was conducted by Mamta and Ajit (2014) to study the effect of organic manures and bio-inoculants on vegetative and floral attributes of chrysanthemum cv. Little Darling. The treatments comprising of VAM, Tricho-derma sp. (each @ 20 g/plant), poultry manure, vermicompost (each @ 300 g/m^2) and their combinations along with control. Among the treatments applied maximum plant height (30.17 cm), number of primary and secondary branches (3.78 and 19.78, respectively), plant spread (28.53 cm) and number of leaves per plant (184.33) were recorded in VAM (20 g/plant) + vermicompost (300 g/m^2) at all stages of plant growth. With respect to flowering, application of VAM (20 g/plant) + vermicompost (300 g/m^2) was found best as it resulted in bud initiation in minimum days (55.78), days to first flowering (73.33), maximum flowering duration (28.33 days), flower longevity (16.33 days), number of flowers per plant (70.56), flower stalk length (7.80 cm) and weight of flower (1.67 g). Maximum days taken to half of leaves (13.67) and flower wilting (17.17) were recorded in vermicompost (300 g/m^2). VAM (20 g/plant) + vermicompost (300 g/m^2) were found best for commercial cultivation of chrysanthemum cv. Little Darling.

The present investigation was carried out by Patanwar *et al.* (2014) to study the

effect of integrated nutrient management on the growth, development and yield of chrysanthemum. The experiment was laid out in randomized block design with three replications and twelve treatments with or without combinations of bio-fertilizers and organic manures with inorganic fertilizers. Result revealed that application of Azo + PSB + 50% RDN through VC + 50% RDF (T_{12}) was found to be more effective and at par in increasing the vegetative growth parameters, viz. plant height (57.02 cm), plant spread (41.91 cm), number of branches per plant (23.07), fresh weight of plant (141.13 g/plant^{-1}), dry weight of plant (41.7 g/plant), fresh weight of root (22.8 g/plant^{-1}), dry weight of root (4.10 g/plant^{-1}). Similarly number of flower per plot (992.8), yield of flower per plot (3.19 kg/plot^{-1}) and total yield of flowers (17.70 tha^{-1}) observed maximum under treatment T_{12} (Azo + PSB + 50% RDN through vermicompost + 50% RDF) followed by T_{11} (Azo + PSB + 50% RDN through FYM + 50% RDF).

The experiment was conducted by Tripathi *et al.* (2013) to study integrated nutrient management of tuberose at the Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut (India) in a randomized block design (RBD), with 12 treatments (T_1: RDF (240:160:100 kg NPK/ha), T_2: 75% RDF/ha, T_3: 125% RDF/ha, T_4: 75% RDF + 250 q FYM/ha, T_5: 75% RDF + 500 q FYM/ha, T_6: 75% RDF + 125 q vermicompost/ ha, T_7: 75% RDF + 250 q vermicompost/ha, T_8: 75% RDF + 250 q FYM + 125 q vermicompost/ha, T_9: 75% RDF + 250 q FYM + 250 q vermicompost/ha, T_{10}: 75% RDF + 500 q FYM + 125 q vermicompost/ha , T_{11}: 75% RDF + 500 q FYM + 250 q vermicompost/ha and T_{12}: untreated (control) which were replicated thrice. The plot size was 3.15 m × 2.25 m with spacing of 45 cm × 30 cm. Suvasini variety was used for the experiment. The entire dose of farmyard manure, vermicompost, phosphorus and potassium and half dose of nitrogen was applied as basal as per treatments and mixed up well in the soil. The remaining half dose of nitrogen in the form of urea was top

dressed in two split doses 30 and 45 days after transplanting. The bulbs of uniform size were transplanted in well prepared field as per the layout in the spring season. The plant growth bulb and bublet yield of tuberose significantly increased with the application of 75% RDF 250 q vermicompost per hectare.

An investigation was carried out by Chaudhary *et al.* (2013) to study the effect of integrated nutrient management on vegetative growth and flowering characters of tuberose with the application of vermicompost and FYM with and without 100, 75 and 50% recommended dose of NPK. The application of 20 t/ha^{-1} FYM produced maximum number of leaves. The components like diameter of florets, length of rachis, fresh weight of plant and vase life of spike were maximum with 50% RDF (60:40:40 kg/ha NPK) + 10 tones/ha each of vermicompost. Application of integrated nutrients, i.e. 50% RDF (60:40:40 kg/ha NPK) + 10 tones/ha vermicompost also produced significantly maximum length of spike, number of florets per spike, duration of flowering and yield of bulbs. The dry weight of plant was found maximum with the application of 75% RDF + 10 tones/ha each of FYM and vermicompost.

An experiment was conducted by Hadwani *et al.* (2013) to investigate the effect of integrated nutrient management on growth, yield and quality of ratoon tuberose cv. Double at Department of Horticulture, Junagadh Agricultural University, Junagadh, India. Sixteen treatment combinations of different nutrients were comprised with three replications. Result showed the significant result and application of FYM @ 30 t/ha + phosphate solubilizing bacteria (PSB) @ 2 g/m^2 + *Azotobacter* @ 2 g/m^2 took minimum days to sprouting (18.47 days), maximum plant height (61.67 cm) and plant spread at E-W and N-S (37.93 cm and 37.07 cm, respectively). With respect to flowering, significantly maximum length of spike (78.00 cm), number of florets per spike (44.07), number of spikes per plant (4.26), number of spikes per net plot (127.67), number of spikes per hectare (4.73 lacks), longest vase life (12.33

days) and longevity of spike (20.80 days) were recorded in treatment ½ RDF + PSB @ 1 g/m^2 + *Azotobacter* @ 1 g/m^2.

Ihram *et al.* (2012) conducted a study in the agro-metrological conditions of Rawalpindi, Pakistan. Different potting media were used in different combinations to check their effect on the morphological parameters as well as on vase life of tuberose. The different treatments included the combinations of FYM, poultry manure, sandy loam soil, leaf compost and coconut coir in equivalent ratio. The highest values of floral diameter, number of flowers per spike and shelf life were observed in sandy loam soil + leaf compost. These findings lead towards better quality cut flower production with maximum vase life.

In order to study the effects of nitrogen, potassium and phosphorous on quantitative and qualitative characteristics of tuberose cv. Double (*Polianthes tuberosa* L.) were done by Mahmoodinezhadedezfully *et al.* (2012) in Safiabad Agricultural Research Centre of Dezful, Iran. The design was a factorial randomized block design with 3 replications. Factors included four levels of nitrogen: 0, 100, 200 and 300 kg ha^{-1} urea, three levels of potassium: 0, 150 and 300 kg/ha as potassium sulfate and a fixed level of phosphorous @ 100 kg P_2O_5/ha as super phosphate. The results showed that potassium had no effect on most of the parameters in the experiment. The effect of nitrogen on stem length, spike length, florets number/spike, leaves nitrogen content, highest quality flowers and LAI were significant at 1% probability level while leaves length and chlorophyll meter readings were significant at 5%. The effect of nitrogen on vase life and leaves number was not significant. The effect of potassium on spike length was significant at 1% but it had not a significant effect on other parameters. N × K had only a significant effect on florets

number spike^{-1} at 1% level of probability. The best nitrogen treatment for most of the parameters was the application of 100 kg ha^{-1} while maximum leaves length and LAI were obtained with the application of 300 kg N/ha urea.

An appropriate fertilization method is an important factor in nutrition of tuberose plants for obtaining suitable quality and quantity yield. This study was conducted by Mohammadi *et al.* (2012) in Farvardin greenhouse of Mashhad Township, Khorasan province, Iran, to find appropriate fertilization method on the growth of tuberose. The experiment was performed by 21 treatments and 3 replications in a randomized completely design. Different methods of fertilization by different fertilizers in three levels of basic potassium were evaluated. The treatment containing 100 kg potassium as base +one-third N and P as base and two-third N as two equal divided + half phosphorus as base, half phosphorus as two equal divided + 3 times potassium foliar spray + N foliar spray had the most length of branch (119 cm) in compared to control (71.5 cm). Treatments with nitrogen and divided phosphorus in different parts of plant growth had more flower growth and quality.

A field experiment was conducted by Tripathi *et al.* (2012) to determine the comparative effect of integrated nutrient management on the cut flower production of tuberose in randomized block design, having 12 treatments: T_1: RDF (240: 160: 100 kg NPK ha^{-1}), T_2: 75% RDF ha^{-1}, T_3:125% RDF ha-^{1}, T_4: 75% RDF + 250 q FYM ha^{-1}, T_5: 75% RDF + 500 q FYM ha^{-1}, T_6: 75% RDF + 125 q Vermicompost ha^{-1}, T_7: 75% RDF + 250 q Vermicompost ha^{-1}, T_8: 75 % RDF + 250 q FYM + 125 q Vermicompost ha^{-1}, T_9: 75% RDF + 250 q FYM + 250 q Vermicompost ha^{-1}, T_{10}: 75% RDF + 500 q FYM + 125 q Vermicompost ha^{-1} , T_{11}: 75% RDF + 500 q FYM + 250 q Vermicompost ha^{-1} and T_{12}: untreated (control) which were replicated thrice. All the treatments had the comparable better floral qualities as well as higher cut flower production than

un-treated control. Among all the treatments, the maximum number of shoot clump^{-1} (18.95) and number of leaves shoot^{-1} (19.44) were recorded with the application of 75% recommended dose of NPK + 500 q FYM ha^{-1} + 250 q Vermicompost ha^{-1}. The maximum spike yield (205030.71 spikes/ha) were recorded with the application of 75% recommended dose of NPK + 500q ha^{-1} FYM + 250 q ha^{-1} Vermicompost followed by 75% recommended dose of NPK + 500q ha^{-1} FYM + 125 q ha^{-1} Vermicompost (199778.50 spikes/ha) although both the treatments did not varied significantly.

A field experiment was conducted by Khalaj and Edrisi (2012) to study the effect of five levels, each of nitrogen (0, 50, 100, 150, 200, 250 kg/ha) and plant spacing (10 × 10, 15 × 15, 20 × 20, 25 × 25 and 30 × 30 cm) of tuberose as a factorial in a Randomized Complete Block Design (RCBD) format with 3 replications at Mahallat National Ornamental Plant Research Station (MNOPRS), Iran. The spacing between plants of 25 × 25 cm had as significant effect on flower stalk height, flowering stem diameter, spike length, floret diameter, floret weight, vase life, bulb number and weight. Nitrogen levels affected stem diameter, stem and spike length. The result showed that an application of 200 kg/ha N can improve growth and yield of tuberose in terms of flower stalk height, stem diameter and bulb weight. Data showed that the plant spacing of 25 × 25 cm with nitrogen application of 200 kg/ha N obtained the maximum qualitative and quantitative characteristics of flowers.

Kabir *et al.* (2011) conducted a field experiment at the farmer's field of Sutiakhali, Mymensingh Sadar Upazilla, Mymensingh, to investigate the effect of organic fertilizers along with half chemical fertilizers on the growth, bulb and flower yield of tuberose cv. single. The experiment consisted of four different sources of fertilizers, viz. (i) recommended chemical fertilizers @ 400, 300, 300, and 100 kg ha^{-1} of urea, TSP, MoP and gypsum respectively; (ii)

vermicompost @ 5 t ha^{-1} along with half of chemical fertilizers; (iii) poultry litter @ 20 t ha^{-1} along with half of chemical and (iv) cowdung @ 20 t ha^{-1} along with half of chemical fertilizers. The experiment was laid out in a randomized complete block design with three replications. Results revealed that plant height, number $plant^{-1}$, leaf length and breadth, number of side shoots $plant^{-1}$, bulb length, bulb diameter and bulb yield both per plant and per hectare, rachis length, spike length and diameter, number of florets $spike^{-1}$ and flower yield both per spike and per hectare were greater in organic fertilizers along with half chemical fertilizers than absolute use of chemical fertilizers. The highest bulb and flower yield both per plant and per hectare were recorded in poultries followed by cowdung.

A field experiment was carried out at by Gupta *et al.* (2011) to quantify the effect of integrated nutrient management (INM) on yield of tuberose. Soil of experimental field was sandy loam rich in organic carbon (0.92%) medium in available phosphorus (23.41 kg ha^{-1}) and exchangeable potassium (209.42 kg ha^{-1}), but low in available nitrogen (223.46 kg/ha^{-1}). The experiment was laid out in a randomized block design (RBD) with 12 treatments using inorganic fertilizers, vermicompost and bio-fertilizers (*Azotobacter* and phosphate solubilizing bacteria) in different combinations including one control treatment. The treatments were control, recommended NPK (100:50:50 kg ha^{-1}), 75% recommended NPK+2.5 tons ha^{-1} vermicompost (VC), 50% recommended NPK + 5.0 tons ha^{-1} VC, 25% recommended NPK + 7.5 tons ha^{-1} VC, 10 tons ha^{-1} VC, recommended NPK + bio-fertilizers, 75% recommended NPK + 2.5 tons ha^{-1} VC + bio-fertilizers, 50% recommended NPK + 5.0 tons ha^{-1} bio-fertilizers, 25% recommended NPK + 7.5 VC tons ha^{-1} + bio-fertilizers, 10 tons ha^{-1} VC + bio-fertilizers and bio-fertilizers alone. The yield of tuberose increased with integrated application of inorganic and organic nutrients. A significant increase

in tuberose yield was observed with 75% recommended NPK + 2.5 tons ha^{-1} VC + bio-fertilizers followed by 75% recommended NPK + 2.5 tons ha^{-1} VC.

An investigation was carried out by Verma *et al.* (2011) at Floriculture Unit of new orchard, Department of Horticulture, College of Agriculture, University of Agriculture Sciences, Dharwad, to standardize the integrated nutrient management on growth, yield and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Raja. The experiment was laid out in randomized block design (RBD) with 8 treatments replicated three times. Individual plot size was 3.0 m × 3.0 m. The treatment included inorganic form of N (150 kg/ha^{-1}), P_2O_5 (100 kg/ha^{-1}) and K_2O (100 kg/ha^{-1}) alone as recommended dose of fertilizer (RDF) as well as in combination with organic manures *viz*., vermicompost (2.5 t/ha^{-1}), farm yard manure (20 t/ha^{-1}) and bio-fertilizers *viz*., *Azospirillum* (500 g/ha^{-1}) and phosphate solubilizing bacteria (500 g/ha^{-1}). The recommended dose of fertilizer (RDF) was 150:100:100 kg N: P_2O_5:K_2O per hectare.The growth and yield observations were recorded in five plants randomly selected in each treatment. The treatment receiving *Azospirillum*, phosphate solubilising bacteria, vermicompost and 50 per cent recommended NPK (T_8) recorded the highest plant height, number of branches, plant spread, dry matter accumulation and yield attributes such as number of flower $plant^{-1}$ and flower yield. The same treatment (T_8) registered significantly higher quality parameters such as stalk length, flower diameter, shelf life of garland flowers. The economic analysis clearly indicated that net returns per hectare and B:C ratio was the highest in the plots treated with *Azospirillum*, PSB, vermicompost and 50% recommended NPK (3, 28, 504 and 6.04 respectively) and these findings can be used in making chrysanthemum production more profitable.

The experiment was conducted on African marigold by Radhika *et al*. (2010) at College Horticulture Nursery, Department of Horticulture, Anand Agricultural University, Anand. The treatments comprised of three biofertilizers

(*Azotobacter*, *Azospirillum* and PSB), three levels of vermicompost (2.0, 3.0 and 4.0 t/ha^{-1}) and three levels of NPK (60, 70 and 80% of RDF) including control (RDF). The experiment was laid out in a randomized block design with ten treatments replicated thrice. The results revealed that application of 70% RDF + 3 t/ha vermicompost + *Azotobacter* + *Azospirillum* + PSB produced significantly maximum plant height, number of branches per plant, plant spread in N-S and E-W directions, average flower weight, number of flowers per plant, flower yield per plant (g) and flower yield per hectare (t) as compared to control.

Field experiments were conducted by Kadu *et al.* (2009) to study the effect of four levels, each of nitrogen (0, 100, 200 and 300 kg ha^{-1}) and phosphorus (0, 100, 150 and 200 kg ha^{-1}) with a fixed level of potassium @ 100 kg ha^{-1} in tuberose cv. Single. Among all the NPK combinations, treatment of 300:150:100 kg NPK ha^{-1}, showed more spike length (106.32 cm), maximum number of florets plant^{-1} (41.58) and number of spikes plant^{-1} (2.47). Further, its effect was also good in parameters such as fresh weight of flowers plant^{-1} (90.89 g) and yield of flowers hectare^{-1} (15.15 tones). Treatment of nitrogen, phosphorus and potassium combination @ 200, 200 and 100 kg ha^{-1}, respectively gave better results in flower and bulb production in tuberose.

Organic materials are the safer sources of plant nutrients which have no detrimental effect to crops and soil. Regular addition of organic matters overcomes the extremes physico-chemical properties of the soil which plays a vital role in flower crop production. Bokashi and EM treatments produced the highest yield in tubeose in comparison to inorganic fertilizer application (Kabir, 2009).

The field experiment with sixteen treatment combinations of inorganic, farm yard manure and vermicompost were conducted on heliconia by Dalve *et al.* (2009) and it was noted that all the INM treatments increased significantly the

fresh weight of marketable and unmarketable rhizomes, number of rhizomes and spikes as compared to treatment 100% RDF of NPK. Out of sixteen treatment combinations, 75% RDF of NPK + 10 t/ha^{-1} vermicompost application enhanced the yield and flowering duration as compared to other treatments.

Sushma and Aruna (2008) studied the effects of bio-fertilizers, chemical fertilizers, vermicompost, poultry manure and their combination on the productivity of tuberose. The experiment was conducted in a completely randomized block design (CRBD) with 4 treatments i.e. T_1: RDF + Vermicompost), T_2: ($^1/_2$ RDF + Vermicompost 5 t/ha), T_3: (RDF + Poultry manure) and T_4: ($^1/_2$ RDF + Poultry manure 5 t/ha). A significant increase in flower and bulb yield was observed with ½ RDF + 10 t/ha Vermicompost of tuberose.

According to the finding of a research and regarding economic matters and environmental anxieties, it was recommended that vermicompost may be used as a soil amendment in the nursery or field production of flower plants (Nazari *et al.* 2008).

Chaitra and Patil (2007) observed significant increase in plant height, number of leaves, number of branches, total dry matter production and also flower yield in China aster with the application of vermicompost @ 2.5 t ha^{-1} with 50 per cent RDF.

Warade *et al.* (2007) observed that, the growth of dahlia in respect of height of plant, number of leaves plant^{-1}, spread of plant, earliness of flowering and yield of flowers was superior in the plants receiving vermicompost 500 g with PSB 25 g/plot^{-1}.

An application of vermicompost as 50% recommended dose of nitrogen (RDN) along with 50% recommended dose of fertilizer (RDF) recorded significantly higher plant height (100.3 cm), maximum number of primary branches (13.1), flowers (66.2), seed yield 499.0 kg per hectare and recorded higher 1000 seed weight (3.7 g), root length (6.2 cm), shoot length (5.5 cm) and vigour index (1047) compared to RDF alone in African marigold (Sunita *et al.,* 2007).

Yadav (2007) conducted an experiment in Bikaner, Rajasthan, India, to study the effect of N (0, 10 and 20 g) and P (0, 6 and 12 g) fertilizers on the growth and flowering of tuberose cv. Shringar. Plant height, number of leaves per plant, number of flowers per spike, length of spike, length of rachis, number of spike per plot and weight of flower per spike were remarkably increased with N and P application alone and in combination.

A field study of boron and zinc on flower production of tuberose was conducted by Halder *et al.* (2007) at Floriculture Research Farm of Horticulture Research Centre, BARI, Joydebpur, Gazipur. The objectives were to evaluate the response of tuberose to B and Zn micronutrients and to find out the optimum dose of boron and zinc for maximizing flower yield and quality of tuberose. Sixteen treatments comprising four levels of b (1.0, 2.0 and 3.0 kg ha^{-1}) and four levels of Zn (0, 1.5, 3.5 and 4.5 kg ha^{-1}) along with blanket does of N_{300} P_{90} K_{170} S_{20} kg/ha and cow dung 5 t/ha were used in the trial. Tuberose (cv. Double) was taken as a test crop. It was revealed that B and Zn and their combination had a profound effect on flower characters and flower yield of Tuberose.

Bulbs of tulip *(Tulipa gesnerina* Linn.) cv. Apeldoorn (8-9 cm circumference) were planted under open field conditions in Kashmir Valley to study the impact of integrated nutrient management on growth and bulb production by Jhon *et al.* (2007). Experimental treatments comprising of four levels each of organic

(sheep) manure (0, 20, 40 and 60 t/ha) and inorganic fertilizers (0:0:0 control, 50:20:20, 75:30:30 and 100:40:40 kg/ha of NPK, respectively). The results revealed that maximum values in terms of plant height (36.15 cm), stem thickness (6.83 mm), wrapper leaf area (133.16 cm^2), bulb number/m^2 (52.75) and their weight (1.14 kg/m^2) were recorded with highest level of 60 t/ha organic manure tested in the study. As regards to inorganic fertilizers, NPK in the ratio of 75:30:30 kg/ha being at par with 100: 40: 40 kg/ha, recorded highest values in terms of plant height (36.25 cm), stem thickness (6.73 mm), wrapper leaf area (133.58 cm^2), bulb number (50.50/m^2) and their weight (1.03 kg/m^2) over lower levels of fertilizers tested in the study.

Regular application of organic amendments may solve the problems of low soil fertility, low water holding capacity and low organic matter content of soil. Significant increase in plant height, leaf number, spike length and number of florets per spike in gladiolus in the plots treated with a combination of vermicompost @ 10 tonnes per hectare + 80 per cent recommended NPK (100:60:60 kg/ha) was stated by Godse *et al.* (2006).

Patel *et al.* (2006) conducted a multifactor experiment on tuberose cv. Single at Instructional Farm of ASPEE College of Horticulture and Forestry, Navarra Agricultural University, Navsari, India. The treatments comprised four levels of nitrogen (100, 200, 300 and 400 kg N/ha,) three levels of phosphorus (100, 150 and 200 kg P/ha) and three spacings i.e. 30 × 20, 30 × 30, and 30 × 45 cm, in a randomized block design with factorial concept replicated thrice. The results revealed that for higher yield of spikes and bulbs, tuberose could be planted at a closer spacing of 30 × 20 cm and fertilized with 400 kg nitrogen and 200 kg phosphorus per hectare. Spikes/plant was found to be higher under wider spacing (30 × 45 cm). Application of nitrogen at 400 kg/ha recorded

significantly the highest values of vegetative characters. The effect of phosphorus was non-significant on vegetative characters while floral characters, viz. rachis length and number of florets/spike were found significant. Bulb yield in terms of clump weight (t/ha) was also found significant and 200 kg P/ha recorded the higher values.

Sultana *et al.* (2006) conducted a field trial on tuberose at the Floriculture field of Horticultural Research Centre, BARI, Joydebpur, Gazipur, Bangladesh during summer season to observe the response of tuberose (cv. single) to different nutrient elements. Nutrients were 4 levels of nitrogen (0, 100, 200 and 300 kg/ha), 3 levels of phosphorus (0, 45 and 90 kg P/ha) and 3 levels of potassium (0, 80 and 160 kg k/ha) along with a blanket dose of 10 t/ha cowdung. The experiment was laid out in a randomized complete block design replicated 3 times. The application of NPK significantly influenced the growth, flowering and flower quality of tuberose. All the parameters except plant height were the highest with 200 kg N, 45 kg P and 80 kg K/ha along with 10 t/ha cowdung. Plant height was highest with 300 kg N, 45 kg P and 80 kg K/ha along with 10 t/ha cowdung.

An investigation was carried out by Waheeduzzaman *et al.* (2006) at Department of Floriculture and Landscaping, Botanic Gardens, Horticultural College and Research Institute, TNAU, Coimbatore, to study the effect of INM practices in improving the flower yield of *Anthurium andreanum* cv. Meringue. The experiment was conducted with six kinds of organic substrates along with inorganic fertilizers. The treatment combination of Panchagavya 4% + 50% recommended dose of fertilizers (RDF) favorably influenced the spathe length (7.50 cm) spathe breadth (7.00 cm), spadix length (4.50 cm) and spike length (32.10 cm). The treatment combination of vermicompost 100 g/plant + 50 % RDF (T_1) recorded the highest value of inflorescence longevity (88.30 day),

number of days for exhibiting gloss loss, spathe bluing and spadix necrosis with the values of respectively 17.50, 18.50 and 21.6 day. The results proved that Panchagavya 4% foliar spray + 50% RDF improved the flower size whereas better vase life was observed in the treatment combination of vermicompost 100 g/plant + 50% RDF.

Rajwal and Singh (2006) studied the effects of various N rates (100, 125 and 150 kg/ha) on the performance of *P. tuberosa* (cv. double) in Muzaffar nagar, Uttar Pradesh, India. The application of 150 kg N/ha resulted in the lowest number of days to the sprouting of bulbs (9.0) and greatest number of sprouts per bulb after 120 days (5.5), number of leaves per bulb after 120 days (44.4), length of the longest leaf (56.2 cm), plant height after 120 days (53.8), spike length (80.4 cm), rachis length (21.5 cm), spike diameter (0.8), weight of the largest bulb per clump (25.1 g) and diameter of the largest bulb per clump (3.1 cm). The number of days to the opening of flowers was lowest (89.6) for 125 kg N/ha. The highest number of bulblets per clump was recorded for 100 kg N/ha (17.5).

Shashikanth (2005) noticed in marigold that application of vermicompost @ 5.0 t ha^{-1} along with recommended dose of fertilizer had increased flower yield (13.9 t ha^{-1}). In the same crop maximum number of flower buds/plant, individual flower weight and flower yield/m^2 were recorded with the application of vermicompost at 1000 g/m^2.

Application of vermicompost (10 t/ha) with N, P_2O_5, K_2O @ 20, 15 and 20 g/m^2 resulted maximum leaf area, length of first order lateral shoots, number of flowers/m^2, flower diameter and weight of flowers/m^2 in rose production (Singh, 2005).

Nitrogen, phosphorus and potassium have a significant effect on spike production and floret quality of cut flowers. Vermicompost and poultry manure are excellent organic fertilizer, as they contains high nitrogen, phosphorus, potassium and other essential nutrients (Chauhan *et al.,* 2005) and increase shelf life.

Padaganur *et al.* (2005) conducted a field experiment at the University of Agricultural Sciences, Dharwad, to study the response of tuberose to vermicompost at different levels (1, 2, 3 kg/sq m) alone and in combination with 50 per cent recommended dose of fertilizer (RDF) and recommended dose of FYM revealed that plants which received vermicompost either alone or in combination with ½ RDF were early to initiate flowering. Significantly higher flower spike yield (1.12 and 1.16 lakhs/ha in 2000 and 2001, respectively) was obtained with the application of 3 kg vermicompost/sq m along with 50 per cent RDF.

Singh *et al.* (2005) studied the effect of varying levels on N (10, 20 and 30 g/m^2), P_2O_5 (10, 20 and 30 g/m^2) and K_2O (10 and 20 g/m^2) on the growth and flowering of tuberose (*Polianthes tuberosa*) cv. Single at Faizabad, Uttar Pradesh, India. The authors reported that application of NPK increased sprouts per bulb, leaves per plant, leaf length, spike length, flowering duration, florets and spikes per clump.

A field experiment was conducted by Pal and Biswas (2005) in Nadia, West Bengal, India, to investigate the effect of N, P and K on growth of flowering of tuberose (*Polianthes tuberosa*) cv. Calcutta Single. The application of 20 g each of N, P_2O_5 and K_2O/m^2 recorded the highest plant height, leaf number and spike length. However application of N, P_2O_5 and K_2O at 20, 15 and 20 g/m^2, respectively, improved spike weight and yield and number of florets per spike for the first year. Application of 15 g each of N, P_2O_5 and K_2O/m^2 improved

plant height and leaf number in ratoon crop. The spike production was highest with N, P_2O_5 and K_2O at 20, 15 and 15 g/m^2, respectively, in ratoon crop.

Kumar *et al.* (2004) conducted a pot culture experiment in sandy loam soil to evaluate the effect of N (0, 50, 100, 200, and 250 ppm) and Zn (0, 2.5, 5.0, 7.5 and 10. 0 ppm) on spike length, bulb production and nutrient content of tuberose cv. Double. Spike length increased significantly with application of N. The maximum spike length (56.7 cm) was recorded at 200 ppm N level which was at par with 150 ppm N. Zinc application also increased the spike length significantly and the maximum spike length (56.7 cm) was observed with 10 ppm Zn level. The application of N and Zn significantly increased the bulb production (number of bulbs, average weight of bulb and yield of bulbs per plant). The application of 100-150 ppm N along with 7.5 ppm Zn was observed optimum for tuberose cultivation.

Farmyard manure, vermicompost, mustard oil cake and poultry manure which supply organic nitrogen significantly influences for increased yield and reduced needs of agro-chemicals in flowers. Bose *et al.* (2003) reported that tuberose yield increased with combined application of vermicompost with NPK and B. The application of poultry manure and bokashi at the rate of 3 t/ha produced better yield in flower crops than with inorganic fertilizers (Patil, 2000).

Rahman (2000) carried out an experiment on tuberose at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh and found that plant height of tuberose was significantly influenced by the application of cowdung. The highest plant height (75.3 cm.) at 100 days was obtained from 10 t/ha of cowdung.

Yadav *et al.* (2000) reported that phosphorus, potassium, nitrogen, boron and zinc with addition of FYM or vermicompost or poultry manure were needed for successful cultivation of tuberose flower. They also stated that application of FYM @ 10 t/ha improved growth and flower characters of tuberose like plant height, plant spread, spike length, rachis length, flower yield and quality.

Kusuma (2000) observed that the golden rod plants supplied with vermicompost (10 tons per hectare) and 100 per cent recommended NPK (100:50:50 kg/ha) produced greater plant height, maximum number of leaves and highest flower yield.

Atiyeh *et al.* (2000) reported that relatively low concentration of vermicompost promoted plant growth in marigold. In the same crop plants applied with vermicompost (15 tons per hectare) + 100 per cent recommended NPK produced maximum number of flowers per plant with greater flower diameter and flower yield than plants without vermicompost and fertilizer application.

Singh and Sangama (2000) studied the N, P and K uptake by *Polianthes tuberosa* cv. Single conducted in Bapatla, Andhra Pradesh, India. Treatments consisted of 4 NPK application rated (100 kg N + 50 kg P_2O_5 + 50 kg K_2O/ha (F_1), 175 kg N + 75 kg P_2O_5 + 75 kg K_2O /ha (F_2), 250 kg N + 100 kg P_2O_5 + 100 kg K_2O/ha (F_3), and 325 kg N + 125 kg P_2O_5 + 125 kg K_2O/ha (F_4). The authors reported that the treatments F_4, F_3 and its combinations resulted in the highest N, P and K uptake, both at 50% flowering stage and harvesting stage.

Patil *et al.* (1999) conducted an experiments to know the effect of 4 rates of fertilizers viz. 150:50:50, 150:100:100, 200:150:150 and 250:200:200 kg NPK/ha in Karnataka, India and reported that among the fertilizer rates, 250:200:200 kg NPK/ha resulted in the highest number of shoots, leaves and spikes, maximum plant height and flower yield. Application of 250:200:200 kg

NPK/ha on tuberose resulted in the highest flower and spike yields (7.86 t/ha, 3.33 spikes/ha, respectively) and plant growth (43.72 cm).

Dalal *et al.* (1999) conducted a field experiment to study the influence of N application rate (0, 50, 60, or 70 kg/ha) on flower quality of *Polianthes tuberosa*. The optimum N application rate was 70 kg/ha which produced maximum rachis length, flower stalk length, flower weight and vase life (30.68 cm, 88.78 cm, 89.14 g/plant and 12.74 days, respectively).

Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers. Amarjeet and Godara (1998) in plots of *Polianthes tuberosa* cv. Single received N fertilizer at 0, 100, 200, 300 or 400 kg/ha and P and K fertilizer each at 0, 100 or 200 kg/ha. Increasing rates of N, P and K increased the number of leaves per plant and plant height significantly. Increasing rates of N and P reduced the number of days for sprouting of bulbs but K had no significant effect.

Fertilizers have great influence on growth, building and flower production in tuberose. Boron and zinc @ 2.0 kg and 3.0 kg per hectare with blanket dose of $N_{300}P_{90}K_{175}$ was recommended for maximizing flower yield and quality of tuberose (Singh and Godara, 1998).

Patel *et al.* (1997) conducted with 4 fertilizer rates (5 kg organic manure/m^2 or NPK at 100 + 50 + 0, 200 + 100 + 50 or 300 + 200 + 100 kg/ha) were compared in trials in Navsari, Gujarat, India with *Polianthes tuberosa* (cv. double) grown for cut flower. Neither plant height nor leaf width was affected by the different fertilizer treatments. Leaf number was highest with highest NPK fertilizer rate. Flower spike length and number of florets/spike were highest with the highest NPK rate.

An experiment was studied by Bhuyan *et al.* (1996) at Jorhat, Assam, India, during 1992 and 1993 to study the effect of applying K at 0-120 g K_2O/m^2 on growth, flowering and bulb production in tuberose for cut flowers. The number and weight of spikes, floret size, shelf-life and vase-life increases as K rate increased up to 60 g/m^2. Bulb production was also greatest with 60 g K_2O/m^2.

Amarjeet (1995) studied a fertilizer trial with P and B in *P. tuberosa* cv. Single. Application of high rates of P and B delayed spike emergence and toxicity. Length of spike and rachis increased significantly at both developmental stages (opening of first floret and last floret) with optimum doses of P and B fertilizer @ 100 kg/ha and 1 kg/ha respectively.

Kulkarni (1994) recorded increased growth and dry weight in China aster with application of vermicompost @ 2.5 to 5.0 tons per hectare alone or in combination with inorganic fertilizers.

Although chemical based conventional farming practices have substantially increased crop yield, they create numerous problems to mankind. Modern agricultural farming using excessive amounts of chemical fertilizers has contributed to the destruction of our natural resources and degradation of the environment. Studies conducted by Belorkar *et al.* (1993) in tuberose revealed many beneficial effect of using bokashi and effective microorganism instead of applying inorganic chemicals.

Baksh *et al.* (1993) in Jessore region investigated that July to August was peak period for tuberose yield and January to March was lean period. But during first year, tuberose yielded highest in January-February when both organic and inorganic fertilizer.

Parthiban *et al.* (1992) worked on *Polianthes tuberosa* cv. Single plants were supplied with 50, 75, 100 or 125 kg N/ha, 25, 50, 75 kg P/ha and 37.5, 62.5 or 87.5 kg K/ha. The highest mean number of leaves, number of side suckers/clump, bulb and bulblet were obtained with the 100 kg N + 75 kg P + 62.5 kg K/ha treatment combination.

Roy (1992) investigated the effect of two doses of potash (250 and 500 kg per hectare) on growth and yield of tuberose and reported that plant characters were greater in 500 kg potash/ha than in 250 kg potash/ha.

A large beneficial population and biologically active metabolites, particularly gibbrellins, cytokinins, auxins and B vitamins were observed with application of vermicompost alone or in combination with organic or inorganic fertilizers, so as to get better yield and quality of diverse crops (Tomati *et al.*, 1991)

Gowda *et al.* (1991) carried out an experiment at the farm under Horticulture Division, University of Agriculture, Bangalore, India, with three rates of N application (100,150 and 200 kg/ha), 3 of $P_2 O_5$ (50, 75 and 100 kg) and 3 of K_2O (100, 125 and 150 kg) were compared for a cut-flower crop of *Polianthes tuberosa* L. grown at a spacing of 30 × 30 cm. All the P_2O_5 and K_2O and half the N were applied as a basal dressing, the remaining N was applied as a top dressing 30 days after planting. The highest yield of flowers (40.20/spike), the longest spikes (81.28 cm) and the longest duration of flowering (29.75 days) were obtained with 200 kg N + 75 kg P_2O_5 + 125 kg K_2O/ha.

Parthiban and Khader (1991) studied in an experiment aimed at determining the fertilizer requirements of *Polianthes tuberosa* cv. Single. N was applied at 50, 75, 100 kg, P at 25, 50, or 75 kg and K at 37.5, 62.5 or 87.5 kg/ha. Application of 100 kg N + 75 kg P + 62.5 kg K/ha resulted the highest number

of spikes/plant, number of flowers/spike (39.67) and the highest flower yield (3578.6 kg/ha).

Bankar and Mukhopadhyay (1990) evaluated the effect of NPK on growth and flowering of tuberose cv. double. N was applied @ 0, 5, 10, 15 g/m^2 P_2O_5 @ 0, 20 or 40 g/ m^2 and K_2O @ 0, 20 or 40 g/m^2. One half of N and all of P were applied before planting, the remaining N was applied as a top dressing before flower emergence. N application advanced flowering and improved growth. The highest number of flower spikes/m^2 was obtained with the highest N rate whereas P had significant effect on floret quality only. K had no appreciable effect. Fertilization of tuberose with N: P_2O_5: K_2O at 20:20:20 g /m^2 was recommended.

Gowda *et al.* (1988) carried out in studies with tuberose cv. grown for cut flowers, the plants received N and P, each at 20, 30 or 40 g/m^2; was applied as a basal dressing. A high number of spikes/plant, a large florets diameter (9.0 cm), the highest number of floret/plant (14.6) and the greatest spike length (89.7 cm) were obtained with the highest N and K rates.

Vermicompost besides being a rich source of micronutrients also acts as a chelating agent and regulates the availability of metabolic micronutrients like iron and zinc to the plants apart from increasing the plant growth and yield by providing nutrients in the available forms (Kale *et al.,* 1987).

Mukhopadhyay *et al.* (1986) conducted a fertilizer experiment for two years with tuberose cv. Single and reported that the yield of bulb and bulblets as influenced by the different fertilizer levels, it was found that only the number of bulblets got increased by adding nitrogen, while the number of flowering size bulbs was not affected by N levels. These showed positive interaction and maximum bulblet production was recorded in the treatment comprising 20 g P_2O_5 and 40 g K_2 O/m^2.

Yadav *et al.* (1985) carried out a three year investigation on nutrient requirements of tuberose in West Bengal, India. In their experiments, 300 kg nitrogen in two splits and 20 kg phosphorus per hectare per year proved to be the most effective in improving the plant growth and flowering. He found that with best agronomic practices in 'single' tuberose about 5 lakh flower spikes and/or 10.5 tons of loose flowers can be obtained per hectare under Nadia District of West Bengal.

Banker and Mukhopadhyay (1985) investigated response of *Polianthes tuberosa* cv. Single to high doses of NPK. N, P_2O_5 and or K_2O were applied at plant and floral characteristics were assessed. N had a significantly beneficial effect on all of the parameters studied whereas P had a significant effect on floret quality only. K had on appreciable effect. Survival of spike in the field was longest (22.8 days) with highest N rate.

The application of compost to the soil increased the water holding capacity, reduced soil erosion and improved the physico-chemical and biological conditions of the soil besides providing plant with nutrients (Okigbo, 1983).

Nambisan and Krishran (1983) reported that the requirement of manures and fertilizers for tuberose vary with climatic conditions and soil types. They recorded from an experiment with tuberose cv. single a flower yield of 1200 kg/ha, by using FYM alone and application of nitrogen and phosphorus fertilizers increased yield to 20951 kg/ha under South Indian condition.

Azad and Yousuf (1982) opined that soil productivity could be enhanced through the utilization of mineral fertilizer as well as organic materials. The growth and physio-morphological characters of lily were positively and significantly influenced by organic amendments.

Nanjan *et al.* (1980) studied the effects of nitrogen, phosphorus and potash on the production of tuberose cv. Single in a neutral clay soil having high amount of potassium. They recommended a nutrient combination of 200 kg nitrogen, 60 kg phosphorus and 50 kg potash/ha is soils low in potassium.

Pathak and Choudhuri (1980) studied that *P. tuberosa* cv. Single plants were supplied with 50 or 75 kg P/ha along with B 1 or 2 kg/ha resulted the greatest plant height (58.93 cm), highest mean number of leaves (41.34) and number of side suckers/clump and flower yield.

Singh *et al.* (1976) recommended that flower yield of tuberose should receive a dose of 180 kg nitrogen, 260 kg phosphorus, 40 kg potash per hectare along with vermicompost (3 t/ha) under Uttar Pradesh, India conditions to have optimum flower yield. According to them nitrogen with vermicompost increased the yield of fresh flowers through increasing the number of spike, number and weight of flower per hill and also the weight of flower per hill and per spike.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted to study the "Integrated nutrient management on growth, yield and quality of tuberose" during March 2014 to February 2015 at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The materials and methods that were used for conducting the experiment are presented in this chapter under the following headings:

3.1 Experimental site

The experiment was conducted at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. The location of the site was about 35 km North of Dhaka city with $24^0 09'$ N latitude and $90^0 26'$ E longitude and elevation of 8.40 m from the sea level (Naznin *et al*., 2015).

3.2 Agro-ecological Zone

The experimental field belongs the Agro-ecological zone of AEZ-28 under Modhupur Tract.

3.3 Soil

The soil of the experimental field was silty clay loam in texture and acidic in nature. Soil sample of the experimental plot was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Gazipur and have been presented in Appendix-I.

3.4 Climate

The climate of experimental site was under the subtropical, characterized by three distinct seasons, the monsoon or the winter season from November to February and the pre-monsoon, period or hot season from March to April and the monsoon, period from May to October. The weather data of the growing period are presented in Appendix II.

3.5 Experimental material

Medium size (2.0-2.5 cm diameter) bulb of tuberose single cultivar (PT-001) was selected as experimental materials. The single ever blooming Mexican Tuberose is one of the most fragrant of cultivated plants. This wonderful cut flower bears clusters of waxy, white tube-shaped flowers from early to late summer. The flowers are beautiful but it is their sweet, rich fragrance that steals the show.

3.6 Treatments

The experiment consisted of 9 treatments comprising different level of organic manure and fertilizer.

T_1: Farmyard manure (5 t/ha) + $^1/_2$ RDF

T_2: Farmyard manure (10 t/ha) + $^1/_2$ RDF

T_3: Poultry refuse (5 t/ha) + $^1/_2$ RDF

T_4: Poultry refuse (10 t/ha) + $^1/_2$ RDF

T_5: Vermicompost (5 t/ha) + $^1/_2$ RDF

T_6: Vermicompost (10 t/ha) + $^1/_2$ RDF

T_7: Bokashi (3 t/ha) + $^1/_2$ RDF

T_8: Bokashi (5 t/ha) + $^1/_2$ RDF and

T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

(Halder *et al*., 2007)

3.6.1 Preparation of farm yard manure

Farm yard manure is prepared basically using cow dung, cow urine, waste straw and other dairy wastes. Cow dung which gets in abundance was collected after cleaning cowshed in a pit close by and was allowed to decompose over a period of time. Every month this manure (compost) was applied to the plants or the field to enrich the soil.

3.6.2 Preparation of poultry refuse

Poultry refuse is basically a waste material which is organic in nature and comprises of urine and feces of animals which are related to poultry e.g. chicken. Poultry manure is a mixture of certain types of bedding material such as sawdust or wood shavings. The manure is acquired by cleaning of the poultry houses on regular basis where thin bedding layers are removed along with such manure. So the manure which is basically the waste from chicken dropping and other mixtures, when used as fertilizer is called Chicken fertilizer.

3.6.3 Preparation of vermicompost

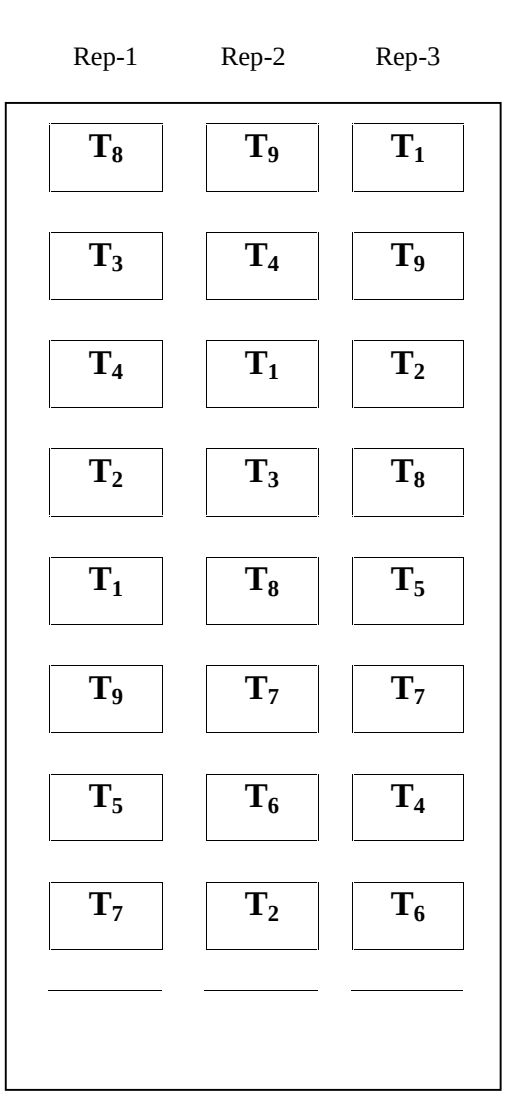
The cowdung collected from local cowshed was decomposed for 10 days before putting into vermicompost process. These were kept in a chari. Twenty kg of decomposed cowdung substrate was taken in a chari for vermicomposting. Two hundred gram of *Eisenia fetida* earthworms were introduced on the top of the substrate in the chari. The chari was covered on the top by jute cloth cover to prevent and protect the earthworms from predators. After 60-70 days, when the substrate looks tea like structure, the vermicompost was ready for use. This vermicompost was collected from Soil Science Division of BARI.

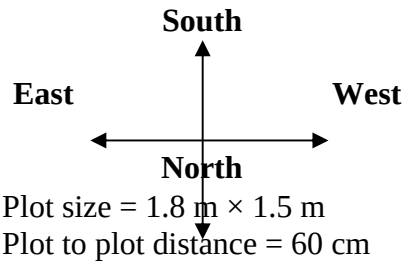
3.6.4 Preparation of bokashi

Bokashi was made comprising fish meal, oil cake, bone meal, rice bran, poultry refuse @ 20 kg, 40 kg, 20 kg, 100 kg and 100 kg, respectively. After adding 50% water, the components were mixed together and 5 kg half fermented cowdung were added which contained effective micro-organism. Then the mixtures were piled for fermentation for several weeks. During fermentation temperature was raised upto 70^0C. While the temperature exceeded 55^0C the piled was broken for removing heat. Therefore, fermented compost namely 'Bokashi' ready to apply in the tuberose field collected from Vegetable Division of HRC, BARI which is high in NPK and other micronutrients.

3.7 Design and Layout

The experiment was laid out in a Randomized Complete Block (RCB) Design with three replications.





Plot size = 1.8 m × 1.5 m
Plot to plot distance = 60 cm
Block to block distance = 80 cm
Plant spacing = 30 cm × 20 cm

T_1: Farmyard manure (5 t/ha) + ½ RDF

T_2: Farmyard manure (10 t/ha) + ½ RDF

T_3: Poultry refuse (5 t/ha) + ½ RDF

T_4: Poultry refuse (10 t/ha) + ½ RDF

T_5: Vermicompost (5 t/ha) + ½ RDF

T_6: Vermicompost (10 t/ha) + ½ RDF

T_7: Bokashi (3 t/ha) + ½ RDF

T_8: Bokashi (5 t/ha) + ½ RDF and

T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

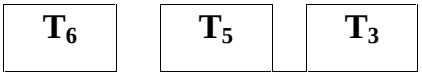


Figure 1. Layout of the experiment

The unit plot size was 1.8 m × 1.5 m accommodating 45 plants per plot. Two adjacent unit plots were separated by 60 cm space and there was 80 cm space between the blocks.

3.8 Land preparation

The experimental plot was first opened on last week of February 2014 with a power tiller for sun curing for 7 days before next ploughing. The land was then ploughed and cross ploughed several times using power tiller to obtain a good tilth. Ploughing was followed by laddering for breaking large soil clods and for leveling the land surface. The weeds and stubbles were removed from the land just after laddering with special care to remove the rhizomes of mutha grass.

3.9 Application of manure and fertilizer doses

Well-decomposed cow dung, poultry manure, vermicompost, bokashi, P, K, B, S and Zn were applied during final land preparation as per treatment. N was applied in three installments at 35, 55 and 75 days after planting of bulbs.

Recommended fertilizer doses

Fertilizers	Dose/ha
N	**150 kg**
P	**30 kg**
K	**100 kg**
S	20 kg
B	1 kg
Zn	1 kg

(Source: Halder *et al.*, 2007)

3.10 Planting of bulbs

Bulbs were thoroughly treated with fungicide Provex for 5 minutes and planted at a depth of 7 cm in furrows on March, 2014. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant.

3.11 Intercultural Operation

3.11.1 Weeding

Weeding was done periodically whenever necessary.

3.11.2 Irrigation

The experimental plot was irrigated as and when necessary during the whole period of plant growth following flood method.

3.11.3 Mulching

The soil was mulched frequently after irrigation by breaking the crust for easy aeration and to conserve soil moisture.

3.11.4 Earthing up

Earthing up were done three times at 40, 60 and 80 days after planting throughout the growing period.

3.11.5 Selection and tagging of plants

Ten plants from each plot were selected randomly and marked by tagging for recording data.

3.11.6 Plant protection measure

Leaf blight disease is a serious problem for tuberose cultivation. But the severity of this disease was not so prominent during the study period. Tilt @ 1.5 ml/L was applied once in a fortnight interval. Compared to disease, the

insects of tuberose are not so serious. Marshal and Malathion @ 1 ml/L were applied to protect mealybugs and aphids.

3.11.7 Harvesting

The spikes of tuberose were harvested from May to July, 2014 at the tight bud stage and when three basal flower buds showed colour so that these may easily open indoors one by one (Bose *et al.* , 2003). Bulbs and bulblets were harvested on February, 2015 when the leaves also started yellowing.

3.12 Data collection

Observation were recorded from randomly chosen 10 plants form each plot on following parameters.

3.12.1 Plant height

Plant height refers to the total length of the 10 randomly selected plants from ground level to tip of erect leaf measured by a meter scale at flower harvest and the mean was calculated and expressed in centimeter.

3.12.2 Days to sprouting

It was recorded by counting the days from bulb planting to sprouting and expressed in days.

3.12.3 Leaves/plant

Number of leaves produced per plant was recorded from the selected plants by counting the number of leaves at flower harvest and average number of leaves produced per plant was worked out.

3.12.4 Plant/hill

Number of plant per hill was recorded by counting all the plant per hill from 10 randomly plants of each unit plot and the mean was calculated.

3.12.5 Plant spread

The plant spread was measured at two positions (NS and EW) at right angles to each other and average was worked out at flower harvest. The readings were taken from the selected plants and expressed in square centimeter.

3.12.6 Days required to 80% flowering

It was recorded by counting the days from bulb planting to 80% visible spike initiation from randomly selected 10 plants in each plot, then averaged and expressed in days.

3.12.7 Spike length

It was measured from the end where from it was cut off at the base to the tip of the spike by measuring scale from 10 randomly selected spikes and then mean was calculated and expressed in centimeter.

3.12.8 Rachis length

Length of rachis refers to the length from the axils of first floret up to the tip of inflorescence from 10 randomly selected plants.

3.12.9 Floret number

It was recorded by counting the number of florets from 10 randomly selected spikes and then mean was calculated.

3.12.10 Spike weight

Ten spikes were cut from 10 randomly selected plants from each unit plot and the weights of spikes were recorded to calculate their mean and expressed in grams.

3.12.11 Flower durability

Flower durability was recorded from the time of first floret opening to the maximum freshness from 10 randomly selected spikes in field condition and expressed in days.

3.12.12 Flower spike yield/ha

Flower spike yield per hectare was computed from counting the number of flower spikes per plot and converted to hectare.

3.12.13 Bulb number

It was calculated from the number of bulb obtained from 10 randomly selected plants and mean was calculated.

3.12.14 Bulblet number

It was calculated from the number of bulblets obtained from 10 randomly selected plants and mean was calculated.

3.12.15 Bulb diameter

Diameter of harvested bulb was measured by using slide calipers from 10 randomly selected plants, averaged and expressed in centimeter.

3.12.16 10 bulblet weight

Weight of 10 bulblet/plant was recorded from the mean weight of 10 randomly selected sample plants and expressed in grams.

3.12.17 Bulb yield

Bulb yield ton per hectare was computed from weighting the bulbs per plot and converted to hectare.

3.12.8 Bulblet yield

Bulblet yield ton per hectare was computed from weighting the bulblets per plot and converted to hectare.

3.13 Statistical Analysis

The recorded data on different parameters were statistically analyzed using 'MSTAT-C' software to find out the significance of variation resulting from the experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between the treatment means were evaluated by Duncan's Multiple Range Test (DMRT) according to Steel *et al*. (1997) at 5% level of probability. The analysis of variance (ANOVA) of data on different characters of tuberose is given in Appendix III-VI.

CHAPTER IV
RESULTS AND DISCUSSION

The experiment was carried out to study integrated nutrient management on growth, yield and quality of tuberose. The analysis of variance (ANOVA) of the data on different growth parameter, flowering duration, yield of flower and bulb are presented in Appendix III-VI. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1 Plant height

Plant height of tuberose showed statistically significant differences due to different levels of organic manures along with half recommended dose of fertilizers at 30, 50, 70 and 90 DAP (Appendix III). At the different days after planting (DAP) the tallest plant (23.0, 45.0, 53.0 and 61.5 cm) was recorded from T_6 treatment at 30, 50, 70 and 90 DAP, respectively followed by T_4 (20.8, 42.3, 50.0 and 60.0 cm) at same DAP, again, at the same DAP the shortest plant (15.0, 35.0, 42.2 and 46.0 cm) was recorded from T_9 treatment (control i.e. absolute use of chemical fertilizer) (Fig. 2). Tuberose is a gross feeder and requires a large quantity of NPK in the form of organic and inorganic fertilizers (Singh *et al.*, 1976 and Singh *et al.,* 1998). Plant height may be attributed to the presence and synthesis of gibberellins in vermicompost. Gibberellins cause both cell elongation and division that stimulates elongation and resulted in increase plant height. These finding are in conformity with the findings of Shankar *et al.* (2010) and Rena *et al.* (2014) in tuberose.

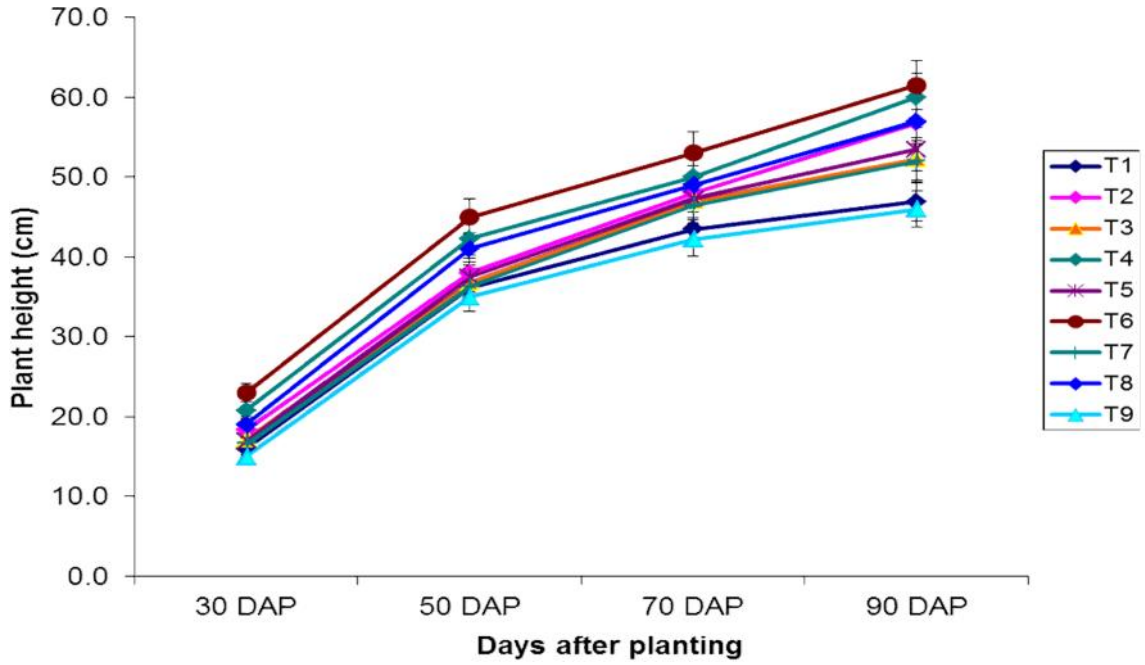


Figure. 2: Effect of organic manure and fertilizer on plant height of tuberose

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3 t/ha) + ½ RDF, T_8: Bokashi (5 t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

Table 1. Effect of organic manure and fertilizer on vegetative growth of tuberose

Treatments	Days to sprouting	Leaves/plant	Plant spread (cm)	Plants/hill
T_1	9.0 ab	26.0 bc	14.5 bc	5.0 ab
T_2	9.0 ab	28.0 bc	16.5 b	6.0 ab
T_3	9.0 ab	30.0 b	17.0 ab	7.0 ab
T_4	8.0 ab	31.0 ab	20.0 a	8.0 ab
T_5	8.0 ab	30.0b	18.0 ab	7.0 ab
T_6	6.0 b	35.0 a	20.5 a	10.0 a
T_7	9.0 ab	28.0 bc	16.05 b	5.0 ab
T_8	9.0 ab	26.0 bc	14.0 bc	5.0 ab
T_9	11.0 a	24.0 c	12.0 c	4.0 b
LSD (0.05)	1.6	3.2	2.8	2.1
Level of Sig.	*	*	*	*
CV%	8.5	12.2	10.7	8.9

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.2 Days to sprouting

The variation among the treatments in respect of days to sprouting of bulb per plant was found significant (Table 1). The bulbs under T_6 (Vermicompost @ 10 t/ha + ½ RDF) took minimum time (6 days) to sprouting, while the bulbs of T_9 (Control) required maximum time (11 days). The earliest emergence of bulbs in T_6 (Vermicompost @ 10 t/ha + ½ RDF) might be due to the early absorption of N, P and K increased the availability of micronutrients as well as plant hormones due to which the time taken for emergence of bulbs was reduced significantly. Padaganur *et al.* (2005) and Kabir *et al.* (2011) reported similar results in tuberose flowers.

4.3 Leaf number

The result revealed that there was a significant variation in number of leaves per plant among the treatments studied (Table 1). The maximum number of leaves were found in T_6 (Vermicompost @ 10 t/ha + ½ RDF) (35.0) followed by T_4 (32.0). The lowest number of leaves/plant was found in control treatment (25.0). The results indicated that essentiality of nitrogenous element in organic form enhanced to constitute chlorophyll which leads to better leaves over control treatment. Kadu *et al.* (2009) reported that the profound effect of nitrogen fertilization on anatomical structure of tuberose.

4.4 Plant spread

The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. There were significant differences among the treatment in respect of plant spread (Table 1). Maximum plant spread was recorded in T_6 (20.5 cm) which statistically similar to T_4 (20.0 cm). The minimum plant spread (12.0 cm) was observed in control. Gowda *et al.* (1991), Kulkarni (1994) and Nazari

et al. (2008) have also reported similar results. The plant spread was found maximum with T_6 and T_4 treatment might be due to getting optimum nutrients resulting higher vegetative growth compared to other treatments.

4.5 Number of plant per hill

Different levels of organic manure and fertilizer showed a statistically significant difference for number of plants/hill at flower harvest under the present study (Appendix VI). The maximum (10.0) number of plants/hill was recorded at T_6 (Vermicompost @ 10 t/ha + ½ RDF) followed by T_4 (Poultry manure @ 10 t/ha + ½ RDF) (8.0). On the other hand the minimum (4.0) number of plants/hill was recorded in the plot with control condition i.e. absolute use of chemical fertilizer. Increase in vegetative growth may be due to better flow of various macro and micro nutrients along with plant growth substances into the plant system in the plots applied with vermicompost and half recommended dose of fertilizer. The observed results are in agreement with the findings of Chopde *et al.* (2007) and Reshma *et al.* (2013) in tuberose. They reported that application of vermicompost with organic fertilizer had tremendous effects on plant growth and development in tuberose.

Table 2. Effect of organic manure and fertilizer on flowering of tuberose

Treatments	Days required to 80% flowering	Spike length (cm)	Rachis length (cm)	Floret number	Spike weight (g)
T_1	86.0 ab	73.5 bc	25.0 bc	38.0 bc	48.0 cd
T_2	81.0 bc	76.0 ab	26.7 bc	42.0 ab	50.0 c
T_3	82.0 bc	75.0 b	28.0 b	40.0 b	52.8 bc
T_4	80.0bc	77.0 ab	30.0 ab	41.0 ab	55.0 b
T_5	81.0 bc	77.2 ab	29.0 ab	40.0 b	53.4 bc
T_6	75.0 d	80.0 a	34.0 a	45.0 a	60.0 a
T_7	83.0 bc	76.7 ab	26.9 bc	43.0 ab	53.0 bc
T_8	85.0 b	74.1 bc	24.6 bc	40.0 bc	51.0 bc
T_9	90.0 a	72.0 c	22.0 c	36.0 c	45.0 d
LSD (0.05)	2.9	1.6	2.2	2.4	3.0
Level of Sig.	*	*	*	*	*

CV%	10.5	9.8	8.7	8.5	8.6

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.6 Days required to 80% flowering

Days required to 80% flowering showed variation for different treatment (Table 2). The minimum days required for bulb planting to 80% flowering was recorded in T_6 (75 days) followed by T_4 (80 days). The minimum time as recorded in this study was similar to those recorded by Nambisan and Krishnamm (1983) and Gupta *et al.* (2011). Vermicompost might have role in supply of macro and micronutrients, enzymes and growth hormones and provides micronutrients such as Zn, Fe, Cu, Mn etc. in an optimum level which help in proper flower development (Kusuma, 2000). Further, increase in absorptive surface area of the roots due to VAM might have led to enhanced uptake and translocation of available water and nutrients like P, Zn, Fe, Mg and Cl, ultimately resulting in better sink for faster mobilization of photosynthesis and early transformation of plant parts from vegetative to reproductive phase. Time required to 80% flowering (90 days) was found to be delayed in control treatment. Similar results were reported by Kusuma (2000) in tuberose.

4.7 Spike length

Length of flower spike for different treatments showed variation due to different treatments in tuberose (Table 2). The longest (80.0 cm) length of flower spike was recorded in T_6 and the shortest spike length was found in control (72.0 cm) treatment (Plate 5). The increased spike length was probably due to presence of macro and micro nutrients in vermicompost and their efficient absorption due to presence of varmicompost in the media which showed the better vegetative and reproductive growth of the plant in T_6. These results are similar to the work of Kabir *et al.* (2012) and Tripathi *et al.* (2012)

who found that spike length was increased with the application of vermicompost along with RDF fertilizer.

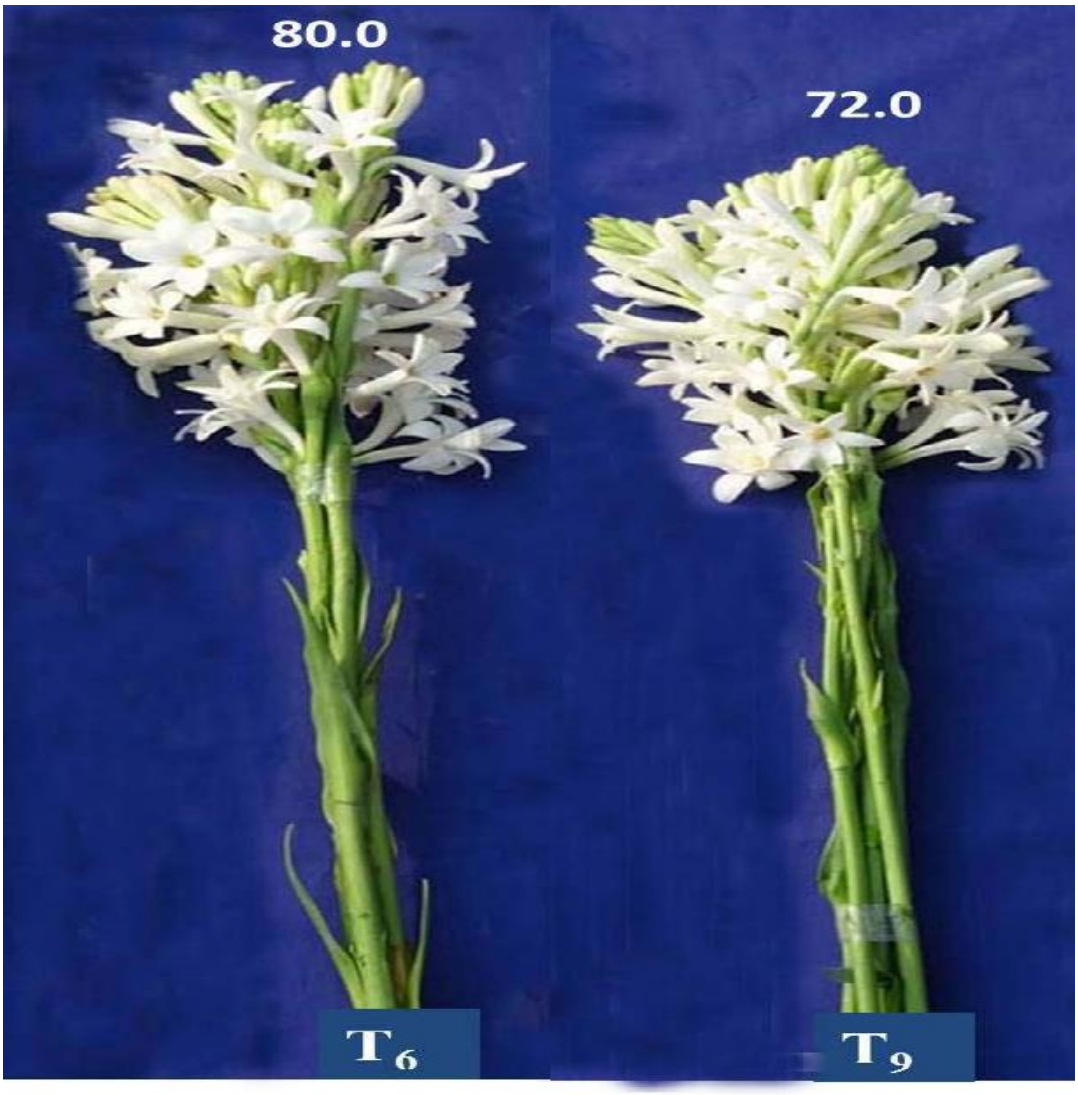


Plate 1. Effect of organic manure and fertilizer on spike length of tuberose

4.8 Rachis length

Different treatments of organic manure and fertilizer had significant effect on the length of rachis in tuberose (Plate 6). The rachis length ranged from 22.0 to 34.0 cm. The maximum length of rachis was obtained in T_6 (34.0 cm), while

the minimum length was found in T_9 (22.0 cm), which differed significantly from all other treatments. The results are in partial agreement with Gupta *et al.* (2011) and Shankar (2011), where they reported that the length of rachis in flowers was increased with the use of organic manure with fertilizer instead of only synthetic fertilizer.

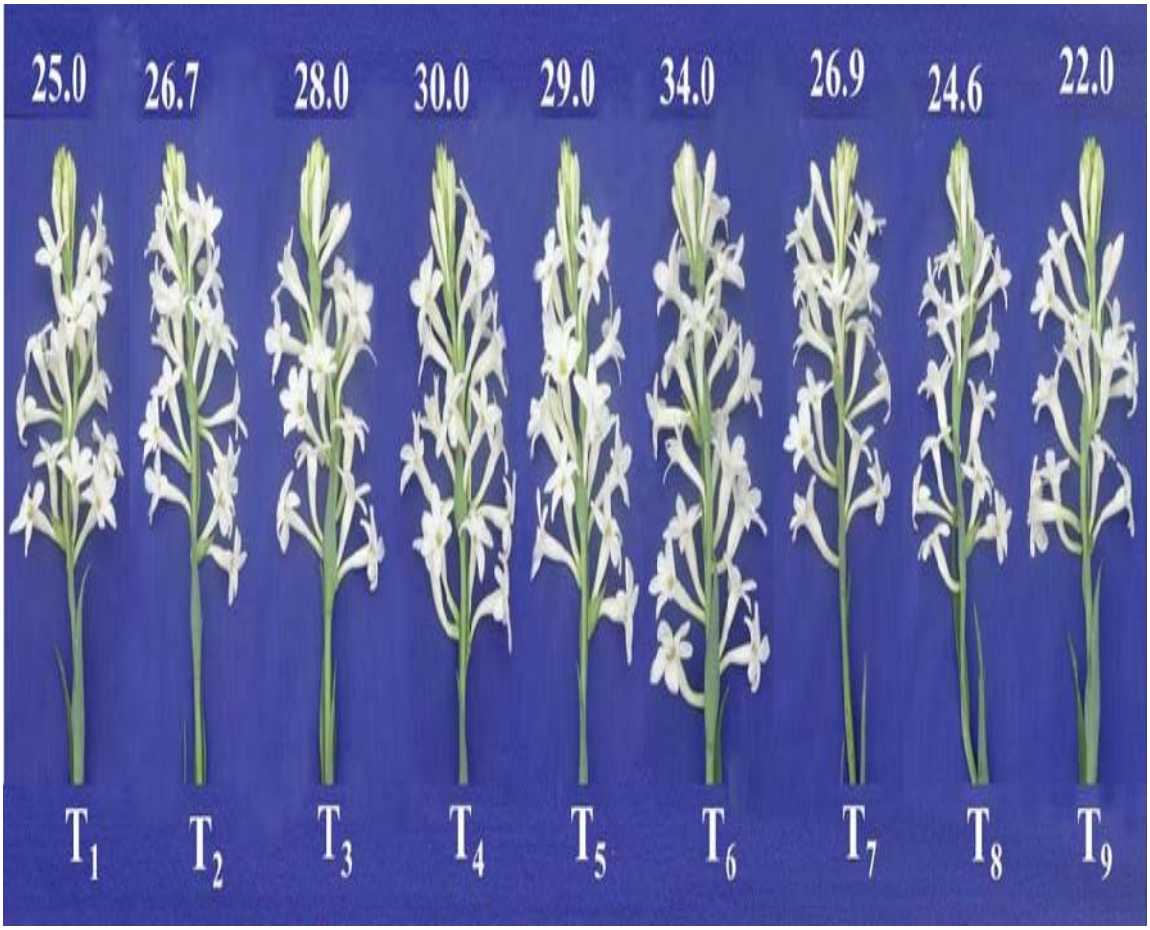


Plate 2. Effect of organic manure and fertilizer on rachis length of tuberose

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.9 Floret number

The floret number is an important parameter of tuberose. Variation was recorded for number on floret/spike for different treatments under the investigation (Table 2). The maximum number of florets was found in T_6 (45)

(Plate 7). The lowest numbers of floret/plant were found in control treatment (36). Increase in number of flowers per plant might be due to presence of growth promotive substances like essential plant nutrients, vitamins, enzymes and antibiotics in vermicompost coupled with RDF. These findings are in conformity with the findings of Patel *et al.* (2011) and Padaganur *et al.* (2011) in tuberose.

Plate 3. Floret number influenced by vermicompost @ 10 t/ha + ½ RDF

4.10 Spike weight

It was revealed from Table 2 that different treatment of organic manure and fertilizer had significant effect on spike weight. The maximum weight of spike was obtained in T_6 (60.0 g) treatment followed by T_4 (55.0 g) treatment and the minimum in treatment T_9 (45.0 g) and was statistically comparable to the remaining treatments. This might be due to the fact that the spikes obtained from plants supplied with vermicompost alone or in combination with fertilizer had more number of florets per spike. Spike with good quality attributes like spike length, rachis length inturn had increased number of florets with increased length and diameter which inturn increased their fresh weight (Table

2). This might be due to the fact that these plants had put forth good vegetative growth which enabled the plants to produce more photosnthates and supply to spikes for their development. The improvement in quality of spikes was mainly due to castings of earthworms which consists of plant growth hormones, various enzymes along with macro and micronutrients (Padaganur *et al*., 2005). Similar improvement in quality by the incorporation of vermicompost was reported by Chopde *et al.* (2007) in tuberose.

4.11 Flower spike yield

The maximum number of flowering spike per hectare (425000) was produced in T_6 (Vermicompost @ 10 t/ha + ½ RDF) which was superior to other treatments. The second highest number of flowering spikes per hectare (400000) was recorded in T_4 (Poultry refuse @ 10 t/ha + ½ RDF). The phenomenon of more number of flowering spikes might be due to slow and unremitting discharge of nitrogenous element from bulky organic manure and fertilizer which influenced to increase chlorophyll content importing dark green colour foliage resulted more food reserve that promoted number of spike per hill. Similar trend has also been reported by Reena *et al.* (2014) in tuberose flower.

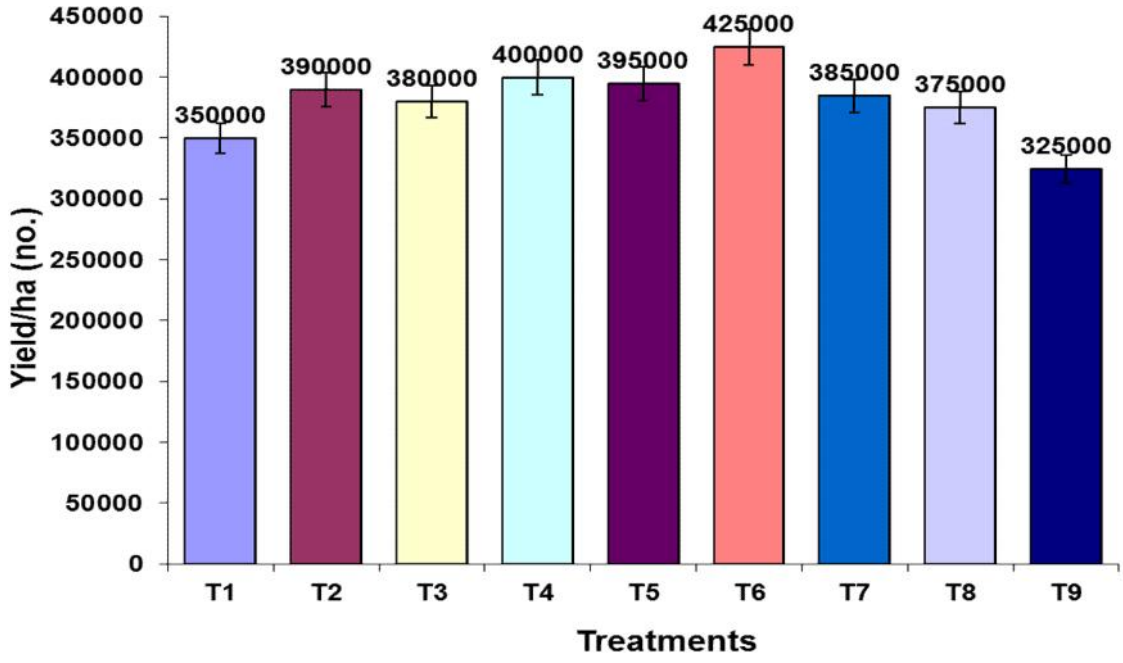


Figure 3. Effect of organic manure and fertilizer on flower spike yield of tuberose

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.12 Flower durability

Maximum duration of flowering was observed in T_6 (Vermicompost @ 10 t/ha + ½ RDF) (15 days) followed by T_4 (13 days) (Poultry manure @ 10 t/ha + ½ RDF). Application of vermicompost, poultry manure with fertilizer influenced flower longevity due to increased nutrient uptake by plant and greater development of water conducting tissues. It might also be due to the presence of ethylene inhibitors or due to presence of cytokinins which delay senescence of florets. The findings were in conformity with the finding of Kusuma (2000) and Kabir *et al.* (2011) in tuberose. The minimum flowering duration was in T_9 (9 days).

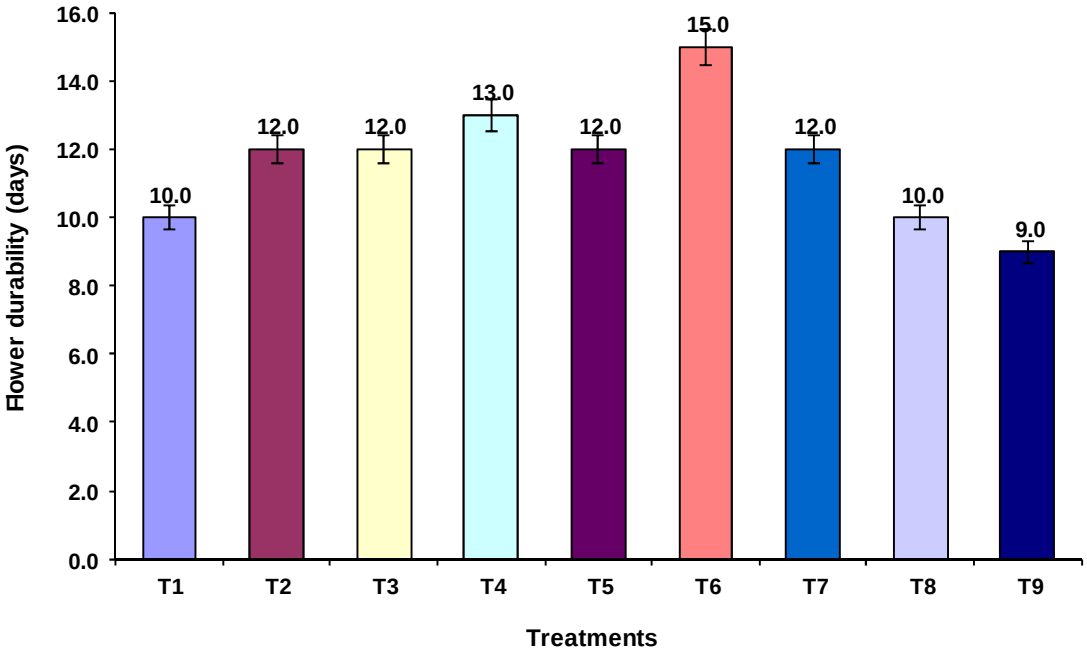


Figure 4. Effect of organic manure and fertilizer on flower durability of tuberose

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi

(3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.13 Number of bulb/hill

Number of bulb per hill showed significantly difference among the treatments (Table 3). The maximum number of bulb/hill (5.0) was found in T_6 (Vermicompost @ 10 t/ha + ½ RDF) which was significantly higher than all other treatments. The lowest number of bulb per hill (2.5) was observed in T_9 (control). Nutrient sources have great influence on bulb production in tuberose (Singh *et al.* 2005).

4.14 Number of bulblet/hill

Number of bulblet/hill showed a statistically significant variation for different treatments under present study (Plate 8). The maximum number of bulblet/hill (15.0) was recorded in T_6 (Vermicompost @ 10 t/ha + ½ RDF). This may be due to improvement of nutrient availability to the plants. The findings of present study are also confirmed with the results of Sankar (2011) in tuberose. The treatment T_9 produced minimum number of bulblets (6.0) (Table 3).

Plate 4. Bulblet number influenced by vermicompost @ 10 t/ha + ½ RDF

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.15 Bulb diameter

Data on the effect of different level of organic manure and fertilizer on tuberose bulb diameter are presented in Table 3. The largest bulb (4.0 cm) was produced in T_6 (Vermicompost @ 10 t/ha + ½ RDF) which were different from other treatments (Plate 9). The smallest bulb (1.5 cm) obtained from control. According to Ramesh *et al.* (2002) and Tripathi *et al.* (2013), the bulb diameter was enhanced when vermicompost with fertilizer and poultry manure with fertilizer was applied in tuberose field.

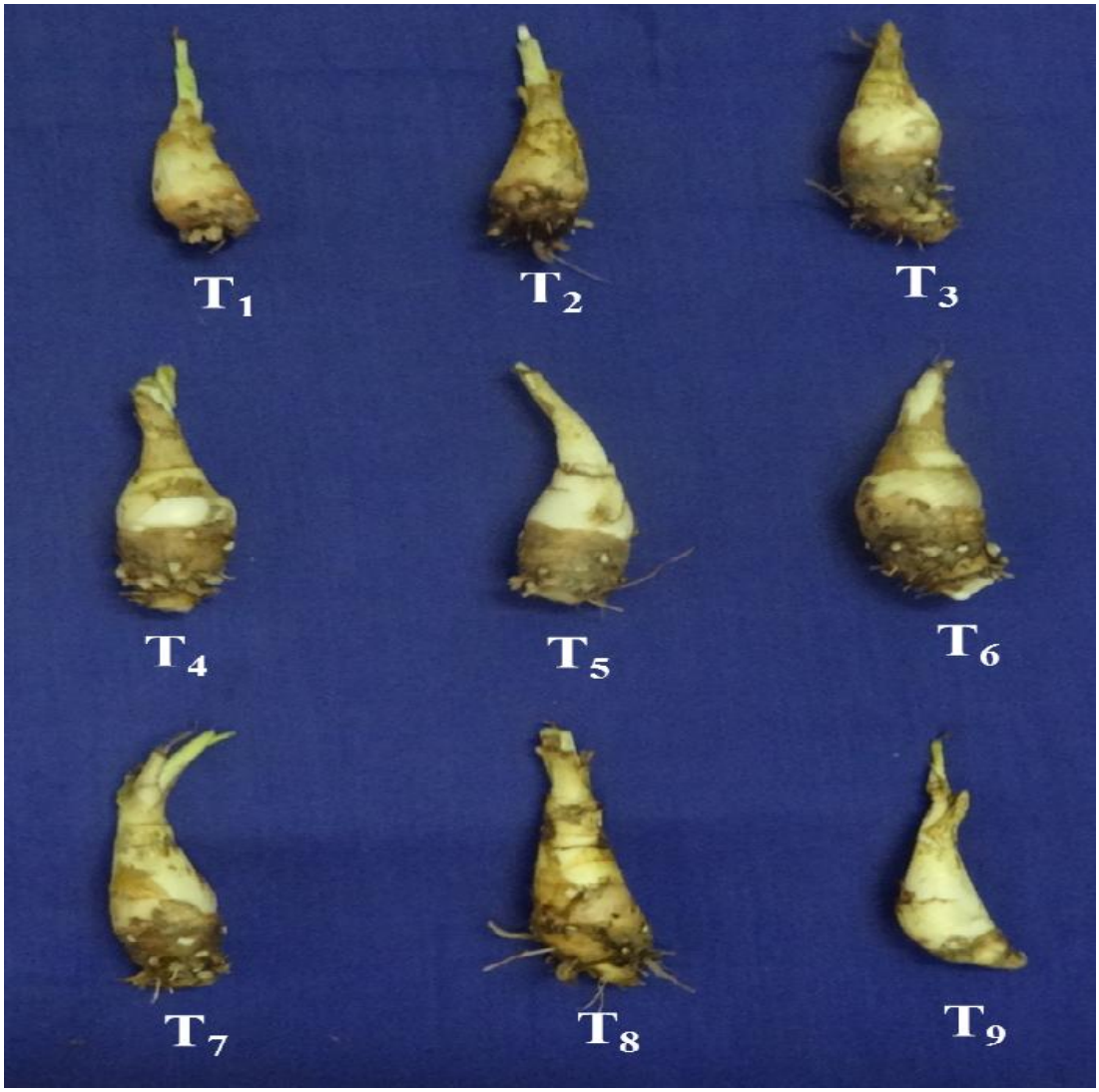


Plate 5. Bulb diameter influenced by organic manure and fertilizer

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

Table 3. Effect of organic manure and fertilizer on bulb production of tuberose

Treatments	Bulb no.	Bulblet no.	Bulb diameter (cm)	Bulb weight (g)	10 bulblet wt. (g)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
T_1	3.0 ab	6.8 bc	1.6 b	26.0 cd	43.0 cd	6.0 b	8.0 ab
T_2	3.5 ab	8.9 bc	2.8 ab	32.0 bc	47.0 bc	7.5 b	8.5 ab
T_3	3.8 ab	8.0 bc	2.7 ab	35.0 b	48.0 bc	8.0 ab	9.0 ab
T_4	4.0 ab	10.0 b	2.8 ab	37.0 ab	51.5 ab	9.0 ab	10.5 ab
T_5	3.8 ab	9.0 bc	2.6 ab	36.0 ab	50.0 b	8.5 ab	10.0 ab
T_6	5.0 a	15.0 a	4.0 a	40.0 a	55.0 a	10.0 a	12.0 a
T_7	3.5 ab	9.5 bc	2.5 ab	34.0 bc	47.0 bc	8.0 ab	9.5 ab
T_8	3.2 ab	7.0 bc	2.3 ab	30.0 c	45.2 c	7.0 b	8.0 ab
T_9	2.5 b	6.0 c	1.5 b	24.0 d	40.0 d	5.0 b	7.5 b
LSD (0.05)	2.1	1.5	1.8	1.3	1.4	1.1	1.9
Level of Sig.	*	*	*	*	*	*	*
CV%	7.7	8.9	8.5	9.2	10.3	10.5	9.8

T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry refuse (5 t/ha) + ½ RDF, T_4: Poultry refuse (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3t/ha) + ½ RDF, T_8: Bokashi (5t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer (RDF) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1kg/ha)

4.16 Bulb weight

Weight of individual bulb showed statistically significant variation for different treatments under the present investigation (Table 3). The maximum weight (40.0 g) of individual bulb was recorded in T_6 (Vermicompost @ 10 t/ha + ½ RDF) which was statistically different from other treatments and the minimum weight (24.0 g) of individual bulb was recorded in T_9 (Control). In an experiment, treatment with vermicompost and poultry manure with fertilizer proved very effective for the development of bulbs stated by Padaganur *et al.* (2005) and Reshma *et al.* (2013) in tuberose.

4.17 Bulblet weight

A statistically significant variation was recorded for different treatments in terms of 10 bulblet weight. The highest weight (55.0 g) was recorded in T_6 (Vermicompost @ 10 t/ha + ½ RDF) treatment. On the other hand, the lowest (40.0 g) weight of ten bulblet was recorded in control condition. Shashikanth (2005) and Kabir *et al.* (2011) found similar result which supports the present findings in tuberose.

4.18 Yield of bulb per hectare

Yield of bulb per hectare showed statistically significant difference for the application of organic manure with fertilizer (Appendix VI). The highest yield of bulb per hectare (10.0 ton) was recorded from T_6 and the lowest yield of bulb per hectare (5. 0 ton) was attained from T_9 (Table 3). The improvement in bulb yield by organic chemical and biofertilizer application might be due to fact that vermicompost which is nutrive fertilizer increased the level of macro and micro nutrients in soil and improve the level of growth promotive substances. These results are consistent with the result of Tripathi *et al.* (2013) who reported that application of organic amendments with chemical fertilizers increased bulb yield.

4.19 Yield of bulblet per hectare

Application of organic manure with fertilizer varied significantly on yield of bulblet per hectare (Appendix VI). The highest yield of bulblet per hectare (12.0 ton) was obtained from T_6 while, the lowest yield of bulblet per hectare (7.5 ton) was recorded from T_9 (Table 3). Beneficial effect of vermicompost @ 10 t/ha with fertilizer might have helped in production of more bulblets. The higher bulblet yield in organic amendments applied plants along with chemical

fertilizers might be produced more assimilates by greater number of leaves. These results were in line as reported by Ramesh *et al.* (2002) and Gupta *et al.* (2011) in tuberose.

CHAPTER V
SUMMARY AND CONCLUSION

Summary

An investigation was carried out at Floriculture Experimental Field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during March 2014 to May 2015 to study the growth, yield and quality of tuberose as influenced by organic manure and fertilizer namely T_1: Farmyard manure (5 t/ha) + ½ RDF, T_2: Farmyard manure (10 t/ha) + ½ RDF, T_3: Poultry manure (5 t/ha) + ½ RDF, T_4: Poultry manure (10 t/ha) + ½ RDF, T_5: Vermicompost (5 t/ha) + ½ RDF, T_6: Vermicompost (10 t/ha) + ½ RDF, T_7: Bokashi (3 t/ha) + ½ RDF, T_8: Bokashi (5 t/ha) + ½ RDF and T_9: Control (Recommended doses of fertilizer) (N_{150} P_{30} K_{100} S_{20} B_1 Zn_1 kg/ha). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 1.8 m × 1.5 m accommodating 45 plants per plot. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant.

Bulbs were planted on March 2014 and the spikes were harvested from May to July, 2014 at the tight bud stage and when three basal flower buds showed colour so that these may easily open indoors one by one. Bulbs and bulblets were harvested on February, 2015 when the leaves also started yellowing.

Data were collected from 10 randomly selected plants of each unit plot. Observation were made on plant height, days to sprouting, number of leaves, spike length, rachis length, number of florets per spike, spikes weight, number of plant per hill, plant spread, days to 80% flowering, flower durability, flower yield, number of bulb, bulblet number, 10 bulblet weight, bulb and bulblet

yield. The collected data were statistically analyzed. The results of the experiment have been summarized below.

Analysis of variance data revealed that all the parameters under the study such as growth, yield (flowering as well as bulb and bulblet production) and yield contributing characters of tuberose varied significantly at 5% level of probability due to influence of organic manure and fertilizer.

Among different treatments, T_6 (Vermicompost @ 10 t/ha + $^1/_2$ RDF) recorded the highest plant height (61.5 cm) after 90 DAP. The lowest plant height was noted in control (46.0 cm). The variation among the treatments in respect of days to sprouting of bulb was also found significant. The bulbs in T_6 (Vermicompost @ 10 t/ha + $^1/_2$ RDF) took minimum time (6 days) to sprouting while the bulbs of T_9 (control) required maximum time (11 days).

The maximum number of leaves was found in T_6 (35.0) (Vermicompost @ 10 t/ha + $^1/_2$ RDF) followed by T_4 (31.0). The lowest number of leaves/plant was found in control (24.0). There were significant differences among the treatment in respect of plant spread. Maximum plant spread was recorded in T_6 (20.5 cm) which was statistically superior from other treatments. The maximum number of plants per hill was found in T_6 (10.0). The lowest number of plants was found in control (4.0). Days required to 80% flowering showed statistically significant variation among the different treatments. The minimum days required for bulb planting to 80% flowering was recorded in T_6 (75 days). Time required to 80% flowering was found delayed in T_9 (90 days).

The longest spike (80.0 cm) and rachis length (34.0 cm) were observed in T_6 treatment while the minimum spike (72.0 cm) and rachis length (22.0 cm) was found in T_9 which differed significantly from all other treatments. The

maximum numbers of florets were found in T_6 (45.0) and the lowest number of floret/plant was found in control (36.0).

It was revealed that different treatments of organic manure and fertilizer had significant effect on weight of spike. The maximum weight of spike was obtained in T_6 (60.0 g) treatment followed by T_4 (55.0 g). The minimum weight was found in T_9 (45.0 g) which was statistically comparable to the remaining treatments. Significant variation among the treatments was observed in respect of flower production in tuberose. The highest number of marketable flowers per hectare (425000) was obtained in T_6 (Vermicompost @ 10 t/ha + $^1/_2$ RDF). Maximum duration of flowering was observed in T_6 (15 days) followed by T_4 (14 days) treatment. The minimum flowering duration was recorded in T_9 (9 days).

The maximum number of bulb (5.0) and bulblet (15.0) were recorded in T_6 (Vermicompost @ 10 t/ha + $^1/_2$ RDF) treatment and T_9 produced minimum number of bulb (2.5) and bulblets (6.0). The largest bulb (4.0 cm) was found in T_6 (Vermicompost @ 10 t/ha + $^1/_2$ RDF) which was statistically different from other treatments. The smallest bulb (1.5 cm) obtained by control (T_9). Weight of individual bulb and bulblet showed statistically significant variation for different treatments. However, treatment with vermicompost @ 10 t/ha + $^1/_2$ RDF proved very effective for the production of flowering spike (425000/ha) and development of bulb and bulblet (10.0 t and 12.0 t, respectively).

Conclusion

- From the result of the experiment, it may be concluded that application of vermicompost @ 10 t/ha along with 50 percent recommended dose of fertilizer (RDF) showed significant improvement in vegetative growth, flowering, flower durability and bulb and bulblet attributes. Therefore, it is beneficial for tuberose cultivation and may be recommended for flower, bulb and bulblet production and flower durability of tuberose.

REFERENCES

Amarjeet, S. 1995. Application of fertilizer on tuberose. *Pakistan J. Agric. Res.,* **38** (4): 20-25.

Amarjeet, S. and Godara, N. R. 1998. Effect of nutritional requirement of tuberose (*Polianthes tuberosa* L.) cv. Single on flower yield characters. *Haryana J. Agric. Res.,* **28** (1):15- 20.

Atiyeh, R. M., Edwads, C. A., Subler, S. and Metzer, J. D. 2000. Earthworm processed organic waste as components of horticulture potting media for growing marigold seedlings. *Compost Sci. Util.,***8**: 215-223.

Azad, M. I. and Yousuf, M. Y. 1982. Recycling of Organic matter to improve the soil productivity. *Pakistan J. Agric. Res.,***22** (2): 15-18.

Banker, G. J. and Mukhopadhyay, A. 1985. Response of *Polianthes tuberosa* L. cv. Single to high doses of NPK. *South Indian Hort.,***33** (3): 214-216.

Basksh, M. E., Huq, A. S. M. A., Rahman, M. M. and Elias, S. M. 1993. Tuberose cultivation in Jessore region: An agro-economic assessment. *Bangladesh J. Agril. Res.,***20** (2) : 197-204.

Belorkar, P. V., Patil, B. N., Dhumal, B. S. and Dalal, S. D. 1993. Effect of EM and bokashi on growth, flowering and yield of tuberose (*Polianthes tuberosa*). *J. Soil Crops.,***2** (1): 110-115.

Bhuyan, B., Pasean, L. and Mahanta, P. 1996. Effect of fertilizer on growth and flower yield of tuberose (*Polianthes tuberosa* L) cv. Single. *J. Agric. Sci.,***9** (2): 119-122.

Bose, T. K., Yadav, L. P., Pal, P., Das, P. and Parthasarathy, V. A. 2003. Tuberose. Commercial Flowers. Nayaprakash, Calcutta, India. pp. 603-644.

Chaitra, R. and Patil, V. S. 2007. Integrated nutrient management studies in China aster (*Callistephus chinensis Nees*) cv. Kamini. *Karnataka J. Agric. Sci.,* **20** (3): 689-690.

Chaudhary, N., Swaroop, K., Jnakiram, T., Biswas, D. R. and Singh, G. 2013. Effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus. *Indian J. Hort.,***70**(1) : 156-159.

Chauhan, S., Singh, C. N. and Singh, A. K. 2005. Effect of vermicompost and pinching on growth and flowering in marigold. cv. Pusa Narangi Gainda. *Prog. Hort.,***37**(2): 419-422.

Chopde, M. R., Pillewan, S. and Bhongle, S. A. 2007. Integrated nutrient management in tuberose. *Adv. Plant Sci.*,**(2)**: 443-444.

Dalal, S. R., Dalal, N. R. and Rajurkar, D. W. 1999. Effect of nitrogen levels and bulb size on quality of flower stalk of tuberose. *Soil Crops*., **9** (1): 88-90.

Dalve, P. D., Mane, S. V., Ranadive, S. N. 2009. Effect of organic amendments with fertilizer on flower quality of heliconia. *J. Maharastra Agric. Sci.*, **34**: 128-130.

Godse, S. B., Golliwar, V. J., Chopde, N., Bramhankar, K. S. and Kore, M. S. 2006. Effect of organic manures and biofertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of gladiolus. *J. Soil Crops.*,**16**: 445-449.

Gowda, J. V. N., Jacob, S. and Huddar, A. G. 1991. Effect of N, P and K on growth and flowering of tuberose (*Polianthes tuberosa* Linn.) cv. Double. *IndianPerfumer*. **35** (2): 100-101.

Gowda, J. V.N., Jayanthi, R. and Raju, B. 1988. Studies on the effect of nitrogen and phosphorus and organic manure on flowering in gladiolus cv. Debonair. *Current Res. Agril. Sci.*,**17** (6): 80-81.

Gupta, A. K., Paney, C. S. Vineeta and Kumar, J. 2011. Effect of integrated nutrient management on yield of tuberose. *J. Plant. Sci.*,**2**(1) : 10-14.

Hadwani, M. K., Varu, D. K., Niketa, P. and Babariya, V. J. 2013. Effect of integrated nutrient management on growth, yield and quality of ratoon tuberose (*Polianthes tuberosa* L.) cv. Double. *Asian J. Hort.*,**8** (2): 448-451.

Halder, N. K., Siddiky, M. A., Ahmed, R. R., Sharifuzzaman, S. M. and Ara, K. A. 2007. Performance of tuberose as Influenced by Boron and Zinc. *South Asian J. Agric.*,**2** (1&2): 51-56.

Hussain, M. A., Amin., N. U. and Sajid, G. A. M.2014. Response of Tuberose (*Polianthes tuberosa*) to potassium and planting depth. *J. Biol. Agric.*,**4** (11): 605-611.

Ihram, S., Umer, H. and Nauman, K. 2012. Effect of different potting media combination on growth and vase life of tuberose (*Polianthes tuberosa* Linn.). *Pakistan. J. Agric. Sci.*,**49** (2): 121-125.

Jhon, A. Q., Mir, M. M., Nelofar and Khan, F. U. 2007. Response of organic manure and inorganic fertilizer on growth and bulb production in tulip (*Tulipa gesneriana* Linn.). *J. Ornam. Hort.*,**10** (3): 157-160.

Kabir, A. K. M., Iman, M. H. Mondal, M. M. A. and Chowdhury, S. 2011.Response of tuberose to integrated nutrient management. *J. Env. Sci. Nat. Res.*,**4** (2): 55-59.

Kabir, K. 2009. Influence of organic amendments with or without effective microorganism on yield and use of preservatives on quality of tuberose. MS thesis, Dept. Hort. SAU, Dhaka. 62 p.

Kabir, K., Sharifuzzaman, S. M., Ara, K. A., Mahtabuddin, A. K. M. and Das, M. R. 2012. Effect of organic amendment and effective microorganism on quality flowering and bulb production in tuberose. *Bangladesh J. Agric.*,**5** (1): 1-7.

Kadu, A. P., Kadu, P. R. and Sable, A. S. 2009. Effect of nitrogen, phosphorus and potassium on growth, flowering and bulb production in tuberose cv. Single. *J. Soil Crops.*,**19** (2): 367-370.

Kale, R. D., Bano, K., Sreenivasa, M. N. and Bagyaraj, D. J. 1987. Influence of worms cast on the growth and mycorrhizal colonization of two ornamental plants. *South Indian Hort.***35**: 433-437.

Khalaj , M. A. and Edrisi, B. 2012. Effect of plant spacing and nitrogen levels on quantity and quality characteristics of tuberose (*Polianthes tuberosa*L.) under field experiment. *Int J. Agri. Sci*., **2** (3) : 244-255.

Kulkarni, B. S. 1994. Effect of vermicompost on growth and flower yield of China aster (*Callistephus chinensis)*. M.Sc. thesis, Univ. Agric. Sci. Bangalore, India. 68 p.

Kumar, H., Ahlawat, V. P., Yadav, B. S. and Sehrawat, S. K. 2004. Response of nitrogen and zinc application on spike length, bulb production and nutrient content in tuberose (*Polianthes tuberosa* L.) cv. Double. *Haryana J. Hort. Sci.*,**33** (3/4): 221-223.

Kusuma, G., 2000, Effect of organic and inorganic fertilizers on growth, yield and quality of tuberose. *An MS Thesis. Univ.Agric. Sci. Bangalore, India.* 60 p.

Mahmoodinezhadedezfully, S. H. A., Gholami, A., Moezin, A. and Hosseinpour, M. 2012. Effects of nitrogen, potassium and phosphorus on quantitative and qualitative characteristics of tuberose cv. Double (*Polianthes tuberosa* L.) *J. Appl. Env. Biol. Sci.*,**2** (9): 485-491.

Mamta, B. and Ajit, K. 2014. Studies on effect of organic manures and bio-inoculants on vegetative and floral attributes of chrysanthemum cv. Little Darling. *Int. J. Life. Sci.*,**9** (3): 1007-1010.

Mazed, H. E. M. K., Pulok, A. I., Rahman, H., Monalesa, N. and Partho, S. G. 2015. Growth and yield of tuberose as influenced by different levels of manures and fertilizers. *Int. J. Multidisci. Res. Dev.*,**2** (4): 555-558.

Mohammadi, T. A., Shariati, Y. and Onsinejad, R. 2012. Effect of potassium fertilizer and different fertilization methods on the growth of tuberose. http://works. bepress.com/y shariati/1.**30** (3) : 4-10.

Mukhopadhyay, A., Banker, G. J. and Shadu, M.K. 1986. Influence of bulb size, spacing and depth of planting on growth, flowering and bulb production in tuberose. *Haryana J. Hort. Sci*., **15** (1/2):18-24.

Nambisan, K. M. P. and Krishnamm. B. M. 1983. Better cultural practice for high yield of tuberose. *South Indian Hort.,* **28** (3): 17-20.

Nanjan, K., Nambisan, K. M. P., Veeragavathatham, D. and Krishnan, B. M. 1980. The influence of nitrogen, phosphorus and potash on yield of tuberose (*Polianthes tuberosa* L.). National Seminar on Technology for Commercial Flower Crops. TNAV. pp.76-78.

Nazari, F., Farahmand, H., Eshghi, S., Niki M. and Eslamzade, M. 2008. Effect of different soil amendments on growth and flowering of African Marigold (*Tagetes erecta* L.) *J. Fruit Ornam. Plant Res.*,**16** : 403-415.

Naznin, N., Hossain, M., Kabita, A., Azizul, H., Mazadul., I and Tuhina, H. 2015. Influence of organic amendments and bio-control agent on yield and quality of tuberose. *J. Hort.***2** (4) :1-8.

Okigbo, B. N. 1983. Cropping systems and compost research in Africa. *Organic Culture*. Ogunasanya Press, lbadan, Nigeria. pp. 30-55.

Padaganur, V. G., Mokashi, N. and Patil. V. S. 2005. Flowering, flower quality andyieldoftuberose(*Polianthes tuberosa* L.) as influenced by vermicompost, farmyard manure and fertilizers. *Karnataka J. Agric. Sci.*, **18** (3) :729-734 .

Pal, A. K. and Biswas, B. 2005. Response of fertilizer on growth and yield of tuberose (*Polianthes tuberosa* L.) cv. Calcutta single in the plains of west Bengal. *South Indian Hort.*,**45** (6) : 349-353.

Parthiban, S. and Khader, M. A. 1991. Effect of N, P and K on flower yield of tuberose. *South Indian Hort*., **39** (6): 363-367.

Parthiban, S., Khader, M. A. and Thamburaj, S. 1992. Effect on N, P and K on growth and development of tuberose bulb production (*Polianthes tuberosa* L.). *South Indian Hort*.,**40** (3): 166-171.

Patanwar, M., Gaurav, V., Chetna, B., Deepika, C. and Eshu, S. 2014. Growth and development of chrysanthemum as influenced by integrated nutrient management. *The Ecoscan.***6:** 459-462.

Patel M. M, Parmar, P. B. and Parmar, B. R. 2006. Effect nitrogen, phosphorus and spacing on growth and flowering in tuberose (*Polianthes tuberosa* L.) cv. Single. *Indian J. Ornam. Hort.,***9** (4): 286-289.

Patel, B. M., Patel, B. N. and Patel, R. L. 1997. Effect of spacing and fertilizer levels on growth and yield of tuberose (*Polianthes tuberosa* L) cv. Double. *J. Applied Hort.,* **3** (1/2): 98-104.

Patel, P. R., Patel, N. K. Valia, R. Z. and Chaudhari, S. R. 2011. Effect of nitrogen and vermicompost on flowering traits of African marigold. *J. Ornam. Hort.*,**14** (3&4) : 31-33.

Pathak, S. M. A. and Choudhuri, S. K. 1980. Effect of phosphorus and boron on yield of tuberose. *Indian J. Plant. Physiol*., **23** : 47-54.

Patil, J. D. 2000. Response of tuberose growth and flowering by organic farming. *Orissa J. Hort.,***28**: 98-101.

Patil, P. R., Reddy, B. S., Patil, S. R. and Kulkarni, B. S. 1999. Effect of community planting and fertilizer levels on growth and flower yield of tuberose (*Polianthes tuberosa* L.) cv. Double. *South Indian Hort*. **47** (1/6): 335-338.

Radhika, M., Patel, H. C., Nayee, D. D. and Sitapara, H. H. 2010. Effect of integrated nutrient management on growth and yield of African marigold (*Tagetes erecta* L.) cv. 'Local' under middle Gujarat agro-climatic conditions. *J. Ornam. Hort.,***5** (2): 347-349.

Rahman, S. 2000. Effect of planting time, mulching and foliar application of urea fertilizer on the growth and yield of tuberose. MS Thesis, Dept. Hort., Bangladesh Agricultural University, Mymensingh. 116 p.

Rajwal, N. and Singh, R. K. 2006. Effect of different levels of nitrogen on the performance of tuberose *(Polianthes tuberosa* L.*) Int. J. Plant Sci.,***1**(1) : 11-112.

Ramesh, K., Gobind, S. and Yadav, D. S. 2002. Studies on N, P and organic amendments requirement of tuberose (*Polianthes tuberosa* Linn.) cv. Single in hilly soils. *Indian Hort.*, **20**: 25-31.

Reena, K., Chaudhary, S., Dilta, B., Sharma, B. and Gupta, Y. 2014. Integrated nutrient management in tuberose. *Int. J. Farm. Sci.,***4**(1): 55-59.

Reshma, M., Sushma, K. and Aruna, J. 2013. Effect of integrated supply of different fertilizers and organic manure on yield of tuberose. *J. Biol. Agric.*,**3** (14): 100-101.

Roy, U. 1992. Effects of inorganic fertilizer on growth, bulb and flower production in tuberose (*Polianthes tuberosa* L.). MSThesis, Dept. Hort., BAU, Mymensingh. 54 p.

Sankar, M. 2011. Response of tuberose (*Polianthes tuberosa* L.) variety Vaibhav to various organic manures in combination with chemical fertilizers. *J. Ornam. Hort.,* **14** (1 & 2) : 28-33.

Shankar, L., Lakhawat, S. S. and Choudhary, M. K. 2010. Effect of organic manures and bio-fertilizers on growth, flowering and bulb production in tuberose.*Indian J. Hort.,* **64**:554-556.

Shashikanth, G. 2005. Effect of different sources of nutrients on growth and yield of tall marigold. MS Thesis, Univ. Agric. Sci. Dharwad, India. 57 p.

Singh, A. K. 2005. Response of rose plant growth and flowering to organic and inorganic fertlization. *J. Ornam. Hort.,* **8**(4): 296-298.

Singh, K. P. and Sangama, S. 2000. Effect of fertilizer on growth and flowering of tuberose (*Polianthes tuberosa*). *J. Applied Hort*., **2** (1): 54-55.

Singh, R. S., Motial, V. S. and Singh, L. B. 1976. Effect of nitrogen, phosphorus and potash fertilizer on tuberose (*Polianthes tuberosa* L.). *Indian J. Hort.*,**33** (3&4): 289-294.

Singh, S. R. P., Dhiraj, K., Singh, V. K. and Dwivedi, R. 2005. Effect of organic manuring and NPK fertilizers on growth, flowering and yield of tuberose cv. Single. *Haryana J. Hort. Sci.*,**34**: 84-86.

Steel, R. G. D., Torrie J. H. and Dickey D. A. 1997. Principles and Procedures of Statistics. A Biometric Approach. 3rd ed. Mc Graw Hill Book Co. Inc., New York. pp. 107-109.

Sultana, S., Khan, F. N., Haque, M. A., Akhter S. and Noor, S. 2006. Effect of NPK on growth and flowering in tuberose. *J. Subtropical Agric. Res. Dev.*,**4** (2) : 11-113.

Sunita, H. M., Hunje, R., Vyakaranahal, B. S. and Bablad, H. B. 2007. Effect of plant spacing and integrated nutrient management on yield and quality of seed and vegetative growth parameters in African marigold (*Tagetes erecta* L.). *J. Ornam. Hort.,* **10** (4): 245-249.

Sushma, K. and Aruna, N. 2008. Effect of different level of fertilizer and organic amendments on tuberose. *Asian J. Ornam.,* **3** : 104-108.

Tomati, U., Grappelli, A., Galli, E. and Rossi, W. 1991. Preparation of fertilizer from vermiculture option for organic waste recovery. *Agrochimiya*., **27** : 244-251.

Tripathi, S. K., Malik, S., Kumar, A. and Kumar, V. 2013. Effect of integrated nutrient management on bulb yield of tuberose (*Polianthes tuberosa* L.). cv. Suvasini. *Asian J. Hort.,***3**(1): 150-154.

Tripathi, S. K., Malik, S., Singh, P., Dhyani, B. P., Kumar, V., Dhaka, S. S. and Singh, J. P. 2012. Effect of integrated nutrient management on cut flower production of tuberose (*Polianthes tuberosa* L.) cv. Suvasini. *Ann. Hort.,***6** (1): 149-152.

Verma, S. K., Angadi, S. G., Patil, V. S., Mokashi, A. N., Mathad, J. C. and Mummigatti, U. V. 2011. Growth, yield and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat) cv. Raja as influenced by integrated nutrient management. *Karnataka J. Agric. Sci.,***24**(5): 681-683.

Waheeduzzaman, M., Jawaharlal, M., Arulmozhiyan, R. and Indhumathi, K. 2006. Effect of integrated nutrient management practices on flower quality and vase life of *Anthurium andreanum* cv. meringue. *J. Ornam. Hort.,***9** (2) : 142-144.

Warade, A. P., Golliwar, V. J., Chopde, N., Lanje P. W. and Thakre, S. A. 2007. Effect of organic manures and bio-fertilizers on growth, flowering and yield of dahlia. *J. Soil Crops***., 17** (2): 354-357.

Yadav, L. P., Bose, T. K. and Maity, R. G. 1985. Response of tuberose (*Polianthes tuberosa* L.) to nitrogen and phosphorus fertilization. *Prog. Hort.,***17**(2): 83-86.

Yadav, P. K. 2007. Effect of nitrogen and phosphorus on growth and flowering of tuberose (*Polianthes tuberosa* cv. Shringar). *Prog. Agric.,***7** (1/2): 189-192.

Yadav, P. K., Singh, S., Dhidiwal, A. S. and Yadav. M. K. 2000. Effect of N and FYM application on floral characters and yield of African marigold (*Tagetes erecta* L.). *Haryana J. Hort. Sci.,* **29** (1 & 2): 69-71.

APPENDICES

Appendix I. Mean monthly weather data during March 2014 to February 2015

Year	Month	Air temperature (°C)		Relative Humidity (%)	Rainfall (mm)
		Max.	Min.		
2014	March	31.42	25.98	69.15	06.40
2014	April	32.10	29.00	75.00	57.50
2014	May	31.33	27.42	76.15	250.10
2014	June	32.00	29.15	64.10	377.50
2014	July	31.20	25.95	85.00	361.50
2014	August	30.86	25.75	86.40	590.00
2014	September	31.50	27.00	86.50	208.45
2014	October	29.75	26.80	85.28	183.40
2014	November	26.22	22.75	80.17	07.50
2014	December	19.90	15.45	89.05	00.00
2015	January	14.22	10.55	90.03	00.0
2015	February	23.75	18.81	86.63	06.49

Source: Bangladesh Agricultural Research Institute, (BARI), Gazipur

Appendix II. Analytical data of soil sample at Floriculture field of HRC, BARI in 2013

Elements		Present	Critical level
Soil P^H		6.1	--
Total N	%	0.777	--
OM		1.46	--
Ca	Mg/100g	4.76	0.2
Mg		1.97	0.8
K		0.15	0.2
P	µg/g	15	14
S		38	14
B		0.32	0.2
Cu		6.0	1.0
Fe		232	10.0
Mn		10	5.0
Zn		3.30	2.0

Source: Soil Science Division, Bangladesh Agricultural Research Institute, (BARI), Gazipur

Appendix III. Analysis of variance of the data on plant height of tuberose as influenced by organic manure and fertilizer

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		30 DAP	50 DAP	70 DAP	90 DAP
Replication	2	1.863	2.164	0.302	0.264
Treatment	8	43.346*	56.761*	95.362*	224.794*
Error	16	0.452	1.61	4.23	2.752

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on different plant characters of tuberose as influenced by organic manure and fertilizer

Source of variation	Degrees of freedom	Days to sprouting	Leaf number	Plant spread	Plants/hill
Replication	2	5.70	25.10	03.15	02. 26
Treatment	8	105.70*	312.02****	212.80****	310.48****
Error	16	5.14	9.10	5.54	07.50

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on different flower characters of tuberose as influenced by organic manure and fertilizer

Source of variation	Degrees of freedom	Days to 80% spike initiation	Spike length	Rachis length	Floret number	Spike weight	Flower durability
Replication	2	08.17	20.40	14.10	12. 30	09.12	11.50
Treatment	8	570.25*	290.10*	487.54*	12.25*	285.07*	113.10*
Error	16	4.70	5.42	3.36	4.69	3.82	4.50

* = Significant at 5% level of probability

Appendix VI. Analysis of variance of the data on different bulb characters of tuberose as influenced by organic manure and fertilizer

Source of variation	Degrees of freedom	Mean square						
		Bulb number	Bulb diameter	Bulb weight	Bulblet number	10 Bulblet weight	Yield of bulb	Yield of bulblet
Replication	2	0.75	10.50	15.60	2.41	25.52	0.08	0.09
Treatment	8	1.53*	12.41*	18.74*	17.76*	45. 18*	18.12*	24.58*
Error	16	0.05	4.25	11.21	12.55	6.46	6.72	5.91

* = Significant at 5% level of probability