VARIETAL EVALUATION OF TUBEROSE (*Polianthes tuberosa* L.) FOR GROWTH, YIELD AND QUALITY

By

Hasna P. M

2018-12-035

THESIS

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF FLORICULTURE AND LANDSCAPING

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARGOD – 671 314

KERALA, INDIA

2020

DECLARATION

I, hereby declare that this thesis entitled **"Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Padannakkad

Date: 28/10/2020

Hasna P.M.

(2018 -12- 035)

CERTIFICATE

Certified that this thesis entitled **"Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality"** is a record of research work done independently by Ms. Hasna P.M under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

28/10/2020

Place: Padannakkad
Date: 28/10/2020

Dr. Meera Manjusha. A.V.
(Major Advisor, Advisory Committee)
Assistant Professor (Horticulture)
Regional Agricultural Research Station
Pilicode, Kasaragod

CERTIFICATE

We, the undersigned members of the advisory committee of Ms. Hasna P.M a candidate for the degree of **Master of Science in Horticulture** with major in Floriculture and Landscaping agree that the thesis entitled **"Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality"** may be submitted by Hasna P.M in partial fulfilment of the requirement for the degree.

28/10/2020

Dr. Meera Manjusha A.V
(Chairman, Advisory Committe)
Assistant Professor (Horticulture)
Regional Agricultural Research
Station
Pilicode, Kasargod

Dr.G.V.Sudarsana Rao
professor and Head
Department of plant physiology
College of Agriculture
Padannakkad, Kasargod
28/10/2020

28/10/2020

Dr.Mini P.K
Professor and Head
Department of Agricultural
Engineering
College of Agriculture
Padannakkad, Kasargod

28/10/20

Dr. Binitha N.K
Assistant professor
Department of Soil Science &
Agricultural Chemistry
College of Agriculture
Padannakkad, Kasargod

ACKNOWLEDGEMENT

This thesis would not have been possible without the inspiration and support of a number of wonderful individual-my thanks and appreciation to all of them for being a part of this journey and making this thesis possible.

I take this opportunity to look back on the path traversed during the course of this endeavour and to remember the guiding faces behind the task with a sense of gratitude.

It is with great respect I express my deep sense of gratitude and indebtedness to ***Dr. Meera Manjusha A. V.*** *Chairman of my Advisory Committee, Assistant Professor, Department of Horticulture, Regional Agriculture Research Station, Pilicode, for her expert advice, valuable suggestions, inspiring guidance, enthusiastic approach, constructive criticisms, unreserved help and kind concern during the conduct of this research work and preparation of thesis. I value her knowledge and wisdom which nurtured this research in right direction without which fulfillment of this endeavor would not have been possible, she has been a support to me during each step of this venture and my obligation to her lasts forever, I really consider it my greatest fortune in having her guidance for my research work.*

I take this opportunity to express sincere thanks to my advisory committee consisting ***Dr. Mini P. K.*** *Professor and Head, Department of Agricultural Engineering,* ***Dr. G. V Sudarsana Rao,*** *Professor and Head, Department of Crop Physiology,* ***Dr. Binitha N. K,*** *Assistant Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Padannakkad, for their constant help, valuable suggestions during the investigation, sensible criticism in animating and ameliorating the manuscript and valuable counsel during the period of study.*

I pay my heartful thanks to ***Dr. Suresh, P. R.*** *Associate Dean, College of Agriculture, Padannakkad for providing me all facilities from the University during the whole course of study.*

I express my sincere thanks to my teachers, ***Dr. A. Rajagopalan , Dr. Satheeshan K. N, Mrs. Reshmika P.K, Mrs. Tanuja T.T. and Dr. Asok Kumar Meena,***

who have always given encouragement and support. Their personal involvement at times of need was highly valuable.

I express my deepest and sincere gratitude to ***Dr. T. Ushabharati*** *(IIHR),* ***Dr. Bridgit T., Dr. Namboodiri Raji vasudevan, Dr. K. M. Sreekumar, Dr. P. K Sajeesh, Dr. Susha S. Thara and Mr. Mohammed Anees*** *for their moral support and valuable guidance during the course of study.*

My diction doesn't seem too rich enough to provide suitable words to articulate my sincere and heartfelt gratitude to my batchmates ***Karishma, Veena Krishnan, Nayana Sunil, Jeevitha, Sugina, Deepa, Fousiya, Shuhaila, Lintu, Haritha and Anuprasad*** *and my seniors* ***Akhil, Vinayak, Amrutha, Fathima, Ajeesh, Priya Philip, Amal, Aparna, Laya, Sreelakshmi, Dhanyasree, Gladis, Jaseera, Radhika, Giffy, Roshni, Anu, and Adarsh*** *and my juniors* ***Archana and Haritha*** *who has given sound and fruitful advice, timely help and also a constant encouragement throughout my venture of this study. I express gratitude to my friends* ***Basil. P. Markose, Swetha, Priya, Saniya****, and other friends for their support. I owe a debt of gratitude to* ***Mr. Visak and Ms. Abhilasha*** *for their kindful help when it is necessary. I express my sincere thanks to* ***Mr.Sukhil, Mr. Mubarak*** *and* ***Mrs. Deepthi*** *for giving access to the laboratory and research facilities.*

I specially thank all the administrative, non-teaching staff, farm officers, labourers who all were directly or indirectly involved during the conduct of the research programme.

I am thankful to ***Kerala Agricultural University*** *for financial support in the form of fellowship during the tenure of the M.Sc. (Agriculture) programme.*

I express my sincere thanks to ***Indian Institute of Horticulture Research****, Banglore and* ***Bidhan Chandra Krishi Viswavidyalaya,*** *Mohanpur for the supply of planting material for my research programme.*

This research work would be incomplete if I do reckon the sacrifices, love, affection and support of my family members, it is immense pleasure to express my sincere gratitude and heartfelt respect to my beloved husband ***Mr. Ashif*** *, Parents****, Mr.***

Abbas , Mrs. Ramla, Mr. Mammunni, Mrs. Sabira, *Sisters (**Asoora, Fasna, Fida**) and Brothers (**Ramis and Ashik**).*

God Almighty for all the bountiful blessings showered on me at each and every moment without which this study would never have seen light. Any omission in this acknowledgement does not mean lack of gratitude.

Hasna P.M.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

%	Per cent
ºC	Degree Celsius
A.	Arka
B.	Bidhan
C.	Culcutta
CD	Critical Difference
cm	centimetre
cm^2	centimetre square
Cv.	cultivar
et al	And others
Fig.	Figure
g	gram
ha	hactare
i.e	That is
IIHR	Indian Institute of Horticultural Research
KAU	Kerala Agricultural University
Kg	Kilogram
m^2	metre square
mg	milligram
ml	millilitre
mm	millimetre
P.	Phule
RARS	Regional Agricultural Research Station
SE	Standard Error
VAM	Vesicular Arbuscular Michorrhiza
Viz.	For namely

Introduction

1. INTRODUCTION

Floriculture is a fast emerging major venture in the world. Now a days, floriculture is lucrative profession with more returns per unit area than other agricultural or horticultural crops. In India, commercial floriculture has increased its credibility by diversification in agriculture and also evolved as a foreign exchange earner. India is bestowed with varied agro-climatic zones conducive for production of sensitive and delicate floriculture products.

Tuberose (*Polianthes tuberosa* L. Family: Amaryllidaceae) is one of the most popular tropical ornamental bulbous flowering plants grown on a commercial scale throughout different states of India. They are much adored by the aesthetic world for their colour, elegance and fragrance. The genus '*Polianthes*' is derived from the Greek word '*polios*' meaning shining or white, and '*anthos*', a flower. The species name '*tuberosa*', indicates the tuberous nature of plant. The name, therefore, is tuber-ose, not tube-rose.

Tuberose is originated in Mexico and it is one of the earliest cultivated flowering plant. It is commonly known as Sempengi in Tamil, Nishigandhi in Malayalam, Rajanigandha in Hindi and Bengali, Nishigandha in Marathi and Gul-eLShabab in Urdu (Biswas *et al.,* 2002). There are three types of cultivars in the genus *Polianthes.* One of them is single flower type (cultivars with single row of corolla segments) which is extensively used for loose flower purpose, perfumery industry and breeding programme as female parent. The other two are semi-double (cultivars with two-three rows of corolla segments) and double (more than three rows of corolla segments) flower types and generally used as cut flower.

In India area under floriculture was 324 thousand hectares with a production of 823 thousand metric tonnes of loose flowers and 1962 thousand metric tonnes of cut flowers (NHB, 2017-18). Production of tuberose in India was 197.21 thousand tonnes (107.91 thousand tonnes loose flower and 89.30 cut flower) and the major growing states are West Bengal, Tamil Nadu, Karnataka, Andra Pradesh, and Maharashtra. Tamil Nadu is the leading producer of loose tuberose with a production

of 62.77 thousand tonnes and West Bengal is the leading producer of cut tuberose with a production of 73.25 thousand tonnes (NHB, 2015-16).

Tuberose occupies an important position among the commercially cultivated flowers in India due to its popularity as loose flower as well as cut flower. Loose flowers have great demand for making garland, veni, worshipping and offerings in religious functions and auspicious days. The long lasting flower spikes are largely used for the vase decoration and preparation of bouquets. The aromatic oil extracted from the fragrant white flowers have great demand for essential oil industry, which fetches a very good price in the international market.

Tuberose is half hardy, perennial bulbous plant. Bulbs are made of scales and leaf bases and stem remain concealed within scales. Roots are adventious and shallow. Numerous lanceolate leaves are found in tuberose which is green, narrow, long and arise in rosette. Flowers have a funnel shaped perianth and are fragrant, waxy, white and born in spikes. Stamens are six in number, ovary 3 locular, ovules numerous and fruits are capsule (Bindiya *et al.,* 2018).

Climatic factor play a critical role for successful production of tuberose. Tropical to subtropical and temperate climates are best suited for its cultivation. Tuberose prefer to grow in open sunny location. It grows in mild climate without extremes of high or low temperature. It can be successfully grown under warm humid areas having temperature around 30 ^{0}C and approximate day length of 16 hours which make it suitable for cultivation under Kerala condition. Tuberose responds well to the application of organic and inorganic nutrients because it is a heavy feeder and highly exhausting crop. Three or four ratoon crops can be taken from single planting. In the first two years, tuberose flower's yield is high, while in the third year, the yield reduces considerably.

Tuberose flowers are now being widely used in perfumery as a source of natural essential oils and aroma compounds. Its unique and exotic aroma strengthen and rejuvenate an individual's mind and body. It also has anti-inflammatory and antispasmodic properties. Tuberose is highly suitable for growing in pots, beds and borders.

The quality and production of any crop or variety largely influenced by its genetic constitution and climatic condition under which they are grown. Hence, the cultivar which performs well in one region may not perform well in other regions of varied agro-climatic conditions. Therefore, in order to select suitable and high yielding cultivar for a particular region it is very much necessary to collect and evaluate all the available genotypes. Growth, yield, quality, vase life, shelf life *etc.* are the important characters to be considered for the evaluation of genotype of tuberose.

As the large scale cultivation of tuberose is gaining popularity, introduction and identification of high yielding varieties suitable for a particular region is necessary. Therefore, the present study was carried out to evaluate tuberose varieties for growth, yield and quality and to screen the varieties for Northern Kerala.

The present study were undertaken with the following objectives

1. To evaluate different tuberose varieties for vegetative, floral, qualitative and post- harvest characters
2. To analyse concrete content in different tuberose varieties
3. To screen the varieties for Northern parts of Kerala

Review of Literature

2. REVIEW OF LITERATURE

Tuberose (*Polianthes tuberosa* L.) one of the most important bulbous ornamental crop grown commercially for its attractive and fragrant cut flowers as well as loose flowers. The flowers of tuberose have a pleasant aroma and are source of essential oils, hence there is great demand for this beautiful and perfumery flowers in the aesthetic world. The long lasting flower spikes are largely used for vase decoration, flower arrangement and bouquet preparations. Loose flowers have great demand for making artistic garlands and floral ornaments. Concrete and absolute from tuberose are extensively used in perfumery industry and fetches a good price in the international market.

Growing urbanisation and improvement in the lifestyle of the people increase the global and domestic demand for flowers year round. To meet this demand it is being cultivated on a commercial scale in different parts of the country. The performance of any crop or variety largely depends upon the climatic conditions of the region under which they are grown. Hence, it is necessary to collect and evaluate all the available varieties in order to select suitable and high yielding cultivar for a particular region.

Relevant research work on tuberose and other flowers from available literature are reviewed in this chapter and which has been compiled under the following headings.

2.1 Factors influencing pre harvest characteristics of tuberose

2.1.1 Factors influencing vegetative characters of tuberose

In general, the growth of all the genotypes increased gradually as the days advanced. Similar variation in plant height was also reported previously by Shiramagond (1997) in gladiolus and Biswas *et al.*, (2002) in tuberose. Significant differences were observed in the study conducted by Bankar and Mukhopadhyay (1980) on morphological characteristics of tuberose cultivars (Single, Double, Semi-double and Variegated). The results revealed that for the commercial cultivation of tuberose cultivar Single was the most suitable, followed by Double and Variegated. The performance of Arka Suvasini found best among the double type cultivars in growth characteristics like number of tillers per plant (Murthy *et al.,* 1997).

Ramachandrudu and Thangam (2009) confirmed that maximum plant height was observed in Arka Prajwal. A study was conducted by Pal and Mitra (2012) to evaluate the performance of different tuberose varieties in the plains of West Bengal. The Culcutta Double recorded the maximum plant height (40.35 cm) whereas Culcutta Single produced the maximum number of leaves (136.39) per plant. Among the thirteen tuberose varieties studied under Udaipur conditions of Rajasthan, the maximum values for plant height and number of leaves per plant were recorded in Cv. Prajwal followed by Phule Rajani among single type cultivars. However, in double type Cv. Suvasini followed by Vaibhav recorded the maximum value (Mahawer *et al.,* 2013).

Chaturvedi *et al.* (2014) screened five different varieties of tuberose (Local, Suvasini, Vaibhav, Prajwal and Shringar) under agro-climatic conditions of Allahabad. Maximum plant height (130.54 cm) was recorded with cultivar Arka Suvasini, while maximum no. of leaves per plant (17.16) were recorded with cultivar Arka Shringar. Krishnamoorthy (2014) evaluated four varieties of tuberose for growth and yield characters and the results revealed that Arka Prajwal produced the maximum number of leaves per clump (383) at one year after planting followed by Arka Niranthara (345).

Lalthawmliana *et al*. (2017) evaluated different cultivars of tuberose under the foothill conditions of Nagaland and claimed that vegetative characters vary significantly among different varieties of tuberose. Among single cultivars maximum plant height was observed in Arka Prajwal (48.63 cm) followed by Phule Rajani (46.40 cm) and the maximum number of leaves per plant was in Sikkim selection (13.33) followed by Phule Rajani (13.00). Among double cultivar Arka Suvasini has the maximum plant height (58.13 cm) and the maximum number of leaves per plant (15.33) which is in similar with the conclusions of Gudi (2006). Angmo (2017) evaluated eleven tuberose cultivars under the mid hill conditions of Himachal Pradesh. Maximum plant height and number of leaves per plant was recorded by the cultivar 'Mexican Single'.

Ranchana *et al.* (2017) claimed that 'Variegated Single' observed with the maximum plant height (117.50 cm) and which is followed by Arka Prajwal' (113.05 cm). This is similar with the findings of Gudi (2006) and Vijayalaxmi *et al.* (2010). The maximum number of leaves per plant (260) in the first year was recorded by the

variety Arka Prajwal. Field performance of different tuberose varieties was evaluated by Gawande *et al.* (2017) under Nagpur conditions of Maharashtra. The results revealed that the maximum number of tillers per plant was recorded in ArkaVaibhav. Gandhi (2017) reported that "Mean performance revealed that a single genotype was not superior for all traits and different genotypes were identified to be superior for various traits".

According to Sadhu and Bose (1973) February planting will result in greater vegetative growth in plains of India. Experiment carried out under Vellanikkara region revealed that January planting observed with the maximum plant height and number of leaves as compared to December and February planting, also flowering was not observed in corms that are planted during February and March (Biswas *et al.*, 2002). Nair *et al. (*2004) conducted an experiment on flowering of tuberose cultivar 'Double' to study the effect of planting date (July to June of the following year) in Andamans during 2000-2002. The result indicated that the ideal time for planting of double cultivar of tuberose under Andaman condition were November and December. To determine the effect of different planting dates on gladiolus Adil *et al*. (2013) carried out an experiment under the ecological conditions of Faisalabad. The results suggest that proper sowing time decrease the cost of production by reducing the crop growth period and also produce elite flowers with better consumer demands. An experiment was conducted by Valid *et al.* (2019) to determine the effect of planting dates and mulching on growth and flowering of tuberose (*Polianthes tuberosa* L.) cultivar Sikkim selection during 2016-2017 under Solan condition. The experiment was laid out in twelve treatment combinations involving three planting dates (20^{th} May, 15^{th} June and 10^{th} July) along with three mulching material (dry grass mulch, black plastic mulch and transparent plastic mulch) and with control treatments. Based on the findings best results in terms of all the growth and flowering parameters were noticed in corms which was planted on 20^{th} May along with black plastic mulch.

Poursafarali *et al,* (2011) conducted an experiment to determine the effect of different cultivation beds (sand, fine gravel, manure, perlite and clay) on the vegetative growth of *Polianthes tuberosa* L. Results showed that best beds in terms of number of

days to germination were sand whereas maximum number of leaves and leaf length obtained were best in perlite.

Application of poultry manure at the rate of 29.63 tonnes per ha as basal dose found to be highly beneficial for growth and yield improvement in tuberose (Sankar, 2008). Study conducted by Mane *et al.* (2006) at Parbhani of Maharashtra reported that growth and bulb production in tuberose cultivar 'single' can be improved by usage of bigger sized bulbs at wider spacing, and planting at medium depth (5cm).

Mukherjee *et al.* (2003) laid out an experiment to determine the economic feasibility of tuberose cultivation under West Bengal. The experiment was based on the data collected from 75 tuberose (*Polianthes tuberosa L.)* farmers in Nadia district of West Bengal during the period of December 1996 to November 1997. Production cost of 100 sticks of cut flower was Rs. 12.67 and one kg of loose flower was Rs.7.07. Production of loose flowers was found to be more economically feasible for growers as compared to cut flower production.

2.1.2 Factors influencing floral characters of tuberose

Irulappan *et al.* (1980) studied eleven tuberose varieties and the results indicated that Culcutta single and Mexican single had maximum flower yield. Farina and Paterniani (1986) evaluated various floral characters of La Perla, Florentina and a single type variety of tuberose in western Liguria region of Italy. The result showed that La Perla and Single cultivar were superior in flower production.

Among the six double cultivars (IIHR 2, IIHR 4, IIHR 5, Vaibhav, Suvasini and Pearl double) studied under Banglore condition, variety Vaibhav recorded maximum number of spikes per plant, length of rachis, flowering period and medium sized bulbs (Radhakrishnan *et al.,* 2003).

Ramachandrudu and Thangam (2009) conducted an experiment to evaluate performance of different tuberose cultivars in Goa. The results claimed that among the cultivars, number of days to flowering was found to be minimum in Mexican Single, while, Arka Suvasini and Arka Prajwal took maximum days to flowering. The

maximum number of florets/spike was recorded in Arka Suvasini, closely followed by Arka Vaibhav.

Martolia and Srivastava (2012) claimed that Arka Shringar yielded highest number of spikes per m^2 followed by Arka Vaibhav and Arka Suvasini in tuberose. The variety Swarna Rekha possess maximum diameter of spike and maximum weight of floret. According to Pal and Mitra (2012) minimum days taken to first floret opening was 113.5 days in the variety Arka Shringar. The variety Culcutta double has maximum field life (20.7 days), spike length and fresh weight (158.80 g) of spike.

The experiment carried out by Susila (2013) to find out the performance of tuberose cultivars under north coastal Andhra Pradesh, revealed that the longest spike and the maximum number of spike were observed in Culcutta single. Maximum number of flowers per spike was recorded in Arka Shringar, while fresh weight of spike was maximum in Hyderabad double. Mahawer *et al.* (2013) reported that among the growth, floral and economics parameters studied Cv. Prajwal in single and Suvasini in double type of tuberose recommended for cut flowers and exhibition purposes under Udaipur conditions. Ranchana *et al*. (2013) studied genetic parameters like yield, quality traits and performance of single genotypes of tuberose under Coimbatore. The results revealed that a high heritability coupled with high genetic advance were observed for flowering duration, weight of florets per spike, number of florets per spike and rachis length. Hence these traits can be used for the selection of varieties.

Krishnamoorthy (2014) claimed that among the four varieties *viz.*, Local cultivar, Phule Rajani, Arka Niranthara and Arka Prajwal cultivated under Pudukkottai district of Tamil Nadu, Arka Prajwal recorded significantly early flowering (153 days), maximum spike length (120 cm), no. of spike per clump (3.5), number of flowers per spike (44 numbers/spike), 100 flower weight (96 g) and duration of flowering (18.85 days) followed by Arka Niranthara.

Prakash *et al.* (2015) evaluated different varieties of tuberose in Muzaffarnagar under western plain zone condition. The results showed that significant variation among floral and spike growth characters. Early flowering was recorded in Arka Niranthara and Phule Rajani (91 days) while maximum number of days to flowering was recorded

in Arka Prajwal (96 days). Arka Prajwal has the longest spike (111 cm) and rachis length (31.53 cm) and maximum number of florates (60.33) and diameter of spike (12.92 mm). Maximum flower diameter (5.30 cm) was observed in cultivar Phule Rajani. Rao and Sushma (2015) evaluated certain double type genotypes for the identification of varieties that are suitable for cultivation under Telengana region during 2010-14. The results showed that variety Culcutta Double recorded maximum plant height (43.2 cm), spike length (88.2 cm), no. of spikes/plant (2.7), rachis length (41.3cm) and no. of bulbs per plant (72.8) over check Hyderabad double.

Arka Prajwal, among single types recorded higher flower yield, increased number of florets per spike, increased weight of floret, early spike emergence and opening of florets, Arka Suvsini among double type was found to be superior in spike yield, earliness in flowering, and longest spike with long florets under Coimbatore centre. It is found that cultivar Prajwal, Shringar, Niranthara, Suvasini, Vaibhav were suitable for flower production on tarai region of Uttarakhand. At Hyderabad region Prajwal, Niranthara, Hyderabad Single, Vaibhav and Hyderabad Double performed better. Arka Niranthara and Arka Vaibhav performed better in Hesssarghatta centre. Among the eight single cultivars and five double cultivars maintained at Ludhiana centre Prajwal and Suvasini performed better among single and double, respectively (ICAR-DFR, 2016). Prashanta *et al.* (2016) claimed that genotype Suvasini is suitable for cultivation in the valley conditions of Garhwal Himalayas followed by Vaibhav and Kalyan Single.

According to Gawande *et al.* (2017) number of days to spike emergence was recorded significantly minimum in the variety Arka Vaibhav (71.87). Similarly, the variety Arka Vaibhav took significantly minimum days (142.33) to 50 percent flowering and it was found to be on par with variety Arka Suvasini (143.67). Similar results were reported by Sateesha *et al*. (2011). His study revealed that Arka Shringar took minimum days required for 50 percent flowering followed Pearl double, Mexican single and Arka Vaibhav. Arka Vaibhav produced significantly the maximum (4.33) spikes per plant and it was closely followed by the variety Arka Suvasini (3.80). Cultivar 'Sikkim Selection' recorded maximum length of spike (97.73 cm), length of rachis (23.05 cm) and number of florets per spike (30.76) with minimum days taken to

first floret opening (82.87 days) under mid hill conditions of Himachal Pradesh (Angmo, 2017). Singh and Dakho (2017) evaluated performance of different tuberose varieties under North Indian plains. Longevity of flower was recorded maximum in Arka Suvasani (23.66 days). Maximum number of florets per spike was recorded in Pearl Double (43.43) followed by Phule Rajani (42.10).

Andrew *et al*. (2017) conducted an experiment to evaluate four double and five single cultivars of tuberose, revealed that cultivars Hyderabad Double, Suvasini, Sikkim Selection and Prajwal performed better under the foothill conditions of Nagaland and were found suitable for commercial cultivation of cut flowers. According to Lalthawmliana *et al.* (2017) minimum number of days taken to spike emergence was found in Sikkim Selection (65.00) and the maximum was in Mexican single (75.33). Spike length was significantly higher in Sikkim Selection (105.20 cm) followed by Arka Prajwal (83.00 cm). The data pertaining to number of florets per spike (42.00), flower diameter (3.25 cm), rachis length (38.67 cm), fresh weight (148.50 g) of spike and duration of flowering (10.33 days) Arka Prajwal recorded maximum value. Results showed that among double cultivars Hyderabad double and Arka Suvasini recorded superior quality for all the floral parameters studied.

According to Dimri (2017) cultivar, Prajwal followed by Vaibhav and Shringar are suitable for cultivation under mid hill conditions of Garwal Himalayas. Variety Arka Niranthara had the potential to be used both as female parent and pollen parent since it has maximum duration of stigma receptivity and lowest pollen sterility among the ten varieties studied (Hemanta *et al.*, 2017).

Bindiya *et al.* (2018) evaluated eight genotypes of tuberose (Arka Vaibhav, Arka Nirantara, Arka Shringar, Arka Prajwal, Arka Suvasini, Pearl Double, Calcutta Single and Mexican Single) for yield and quality. Spike yield per hectare (2.97 lakhs), loose flower yield (5.09 t), spike length (103.27 cm) and shelf life (6.26 days) were recorded maximum in genotype Arka Prajwal and also it was the variety reached earliest in 50% flowering (5.46 days). Rachis length (34.27 cm) and weight of 100 flowers (216.30 g) were recorded maximum in the genotype Arka Vaibhav. Flower diameter (6.04 cm) and overall acceptability was recorded maximum in genotype A. Suvasini, whereas genotype Arka Shringar produced maximum number of florets per

spike (47.27). In another study, Arka Niranthara recorded maximum length of spike, Phule Rajani recorded maximum number of florets per spike, Arka Prajwal reported maximum length of floret and Calcutta Single recorded maximum duration of flowering (Singh *et al.,* 2018). Madhumathi *et al.* (2018) evaluated tuberose genotypes for vegetative, flowering and yield traits. The results revealed that floral parameters *viz.,* length, diameter and weight of floret were recorded maximum in Arka Prajwal genotype.

Patel *et al.* (2006) found that application of nitrogen at 400 kg per ha recorded significantly the maximum values of vegetative and floral characters. The effect of phosphorous was found significant with floral characters *viz.,* rachis length, number of florets per spike whereas it is non-significant with vegetative characters. Dahal *et al.,* 2014 carried out an experiment at farmer's field of Nepal during 2012, using double cultivars of tuberose to standardize nitrogen application at different stages to improve growth, flowering and vase life. Result of the study revealed that application of three equal split doses of nitrogen *i.e.*,33% N basal + 33% N at 50 days after planting + 33% N at 70 days will increase growth, flowering and vase life.

Afifipour and Khosh – Khui (2015) reported that application of amino acids will improve all growth and flowering characteristics of tuberose cultivars. According to Valid *et al.* (2019) maximum number of florets and longest spike was observed under black plastic mulch. The results are in conformity with the findings of Messar (2011) who observed maximum number of florets under black plastic mulch in gladiolus.

2.1.3 Factors influencing qualitative characters of tuberose

Sadhu and Bose (1973) reported that the average yield of concrete from the flowers of tuberose is 0.08 to 0.14 per cent of which nearly 18.00 to 23.00 per cent constitute the alcohol-soluble absolute.

Time of harvesting and method of processing are two important factors which greatly influences the concrete and essential oil yield in aromatic plants (Kothari and Singh, 1995; Ram and Kumar 1999).

It has been found that the concrete content in Single petalled cultivar Shringar was 0.1602 per cent (Mohan *et al.*, 2003) and in Double petalled cultivar Vaibhav was 0.0311per cent (Mohan *et al*., 2004). The results are in accordance with the early findings of Srinivas *et al*. (1996). An experiment was conducted by Martolia and Srivastava (2012) during 2007 and 2008 to find out suitable tuberose varieties for fresh flowers and for concrete content. The results indicated that Arka Shringar had maximum concrete and absolute content and cultivar double had minimum values.

Ray *et al.* (2014) laid out an experiment to characterize the volatile aroma compounds from the concrete and flower of jasmine grown in India. The results indicated that completely opened flowers contain maximum fragrance and need to be collected for concrete extraction. Since an export commodity, ideal blossoming time and quality testing of jasmine flowers are extremely crucial matters in the export of flowers and concrete.

Ranchana *et al.* (2015) carried out an experiment to analyse the tuberose concrete content using solvent extraction technique. The results indicated that percentage yield of concrete from single type tuberose ranges from 0.11 to 0.16 per cent and that of double type from 0.06 to 0.09 per cent. The major chemical component detected was 9-(4'-Aminobenzo-18-crown-6) methyl anthracene and 2-propoxyl-4-phenylthiophene in single and double type tuberose, respectively.

To find out the effect of harvesting time on concrete and absolute recovery of tuberose flower Chaudhari and Kumar (2017) carried out a comparative study on single and double petalled cutivars. The results showed that flower harvested in the morning have better concrete and absolute recovery as compared to the flower harvested in the evening. They also reported that double petalled flower type contains less concrete and absolute than single petalled type. Cultivar Prajwal [(0.161 - 0.047 per cent), and (0.153 - 0.037 per cent)] among single and Suvasini [(0.076 - 0.015 per cent), and (0.066 - 0.012 per cent)] among double recorded maximum concrete and absolute recovery in the morning and evening respectively.

Singh *et al.* (2009) conducted a comparative study in variety Shringar (single) and Vaibhav (double) to determine the aroma constituents of flower. The results

showed that single petalled cultivar gave stronger aroma compared to double petalled cultivar. Presence of Methyl Palmitate, a low perfumery grade fatty material, in high concentration reduces the odour value of double petalled cultivar. Bindiya *et al.* (2018) reported that scores for fragrance is highest in genotype Suvasini (4.63) and it was on par with Shringar (4.44) followed by Prajwal (4.14).Consumer acceptability was higher in Suvasini followed by Prajwal, Vaibhav and Shringar.

An experiment was conducted to assess variation in concrete recovery and chemical constituents among the six tuberose cultivars (A. Niranthara, A. Shringar, A. Vaibhav, A. Suvasini, Hyderabad Single and Mexican Double) in Assam condition. The results revealed that single cultivars contain more concrete per cent than double cultivars. Cultivar Shringar results highest concrete per cent among the six cultivars (Gogoi and Talukdar, 2019).

A comparison between different methods of essential oil extraction like, cold enfleurage, hot enfleurage, solvent extraction with hexane and solvent extraction with petroleum ether from the double type tuberose variety was carried out by Rakthaworn *et al.* (2009). The results showed that percentage yields of tuberose oil from cold enfleurage (0.3137 per cent), hot enfleurage (6.5808 per cent), hexane (0.0279 per cent) and petroleum ether (0.0182 per cent) extractions respectively. Prapassorn *et al*., 2009 compared different essential oil extraction methods (cold and hot enfluerage, solvent extraction with hexane and petroleum ether) in double variety of tuberose (*Polianthes tuberosa* L.). Results claimed that percentage yield of oil is maximum in hot enfluerage method of extraction. Ahamadian *et al*., 2018 conducted an experiment using different methods of essential extraction involving Hydrodistillation extraction, Solvent-assisted hydro distillation extraction, Accelerated organic solvent extraction and Organic solvent extraction to compare the volatile compounds present at the different stages of development of tuberose flower. Results of the study showed that flower at half-opened stage had the highest values of volatile compounds in all extraction methods whereas nearly slight opened bud had the least. Among the different extraction methods Solvent-assisted hydro distillation and Accelerated organic solvent gave the rapid result.

The yield of concrete and absolute from tuberose were found highest in flowers harvested at September to October month. The concentration of essential oil remained

low in May and June (Sharma *et al.*, 1977). Srinivas *et al*. (2011) conducted an experiment to determine concrete content of four genotypes of tuberose over March and October seasons. The results revealed that Single genotype yielded higher concrete content (ranges from 0.134 to 0.136 per cent) than the double (ranges from 0.107 to 0.108 per cent). Also, the flowers harvested during October yielded maximum concrete per cent compared to those harvested during March.

To study the consequence of foliar nutrition on essential oil content of flowers of tuberose Sharga and Motial (1983) carried out an experiment. The result indicated that essential oil yield was maximum in plants treated with medium Nitrogen, highest Phosphorous and lowest Potassium. Application of N (75 kg/ha), P (37.5 kg/ha), K (50 kg/ha) + Azotobacter + Azospirillum + VAM at the ratio of 2: 2: 8 significantly increased the flower yield to 15249.95 kg/ha and that of concrete yield to 36.40 kg/ha (Shivalingappa *et al.,* 2001). Concrete content of tuberose can be improved by the application of biogas slurry, it might be due to the improvement of growth and yield as a result of more nitrogen and increased oxidizing and reducing capacity of oils in the flower petals (Sankar, 2008).

Based on the analysis of nine tuberose hybrids Huanga *et al*. (2001) reported that diversity of tuberose flower colour can be extended by inducing anthocyanins and carotenoids from *P. howardii* into *P. tuberosa.* Srivastava and Shridhar (2002) claimed that coloured floral buds had low concrete content.

2.2. Factors influencing post-harvest characters of tuberose

Percentage opened and wilted flowers were significantly negatively correlated with the vase-life. Whereas, fragrance of the flowers and net water uptake not correlated with vase life (Anjum *et al.*, 2001). According to Bhattacharjee and De (2003) longevity of flower species and cultivars after harvest will vary based on their genetic constitution. Anthurium and orchids have maximum vase life compared to rose and Dianthus, whereas lilies have minimum vase life than rose and gerbera.

Varu and Bharad (2010) carried out an experiment to study the effect of spike length and stage of harvest on vase-life of cut flowers in cultivar Double. As regards to spike length, 90 cm had maximum vase life, uptake of water and percentage of opened

florets. Flowers harvested at two-floret opened stage recorded with longest vase life and that harvested at three-floret opened stage noticed with maximum percentage of opened florets, while maximum uptake of water observed in one-floret opened stage. Singh *et al*. (2013) reported that high light intensity results in to high rate of photosynthesis for increased longevity of cut flowers.

Kumar *et al*. (2016) reported that tinted spikes of tuberose cultivar Arka Suvasini harvested at 1-2 basal florets open stage had a higher vase life (8.01 days) and highest mean water uptake (59.42 g per spike). Lalthawmliana *et al.* (2017) reported that maximum vase life was observed in Arka Prajwal (12.33 days) and Hyderabad double (12.00 days) among single and double cultivars respectively. Among the eight genotype evaluated by Bindiya *et al*, (2018) maximum shelf life (9.02 days) was observed by Arka Prajwal and minimum days of vase life (6.20 days) in Arka Niranthara.

Among the different varieties studied for vase life, Arka Suvasini recorded the maximum fresh weight (g) of cut spike and maximum water uptake (ml) in vase during all stages of observation (at harvest, on 3rd day and 5th day in vase and at senescence) and also recorded longest vase life (days) of cut spike (Kumar *et al.*, 2018). Singh *et al.* (2018) evaluated fourteen different tuberose varieties for post-harvest characters at Varanasi. The results of the study revealed that the cultivar Arka Vaibhav had maximum weight of spike at first, third and sixth day, maximum days taken to withering of first floret and maximum days to 50 per cent flower opening. Maximum water uptake was found in cultivar Phule Rajani while maximum vase life was recorded in cultivar Calcutta Single and Phule Rajani.

According to Gupta and Dubey (2018) deterioration of harvested flowers depends on pre-harvest factors, harvest factors and post -harvest factors.

Sugar act as food supplement and also improves water balance in cut flowers. Among the reducing sugars glucose was found most effective in improving the vase life, followed by fructose (Ichimura *et al.,* 2006). Study conducted by Mei-hua *et al*. (2008) in carnation (*Dianthes caryophyllus*) showed that salicylic acid can extending the vase life of cut flowers with decrease reactive oxygen species and ethylene.

Carbohydrate stress in cut tuberose flowers leads to many buds abortion under normal display condition. Vase life of tuberose flowers can be improved by the application of 1.5 per cent sugar in holding solution and/ or pre-treatment with 20 per cent sucrose (15-20 hours) (Naidu and Reid, 1989). Abbasi and Asil (2011) reported that senescence of tuberose flower may not be depending on ethylene concentration. Hutchinson *et al.* (2003) reported that vase life and floret opening of cut tuberose flower can be improved by the application of low concentration of benzyl adenine (<25mgl^{-}),10 per cent sucrose pulse (24 hours)and silver thiosulphate pulse(2mM for 24 hours). Cut tuberose had a vase life of 13 days with 63 per cent floret opening when placed in deionized water without pulsing. According to Saeed *et al*., (2013) vase life and quality of gladiolus cut flower can be improved by the application of GA3 at 25–50 mgl^{-1}.

Materials and Methods

3. MATERIALS AND METHODS

The research entitled "Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality" was conducted at the Department of Floriculture and Landscaping, College of Agriculture, Padannakkad, Kasargod and Regional Agricultural Research Station , Pilicode during the period of 2019-2020. The present chapter deals with the experimental materials used and the methods followed during the course of investigation.

3.1 EXPERIMENTAL SITE

The experiment was laid out at the research field of Regional Agricultural Research Station, Pilicode. The qualitative and postharvest studies were carried out under Department of Floriculture and Landscaping, College of Agriculture, Padannakkad, Kasargod.

3.2 AGROCLIMATIC CONDITIONS

The experimental site comes under tropical humid region. Monthly average meteorological data relating to mean values of maximum temperature, minimum temperature, relative humidity and rainfall during the period of experiment recorded at Meteorological observatory, RARS, Pilicode are presented in Fig 1. and Appendix.

3.3 SOIL

The soil of the site was lateritic loam. The soil were collected from different parts of the experimental field and analysed for physical and chemical properties as per method indicated in Table 1 The soil of the experimental site were strongly acidic in reaction with a pH of 4.37, organic carbon content 0.89 per cent, available N 250 Kg ha^{-1}, available P 42.3 Kg ha^{-1} and available K 404.32 Kg ha^{-1}.

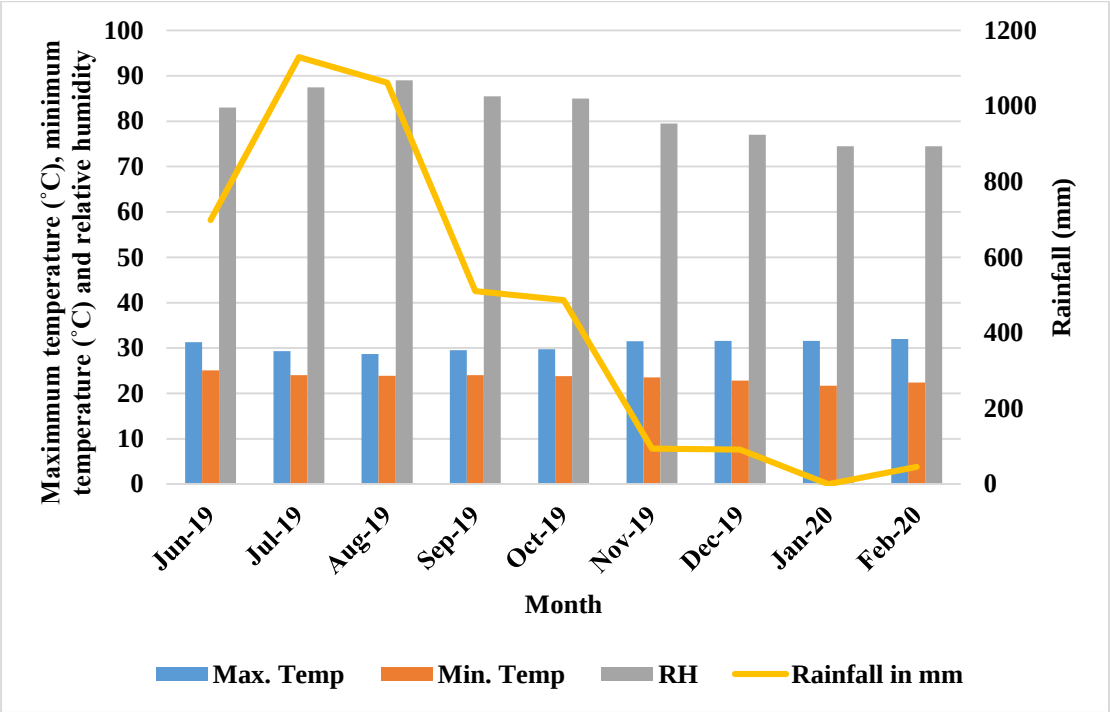


Fig 1. Weather conditions during experimental period

Table 1. Physico-chemical properties of soil

Particulars	Content	Method used	Rating
Physical properties			
Bulk density (g cm^{-3})	1.33	Undisturbed core sample (Black *et al.*, 1965)	
Particle density (g cm^{-3})	2.45	Pycnometer (Black *et al.*, 1965)	
Chemical properties			
pH	4.37	1:2.5 soil water suspension- pH meter (Jackson, 1958)	Strongly acidic
EC	0.124	Conductivity meter	Suitable for all crops
Organic carbon (%)	0.89	Walkley and Black (1934)	High
Organic matter (%)	1.53		
Available N (kg ha^{-1})	250	Subbiah and Asija (1956)	Low
Available P (kg ha^{-1})	42.3	Jackson (1958)	High
Available K (kg ha^{-1})	404.32	Pratt (1965)	High
Available Ca (mg kg^{-1})	170	Jackson (1958)	Low
Available Mg (mg kg^{-1})	78	Jackson (1958)	Low
Available S (mg kg^{-1})	5.62	Black *et al.* (1965)	Low
Available Zn (mg kg^{-1})	1.69	Emmel *et al.* (1977)	High
Available Fe (mg kg^{-1})	10.4	Sims and Johnson (1991)	High
Available Cu (mg kg^{-1})	0.65	Emmel *et al.* (1977)	High
Available Mn (mg kg^{-1})	22.0	Sims and Johnson (1991)	High

3.4 EXPERIMENTAL MATERIAL

The materials used for the experiment, mentioned in Table 1. were ten genotypes of tuberose (*Polianthes tuberosa* .L)comprising *viz.* single (7 genotypes), semi-double (1 genotype) and double (2 genotypes). The bulbs of genotype Arka Prajwal, Arka Niranthara, Arka Shringar, Arka Sugandhi, Arka Suvasini and Arka Vaibhav were collected from the Department of Floriculture and Landscaping, Indian Institute of Horticultural Research, Banglore and other genotypes *i.e*, Culcutta Single, Culcutta Double, Bidhan Ujwal and Phule Rajani were collected from Bidhan Chandra Krishi Viswavidyalaya, Mohanpur.

Table 2. Tuberose varieties used for the study

Sl. No.	Varieties	Group
1	Arka Prajwal	Single
2	Arka Niranthara	
3	Arka Shringar	
4	Arka Sugandhi	
5	Bidhan Ujwal	
6	Phule Rajani	
7	Culcutta Single	
8	Arka Vaibhav	Semi- double
9	Arka Suvasini	Double
10	Culcutta Double	

3.5 EXPERIMENTAL DETAILS

The experiment consisting of ten tuberose varieties (Plate 1a & 1b.) was laid out in Randomized Block Design with three replications under open field conditions.

3.5.1 LAYOUT OF EXPERIMENT

Crop : Tuberose (*Polianthes tuberosa*. L)

Growing conditions : Open field

Experimental design : RBD

Treatments (varieties) : 10

Replications : 3

Total no. of plots : 30

Plot size : 2 x 1 m^2

Planting distance : 20 cm x 25 cm

No. of plants per plot: 40

Layout of experimental field is given in Fig 2.

3.5.2 SOIL PREPARATION

Land was brought to a fine tilth by tractor ploughing and levelled properly. All weeds and residues of previous crops were removed. Beds of size 2x1 m^2 and 15cm height at a distance of 50 cm in between were taken shown in Plate 2. 100 g of limes were applied on each plot and kept as such for one week. Then FYM @ 1kg per plot were uniformly distributed and mixed thoroughly. Beds were mulched using black polythene sheets.

3.5.3 TREATMENT AND PLANTING OF BULBS

Pest and disease free bulbs, preferably those of size 2-5 cm were selected for planting. Before planting, the bulbs were treated with Carbendazim solution ($2gl^{-1}$) for half an hour in order to control the incidence of fungal diseases shown in Plate 3. The

T_1- Arka Vaibhav

T_2- Arka Prajwal

T_3- Arka Niranthara

T_4- Arka Shringar

T_5- Arka Suvasini

Plate 1a. Tuberose varieties used for the experiment

T_6- Arka Sugandhi

T_7- Bidhan Ujwal

T_8- Phule Rajani

T_9- Culcutta Single

T_{10}- Culcutta Double

Plate 1b. Tuberose varieties used for the experiment

Fig 2. Layout of experimental field

R_3
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T_8
T_9
T_{10}

R_1	R_2
T_6	T_5
T_3	T_2
T_9	T_4
T_1	T_3
T_5	T_{10}
T_8	T_1
T_2	T_7
T_{10}	T_9
T_4	T_8
T_7	T_6

No. of treatments: 10

No. of replications: 3

No. of plants per plot: 40

Spacing: 20 cm x 25 cm

Plot size: 2x1 m^2

Design: RBD

tuberose bulbs of uniform size were planted at a depth of 5cm in bed on June 2019 is shown in Plate 4. Experimental field at 3 months after planting represented in Plate 5.

3.5.4 CULTURAL OPERATIONS

Uniform cultural operations and crop management practices were carried out in all varieties during the period of study. Fertilizers, farm yard manure and lime were given as per the KAU package of practices recommendations crops (2016). Hand weeding were done periodically to keep the field weed free and staking were done when it is needed. Periodic irrigation were also given.

3.6 OBSERVATIONS RECORDED

For the collection of experimental data, five plants were randomly selected from each plot and tagged with labels.

3.6.1 Vegetative characters

Vegetative characters are recorded at three months intervals from the date of planting.

3.6.1.1 Plant height

The height of plants were measured from the base of the plant to the tip of the plant with the help of a meter scale. The first observation was recorded at 3 months after planting and further at trimonthly intervals and expressed in centimetres.

3.6.1.2 Number of leaves per hill

The number of fully expanded leaves per hill was counted and recorded at trimonthly intervals.

3.6.1.3 Number of tillers per hill

The number of tillers per hill was counted and recorded.

Plate 2. Layout of beds and field preparation

Plate 3. Bulb treatment

Plate 4. Planting of bulb

Plate 5. Field at 3 months after planting

3.6.2 Floral characters

3.6.2.1 Days to spike emergence

Number of days taken to spike emergence from the date of planting of bulbs were counted and recorded.

3.6.2.2 Days to 50 per cent flowering

Number of days taken to flower 50 per cent of flowers in a spike were recorded.

3.6.2.3 Days to first floret opening

Number of days taken to first floret opening were calculated from the visible spike emergence to the day when first floret opened.

3.6.2.4 Days to complete opening of spikes

Days from the first floret opening to last floret opening of spikes were counted and recorded.

3.6.2.5 Number of spikes per hill

Number of spikes per hill at a time were counted and recorded.

3.6.2.6 Length of spikes

Length of spike measured from the ground level to the tip of the top floret were taken and expressed in centimetres.

3.6.2.7 Girth of peduncle

Diameter at the middle of spike were measured and expressed in centimetres.

3.6.2.8 Length of rachis

Length of spike from base of first floret to the tip of last floret were measured and recorded in centimetres.

3.6.2.9 Longevity of spikes

Number of days taken for 50 per cent of the florets to wilt in each spikes were recorded

3.6.2.10 Number of florets per spikes

Number of florets present in a spike were recorded

3.6.2.11 Length of floret

Length of floret from base to the tip of the floret were taken and expressed in centimetres.

3.6.2.12 Diameter of floret

Diameter of floret were measured at the full bloom stage and expressed in centimetres.

3.6.2.13 Weight of 100 florets

Weight of fully opened 100 florets were taken and expressed in grams.

3.6.2.14 Loose flower yield

Weight of floret at each harvest from a spike were recorded and added and expressed in grams.

3.6.2.15 Loose flower yield per unit area

It was calculated by multiplying loose flower yield per plant into number of plants per square meter and expressed in gm^{-2}.

3.6.2.16 Bending of spikes

Bending of spike during the growth period were observed.

3.6.3 Qualitative characters

Observations on bud colouration, Floret colouration and Pigmentation on peduncle are recorded based on the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability.

3.6.3.1 Bud colouration

Bud colour were recorded.

3.6.3.2 Floret colouration

Flower colour were recorded.

3.6.3.3 Pigmentation on peduncle

Pigmentation on peduncle were recorded.

3.6.3.4 Concrete recovery

The method of extraction of concrete from tuberose florets was standardized. Solvent extraction was best suited for tuberose. In this method, flowers which are about to open were harvested carefully at early morning as crushing would damage concrete recovery. Florets were cut into small bits and soaked in 20 ml hexane and left over night. Hexane was filtered in the next morning. The flower bits were rinsed with fresh hexane and the entire hexane fraction was evaporated in a rotary evaporator (Plate 6.) at 50-55˚C to get semi liquid yellow coloured concrete (Plate 7).

3.6.3.4.1 Concrete per cent

Concrete per cent was calculated by recovery of concrete (g) divided by weight of florets and was expressed in terms of per cent weight of concrete yield per unit floret weight (% W/w).

3.6.4 Post-harvest studies

3.6.4.1 Fresh weight of spike

Weight of freshly harvested spikes were taken and recorded in grams.

3.6.4.2 Vase life

Vase lives of flowers are checked by dipping spikes in water till 50 % florets in a spike get faded. Expressed in days.

Plate 6. Rotary evaporator

Plate 7. Yellow coloured tuberose concrete after extraction

3.6.4.3 Number of florets opened at a time

Number of florets opened in each varieties at the first day of vase were recorded.

3.6.4.4 Water uptake

Amount of water taken up by the spike at the end of vase life was measured and recorded and expressed in milliliters.

3.6.5. Pest and diseases

Pests and diseases occurred during the crop period were observed and recorded.

3.6.6 Statistical analysis

Observations on different characters were tabulated and statistically analysed using the OPSTAT and WASP online Agriculture Data Analysis (Panse and Sukhatme, 1985).

Results

4. RESULTS

An experiment entitled "Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality" was carried out at College of Agriculture, Padannakkad and RARS, Pilicode during 2019-2020. The objective of the experiment was to evaluate tuberose varieties for growth yield and quality and to screen varieties suitable for northern Kerala condition. The observations on vegetative characters, floral characters, qualitative characters and post-harvest characters were recorded and the data were subjected to statistical analysis. The results are presented in this chapter.

4.1 VEGETATIVE CHARACTERS

Crop growth stages are represented in Plate 8.

4.1.1 Plant height

The data presented in Table 3 on plant height showed that there was significant difference among different tuberose varieties at 3 MAP, 6 MAP and 9 MAP. The maximum plant height at 3 MAP was observed in variety Culcutta Double (70.60 cm) followed by Phule Rajani, Arka Suvasini and Arka Prajwal which are on par (66.87, 65.53 and 63.33 cm, respectively). At 6 MAP maximum plant height was recorded by variety Arka Suvasini (79.87 cm) followed by Arka Prajwal (67.40 cm) and minimum was in variety Bidan Ujwal (38.07 cm). Similar results were obtained in plant height at 9 MAP also. The pooled mean data for 9 months revealed that maximum plant height was observed in variety Arka Suvasini (66.56 cm) whereas minimum plant height was obtained in Arka Sugandhi (38.09 cm).

4.1.2 Number of leaves per hill

There was significant difference in number of leaves per hill at different age of plant (Table 4). Maximum number of leaves was recorded in variety Arka Vaibhav (90.21, 129.00) followed by Arka Suvasini (83.18, 84.73) at 3 MAP and 6 MAP, while minimum number of leaves was recorded by Arka Prajwal (25.17, 37.60 at 3 MAP and 6 MAP respectively). At 9 MAP maximum number of leaves was observed in Culcutta Single (68.32) followed by Arka Niranthara (67.13). On pooling the data for 9 months

a. Bulb emergence

b. Spike emergence

c. Flowering stage

Plate 8. Crop growth stages

maximum number of leaves was obtained in Arka Vaibhav followed by Arka Suvasini whereas minimum number of leaves was attained Arka Prajwal.

4.1.3 Number of tillers per hill

Table 5 shows effect of different treatments on number of tillers per hill. At 3 MAP maximum number of tillers per hill was observed in variety Arka Vaibhav (4.39) followed by Arka Suvasini (3.60). Arka Suvasini (4.93) recorded maximum tillers followed by Arka Niranthara (4.00) at 6 MAP. Bidan Ujwal (5.00) followed by Arka Sugandhi (4.20) recorded maximum tillers at 9 MAP. The pooled mean showed that maximum number of tillers per hill in Arka Vaibhav (3.71) whereas minimum in Culcutta Double (2.28).

4.2 FLORAL CHARACTERS

4.2.1 Days to spike emergence

The data presented in Table 6 revealed that there was significant difference among all the varieties of tuberose with respect to days taken to spike emergence. The minimum days to spike emergence was found in variety Arka Shringar (63.25) which is followed by Arka Suvasini (65.08). The maximum days taken to spike emergence was found in variety Culcutta Double followed by Arka Niranthara (88.88 and 82.46 respectively).

4.2.2 Days to 50 per cent flowering

Treatments differed significantly in days taken to 50 per cent flowering (Table 6.) Variety Phule Rajani took maximum days to 50 per cent flowering (126.15) which was on par with variety Culcutta Double (126.03). Minimum number of days for 50 per cent flowering was observed in variety Arka Prajwal (108.38) followed by variety Bidan Ujwal (108.62) which was on par with variety Arka Shringar, Arka Sugandhi and Arka Vaibhav (108.83, 109.03 and 110.09 days, respectively).

Table 3. Effect of different tuberose varieties on plant height at various stages of growth

Sl. No	Treatments (Varieties)	Plant height (cm)			
		3 MAP	6 MAP	9 MAP	Pooled mean
1	Arka Vaibhav	57.13	60.47	47.35	54.98
2	Arka Prajwal	63.33	67.40	48.33	59.69
3	Arka Niranthara	55.00	55.40	38.60	49.69
4	Arka Shringar	59.60	48.40	35.39	47.80
5	Arka Suvasini	65.53	79.87	54.27	66.56
6	Arka Sugandhi	39.93	42.33	32.00	38.09
7	Bidan Ujwal	49.47	38.07	31.60	39.71
8	Phule Rajani	66.87	48.53	45.07	53.49
9	Culcutta Single	46.87	57.33	46.48	50.23
10	Culcutta Double	70.60	53.73	40.54	54.96
C.D (p=0.05)		**12.55**	**6.06**	**3.75**	
SEm (±)		**4.19**	**2.03**	**1.25**	

*MAP- Months after planting

Table 4. Effect of different tuberose varieties on number of leaves per hill at various stages of growth

Sl. No.	Treatments (Varieties)	Number of leaves per hill			
		3 MAP	6 MAP	9 MAP	Pooled mean
1	Arka Vaibhav	90.21	129.00	56.49	91.90
2	Arka Prajwal	25.17	37.60	32.47	31.75
3	Arka Niranthara	37.90	55.73	67.13	53.59
4	Arka Shringar	56.11	56.80	64.27	59.06
5	Arka Suvasini	83.18	84.73	61.80	76.57
6	Arka Sugandhi	31.52	42.47	41.00	38.33
7	Bidan Ujwal	62.91	38.00	48.20	49.70
8	Phule Rajani	44.70	48.00	66.60	53.10
9	Culcutta Single	36.91	57.33	68.32	54.19
10	Culcutta Double	48.92	53.73	57.54	53.40
C.D (p=0.05)		**5.87**	**13.49**	**10.47**	
SEm (±)		**1.96**	**4.51**	**3.50**	

*MAP- Months after planting

Table 5. Effect of different tuberose varieties on number of tillers per hill at various stages of growth

Sl. No.	Treatments (Varieties)	Number of tillers per hill			
		3 MAP	6 MAP	9 MAP	Pooled mean
1	Arka Vaibhav	4.39	2.73	4.00	3.71
2	Arka Prajwal	2.21	3.22	2.93	2.79
3	Arka Niranthara	2.49	4.00	3.33	3.28
4	Arka Shringar	1.58	2.32	3.82	2.57
5	Arka Suvasini	3.60	4.93	1.93	3.49
6	Arka Sugandhi	1.64	1.86	4.20	2.57
7	Bidan Ujwal	1.86	2.17	5.00	3.01
8	Phule Rajani	2.73	1.86	3.33	2.64
9	Culcutta Single	1.52	2.47	3.23	2.40
10	Culcutta Double	1.91	1.94	3.00	2.28
C.D (p=0.05)		**0.56**	**0.89**	**1.22**	
SEm (±)		**0.19**	**0.30**	**0.41**	

*MAP- Months after planting

Table 6. Tuberose varietal influence on days to spike emergence and days to 50 per cent flowering

Sl. No.	Treatments (Varieties)	Days to spike emergence	Days to 50 % flowering
1	Arka Vaibhav	71.83	110.09
2	Arka Prajwal	68.12	108.38
3	Arka Niranthara	82.46	124.61
4	Arka Shringar	63.25	108.83
5	Arka Suvasini	65.08	111.23
6	Arka Sugandhi	66.82	109.03
7	Bidan Ujwal	65.88	108.62
8	Phule Rajani	69.13	126.15
9	Culcutta Single	68.54	122.93
10	Culcutta Double	88.88	126.03
C.D (p=0.05)		**4.84**	**2.83**
SEm (±)		**1.62**	**0.95**

4.2.3 Days to first floret opening

Days to first floret opening were maximum in variety Culcutta Double (24.87 days) which is on par with variety Arka Suvasini (22.93). Variety Bidhan Ujwal took minimum days to first floret opening (11.73) which is on par with Arka Shringar (11.87). Data given in Table 7.

4.2.4 Days to complete opening of spike

It was observed that number of days to complete opening of spikes were maximum in variety Arka Suvasini (26.15). Early completion of opening of florets in a spike was observed in Arka Niranthara (14.20) which is on par with Bidan Ujwal, Arka Shringar, Culcutta Single and Arka Prajwal (14.73, 15.27, 15.53 and 15.80 days, respectively). Data represented in Table 7.

4.2.5 Number of spikes per hill

Regarding the number of spikes per hill no significant variation was observed among the treatments (Table 8).

4.2.6 Length of spikes

The data depicted in Table 8 and Plate 9 showed that there was significant difference among all the varieties for the length of spike. Maximum length of spike was observed in variety Arka Prajwal (111.80 cm) followed by Arka Suvasini (109.07 cm) which was on par. Minimum spike length was recorded in Bidan Ujwal (65.73 cm) which is on par with variety Arka Sugandhi, Arka Shringar and Phule Rajani.

4.2.7 Girth of peduncle

It is evident from the data presented in Table 8 that significant variation occurred among different treatments on girth of peduncle. Girth of peduncle recorded maximum in variety Arka Prajwal (3.05 cm) and minimum was recorded in variety Arka Sugandhi (2.11 cm).

Table 7. Tuberose varietal influence on days to first floret opening and days to complete opening of spike

Sl. No.	Treatments (Varieties)	Days to first floret opening	Days to complete opening of spike
1	Arka Vaibhav	20.00	23.17
2	Arka Prajwal	16.67	15.80
3	Arka Niranthara	14.73	14.20
4	Arka Shringar	11.87	15.27
5	Arka Suvasini	22.93	26.15
6	Arka Sugandhi	13.07	21.87
7	Bidan Ujwal	11.73	14.73
8	Phule Rajani	19.60	17.50
9	Culcutta Single	17.67	15.53
10	Culcutta Double	24.87	19.80
C.D (p=0.05)		**2.39**	**3.97**
SEm (±)		**0.80**	**1.33**

4.2.8 Length of rachis

Maximum length of rachis was observed in variety Arka Suvasini (47.60 cm) followed by Culcutta Double and Arka Vaibhav which were on par (44.77 and 44.53 cm, respectively). Data given in Table 8.

4.2.9 Longevity of spikes

Longevity of spike was maximum in variety Arka Suvasini (13.60 days) followed by Arka Vaibhav (11.50 days). This was followed by Culcutta Single and Arka Shringar which were statistically on par. Minimum longevity of spikes were observed in variety Arka Prajwal (7.40 days). Data given in Table 9.

4.2.10 Number of florets per spike

Significant variation among treatments were observed for number of florets per spike during the crop growth (Table 9). Variety Arka Vaibhav had maximum number of florets per spike (63.00) which was on par with variety Arka Suvasini (62.10). Minimum number was recorded in variety Culcutta Single (47.47).

4.2.11 Length of floret

From the Table 9 it is clear that maximum length of floret was observed in variety Culcutta Single (7.03 cm) which was statistically on par with Arka Prajwal and Arka Niranthara (6.97 and 6.69 cm, respectively).

Table 8. Tuberose varietal influence on number of spikes per hill, length of spike, girth of peduncle and length of rachis

Sl. No.	Treatments (Varieties)	Number of spikes per hill	Length of spike (cm)	Girth of peduncle (cm)	Length of rachis (cm)
1	Arka Vaibhav	1.27	91.17	2.65	44.53
2	Arka Prajwal	1.00	111.80	3.05	40.00
3	Arka Niranthara	1.00	92.53	2.42	36.47
4	Arka Shringar	1.00	75.20	2.44	30.20
5	Arka Suvasini	1.07	109.07	2.82	47.60
6	Arka Sugandhi	1.33	65.87	2.11	32.07
7	Bidan Ujwal	1.40	65.73	2.29	24.90
8	Phule Rajani	1.00	76.60	2.52	35.10
9	Culcutta Single	1.07	106.00	2.39	37.60
10	Culcutta Double	1.00	101.07	2.77	44.77
C.D (p=0.05)		**NS**	**13.73**	**0.33**	**11.18**
SEm(±)		**0.11**	**4.59**	**0.11**	**3.74**

Table 9. Tuberose varietal influence on longevity of spikes, number of florets per spike and length of floret

Sl. No.	Treatments (Varieties)	Longevity of spikes (days)	No. of florets per spike	Length of floret (cm)
1	Arka Vaibhav	11.50	63.00	5.68
2	Arka Prajwal	7.40	51.67	6.97
3	Arka Niranthara	7.67	50.67	6.69
4	Arka Shringar	10.00	53.80	6.07
5	Arka Suvasini	13.60	62.10	5.28
6	Arka Sugandhi	7.80	60.20	5.59
7	Bidan Ujwal	9.27	51.40	5.65
8	Phule Rajani	7.68	51.20	5.78
9	Culcutta Single	10.20	47.47	7.03
10	Culcutta Double	9.30	56.80	5.78
C.D (p=0.05)		**1.71**	**9.38**	**0.41**
SEm (±)		**0.57**	**3.13**	**0.14**

4.2.12 Diameter of floret

Data presented in Table 10 shows that maximum diameter of floret was observed in variety Arka Suvasini (3.53 cm) followed by Culcutta Double and Arka Prajwal (3.14 and 2.79 cm, respectively). Minimum diameter were observed in variety Arka Sugandhi (2.21 cm).

4.2.13 Weight of 100 floret

Weight of 100 florets were maximum in variety Arka Suvasini (235.43 g) followed by Culcutta Double and Arka Vaibhav which was statistically on par (187.47 and 174.13 g respectively). Minimum weight of 100 florets were recorded by variety Arka Sugandhi (80.67 g). Data given in Table 10.

4.2.14 Loose flower yield

Significant variation were observed among varieties for loose flower yield during crop growth (Table 10). Maximum yield was recorded by the variety Arka Suvasini followed by Arka Vaibhav which was on par (131.31 and 106.28 g, respectively). Minimum loose flower yield was recorded in variety Culcutta Single (42.47 g).

4.2.15 Loose flower yield per unit area

Maximum loose flower yield per unit area were recorded by the variety Arka Suvasini followed by Arka Vaibhav which was on par (2626.26 and 2125.50 gm^{-2}, respectively). Data given in Table 10.

4.2.16 Bending of spikes

Regarding the bending of spikes double type (Arka Suvasini and Culcutta Double) and semi-double type (Arka Vaibhav) varieties showed bending.

Table 10. Tuberose varietal influence on diameter of floret, weight of 100 floret, loose flower yield and loose flower yield per unit area

Sl. No.	Treatments (Varieties)	Diameter of floret (cm)	Weight of 100 floret (g)	Loose flower yield (g)	Loose flower yield per unit area (g/m2)
1	Arka Vaibhav	2.43	174.13	106.28	2125.50
2	Arka Prajwal	2.79	140.93	77.29	1545.73
3	Arka Niranthara	2.60	90.76	51.23	1024.67
4	Arka Shringar	2.51	91.46	51.47	1029.33
5	Arka Suvasini	3.53	235.43	131.31	2626.26
6	Arka Sugandhi	2.21	80.67	52.49	1049.80
7	Bidan Ujwal	2.67	110.27	51.33	1026.50
8	Phule Rajani	2.65	88.17	49.30	986.00
9	Culcutta Single	2.38	99.50	42.47	849.47
10	Culcutta Double	3.14	187.47	104.33	2086.580
C.D (p=0.05)		**0.44**	**27.67**	**28.22**	**564.41**
SEm (±)		**0.15**	**9.24**	**9.43**	**188.50**

4.3 Qualitative characters

The data recorded for qualitative characters are represented in Table. 11a and 11b.

4.3.1 Bud colouration

Most of the varieties under study showed pinkish green colouration on bud. Buds of Arka Vaibhav and Arka Sugandhi was green in colour. Whereas variety Bidhan Ujwal observed with yellowish green buds.

4.3.2 Floret colouration

There was no significant variation observed in floret colouration among the ten varieties studied. All the varieties showed white florets.

4.3.3 Pigmentation on peduncle

Arka Niranthara, Arka Sugandhi and Culcutta Double have strong pigmentation on peduncle. Whereas varieties like Arka Vaibhav, Arka Shringar, Arka Suvasini, Phule Rajani and Culcutta Single have medium pigmentation on peduncle. Peduncle have weak pigmentation in Arka Prajwal and Bidhan Ujwal.

4.3.4 Concrete recovery (%)

Significant variation between treatments were observed in concrete content of flowers. Concrete recovery ranges from 0.012 to 0.117 %. Maximum concrete content was obtained from the variety Arka Sugandhi (0.117 %) followed by Culcutta Single (0.079 %). Minimum concrete content was recorded by variety Arka Vaibhav (0.012 %) followed by Arka Suvasini, Culcutta Double and Phule Rajani (0.017, 0.019 and 0.02 % respectively) which was on par.

Table 11a. Tuberose varietal influence on bud colouration, floret colouration and pigmentation on peduncle

Sl. No.	Treatments (Varieties)	Bud colouration	Floret colouration	Pigmentation on peduncle
1	Arka Vaibhav	Green	White	Medium
2	Arka Prajwal	Pinkish green	White	Weak
3	Arka Niranthara	Pinkish green	White	Strong
4	Arka Shringar	Pinkish green	White	Medium
5	Arka Suvasini	Pinkish green	White	Medium
6	Arka Sugandhi	Green	White	Strong
7	Bidan Ujwal	Yellowish green	White	Weak
8	Phule Rajani	Pinkish green	White	Medium
9	Culcutta Single	Pinkish green	White	Medium
10	Culcutta Double	Pinkish green	White	Strong

Table 11b. Tuberose varietal influence on concrete recovery

Sl. No.	Treatments (Varieties)	Concrete recovery (%)
1	Arka Vaibhav	0.012
2	Arka Prajwal	0.023
3	Arka Niranthara	0.023
4	Arka Shringar	0.030
5	Arka Suvasini	0.017
6	Arka Sugandhi	0.117
7	Bidan Ujwal	0.033
8	Phule Rajani	0.020
9	Culcutta Single	0.079
10	Culcutta Double	0.019
	C.D (p=0.05)	**0.016**
	SEm (±)	**0.005**

4.4 Post-harvest studies

The data recorded for post-harvested characters are depicted in Table 12 and Plate 10 shows the vase study of spikes.

4.4.1 Fresh weight of spikes

Regarding the fresh weight of spikes significant variation was observed among treatments. Maximum weight of spike was recorded in the variety Arka Suvasini (133.52g) followed by Culcutta Double (115.21g) which was statistically on par with variety Arka Prajwal (110.67g). Minimum spike weight was recorded by Arka Sugandhi (36.81g).

4.4.2 Vase life

Maximum days to 50 per cent floret wilt was recorded in variety Culcutta Double (8.53) followed by Arka Suvasini (8.13) which are significantly similar. Minimum number of days in vase was recorded in variety Arka Sugandhi (6.53).

4.4.3 Number of florets opened at a time

Maximum number of florets opened at the first day was maximum in variety Arka Shringar followed by Bidhan Ujwal (4.33 and 4, respectively). Number of florets opened on first day was found minimum in variety Phule Rajani followed by Arka Vaibhav (1.67 and 2.33, respectively).

4.4.4 Water uptake

Variety Arka Niranthara recording maximum water uptake (10.80 ml) followed by Arka Prajwal, Culcutta Double and Arka Suvasini which was statistically on par (9.80, 9.33 and 9.00 ml, respectively). Minimum water uptake was recorded in variety Arka Sugandhi and Bidan Ujwal (4.87 ml each) which was significantly similar.

Table 12. Tuberose varietal influence on post-harvest characters

Sl. No.	Treatments (Varieties)	Fresh weight of spike (g)	Vase life (days)	No. of florets opened on first day	Water uptake (ml)
1	Arka Vaibhav	70.54	6.93	2.33	7.27
2	Arka Prajwal	110.67	7.20	2.67	9.80
3	Arka Niranthara	67.10	7.20	3.01	10.80
4	Arka Shringar	59.19	7.33	4.33	6.53
5	Arka Suvasini	133.52	8.13	2.67	9.00
6	Arka Sugandhi	36.81	6.53	3.01	4.87
7	Bidan Ujwal	48.39	6.73	4.00	4.87
8	Phule Rajani	53.51	7.13	1.67	6.07
9	Culcutta Single	59.42	7.07	2.67	7.20
10	Culcutta Double	115.21	8.53	3.01	9.33
C.D (p=0.05)		**15.62**	**0.70**	**0.015**	**0.90**
SEm (±)		**5.22**	**0.23**	**0.005**	**0.30**

4.5. Pests and diseases

Tuberose is hardy crop not that much affected by attack of pest and diseases. Even though during monsoon season variety Bidhan Ujwal was severely affected by leaf blight. Bud rot is also noticed in some varieties. Irrespective of the varieties mild incidence of nematodes, grass hoppers and cotton boll worm (*Helicoverpa armigera*) was observed.

Represented in plate 11.

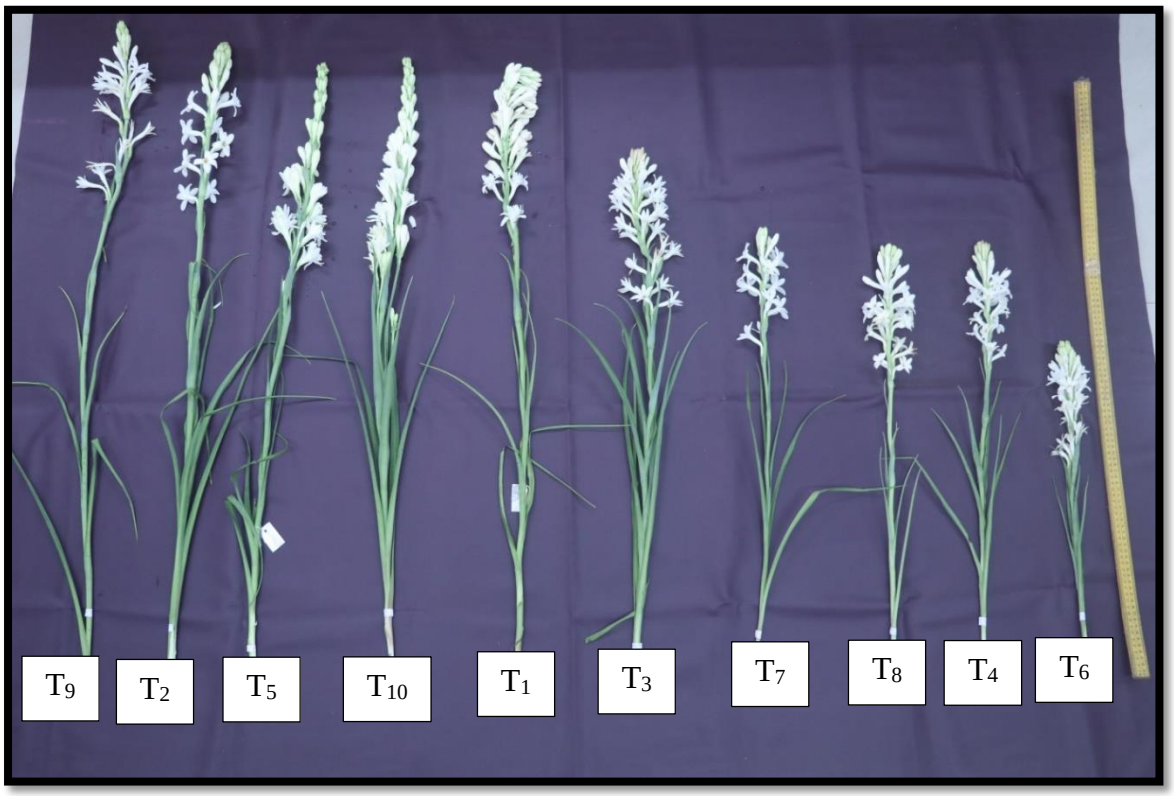


Plate 9. Spike length comparison

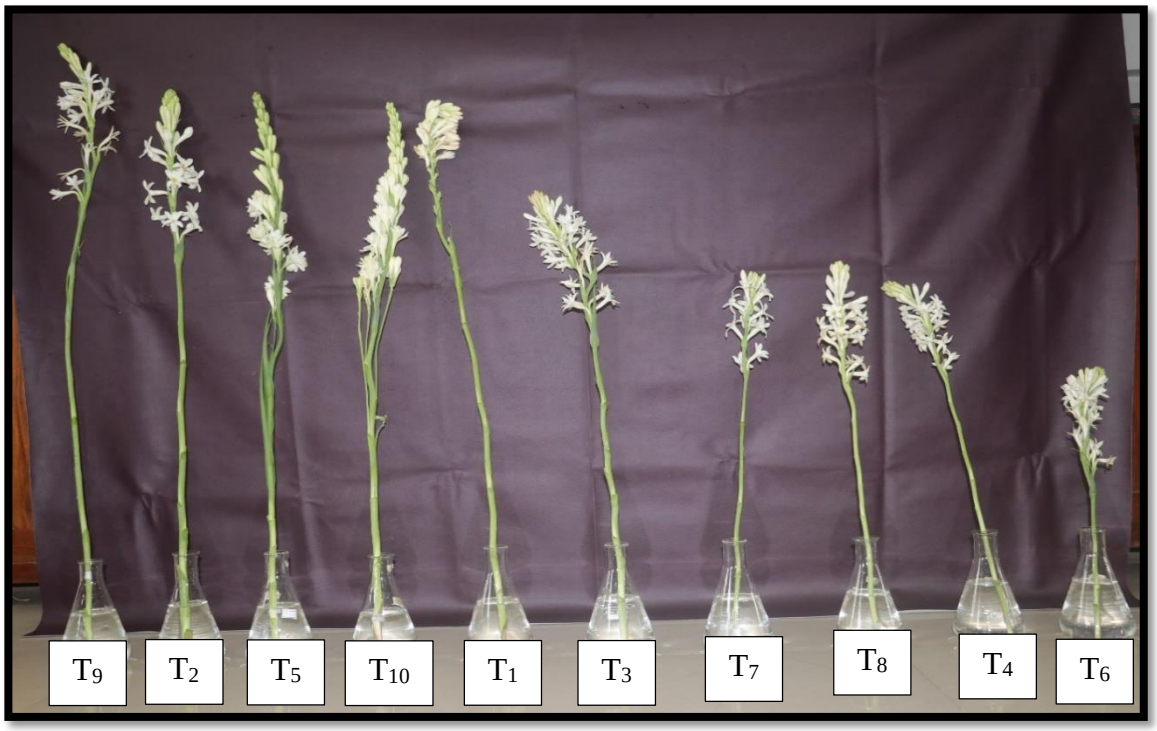


Plate 10. Vase study of spikes

a. Leaf blight attack

b. Bud rot incidence

c. Attack of cotton ball worm

Plate 11. Pest and Disease incidence

Discussion

5. DISCUSSSION

Tuberose is one of the most popular bulbous ornamental flower crop commercially cultivated under different agro- climatic conditions in India. It has great economic potential in loose flower and cut flower trade and also in essential oil industry (Sadhu and Bose, 1973). Even though warm humid tropical condition of Kerala is favourable for the production of tuberose its cultivation is very limited due to lack of proper technical knowledge on scientific care, cultural practices as well as poor marketability of produce.

The present experiment was carried out at the Department of Floriculture and Landscaping, College of Agriculture, Padannakkad and Regional Agricultural Research Station, Pilicode, Kasargod to evaluate tuberose varieties for growth, yield and quality and to screen varieties for northern Kerala. The experiment consisted of ten varieties *i.e*, Arka Vaibhav, Arka Prajwal, Arka Niranthara, Arka Shringar, Arka Suvasini, Arka Sugandhi, Bidhan Ujwal, Phule Rajani, Culcutta Single and Culcutta Double being collected from southern and eastern parts of India. Successful production of any crop depends on the identification of suitable varieties for a particular area. For the commercial production the cultivar should be high yielding with quality produce and enough to resist pest and diseases.

The results generated from the present study are discussed hereunder with scientific explanation in the light of support of available literatures under appropriate headings.

5.1 Vegetative characters

Vegetative characters like plant height, number of leaves per hill and number of tillers per hill have significant influence on the growth and yield potential of tuberose (Fig 3.). According to Bichoo *et al.,* 2002 in gladiolus all these vegetative characters are genetically controlled and expressed differently depending on the growing condition.

The variation among the plant height might be due to the differences in the genetic makeup and the diversified origin of the cultivar, which results into changes in

the expression of phenotype under specific geographical location. The results of variation in plant height due to genotypic differences and environmental variation are in agreement with the findings of Sateesha *et al.* (2011), Ranchana *et al.* (2015), Dimri (2017) in tuberose; Nagaraju and Parthasarathy (2001) in gladiolus, Negi *et al.* (2014) in liliums.

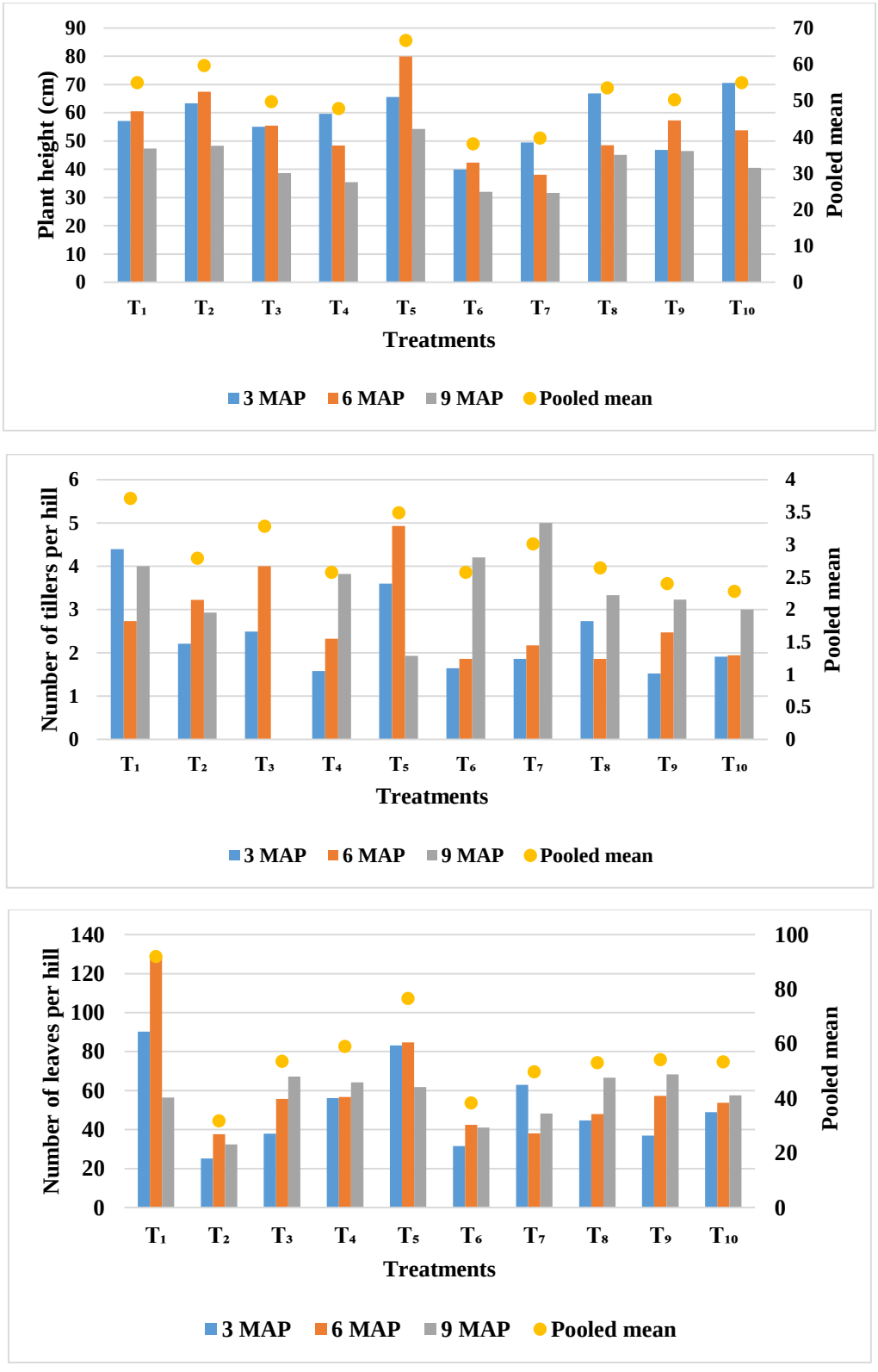
In the current study, plant height is documented at every three month intervals. Plant height showed a progressive increase up to six months thereafter a slight decrease is observed, it may be due to drooping of leaves in summer months. Similar findings were reported by Sankar (2008) in tuberose. Pooled mean for the 9 months showed that variety Arka Suvasini and Arka Sugandhi recorded maximum and minimum values for plant height respectively. Lalthawmliana *et al*. (2017) reported maximum plant height in Arka Suvasini (58.13 cm) under the foot hill conditions of Nagaland. The increased plant height may be due to increased photosynthetic capacity of plant.

Leaves are the primary site of photosynthesis, which greatly influence the growth and yield of any crop. Similar to plant height there were reduction in number of leaves per plant at 9^{th} months after planting. This might be due to drooping and drying of leaves. The variation in number of leaves per hill is attributed by the hereditary traits which is further modified by the environmental factors like temperature, relative humidity, light intensity *etc.* which has been in accordance with the findings of Ramachandrudu and Thangam (2009) and Mahawer *et al*. (2013) in tuberose.

Some varieties of tuberose are vigorous in growth and some were less vigorous, this may be due to varietal characters responsible by a gene.

5.2 Floral characters

Duration from planting to spike emergence and days to first floret opening indicates the early or delayed flowering habitat of a cultivar, which is an important parameter for selecting a variety for a particular area. Early spike emergence is favourable for tuberose growers as it leads to early availability of flowers in market.



*MAP- Months after planting

Fig 3. Effect of different varieties of tuberose on vegetative characters

It was revealed from this study that early spike emergence was found in variety Arka Shringar (63.25 days). Late spike emergence was found in variety Culcutta Double followed by Arka Niranthara (88.88 and 82.46 days, respectively). Earlier flower initiation in Arka Shringar may be due to its reduced juvenile period. Variety Bidhan Ujwal took minimum days to first floret opening (11.73) which was on par with Arka Shringar (11.87). Those variation is primarily due to the genetic inheritance and difference in the environmental condition. The significant difference in days to spike emergence and days to first floret opening was also reported by Ramachandrudu and Thangam (2009), Patil *et al.* (2009), Chaturvedi *et al.* (2014) and Dimri *et al*.(2017) in tuberose (Fig 4a.).

In a tuberose spike, flower opening are in acropetal succession. The number of days to complete opening of spike varies with number of florets per spike. From the present investigation it is found that maximum number of days to complete opening of spikes were found in variety Arka Suvasini. Early completion of opening of florets in a spike was observed in Arka Niranthara which is on par with Bidhan Ujwal, Arka Shringar, Culcutta Single and Arka Prajwal (Fig 4a.). Variety Arka Vaibhav had maximum number of florets per spike (63.00) which was on par with variety Arka Suvasini (62.10). Minimum number was recorded in variety Culcutta Single (47.47) (Fig 4b.). The variation among blooming period is also reported by Ramachandrudu and Thangam (2009), Singh *et al.* (2018) in tuberose and Simmy (2012) in gladiolus.

Tuberose has gained popularity as a cut flower owing to its attractive, elegant and fragrant spikes. Long spike, large number of closely arranged florets makes it an ideal cut flower. The long lasting flower spikes are largely used for the decoration of vases and preparation of bouquets. Spike characters are significant in determining the suitability of tuberose as a cut flower.

Longer spike length is a desirable character for cut flower. In the present study maximum length of spike was observed in variety Arka Prajwal (111.80 cm) followed by Arka Suvasini (109.07 cm) which was on par. The longest spike in Arka Prajwal may be due to more internodal distance. The variation in spike length is also reported by Susila (2013), Krishnamoorthy (2014), Prakash *et al.* (2015) and Bindiya *et al.*

(2018) in tuberose. This variation among spike length might be due to difference in genetic makeup (Fig 4b.).

A long rachis with more closely arranged floret is desirable, which give a compact appearance to the spike. The number of florets per spike is closely associated with length of rachis, as longer the rachis more the number of florets on the spike. The varieties under study exhibited significant difference in rachis length. Maximum length of rachis was observed in variety Arka Suvasini (47.60 cm) followed by Culcutta Double and Arka Vaibhav which were on par (44.77 and 44.53 cm respectively) (Fig 4b.). This variation among cultivars might be due to genetic traits and prevailing climatic condition. These findings are accordance with Singh and Singh (2013) and Ranchana *et al.* (2013) in tuberose.

Longevity of spike was maximum in variety Arka Suvasini (13.60 days) followed by Arka Vaibhav (11.50 days). It may be due to longest spike and more number of florets per spike in these varieties. High light intensity results in to high rate of photosynthesis for increased longevity of cut flowers. Similar findings in tuberose were reported by Singh *et al.* (2013) (Fig 4c.).

Diameter of the spike determine the firmness and strength of the spike. Sturdy and rigid spike will provide greater mechanical support, whereas weak and thin spike will bend after some time in vases. In the present investigation girth of peduncle recorded maximum in variety Arka Prajwal (3.05 cm). The significant variation in spike diameter is due to the differences in the genetic makeup of different varieties. Similar variation is previously observed by Singh (2004) in tuberose (Fig 4d.).

Flower related parameters like length of floret, diameter of floret and weight florets plays an important role when the quality of flower is concerned. For the better appearance of spike, it should have floret with bigger diameter. As the diameter of the floret increases tendency of crowding by overlapping will increases this will further enhance the beauty of spike. For the preparation of garlands, veni etc. longest florests are more attractive.

In the present experiment maximum length of floret was observed in variety Culcutta Single (7.03 cm) which was statistically on par with Arka Prajwal and Arka

Niranthara (6.97 and 6.69 cm, respectively). Maximum diameter of floret was recorded in variety Arka Suvasini (3.53 cm) followed by Culcutta Double and Arka Prajwal (3.14 and 2.79 cm, respectively). Similar finding in tuberose was observed by Bindiya *et al.* (2018). Variation in floret size in all the ten cultivars might be due to the difference in genetic makeup and the environmental condition during the experimental period. Accumulation of more carbohydrate in bud also contribute to more floret size (Fig 4d.).

Weight of 100 florets were maximum in variety Arka Suvasini (235.43 g) followed by Culcutta Double and Arka Vaibhav which was statistically on par (187.47 and 174.13 g, respectively). The maximum weight of floret in variety Arka Suvasini was due to bold and big size florets and lesser weight in other varieties was due to the production of small sized flowers (Fig 4d.). Based on the present study maximum loose flower yield was recorded by the variety Arka Suvasini followed by Arka Vaibhav. Minimum loose flower yield was recorded in variety Culcutta Single (42.47 g). The maximum loose flower yield in Arka Suvasini may be due to more number of leaves it will lead to greater accumulation of assimilates for flower development. Increased floret size and weight of individual florets also leads to increased yield of loose flower. This is supported with the findings of Mahoviya (2003) in tuberose (Fig 4e.).

5.3 Qualitative characters

Nowadaystuberose flowers being widely used in perfumery industry as a source of natural essential oils and aroma compounds due to its unique and exotic aroma. Concrete represent crude form of essential oil. Selection of different genotypes in terms of concrete recovery is the primary base for breeding programme. In the current investigation concrete recovery ranges from 0.117 to 0.012 %. Maximum concrete obtained from the variety Arka Sugandhi (0.117%) followed by Culcutta Single (0.079%). Minimum concrete content was recorded by variety Arka Vaibhav (0.012%) (Fig 5).

Single type cultivars had more concrete content compared to semi double and double type cultivars and also concrete recovered from single petalled tuberose has

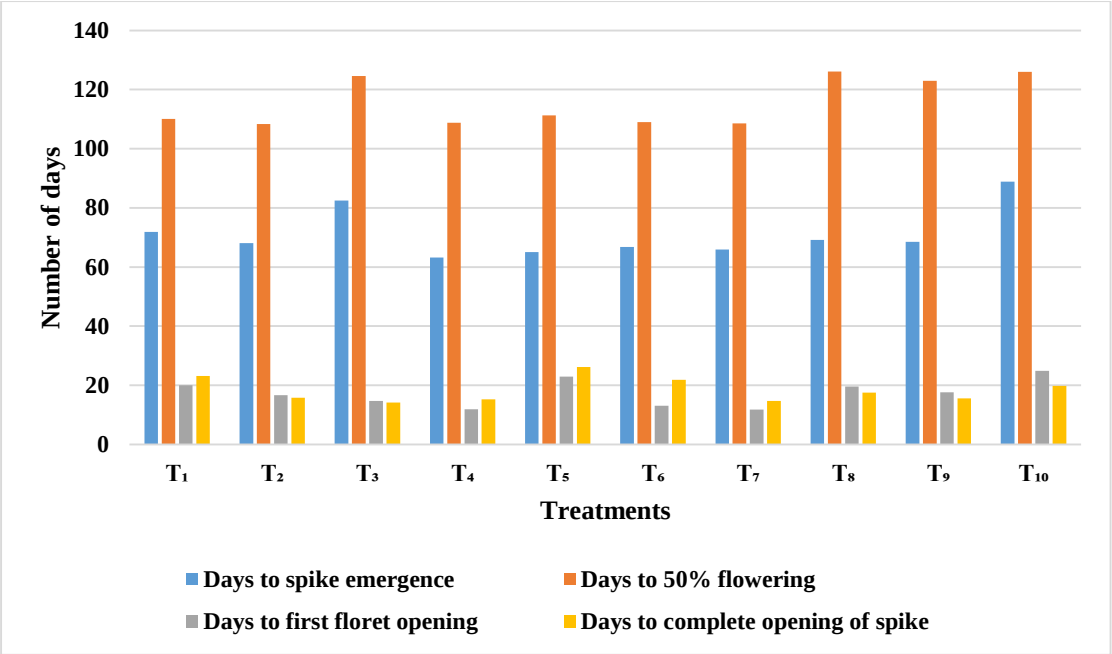


Fig 4a. Effect of different varieties of tuberose on days to spike emergence, days to 50 % flowering, days to first floret opening and days to complete opening of spike

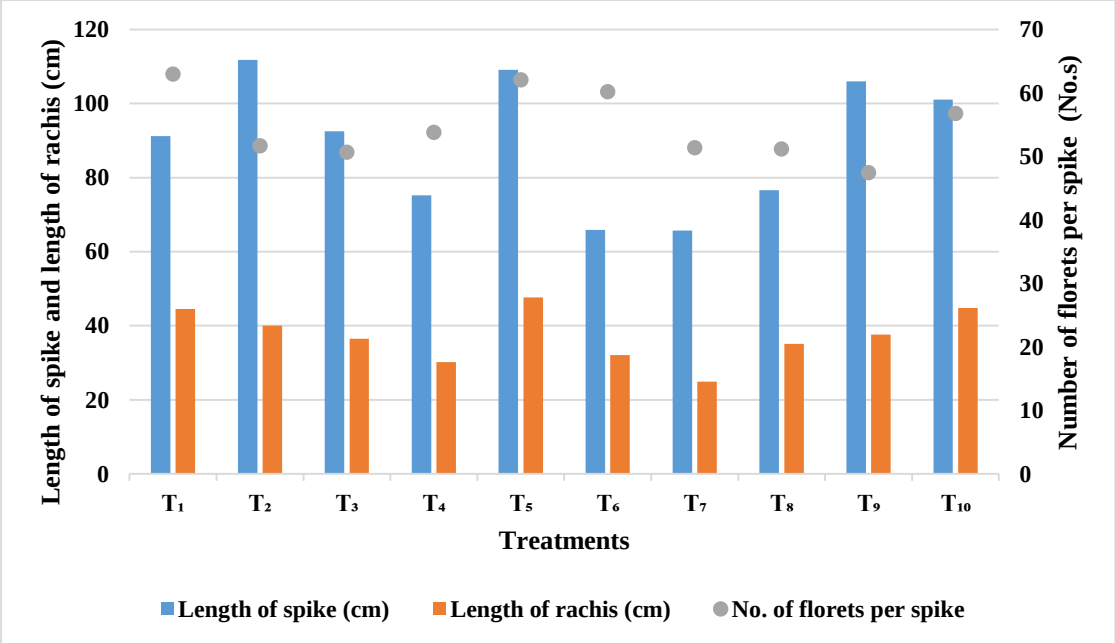


Fig 4b. Effect of different varieties of tuberose on length of spike, length of rachis and number of florets per spike

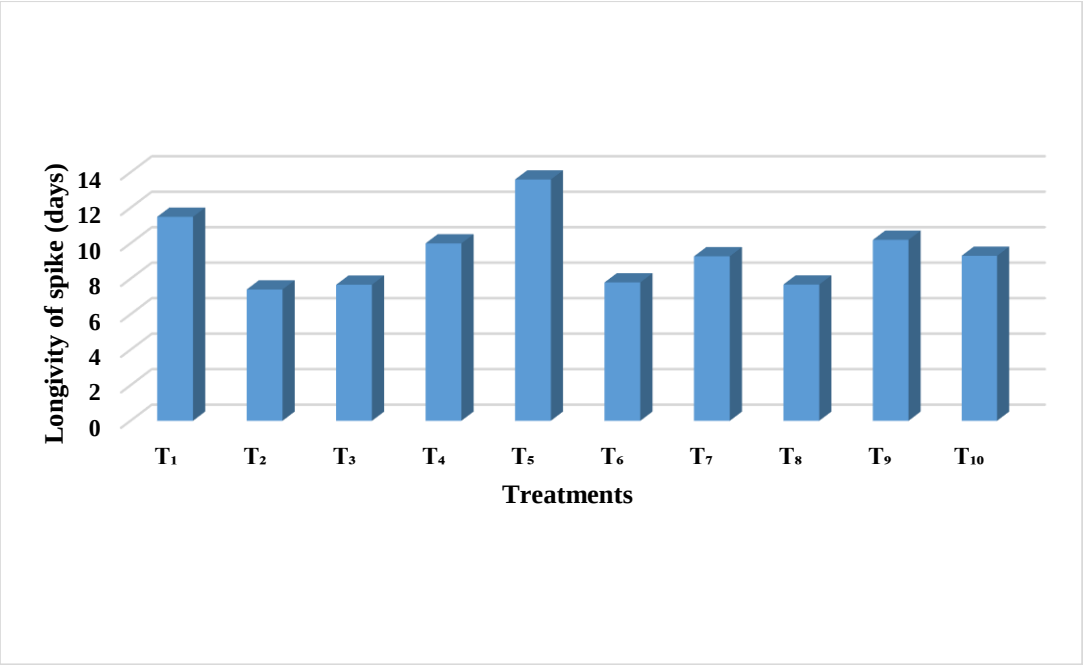


Fig 4c. Effect of different varieties of tuberose on longevity of spike

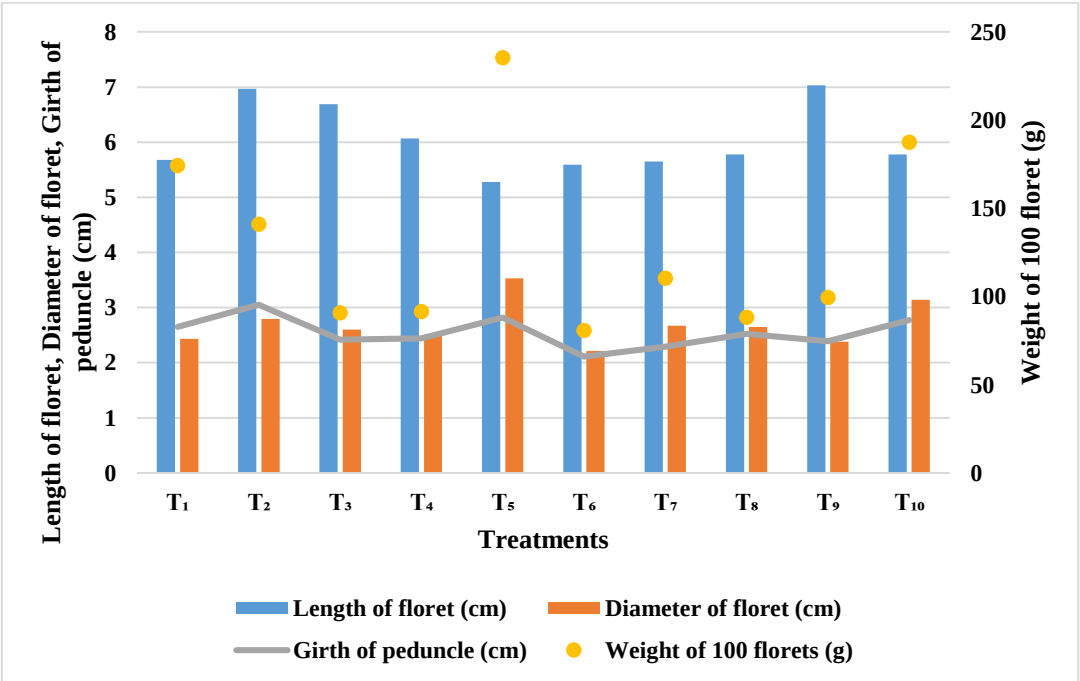


Fig 4d. Effect of different varieties of tuberose on length of floret, diameter of floret, girth of peduncle and weight of 100 florets

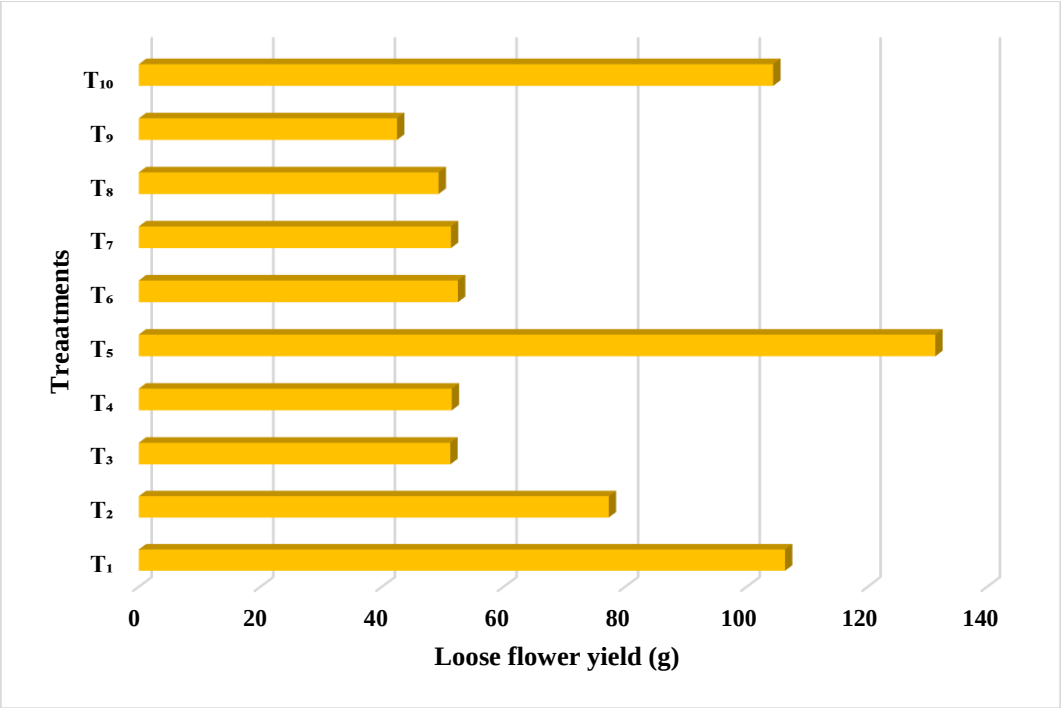


Fig 4e. Effect of different varieties of tuberose on loose flower yield

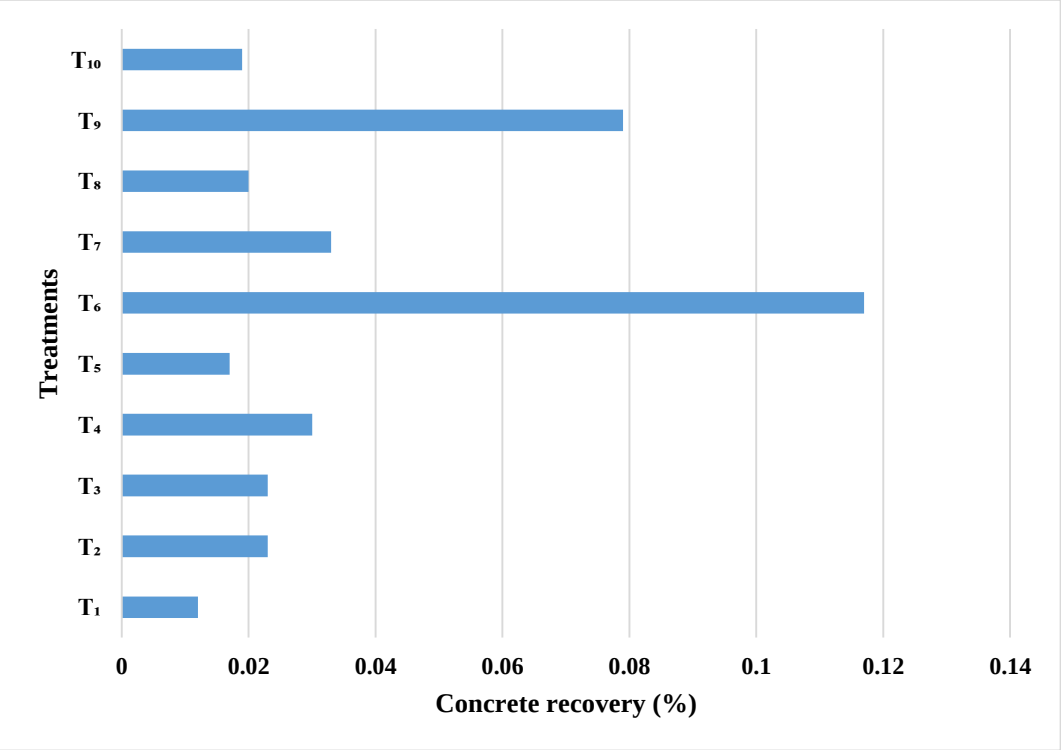


Fig 5. Effect of different varieties of tuberose on concrete recovery

stronger aroma than the aroma obtained from double petalled tuberose concrete, it might be due to accumulation of more fragrant components in single type. The results were in conformity with the findings of Mahoviya (2003), Martolia (2010) and Chaudhari and Kumar (2017) in tuberose. Stage of harvest, growing environmental condition, season and method of extraction have significant influence on the recovery of concrete. Variation in concrete content of harvested flowers in different months may be due to variation in temperature, as the temperature increases concrete recovery decreases due to evaporation of volatile aromatic compounds and reduction in weight of flowers. Kumar *et al*. (2013) reported similar results in damask rose under Indian condition. Srivastava and Shridhar (2002) claimed that coloured floral buds had low concrete content compared to colourless buds.

Variation in bud colouration, floret colouration and intensity of pigmentation on peduncle is due to different genetic makeup and colouring pigment present in the different cultivars under study. Pinkish colouration may be due to flavonoid pigments and greenish may be due to chlorophyll pigments present in these cultivars. Similar findings were reported by Mahawer *et al*, (2013) in tuberose.

5.4 Post-harvest spike characters

Flowers are more vulnerable to post harvest losses due to its high perishability. Prolonged post-harvest life of flower is essential to satisfy the consumers. The major factors which leads to the deterioration of harvested flowers are; Pre-harvest factors, Harvest factors and Post-harvest factors (Gupta and Dubey, 2018).

Fresh weight of spike is an important parameter which indicates the size and freshness. High moisture content leads to more weight of spike. The growing environmental condition have significant influence on this parameter. In the present study variety Arka Suvasini (133.52g) followed by Culcutta Double (115.21g) recorded maximum value for this parameter and minimum was recorded by Arka Sugandhi (36.81g). Maximum fresh weight of spike in Arka Suvasini and Culcutta double might be due to double type (more than 3 rows of corolla segments) nature of flower. The minimum value in Arka Sugandhi might be due to its single type (one

row of corolla segment) nature. Mahoviya (2003) and Kumar *et al*. (2018) reported similar results previously in tuberose (Fig 6).

In the present investigation vase life of tuberose varies significantly among different cultivars (Fig 7.). Maximum vase life was recorded in variety Culcutta Double (8.53 days) followed by Arka Suvasini (8.13 days) which are significantly on par. Minimum number of days in vase was recorded in variety Arka Sugandhi (6.53 days). Performance of spike in vase determines the quality of tuberose as cut flower. Variation in vase life might be due to difference in genetic makeup of the cultivars and it is directly related to the number of florets per spike. More the number of florets it will takes longer time to open the last floret in spike. It is in accordance with the findings Angmo (2017) and Kumar *et al* (2018) in tuberose. Better vase life may be due to the longer spike length, hence it can absorb more water thereby maintain high turgidity and freshness of spike. Moreover, longer spike containing higher amount of reserved carbohydrates. This is in line with the findings of Varu and Barad (2010) in tuberose.

Freshness of cut flower is directly correlated with uptake of water. Deficiency of water and wilting of flower occurs when the rate of transpiration exceeds the rate of absorption. In the current study amount of water uptake is significantly influenced by the varietal difference. Maximum water uptake (10.80 ml) was recorded by variety Arka Niranthara and minimum was recorded in Arka Sugandhi and Bidhan Ujwal which are statistically on par. Longer spike can absorb more amount water due to greater area of xylem as well as more amount of reserved carbohydrates. Lower pH of holding solution may be one of the reason for greater uptake of water. Blockage of xylem vessels by air, microorganism like bacteria, fungi, *etc*. will interrupt the upward movement of water this will lead to water deficit in cut flowers. Variation in amount of water uptake by cut spikes was previously reported by Singh *et al.* (2018), Kumar *et al.* (2018) in tuberose, Kumar *et al.* (2007) in gladiolus and Kim *et al*. (2004) in gerbera (Fig 7.).

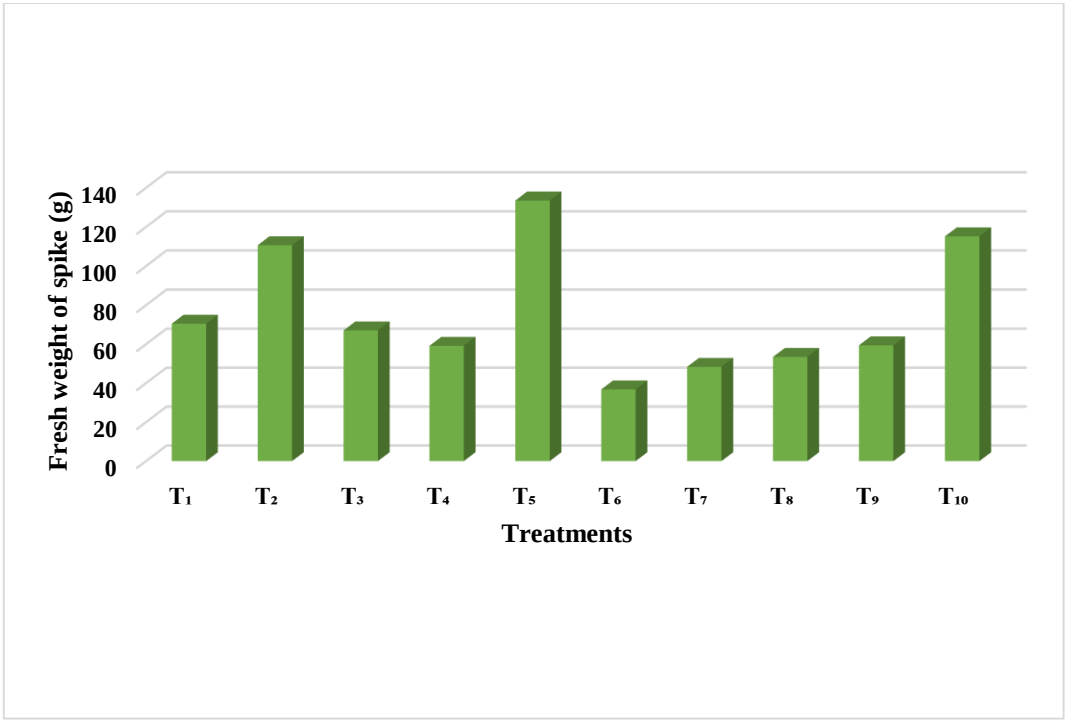


Fig 6. Effect of different varieties of tuberose on fresh weight of spike

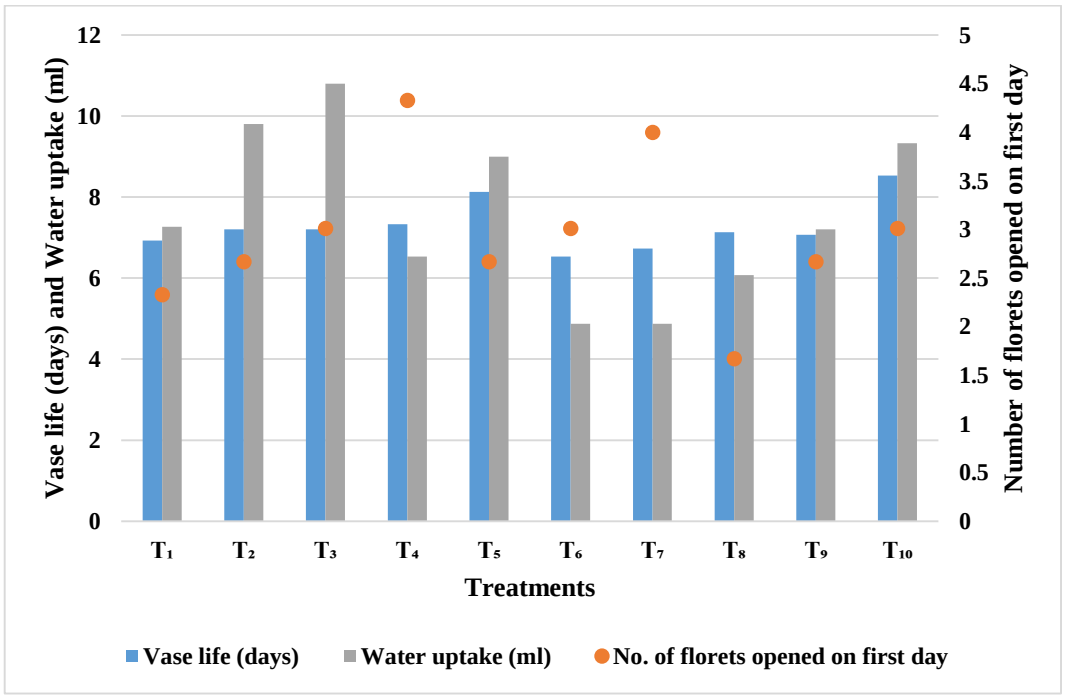


Fig 7. Effect of different varieties of tuberose on vase characters

Number of florets opened at a time increases the attractiveness of cut spike in vase. The variation in number of florets opened at first day was noticed by Singh *et al.* (2017).

Table 13 represents the ranking of different characters on treatments based on the results obtained. Parameters like length of spike, number of florets per spike, diameter of floret, rachis length, fresh weight of spike, vase life *etc.* are considered while selecting a flower for cut flower purpose. From the table it is understood that Arka Suvasini found to be superior for these parameters, hence this variety may be used for commercial cultivation of cut flowers. Similar findings were reported by Mahawer *et al*. 2013. In general single type varieties having longest floret, maximum girth, maximum loose flower yield per unit area, good aroma *etc.* are used for loose flower purpose. Present study shows that Arka Prajwal possess maximum rank for these parameters, hence this can be used for loose flower production in northern region of Kerala. Arka Sugandhi recorded maximum concrete recovery hence this variety can be recommended for oil extraction purpose.

Table 13. Ranking of different characters on varieties of tuberose

Treatments (Varieties)	Characters										
	Plant height (cm)	**No.of leaves per hill**	**No.of tillers per hill**	**Days to spike emergence (Min)**	**Days to 50% flowering (Min)**	**Days to first floret opening (Min)**	**Days to complete opening of spikes (Min)**	**Length of spikes (cm)**	**Girth of peduncle (cm)**	**Length of rachis (cm)**	**Longevity of spikes (days)**
Arka Vaibhav		✓	✓								
Arka Prajwal					✓		✓	✓	✓		
Arka Niranthara							✓				
Arka Shringar				✓		✓	✓				
Arka Suvasini	✓							✓		✓	✓
Arka Sugandhi											
Bidhan Ujwal					✓	✓	✓				
Phule Rajani											
Culcutta Single							✓				
Culcutta Double											

Table 13 continued...

Treatments (Varieties)	Characters										
	Number of florets per spike	**Length of floret (cm)**	**Diameter of floret (cm)**	**Weight of 100 florets (g)**	**Loose flower yield (g)**	**Loose flower yield per unit area (gm^{-2})**	**Concrete recovery (%)**	**Fresh weight of spikes (g)**	**Vase life**	**Number of florets opened at a time**	**Water uptake (ml)**
Arka Vaibhav	✓										
Arka Prajwal		✓	✓		✓	✓					
Arka Niranthara		✓									✓
Arka Shringar										✓	
Arka Suvasini	✓		✓	✓	✓	✓		✓	✓		
Arka Sugandhi							✓				
Bidhan Ujwal											
Phule Rajani											
Culcutta Single		✓									
Culcutta Double									✓		

Summary

6. SUMMARY

Among the wide varieties of commercially cultivated flowers in India tuberose (*Polianthes tuberosa* L.) occupies an important position due to its popularity as cut flower as well as loose flower. The flowers of tuberose are source of essential oil also, which is considered as one of the most valuable perfumery material in the world because of its beautiful fragrance. Warm humid tropical conditions makes it is suitable for the successful production under Kerala. The performance of varieties of any crop differs from one region to another region *i.e*. the variety perform well in one region may not perform well in other region. Therefore, selection of suitable and high yielding genotype is an important criteria for successful production of any crop.

The present study entitled "Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality" was carried out at the Department of Floriculture and Landscaping, College of Agriculture, Padannakkad and RARS, Pilicode during the year 2019 and 2020. The experiment was laid out in Randomized block design with ten treatments consisting of single, semi double and double petalled cultivars of tuberose collected from Department of Floriculture and Landscaping, Indian Institute of Horticultural Research, Banglore and Bidhan Chandra Krishi Viswavidyalaya, Mohanpur. Altogether there were three replications having forty plants per each replication. The varieties were screened for vegetative, floral, quality and post- harvest parameters and the observations were taken from five randomly selected and tagged plants per replication. The mean value of the data recorded was taken to represent a particular variety with respect to a character. The observation recorded on various biometric parameters during the plant growth period was subjected to statistical analysis.

The salient findings of the current study is summarized below:

The study clearly indicated that genotypic differences among varieties and variation in environmental factors significantly influence vegetative and floral characters of tuberose. The maximum plant height was observed in variety Culcutta Double (70.60 cm) at 3 months after planting. Whereas plant height recorded was maximum in variety Arka Suvasini at 6^{th} and 9^{th} months after planting (*i.e.,* 79.87 and 54.27 cm respectively). Based on the pooled mean data for 9 months, maximum plant

height was observed in variety Arka Suvasini (66.56 cm) while on contrast minimum plant height in Arka Sugandhi (38.09 cm).

Variety Arka Vaibhav recorded maximum number of leaves per hill at 3rd and 6th months after planting (90.21 and 129.00 respectively). At 9 months after planting maximum number of leaves was observed in Culcutta Single (68.32). On pooling the data for 9 months maximum number of leaves was obtained in Arka Vaibhav. Whereas minimum number of leaves was observed in Arka Prajwal for entire period (25.17, 37.60 and 32.47 for 3rd, 6th and 9th months after planting, respectively).

Maximum number of tillers per hill was recorded by variety Arka Vaibhav (4.39), Arka Suvasini (4.93), Bidan Ujwal (5.00) at 3, 6 and 9MAP respectively. The pooled mean showed that maximum number of tillers per hill was obtained in variety Arka Vaibhav (3.71) whereas minimum in Culcutta double (2.28).

The significant difference in days to spike emergence and days to first floret opening is primarily due to the genetic inheritance and difference in the environmental condition. Early spike emergence were found in variety Arka Shringar (63.25 days) whereas maximum days taken to spike emergence and days to first floret opening were found in variety Culcutta Double (88.88 and 24.87 respectively). Variety Bidhan Ujwal took minimum days to first floret opening (11.73).

Significant difference for floral parameters was recorded amongst the cultivars under study. It might be due to difference in genetic makeup and variation in prevailing environmental condition. Minimum number of days to 50 per cent flowering (108.38), longest spike (111.80 cm) and maximum diameter of peduncle (3.05 cm) was recorded in variety Arka Prajwal. Whereas variety Arka Suvasini recorded maximum value for rachis length (47.60 cm), longevity of spike (13.60 days), days to complete opening of spikes (26.15), diameter of floret (3.53 cm), weight of 100 florets (235.43 g), loose flower yield (131.31 g) and fresh weight of spike (133.52 g). Variety Arka Vaibhav recorded maximum number of florets per spike (63.00). Longest floret was observed in variety Culcutta Single (7.03 cm). Variety Culcutta Double was found to be superior among other varieties in terms of vase life (8.53 days) of spike.

Pinkish green colouration on bud is observed for most of the varieties under study. For all the varieties flower colour was white. Variation in pigmentation of peduncle were noticed for some varieties. This might be due to different genetic makeup and colouring pigment present in the different cultivars.

Concrete recovery found maximum in single petalled cultivars than semi double and double type cultivars. Stage of harvest, growing environmental condition, season and method of extraction have significant influence on the recovery of concrete. In the present study concrete recovery ranges from 0.012 to 0.117 %. Maximum concrete content was obtained from the variety Arka Sugandhi (0.117 %) followed by Culcutta Single (0.079 %). Minimum concrete content was recorded by variety Arka Vaibhav (0.012 %).

From the results of investigation it can be concluded that growth, yield and quality of tuberose is significantly influenced by various factors like genotype, season, prevailing environmental condition etc. Among these factors, genetic makeup themselves contribute much to their performance. Out of the ten genotypes of tuberose (*Polianthes tuberosa* L.) comprising single, semi- double and double petalled cultivars, the variety Arka Prajwal, Arka Shringar, and Culcutta Single among single petalled type, Arka Vaibhav the only semi petalled type and variety Arka Suvasini and Culcutta Double among double petalled type were found to be superior in terms of growth and yield of flower under northern Kerala condition. These varieties can be used for the large scale commercial production in northern parts of Kerala. Moreover, with respect to concrete production the single petalled variety Arka Sugandhi were found to be more suitable.

Future line of works

1. Standardization of crop specific greenhouse cultivation practices
2. Evolving new high yielding varieties specially for protected cultivation
3. Further research is required for the development of coloured tuberose cultivars

References

REFERENCES

Abbasi, A., and Asil, M. H. 2011. Study on prolonging the vase life of tuberose cut flowers (*Polianthes tuberosa* L.). *South. West. J. Hortic.* 2(2): 157-165.

Adil, M., Ahmad, W., Ahmad, K. S., Shafi, J., Shehzad, M. A., Sarwar, M. A., Salman, M., Ghani, M. I., and Iqabal, M. 2013. Effect of different planting dates on growth and development of *Gladiolus grandiflorus* under ecological conditions of Faisalabad, Pakistan. *Universal J. Agri. Res*. 1(3): 110-117.

Afifipour, Z., and Khosh-Khui, M. 2015. Efficacy of spraying a mixture of amino acids on the physiological and morphological characteristics of tuberose (*Polianthes tuberosa* L.). *Int. J. Hortic. Sci. Tech.* 2(2): 199-204.

Ahmadiana, M., Ahmadia, N., Babaeia, A., Naghavib, M. R and Ayyaria, M. 2018. Comparison of volatile compounds at various developmental stages of tuberose (*Polianthes tuberosa* L. *cv*. Mahallati) flower with different extraction methods. *J. Essent. Oil. Res.* 30(3): 197-206.

AICRP (Floriculture) [All India Coordinated Research Project on Floriculture]. 2016. *Annual Report 2015-2016*, Indian Council of Agricultural Research- Directorate of Floricultural Research, Pune, Maharashtra, 561p.

Andrew, L., Rokolhu, K., Angngoi, B.Y., and Lokam, B. 2017. Evaluation of tuberose (*Polianthes tuberosa* L.) cultivars under the foothill conditions of Nagaland. *J. Ornam. Hortic.* 20(1&2): 69-74.

Angmo, T. 2017. Evaluation of tuberose (*Polianthes tuberosa* L.) cultivars under mid hill conditions of Himachal Pradesh. M. Sc. Thesis, Dr.Yashwant Singh Parmar University of Horticulture and Forestry. Solan. HP. 135p.

Anjum, M. A., Naveed, F., Shakeel, F., and Amin, S. 2001. Effect of some chemicals on keeping quality and vase- life of tuberose (*Polianthes tuberosa* L.) cut flowers. *J. Res. Sci.* 12(1): 1-7.

Bankar, G.J., and Mukhopadhyay, A. 1980. Varietal trial on tuberose (*Polianthes tuberosa* L.).*S. Indian Hortic.* 28(4): 150-151.

Bhattacharjee, S. K. and De, L. C. 2003. Advanced Commercial Floriculture. Aavishkar Publishers, Rajsthan. Pp.180-190.

Bichoo, G. A., Jhon, A. Q and Wani, S. A. 2002. Genetic variability in some quantitative characters of gladiolus. *J. Ornam. Hortic*. 5 (1): 22-24.

Bindiya, C., Naik, B., Kamble, S., Tirakannanavar, S and Parit, S. 2018. Evaluation of different genotypes of tuberose (*Polianthes tuberosa* L.) for growth, flowering and yield characters. *Int. J. Curr. Microbiol. App. Sci.* 7(7):4135-4141.

Biswas, B., Kumar, N. P. and Bhattacharjee, S. K. 2002. *Tuberose*. Tech. Bulletin, All India Coordinated Research Project on Floriculture, New Delhi, pp.1-25.

Black, C. A., Evans, D. D., Ensminger, L. E., White, J. L., and Clark, F. E. 1965. *Methods of soil analysis. Am. Soc. Agron*. Madison, USA, 156p.

Chaturvedi, A.,Mishra, T. S.,Kumar, N., and Singh, S. S. 2014.Screening of different cultivars of tuberose (*Polianthes tuberosa* L.) under agro climatic conditions of Allahabad. *J. Progressive hortic.* 46 (1): 146-148.

Chaudhari, V and Kumar, M. 2017. Effect of harvesting time of flowers on concrete and absolute recovery in tuberose (*Polianthes tuberosa* L.): A comparative study of single and double petalled cultivars. *Int. J. Chem. Stud.* 5(4): 1416-1420.

Dahal, S., Mishra, K., Pun, U. K., Dhakal, D. D and Sharma, M. 2004. Evaluation of split doses of nitrogen at different growth stages of Tuberose (*Polianthes tuberosa* L.) for improving flowering and vase-life. *Nepal J. Sci. Tech.* 15(1): 23-30.

Dimri, S. 2017.Screening of suitable germplasm of tuberose (*Polianthes tuberosa* L.) for mid hill conditions of Garwal Himalayas. Msc thesis. VCSG Uttarakhand University of Horticulture and Foresty. Uttarakhand. 80p.

Emmel, R. H., Solera, J. J., and Stux, R. L. 1977. *Atomic absorption methods manual*. Instrumentation Laboratory Inc., Wilmington, pp. 67-190.

Farina, E. and Paterniani, T. 1986. The cultural programming of tuberose for cut flowers. Results of two year trials in the region of western Liguria. Annali- dell Sperimentale-perla Floricoltura, 17 (1): 49-63.

Gandhi, P. D. 2017. Evaluation of tuberose (*Polianthes tuberosa* L.) for quality, yield and tolerance/resistance to root knot nematode (*Meloidogyne incognita*.) M. Sc. (Ag) thesis, Dr. Y.S.R. Horticultural University, West Godavari, Andhra Pradesh. 156p.

Gawande, M.B., Ganjure, S. L., Patil, D. A., Budhvat, K. P., Kedar, D. P., and Golliwar, V. J. 2017. Field performance of tuberose varieties for growth, flowering and yield parameters under Nagpur (Maharashtra) conditions. *Trends in Biosci.* 10(4): 1198-1200.

Gogoi, K., and Talukdar, M. C. 2019. Assessment of variation in concrete recovery and chemical constituents among the tuberose cultivars in Assam Condition. *Int. J. Curr. Microbiol. App. Sci.* 8(2): 1661-1667.

Gudi, G. 2006. Evaluation of tuberose (*Polianthes tuberosa* L.) varieties for growth, flower and concrete yield. M.Sc. Thesis, UAS, Dharwad. 180p.

Gupta, J., and Dubey, R. K. 2018. Factors affecting post-harvest life of flower crops. *Int. J. Curr. Microbiol. App. Sci.* 7(1): 548-557.

Hemanta, L., Srivastava, R., and Devi, M. P. 2017. Studies on floral biology of tuberose (*Polianthes tuberosa* L.) under Tarai regions of Uttarakhand. *J. Crop. Weed.* 13(2): 106-111.

Huanga, K., Miyajimaa, I., Okuboa, H., Shenb, T. and Huangb, T. 2001. Flower colours and pigments in hybrid tuberose (*Polianthes tuberosa* L.). *Sci. Hortic.* 88:235-241.

Hutchinson, M. A., Chebet, K. and Emongor, V. E. 2003. Effect of accel, sucrose and silver thiosulphate on the water relation and post-harvest physiology of cut tuberose flower. *African. Crop. Sci. J.* 11(4): 279-287.

Ichimura, K., Kishimoto, M., Norishikori, R., Kawabata, Y. and Yamada, K. 2005. Soluble carbohydrates and variation in vase life of cut rose cultivars 'Delilah' and 'Sonia'. *J. Hortic. Sci. Biotechnol.* 80: 280- 286.

Irulappan, I., Doraipandian, A., and Muthuswamy, S. 1980. Varietal evaluation in tuberose (*Polianthes tuberosa* Linn.). *National seminar on production technology for commercial flower crops*. Coimbatore, India. Tamil Nadu Agricultural University. pp 67-70.

Jackson, M. L. 1958. Soil chemical analysis. In Cliffs, E. N. J. (Ed.). Soil Science University of Wisconsin, USA, Madison, pp. 89-102.

Jackson, M. L. 1958. Soil chemical analysis. In Cliffs, E. N. J. (Ed.). Soil Science University of Wisconsin, USA, Madison, pp. 89-102.

KAU (Kerala Agricultural University). 2016. *Package of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 392p.

Kim, Y. A., Choi, S. R., Kweon, O. K., Joung H. Y., Shin, H. K. and Jong, S. L. 2004. Characteristic and vase life in 36 cultivar of cut gerbera flowers. *Korean J. Hortic. Sci. Tech*. 22(2): 228-235.

Kothari, S. K. and Singh, U. B. 1995. The effect of row spacing and nitrogen fertilization on scotch spearmint (*Menthagracilis* Sole). *J. Essent. Oil Res.* 7:287-297.

Krishnamoorthy, V. 2014. Assessment of tuberose (*Polianthes tuberosa* L.) varieties for growth and yield characters. *Asian. J. Hortic.* 9(2): 515-517.

Kumar R, Sharma S, Sood S, Agnihotri VK, and Singh B. 2013. Effect of diurnal variability and storage conditions on essential oil content and quality of damask rose (*Rosa damascena* Mill.) flowers in north western Himalayas. *Sci. Hort*. 154:102-108.

Kumar, B. S., Kameswari, P. L., Pratap, M., and Venkateswarrao, P. 2016. Vase life of tinted spikes of tuberose cultivar Suvasini. *J. Environ. Ecol.* 34(3): 1155-1161.

Kumar, M., Kumar, M., Kumar, V., Singh, J. B and Prakesh, S. 2007. Evaluation of gladiolus cultivars under Western Uttar Pradesh condition. *Prog. Res*. 2(1/2):79-81.

Kumar, S., Kumar, H., Sankar, V. M., and Kumar, A. 2018. Studies on vase life of different cultivars of tuberose (*Polianthes tuberosa* Linn). *Int. J. Chem. Stud.* 6(5): 2015-2019.

Lalthawmliana, A., Keditsu, R., Buchem, Y. A., and Bagang, L. 2017. Evaluation of tuberose (*Polianthes tuberosa* L.) cultivars under the foothill conditions of Nagaland. *J. ornam. Hortic*. 20 (1&2): 69-74.

Madhumathi, C., Bhargav, V., Reddy, S. D., Sreedhar, D., and Lakshmi, N. T. 2018. Evaluation of tuberose genotypes for vegetative, flowering and yield traits. *Int. J. Chem. Stud.* 6(6): 88-90.

Mahawer, L. N., Bairwa, H. L., and Shukla, A. K. 2013. Field performance of tuberose cultivars for growth, floral and economic characters under sub-humid southern plains and Aravalli hills of Rajasthan. *Indian J. Hortic.* 70(3): 411-416.

Mahoviya, R. 2003. Studies on performance of different tuberose (*Polianthes tuberosa* Linn) cultivars and their vase life. M. Sc. Thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur, Madhya Pradesh, 107p.

Mane, P. K., Bankar, G. J and Makne, S. S. 2006. Effect of spacing, bulb size and depth of planting on growth and bulb production in tuberose (*Polianthes tuberosa* L.) *Cv*. Single. *I. J. Agri. Res.* 40(1): 64-67.

Martolia, K. and Srivastava, R. 2012. Evaluation of different tuberose (*Polianthes tuberosa*) varieties for flowering attributes, concrete and absolute content. *Indian J. Agric. Sci.* 82(2): 177-180.

Mei-hua, F., Jian-xin, W., Shil, S. H. I. G. and Fan, L. 2008. Salicylic Acid and 6-BA Effects in Shelf-life Improvement of *Gerbera jamesonii* Cut Flowers. Anhui Agricultural Science Bulletin.

Messar, Y. 2011. Studies on effect of mulches and micronutrient foliar sprays on growth and flowering in Gladioli. M. Sc. Thesis. Dr YSR Horticultural University, Hyderabad. 70p.

Mohan, J., Singh, K. P. and Singh M. 2003. Evaluation of tuberose (*Polianthes tuberosa*) cultivars for concrete recovery. In: Abstracts of National Symposium on Recent Advances in Indian Floriculture. Trissur, Kerala. 79p.

Mohan, J., Singh, K. P., Suneja, P., Kumar, A. and Singh, M. 2004. Estimation of concrete content in Double petalled cultivars in tuberose (*Polianthes tuberosa* Linn.). In: Abstracts of National Symposium on Recent Trends and Future Strategies in Ornamental Horticulture. Dharwad, Karnataka. 120p.

Mukharjee, A. K., Banerjee, B. N. and Bhattacharryya, K. 2003. Prospects of tuberose (*Polianthes tuberosa* L.) cultivation in West Bengal- a case study. *J. Inteacadamia.* 7(8): 328-333.

Murthy, N. and Srinivas, M., 1997. Genotypic performance and character association studies in tuberose (*Polianthes tuberosa* L.). *J. Ornam. Hortic*. 5(1-2): 31-34.

Nagaraju, V. and Parthasarathy, V. A. 2001. Evaluation of gladiolus germplasm at midhills of Meghalaya. *Indian J. Hortic*. 58(3):269-275.

Naidu, S. N and Reid, M. S. 1989. Post- harvest handling of tuberose (*Polianthes tuberosa* L.). *ActaHortic.* 261(1): 41.

Nair, S. A., Shiva, K. N., and Singh, D. N. 2004. Effect of planting time on flowering of tuberose cv. Double in Andamans. *Indian. J. Hortic.* 61(4): 372-375.

Negi, R., Kumar, S.and Dhiman, S. R. 2014. Evaluation of Liliums (Lilium sp.) cultivars for low hills of Himachal Pradesh. *Int. J. Sci. Res. Tech.* 2(4): 8-10.

NHB [National Horticultural Board]. 2018. *Area and production of horticulture crops for 2017-18*[on line]. Available: http://nhb.gov.in/statistics/State_Level/2017-18-(Final).pdf [14 June 2019].

NHB [National Horticultural Board]. 2019. Indian Horticulture Database- 2015-16. National Horticultural Board, Gurgaon, 286p.

Pal, A. K., and Mitra, M. 2012. Performance of tuberose (*Polianthes tuberosa* L.) varieties in the plains of West Bengal. *J. Syst. Biotechnol. Bioprospecting*. 862 - 863.

Panse, V .G. and Sukhatme, P. V. 1985. Statistical methods for agricultural Research. ICAR, New Delhi, 8: 308-318.

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

Patil, V. S., Munikrishnappa, P. M. and Shantappa, T. 2009. Performance of growth and yield of different genotypes of tuberose under transitional tract of north Karnataka. *J. Ecobiology*. 24(4): 327-333.

Perk, D. S., Singarwad, P. S., Tawale, J. B. and Maske, V. S. 2009. Consumer preference for flower in general and specific purpose. *Asian J. Hortic.* 4(2): 338-339.

Poursafarali, E., Hashemabadi, D. and Kaviani, B. 2011. Effect of different cultivation beds on the vegetative growth of *Polianthes tuberosa* L. *African. J. Agri. Res.* 6(19): 4451-4454.

Prakash, S., Arya, J. K., Singh, R. K., and Singh, K. P. 2015.Varietal performance of tuberose in Muzaffarnagar under western plain zone condition. *Asian J. Hortic.* 10(1): 149-152.

Prapassorn, R., Uraiwan, D., Udomlak, S., Srunya, V., Vichai, H., Potechaman, P. and Putthita, P. 2009. Extraction methods for tuberose oil and their chemical components. *Kasetsart J. (Nat. Sci.)*. 43: 204 – 211.

Prashanta, M., Parul, P. and Rana, D. K. 2016. Evaluation of tuberose genotypes for vegetative, floral and bulb yielding attributes under the valley conditions of Garhwali Himalayas. *Int. J. Agric. Sci.* 8(62): 3522-3524.

Pratt, P. F. 1965. Potassium in methods of soil analysis. (2nd Ed.). American Society of Agronomy, Madison, USA, pp. 1019-1021.

Radhakrishan, K. N., Srinivas, M. and Janakiram, T. 2003. Performance of new promising genotypes of tuberose. In: National Symposium on recent advances in Indian Floriculture, KAU, Kerala, Nov. 12-14. 86 p.

Raktaworn, P., Dilokkunanant, U., Sukkatta, U., Vajrodaya, S., Haruethaitanasan, V., Pitpiangchan, P., and Punjee, P. 2009. Extraction methods for tuberose oil and their chemical components. *Kasetsart J. (Nat. Sci.)* 43: 204 – 211.

Ram M, and Kumar S. 1999.Optimization of interplant space and harvesting time for high essential oil yield in different varieties of mint *Menthaarvensis*. *J. Med. Aromat. Plant Sci.* 21:38-45.

Ramachandrudu, K. and Thangam, M. 2009. Performance of tuberose (*Polianthes tuberosa* L.) cultivars in Goa. *J. Hortic. Sci.* 4 (1): 76-77.

Ranchana, P., Kannan, M., and Jawaharlal, M. 2013. The Assessment of Genetic Parameters: Yield, Quality Traits and Performance of Single Genotypes, of Tuberose. *Adv. Crop. Sci. Tech.* 1(3): 1-4.

Ranchana, P., Kannan, M., and Jawaharlal, M. 2015. Chemical composition of concrete content of tuberose (*Polianthes tuberosa* L.) growing in Tamil Nadu. *Progressive hortic.* 47(2): 267-270.

Ranchana, P., Kannan, M., and Jawaharlal, M. 2017. The assessment of genetic parameters: yield, quality traits and performance of single genotypes, of tuberose (*Polianthes tuberosa* L.).*Adv. Crop Sci. Tech.* 1(3): 1-4.

Rao, K. D., and Sushma, K. 2015. Evaluation of certain tuberose (*Polianthes tuberose* L.) double genotypes for assessing the yield and quality traits under agro climatic conditions of Telangana. *J. Res.* 43 (1/2): 51-56. ref.4.

Ray, H., Majumdar, S., Biswas, S. P., Das, A., Ghosh, T. K. and Ghosh, A. 2014. Characterization of the volatile aroma compounds from the concrete and Jasmine flowers grown in India. Chemical engineering transactions. VOL. 40.

Sadhu, M. K. and Bose, T. K. 1973. Tuberose for most artistic garland. *Indian J. Hortic.* 18 (3): 17-20.

Saeed, T., Hassam, I., Abbasi, N. A. and Jilani, G. 2014. Effect of gibberlic acid on vase life and oxidative activities in senescing cut gladiolus flowers. *Plant Growth Regul*. 72: 89-95.

Sankar, M. 2008. Response of tuberose (*Polianthes tuberosa* L.) to organic manure and growth promoting microorganisms. PhD thesis. Kerala agricultural university. 160p.

Sateesha, G. R., Kumar, A., and Biradar, M. S. 2011. Performance of different tuberose (*Polianthes tuberosa* L.) varieties under field conditions. *J. Plant. Arch.* 11(1): 359-360.

Sharga, A. N. and Motial, V. S. 1983. Studies on the effects of foliar nutrition on essential oil content of tuberose (*Polianthes tuberosa* L.). *Indian. J. Hortic.* 40 (3/4): 260-265.

Sharma, M. L., Singh, G. P., Chandra, V. and Singh, A. 1977. Optimum conditions for harvesting of tuberose flowers for the production of concrete. *Indian Perfumer*. 21 (1): 41-43.

Shiramagond, M. S. 1997. Evaluation of varieties in gladiolus under Ghataprabha Command Area. M. Sc. (Agri.) Thesis. University of Agricultural Science. Dharwad. 180p.

Shivalingappa, J., Khan, M. M., Farooqi, M. V., Sreeramu, B. S. and Srinivasappa, K. N. 2001. Influence of various biofertilizers growth, flower and concrete content in tuberose. *Indian Perfumer,* 45 (3): 179-183.

Simmy, A. M. 2004. Enhancement of spike qualities of gladiolus. M. Sc. Thesis. Kerala agricultural university. Trissur. 224p.

Sims, J. R. and Johnson, G. V. 1991. Micronutrient soil tests. In: Mortvedt, J. J. (Ed.), *Micronutrients in Agriculture* (2nd Ed.). Soil Science Society of America, Madison, USA, pp. 427-476.

Singh, A. K and Dhako, J. 2017. Evaluation of performance and superiority of tuberose (*Polianthes tuberosa* L.) cultivars for growth and flowering under north Indian plain. ***J.*** *Environ. Ecol*.35(1): 341-345.

Singh, A., Singh, A. K., Sisodia, A., Padhi, M., and Pal, A. K. 2018. Evaluation of tuberose cultivars for postharvest characters. *J. Pharmacog. Phytochem*. 7(4): 1310-1312.

Singh, A., Singh, A. K., Sisodia, A., Padhi, M., and Pal, A. K. 2018. Performance of tuberose varieties for flowering and flower yield parameters under Indo-gangetic plains of eastern Uttar Pradesh, India. *Int. J. Curr. Microbiol. App. Sci*. 7(8): 1129-1133.

Singh, K. P. 2004. Performance of single petalled tuberose cultivars under Delhi conditions. National Symposium on Recent Trends and Future strategies in Ornamental Horticulture, New Series, Dharwad, pp. 18.

Singh, K. P. and Singh, M. C., 2013, Evaluation of double petalled cultivars of tuberose (*Polianthes tuberosa* L.) under Delhi condition. *Asian J. Hortic*. 8 (2): 512-514.

Singh, K. P., Suneja, P., Mohan, J., and Singh, M. C. 2009. Gas chromatographic evaluation of floral extract of two single and double type cultivars of tuberose (*Polianthes tuberosa* Linn.). *J. Progressive Hortic.* 41(2):

Singh, Kushal, Kumar, Gunjeet, Saha, T. N. and Kumar, Ramesh. 2013. Post-harvest technology of cut flowers. Venus Printers and Publishers, New Delhi. 26-28pp.

Srinivas, M., Murthy, N. and Chandravadana, M. V. 1996. Genotypic and seasonal variation for concrete content in tuberose (*Polianthes tuberosa* L.). *J. Essent. Oil. Res.* 8(5):541-542.

Srinivas, M., Murthy, N., and Chandravadana, M. V. 2011. Geotypic and seasonal variation in concrete content of tuberose (*Polianthes tuberosa* L.). *J. Essential. Oil. Res.* 8(5): 541-542.

Srivastava, H. C. and Shridhar, C. J. 2002. Tuberose (*Polianthes tuberosa* L.) hybrid for high concrete yield and coloured floral buds. *Plant Archives*. 2 (2): 333-335.

Subbiah, B. V. and Asija, G. L. A. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci*. 32: 325-327.

Susila, T. 2013. Performance of tuberose cultivars under north coastal Andra Pradesh. *Indian J*. 33(2): 161-162.

Valid, N., Chaudhary, S. V. S., Sharma, B. P., Gupta, Y. C and Chauhan, G. 2019. Effect of planting dates and mulching on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Sikkim Selection. *Int. J. Curr. Microbiol. App. Sci*. 8(5): 199-206.

Varu, D. K., and Barad, A. V. 2010. Effect of stem length and stage of harvest on vase-life of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. *J. Hort. Sci.* 5(1): 42-47.

Vijayalaxmi M., Rao M. A., Padmavatamma A. S., and Shanker, S. A. (2010) Evaluation and variability studies in tuberose (*Polianthes tuberosa* L.) single cultivars. *J. Ornam. Hortic*. 13: 251- 256.

Walkley, A. J. and Black, I. A. 1934. Estimation of soil organic carbon by chromic acid and titration method. *Soil Sci.* 31: 21-38.

VARIETAL EVALUATION OF TUBEROSE (*Polianthes tuberosa* L.) FOR GROWTH, YIELD AND QUALITY

By

HASNA P M

(2018-12-035)

Abstract of the Thesis

submitted in partial fulfilment of the requirement

for the degree of

MASTER OF SCIENCE IN HORTICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF FLORICULTURE AND LANDSCAPING

COLLEGE OF AGRICULTURE

PADANNAKKAD, KASARAGOD- 671314

ABSTRACT

Tuberose (*Polianthes tuberosa* L. Family: Amaryllidaceae) is one of the most popular tropical ornamental bulbous flowering plant grown on a commercial scale throughout different states of India. They are much adored by the aesthetic world for their colour, elegance and fragrance. As the commercial cultivation of tuberose is gaining importance, introduction and identification of high yielding varieties is necessary. The quality and production of any crop or variety largely influenced by its genetic makeup and climatic condition under which they are grown. Therefore, in order to select suitable and high yielding cultivar for a particular region it is very much necessary to collect and evaluate all the available genotypes.

The study entitled "Varietal evaluation of tuberose (*Polianthes tuberosa* L.) for growth, yield and quality" was carried out at the Department of Floriculture and Landscaping, College of Agriculture, Padannakkad, Kasaragod and RARS Pilicode during 2019-2020. The experiment was laid out in Randomized block design with ten treatments and three replications. The varieties were screened for vegetative, floral, quality and post- harvest parameters.

The study clearly indicated that genotypic differences among varieties and variation in environmental factors significantly influence vegetative and floral characters of tuberose. Minimum number of days to 50 % flowering (108.38 days), longest spike (111.80 cm) and maximum diameter of peduncle (3.05 cm) was recorded in variety Arka Prajwal. Variety Arka Suvasini recorded maximum value for rachis length (47.60 cm), longevity of spike (13.60 days), days to complete opening of spikes (26.15 days), diameter of floret (3.53 cm), weight of 100 florets (235.43 g), loose flower yield (131.31 g) and fresh weight of spike (133.52 g). Variety Arka Vaibhav recorded maximum number of florets per spike (63.00). Longest floret was observed in variety Culcutta Single (7.03 cm). Variety Culcutta Double found to be superior in terms of vase life (8.53 days) of spike.

Concrete recovery found maximum in single petalled cultivars than semi double and double type cultivars. Stage of harvest, growing environmental condition, season and method of extraction have significant influence on the recovery of concrete. In the

present study concrete recovery ranges from 0.012 to 0.117 % and maximum concrete obtained for the variety Arka Sugandhi.

Out of the ten genotypes of tuberose (*Polianthes tuberosa* L.) comprising single, semi- double and double petalled cultivars, the variety Arka Prajwal, Arka Shringar, Arka Sugandhi and Culcutta Single among single petalled type, Arka Vaibhav the only semi petalled type and variety Arka Suvasini and Culcutta Double among double petalled type were found to be superior in terms of growth, yield and quality of flower under northern Kerala condition. Among these Arka Prajwal can be recommended for loose flower production, Arka Suvasini for cut flower production and Arka Sugandhi for oil extraction purpose.

സംക്ഷിപ്തം

ഇന്ത്യയിലെ പുഷ്പവിപണിയിൽ വളരെയധികം പ്രാധാന്യം അർഹിക്കുന്ന ഒരു പുഷ്പമാണ് ട്യൂബറോസ്. വാണിജ്യാടിസ്ഥാനത്തിലുള്ള കൃഷിക്കു പ്രാധാന്യമേറിയതോടെ ഉത്പാദനക്ഷമതയേറിയ ഇനങ്ങൾ കർഷകർക്കിടയിലേക്ക് കൊണ്ടുവരേണ്ടിയിരിക്കുന്നു. വളർച്ചയിലും ഉത്പാദനത്തിലും ഗുണമേന്മയിലും വടക്കൻ കേരളത്തിന് അനുയോജ്യമായ ട്യൂബറോസ് ഇനത്തെ കണ്ടെത്തുന്നതിനായി 2019 - 2020 കാലയളവിൽ കാർഷിക കോളേജ് പടന്നക്കാട്, ആർ. എ. ആർ. എസ്. പിലിക്കോട് എന്നിവിടങ്ങളിലായി ഒരു പരീക്ഷണം നടത്തുകയുണ്ടായി. ഇതിനായി പത്തു ട്യൂബറോസ് ഇനങ്ങൾ ശേഖരിക്കുകയും അവയുടെ വിവിധ സവിശേഷതകൾ വിലയിരുത്തുകയും ചെയ്തു.

അർക്ക പ്രജ്വൽ ,അർക്ക ശ്രിങ്കാർ ,അർക്ക സുഗന്ധി , അർക്ക സുവാസിനി , അർക്ക വൈഭവ് , കൽക്കട്ട സിംഗിൾ , കൽക്കട്ട ഡബിൾ എന്നീ ഇനങ്ങൾ വടക്കൻ കേരളത്തിൽ വാണിജ്യാടിസ്ഥാനത്തിൽ കൃഷി ചെയ്യുന്നതിന് അനുയോജ്യമാണെന്ന് കണ്ടെത്തി.

മേൽപറഞ്ഞ ഇനങ്ങളിൽ അർക്ക പ്രജ്വൽ ലൂസ് ഫ്ലവർ ഉത്പാദനത്തിനും അർക്ക സുവാസിനി കട് ഫ്ലവർ ഉത്പാദനത്തിനും അർക്ക സുഗന്ധി സുഗന്ധദ്രവ്യ വ്യവസായത്തിനും ശുപാർശ ചെയ്യാം.

Appendix

Appendix

Weather data during the crop period

Month	Temperature (°C)		Mean Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Max	Min	
June 2019	31.3	25.1	92	74	698.2
July 2019	29.3	24.0	94	81	1129.3
August 2019	28.7	23.9	95	83	1061.6
September 2019	29.5	24.0	93	78	510.1
October 2019	29.7	23.8	92	78	487.2
November 2019	31.5	23.5	91	68	93.6
December 2019	31.6	22.8	92	62	91
January 2020	31.6	21.7	91	58	0
February 2020	32.0	22.4	91	58	45.8