# BREEDING BIOLOGY AND CROSS COMPATIBILITY OF CLOSE WILD RELATIVES OF BRINJAL
(*Solanum melongena* L.)

By
**NEERAJA PUTHIAMADOM**
**(2014-11-112)**

**THESIS**

**Submitted in partial fulfillment of the requirement for the degree of**

MASTER OF SCIENCE IN AGRICULTURE

*Faculty of Agriculture*
*Kerala Agricultural University*

**Department of Plant Breeding and Genetics**
**COLLEGE OF HORTICULTURE**
**VELLANIKKARA, THRISSUR - 680 656**
**KERALA, INDIA**
**2016**

## DECLARATION

I, hereby declare that the thesis entitled **"Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)"** is a bonafide record of research done by me during the course of study and the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other university or society.

Neeraja

**Neeraja Puthiamadom**
**(2014-11-112)**

Vellanikkara

Date: 20/03/17

Dr. K. T. Presanna Kumari

Professor and Head

Department of Plant Breeding and Genetics

College of Horticulture

Kerala Agricultural University, Vellanikkara

Date:
20-3-17

## CERTIFICATE

Certified that this thesis entitled **"Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)"** is a record of research work done independently by **Ms. Neeraja Puthiamadom (2014- 11- 112)** 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.

Presanna Kumari
20/3/17

Place: Vellanikkara

Dr. K. T. Presanna Kumari

Chairperson

Advisory Committee

## CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Neeraja Puthiamadom (2014-11-112)** a candidate for the degree of Master of Science in Agriculture with major field in Plant Breeding and Genetics agree that this thesis entitled **"Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)"** may be submitted by **Ms. Neeraja Puthiamadom** in partial fulfillment of the requirement for the degree.

Presanna Kumari

**Dr. Presanna Kumari K. T**

Professor and Head

Department of Plant Breeding and Genetics

College of Horticulture, Vellanikkara

**(Chairperson)**

20/3/17

**Dr. Beena. S**

Professor

Department of Plant Pathology

College of Horticulture, Vellanikkara

**Dr. Latha. M**

Principal Scientist

NBPGR, RS

Vellanikkara

**Dr. Minimol J. S**

Assistant Professor, PBGN

Cocoa Research Centre, Vellanikkara

20/3/17

**EXTERNAL EXAMINER**

Dr. Sheela, M.N

Pr. Scientist & Head,

ICAR-CTCRI

TVM, Kerala.

***Acknowledgement***

*With great respect, I express my deep sense of gratitude and indebtedness to* ***Dr. K. T. Presanna Kumari,*** *Professor, Department of Plant Breeding and Genetics, Chairperson of my Advisory Committee, for the selection of topic and for the meaningful guidance. I remember with gratitude, the unfailing patience, kind consideration and support, motherly approach and timely help given by her at various stages of my work and strenuous efforts to critically scrutinize the manuscript which has helped a lot for the improvement and successful completion of the work.*

*With deep reverence, I express my whole hearted gratitude and never ending indebtedness to* ***Dr. Latha. M****, Principle Scientist, NBPGR, RS, Vellanikkara and member of my Advisory committee for her expert guidance, constant encouragement, care and support throughout the course of the study.*

*I am deeply obliged to* ***Dr. Minimol. J. S,*** *Assistant Professor, Cocoa Research Station, Vellanikkara, and member of my Advisory Committee, for her ever willing help, creative suggestions and constant encouragement throughout the period of work.*

*I express my heartfelt gratitude to* ***Dr. Beena S,*** *Professor, Department of Plant Pathology, College of Horticulture, Vellanikkara and member of my Advisory Committee for her unbounded support, valuable guidance and creative suggestions.*

*I would like to express my extreme indebtedness and deep obligation to* ***Dr. Dijee Batian,*** *Professor,* ***Dr. Jiji Joseph****, Professor,* ***Dr. Rose Mary Francis****, Professor, Department of Plant Breeding and Genetics, for their meticulous help, unwavering encouragement, affectionate advice and personal support.*

*I am thankful to* ***Dr. Biju S.*** *Professor, Department of Plant Breeding and Genetics, College of Horticulture, for his valuable support.*

*I am deeply obliged to* ***Dr. Indiradevi****, Professor, Department of Agricultural economics, for her unfailing motivation, care and personal support rendered throughout the period of the study.*

*I express my profound gratitude to* ***Dr. Ushakumari,*** *Professor, Department of Agricultural Entomology for her valuable guidance and suggestions during the course of the study. I am highly obliged to* ***Dr. Pradeep Kumar,*** *Associate Professor, Department of Olericulture, for his valuable suggestions.*

*I wish to express my profound gratitude to* ***Dr. S. Krishnan,*** *Professor, Department of Agricultural Statistics, for his valuable suggestions and guidance made in the study.*

*With deep reverence, I express my heartfelt thanks to* ***Dr. Santhosh Kumar A.V****, Associate Professor of College of Forestry, Thrissur, for his crucial support and the facilities provided for undertaking the laboratory studies and technical guidance. I also thank* ***Nishadh chettan,*** *Research Assistant, College of Forestry, Thrissur for helping me to carry out the laboratory studies.*

*With immense pleasure I express my gratitude to* ***Mrs. Joicy****, Scientific Assistant, COH, Vellanikkara for rendering necessary help whenever needed.*

*Words fail to express my heartfelt gratitude to* ***Dr. B. G. Prakash,*** *Professor and Head, Department of Plant Breeding and Genetics, College of Horticulture, Mysore for the personal support, constant encouragement and valuable guidance rendered by him throughout the past six years.*

*I express sincere thanks to my intimate friends* ***Reshma, Neenu, Vidya and Revathy*** *for their promt help, support, jovial companionship, care and encouragement throughout the PG programme. I express my deep sense of gratitude to my batch mates* ***Riya*** *and* ***Tintu*** *for the constant help, and strenuous efforts to give perfection to my manuscript. I heartfully thank my Seniors* ***Ajin bhaiyya*** *and* ***Asna chechi*** *for extending helping hands and giving splendid ideas*

*to improve my manuscript. With due gratitude I acknowledge the support and motivation given by my senior* ***Suma chechi.***

*I express deep sense of gratitude to my senior* ***Ashish chettan*** *for his support, help and constant encouragement throughout the entire PG programme. I express my deep sense of gratitude to my dearest friends* ***Aslam*** *and* ***Charan*** *for the love and care rendered throughout the six years of journey together. I sincerely thank my batchmates,* ***Sameer, Uma, Priyanka, Navya, Sandhya, Indra, Manjusree,*** *juniors,* ***Reshma, Sunil, Nikhil, Nagu, Veeresh and*** *Seniors* ***Manjunath, Jeevan, Vikram*** *and* ***Arun kumar*** *for all the help extended throughout the period of the Study. I am deeply thankful to all the people who contributed in various ways to my thesis. I am grateful to all my teachers and batchmates.*

*I take this opportunity to extend my gratitude to all the non-teaching staff members,* ***Mrs. Shymol, Mrs. Revathy, Mrs. Hitha, Mrs. Sanitha*** *and* ***Mrs. Smitha*** *of the Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara for the help offered at different stages of study.*

*I extend my thanks to the all the successive* ***Associate Deans*** *of the College of Horticulture, to* ***Smt. V. S. Swapna*** *and* ***Dr. A. T. Francis,*** *Librarians,* ***Mr. Aravind K. S.*** *of Students' Computer Club and to the staff in the Photostat Section of the College of Horticulture for rendering necessary help and support whenever needed..*

*I wish to acknowledge with gratitude the award by* ***Kerala Agricultural University*** *for the KAU Junior Fellowship offered during the tenure of the M.Sc.(Ag.) programme.*

*I am grateful to* ***Appu****, my dearest friend since childhood for the unfailing motivation, support and valuable criticisms for every endeavour I undertake.*

*I owe gratitude to my best friends since school,* ***Indu and Aarya*** *for the never ending love, constant motivation, encouragement and support in everything I do.*

*Words fail to express my gratitude to my* ***achan*** *for being my mentor, my teacher, my role model and unfailing inspiration and for also being a patient*

*listener even to the silly anxieties I express. I owe gratitude to my* ***amma*** *for her love, prayers and support extended throughout the thesis work. With immense love I express my gratitude to my* ***chechi*** *and family for the unfailing support, encouragement, valuable suggestions, fruitful criticism, everlasting love and care. I am deeply indebted to my brother* ***Manu*** *for the unfailing care, constant encouragement, personal sacrifices and all the efforts to make me feel comfortable. Without their support this endeavour would have remained incomplete.*

*I think no words can really express my indebtedness to* ***Lord Almighty.*** *I humbly bow my head before* ***Him.***

Neeraj

*NEERAJA PUTHIAMADOM*

# Dedication

*Dedicated to the endless love of my Achan*

## CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# LIST OF PLATES

# *INTRODUCTION*

# 1. INTRODUCTION

Brinjal, botanically known as *Solanum melongena* L. is an important vegetable crop of the tropics and subtropics. It is known by different names *viz.*, eggplant, aubergine (French word) in European countries, garden egg, guinea squash and melongena ( Sekara *et al.*, 2007).

de Condolle (1966) stated that *S. melongena* L. has been known to Indians since ancient times, and is regarded as a native of Asia. Now, it is grown in temperate, tropical and warmer temperate zones of the world. In India, brinjal is grown throughout the year in all parts of the country except in higher altitudes. It occupies an area of 711.3 thousand hectares which accounts for nearly 7.6 % of the total area under vegetables, with a productivity of 19.1 metric tons per hectare. India is the second largest producer of brinjal with a world production share of 26% [NHB database 2014].

The unripe fruits of brinjal are consumed as a cooked vegetable and the dried shoots contribute to fuel in rural areas. Brinjal contains water, proteins, carbohydrates and is low in fat and calories. It is a rich source of vitamins and minerals, total sugars, protein and other nutrients.

A wide range of fruit shapes are present in Brinjal. The shape varies from ovoid or oblong to long cylindrical. The fruit colour may be white, yellow, green or purple. The oblong shaped brinjal fruits are rich in total sugars whereas long fruited cultivars have higher content of phenols, glycoalkaloids and amide proteins (Bajaj *et al.*, 1979). Glycoalkaloid is a major constituent of Solanaceae family which contributes to the bitterness of fruits.

Brinjal is known to have medicinal properties and is a good remedy for diabetes and liver ailments (Shukhla and Naik, 1993). Even the skin of brinjal

contains fibre, potassium, magnesium and anti oxidants. Owing to all these facts, eggplant is one among the top ten preferred vegetables in the world.

Inspite of all these significances, majority of high yielding varieties of brinjal are susceptible to a wide range of pests and diseases, among which fruit and shoot borer (*Leucinodes arbonalis*) causes severe crop loss of about 38-55% (Tripathy *et al.*, 1966). Other pests of brinjal include epilachna beetle, mealy bug, aphids, tetranychid mite and leafhoppers. Among the diseases affecting brinjal, phomopsis blight, *Cercospora* leaf spot, damping off and bacterial wilt are severe. The pest and disease incidence is a limiting factor in accelerating the yield potential of brinjal.

Many wild allied species of brinjal (*S. melongena*) are good donor sources with respect to hardiness and resistance to pest and diseases. The important allied species of *S. melongena* are *S. incanum* L. (thorn apple), *S. viarum* Dunal (tropical soda apple), *S. indicum* Linn. (Indian night shade), *S. gilo* Raddi (scarlet egg plant), *S. macrocaron* L. (Gboma eggplant) *etc.* Hence, it is the need of the hour to transfer the desirable genes from the wild species to the cultivated ones. Many research works are going on for the development of transgenic brinjal types with resistance to biotic and abiotic stress. Though work on Bt brinjal was started in 2000, no GM crop has been released so far for cultivation in open condition. Adaptability of the GM crops among the people is also poor. Hence, the conventional techniques receive special attention in the development of resistant types. However, for distant or interspecific hybridization, the knowledge of the breeding behaviour of the different species as well as the crossability of the important species is essential. Besides these, the crossability and hybridization studies of *S. melongena* and the related species are in general inconclusive and often contradictory (Rao, 1979; Rai *et al.*, 2004). Keeping in view of the above facts, the present investigation entitled "Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)" was undertaken with the following objectives:

1. Elucidate the reproductive biology of the variants of the related wild species of brinjal.
2. Evaluate the cross compatibility of the wild species with brinjal.

# REVIEW OF LITERATURE

# 2. REVIEW OF LITERATURE

*Solanum melongena* L. belonging to the genus *Solanum* is an important solanaceous crop of the tropics and subtropics. The sanskrit name 'Amar kosh' which prevailed during 1106 AD, refers to brinjal and it provides a strong evidence for its cultivation in India since ages (Bhaduri, 1951). Chandra and Murthy (1968) provided the earliest record for existence of egg plant in India. Swarup (1995) reported that there was existence of brinjal in India since 3$^{rd}$ century BC. Atleast 33 sanskrit names are reported for eggplant in ancient Indian literature, the most commonly used ones being Varttaka, Bhantaki and Nattingan.

## 2.1. Origin and distribution

Scientists have varied opinions with regard to the origin of brinjal. According to Vavilov (1926), brinjal is believed to have originated in Indo-Burma region. However, Sampson (1936) was of the opinion that brinjal originated in African continent. But, there is no evidence for its origin in Africa, though there is spiny African brinjal .

There is also a concept that India is the centre of diversity of brinjal (Bhadhuri, 1951; Vavilov, 1951; Lester and Hasan, 1991). Later, Zeven and Zhukovsky (1975) stated that brinjal had its origin in India and was distributed to China by 5$^{th}$ century BC.

There are evidences to indicate that brinjal originated in Asia. Khan (1979) reviewed that southwest Asia including Arabia, Indoburma, China and Japan were the probable places of origin of brinjal by different authors.

According to Lester and Hasan (1991) eggplant is a native of India, and China is considered to be the centre of diversity.

Isshiki *et al.* (1994) based on isoenzyme and morphological variations noticed in the germplasm collection from India, arrived at the conclusion that Bangladesh is the centre of origin of brinjal.

Karihaloo and Gottlieb (1995) reported that several advanced cultivars and numerous land races of brinjal were cultivated in India for their young unripe fruits which were consumed in fresh, dried or pickled form.

According to Swarup (1995) India or Indochina could be recognized as the centres of diversity of eggplant. Lawande and Chavan (1998) stated that eggplant is a vegetable belonging to Solanaceae family, and had its origin in India and China regions.

Daunay *et al.* (2001) stated that the cultivation of brinjal gradually extended to the Mediterranean region during the Arab inquists in the $7^{th}$ century.

Chattopadhyay *et al.* (2009) reported that rich diversity of brinjal was observed in various parts of India like Eastern Ghats, north – eastern region, central and east India.

**2.2. Biodiversity and evolution**

The family Solanaceae comprises of 2300 species, out of which nearly half belongs to the genus *Solanum*. The genus *Solanum* has tremendous species diversity. Various scientists have traced the evolutionary relationship between brinjal and wild relatives over the years (Bitter, 1923).

Choudhary (1976) described 3 botanical varieties under the species *melongena*, *viz.*, *Solanum melongena* var *esculentum* (round or eggshaped fruits), *S. melongena* var *serpentinum* (long slender fruits) and *S. melongena* var *depressum* (dwarf brinjal).

Daunay *et al.* (1991) stated that within the eggplant complex, there is high level of morphological plasticity manifested at genera, species and cultivar levels.

Lester and Hasan (1991) adopted an informal taxonomic scheme for brinjal. They also mentioned about the taxonomic confusion between *S. melongena* and *S. incanum*.

Karihaloo and Gottlieb (1995) described a number of wild taxa that were present in India, and having close similarity to *S. melongena*. They proved high genetic identity among *S. melongena*, *S. incanum* and *S. insanum*, based on enzymatic electrophoretic studies.

Sakata and Lester (1997) stated that *S. incanum* and *S.macrocarpon* were closely related to *S. melongena*.

The use of molecular markers, assisted by morphological analysis could enable proper classification of eggplant accessions cultivated around the world. Other parameters like morphological features, crossability and fertility of $F_1$ were insufficient to attain proper classification (Daunay and Lester, 1998; Furini and Wunder, 2003).

Lester (1998) stated that *S. aethiopicum* and *S. macrocarpon* were domesticated in Africa from their wild relatives *S. anguivi* and *S. dasyphyllum* respectively.

Daunay *et al.* (2001a) reported that *S. melongena* would have been derieved from *S. incanum* and was domesticated in India and south east regions of China.

Daunay *et al.* (2001b) reported that cultivation of *S. aethiopicum* and *S. macrocarpon* was limited to Africa.

Doganlar *et al.* (2002) stated that genomics in genus *Solanum* is evolving at a moderate pace compared to other plant species.

Karihaloo *et al.* (2002) found that all the members of eggplant complex possessed very high similarity among each other.

According to Furini and Wunder (2003) all the members of eggplant family exhibited sufficient genomic flexibility, to adapt to environmental changes.

Levin *et al.* (2005) and Levin *et al.* (2006) observed that species belonging to the subgenus of *Solanum viz.*, *Leptostemonum* included a number of economically important species, such as cultivated eggplants. According to them, the common name "eggplant" encompassed three closely related cultivated species, which could be broadly grouped into two sections, *viz.*, section melongena comprising of *S. melongena* and *S. macrocarpon* and section oliganthes comprising of *S. aethiopicum* L.

Singh *et al.* (2006) established close phylogenetic relationship between *S. melongena* and *S. incanum*.

All the wild and weedy relatives of brinjal found across the globe are collectively referred to as brinjal eggplant complex according to Samuel (2010).

## 2.3. Phytographic characters

### 2.3.1. Plant

Eggplant is a herb with semi spreading or erect habit. Though it is perennial in nature it is widely cultivated as an annual. Plant is erect and well branched with fibrous or lignified root system. Leaves are large, simple and are arranged in alternate fashion of phyllotaxy. In certain cultivars, spines were present on the leaves and calyx (Swarup, 1995).

### 2.3.2. Flowers

According to Prasad and Prakash (1968) young flower buds of eggplant were oval or conical in shape. Corolla of the eggplant consisted of 5-10 petals. Colour of the corolla varied from purple or pink or white, depending on the variety. Filaments were short with yellow coloured anthers arranged around the pistil (Mc Gregor, 1976). Konys (1993) reported that eggplant flowers showed positive geotropism.

According to Lawande and Chavan (1998) eggplant flowers were large and showy, that appeared alone or in clusters of 2-3 flowers. Flowers were complete, actinomorphic and hermaphrodite. Spines were present on the calyx of certain flowers (Lawande and Chavan, 1998).

### 2.3.3. Fruits and seeds

Seeds of eggplant were uniform in colour, but highly polymorphic with respect to size (Cooke, 1984).

George (1985) reported that fruits of eggplant were green, violet or purple in colour at utility ripeness and brown or yellow at physiological ripeness. According to Swarup (1995) fruits of egg plant attained brown, red or yellow colour at physiological ripeness.

SDS – PAGE of seed protein is widely used to distinguish between the cultivars of eggplant (Sathaiah and Reddy, 1985; Gupta and Robbelen, 1986; Gardiner and Forde, 1988; Huaman and Stegimann, 1989; Rao *et al.*, 1990; Stegemann *et al.*, 1992; Yupsanis *et al.*, 1992; Wang *et al.*, 1994).

## 2.4. Heterostyly

Flowers of brinjal exhibited heterostyly. Magtang (1936) classified the flowers of eggplant based on the correlation of the length of style with anthers, into homostylic or heterostylic flowers. According to him heterostyly was a condition in which style length was higher or lower than the level of anthers and homostyly was the condition in which style length was as high as the level of anthers.

Tatebe (1938) reported the abortive nature of short styled flowers. Pal and Singh (1943) observed three types of flowers in brinjal *viz*., long styled, pseudo short styled and true short styled. True short styled flowers did not set fruits on hand pollination, while long styled and pseudo short styled fruits produced fruits abundantly.

Krishnamurthy and Subramanian (1954) classified flowers of eggplant into four groups based on length of style *viz*., 1) long styled flowers with large sized ovary 2) medium styled flowers with medium sized ovary 3) pseudo short styled flowers with rudimentary ovary 4) true short styled flowers with rudimentary ovary.

Oganesjan (1965) reported that the highest percentage of fruitset was obtained when longstyled flowers were selected as female parents.

Several other authors (Prasad and Prakash, 1968; Rylski *et al*., 1984; Handique and Sharma, 1995; Gorecki and Espinosa – Flores, 1996; Passam and Bolmatis, 1997; Kowalska, 2003a and 2006) also reported the heterostylic nature of eggplant flowers.

Handique and Sharma (1995) studied the significance of heterostyly in promoting cross pollination in brinjal.

Percentage of occurrence of long pistilled flowers were high compared to medium and short pistilled flowers (Gorecki and Espinosa – Flores, 1996; Passam and Bolmatis, 1997; Kowalska, 2003a and 2006).

## 2.5. Flowering biology

Prasad and Prakash (1968) reported that flowering initiation occurred in brinjal nearly 40 – 45 days after transplanting and maximum number of flowers opened between 7 to 8 a.m. The flowers began to close by 2 p.m. By late evening, the flowers were completely closed. Flowers opened again the next day and this procedure was repeated for 1-3 days after the opening of flowers.

According to Vijay *et al.* (1977) peak flower production in brinjal occured 70-75 days after transplanting. They also reported that flowers of brinjal opened between 4.30 a.m. and 9 a.m.

Deshpande *et al.* (1978) observed anthesis in eggplant between 6 a.m. and 4 p.m. While Sindhu *et al.* (1980) reported that anthesis occurred in the flowers of brinjal between 7.30 a.m. and 11 a.m.

### 2.5.1. Stigma receptivity

Kakizaki (1930) reported that stigma became receptive in the flowers of eggplant, immediately after anthesis and receptivity persisted for a period of 2-3 days.

According to Tatebe (1938) stigma receptivity initiated a day prior to flower opening and continued for 2 days even after flower opening in brinjal.

Pal and Singh (1943) stated that stigma receptivity initiated nearly 2hrs after anthesis and continued for 3 days. In certain varieties of brinjal, stigma receptivity lasted for a period of seven days. They also observed peak receptivity during 2$^{nd}$ day of flower opening.

Popova (1958) stated that stigma receptivity persisted for a period of 6-8 days in eggplant.

Prakash (1968) reported that sensitivity of stigma depended on the age of the flower. Maximum receptivity was observed on the day of flower opening.

Oyelana and Oguwenmo (2012) reported that in certain wild species of *Solanum viz*., *S. aethiopicum*, *S. gilo*, *S. anguivi*, and *S. scabrum*, stigma receptivity initiated about 45 minutes before anthesis. In *S. melongena*, *S. torvum* and *S. erianthum* peak stigmatic receptivity was observed nearly 60 minutes prior to the opening of flowers. Receptivity of stigma could be observed from plumpy and sticky appearance of the stigmatic cup.

**2.5.2. Anther dehiscence**

Kakizaki (1930) observed that soon after anthesis, pollen grains emerged through the apical pores of the anthers of *Solanum* sp.

Magtang (1936) reported that anthers of egg plant flowers exhibited dehiscence, one after the other.

According to Prasad and Prakash (1968) duration of anther dehiscence was dependent on temperature and atmospheric humidity. They observed that anthers bursted in upward direction, 15-30 minutes after flower opening.

Oyelana and Oguwenmo (2012) observed that in *S. torvum*, *S. anguivi* and *S. erianthum*, anthers dehisced 20 minutes after the opening of flowers. However in the flowers of *S. gilo*, *S. melongena* and *S. scabrum*, anthers dehisced 30 minutes prior to anthesis.

**2.5.3. Palynology**

Evaluation of pollen viability is crucial in the process of hybridization. The viability of pollen grains in brinjal was found to be affected by many endogenous factors like nutritional status of the plant (Howlett, 1936), agricultural pesticides and other chemicals (Mac Daniels and Hildebrand, 1939; Dubey and Mall, 1972), low

temperature (Chira, 1963), luminosity (Gross, 1971), stage of flower development (Lacerda *et al.*, 1994) and high temperature (Giordano *et al.*, 2003).

Pal and Singh (1943) observed maximum pollen fertility on the 2$^{nd}$ day of flower opening in brinjal. Popova (1958) found that pollen grains remained viable upto 7-10 days in brinjal.

According to Prasad and Prakash (1968) pollen grains of eggplant were heavy and could be transferred to a distance of 1 m only.

The amount of pollen grains produced was influenced by high temperature, low light intensity and improper N: P ratio (Gosiewski and Skapski, 1988; Wysocka – Owczarek, 1993).

Abak and Guler (1994) stated that under low temperature, pollen fertility ranged from 6 to 45 %. The ideal temperature for pollen germination ranged from 20 – 27°C (Dobromilska and Fawceet, 1999).

Oyelana and Oguwenmo (2012) reported that the shape of pollen grains was round, oblong, triangular or rectangular depending on the species of *Solanum*. The largest pollen grains were observed in *S. gilo*.

Kumchai *et al.* (2013) evaluated the viability of eggplant pollen based on the methods given by Alexander (1969). The aborted pollens stained blue in colour and viable pollens stained red in colour.

Devi *et al.* (2015) evaluated the viability of eggplant pollen by staining the crushed pollen grains with 0.5 % Iodine and 1 % KI for 15 minutes. The viable pollen grains were stained red and semi sterile pollen grains were pink in colour. The unstained cells indicated the sterility of the pollen grains.

**2.6. Pollination**

Kakizaki (1930) stated that flowers of eggplant were self pollinated to certain extent. However, Schmidt (1935) observed cross pollination in brinjal.

Magtang (1936) observed that flowers of eggplant did not set fruits on bagging. Dascalov and Murtazov (1937) found that cross pollination occurred in brinjal to an extend of 30 to 40%.

Popova (1958) reported that fruit set was maximum in brinjal when stigma received pollen from different plants. An out crossing to an extend of 6.7% was reported by Sambandam (1964) in the flowers of eggplant.

Appropriate pollination of flowers is one of the principal conditions for achieving good quality and yield (McGregor, 1976; Polyverente *et al.*, 2005) in brinjal.

According to Agarwal (1980) as out crossing occurred to an extent of 0 to 48 %, eggplant can be treated as an often cross pollinated crop.

Cross pollination occurred in brinjal due to transfer of pollen by thrips, ants and bees (George, 1985; Lawande and Chavan, 1998).

Abak *et al.* (1995), Stepowska (1996) and Dobromilska (1997) observed that bumble bees were helpful in increasing fruit set in eggplants.

Eggplant was reported to be self fertile and required cross pollination for better fruit set (Amoaka and Yeboah Gyan, 1995).

An out crossing to an extent of 3.7 % was observed in eggplants in China by Chen *et al.* (2000)

Kowalska (2003a, 2003b, 2006) reported that flowers pollinated by insects showed early fruit set and produced high quality fruits compared to self pollinated plants in brinjal.

## 2.7. Wild relatives of brinjal

Brinjal (*S. melongena*. L) has potential wild relatives that exhibited resistance to a large number of pests and diseases (Behera and Singh, 2002). The wild relatives and the resistance reported are presented in Table 1.

### 2.7.1. *Solanum gilo*

Collonier *et al.* (2001) reported that *S. gilo* plants were resistant to bacterial wilt. *S. gilo* recently renamed as *S. aethiopicum* is a fruit and leaf vegetable (Macha, 2005). *S. gilo* was found to be less susceptible to many pathogens including fungi, bacteria and root knot nematodes (Kouassi *et al.*, 2014).

### 2.7.2. *Solanum viarum*

The gelatinous layer surrounding the seeds of *S. viarum* is a rich source of solasodine, a nitrogenous analogue of diosgenin (Saini, 1966).

Drugs made out of solasodine proved to be effective in treating cancer, rheumatic arthritis and Addison's disease (Chandra and Srivastava, 1984).

Table 1. Biotic stress resistance reported in wild relatives of brinjal

| Wild species | Resistance reported |
|---|---|
| *S. gilo* | Resistance to bacterial wilt (Collonier *et al.*, 2001) |
| *S. indicum* | Resistance to little leaf and shoot and fruit borer (Patel *et al.*, 2001; Bahgat *et al.*, 2008) |
| *S. viarum* | Resistance to the attack of shoot and fruit borer (Ghosh *et al.*, 2007) |
| *S. torvum* | Resistance to pests, nematodes and pathogens (Collonier *et al.*, 2003; Clain *et al.*, 2004; Gousset *et al.*, 2005) |
| *S. macrocarpon* | Resistance to fungal diseases (Bukanya, 1994; Macha, 2005) |
| *S. incanum* | Resistance to verticilium wilt (Robinson *et al.*, 2001; Prohens *et al.*, 2013) |
| *S. integrifolium* | Resistance to phomopsis blight, little leaf, bacterial wilt and shoot and fruit borer (Kalloo, 1993) |

*S. viarum* is often treated as a noxious weed by Mullahey and Colvis (1993). However, Wunderlin *et al.* (1993) considered *S. viarum* as a woody herb.

According to Ghosh *et al.* (2007) *S. viarum* exhibited resistance to the attack of shoot and fruit borer.

### 2.7.3. *Solanum torvum*

*S. torvum* was found to be an effective rootstock in grafting susceptible tomato with eggplant varieties (Peregrine and Ahmad, 1982 ; Singh and Gopalakrishnan,

1997). It exhibited high level of resistance to pests, nematodes and pathogens (Collonier *et al.*, 2003; Clain *et al.*, 2004; Gousset *et al.*, 2005).

It is closely related to *S. melongena* and possessed desirable traits like resistance to diseases, that could be transferred to the genome of eggplant by introgression (Singh *et al.*, 2006; Baysal *et al*, 2010).

### 2.7.4. *Solanum macrocarpon*

*S.macrocarpon* is used as a vegetable. Fruits were sweeter compared to other relatives of brinjal. It exhibited considerable resistance to fungal diseases (Bukanya, 1994; Macha, 2005).

### 2.7.5. *Solanum incanum*

According to Nishio *et al.* (1984) *S. melongena* was more closely related to *S. incanum* than any other species. *S. incanum* exhibited resistance to *verticilium* wilt (Robinson *et al.*, 2001; Prohens *et al.*, 2013).

### 2.7.6. *Solanum indicum*

*S. indicum* is widely used for its medicinal properties to cure human ailments. Apart from this, it is highly resistant to little leaf as well as shoot and fruit borer (Patel *et al.*, 2001; Bahgat *et al.*, 2008).

### 2.7.7. *Solanum integrifolium*

*S. integrifolium* exhibited higher level of resistance to phomopsis blight, little leaf, bacterial wilt and shoot and fruit borer (Kalloo, 1993).

**2.8. Cross compatibility**

Unilateral success was reported when *S. melongena* was used as female parent in hybridization with *S. melongena* var *insanum* and *S. melongena* var *potangi* (Bhaduri, 1951).

Hybridization studies in brinjal have generally been inconclusive and the results were often contradictory (Nasrallah and hopp, 1963; Rao, 1979; Attavian *et al.*, 1983).

Rajasekharan (1969) studied the interrelationship among eight different species of *Solanum* by making crosses in all possible combinations. He obtained successful hybrids from *S. indicum* x *S. melongena* as well as *S. xanthocarpum* x *S. trilobatum*.

Rajasekharan (1970) reported that *S. melongena* is cross compatible with *S. indicum*.

Omidiji (1974) studied the relationship between five cultivated species of brinjal. Fertile diploid and hexaploid hybrids were obtained from the cross between *S. macrocarpon* x *S. melongena* as well as *S. nodiflorum* x *S. nigrum*, respectively. The diploid hybrid obtained from the cross between *S. macrocarpon* x *S. incanum* was partially fertile. The $F_2$ plants derived from *S. macrocarpon* x *S. incanum* and *S.macrocarpon* x *S. melongena* were quite variable in fertility. But the $F_2$ plants derived from the cross between *S. nodiflorum* x *S. nigrum* were vigorous and uniform. The morphological comparison of these species and their inter crossability as well as the crossability and fertility of their hybrids indicated that *S. macrocarpon* is more closely related to *S. melongena* than to *S. incanum*.

According to Vishwanathan (1975), Rao (1975) and Handique (1986) *S. melongena* was not cross compatible with most of the wild relatives except *S. incanum*. Other wild species *viz.*, *S. indicum*, *S. sisymbrifolium*, *S. nigrum* and *S. torvum* were incompatible with the cultivated *S. melongena* genotypes. The fruits

obtained from the cross between cultivated *S. melongena* (Punjab Sadabahar) and *S. torvum* produced a few seeds which later failed to germinate.

Rao (1979) observed bilateral success when *S. melongena* was crossed with *S. melongena* var *insanum* and *S. melongena* var *potangi.*

Successful hybrids were obtained in the cross between *S. melongena* and *S. macrocarpon* by Schaff *et al.* (1980).

Schaff *et al.* (1982) mentioned about the possibility of transferring genes for resistance to two spotted mites from *S. macrocarpon* to *S. melongena* as well as resistance to *Pseudomonas solanacearum* from *S. gilo* to *S. melongena.*

Nishio *et al.* (1984) classified *Solanum* species into the following three groups based on cross compatibility.

1. *S. melongena*, *S. incanum* and *S. macrocarpon*
2. *S. integrifolium*, *S. gilo* and *S. nodiflorum*
3. *S. indicum*, *S. mamosum*, *S. torvum*, *S. sisymbrifolium* and *S. taxicarum*

Cross compatibility was observed within and between the first two groups. They also found that *S. melongena* was more closely related to *S. incanum* than any other species.

According to Lester and Niakan (1986), Hasan (1989) and Daunay *et al.* (1991), *S. melongena*, *S. gilo* and *S.macrocarpon* were highly inter crossable.

Gowda *et al.* (1990) conducted interspecific hybridization between *S.macrocarpon* and *S. melongena* to transfer genes for resistance to shoot and fruit borer.

The crossability of *S. melongena* with *S. aethiopicum*, *S. incanum* and *S. torvum* was also reported by (Daunay *et al.*, 1991; Nee, 1991; Rao, 2011).

Production of hybrid seeds was found to be hampered by pre and post fertilization barriers (Gowda and Seenappa, 1991; Behera and Singh, 2002) in *Solanum* sp.

Possibility of production of fertile hybrids between *S. melongena* and *S. aethiopicum* was reported by Daunay *et al.* (1993). According to Collonier *et al.* (2001) *S. aethiopicum* could be easily crossed with *S. melongena*, but the fertility of their progeny was very low.

Behera and Singh (2002) had undertaken interspecific hybridization involving 5 different species of *Solanum*. *S. indicum* when used as a pollen parent was cross compatible with *S. incanum* and *S. melongena*, whereas $F_1$ seedlings died after 10 – 15 days of germination in the reciprocal cross (*S. indicum* x *S. melongena*).

Rizza *et al.* (2002) developed dihaploids through anther culture of somatic hybrids between *S. melongena* and *S. gilo*. The dihaploids showed complete resistance to fungal wilt caused by *Fusarium oxysporum fsp melongena.*

Alba *et al.* (2005) reported that *S. aethiopicum* and *S. macrocarpon* possessed many agronomically desirable traits and could be used for the genetic improvement of *S. melongena.*

Ali and Fujieda (2007) reported that *S. melongena* was found to be compatible with *S. gilo*, *S. insanum* and *S. integrifolium*. *S. indicum* when used as male or female parent, produced unfilled seeds. Poor germination of pollen, retarded growth of pollen tubes before reaching ovary, irregular callose deposition *etc* could be observed in incompatible crosses.

According to Sekara *et al.* (2007) inter specific hybridization is an important approach to incorporate useful genes in crop improvement of brinjal.

Pugalendhi *et al.* (2010) conducted a study in brinjal utilizing the wild relative (*S. viarum*) as a resistant source to shoot and fruit borer in brinjal. Hybridization was done between *S. viarum* and *S. melongena* and the $F_1$ hybrids were raised. Selfing was done in every generation followed by selection till $F_9$ generation. In the $F_9$ generation high yielding plants with negligible infestation of shoot and fruit borer were selected. Molecular studies also confirmed the introgression of genes from donor parent, *S. viarum* to brinjal.

Ghosh *et al.* (2011) obtained successful hybrids when *S. melongena* was crossed with *S. viarum*.

Kumchai *et al.* (2013) developed interspecific hybrids of *S. torvum* and *S. melongena*. These hybrids exhibited lesser pollen viability compared to the parents, due to abnormal meiosis.

Devi *et al.* (2015) conducted hybridization programme involving 13 cultivated genotypes of brinjal and four wild relatives (*S. incanum*, *S. aethiopicum*, *S. integrifolium*, and *S. indicum* ) of brinjal. Maximum fruitset was recorded in the cross DBSR – 91 x *S. aethiopicum* followed by Pusa bindu x *S. aethiopicum*. Among the four wild species of brinjal, *S. incanum* was found to be highly cross compatible with *S. melongena* types.

# MATERIALS AND METHODS

## 3. MATERIALS AND METHODS

The investigation entitled "Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)" was carried out in the department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara during August 2014 – July 2016. The details regarding the experimental materials and the methodology followed for the present investigation are described below.

### A. Materials

The variant forms of four wild species of *Solanum* maintained by NBPGR – RS, Vellanikkara, as well as two high yielding varieties of *S. melongena* (Haritha and Surya) from Kerala Agricultural University formed the material for the study, the details of which are presented in Table 1.

Table 2. Details of the *Solanum* species used for the study

| Sl.No. | Species | Acc. No. | IC No. | Common name |
|---|---|---|---|---|
| 1 | *S. viarum* | TCR 190 | IC241673 | Tropical soda apple |
| 2 | *S. gilo* (*S. aethiopicum* L). | NE 45 | IC611554 | Scarlet egg plant, Ethiopian egg plant, Bitter tomato |
| 3 | *S. incanum* | TCR 212 | IC203609 | Thorn apple, Bitter apple |
| 4 | *S. indicum* | TCR 196 | IC241674 | African egg plant, Indian night shade |
| 5 | *S. melongena* | | | Brinjal, Egg plant |
| | Haritha | - | - | - |
| | Surya | - | - | - |

Before raising nursery, the seeds of all the wild types (Plates 1 and 2) were treated with one per cent $KNO_3$ solution for one hour and washed thoroughly in distilled water three to four times to enhance germinability (Shim *et al.*, 2008; Giri and Tamata, 2012). The seedlings were transplanted at two leaf stage into grow bags of size 35 x 25 x 20 cm in a replicated fashion with five replications (Plate 3). The agronomic practices as per the Package of Practices Recommendations by KAU (2011) was followed.

**B. Methodology**

The vegetative, floral and fruit characters were critically evaluated in the four different wild species as well as *S. melongena* varieties, Haritha and Surya. The descriptor developed by IPGRI (1988) was followed for the evaluation of vegetative, floral and fruit characters.

**3.1. Vegetative characters**

Both qualitative and quantitative characters were considered for evaluation of the genotypes. Observations were recorded from five different plants of each genotype and mean was computed. The descriptor and descriptor states used for evaluation are presented as **Annexure I**.

**3.1.1. General features**

The days to germinate, germination per cent and days to transplanting were observed in different genotypes evaluated. Plant growth habit and branching intensity were recorded as per the descriptor. The height as well as stem girth were also recorded at flowering stage. The height was measured from the ground level to the tip of the main stem. Stem girth was measured at ground level.

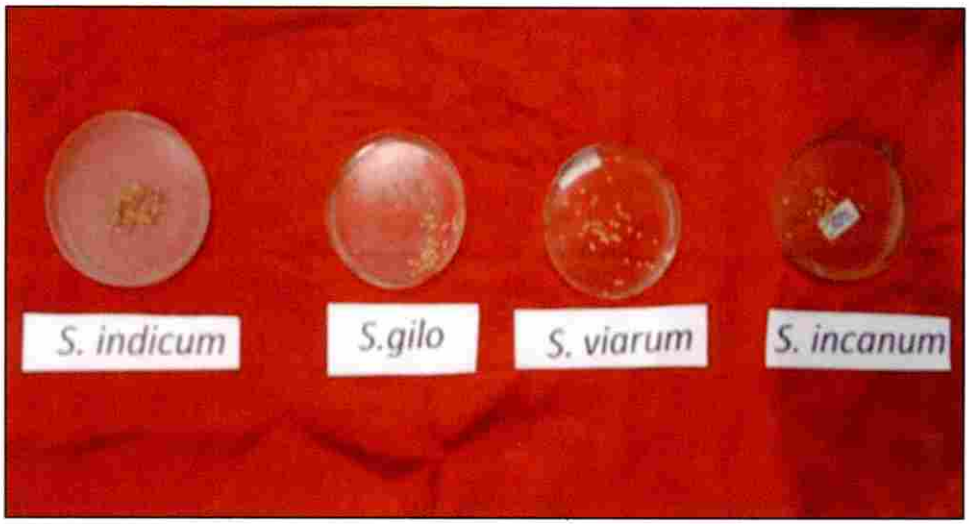



Plate 1. Seeds of wild species

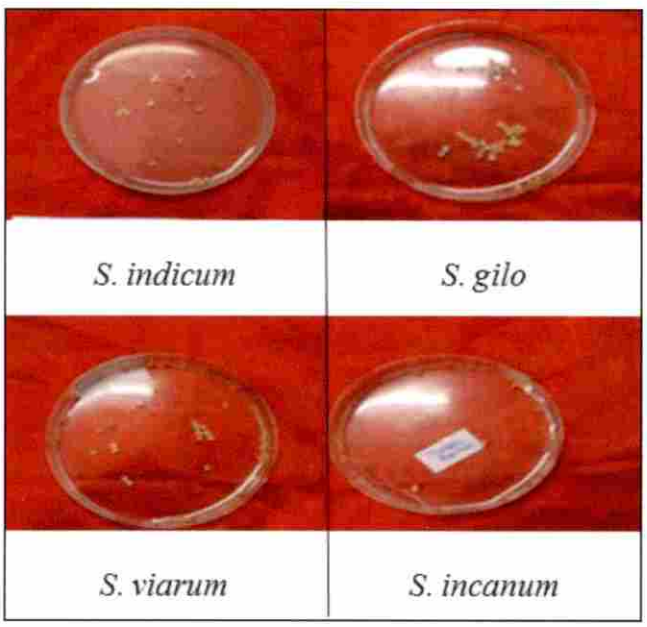



Plate 2. Seeds of wild species treated with $KNO_3$

### 3.1.2. Leaf

The fully mature leaf at the 3rd node from the tip of the main stem from five different plants of each genotype was taken for recording observations. The colour of petiole, colour as well as the lobing of lamina, angle at the tip of the leaf blade and presence or absence of prickles on the leaf were the qualitative characters considered for evaluation. The characters *viz*., length of petiole, length and breadth of lamina were recorded for biometric evaluation. The breadth of lamina was taken at its broadest point.

## 3.2. Flowering biology

### 3.2.1. Flowering behaviour

The days taken for visual observation stage of first flower bud since transplanting into the grow bag as well as the days taken for the opening of the flower bud from visual observation stage were recorded from five different plants of each genotype. The number of flowers per inflorescence and longevity of flowers were also observed from all the genotypes evaluated.

### 3.2.2. Floral morphology

The floral features of the four different wild variants as well as Haritha and Surya were described after examining the fresh flowers on the first day of blooming. The presence of pseudo or heterostyly if present in any of the evaluated genotypes were also noted.

The observations on the following biometric characters were taken from five flowers each of the different genotypes studied.

1. Length of flower bud (cm)
2. Circumference of the flower bud at the broadest point (cm)
3. Number of sepal lobes per flower

4. Length of sepal lobe (cm)
5. Number of petal lobes per flower
6. Length of petals (cm)
7. Length of filament and anther lobe (cm)
8. Length of style (cm)
9. Number of carpels per flower

The length of sepal and petal lobes were taken at their longest points.

### 3.3. Anthesis

The process as well as the time of flower opening, anther dehiscence and stigma receptivity were closely observed in all the genotypes evaluated.

#### 3.3.1. Determination of anther dehiscence

Ten fully mature flower buds of each type, were examined with hand lens since a day prior to anthesis, at regular intervals of one hour starting from 5 a.m. till the dehiscence of pollen grains to determine the time of anther dehiscence (Prasad and Krishnaprasad, 1994).

#### 3.3.2. Determination of stigmatic receptivity

The stigmatic surface was observed at hourly interval starting from 5 a.m. on the previous day of flower opening for any change in colour or appearance in the same selected buds to find out the onset of stigma receptivity. Duration of stigma receptivity was also determined following standard procedures (Radford *et al.*, 1974). Moist conditions of stigmatic surface and/ or change in colour of stigmatic surface were considered as indications of onset of receptivity. Loss of receptivity was also indicated by fading of the colour or drying up of stigmatic surface.

### 3.4. Palynology

The pollen grains were examined in detail as per the standard procedures suggested by Nair (1970). Size, shape and viability of pollen grains were examined. The size of the pollen was measured using phase contrast microscope. The fertility of pollen grain was estimated following acetocarmine staining technique (Moore and Webb, 1972). Pollen grains were obtained by squeezing the anthers with a sharp needle. They were then stained with one percent acetocarmine. The well stained pollen grains were considered to be fertile and the unstained ones as sterile. Observations were taken from five different fields of the prepared slides in each genotype. The fertility was computed and expressed as percentage.

### 3.5. Pollination biology

Three sets of ten fully mature flower buds each from each of the genotypes were used to find out the mode of pollination prevailing in the species variants. Only long styled flower buds were used for this study. First set of ten flower buds in each genotype was protected with butter paper cover starting from a day prior to flower opening till the completion of anthesis. Another set of buds from each genotype was emasculated but kept unprotected. The third set, kept unprotected without emasculation was taken as the control. The extent of fruit set in protected buds, emasculated but unprotected buds and unprotected buds were recorded and expressed as percentage.

### 3.6. Fruit characters

The days taken from anthesis to fruit set, days taken from fruit set to fruit maturity as well as length, breadth and weight of fruits were recorded. The qualitative characters of the fruits were also studied following the IPGRI descriptor (1988).

### 3.7. Cluster analysis

Cluster analysis based on qualitative characters was done using NTSYS. MINI TAB was used for cluster analysis in the case of quantitative characters. Cluster diagrams were also drawn.

The descriptive statistics like Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Heritability and Genetic gain were also computed. The genotypic and phenotypic coefficients of variation (GCV and PCV) were worked out according to the method given by Singh and Chaudhary (1977). Heritability in broad sense and expected genetic advance on the basis of per cent of mean at five per cent intensity of selection were worked out according to the method given by Allard (1960).

### 3.8. Cross compatibility

The cross compatibility of the four wild species variants with *S. melogena* types, Haritha and Surya, were assessed by making crosses, both direct and reciprocal and examining the fruit set in each case. The flowers of the selected female parents were emasculated on the day prior to anthesis. Both hand emasculation and soda straw methods were tried.

The long styled flowers alone were used for the study. The emasculated flowers were carefully bagged to avoid contamination by foreign pollen. On the next day, during the period of peak stigma receptivity, pollen from the desired male parent was dusted on the stigma of the emasculated flower. After pollination also the flowers were kept protected with proper labelling.

The details of crosses are presented in Table 3.

### 3.9. Evaluation of the progeny

The progenies from different crosses were raised in the field, in progeny row fashion (Plate 4) and evaluated based on various phytographic, leaf, floral and fruit characters.

### 4.0. Incidence of pest and diseases

Incidence of pest and diseases in the parental generation as well as the $F_1$ generation was recorded.

Table 3. List of crosses between *S. melongena* varieties and wild variants

| Direct crosses | Reciprocal crosses |
|---|---|
| Haritha x *S. incanum* | *S. incanum* x Haritha |
| Haritha x *S. indicum* | *S. indicum* x Haritha |
| Haritha x *S. viarum* | *S. viarum* x Haritha |
| Haritha x *S. gilo* | *S. gilo* x Haritha |
| Surya x *S. incanum* | *S. incanum* x Surya |
| Surya x *S. indicum* | *S. indicum* x Surya |
| Surya x *S. viarum* | *S. viarum* x Surya |
| Surya x *S. gilo* | *S. gilo* x Surya |

### 4.1. Statistical analysis

Appropriate statistical analysis was done where ever necessary.

Plate 3. Layout of the experiment


Plate 4. Progeny evaluation

# *RESULTS AND DISCUSSION*

# 4. RESULTS AND DISCUSSION

The results of the work entitled "Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)" carried out in the department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara, during 2014 – 2016 are presented below.

## 4.1. Evaluation of vegetative characters

The observations on various vegetative characters, both qualitative and quantitative, were recorded from the four wild variants of *Solanum* and *S. melongena* varieties, Haritha and Surya.

### 4.1.1. General features

The wild variants of *Solanum* along with *S. melongena* varieties, Haritha and Surya were evaluated based on days to germinate, germination percent, days to transplanting (two leaf stage), plant growth habit, branching intensity, height as well as stem girth. The results are presented in Table 4 and Plate 5.

All the wild species except *S. indicum* were on par with respect to the days taken for germination. Among the wild species, the speed of germination was the highest in *S. indicum* which took only 5 days to germinate. The *S. melongena* varieties Haritha and Surya differed among themselves (5.80 days and 9.00 days respectively) and also from the wild variants in the days taken for germination.

The wild variants exhibited comparatively lower germination per cent ranging from 21.13 in *S. gilo* to 48.45 in *S. indicum*. Gisbert *et al.* (2011) also observed poor germination in the wild variants of *Solanum* and reported that low germination may be due to dormancy of the seeds. The varieties of *S. melongena*, Haritha and Surya recorded 63.43 per cent and 60 per cent germination respectively.

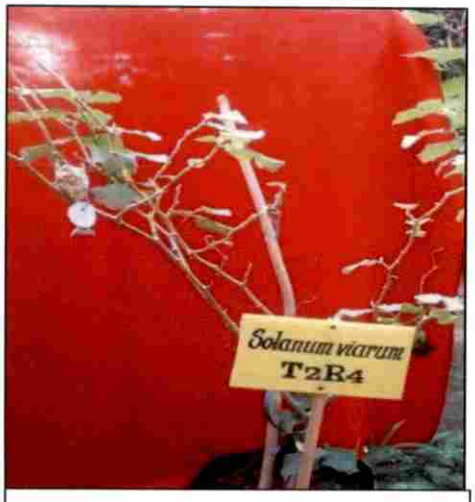
Among the wild types, *S. viarum* and *S. gilo* were on par with respect to days to attain the two leaf stage, making it ready for transplanting. They also differed from the other two wild species, *S. indicum* and *S. incanum* significantly. *S. incanum* took the highest number of days (55 days) and *S. indicum* the lowest (28 days). All the wild variants evaluated varied significantly from *S. melongena* varieties, Haritha and Surya. *S. melongena* varieties, Haritha and Surya exhibited significant difference among themselves with Surya taking only 32 days to attain the two leaf stage.

It can hence, be concluded that in the wild species *S. incanum* initiation of germination as well as initial growth was slow. The wild type *S. indicum* exhibited faster germinability and initial growth than even the cultivated species, *S. melongena* represented by Haritha and Surya. It's germinability was nearly double that of the other wild types *S. incanum, S. viarum* and *S. gilo* studied (Table 4).

All the wild variants of *Solanum* except *S. indicum* resembled *S. melongena* in having upright growth habit. *S. indicum* exhibited an intermediate growth habit and was distinctly different from the other wild variants. According to Swarup (1995) eggplant is a herb with semi spreading or erect growth habit.

In all the wild variants except *S. indicum* and also in *S. melongena* varieties, Haritha and Surya the branching intensity was found to be weak. The mean number of primary branches ranged from two to five in these genotypes. However, the wild species *S. indicum*, was characterized by very weak branching habit (Plate 5).

*S. indicum* did not flower during the entire experiment period. This may be due to the endemic nature of this species to Tamil Nadu. Hence, the height and stem girth measured at flowering stage in all the other types could not be taken in *S. indicum*. All the wild variants of *Solanum* were taller than *S. melongena* variety Surya (Table 4). However, the height at flowering in *S. viarum* and *S. incanum* was on par with that of *S. melongena* variety Haritha. Among the wild variants, *S. gilo* was the tallest with a mean height of 105cm.




*S. viarum*


*S. gilo*


*S. incanum*


*S. indicum*


Haritha


Surya

Plate 5. General morphological features of different *Solanum* species

All the wild variants exhibited significantly higher stem girth, compared to *S. melongena* variety Surya. However, the stem girth in *S. incanum* and *S. gilo* were on par with *S. melongena* variety Haritha (Table 4). The wild types *S. viarum* and *S. incanum* were on par. *S. gilo* was on par with *S. incanum*. However, it was significantly different from *S. viarum* in this character.

Table 4. General features of different species of *Solanum*

| Types | Days to germinate | Germination % | Days to Transplanting | Growth habit | Branching Intensity | Height (cm) | Stem girth (cm) |
|---|---|---|---|---|---|---|---|
| *S. viarum* | 13.00 | 22.79 | 40.00 | Upright | Weak (2 to5) | 85.70 | 3.94 |
| *S. gilo* | 13.00 | 21.13 | 40.00 | Upright | Weak (2 to 5) | 105.00 | 3.24 |
| *S. incanum* | 13.40 | 26.57 | 55.00 | Upright | Weak (2 to 5) | 89.80 | 3.64 |
| *S. indicum* | 5.00 | 48.45 | 28.00 | Intermediate | Very weak(<2) | * | * |
| *S. melongena* | | | | | | | |
| Haritha | 5.80 | 63.43 | 32.00 | Upright | Weak (2 to 5) | 74.60 | 3.46 |
| Surya | 9.00 | 60.00 | 42.00 | Upright | Weak (2 to 5) | 55.80 | 2.36 |
| CD (0.05) | 0.65 | -- | 0.75 | -- | -- | 20.43 | 0.45 |
| CV (%) | 5.07 | -- | 1.46 | -- | -- | 18.67 | 10.14 |

* Did not flower

### 4.1.2. Evaluation of leaf characters

Both qualitative and quantitative characters of leaves of different species were observed and features were recorded.

The observations on qualitative characters of leaf *viz.,* colour of the petiole, colour as well as lobing of the lamina, angle at the tip of leaf blade and presence or absence of prickles on leaf are depicted in Table 5 and Plates 6a and 6b.

*S. incanum* differed from other wild types as well as *S. melongena* represented by Haritha and Surya in the colour of petiole. The petiole was greenish violet in *S. incanum* where as it was green in all the other genotypes evaluated.

The lamina was dark green in colour in all the wild types except *S. gilo* where it was light green. The *S. melongena* variety Haritha resembled *S. gilo* in lamina colour. However, Surya, another high yielding variety under *S. melongena* was having green lamina and it differed from all the other genotypes evaluated in this character.

The lobing of lamina was intermediate in all the wild species evaluated except *S. indicum*. *S. indicum* however, exhibited strong lobing and hence, differed from the other wild types. *S. melongena* cultivars Haritha and Surya also resembled the wild types *S. incanum*, *S. viarum* and *S. gilo* in the lobing of lamina.

Leaf tip angle of *S. incanum* was intermediate. *S. melongena* cultivars, Haritha and Surya also resembled *S. incanum* in the nature of leaf tip angle. The wild types *S. viarum* and *S. gilo* were having acute leaf tip, The leaf tip angle of *S. indicum* alone was very acute (Plate 6b).

*S. viarum* was found to bear prickles on the leaves (Plate 6a). *S. incanum* and *S. gilo* resembled *S. melongena* varieties, Haritha and Surya in the non prickly nature. Sen Gupta (1961) and Babu and Hepper (1978) also observed that stem of *S. viarum*

*S. viarum*

*S. gilo*

*S. incanum*

Plate 6a. Leaves of different *Solanum* species

*S. indicum*

Haritha

Surya

Plate 6b. Leaves of different *Solanum* species

was herbaceous and woody, bearing short, straight, slender prickles mixed with stout, compressed, or hooked prickles. Mullahey *et al.* (1993) also reported the prickly nature of *S. viarum*.

Observations on various biometric characters of leaf such as petiole length, length and breadth of the lamina taken from the leaf at the 3rd node from the tip of the plant, in all the selected members of *Solanum* species are presented in Table 6.

From Table 6 it can be seen that there was significant difference among the species studied, for various biometric characters of the leaf. Among the wild species, the petiole length ranged from 2.02 cm in *S. incanum* to 19.4 cm in *S. indicum*. The three wild species except *S. indicum* were on par with *S. melongena* represented by Haritha and Surya.

The length and breadth of lamina were significantly higher in the wild type *S. indicum* (26.20 cm and 22.80 cm respectively). The other three wild species *S. viarum*, *S. gilo* and *S. incanum* were on par with respect to length and breadth of lamina. Among the *S. melongena* varieties, Haritha was having longer leaves with a length of 16.54 cm and a breadth of 13.42 cm. However, the leaves of Haritha were significantly smaller than *S. indicum* which was bearing the biggest leaves among the evaluated genotypes.

The wild variant *S. viarum* was characterized by upright growth habit and presence of prickled dark green leaves with acute leaf tip. The light green non prickled leaves with acute tip helps in distinguishing *S. gilo*. *S. incanum* could be distinguished by its intermediate growth habit and leaves with greenish violet petioles. Intermediate growth habit, very weak branching intensity, leaves with long petiole, large, strongly lobed lamina having very acute leaf tip are the features of *S. indicum*.

Table 5. Qualitative characters of leaf in different species of *Solanum*

| Types | Petiole colour | Lamina colour | Lobing of lamina | Leaf tip angle | Leaf prickles |
|---|---|---|---|---|---|
| *S. viarum* | Green | Dark green | Intermediate | Acute | Few |
| *S. gilo* | Green | Light green | Intermediate | Acute | None |
| *S. incanum* | Greenish violet | Dark green | Intermediate | Intermediate | None |
| *S. indicum* | Green | Dark green | Strong | Very acute | None |
| *S. melongena* | | | | | |
| Haritha | Green | Light green | Intermediate | Intermediate | None |
| Surya | Green | Green | Intermediate | Intermediate | None |

Table 6. Biometric characters of leaf in different species of *Solanum*

| Types | Petiole length (cm) | Lamina length (cm) | Lamina breadth (cm) |
|---|---|---|---|
| *S. viarum* | 2.50 | 7.98 | 6.60 |
| *S. gilo* | 2.06 | 7.86 | 6.12 |
| *S. incanum* | 2.02 | 10.06 | 8.40 |
| *S. indicum* | 19.40 | 26.20 | 22.80 |
| *S. melongena* | | | |
| Haritha | 5.24 | 16.54 | 13.42 |
| Surya | 3.18 | 10.04 | 8.56 |
| CD (0.05) | 5.88 | 6.01 | 3.11 |
| CV (%) | 78.61 | 35.13 | 21.71 |

**4.2. Flowering biology**

Observations on the flowering behaviour as well as floral morphology of the four wild species and the cultivated species *S. melongena* represented by Haritha and Surya are presented below.

### 4.2.1. Flowering behaviour

The days taken for initiation of first flower bud, days for opening of flower bud after initiation, as well as number of flowers per inflorescence were recorded and the results are presented in Table 7.

No flowering was observed in the wild species *S. indicum*. The lack of flowering in *S. indicum* can be attributed to its endemic nature to Tamil Nadu. Among the wild species which produced flowers, *S. gilo* took the highest number of days for flowering initiation (70.80 days) and *S. viarum,* the lowest (41.20 days). Significant difference was observed among the *S. melongena* varieties Haritha and Surya in the days taken for flowering (42.80 days and 55.00 days respectively). The cultivated type Haritha however, was on par with the wild type *S. viarum*. Surya, another high yielding variety under *S. melongena* resembled *S. incanum* in days to initiation of flowering. Prasad and Prakash (1968) also reported that flowering initiation occurred in brinjal nearly 40 – 45 days after transplanting.

Even though the different species differed significantly in the days to initiation of flowering, no significant difference could be observed among the species for days to opening of the flower bud after initiation. Irrespective of species, it took only 9 to 10 days for flower opening after initiation of flower bud (Table 7).

*S. viarum* was significantly different from all the other species in the number of flowers per inflorescence recording a value of 3.60. Haritha and Surya belonging to *S. melongena* did not differ significantly in the number of flowers per inflorescence (Table 7). Som and Maity (1986) as well as Pradeepa (2002) also observed that in *S. gilo* flowers were borne either solitarily or in clusters of two or more.

### 4.2.2. Floral morphology

The flowers of *Solanum* species are positively geotropic. In all the species evaluated, flowers are pedicellate, zygomorphic, bisexual, hypogynous and complete. Calyx is cup like, persistent and with five sepals which are united. Depending on the species prickles may or may not be present on the calyx. Corolla is rotate with five petals which are united. However, in *S. gilo* and S. *melongena* variety Surya petal number showed a variation from 4 to 6. The aestivation is valvate in both calyx and corolla. Androecium consists of five stamens, epipetalous and arranged in the form of a cone around the style. Anthers are basifixed and dehiscing through apical pores. Gynoecium is bicarpellary syncarpous with axile placentation. The ovary is oblique in position with respect to the floral axis. This feature makes the flower zygomorphic.

Table 7. Flowering behaviour in different species of *Solanum*

| Types | Days to flower bud initiation | Days to opening of flower bud | Flowers per inflorescence |
|---|---|---|---|
| *S. viarum* | 41.20 | 10.20 | 3.60 |
| *S. gilo* | 70.80 | 10.40 | 1.80 |
| *S. incanum* | 56.00 | 10.20 | 2.20 |
| *S. indicum* | No flowering | | |
| *S. melongena* | | | |
| Haritha | 42.80 | 9.60 | 2.00 |
| Surya | 55.00 | 10.00 | 1.40 |
| CD (0.05) | 1.97 | NS | 1.31 |
| CV (%) | 2.80 | NS | 15.46 |

The floral formula and **floral diagram** are represented below

$$\nearrow \\ ♀ / \ K_{(5)}C_{(5)}\overline{A}_{(5)}\underline{G}_{(2)}$$

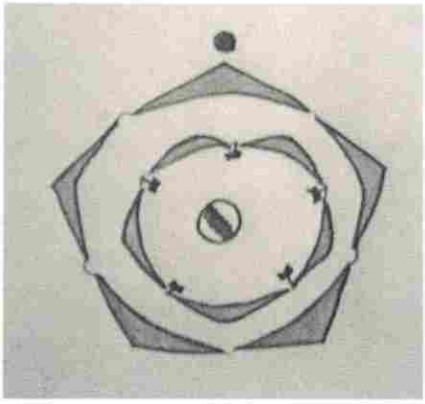


Fig. 1. Floral diagram of *Solanum* species

In the flowers of *S. viarum*, calyx is green with prickles. The corolla in this species is light violet in colour. The stamens are with yellowish white filaments and yellow anthers. The stigma is glossy green.

The flowers of *S. gilo* are characterized by the presence of petals which are white, stamens with yellowish white filaments and yellow anthers as well as glossy green stigma. In this species calyx is non prickly. PROTA (2004) also reported that *S. gilo* was having white or pale purple petals.

*S. incanum* flowers can be distinguished by the green non prickly calyx and pale violet petals. The filaments of stamens are yellowish white and anthers are yellow. The stigma is glossy green.

In *S. melongena* variety Haritha, the flowers are having green non prickly calyx, white petals and stamens with yellowish white filaments and yellow anthers.

In the flowers of Surya, also a *S. melongena* variety, the calyx is non prickly and purplish green in colour. The corolla is bluish violet. The stamens are with yellow anthers and yellowish white filaments. Mc Gregor, 1976, also observed that colour of the corolla would be purple or pink or white, depending on the variety and filaments were short with yellow coloured anthers arranged around the pistil.

In both Haritha and Surya belonging to *S. melongena* the stigma is glossy green.

The presence of prickles on the calyx was observed to be a unique feature of *S. viarum.* All the other wild variants, as well as *S. melongena* varieties, Haritha and Surya, were devoid of prickles on the calyx. Irrespective of species difference, the calyx is persistent. Lawande and Chavan, 1998 also observed that flowers were complete with spines present on the calyx of certain species. Unlike in the present study Lawande and Chavan (1998) however, reported that flowers were actinomorphic in *Solanum* species.

Observations on the biometric characters of the flower like length and circumference of flower bud, length of sepal, length of petal, length of filaments and anthers as well as length of style were also recorded from the different species evaluated. The results are presented in Table 8.

*S. gilo* was significantly different from all other species evaluated, in the length and circumference of flower bud (0.80 cm and 1.32 cm respectively). *S. melongena* variety, Haritha and Surya were on par with each other and also with the wild species *S. incanum* in the length and circumference of flower bud. The length of calyx was significantly different in different species evaluated. However, the varieties under the species *melongena* (Haritha and Surya) were on par with respect to this character (1.70 cm and 1.60 cm respectively). With regard to corolla length also, Haritha (1.92 cm) and Surya (1.96 cm) were on par. The petals were the shortest in *S. gilo* (0.82 cm). The evaluated types did not differ significantly in the length of stamens. The length of style varied from 0.3 cm in short styled flowers to 1.20 cm in long styled flowers (Table 8).

Irrespective of species, long and short styled flowers were common. Long styled flowers had high frequency of occurrence compared to medium and short

styled flowers as reported by Gorecki and Espinosa – Flores (1996); Passam and Bolmatis (1997) and Kowalska (2003a and 2006). The medium styled flowers were however, very rare. Hence, it can be stated that heterostyly is present in all the species (Plate 7). Pal and Singh (1943) also observed three types of flowers in brinjal *viz.*, long styled, pseudo short styled and true short styled. True short styled flowers did not set fruits on hand pollination, while long styled and pseudo short styled fruits produced fruits abundantly (Pal and Singh,1943).

**4.3. Anthesis**

Observations on the time of flower opening, changes in the colour of the corolla associated with anthesis and blossom life are presented in Table 9.

The flowers of *S. gilo* and *S. incanum* opened between 5 a.m. and 6 a.m. as well as 6 a.m. and 7 a.m. respectively. Seasonal influence on the time of anthesis was prominent in the flowers of *S. viarum*. Here, the flowers opened between 11 a.m. and 11.30 a.m. during September – October period and between 6 a.m. and 7 a.m. during the rest of the year. In *S. melongena* the opening time varied from 4 a.m. and 7 a.m. depending on the genotype.

The colour of the corolla determined, following IPGRI descriptor, remained constant throughout the flowering period in *S. gilo* as well as *S. melongena* variety Haritha. However, in *S. viarum*, the corolla colour changed from white to light violet on the day prior to flower opening.

In *S. melongena* variety Surya a change in colour from white to bluish violet was noticed on the day prior to anthesis and the bluish violet colour was retained till withering. In *S. incanum* the corolla was white in colour till two days prior to anthesis and it changed to pale violet on the previous day of flower opening. No further change in colour of the corolla was noticed after anthesis in any of the types evaluated (Plates 8 to 12).

Table 8. Biometric characters of the flowers of different species of *Solanum*

| Types | Length of flower bud (cm) | Circumference of flower bud (cm) | Length of sepal lobe (cm) | Length of petal lobe(cm) | Length of filament (cm) | Length of anther (cm) | Length of style (cm) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Short | Long |
| *S. viarum* | 1.38 | 1.84 | 1.06 | 1.50 | 0.20 | 0.60 | 0.30 | 1.20 |
| *S. gilo* | 0.80 | 1.32 | 0.63 | 0.82 | 0.20 | 0.40 | 0.30 | 1.20 |
| *S. incanum* | 1.76 | 2.06 | 1.33 | 1.22 | 0.20 | 0.60 | 0.30 | 1.20 |
| *S. indicum* | Not flowered | | | | | | | |
| *S. melongena* | | | | | | | | |
| Haritha | 1.84 | 1.99 | 1.70 | 1.92 | 0.20 | 0.60 | 0.30 | 1.20 |
| Surya | 1.66 | 2.25 | 1.60 | 1.96 | 0.20 | 0.60 | 0.30 | 1.20 |
| CD (0.05) | 0.34 | 0.42 | 0.26 | 0.42 | NS | NS | NS | NS |
| CV (%) | 17.06 | 16.63 | 15.70 | 21.28 | -- | -- | -- | -- |

Long styled flower

Medium styled flower

Short styled flower

Plate 7. Heterostyly in different *Solanum* species


Plate 8. Stages of flower development in *S. viarum*

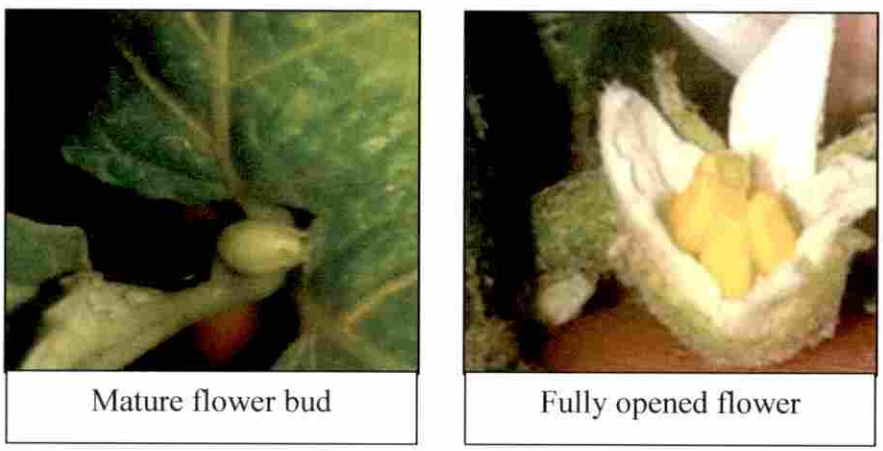



Plate 9. Stages of flower development in *S. gilo*

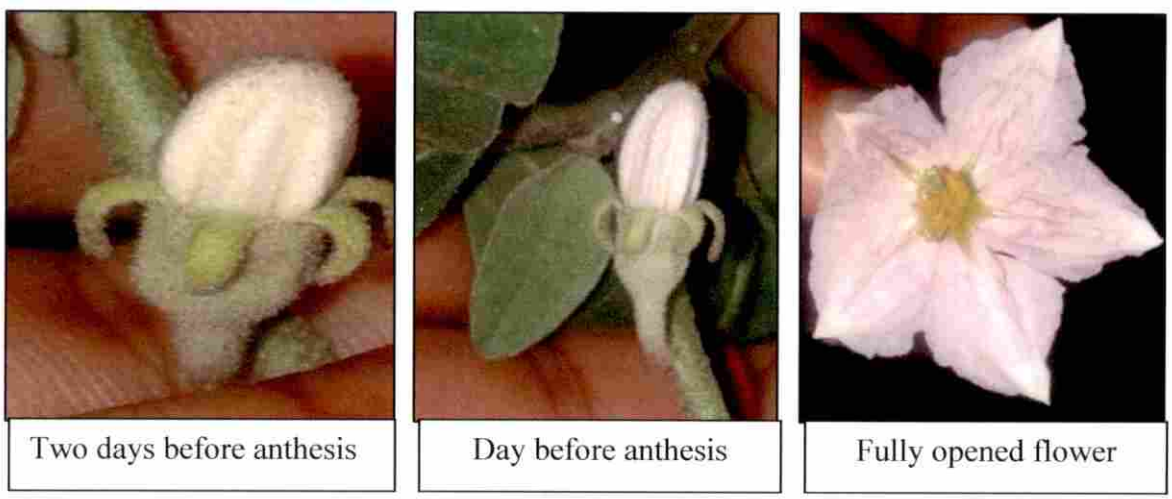


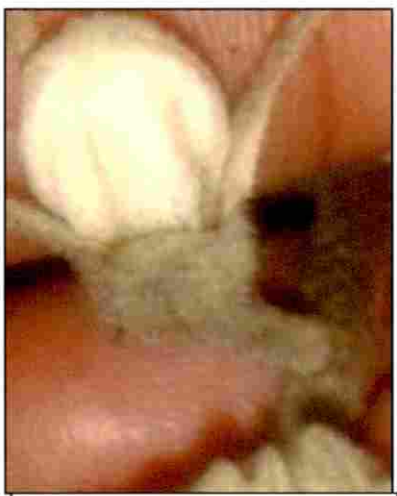

Plate 10. Stages of flower development in *S. incanum*

Mature flower bud

Immediately before anthesis

Fully opened flower

Plate 11. Stages of flower development in Haritha



Two days before anthesis

Day before anthesis

Fully opened flower

Plate 12. Stages of flower development in Surya

### 4.3.1. Determination of anther dehiscence

The colour and appearance of flower buds were observed with hand lens in fully mature buds starting from 6 a.m. on the previous day of anthesis in all the types and the results presented in Table 10.

The time of anther dehiscence varied with the species (Table 10). In the wild variants *S. viarum* and *S. incanum,* anthers dehisced between 9 a.m. to 10 a.m. and 9 a.m. to 12 a.m. respectively depending on weather conditions. The pollen grains dehisced nearly two to five hours after flower opening in these species. The dehiscence once started, continued for three days. However, in the cultivated types, Haritha and Surya, anther dehiscence commenced along with the opening of flowers. However, according to Oyelana and Oguwenmo (2012) anthers dehisced 30 minutes prior to anthesis in *S. melongena*. In *S. gilo*, the anthers dehisced nearly 30 minutes before flower opening. Oyelana *et al.* (2016) also reported that anther dehiscence in *S. gilo* occurred 30 minutes prior to the opening of flower. The pollen grains were dehisced through the apical pore of anthers in all the types evaluated (Plate 13).

Table 9. Anthesis in different species of *Solanum*

| Types | Time of flower opening | Corolla colour | | |
|---|---|---|---|---|
| | | Two days before anthesis | Previous day of anthesis | At anthesis |
| *S. viarum* | 6 to 7 a.m.<br>11. to 11.30 a.m.<br>(Sept. – Oct.) | White | Light violet | Light violet |
| *S. gilo* | 5 to 6 a.m. | White | White | White |
| *S. incanum* | 6 to 7 a.m. | White | Pale violet | Pale violet |
| *S. indicum* | Did not flower | | | |
| *S. melongena* | | | | |
| Haritha | 4 to 7 a.m. | White | White | White |
| Surya | 5 to 7 a.m. | White | Bluish violet | Bluish violet |

Table 10. Anther dehiscence in different species of *Solanum*

| Types | Anther dehiscence |
|---|---|
| *S. viarum* | 2-3 hours after flower opening |
| *S. gilo* | 30 minutes before flower opening |
| *S. incanum* | 2-5 hours after flower opening |
| *S. indicum* | Not flowered |
| *S. melongena* | |
| Haritha | At flower opening |
| Surya | At flower opening |

### 4.3.2. Determination of stigma receptivity

The stigmatic surface was observed for presence of exudates or colour change from the previous day of flower opening starting from 6 a.m. The onset of receptivity was indicated by the change in colour of the stigmatic surface (Plate 13). The plumpy

and sticky appearance of the stigmatic surface at the time of stigma receptivity was reported by Oyelana and Oguwenmo (2012). The loss of receptivity is indicated by the fading in the colour followed by drying up of the stigmatic surface. The results are presented in Table 11.

The change in the colour of the stigmatic surface from glossy green to deep yellow at the time of initiation of stigmatic receptivity is a unique feature of *S. gilo*. In other wild variants of *Solanum*, the the stigmatic surface at the time of peak stigmatic receptivity was observed to be moist plumpy and glossy green. The colour was found to fade with the decline in stigma receptivity. The *S. melongena* varieties Haritha and Surya also followed the same pattern.

Stigma became receptive an hour before flower opening in *S. viarum* and *S. incanum* and remained receptive for 36 hrs after flower opening (Table 11). In *S. gilo* stigma receptivity initiated an hour after flower opening and was retained till 48 hours after flower opening. Oyelana and Oguwenmo (2012) also reported that in wild species of *Solanum viz.*, *S. aethiopicum*, *S. gilo*, *S. anguivi*, and *S. scabrum*, stigma receptivity initiated about 45 minutes before anthesis. In *S. melongena* variety, Surya, the stigma became receptive 12 hrs before flower opening and remained receptive till 24 hours after flower opening. In *S. melongena* variety, Haritha, stigma receptivity initiated an hour before flower opening. However, the receptivity was retained only for 2 – 3 hours after flower opening (Table 11). In *S. melongena* peak stigmatic receptivity was observed nearly 60 minutes prior to the opening of flowers by Oyelana and Oguwenmo (2012). However, according to Tatebe (1938) stigma receptivity initiated a day prior to flower opening and continued for 2 days even after flower opening in brinjal. According to Kakizaki (1930) stigma became receptive immediately after anthesis in the flowers of brinjal and receptivity persisted for a

*S. viarum*

*S. incanum*

Unreceptive stigma

Receptive stigma

*S. gilo*

Haritha

Surya

Plate13. Anther dehiscence and stigma receptivity in different *Solanum* species

period of 2-3 days. Unlike in the present study Pal and Singh (1943) also observed that stigma receptivity initiated nearly 2hrs after anthesis in brinjal.

Table 11. Stigma receptivity in different species of *Solanum*

| Types | Stigma receptivity |
|---|---|
| *S. viarum* | One hour before flower opening to 36 hours after flower opening |
| *S. gilo* | One hour after flower opening to 48 hours after flower opening |
| *S. incanum* | One hour before flower opening to 36 hours after flower opening |
| *S. indicum* | Not flowered |
| *S. melongena* | |
| Haritha | One hour before flower opening till 2-3 hours after flower opening |
| Surya | 12 hours before flower flower opening till 24 hours after flower opening |

All the species evaluated except *S. gilo* exhibited protogyny. *S. gilo*, a wild species from N. E. India was found to be protandrous.

**4.4. Palynology**

The morphological features of the pollen grains including the size and shape of pollen grains were observed with a phase contrast microscope and the results are presented in Table 12.

The shape of the pollen grain was uniform in all the types evaluated (Plates 14 and 15). Pollen grains were oblong and bi or trizonocolporate. Exine was with ornamentation in all the species. Oyelana and Oguwenmo (2012) reported that the

shape of pollen grain might be round, oblong, triangular or rectangular depending on the species of *Solanum*.

There was significant variation among the types for the length of pollen grain. It was the highest (0.06 µm) in *S. viarum* and the lowest in *S. incanum* which was on par with *S. gilo*. Pollen grains of *S. melongena* Haritha and Surya did not differ significantly in length. However, their pollen grains were longer than that of the two wild variants *S. incanum* and *S. gilo*.

Table 12. Pollen morphology in different species of *Solanum*

| Types | Shape | Size of pollen | | |
|---|---|---|---|---|
| | | Length (µm) | Width (µm) | Perimeter (µm) |
| *S. viarum* | Oblong | 0.06 | 0.03 | 0.14 |
| *S. gilo* | Oblong | 0.02 | 0.04 | 0.13 |
| *S. incanum* | Oblong | 0.01 | 0.03 | 0.11 |
| *S. indicum* | Did not flower | | | |
| *S. melongena* | | | | |
| Haritha | Oblong | 0.05 | 0.03 | 0.14 |
| Surya | Oblong | 0.04 | 0.05 | 0.12 |
| CD (0.05) | - | 0.01 | 0.01 | 0.01 |
| CV (%) | - | 21.1 | 14.9 | 4.92 |

*S. viarum, S. incanum, S. gilo* and *S. melongena* type, Surya were on par with respect to the width of pollen grains. The width of the pollen grain was the highest in *S. melongena* type Surya. There was significant difference among the entries with respect to the perimeter of the pollen grains. However, Oyelana and Oguwenmo (2012) observed that *S. gilo* was having the largest pollen grains.

The fertility of the pollen grains in different species were also examined. Repeated observations were taken on pollen fertility in each type under evaluation, consecutively for three days after dehiscence and the results are presented in Table 13.

Table 13. Pollen fertility in different species of *Solanum*

| Types | Pollen fertility % | | |
|---|---|---|---|
| | On the day of flower opening | 2nd day of flower opening | 3rd day of flower opening |
| *S. viarum* | 94.04 | 90.08 | 97.33 |
| *S. gilo* | 75.50 | 87.50 | 44.61 |
| *S. incanum* | 83.35 | 92.42 | 69.15 |
| *S. indicum* | Did not flower | | |
| *S. melongena* | | | |
| Haritha | 87.70 | 91.90 | 85.30 |
| Surya | 91.60 | 87.95 | 97.33 |

In *S. incanum*, *S. gilo and S. melongena* variety Haritha pollen fertility was at peak during the second day of flower opening and declined on the third day of flower opening. Pal and Singh (1943) also observed maximum pollen fertility during the second day of flower opening in *S. melongena* (brinjal). In *S. viarum* and *S. melongena* variety Surya, pollen fertility declined during the second day of flower opening (90.08% and 87.95% respectively). However, on the third day of flower opening an increasing trend was noticed (97.33) and the fertility reached the peak on the third day of flower opening. With the closing of the flower on the third day evening the fertility was completely lost in all the species evaluated. Hence, it can be concluded that pollen viability lasted for only three days in all the genotypes

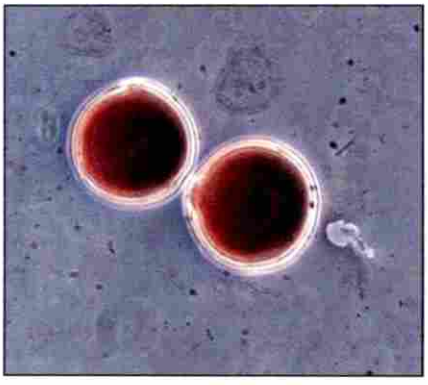


Plate 14. Structure of pollen grains in *Solanum* species

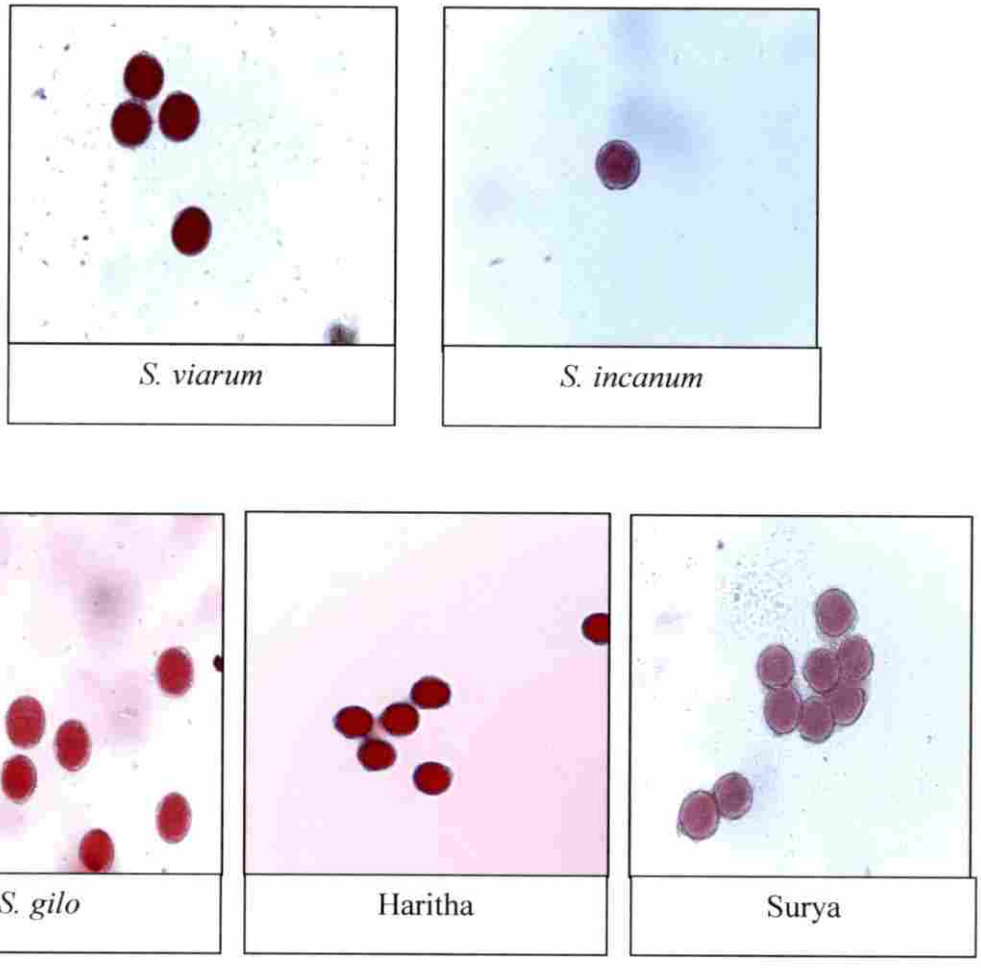



Plate 15. Pollen morphology of different species of *Solanum*

evaluated. In contrary to this, Popova (1958) found that pollen grains remained viable up to 7-10 days in *S. melongena* (brinjal).

**4.5. Mode of pollination**

Mode of pollination prevalent in the *Solanum* species was estimated by observing the fruit set in three different sets of mature flower buds *viz.*, protected, unprotected and emasculated but unprotected buds (Plate 16). The long styled flowers alone were used for this study. The results are presented in Table 14.

Table 14. Fruit set in protected and unprotected buds in different species of *Solanum*

| Types | Fruit set (%) | | |
|---|---|---|---|
| | Protected | Emasculated but unprotected | Unprotected |
| *S. viarum* | 0 | 0 | 60 |
| *S. gilo* | 0 | 0 | 0 |
| *S. incanum* | 0 | 0 | 80 |
| *S. indicum* | Did not flower | | |
| *S. melongena* | | | |
| Haritha | 0 | 0 | 80 |
| Surya | 0 | 0 | 100 |

None of the protected buds set fruits. It indicates the absence of self pollination. Magtang (1936) also observed that flowers of eggplant did not set fruits on bagging. However, according to Kakizaki (1930) flowers of eggplant were self pollinated to certain extent.

No fruit set observed in emasculated but unprotected buds also. It may be because of the absence of sufficient pollinators. Cross pollination occurred in brinjal

Protected buds

Emasculated but unprotected buds

Unprotected buds

Plate 16. Conditions of flower buds for estimation of mode of pollination

due to transfer of pollen by thrips, ants and bees (George, 1985; Lawande and Chavan, 1998). Abak *et al.* (1995), Stepowska (1996) and Dobromilska (1997) observed that bumble bees were helpful in increasing fruit set in eggplants.

With unprotected buds, fruit set ranging from 60% in *S. viarum* to 100% in *S. melongena* type Surya was observed (Table 14). This indicates that *Solanum* species are adapted to cross pollination.

Cross pollination is reported to occur in brinjal due to the transfer of pollen by thrips, ants and bees (George, 1985; Lavande and Chavan, 1998). Popova (1958) reported that fruit set was maximum in brinjal when stigma received pollen from different plants. Out crossing to an extend of 6.7% was reported by Sambandam (1964) in the flowers of eggplant. According to Agarwal (1980), out crossing occurred to an extent of 0 to 48 per cent in eggplant and hence, can be treated as an often cross pollinated crop.

**4.6. Evaluation of fruit characters**

Various qualitative and quantitative characters of fruits belonging to the different species of *Solanum* were observed since initiation of fruit set till ripening of fruits.

Observations on various qualitative characters of the fruit such as position of the fruit, presence or absence of prickles on pedicel, fruit colour at commercial ripeness, colour at physiological ripeness, fruit shape (position of the broadest portion of the fruit), fruit curvature, cross section of the fruit, fruit apex and fruit flesh density were recorded following the IPGRI descriptor and are presented in Table 15.

The fruits were observed to be pendant in all the wild variants as well as in *S. melongena* varieties Haritha and Surya. Prickles were present on the pedicel of fruits in *S. viarum* alone. While the other wild variant exhibited non prickly nature, like that of *S. melongena* varieties Haritha and Surya.

At commercial ripeness, fruits of *S. incanum* were pale green in colour. *S. melongena* variety Haritha also exhibited a similar colouration at commercial ripeness. The fruits of *S. viarum* were green with white stripes and that of *S. melongena* variety Surya were purple in colour. The fruit colour at commercial ripeness recorded in different types are presented in Plate 17.

There was uniform distribution of colour in the fruits of *S. incanum* as well as in *S. melongena* types Haritha and Surya at commercial ripeness. However, a mottled distribution of colour was observed in the commercially ripe fruits of *S. viarum*.

Table 15. Qualitative characters of fruits in different species of *Solanum*

| Types | Position | Colour at commercial ripeness | Colour distribution at commercial ripeness | Colour at Physiological maturity | Curvature | Cross section | Shape ( Position of the broadest portion) | Apex | Flesh density |
|---|---|---|---|---|---|---|---|---|---|
| *S. viarum* | Pendant | Green with white stripes | Mottled | Deep yellow | None | Circular, without grooves | 1/2 way from base | Rounded | Loose |
| *S. gilo* | No fruit set | | | | | | | | |
| *S. incanum* | Pendant | Pale green | Uniform | Deep yellow | None | Circular, without grooves | 1/2 way from base | Rounded | Loose |
| *S. indicum* | No flowering | | | | | | | | |
| *S. melongena* | | | | | | | | | |
| Haritha | Pendant | Pale green | Uniform | Deep yellow | Slightly curved | Circular, without grooves | $3/4^{th}$ way from base | Protruded | Very dense |
| Surya | Pendant | Purple | Uniform | Light brown | None | Circular, without grooves | 1/2 way from base | Rounded | Dense |

The fruit colour completely changed from pale green to deep yellow at physiological maturity in *S. incanum* as well as *S. melongena* variety Haritha. However, in *S. viarum* the fruit colour changed from green to deep yellow at physiological maturity (Plate 18). In *S. melongena* variety, Surya the change in colour was from purple to light brown. George (1985) reported that fruits of brinjal were green, violet or purple in colour at utility ripeness and brown or yellow at physiological ripeness. According to Swarup (1995) fruits of brinjal attained brown, red or yellow colour at physiological ripeness.

No curvature was observed in the fruits of *S. viarum, S.incanum* as well as *S. melongena* variety Surya. However, the fruits of *S. melongena* type Haritha were slightly curved and distinctly different from Surya. The cross section of the fruits of the wild variants as well as *S. melongena* varieties, Haritha and Surya were circular, without any grooves (Plates 19).

The position of the broadest portion of the fruit belonging to the wild variants, *S. viarum* and *S.incanum,* was at about half way from the base towards the tip, as in *S. melongena* variety Surya. The fruits of *S. melongena* variety, Haritha had the broadest portion at about $3/4^{th}$ way from the base towards the tip (Plate 17).

The fruit apex was rounded in *S. viarum, S.incanum* as well as in *S. melongena* variety Surya. The apex of fruits in *S. melongena* type, Haritha was protruded (Plate 17).

The flesh density of fruits in *S. viarum* and *S.incanum* were loose, while that of *S. melongena* variety, Surya was dense. However, the flesh density of *S. melongena* variety, Haritha was very dense (Plate 19). The cotyledon colour of seeds was yellow in all the entries.

*S. gilo,* though flowered well, did not set fruits. This may be attributed to its endemic nature to North – East regions.

*S. viarum*

*S. incanum*

Surya

Haritha

Plate 17. Fruits of different *Solanum* species at commercial ripeness

*S. viarum*

*S. incanum*

Haritha

Surya

Plate 18. Fruits of different *Solanum* species at physiological ripeness

*S. viarum*

*S. incanum*

Haritha

Surya

Plate 19. Cross section of fruits of different *Solanum* species

The *S. melongena* variety, Haritha differed from Surya in the nature of fruit apex, position of the broadest portion of the fruit, curvature of fruit and change in fruit colour at maturity and physiological ripeness (Table 15).

The fruits in all the evaluated types were observed, since the initiation of fruit set till the attainment of fruit maturity for various biometric characters like days from fruit set to maturity, length and breadth of fruit, weight of fruit and relative fruit calyx length per cent. The results are presented in Table 16.

There was significant difference among the entries with respect to days taken for maturity of the fruits from anthesis. The wild variants, *S. viarum* and *S. incanum* took significantly more number of days for the fruits to mature after their setting in comparison with the cultivated type *S. melongena*. Even the cultivated types, Haritha and Surya differed significantly in this character.

From the Table 16, it can be seen that fruit length varied from 4.50 cm in *S. incanum* to 16.40 cm in *melongena* variety, Haritha. The fruit length was significantly lower in the wild variants *S. viarum* and *S. incanum* compared to the *S. melongena* types Haritha and Surya. Haritha was having nearly double sized fruits when compared to Surya (16.40cm and 8.80cm respectively).

Similarly, the fruit breadth in the wild variants, *S. viarum* and *S. incanum* were on par. The fruits of *S. melongena* varieties Haritha and Surya were significantly broader compared to the wild species. The highest fruit breadth was observed in Surya and the lowest in *S. incanum.* There was a significant difference among the *S. melongena* types Haritha and Surya in breadth of fruits as well.

The wild species exhibited significantly lower fruit weight compared to the *S. melongena* variety Surya. The fruit weight of the wild species, *S. viarum* and *S. incanum* were on par with that of Haritha, a *S. melongena* variety. Among the types

evaluated, the heaviest fruits were found in *S. melongena* type, Surya and the lightest in *S. viarum.*

Significant variation was observed among the entries for relative fruit calyx length. The relative fruit calyx length in *S. viarum* was significantly higher than that of *S. melongena* variety, Haritha but, lower than that of *S. melongena* variety, Surya. The *S. incanum* was having relative fruit calyx length significantly lower than both the *S. melongena* types (Table 16).

Table 16. Biometric characters of fruit in different species of *Solanum*

| Types | Length (cm) | Breadth (cm) | Weight (g) | Days from fruit set to maturity | Relative fruit calyx length (%) |
|---|---|---|---|---|---|
| *S. viarum* | 5.12 | 8.44 | 72.01 | 30.40 | 35.02 |
| *S. gilo* | Did not set fruits | | | | |
| *S. incanum* | 4.50 | 8.34 | 84.35 | 34.20 | 27.26 |
| *S. indicum* | Did not flower | | | | |
| *S. melongena* | | | | | |
| Haritha | 16.40 | 10.88 | 144.4 | 25.80 | 29.96 |
| Surya | 8.80 | 12.22 | 200.99 | 20.60 | 38.05 |
| CD (0.05) | 1.33 | 1.10 | 70.42 | 1.77 | 1.79 |
| CV (%) | 11.42 | 8.23 | 41.87 | 4.77 | 4.08 |

### 4.7. Cluster analysis

Cluster analysis was done and dendrograms were constructed using 'NTSYS' software for qualitative characters and 'Minitab 17' for biometric characters. Since one species did not flower and another did not set fruits though flowered, separate dendrograms were drawn taking into consideration vegetative characters alone, vegetative and floral characters together and fruit characters alone.

#### 4.7.1. Vegetative characters

Seven qualitative characters in all the evaluated types were considered and the dendrogram obtained is depicted in Fig 2. The clusters obtained at 75% similarity and the members included in each cluster are presented in Table 17.

At 75 per cent similarity level four clusters were obtained. Among the types evaluated, *S. viarum*, *S. indicum and S. incanum* fell into three different clusters. However, *S. gilo*, a wild type was grouped in the same cluster along with *S. melongena* varieties, Haritha and Surya indicating its similarity with cultivated species. Haritha and Surya exhibited cent per cent similarity in vegetative characters. This may be because of the similarity in growth habit, branching habit and leaf characters. The other wild variants were distinct from the cultivated varieties and also from each other. Among the wild types, in qualitative vegetative characters, *S. indicum* was found to be more distinct from other types followed by *S. viarum* and *S. incanum* (Fig. 2).

Dendrogram was also constructed based on eight quantitative vegetative characters. The Fig. 3 depicts the dendrogram based on biometric vegetative characters. At 69% similarity three clusters were obtained (Table 18). *S. melongena* varieties, Haritha and Surya, fell into the same cluster. *S. viarum, S. incanum* and *S. gilo* were grouped together *S. indicum* formed a separate cluster. The cluster distances

are presented in Table 19. The highest cluster distance was obtained between cluster I and cluster II.

In the clustering pattern obtained based on qualitative as well as quantitative vegetative characters *S. indicum* was distinctly different from all the other types.

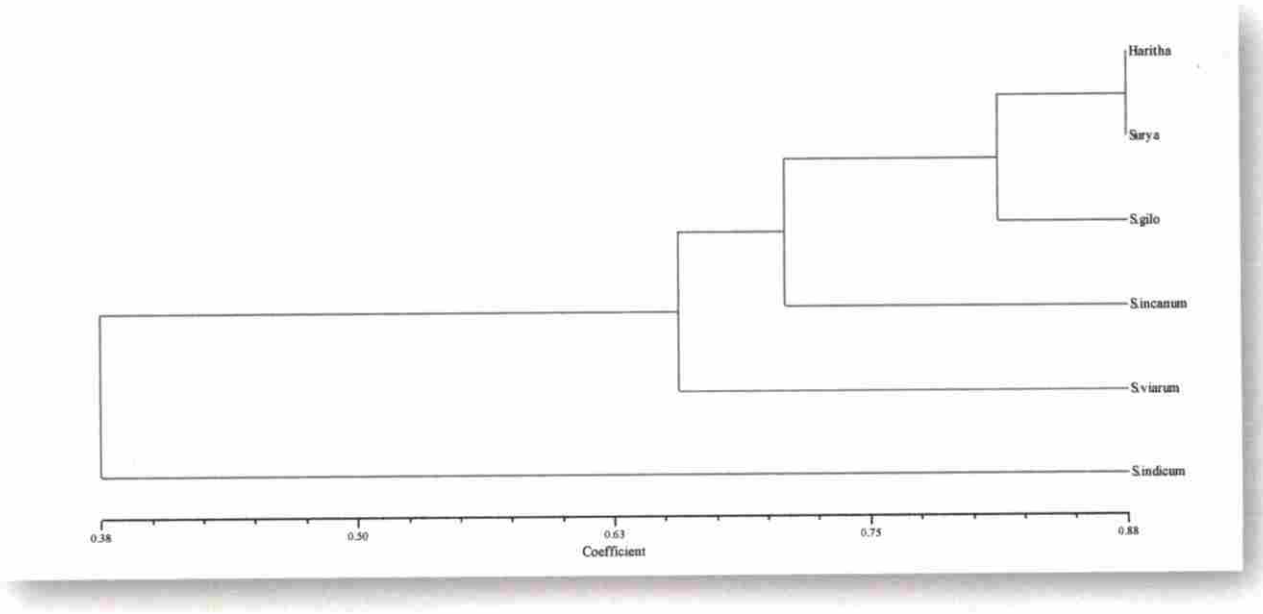



Fig. 2. Dendrogram based on qualitative vegetative characters

Table 17. Details of clusters formed based on qualitative vegetative characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. indicum* |
| 2 | II | *S. viarum* |
| 3 | III | *S. incanum* |
| 4 | IV | *S. gilo*, *S. melongena* types Haritha and Surya |

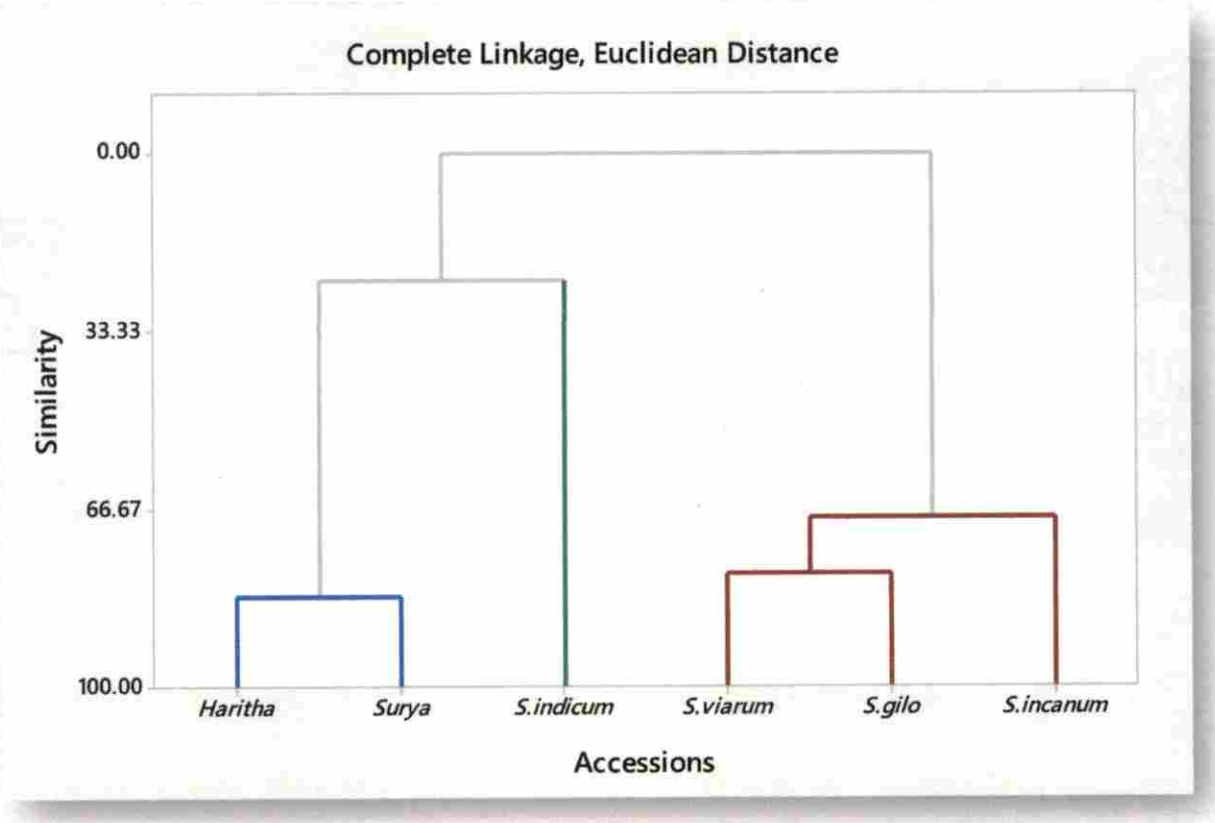



Fig. 3. Dendrogram based on quantitative vegetative characters

Table 18. Details of clusters formed based on biometric vegetative characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. melongena* types Haritha and Surya |
| 2 | II | *S. viarum*, *S. incanum*, *S. gilo* |
| 3 | III | *S. indicum* |

Table 19. Inter cluster distances based on vegetative characters

| Cluster No. | Cluster I | Cluster II | Cluster III |
|---|---|---|---|
| Cluster I | 0.00 | 62.40 | 48.18 |
| Cluster II | | 0.00 | 56.47 |
| Cluster III | | | 0.00 |

### 4.7.2. Vegetative and floral characters

The cluster analysis was also done taking vegetative and floral characters in all the types but excluding *S. indicum* which did not flower. Both qualitative and quantitative characters were considered. Results are presented in Tables 20, 21 and 22.

In the cluster diagram obtained based on seven qualitative vegetative characters along with two qualitative floral characters (Fig. 4) four clusters were obtained at 75 per cent similarity (Table 20). *S. melongena* varieties Haritha and Surya were falling in different cluster. Though *S. gilo*, a wild species and Haritha, a *S. melongena* variety were forming a single cluster. *S. melongena* variety surya as well as the wild species *S. incanum* and *S. viarum* formed separate clusters. *S. viarum* bearing prickles on leaf, stem and calyx was distinct from all the other types evaluated.

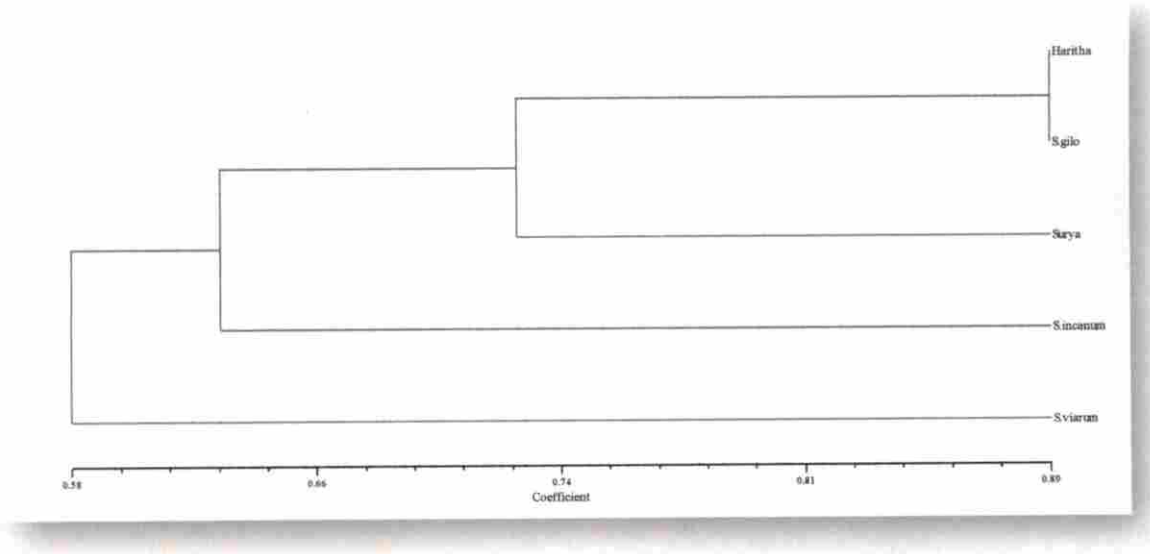



Fig. 4. Dendrogram based on qualitative vegetative and floral characters

Table 20. Details of clusters formed based on qualitative vegetative and floral characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. viarum* |
| 2 | II | *S. incanum* |
| 3 | III | *S. melongena* variety Surya |
| 4 | IV | *S. gilo*, *S. melongena* variety Haritha |

The Dendrogram drawn considering 14 biometric vegetative and floral characters together is shown as Fig. 5. At 69.58 per cent similarity level, three clusters were obtained (Table 21). The cluster distances are presented in Table 22. The highest cluster distance was observed between clusters I and II (64.82) followed by clusters I and III (63.80). The cluster distance between clusters II and III is only 27.53. Hence, they are more closely related.

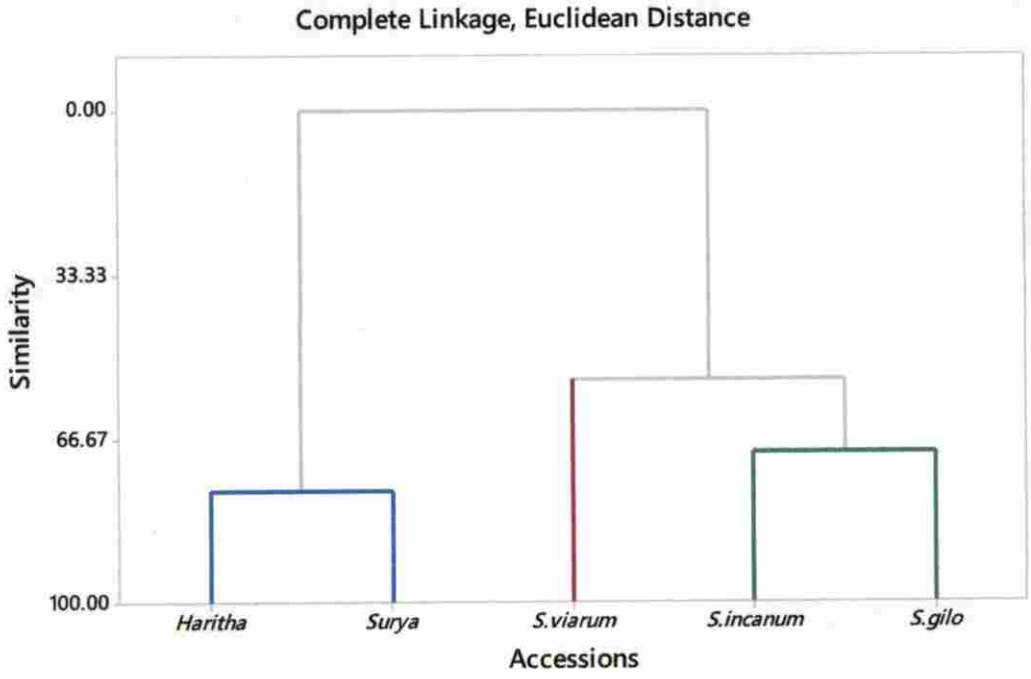



Fig. 5. Dendrogram based on biometric vegetative and floral characters

Table 21. Details of clusters formed based on biometric vegetative and floral characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. melongena* varieties Haritha and Surya |
| 2 | II | *S. viarum* |
| 3 | III | *S. incanum*, *S. gilo* |

Table 22. Inter cluster distances based on vegetative and floral characters

| Cluster No. | Cluster I | Cluster II | Cluster III |
|---|---|---|---|
| Cluster I | 0.00 | 64.82 | 63.80 |
| Cluster II | | 0.00 | 27.53 |
| Cluster III | | | 0.00 |

### 4.7.3. Fruit characters

The cluster analysis was also attempted taking into consideration nine qualitative and seven quantitative characters of the fruits of genotypes which had set fruits. Hence, *S. gilo* and *S. indicum* were not included for this clustering.

At 60% similarity three clusters were obtained in the dendrogram drawn considering qualitative fruit characters alone (Fig. 6 and Table 23). At 65 per cent similarity, three clusters were formed. Fruits of both wild were observed to be distinct from each other. Haritha and Surya, the varieties belonging to *S. melongena* were falling in the same cluster.

Separate dendrogram was also drawn considering only the biometric characters of fruits. Seven characters were considered. Among all the entries, *S. viarum* and *S. incanum* were closely related. Three clusters were formed at 84.40 per cent similarity (Fig. 7). The clusters formed and inter cluster distances are presented in Tables 24 and 25 respectively.

All the clustering patterns revealed that *S. melongena* varieties, Haritha and Surya were distinct from the wild species.

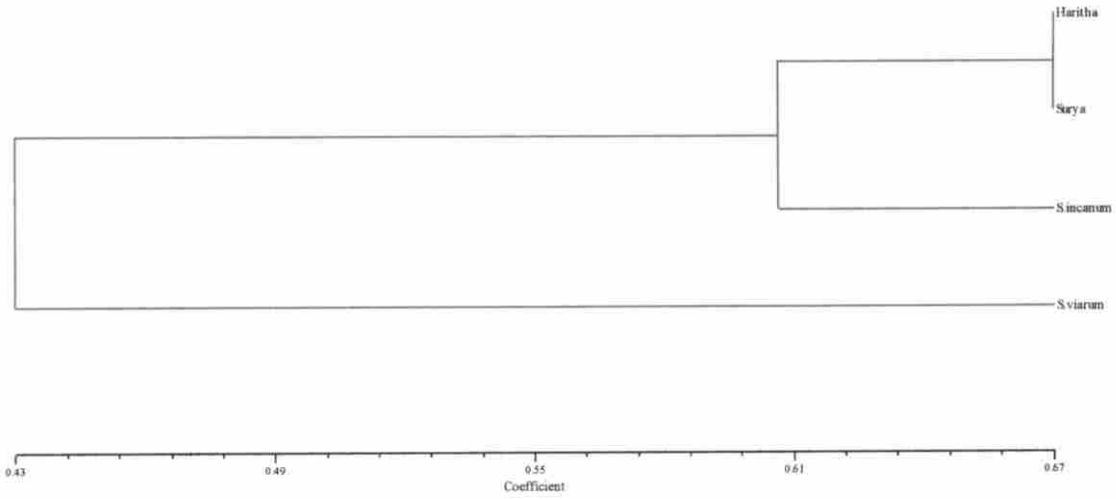



Fig. 6. Dendrogram based on qualitative fruit characters

Table 23. Details of clusters formed based on qualitative fruit characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. melongena* varieties Haritha and Surya |
| 2 | II | *S. incanum* |
| 3 | III | *S. viarum* |

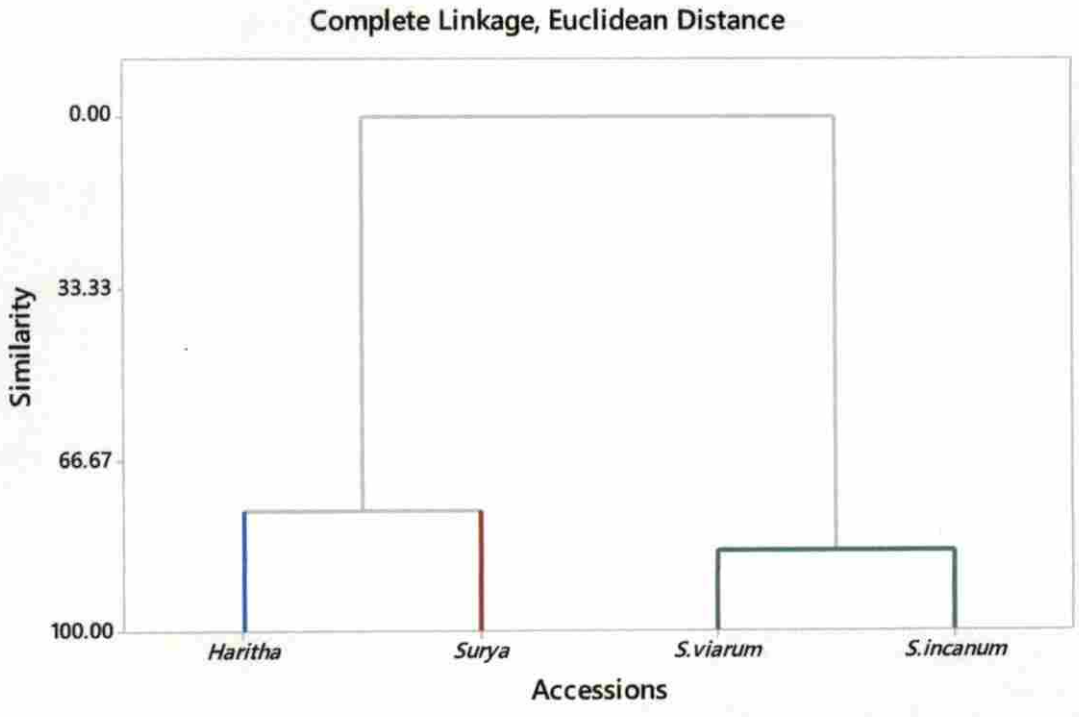



Fig. 7. Dendrogram based on quantitative fruit characters

Table 24. Details of clusters formed based on biometric fruit characters

| Sl. No. | Cluster No. | Cluster members |
|---|---|---|
| 1 | I | *S. melongena* variety Haritha |
| 2 | II | *S. melongena* variety Surya |
| 3 | III | *S. viarum*, *S. incanum* |

Table 25. Inter cluster distances based on fruit characters

| | Cluster 1 | Cluster 2 | Cluster 3 |
|---|---|---|---|
| Cluster 1 | 0.00 | 30.27 | 97.84 |
| Cluster 2 | | 0.00 | 123.56 |
| Cluster 3 | | | 0.00 |

**4.7.4. Descriptive statistics**

Descriptive statistics for various biometric characters in *Solanum* species is presented in Table 26.

High Phenotypic Coefficient of Variation (PCV) was observed for all the characters except relative fruit calyx length. The highest PCV was observed for petiole length (137.87%) and the lowest for relative fruit calyx length (17.10%). Genotypic Coefficient of Variation (GCV) was high for most of the characters observed. Petiole length recorded the highest GCV (113.26%). However, stem girth, circumference of flower bud, fruit breadth and relative fruit calyx length exhibited moderate GCV.

High heritability was observed for days to germinate, days to transplant, stem girth, petiole length, lamina length, lamina breadth, days to flower bud initiation, length of flower bud, sepal lobe length, petal lobe length, days from anthesis to fruit set, fruit length, fruit breadth, days from fruit set to maturity and relative fruit calyx length. Among the characters observed, the lowest heritability was recorded by number of flowers per inflorescence (33.33%) and the highest by days to transplant (99.60%)

Genetic Gain (GG) was high for all the biometric characters. Petiole length recorded the highest GG (191.62%) followed by fruit length (126.44%).

Petiole length and fruit length were having high Genotypic Coefficient of Variation coupled with high heritability and Genetic Gain. Selection programme based on petiole length can bring about an improvement of 191.62 % in the population. An improvement of 126.44% can be brought about in the population if selection programme is based on fruit length.

Table 26. Descriptive statistics for biometric characters in different species of *Solanum*

| Character | PCV (%) | GCV (%) | Heritability (%) | Genetic Gain (%) |
|---|---|---|---|---|
| Days to germinate | 39.02 | 38.68 | 98 | 79.02 |
| Days to transplant | 23.66 | 23.62 | 99.6 | 48.56 |
| Plant height (cm) | 27.86 | 20.69 | 55.10 | 31.63 |
| Stem girth (cm) | 20.12 | 17.38 | 74.65 | 30.93 |
| Petiole length (cm) | 137.87 | 113.26 | 67.50 | 191.62 |
| Lamina length (cm) | 62.92 | 52.17 | 68.84 | 89.24 |
| Lamina breadth (cm) | 49.54 | 46.28 | 87.00 | 88.92 |
| Days for initiation of flower bud | 22.65 | 22.48 | 98.46 | 45.95 |
| Flowers/inflorescence | 55.67 | 32.14 | 33.33 | 38.23 |
| Flower bud length (cm) | 32.19 | 27.33 | 72.10 | 47.80 |
| Circumference flower bud (cm) | 23.58 | 16.87 | 51.18 | 24.86 |
| Sepal lobe length (cm) | 37.02 | 33.57 | 82.19 | 62.69 |
| Petal lobe length (cm) | 37.63 | 31.01 | 68 | 52.65 |
| Petal lobe breadth (cm) | 47.56 | 33.19 | 48.69 | 47.71 |
| Days from anthesis to fruit set | 21.48 | 20.11 | 88.11 | 38.91 |
| Days from fruit set to maturity | 21.58 | 21.04 | 95.12 | 42.29 |
| Relative fruit calyx length (cm) | 17.10 | 16.51 | 92.93 | 32.74 |
| Fruit length (cm) | 63.45 | 62.44 | 96.76 | 126.44 |
| Fruit breadth (cm) | 20.46 | 18.75 | 83.81 | 35.30 |
| Fruitweight (g) | 60.42 | 43.55 | 51.96 | 64.66 |

PCV and GCV (Sivasubramanian and Menon, 1973): - Low: less than 10%, Moderate: 10-20 %, High: more than 20%

$h^2$ (Johnson *et al.*, 1955): - Low: less than 30%, Moderate: 30-60 %, High: more than 60%

GG (Johnson *et al.*, 1955): - Low : less than 10%, Moderate: 10-20 %, High: more than 20%

### 4.8. Cross compatibility among wild and cultivated species of *Solanum*

The hybridization was done with *S. melongena* varieties Haritha and Surya taking the wild variants as both male and female parents (Plate 20). The long styled flowers in the selected female parents were emasculated on the previous day of anthesis and carefully bagged. During peak period of stigma receptivity pollen from the desired male parent was dusted on the stigma and again protected. Soda straw method was also tried for emasculation.

#### 4.8.1. Evaluation of cross compatibility

Emasculation and pollination done using soda straw did not give any results (Plate 20). However, when hand emasculation was done fruit set was obtained. The fruit set in each cross was recorded and the results are presented in Table 27.

*S. melongena* variety, Haritha, when used as female parent, was not compatible with *S. viarum*. However, the reciprocal cross (*S. viarum* x *S. melongena* variety Haritha) was compatible with a fruit set of six per cent (Table 27).

When the pollen of *S. incanum* was dusted on *S. melongena* variety Haritha, long pale green fruits were obtained. A fruit set of 5.55% was observed in this cross. However, in the reciprocal cross there was a fruit set of 20 %.

*S. melongena* variety Haritha when used either as female or male parent with *S. gilo* did not produce any fruits.

*S. melongena* variety Surya when used as female parent and *S. viarum* as male parent a fruit set of 20 per cent was noticed. In accordance with this Ghosh *et al.* (2011) obtained successful hybrids when *S. melongena* was crossed with *S. viarum*.

The reciprocal cross (*S. viarum* x Surya) was also successful. A fruit set of 20% was observed in the reciprocal cross also.

When the pollen of *S. incanum* was dusted on the stigma of *S. melongena* type Surya, the fruits produced were dark violet with green triangular patches. Size and shape of the fruits were similar to that of Surya. There was no fruit set in the

Emasculation

Emasculated flower

Hand pollination

Soda straw method

Pollination

Bagging

Plate 20.Steps in hybridisation of *Solanum* species

reciprocal cross (*S. incanum* x Surya). According to Vishwanathan (1975), Rao (1975) and Handique (1986) *S. melongena* was not cross compatible with most of the wild relatives except *S. incanum.* Nishio *et al.* (1984) found that *S. melongena* was more closely related to *S. incanum* than any other species. The crossability of *S. melongena* with *S. incanum* was also reported by (Daunay *et al*, 1991; Nee, 1991; Rao, 2011).

In the cross of S. melongena variety Surya with *S. gilo* there was initiation of fruit set. However, there was fruit drop within 4 days after initiation of fruit set due to embryo abortion. The reciprocal cross was also unsuccessful (Table 27). However, Behera *et al.* (2006) obtained 54% fruit set in crosses between *S. gilo* as male parent with various cultivars of *S. melongena viz.*, Annamalai and Pusa kranthi. Yadhav *et al.* (2005) obtained successful hybrids when *S. gilo* was used as a male parent in cross between various variants of *S. melongena viz.*, Pongal, Arka keshav and RCMB-1. Ali and Fujieda (2007) also reported that *S. melongena* were compatible with *S. gilo.*

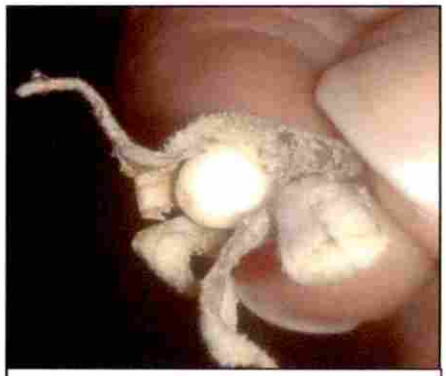
Table 27. Fruit set in different direct and reciprocal crosses

| Crosses | Fruit set (%) | Compatibility |
|---|---|---|
| *S. melongena* variety Haritha X *S. viarum* | 0 | No |
| *S. melongena* variety Haritha X *S. incanum* | 5.55 | Yes |
| *S. melongena* variety Haritha X *S. gilo* | 0 | No |
| *S. viarum* X *S. melongena* variety Haritha | 6.00 | Yes |
| *S. incanum* X *S. melongena* variety Haritha | 20.00 | Yes |
| *S. gilo* X *S. melongena* variety Haritha | 0 | No |
| *S. melongena* variety Surya X *S. viarum* | 20.00 | Yes |
| *S. melongena* variety Surya X *S. incanum* | 6.00 | Yes |
| *S. melongena* variety Surya X *S. gilo* | 0 Fruit drop 4 days after initiation of fruit set | No |
| *S. viarum* x *S. melongena* variety Surya | 20 | Yes |
| *S. incanum* x *S. melongena* variety Surya | 0 | No |
| *S. gilo* x *S. melongena* variety Surya | 0 | No |

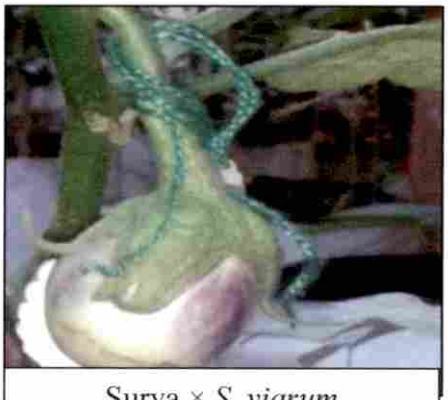
*S. viarum* × Haritha

Haritha × *S. incanum*

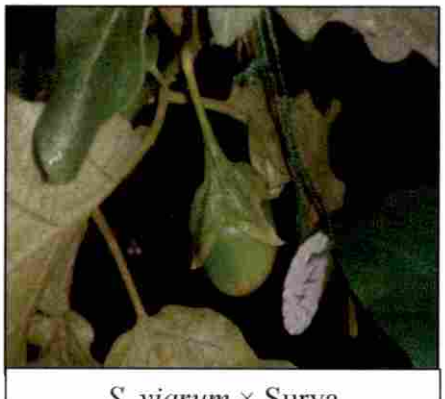
*S. incanum* × Haritha



Surya × *S. gilo*



Surya × *S. viarum*



*S. viarum* × Surya

Surya × *S. incanum*

Plate 21. Hybrid fruits from various inter specific croses of *Solanum* species

**4.8.2. Evaluation of hybrid fruits**

The fruits obtained after crossing were harvested at the stage of physiological ripeness. The qualitative characters of hybrid fruits obtained from different successful crosses are depicted below.

The fruits from the cross *S. viarum* x *S. melongena* variety Haritha were small green with white stripes. The colour and shape of the fruits were similar to that of the female parent *S. viarum*. Fruit apex was rounded. The broadest portion of the fruit was at about half way from base to tip (Plate 21).

Long pale green fruits were formed in the cross of *S. melongena* variety Haritha with *S. incanum* as male parent. The fruit apex was protruded. The shape and colour of the fruit was similar to that of the female parent , Haritha (Plate 21).

Pale green fruits similar to that of the female parent *S. incanum* in size and shape were obtained in the cross of *S. incanum* as female parent with *S. melongena* variety Haritha (Plate 21).

Small egg shaped fruits with green patches on the violet surface were formed in the cross of Surya as female parent with *S. viarum*. The fruit apex was rounded and the broadest portion of fruit was at about half way from the base to tip (Plate 21).

The hybrid fruits of *S. viarum* x Surya were green with white stripes. The colour and shape of the fruits were exactly like that of the female parent *S. viarum*. The position of the broadest portion of the fruit was at about half way from the base to tip. The fruit apex was rounded (Plate 21).

The fruits produced in the cross Surya with *S. incanum* as male parent were dark violet with green triangular patches. The size and shape of the fruits were similar to that of Surya (Plate 21).

The biometric characters of hybrid fruits such as fruit weight, number of seeds per fruit and 100 seed weight are presented in Table 28.

The fruit weight was the highest in *S. melongena* variety Haritha x *S. incanum* and the lowest in *S. viarum* x Surya. The highest number of seeds were observed in the fruits from *S. melongena* variety Haritha x *S. incanum* and the lowest in *S. viarum* x *S. melongena* variety Surya. The 100 seed weight was the highest in *S. viarum* x Surya fruits and the lowest in Haritha x *S. incanum.*

The mean number of days to germinate, germination per cent and survival in the field exhibited by the hybrid seeds from various crosses involving wild variants and *S. melongena* types are presented in Table 29.

The highest germinability was observed for the hybrid seeds from the cross Surya x *S. viarum* (91.67%) and the lowest for seeds from *S. viarum* x Haritha (41%). The days taken to germinate was the highest in *S. melongena* variety Haritha x *S. incanum* seeds and the lowest in *S. viarum* x *S. melongena* variety Haritha seeds.

Table 28. Biometric characters of hybrid fruits and seeds from various crosses

| Cross | Fruit weight (g) | Seeds/ fruit | 100 Seed weight (g) |
|---|---|---|---|
| *S. viarum* x Haritha | 29.80 | 131.00 | 2.65 |
| Haritha x *S. incanum* | 259.70 | 618.00 | 1.70 |
| *S. incanum* x Haritha | 66.28 | 233.00 | 2.03 |
| Surya x *S. viarum* | 43.40 | 124.66 | 2.68 |
| *S. viarum* x Surya | 28.07 | 114.66 | 3.79 |
| Surya x *S. incanum* | 215.70 | 462.00 | 2.58 |

Table 29. Germinability of hybrid seeds and survival of hybrid seedlings

| Cross | Days to germinate | Germination % | Survival in field (%) |
|---|---|---|---|
| *S. viarum* x Haritha | 2.67 | 41.00 | 0 |
| Haritha x *S. incanum* | 70.00 | 7.00 | 0 |
| *S. incanum* x Haritha | 61.50 | 6.00 | 0 |
| Surya x *S. viarum* | 4.33 | 91.67 | 100.00 |
| *S. viarum* x Surya | 4.00 | 85.00 | 66.67 |
| Surya x *S. incanum* | 6.00 | 55.00 | 70.00 |

The seedlings of *S. viarum* x *S. melongena* variety Haritha, *S. melongena* variety Haritha x *S. incanum* and *S. incanum* x *S. melongena* variety Haritha did not establish in the field, indicating hybrid inviability. Seedlings of *S. melongena* variety Surya x *S. viarum* and *S. melongena* variety Surya x *S. incanum* showed 100 per cent survival in the field. However, seedlings of *S. viarum* x Surya showed a survival per cent of 66.67 (Plates 22, 26 and 30) only. The production of hybrid seeds was found to be hampered by pre and post fertilization barriers (Gowda and Seenappa, 1991; Behera and Singh, 2002) in *Solanum* species.

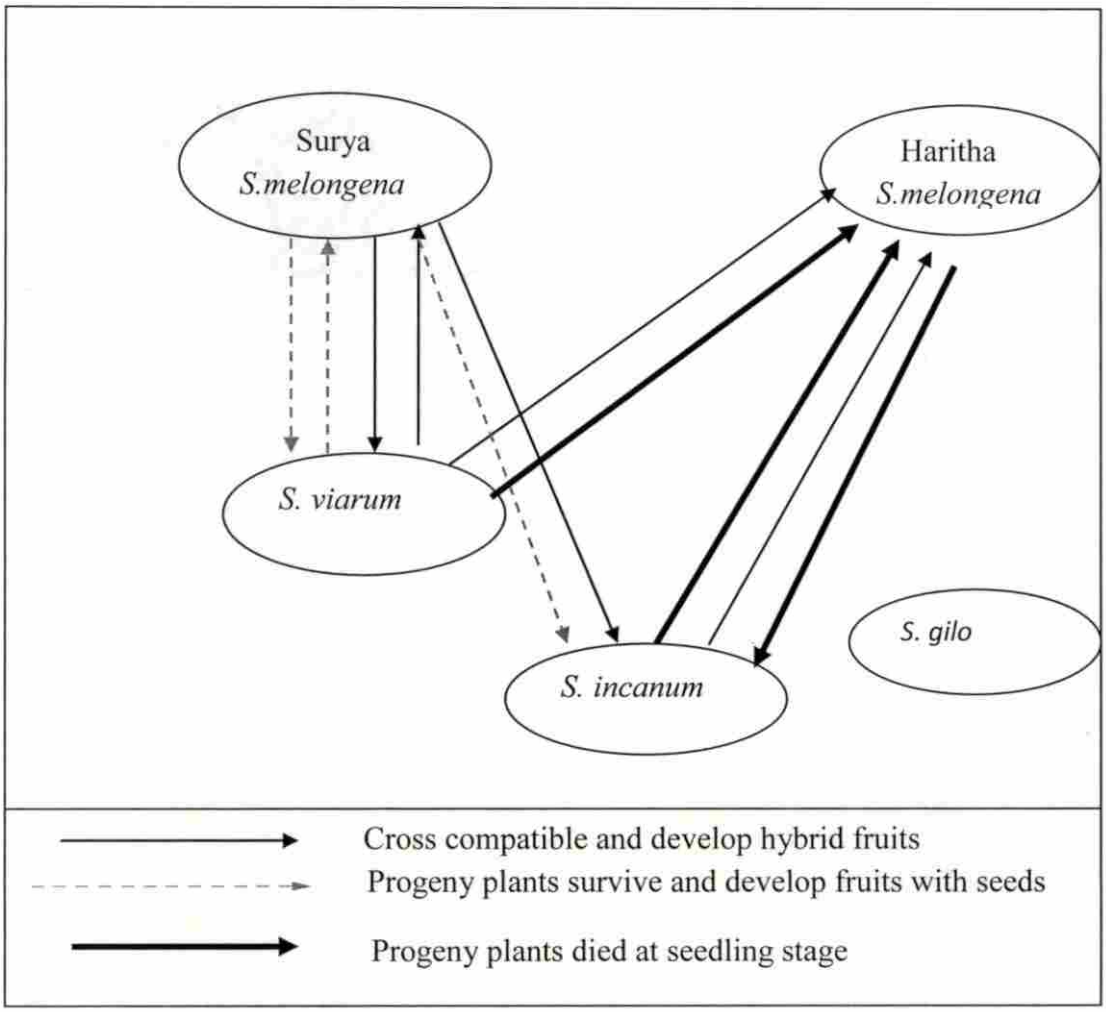



Fig. 8. Cross compatibility among the wild and cultivated varieties of *Solanum* species

### 4.9. Evaluation of the progeny

Among the successful crosses that set seeds, the progeny of only three crosses *viz., S. melongena* variety Surya x *S. viarum*, *S. viarum* x *S. melongena* variety Surya and *S. melongena* variety Surya x *S.* incanum, could be carried forward for field evaluation. Four progeny plants of the cross *S. melongena* variety Surya x *S. viarum*, ten plants of the cross *S. viarum* x *S. melongena* variety Surya cross and seven plants of the cross *S. melongena* variety Surya x *S.incanum* established in the field and set fruits. Progeny plants were subjected to evaluation based on various phytographic characters. Both qualitative and quantitative characters were considered for evaluation.

#### 4.9.1. Progeny of the cross Surya x *S. viarum*

##### 4.9.1.1. General characters

The growth habit and branching intensity of the progeny plants from this cross are presented in Table 30.

Table 30. General characters of progeny of Surya x *S. viarum*

| Characters | Progeny | Surya | *S. viarum* |
|---|---|---|---|
| Growth habit | Upright | Upright | Upright |
| Branching intensity | Very weak (<2) | Weak (2 to 5) | Weak (2 to 5) |

All the progeny plants were upright in growth habit and resembled the parents in this character. In the case of branching intensity, it was weak in both the parents. The progeny plants differed from both the parents in this character.

### 4.9.1.2. Leaf characters

The observations on the qualitative characters of the leaf *viz.*, colour of the petiole, colour of lamina, lobing of lamina, leaf tip angle and presence or absence of prickles on the leaf in the progeny of the cross Surya x *S. viarum* are presented in Table 31.

Table 31. Leaf characters of progeny of Surya x *S. viarum*

| Characters | Progeny | Surya | *S. viarum* |
|---|---|---|---|
| Petiole colour | Dark violet | Green | Green |
| Lamina colour | Green | Green | Dark green |
| Leaf blade lobing | Intermediate | Intermediate | Intermediate |
| Leaf tip angle | Acute | Intermediate | Acute |
| Leaf prickles | None | None | Few |

The colour of petiole was dark violet in the progeny while that of the parents, Surya as well as *S. viarum* were green (Plate 23). All the progeny plants were with green lamina and resembled the female parent Surya in this character. *S. viarum*, the male parent had dark green lamina. Leaf blade lobing was intermediate in the progeny as well as parents. The leaf tip angle was acute in the progeny as well as male parent *S. viarum*. Even though the male parent *S. viarum* had prickles on the leaf progeny plants were devoid of prickles and resembled the female parent Surya (Plates 6a and 6b).

### 4.9.1.3. Floral characters

Observations on qualitative floral features *viz.*, presence or absence of prickles on calyx and corolla colour in the progeny of Surya x *S. viarum* are presented in Table 32.


Plate 22. Progeny of Surya × *S. viarum*


Plate 23. Leaves of Surya × *S. viarum* progeny

Plate 24. Flower of Surya × *S. viarum* progeny

Table 32. Floral characters of progeny of Surya x *S. viarum*

| Characters | Progeny | Surya | *S. viarum* |
|---|---|---|---|
| Corolla colour | Bluish violet | Bluish violet | Light violet |
| Prickles on calyx | Few in 25%<br>None in 75% | None | Few |

Corolla colour was bluish violet in the progeny as in the case of the female parent Surya. The progeny however, showed segregation for prickles on the calyx. The female parent Surya was devoid of prickles and male parent *S. viarum* was with prickles (Table 32).

The biometric floral characters *viz.*, length as well as circumference of the flower bud, and length of sepal as well as petal were recorded from the progeny of cross Surya x *S. viarum* and presented in Table 33.

Table 33. Biometric floral characters of progeny of Surya x *S. viarum*

| Progeny / Parents | Length of flower bud (cm) | Circumference of flower bud (cm) | Sepal length (cm) | Petal length (cm) |
|---|---|---|---|---|
| P1 | 2.36 | 2.68 | 2.14 | 1.66 |
| P2 | 2.00 | 2.40 | 2.14 | 2.28 |
| P3 | 2.18 | 2.38 | 2.26 | 1.76 |
| P4 | 1.28 | 1.48 | 1.42 | 1.16 |
| Surya | 1.66 | 2.25 | 1.60 | 1.96 |
| *S. viarum* | 1.38 | 1.84 | 1.06 | 1.50 |
| CD (0.05) | 0.38 | 0.36 | 0.42 | 0.23 |
| CV (%) | 14.51 | 12.07 | 15.61 | 9.93 |

The length and circumference of the flower buds in progeny plants P1, P2 and P3 were on par. It was significantly higher than that of P4. With respect to length of sepal and petal P4 was significantly different from the other three progeny plants. Progeny plant P4 was producing the smallest flowers (Table 33). The progeny plants P1, P2 and P3 were significantly different from both the parents as well in length of flower bud and length of sepal.

**4.9.1.4. Fruit characters**

Qualitative fruit characters of progeny plants of Surya x *S. viarum* are depicted in Table 34 and Plate 25.

Table 34. Fruit characters of progeny of Surya x *S. viarum*

| Characters | Progeny | Surya | *S. viarum* |
|---|---|---|---|
| Fruit position | Pendant | Pendant | Pendant |
| Fruit shape (position of broadest portion) | 1/2 way from base | 1/2 way from base | 1/2 way from base |
| Fruit curvature | None | None | None |
| Fruit apex | Rounded | Rounded | Rounded |
| Fruit colour distribution | Uniform | Uniform | Mottled |
| Fruit colour at commercial ripeness | Purple black in 75% and purple in 25% | Purple | Green with white stripes |
| Colour at physiological ripeness | Light brown | Light brown | Deep yellow |
| Fruit cross section | Circular, without grooves | Circular, without grooves | Circular, without grooves |
| Fruit flesh density | Spongy | Dense | Loose |
| Pedicel prickles | Few | Absent | Few |

The progeny exhibited segregation in the colour of fruit at commercial ripeness. In 75 per cent of progeny plants the fruits were purple black in colour where as in the remaining 25 per cent the fruits were purple coloured like the female parent Surya.

No variability was observed in the progeny for the fruit characters *viz*., fruit position, fruit shape, fruit curvature, fruit apex, fruit colour distribution, fruit cross section, fruit flesh density and pedicel prickles. Fruit position was pendant and fruit apex was rounded in parents and progeny (Table 34).

In fruit colour distribution and colour of fruit at physiological ripeness the progeny resembled the female parent Surya. However, in the case of fruit flesh density the progeny was distinctly different from both the parents. All the progenies of this cross resembled the male parent *S. viarum* in presence of prickles on the pedicel.

The observations on biometric characters of fruit *viz.,* length, breadth and weight of fruit in the progeny plants of Surya x *S. viarum* are presented in Table 35.

Among the fruit characters, the highest variability was observed for fruit weight. Fruit length breadth and weight of progenies P1 and P2 from the cross Surya x *S. viarum* were on par. P4 registered significantly lower values in the case of above traits (Table 35).

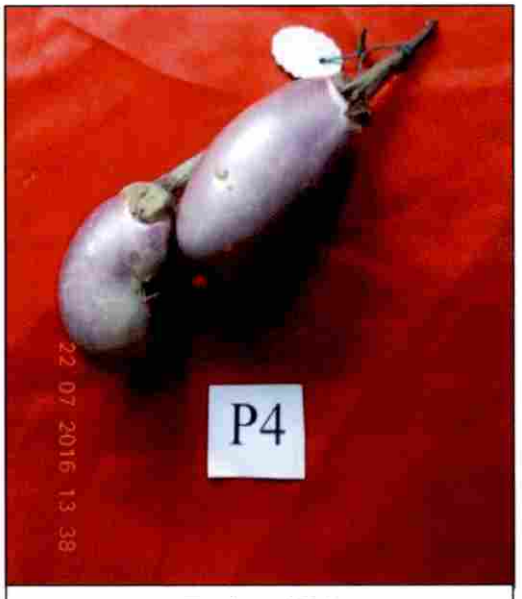
Table 35. Biometric fruit characters of progeny of Surya x *S. viarum*

| Progeny / Parents | Fruit length (cm) | Fruit breadth (cm) | Fruit weight (g) |
|---|---|---|---|
| P1 | 10.60 | 18.00 | 112.19 |
| P2 | 11.00 | 19.20 | 118.34 |
| P3 | 13.60 | 21.00 | 200.06 |
| P4 | 8.20 | 10.60 | 69.13 |
| Surya | 8.80 | 12.22 | 200.99 |
| *S. viarum* | 5.12 | 8.44 | 72.01 |
| CD (0.05) | 1.47 | 2.12 | 64.77 |
| CV (%) | 10.10 | 9.19 | 38.67 |


Fruits of P1


Fruit of P2


Fruit of P3




Fruits of P4

Plate 25. Fruits of progeny plants of Surya × *S. viarum*

### 4.9.2. Progeny of the cross *S. viarum* x Surya

#### 4.9.2.1. General characters

The details of general characters of the progenies from the cross *S. viarum* x Surya are presented in Table 36. In all the progenies the growth habit was upright like the parents. Unlike in the case of parents, the branching intensity was very weak in the progenies.

Table 36. General characters of progeny of *S. viarum* x Surya

| Characters | Progeny | *S. viarum* | Surya |
|---|---|---|---|
| Growth habit | Upright | Upright | Upright |
| Branching intensity | Very weak (<2) | Weak (2 to 5) | Weak (2 to 5) |

#### 4.9.2.2. Leaf characters

The observations on the qualitative characters of the leaf *viz*., colour of the petiole, colour of lamina, lobing of lamina, leaf tip angle and presence or absence of prickles on the leaf in the progeny from the cross *S. viarum* x Surya are presented in Table 37.

In petiole colour and leaf blade lobing the progeny was distinctly different from both the parents. The petiole colour was dark violet in the progeny while that of parents, *S. viarum* as well as Surya were green (Plates 6a and 6b). Unlike the parents, progeny exhibited strong leaf blade lobing. Leaf blade lobing was intermediate in the progeny of the cross Surya x *S. viarum*. However, it was strong in the progenies of reciprocal cross *S. viarum* x Surya (Plate 27).

The lamina colour was green in the progeny and male parent Surya, where as it was dark green in the female parent *S. viarum*. Both *S. viarum* as well as Surya had

intermediate lobing. The leaf tip angle was acute in the progeny and female parent *S. viarum* where as it was intermediate in the male parent Surya.

Prickles were absent on the leaves of progeny of Surya x *S. viarum*. However, that character segregated in the progenies of the reciprocal cross *S. viarum* x Surya (70% of progeny with prickles and 30% without prickles). Presence of prickles on leaf is a unique feature of *S. viarum* (Table 37).

Table 37. Leaf characters of progeny of *S. viarum* x Surya

| Characters | Progeny | *S. viarum* | Surya |
|---|---|---|---|
| Petiole colour | Dark violet | Green | Green |
| Lamina colour | Green | Dark green | Green |
| Leaf blade lobing | Strong | Intermediate | Intermediate |
| Leaf tip angle | Acute | Acute | Intermediate |
| Leaf prickles | Few in 70% and None in 30% | Few | None |

**4.9.2.3. Floral characters**

Observations on qualitative floral features *viz.*, presence or absence of prickles on calyx and corolla colour in the progeny of *S. viarum* x Surya are presented in Table 38.

Table 38. Floral characters of progeny of *S. viarum* x Surya

| Characters | Progeny | *S. viarum* | Surya |
|---|---|---|---|
| Corolla colour | Bluish violet | Light violet | Bluish violet |
| Prickles on calyx | Few | Few | None |

Plate 26. Progeny of *S. viarum* × Surya

Plate 27. Leaves of *S. viarum* × Surya progeny

Plate 28. Flowers of *S. viarum* × Surya progeny

The corolla colour was observed to be bluish violet in Surya x *S. viarum* progeny as well as its reciprocal cross *S. viarum* x Surya (Table 38 and Plates 24 and 28). The progeny resembled Surya in this character. The prickles on the calyx showed segregation among the progeny plants in the cross Surya x *S. viarum*. However, there was no segregation for this character in the reciprocal cross *S. viarum* x Surya. All the progeny plants were prickled like the female parent *S. viarum*.

Biometric floral features of individual progeny plants from the cross S. *viarum* x Surya are presented in Table 39.

The progeny plants P1, P4, P6, and P10 were on par with respect to length of flower bud and were significantly superior to others. In the case of circumference of flower bud, the progeny plants P1, P4, P6, P8 and P10 were on par and significantly different from other progeny plants of the same cross. The sepal length varied from 1.32 cm in P1 to 2.34 cm in P2. The petal length varied from 1.34 cm in P2 to 2.30 cm in P3 and P4 (Table 39).

In both direct and reciprocal crosses between Surya and *S. viarum*, transgressive segregrants were also observed with respect to biometric floral characters.

Table 39. Biometric floral characters of progeny of *S. viarum* x Surya

| Progeny/ Parents | Length of flower bud (cm) | Circumference of flower bud (cm) | Sepal length (cm) | Petal length (cm) |
|---|---|---|---|---|
| P1 | 2.44 | 2.62 | 1.32 | 2.0 |
| P2 | 1.36 | 1.60 | 2.34 | 1.34 |
| P3 | 1.36 | 1.60 | 2.06 | 2.30 |
| P4 | 2.42 | 2.60 | 2.32 | 2.30 |
| P5 | 1.50 | 1.70 | 2.04 | 1.62 |
| P6 | 2.26 | 2.50 | 1.64 | 1.46 |
| P7 | 1.58 | 1.78 | 1.62 | 2.16 |
| P8 | 2.00 | 2.28 | 1.98 | 1.98 |
| P9 | 1.38 | 1.58 | 2.18 | 1.78 |
| P10 | 2.06 | 2.26 | 2.00 | 1.86 |
| *S. viarum* | 1.38 | 1.84 | 1.06 | 1.50 |
| Surya | 1.66 | 2.25 | 1.60 | 1.96 |
| CD (0.05) | 0.42 | 0.41 | 0.44 | 0.41 |
| CV (%) | 17.83 | 15.72 | 17.44 | 17.14 |

**4.9.2.4. Fruit characters**

Qualitative fruit characters of progeny plants of S. *viarum* x Surya are depicted in Table 40 and Plates 29a to 29b.

In 50 per cent of the progeny plants of *S. viarum* x Surya cross the broadest portion of the fruit was at $3/4^{th}$ way from base. In the remaining ones the broadest portion of the fruit was at half way from base (Table 40). The fruits of 60 per cent of the progeny plants of *S. viarum* x Surya, were green with white stripes and purplish tinge at commercial ripeness. Green with white stripes was the feature of female parent *S. viarum* and purplish tinge was that of male parent, Surya. In 20 per cent of the progeny fruits were purple with white patches. Fruit colour at commercial ripeness was green with white stripes in 10 per cent of the progeny. Another 10 per cent of the progeny had pale green fruits a character neither of the parents possessed. But, the shape of the fruit was exactly like that of *S. viarum.* The parent of Surya (Sm -6) produced white, green as well as purple coloured fruits.

The presence of prickles on the pedicel was also showing segregation in the progeny. Presence of prickles on the pedicel, a unique feature of *S. viarum* was observed in 70 per cent of the progeny plants (Table 40).

Fruit position was pendant, fruit apex was rounded and fruit cross section was circular without grooves in both the parents and progeny. There was no curvature for the fruits in the parents as well as the progeny.

Table 40. Fruit characters of progeny of *S. viarum* x Surya

| Characters | Progeny | *S. viarum* | Surya |
|---|---|---|---|
| Fruit shape | 3/4$^{th}$ way from base in 50% and ½ way from base in 50% | ½ way from base | ½ way from base |
| Fruit colour distribution | Mottled | Green with white stripes | Purple |
| Fruit colour at commercial ripeness | Green with white stripes and purplish tinge in 60%, Purple with white patches in 20%, Green with white stripes in10%, Pale green fruits in 10% | Mottled | Uniform |
| Colour at physiological ripeness | Deep yellow | Deep yellow | Light brown |
| Fruit flesh density | Loose | Loose | Dense |
| Pedicel prickles | Few in 75%) and None in 25% | Few | Absent |

Observations on biometric characters of fruits in the individual progeny plants of *S. viarum* x Surya are presented in Table 41.

Table 41. Biometric fruit characters of *S. viarum* x Surya

| Progeny/ Parents | Fruit length (cm) | Fruit breadth (cm) | Fruit weight (g) |
|---|---|---|---|
| P1 | 7.20 | 12.4 | 48.72 |
| P2 | 4.00 | 4.50 | 23.87 |
| P3 | 6.00 | 13.20 | 42.28 |
| P4 | 7.00 | 12.40 | 40.90 |
| P5 | 4.50 | 5.00 | 24.27 |
| P6 | 4.96 | 9.14 | 14.57 |
| P7 | 6.60 | 11.60 | 35.76 |
| P8 | 6.00 | 10.40 | 25.72 |
| P9 | 6.10 | 11.16 | 31.16 |
| P10 | 7.60 | 13.80 | 44.79 |
| S. *viarum* | 5.12 | 8.44 | 72.01 |
| Surya | 8.80 | 12.22 | 200.99 |
| CD (0.05) | 0.89 | 2.06 | 10.16 |
| CV (%) | 10.23 | 13.70 | 22.26 |

Fruits of P1

Fruit of P2

Fruits of P3

Fruits of P4

Fruit of P5

Plate 29a. Fruits of progeny plants of *S. viarum* × Surya

Fruit of P6

Fruits of P7

Fruit of P8

Fruit of P9

Fruit of P10

Plate 29b. Fruits of progeny plants of *S. viarum* × Surya

Significant variability was observed among the progeny of *S. viarum* x *S. melongena* variety Surya cross for fruit length breadth and weight. The fruit length varied from 4.00cm in P2 to 7.60cm in P10, fruit breadth from 4.5cm in P2 to13.80cm in P10 and fruit weight from 14.57g in P6 to 48.72g in P1 (Table 41). Among the progenies P1 and P10 can be considered as superior with respect to these characters.

### 4.9.3. Progeny of the cross Surya x *S. incanum*

#### 4.9.3.1. General characters

The details of general characters of the progeny from the cross Surya x *S. incanum* are presented in Table 42. The growth habit was upright like the parents in all the progeny plants. Unlike the parents the branching intensity was very weak in the progeny members.

Table 42. General characters of progeny of Surya x *S. incanum*

| Characters | Progeny | Surya | *S. incanum* |
|---|---|---|---|
| Growth habit | Upright | Upright | Upright |
| Branching intensity | Very weak (<2) | Weak (2 to 5) | Weak (2 to 5) |

#### 4.9.3.2. Leaf characters

The observations on the qualitative characters of the leaf *viz.* colour of the petiole, colour of lamina, lobing of lamina, leaf tip angle and presence or absence of prickles on the leaf in the progeny from the cross *S. melongena* variety Surya x *S. incanum* are presented in Table 43.

Colour of the petiole was dark violet in the progeny while that of parents, Surya and *S. incanum* were green and greenish violet respectively.

The lamina colour was green and leaf blade lobing was intermediate in the progeny of cross Surya x *S. incanum*. The lobing of leaf blade was intermediate in the parents also (Plates 6a and 6b).

The lamina colour was found to be green in the progeny of all the three crosses and can be considered to be contributed by Surya when used as either male or female parent.

The leaf tip angle was very acute in the progeny of Surya x *S. incanum* cross (Plate 31) while in both the parents it was intermediate. However, it was acute in the progeny of Surya x *S. viarum* and it's reciprocal cross.

The progeny of Surya x *S. incanum* were devoid of prickles (Plate 31).

Table 43. Leaf characters of progeny of Surya x *S. incanum*

| Characters | Progeny | Surya | *S. incanum* |
|---|---|---|---|
| Petiole colour | Dark violet | Green | Greenish violet |
| Lamina colour | Green | Green | Dark green |
| Leaf blade lobing | Intermediate | Intermediate | Intermediate |
| Leaf tip angle | Very acute | Intermediate | Intermediate |
| Leaf prickles | None | None | None |


Plate 30. Progeny of Surya × *S. incanum*

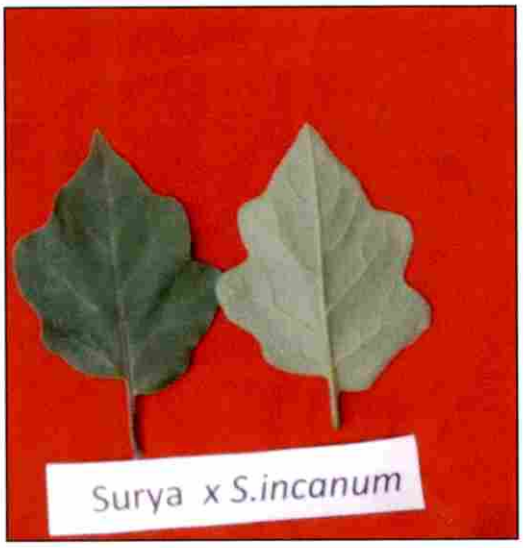



Plate 31. Leaves of Surya × *S. incanum* progeny

Plate 32. Flowers of Surya × *S. incanum* progeny

**4.9.3.3. Floral characters**

Observations on qualitative floral features *viz.*, presence or absence of prickles on calyx and corolla colour in the progeny of *S. melongena* variety Surya x *S. incanum* are presented in Table 44.

Table 44. Floral characters of progeny of Surya x *S. incanum*

| Characters | Progeny | Surya | *S. incanum* |
|---|---|---|---|
| Corolla colour | Light violet | Bluish violet | Pale violet |
| Prickles on calyx | None | None | None |

The corolla colour in the progeny of Surya x *S. incanum* was light violet. Corolla colour of one of the parents, Surya, was bluish violet and that of *S. incanum* was pale violet (Plates 10, 12 and 32). The progeny from the cross between Surya and *S. incanum* were having non prickled calyx and resembled the parents.

The observations on biometric floral features of the progeny from the cross *S. melongena* variety Surya x *S. incanum* are presented in Table 45.

The length of flower bud varied from 1.50 cm in P3 to 2.66 cm in P10 (Table 45). The circumference of flower bud ranged from 1.80 cm in P3 to 2.92 cm in P1. With respect to sepal length and petal length also there were significant differences among the progeny plants.

Transgressive segregants were also observed with respect to the biometric floral characters.

Table 45. Biometric floral characters of progeny of Surya x *S. incanum*

| Progeny/ Parents | Length of flower bud (cm) | Circumference of flower bud (cm) | Sepal length (cm) | Petal length (cm) |
|---|---|---|---|---|
| P1 | 2.60 | 2.92 | 2.36 | 1.86 |
| P3 | 1.50 | 1.80 | 2.50 | 1.76 |
| P5 | 2.18 | 2.50 | 2.10 | 1.56 |
| P6 | 1.54 | 1.82 | 1.98 | 1.60 |
| P7 | 1.78 | 2.24 | 2.34 | 1.74 |
| P8 | 2.02 | 2.30 | 1.56 | 2.50 |
| P10 | 2.66 | 2.88 | 2.16 | 1.38 |
| Surya | 1.66 | 2.25 | 1.60 | 1.96 |
| *S. incanum* | 1.76 | 2.06 | 1.33 | 1.22 |
| CD (0.05) | 0.45 | 0.42 | 0.35 | 0.52 |
| CV (%) | 17.20 | 13.72 | 12.58 | 22.6 |

**4.9.3.4. Fruit characters**

Fruit characters of progeny plants belonging to Surya x *S. incanum* cross are presented in Table 46 and Plate 33.

The fruits characters of all the progeny plants of this cross were similar except for fruit colour and shape (position of the broadest portion of the fruit). In 72 per cent

of progeny, the broadest portion of the fruit was at about 3/4$^{th}$ way from base, while in 28 per cent of progeny, the broadest portion of the fruit was at half way from base to tip. At commercial ripeness, 43 per cent of progeny were pale green with purplish tinge. Green fruits with white stripes and purplish tinge were observed in 43 per cent of progeny. Fruits were green with white stripes in 14 per cent of progeny. Fruit colour distribution was mottled in the progeny where as it was uniform in parents.

In fruit characters *viz.*, position, curvature, cross section and apex as well as pedicel prickles the progeny resembled both the parents.

Observation on biometric fruit parameters of progenies from *S. melongena* variety Surya x *S. incanum* is presented in Table 47.

There was no significant difference among the progeny plants for fruit length. The fruit breadth of progeny plants P1, P3, P6, P7, P8 and P10 were on par. P5, exhibited significantly lower value for fruit breadth. The fruit weight of P1, P3, P7 and P8 were on par. P5 exhibited significantly higher fruit weight among the progeny plants (Table 47).

Table 46. Fruit characters of the progeny of Surya x *S. incanum*

| Characters | Progeny | Surya | *S. incanum* |
|---|---|---|---|
| Fruit shape | ¾ th way from base in 72%<br>½ way from base in 28% | ½ way from base | ½ way from base |
| Fruit colour distribution | Mottled | Uniform | Uniform |
| Fruit colour at commercial ripeness | Pale green with purple tinge in 43%<br>Green with white stripes and purplish tinge in 43%<br>Green with white stripes 14% | Purple | Pale green |
| Fruit colour at physiological ripeness | Deep yellow | Light brown | Deep yellow |
| Fruit flesh density | Loose | Dense | Loose |

Table 47. Biometric fruit characters of progeny of Surya x *S. incanum*

| Progeny / Parents | Length of flower bud (cm) | Circumference of flower bud (cm) | Sepal length (cm) | Petal length (cm) |
|---|---|---|---|---|
| P1 | 2.36 | 2.68 | 2.14 | 1.66 |
| P2 | 2.00 | 2.40 | 2.14 | 2.28 |
| P3 | 2.18 | 2.38 | 2.26 | 1.76 |
| P4 | 1.28 | 1.48 | 1.42 | 1.16 |
| *S. melongena* type Surya | 1.66 | 2.25 | 1.60 | 1.96 |
| *S. viarum* | 1.38 | 1.84 | 1.06 | 1.50 |
| CD (0.05) | 0.38 | 0.36 | 0.42 | 0.23 |
| CV (%) | 14.51 | 12.07 | 15.61 | 9.93 |

**4.9.4. Heterotic effect in progenies**

Heterotic effect for fruit characters in the progenies of different crosses was estimated. Average heterosis and Heterobeltiosis were computed.

Heterosis estimated in the progenies of *S. melongena* variety Surya x *S. viarum* is presented in Table 48.

Fruits of P1

Fruit of P2

Fruit of P3

Fruit of P4

Fruits of P5

Fruits of P6

Fruits of P7

Plate 33. Fruits of progeny plants of Surya × *S. incanum*

Table 48. Heterosis in the progeny of *S. melongena* variety Surya x *S. viarum*

| Progeny | Average heterosis (%) | | | Heterobeltiosis (%) | | |
|---|---|---|---|---|---|---|
| | Fruit length | Fruit breadth | Fruit weight | Fruit length | Fruit breadth | Fruit weight |
| P1 | 52.30 | 74.25 | -17.81 | 20.45 | 47.30 | -44.18 |
| P2 | 58.05 | 85.87 | -13.30 | 25 | 57.12 | -41.12 |
| P3 | 95.40 | 103.29 | 46.56 | 54.54 | 71.85 | -0.47 |
| P4 | 17.82 | 2.61 | -49.36 | -6.82 | -13.26 | -65.61 |

Heterosis was positive (average heterosis and heterobeltiosis) for both fruit length and fruit breadth among the progenies of cross *S. melongena* variety Surya x *S. viarum*. The average heterosis for fruit weight was negative in all the progenies except P3. However, Heterobeltiosis was negative for fruit weight in all the progenies.

Heterosis estimated in the progeny of *S. viarum* x *S. melongena* type Surya is presented in Table 49.

Table 49. Heterosis in the progeny of *S. viarum* x Surya

| Plants | Average heterosis (%) | | | Heterobeltiosis (%) | | |
|---|---|---|---|---|---|---|
| | Fruit length | Fruit breadth | Fruit weight | Fruit length | Fruit breadth | Fruit weight |
| P1 | 3.45 | 20.04 | -64.31 | -18.18 | 1.47 | -75.76 |
| P2 | -42.53 | -56.44 | -82.51 | -54.55 | -63.18 | -88.12 |
| P3 | -13.79 | 27.78 | -69.03 | -31.82 | 8.02 | -78.96 |
| P4 | 0.57 | 20.04 | -70.04 | -20.45 | 1.47 | -79.65 |
| P5 | -35.34 | -51.60 | -82.22 | -48.86 | -59.08 | -87.92 |
| P6 | -28.74 | -11.52 | -89.33 | -43.64 | -25.20 | -92.75 |
| P7 | -5.17 | 12.29 | -73.80 | -25.00 | -5.07 | -82.21 |
| P8 | -13.79 | 0.68 | -81.16 | -31.82 | -14.89 | -87.20 |
| P9 | -12.36 | 8.03 | -77.17 | -30.68 | -8.67 | -84.49 |
| P10 | 9.19 | 33.59 | -67.19 | -13.64 | 12.93 | -77.72 |

The progenies P1, P4 and P10 exhibited positive average heterosis for fruit length and fruit breadth. The progeny plants P3, P7, P8 and P9 showed positive

heterosis for fruit breadth alone. Progenies P1, P3, P4 and P10 had positive heterobeltiosis for fruit breadth. However, none of the progeny plants recorded positive heterobeltiosis for fruit length and weight (Table 49).

Heterosis estimated in the progenies of *S. melongena* variety Surya x *S. incanum* is presented in Table 50.

Table 50. Heterosis in the progeny of Surya x *S. incanum*

| Plants | Average heterosis (%) | | | Heterobeltiosis (%) | | |
|---|---|---|---|---|---|---|
| | Fruit length | Fruit breadth | Fruit weight | Fruit length | Fruit breadth | Fruit weight |
| P1 | -0.75 | 24.51 | -70.60 | -25.00 | 4.75 | -79.13 |
| P3 | 2.26 | 25.49 | -69.37 | -22.73 | 5.56 | -78.26 |
| P5 | 8.27 | -2.72 | -63.13 | -18.18 | -18.17 | -73.83 |
| P6 | -6.77 | 22.57 | -75.67 | -29.55 | 3.11 | -82.73 |
| P7 | 2.26 | 20.62 | -71.41 | -22.73 | 1.47 | -79.71 |
| P8 | 11.28 | 20.62 | -68.87 | -15.91 | 1.47 | -77.90 |
| P10 | -3.76 | 15.76 | -80.19 | -27.27 | -2.62 | -85.94 |

The progenies P3, P5, P7 and P8 exhibited positive average heterosis for fruit length. Except P5 all the progeny plants from the cross *S. melongena* variety Surya x *S. incanum* exhibited positive average heterosis for fruit breadth. All the plants exhibited negative average heterosis for fruit weight. All the progeny plants exhibited negative heterobeltiosis for fruit length and fruit weight. While P1, P3, P6, P7 and P8 showed positive heterobeltiosis for fruit breadth (Table 50).

**4.9.5. Palynology**

The fertility as well as shape and size of pollen grains were estimated by making observations consecutively for three days. The results are presented in Table 51 and 52.

Table 51. Pollen fertility in the progeny of different crosses

| Crosses | Pollen fertility (%) | | |
|---|---|---|---|
| | Day 1 | Day 2 | Day 3 |
| Surya x *S. viarum* | 100 | 98 | 0 |
| *S. viarum* Surya | 97.33 | 94.70 | 100 |
| Surya x *S. incanum* | 85 | 89 | 73 |

The pollen grains of progenies from *S. viarum* x *S. melongena* variety Surya exhibited maximum fertility on the 3rd day of flower opening and they remained viable for 3 days after flower opening. However, a decline in pollen fertility was observed on the 2nd day of flower opening in the progenies of cross *S. melongena* variety Surya x *S. viarum*. In the progenies of cross *S. melongena* variety Surya x *S. incanum* fertility was maximum on the second day of flower opening and then declined (Table 51).

Pollen grains were found to be round and mono-,bi- or trizonocolporate (Plate 34). There was significant difference among the progenies in the length of pollen only. Smaller pollen grains were found in the progenies of cross *S. melongena* variety Surya x *S. incanum*.

Table 52. Shape and size of pollen grains in the progeny of different crosses

| Crosses | Shape | Length (µm) | Width (µm) |
|---|---|---|---|
| Surya x *S. viarum* | Round | 0.06 | 0.03 |
| *S. viarum* x Surya | Round | 0.05 | 0.03 |
| Surya x *S. incanum* | Round | 0.02 | 0.02 |
| CD (0.05) | - | 0.01 | NS |
| CV (%) | - | 20.02 | 25.32 |

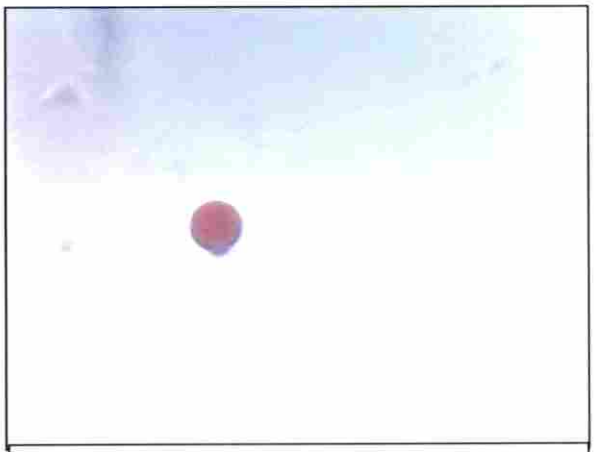
**4.10. Incidence of pest and diseases**

The incidence of insect pests in the parental generation as well as in the progeny population was noted and are presented in Table 53 and 54 as well as Plates 35a to 35b.

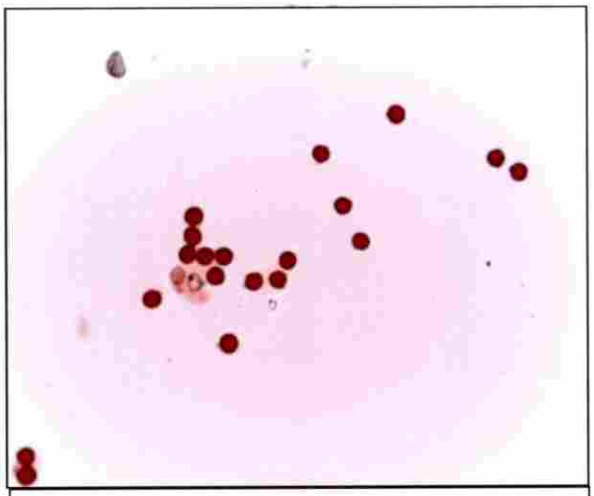
All the wild variants of *Solanum* were observed to be unaffected by the attack of a wide range of pests affecting brinjal. *S. melongena* type Haritha was affected by almost all the pests except stem borer. *S. melongena* type Surya was affected by all the pests except tingid bug, mites and stem borer.

Among the wild variants of *Solanum*, *S. viarum* was unaffected by most of the pests except grasshopper, tingid bug and mites. *S. incanum* was affected by grasshopper and mealybug. *S. gilo* was affected by mites alone. It was observed to be unaffected by the attack of other common pests of brinjal.

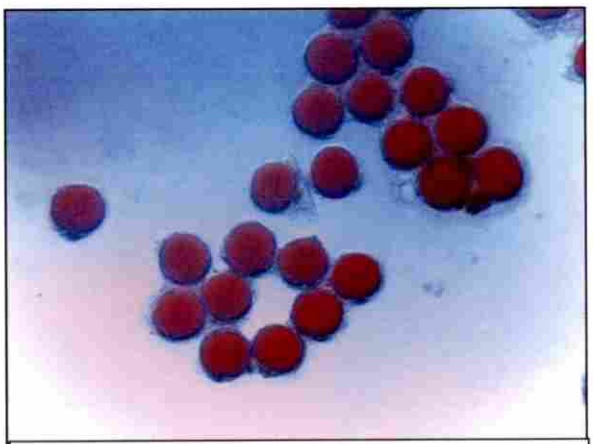
Unlike the other wild species of brinjal, *S. indicum* was affected by the attack of almost all the pests of brinjal except tingid bug, epilachna beetle, aphids and



Surya × *S.viarum*



*S. viarum* × Surya



Surya × *S. incanum*

Plate 34. Pollen morphology of the progeny of different crosses

whitefly. Wild species of brinjal were observed to bear resistance to the attack of pests of brinjal, compared to the cultivated varieties. Among the wild species, wider range of resistance was observed in *S. gilo*.

*S. indicum* was observed to be susceptible to the attack of pests.

Most of the insect pest that caused severe damage to the parent generation did not attack the progenies. The attack of Epilachna beetle and brinjal shoot and fruit borer were prevalent in the progeny population.

The incidence of diseases in the parental generation comprising the different species of *Solanum* is presented in Table 55.

The incidence of diseases in the evaluated genotypes was less when compared to pest incidence. Damping off and *Cercospora* leaf spot were observed in *S. melongena* types Haritha and Surya. The wild genotypes evaluated except *S. viarum* were free from disease incidence. *S. viarum* was found susceptible to *Cercospora* leaf spot. Kouassi *et al.* (2014) also observed that *S. gilo* was found to be less susceptible to many pathogens including fungi, bacteria and root knot nematodes.

Incidence of diseases in the progeny populations from different crosses is presented in Table 56.

No incidence of diseases was observed in the progeny. The diseases that prevailed in the parental generation were not found in the progeny population.

Table 53. Incidence of pests in different species of *Solanum*

| Pests | *S. viarum* | *S. gilo* | *S. incanum* | *S. indicum* | *S. melongena* variety | |
|---|---|---|---|---|---|---|
| | | | | | Haritha | Surya |
| Aphids | - | - | - | - | Y | Y |
| White fly | - | - | - | - | Y | Y |
| Mealy bug | - | - | Y | Y | Y | Y |
| Epilachna beetle | - | - | - | - | Y | Y |
| Mites | Y | Y | - | Y | Y | - |
| Tree hopper | - | - | - | Y | Y | Y |
| Leaf miner | - | - | - | Y | Y | Y |
| Shoot and fruit borer | - | - | - | Y | Y | Y |
| Grass hopper | Y | - | Y | Y | Y | Y |
| Tingid bug | Y | - | - | - | Y | - |
| Stem borer | - | - | - | Y | - | - |

Table 54. Incidence of pests in the progeny population of different crosses

| Pests | Surya x *S. viarum* | *S. viarum* x Surya | Surya x *S. incanum* |
|---|---|---|---|
| Epilachna beetle | Y | Y | - |
| Aphids | - | - | - |
| Whitefly | - | - | - |
| Mealybug | - | - | - |
| Mites | - | - | - |
| Tree hopper | - | - | - |
| Leaf miner | - | - | - |
| Shoot and fruit borer | Y | Y | Y |
| Grass hopper | - | - | - |
| Tingid bug | - | - | - |

Table 55. Incidence of diseases in different species of *Solanum*

| Types | Damping off | *Cercospora* leaf spot |
|---|---|---|
| *S. viarum* | - | Y |
| *S. gilo* | - | - |
| *S. incanum* | - | - |
| *S. indicum* | - | - |
| *S. melongena* varieties | | |
| Haritha | Y | Y |
| Surya | Y | Y |

Table 56. Incidence of diseases in progeny populations of different crosses

| Diseases | *S. viarum* x Surya | Surya x *S. viarum* | Surya x *S. incanum* |
|---|---|---|---|
| Damping off | - | - | - |
| *Cercospora* leaf spot | - | - | - |

Serpentine leaf miner

Aphid

Epilachna beetle

Tingid bug

Plate 35a. Pest and diseases in different *Solanum* species

Leaf folder

Brinjal shoot and fruit borer

Tree hopper

Spider mite

*Cercospora* leaf spot

Plate 35b. Pest and diseases in different *Solanum* species

# SUMMARY

## 5. SUMMARY

The investigation entitled "Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)" was carried out in the Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara, during 2014 – 2016.

Four wild species variants of *Solanum viz., S. viarum, S. gilo, S. incanum and S. indicum* maintained at NBPGR - RS, Vellanikkara along with *S. melongena* varieties Haritha and Surya from Kerala Agricultural University formed the material for study. These genotypes were evaluated for various vegetative, floral and fruit characters. The cross compatibility of the wild variants with *S. melongena* types were also assessed by making crosses both direct and reciprocal. The progenies obtained from the successful crosses were also evaluated based on various morphological characters.

The wild variants exhibited comparatively lower percentage of germination ranging from 21.13 in *S. gilo* to 48.45 in *S. indicum.* The varieties of *S. melongena,* Haritha and Surya recorded 63.43% and 60% germination respectively.

The wild variant of *S. viarum* was characterized by upright growth habit and presence of prickled dark green leaves with acute leaf tip. *S. gilo* could be distinguished by light green non prickled leaves with acute tip. *S. incanum* had intermediate growth habit and leaves with greenish violet petioles. Intermediate growth habit, very weak branching intensity, leaves with long petiole, large strongly lobed lamina having very acute leaf tip were the features of *S. indicum.*

Among the different species evaluated *S. indicum* did not flower during the entire experiment period. This may be due to the endemic nature of this species to Tamil Nadu. Hence, the height and stem girth measured at flowering stage in all the

other types could not be taken in *S. indicum*. All the wild variants of *Solanum* were significantly taller than *S. melongena* variety Surya.

Among the wild species which flowered, *S. gilo* took the highest number of days for flower bud initiation (70.8 days) and *S. viarum,* the lowest (41.2 days). Significant difference was observed among the *S. melongena* varieties Haritha and Surya (42.8 days and 55 days respectively) in the days taken for flower initiation.

Even though there was significant difference among the different species for days to initiation of flowering, no significant difference could be observed for days to opening of the flower bud after initiation. Irrespective of species, it took only 9 to 10 days for the flower bud to open after it's initiation.

The flowers of all the *Solanum* species evaluated were morphologically similar. In all the species the flowers are pedicellate, zygomorphic, complete, hypogynous and positively geotropic with rotate corolla. Calyx is persistent with or without prickles, depending on the species.

*S. gilo* was significantly different from all other species evaluated, in the length and circumference of flower bud (0.80 cm and 1.32 cm respectively). *S. melongena* varieties, Haritha and Surya were on par in the length and circumference of flower bud as well as length of sepals and petals. Irrespective of species long and short styled flowers were common. The medium styled flowers were however, rarely found. Hence, heterostyly is present in all the species.

Flowers of *S. gilo* and *S. incanum* opened between 5 – 6 a.m. as well as 6 a.m. and 7 a.m. respectively. Seasonal influence on the time of anthesis was prominent in the flowers of *S. viarum,* where the flowers opened between 11 a.m. and 11.30 a.m. during September – October period and between 6 a.m. and 7 a.m. during the rest of the year. In *S. melongena* the opening time varied from 4 a.m. and 7 a.m. depending on the variety.

The flowers of all the species closed in the evening by 6 p.m. and opened again the next day morning at the same time. This pattern continued till the 3rd day of flower opening after which the flowers withered. Unfertilized flowers, however, dropped off completely after the third day of opening. The blossom life was hence, three days in all the species.

A change in corolla colour prior to anthesis was observed in *S. viarum*, *S. incanum* as well as *S. melongena* variety Surya. The corolla colour changed from white to light violet in *S. viarum*, white to pale violet in *S. incanum* and white to bluish white in *S. melongena* variety Surya.

Depending on the species there was variation in the time of anther dehiscence. The pollen dehiscence occurred nearly two to five hours after flower opening in *S. viarum* and *S. incanum* depending on weather conditions. In *S. gilo*, the anthers dehisced nearly 30 minutes before flower opening. However, in the cultivated varieties, Haritha and Surya, anther dehiscence commenced along with the opening of flowers. The dehiscence once started, continued for three days.

The change in the colour of the stigmatic surface from glossy green to deep yellow at the time of initiation of stigma receptivity is a unique feature of *S. gilo*. In the other wild types of *Solanum*, stigmatic surface was observed to be moist and glossy green with the onset of stigma receptivity. The colour was found to fade with the decline in stigma receptivity.

In all the species of *Solanum* evaluated except *S. gilo* protogyny was observed. However, in *S. gilo* pollen dehiscence occurred 30 minutes before flower opening and stigma receptivity initiated an hour after flower opening. Hence, it was considered to be protandrous.

The shape of the pollen grain was uniform in all the types evaluated and more than 80% pollen fertility was observed till the withering of the flower on the

third day of flower opening. With the closing of the flower on the third day evening the fertility was completely lost in all the species evaluated.

None of the protected buds set fruits indicating the absence of self pollination. However, with unprotected buds, fruit set ranging from 60% in *S.viarum* to 100% in *S. melongena* variety Haritha was observed. This indicates that cross pollination is the rule in *Solanum* species.

Fruits were pendant in all the wild variants as well as in *S. melongena* varieties Haritha and Surya. However, prickles were present on the pedicels of fruits in *S. viarum*. At commercial ripeness, the fruits of *S. viarum* were green with white stripes and that of *S. melongena* type Surya were purple in colour. The fruits of *S. incanum* and *S. melongena* variety Haritha were pale green in colour. There was uniform distribution of colour in the fruits of *S. incanum* as well as in *S. melongena* varieties Haritha and Surya at commercial ripeness. However, a mottled distribution of colour was observed in the commercially ripe fruits of *S. viarum*

Hybridization was done with *S. melongena* varieties Haritha and Surya taking the wild variants except *S. indicum* which did not flower during the experimental period, as both male and female parents. The long styled flowers in the selected female parents alone were used crossing. Out of the 12 crosses tried *S. viarum* x Haritha, Haritha x *S. incanum*, *S. incanum* x Haritha, Surya x *S. viarum*, *S. viarum* x *S.* Surya and Surya x *S. incanum* set seeds. However, the seedlings of *S. viarum* x Haritha, Haritha x *S. incanum* and *S. incanum* x Haritha did not establish in the field, indicating hybrid inviability. The seedlings of the crosses Surya x *S. viarum*, *S. viarum* x Surya and Surya x *S. incanum* established in the field. Hence, only these three crosses could be considered successful. Progeny plants from the successful crosses were subjected to evaluation based on various phytographic characters. The progeny of the cross Surya x *S. viarum* was found to be superior in fruit weight as well as absence of prickles on leaf and fruit pedicel.

All the wild variants of Solanum except *S. indicum* were found to be unaffected by majority of the common pests of brinjal viz., aphids, white fly, mealy bug etc. In *S. gilo*, *S. incanum* and *S. indicum* no incidence of *Cercospora* leaf spot or damping off was noticed. The incidence of pest and diseases were less in the progenies from the crosses between wild and cultivated.

# *REFERENCES*

## 6. REFERENCES

Abak, K. and Guler, H. Y. 1994. Pollen fertility and the vegetative growth of various egg plant genotypes under low temperature greenhouse conditions. *Acta. Hortic.* 366: 85-91.

Abak, K., Sari, M., Paksoy, M., 1995. Efficiency of bumble bees on the yield and quality of eggplant and tomato grown in unheated glasshouses. *Acta. Hortic.* 412: 268–274.

Agarwal, R. L. 1980. *Seed Technology*. Oxford and IBH Publishing Co, New Delhi, 123p.

Alba, V., Lotti, T., D'alessandro, A., Mennella, G., Riciardi, L., and Sunseri, F. 2005. Genetic diversity on African eggplant: molecular and chemical analyses. *Proceedings of 19$^{th}$Annual congress of Italian Society of Agricultural Genetics*, 12-15 Sept., Potenza, Italy 34: 135-139.

Alexander, M. P. 1969. Differential staining of aborted and non aborted pollen. *Stain. Technol.* 44: 117-122.

Ali, M., Okubo, H., and Fujieda, K. 2007. Production and characterization of *Solanum amphidiploids* and their resistance to bacterial wilt. *Sci. Hort.* 49: 181-196.

Allard, R. W. 1960. *Principles of Plant Breeding*. John willey and Sons, New York, 485p.

Amoako, J. and Yeboah-Gyan, K. 1995. Insect pollination of three Solanaceous vegetable crops in Ghana with special reference to the role of African honey bee (*Apis mellifera adansonii*) for fruit set. *Acta. Hort.* 288: 255-259.

Attavian, B. N., Jelenkovic, B., and Pollack, B. L.1983. Cytogenetical and fertility studies of selected non tuberous *Solanum* species and their hybrid derivatives. *J. Am. Soc. Hort. Sci.* 108: 10-15.

Babu, C. R. and Hepper, F. N. 1978. Taxonomy and nomenclature of *Solanum khasianum* and some of its relatives. *Kew. Bull.* 34: 409.

Bahgat, A., Abdelaziz, H., Raafat, M., Mahdy, A., Elkhatib, A. S., Ismail, A., and Khayyal, M. T. 2008. *Solanum indicum* spp. distichum extract is effective against-induced hypertension in rats. *Fundam. Clin. Pharmacol.* 22:693–699.

Bajaj, K. L., Kaur, G., and Chadha, M. L. 1979. Glycoalkaloid content and other chemical constituents of the fruits of some egg plant (*Solanum melongena L.*) varieties. *J. Plant. Foods*. 3(**3**): 163-168.

Baysal, O., Siragusa, M., Gumruckcu, E., and Zengin, S. 2010. Molecular characterization of *Fusarium oxysporum fsp. melongenae* by ISSR and RAPD markers on eggplant. *Biochem. Genet.* 48: 524-537.

Behera, T. K. Sharma, P., Singh, B. K., Kumar, G., Kumar, R., Mohapatra, T., and Singh, N.K. 2006. Assesment of Genetic diversity and species relationship in eggplant using STMS markers. *Sci. Hort.* 107: 352-357.

Behera, T. K. and Singh, N. 2002. Inter-specific crosses between eggplant (*Solanum melongena* L.) with related *Solanum* species. *Sci. Hort.* 95:165-172.

Bhaduri, P. N. 1951. Inter-relationship of the non-tuberiferous species of *Solanum* with some consideration on the origin of brinjal (*Solanum melongena* L.). *Indian J. Genet. Plant Breed.* 11:75-82.

Bitter, G. 1923. Solana Africana. *Abh. Nature. Ver. Bremen.* 24:292-550.

Bukanya, Z. R. 1994. *Solanum macrocarpon*: an under utilized but potential vegetable in Uganda. In: Senyani, J. H and Chikuni, A. C (eds.). *Proceedings XIII$^{th}$ Plenary Meeting AETFAT*.17-24.

Chandra, V. and Murthy, A. S. 1968. Eggplant or Brinjal (*Solanum melongena* L.) *Indian. J. Sci*. 2:127-144.

Chandra, V. and Srivastava, S. N. 1984. *Solanum viarum* Dunal syn. *Solanum khasianum* Clarke, a crop for production of Solasodine. *Ind. Drugs*. 16(**3**): 53-60.

Chattopadhyay, S. B., Sarkar, A., and Hazra, P. 2009. Study of crossability of three species of *Solanum* in gangetic plains of West Bengal. *J. Crop. Weed.* 5: 53-56.

Chen, N. C., Hiu, L., and Li, H. M. 2000. *Vegetable production training manual*. Asian Vegetable Research and Development Center, Taiwan. pp.15-32.

Chira, E. 1963. The pollen sterility of scots and black pines (*Pinus silvestris* L.) *Lesn. Aopis*. 9: 821-826.

Choudhary, B. 1976. *Evolution of crop plants*. In: Vegetables (4$^{th}$ ed.). National Book Trust, New Delhi: pp. 50-58.

Clain, C., Silva, D. D., Focka, I., and Vaniet, S. 2004. RAPD genetic homogeneity and high levels of bacterial wilt tolerance in *Solanum torvum* Sw. (Solanaceae) accessions from Reunion Island. *Plant Sci*. 166: 1533-1540.

Collonier, C., Fock, I., Rotino, G. L. and Daunay, M. C. 2001. Applications of biotechnology in eggplant. *Plant Cell Tissue Organ. Cult*. 95: 91-107.

Collonier, C., Fock, I., Daunay, M. I., and Servaes, A. 2003. Somatic hybrids between *Solanum melongena* and *S. sisymbrifolium*, as a useful source of resistance against bacterial and fungal wilts. *Plant. Sci.* 164: 849-861.

Cooke, R. J. 1984. The characterisation and identification of crop cultivars by electrophoresis. *Electrophoresis.* 5: 59-72.

Daskalov, H., and Murtazov, T. 1937. Flowering biology of egg plant. *News. Inst. Pl. Ind. Sofia.* 4:65-72.

Daunay M. C. and Lester R. N., 1998. The usefulness of taxonomy for *Solanaceae*breeders, with special reference to the genus *Solanum* and to *Solanum melongena* L. (egg plant). *Cap. New*. 7: 70-79.

Daunay, M. C., Lester, R. N., and Ano, G. 2001a. Cultivated egg plant the chromosomes of the Solanaceous species indicates plants. In: Rier, A., Jacquot, M., Hamon, S., and Nicolas, D (eds.), *Tropical Plant Breeding*, Oxford University Press, Oxford. pp. 200-225.

Daunay, M. C., Lester, R. N., Gebhardt, C., Hennart, J. W., and Jahn, M. 2001b. Genetic Resources of eggplant *(Solanum melongena* L.) and allied species: a new challenge for molecular geneticists and eggplant breeders. In: Van Den Berg R. G: Barendse G. W., and Mariani, C. (eds.), Solanaceae V. Nijmegen University Press, Nijmegen, The Netherlands, pp. 251-274.

Daunay, M. C., Lester, R. N., Gebhardt, C., Hennart, J. W., Jahn, M., Frary, A., and Doganlar. S . 2001. *Genetic resources of eggplant (Solanum melongena* L.*) and allied species: a new challenge for molecular genetics and egg plant breeders.* In Van Den Berg R. G, Bardense, G. M and Miriani (ed.). Solanaceae. Nijmegan Univerity press, Nigmegan, Netherlands, 5: 251-274.

Daunay, M. C., Lester. R. N., and Laterrot, H. 1991. The use of wild species for the genetic improvement of brinjal-eggplant (*Solanum melongena*) and tomato (*Lycopersicon esculentum*) In: Hawkes, J. G., Lester, R. N., Nee, M., and Estrada, R. N.(Eds.), Solanaceae III: Taxonomy, Chemistry, Evolution. Royal Botanic Gardens, Kew, pp. 389-412.

Daunay, M. C., Chaput, M. H., Sihachakr, D., Allot, M., Vedel, F., and Ducreux, G. 1993. Production and characterization of fertile somatic hybrids of egg plant (*Solanum melongena* L.) with *Solanum aethiopicum* L. *Theor. Appl. Genet*. 85(**6-7**): 841-850.

de Condolle, M. A. P. 1966. *Physiologie vegetable*. Tome III, Bechet Jenune, Lib. Fac. Med. Paris. pp.1474-1475.

Deshpande, A., Bankapur, V. M., and Nalwadi U. G. 1978. Some aspects of blossom biology in brinjal relatives. *Curr. Res.* 7(**10**) 174-175.

Devi, P., Munshi, A. D., Behara, T. K., Choudhary, H., Vinod., Gurung, B., and Saha, P. 2015. Cross compatibility in interspecific hybridization of eggplant, *Solanum melongena*, with its wild relatives. *Sci. Hortic.*193 : 353-358.

Dobromilska, R. 1997. Yielding varieties of sweet peppers based on pollination. VII *Plants. Garden*. pp. 399-402.

Dobromilska, R. and Fawceet, M. 1999. The importance of bumble bees in natural cultivation of tomatoes under covers. *Prob. Post. Nauk. Rol. Sci*. 466: 493-502.

Doganlar, Anne, F., Marie ,C., Daunay, Richard, N., and Lester. 2002. A comparative genetic linkage map of egg plant (*Solanum melongena*) and its implication for genome evolution in the Solanaceae. *Genetics*. 161: 1713-1726.

Dubey, P. S. and Mall, L. P. 1972. Herbicidal pollution. Pollen damage by the herbicide vapours. *Experientia*. 28: 600.

Furini, A. and Wunder, J. 2003. Analysis of eggplant (*Solanum melongena*) related germplasm: morphological and FLP data contribute to phylogenetic interpretation and germplasm utilization. *Theor. Appl. Genet*. 108: 197-208.

Gardiner, S. E. and Forde, M. B. 1988. Identification of cultivars and species of pasture legumes by sodium dodecylsulphate polyacrylamide electrophoresis of seed proteins. *Plant Variet. Seeds* 1: 13-26.

George, R. A. T. 1985. *Vegetable Seed Production*, New York, 223–229p.

Ghosh, S. K., Laskar, N., and Senapati, S. K. 2007. Seasonal incidence of predator *Menochilus sexmaculatus* (Ber.) on brinjal and harmful effects of insecticides on the predator. *Indian. J. Agric. Res.* 41(**2**): 102 -106.

Ghosh, Sunilkumar, and Senapati. 2011. Evaluation of brinjal varieties commonly grown in terai region of West-Bengal against pest complex. *Crop. Res*. 21(**2**): 157-163.

Giordano, L. B., Aragao, F. A. S., and Boiteux, L. S. 2003. Genetic improvement of tomato. *Agric. Rep*. 24: 43-57.

Giri, G. S. and Tamata, S. W. F. 2012. Seed priming winter wheat for germination, emergence and yield. *Crop. Sci.* 43(**21**): 2135-2141.

Gisbert, C., Prohens, J., and Nuez, F. 2011. 537 Treatments for improving seed germination in eggplant and related species. *Acta Hort*. 898: 45-51.

Górecki, R. S. and Espinosa-Flores, A. 1996. Wpływheterostyliikwiatówoberżyny *Solanum melongena* L. odm.Rodonawiązanieo wocóworazlicz bęnasion. *Mat. Konf. Międzyn. Symp.*, 15-19 lipiec, Skierniewice, 50-51.

Gosiewski, W. and Skąpski, H. 1988. *Pomidoryszklarniowe*. PWRiL, Warszawa, 52p.

Gousset, C., Collonnier, C., Mulya, K., and Mariska, I. 2005. *Solanum torvum*, as a useful source of resistance against bacterial and fungal diseases for improvement of egg plant (*S. melongena* L.). *Plant. Sci.* 168: 319-327.

Gowda, P. H. R. and Seenappa, K., 1991.Occurrence of natural inter-specific hybrids of *S. incanum* L. *Crop Res*. 4: 352-354.

Gowda, P. H. R., Shivashankar, K. T., and Joshi, S. H. 1990. Interspecific hybridization between *Solanum melongena* and *Solanum macrocarpon*: study of the $F_1$ hybrid plants. *Euphytica* 48(**1**): 59-61.

Gross, J. A. 1971. Effect of salinity on pollen. *Am. J. Bot.* 58: 721-725.

Gupta, S. K. and Robbelen, G. 1986. Identification of rapeseed (*Brassica napus*) cultivars by electrophoresis. *Euphytica*. 96: 363-370.

Handique, A. K. 1986. Breeding behavior of *Solanum khasianum* Clarke, *Euphytica.* 35 : 631-645.

Handique, A. K. and Sarma, A. 1995. Alteration of heterostyly in *Solanum melongena* L. through gamma-radiation and hormonal treatment. *J. Nuc. Agric. Biol*. 24: 121–126.

Hasan, S. M. Z. 1989. Biosystematic study of *Solanum melongena* L. In Asia and Africa. Ph.D. (Plant breeding and genetics) thesis, University of Birmingham, UK, 200p.

Howlett, F. S. 1936. The effect of carbohydrate and nitrogen deficiency upon microsporogenesis and the development of the male gametophyte in the tomato (*Lycopersicom esculentum* Mill.). *Annals. Bot.* 50: 767-804.

Huaman and Stegimann. 1989. Use of electrophoretic analyses to verify morphologically identical clones in a potato collection. Plant Varieties and Seeds 2: 155-161.

IPGRI. 1988. Descriptors for eggplant. International Plant Genetic Resources Institute, Rome. pp. 1-23.

Isshiki, S., Okubo, V., and Fujieda, K . 1994. Genetic control of isozymes in egg plant and its wild species. *Euphytica.* 80: 145-150.

Johnson, H. W., Robinson, H. W., and Comstock, R. E. 1955. Estimation of genetic and environmental variability in soybeans. *Agron. J.* 47: 314-318.

Kakizaki,Y. 1930. Breeding crossed egg plants in Japan. *J. Hered.* 253-258.

Kalloo, G. 1993. Egg plant *Solanum melongena* L. In: Kalloo, G., and Bergh, B. O. (Eds.). Genetic improvement of vegetable crop. Pergamon Press, Oxford. pp. 587–604.

Karihaloo, J. L. and Gottlieb, L. D. 1995. "Allozyme variation in the eggplant", *Solanum melongena* L. (Solanaceae)". *Theor. Appl. Genet.* 90: 578-583.

Karihaloo, J. L., Kaur, M., and Singh S. 2002. Seed protein diversity in *Solanum melongena* L. and its wild and weedy relatives. *Genet. Res. Crop. Evol.* 49(**9**): 533-539.

KAU [Kerala Agricultural University]. 2011. Package of Practices Recommendations: Crops (14$^{th}$ Ed.). Kerala Agricultural University, Thrissur, 360p.

Khan, R. 1979. *Solanum melongena* and its ancestral forms. In: Hawkes, J. G, Lester, R. N, and Skelding, A. O (eds.). The biology and taxonomy of the Solanaceae. Academic Press, London, pp 629 - 635.

Konys, E. 1993. Warzywapsiankowate. [w] Gapiński M., (red.), Warzywamałoznane i zapo- mniane. PWRiL, Poznań, 78-82.

Kouassi, A., Belisika, Tianbi, T.N, Alla-N'Nan, O., and Toure, B. T. 2014. Identification of three distinct eggplants subgroups within the *Solanum aethiopicum* Gilo group from Cote d'ivore by morph-agronomic characterization. *Agriculture*. 4: 260-273.

Kowalska, G. 2003a. The influence of heterostyly, pollination method and harmonization on eggplant's (*Solanum melongena* L.) flowering and fruiting. *Acta. Agro. Botanica*. 56 (**1-2**): 61-76.

Kowalska, G. 2003b. The effect of pollination method and flower hormonization on yielding of eggplant (*Solanum melongena* L.) grown in a plastic tunnel. *Folia. Hortic*. 15(**2**): 77-87.

Kowalska, G. 2006. Eggplant (*Solanum melongena* L.) flowering and fruiting dynamics depending on pistil type as well as way of pollination and flower harmonization. *Folia. Hortic*. 18(**1**): 17-29.

Krishnamurthy, S. and Subramanian, D. 1954. Some investigations on the types of flowers in brinjal (*Solanum melongena* L.) based on the style length and fruit set under natural conditions. *Indian J. Hort*. 11: 63-67.

Kumchai, J., Wei, Y. C., Lee, C. Y., Chen, F. C., and Chin. S. W. 2013. Production of interspecific hybrids between commercial cultivars of the eggplant (*Solanum melongena* L.) and its wild relative *S. torvum*. *Genet. Mol. Res*. 12: 755-764.

Lacerda, C. A., Almeida, E. C., and Lima, J. O. G. 1994. Estádio de desenvolvimento da flor de *Lycopersicom esculentum* Mill. Cv. Santa Cruz Kada ideal paracoleta de pólen a sergerminadoemmeio de cultura. Pesquisa Agropecuária Brasileira 29: 169-175.

Lawande, K. E and Chavan, J. K. 1998. Egg plant (Brinjal). Salunkhe D. K., Kadam S. S., (red.), *Handbook of vegetable science and technology. Production, composition, storage and processing*. New York. pp. 225–244.

Lester, R. N. 1998. Genetic resources of capsicums and eggplants. Xth EUCARPIA Meeting on Genetics and Breeding of Capsicum. Burnham, C. R. 1962 Discussions in Cytogenetics. Burgess Publishing, Minneapolis and Eggplant, Avignon, France, pp. 25-30.

Lester, R. N. and Hasan, S. M. Z. 1991. Origin and domestication of the eggplant *Solanum melongena* from *Solanum incanum*, in Africa. In Hawkes J. G Lester, R. N., Nee, M., and Estrada (ed.). Solanaceae iii: taxonomy chemistry, Evolution, 369-387.

Lester, R. N. and Niakan, L. 1986. Origin and domestication of the scarlet eggplant, *Solanum aethiopicum* from *S. anquivi* in Africa. In Solananceae: biology and systematics, D' Arcy, W. G., ed., New York, USA, Columbia University Press, 433-456.

Levin, R. A., Myers N. R., and Bohs, L. 2006. Phylogenetic relationship among the "spiny solanums" (*Solanum* subgenus *Leptostemonum*, Solanaceae). *Am. J. Bot*. 93: 157-169.

Levin R. A., Watson, K., and Bohs, L. 2005. A four-gene study of evolutionary relationships in Solanum section *Acanthophora. Am. J. Bot*. 92(**4**): 603-612.

Mac Daniels, L. H. and Hildebrand, E. M. A. 1939. Study of pollen germination upon the stigmas of apple flowers treated with fungicides. *Proceedings of the American Society for Horticultural Science*. 36: 137.

Macha, E. S. 2005. African eggplants promising vegetables for home consumption and sale in Tanzania. Proceedings of the Third Horticulture Workshop on Sustainable Horticultural Production in the Tropics, Maseno, Kenya, 63p.

Magtang, M. V. 1936. Floral biology and morphology of the egg plant. *Philipp. Agrie*. 25: 30-64.

Mc Gregor, S. E. 1976. Insect pollination of cultivated crop plant. *Agric. Res. Serv.* US Dep. of Agric., Washington D. C., 12 (4): 43-69.

Moore, P. D. and Webb, J. A. 1972. *An Illustrated Guide To The Pollen Analysis*. Hodder and Stoughton, London, 133p.

Mullahey, J. J. and Colvis, D. L. 1993. Tropical soda apple: A new noxious weed in Florida. University of Florida, Florida Cooperative extension service, Fact sheet WRS-7, 68p.

Mullahey, J. J., Nee, M., Wunderlin, R. P., and K. R. Delaney. 1993. Tropical soda apple (*Solanum viarum*): a weed threat in subtropical regions. *Weed. Technol*. 7:783-786.

Nair, P. K. K. 1970. *Pollen Morphology of Angiosperms*. Scholar publishing house, Bisheswar Nath road, Lucknow, 160p.

Nasrallah, M. E. and Hopp, R. J. 1963. Inter-specific crosses between *S. melongena* L. (egg plant) and related *Solanum* species. *Proc. Amer. Soc. Hort*. Sci. 83 :571-574.

Nee, M. 1991. Synopsis of *Solanum* section *Acanthophora*: a group of interest for glycoalkaloids. In: Hawkes, J. G., Lester, R. N., Nee, M., and Estrada, N., eds. Solanaceae III. 3: 22-25.

N. H. B [National Horticulture Board]. (2014). www. nhbdatabase. org, internet communication.

Nishio, T., Mochizuki, D. L., and Yamakawa, K. 1984. Interspecific crosses between egg plant and related species. *Bull. Veg. Ornamental Crops, Res. Stn. A.,* 12 : 57-64.

Oganesjan, A. G. 1965. The influence of certain factors on fruit and yielding capacity of hybrid seeds of eggplant. *News Min. Product stock agric. prod. Armen*. SSR. 3: 59-63.

Omidiji, M. O. 1974. Interspecific hybridization in the cultivated, non-tuberous *Solanum* species. *Euphytica* 24: 341-353.

Oyelana, O. and Oguwenmo, O. K. 2012. Floral biology and the effects of plant-pollinator interaction on pollination intensity, fruit and seed set in *Solanum. Afric. J. Biot.* 11(**84**): 14967-14981.

Oyelana, O., Oguwenmo, O. K., and Nwangburuka, C. 2016. Cytomorphological analysis of a novel hybrid from *S. melongena* x *S. scabrum. Spanish. J. Ag. Res.* 7(**2**) :355-353.

Pal, B. P., and Singh, H. B. 1943. Floral characters and fruit formation in the egg plant. *I. J. Genet*. 3(**1**): 45-58.

Passam, H. C. and Bolmatis, A. 1997. The influence of style length on the fruit set, fruit size and seed content of aubergines cultivated under high ambient temperature. *Trop. Sci*. 37: 221-227.

Patel, D. A., Shukla, P. T., and Jadeja, A., 2001. Morphological studies on interspecific hybrids between *Solanum indicum* L. and *Solanum melongena* L. *Indian. J. Genet.* 61: 180-182.

Peregrine, W.T. H. and Ahmad, K. 1982. Grafting - a simple technique for overcoming bacterial wilt in tomato. *Trop. Pest. Manag.* 28: 71-76.

Polverente, M. R., Fontes, D. C., and Cardoso, A. I. I. 2005. Producao e qualidade de sementes de berinjelaemfunção do horãrio de polinizacao manual. Bragantia, Campinas. 64(3): 467-472.

Popova, D. 1958. Some observations on the flowering, pollination and fertilization of the eggplant. *Inst. Rasten. Plant. Ind.* 5: 211.

Pradeepa, G. L. 2002. Fruit-setting behaviour in relation to floral morphology of eggplant. *Trop. J. Ag. Ext.* 5(**1-2**): 13 – 18.

Prakash, R. 1968. Floral biology of brinjal (*Solanum melongena* L.). *I. J. Agric. Sci.* 38: 1053-1061.

Prasad, D. N. and Prakash R. 1968. Floral biology of brinjal (*Solanum melongena* L.). *I. J. Agric.Sci.* 38: 1053–1061.

Prasad, M. K. and Krishnaprasad, M. 1994. *Outlines of microtechniques.* Emkey Publishers, New Delhi, 103p.

Prohens, J., Whitaker, B. D., Plazas, M., Vilanova, S., Hurtado, M., Blasco, M., Gramazio, P., and Stommel, J. R. 2013. Genetic diversity in morphological characters and phenolic acids content resulting from an interspecific cross between eggplant, *Solanum melongena*, and its wild ancestor (*S. incanum*). *Ann. Appl. Biol.* 162: 242-257.

PROTA. 2004. Plant Resources of Tropical Africa, In: Grubben, G. J. H. and Denton, O. A (eds.), *Vegetables*. The Netherlands: Backuys Publishers, 668p.

Pugalendhi, L., Veeraraghavathatham, D., Natarajan, S., and Parineetha, D. 2010. Utilizing wild relative (*Solanum viarum*) as a resistant source to shoot borer in brinjal (*Solanum melongena*. L). *Electron. J. Plant. Breed.* 1(**4**) 643-648.

Radford, A. E., Dickson, W. C., Massery, J. R., and Ritchiebell. 1974. *Vascular plant systematics.* Harper and Raw publishers, New York, 891p.

Rai, N., Asati, B. S., and Yadav, D. S. 2004. Conservation and genetic enhancement of underutilized vegetable crop species in North-Eastern region of India. *Leisa India.* 6: 11-12.

Rajasekharan. 1969. Incompatibility existing among wild brinjal types. *Annamalai Univ. Agric. Res. An.* 1: 49-60.

Rajasekaran, S. 1970. Cytogenetic studies of the $F_1$ hybrid *Solanum indicum* L., *S. melongena* L. and its amphidiploid. *Euphytica* 19:217-224.

Rao, G. R., 1975. Results of inter-specific cross pollination between *S. melongena* and *S. incanum* in egg plant breeding. *Proc. Indian Natl. Sci. Acad.* 47 (**6**): 893-896.

Rao, G. R. 2011. Some observations of inter-specific hybrids of *S. melongena* L. *Proc. Indian Acad. Sci.* 89(**2**): 117-121.

Rao, T. N., Nerkar, Y. S., and Patil, Y. D. 1990. Identification of cultivars of cotton by sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) of soluble seed proteins. *Plant Variet. Seeds* 5: 83-91.

Rao, N. 1979. The barriers to hybridization between *Solanum melongena* and some other species of *Solanum.* In: Hawkes, J. G, Lester, R.N., and Skelding, A.D. (eds). The biology and taxonomy of the Solanaceae. Academic Press, London, pp. 605-614.

Rizza, F., Mennella, G., Collonnier, C., Sihachakr, D., Kashyap, V., Rajam, M., Prestera, M., and Rotino G., 2002. Androgenic dihaploids from somatic

hybrids between *Solanum melongena* and *S. aethiopicum* group *gilo* as a source of resistance to *Fusarium oxysporum* fsp. *melongenae*. *Plant.Cell. Rep*. 20(**11**): 1022-1032.

Robinson, R. W., Shail, J. W., and Gao, Y., 2001. Interspecific hybridization of eggplant for verticellium wilt resistance and other useful traits. In: van den Berg, R. G., Barendse, G. W. M., Van der Weerden, G.M., and Mariani, C. (Eds.), Solanaceae V. Advances in Taxonomy and Utilization. Nijmegen University Press, Nijmegen, The Netherlands, pp. 279-292.

Rylski, I., Nothmann, J., and Arcan, L. 1984. Different fertility in short-styled eggplant flowers. *Scientia. Hort*. 22: 39-44.

Saini, A. D. 1966. Alkaloidal content of *Solanum khasianum* Clarke. *Curr. Sci*. 35: 600-612.

Sakata, Y. and Lester, R. N. 1997. Chloroplast DNA diversity in brinjal eggplant (*Solanum melongena* L.) and related species. *Euphytica* 97: 295-301.

Sambandam, C. N. 1964. Natural cross pollinaton in egglant (*Solanum melongena* L.). *Econ. Bot*. 18(**2**): 128–131.

Sampson, H. C. 1936. Flowering in vegetables. *Bull. Misc Inf. Roy. Bot. Gdn*. Kew, *Add. Ser*. 12:159-172.

Samuel, J. 2010. Taxonomic relationships of eggplant wild relatives in series Incaniformia Bitter .In. Advances in Genetics and Breeding of Capsicum and Eggplant, pp. 89-95.

Sathaiah, Y. and Reddy, T. P. 1985. Seed protein profiles of castor (*Ricinus communis* L.) and some *Jatropha* species. *Genet. Agr*. 39: 35-43.

Schaff, D. A., Boyer, C. H., and Pollock, B. L. 1980. Result of crosses between *S. melongena* and *S. macrocarpon* types. *Hort. Sci.* 15: 419-426.

Schaff, D. A., Jelenkovic, G., Boyer, C. D., and Pollack, B. L., 1982. Hybridization and fertility of hybrid derivatives of *Solanum melongena* L. and *Solanum macrocarpon* L. *Theoret. Appl. Genet*. 62: 149–153.

Schmidt, M. V. 1935. A contribution to breeding and seed production in peppers and eggplant. Nikita state Bot. Gdn., Crimean regional exp. Sta. Veg. Culture, pp. 105.

Sekara, A., Cebula, S., and Kumar, E. 2007. Cultivated eggplant- Origin, breeding objectives and genetic resources a review. *Folia. Hortic*. 19: 97-114.

Sengupta, G. 1961. A taxonomic note on *S. khasianum* and the description of a new variety under it. *Bull. Bot. Surv. India.*3(**364**): 411-415.

Shim, Y., Zhang, Y., Liu, H., Shen, S., and Zhang, S. 2008. Improvement of eggplant seed germination and seedling emergence at low temperature by seed priming with incorporation of SA into $KNO_3$ solution. *Front. Agric. China*. 5 (**4**): 534-537.

Shukla, V. and Naik, L. B. 1993. Agro-techniques of solanaceous vegetables, in 'Advances in Horticulture', Vol.5, Vegetable Crops, Part 1 (K. L. Chadha and G. Kalloo, eds.), Malhotra Pub. House, New Delhi, 365p.

Sivasubramanian, S. and Menon, M. 1973. Heterosis and inbreeding depression in rice. *Madras Agric. J.* 60: 1139-1144.

Sindhu, A. S., Kalloo. and Panditha, M. L. 1980. Studies on some important aspects of floral biology in vegetable crops. *Haryana. J. Hort. Sci*. 9(**3-4**) 207-217.

Singh, P. K. and Gopalakrishnan, T. R. 1997. Grafting for wilt resistance and productivity in brinjal (*Solanum melongena* L.). *Hort. J.* 10: 57-64.

Singh, R. K. and Chaudhary, B. D. 1977. *Biometrical Methods in Quantitative Genetic Analysis*. Kalyani Publishers, New Delhi, 318pp.

Singh, A.K., Singh M., Singh R., Kumar S., and Kalloo, G. 2006. Genetic diversity within the genus *Solanum* (Solanaceae) as revealed by RAPD markers. *Curr. Sci.* 90(**5**): 711-716.

Som, M. G. and Maity, T. K. 1986. Brinjal. In: Vegetable Crops in India (Eds). Bose, T. K. and Som, M. G., Naya Prakash, Calcutta, pp. 293-335.

Stegemann, A. A., Shah, E., Krogerreckle. F., and Hiza, M. 1992. Sweet potato (*Ipomoea batatas* L.): genotype identification by electrophoretic methods and properties of their proteins. *Plant Variet. Seeds* 5: 83-91.

Stępowska, A. 1996. Trzmielziemny (Bombusterrestris) jakonaturalnyzapylaczpapryki pod osłonami. Mat. Symp. Noweroślinyi. Września, Poznań, 249-252.

Swarup, V. 1995. Genetic resources and breeding of aubergine (*Solanum melongena* L.). *Acta. Hort.* 412: 71-79.

Tatebe, T. 1938. On pollination of eggplant. *J. Hort.* 2: 61-69.

Tripathy, M. K., Senapati, B., and Patra, R. 1966. Relationship of fruiting period and crop age with shoot and fruit infestation in brinjal by *Leucinodes orbonalis* Guen. at Bhubaneswar. *Environ. Eco.*15: 142-144.

Vavilov, N. I. 1926. Studies on the origin of cultivated plants. *Russian Bulletin of Applied Botany and Plant Breeding.* 14: 1-245.

Vavilov, N. I .1951. The origin, variation, immunity and breeding of cultivated plants. *Chron. Bot.* 13: 1-364.

Vijay, O. P., Nath, P., and Jalikop, S. H. 1977. Studies on floral biology of egg plant. *Ind. J. Ag. Sci.* 46(**6**): 288-289.

Vishwanathan, T. V. 1975. On the occurrence of natural hybridization between *Solanum incanum* L. and *Solanum melongena* L. *Curr. Sci.* 44: 134-140.

Wang, C., Bian, K., Zhang, H. X., Zhou, Z. M., and Wang, J. A. 1994. Polyacrylamide gel electrophoresis of salt soluble protein for maize variety identification and genetic purity assessment. *J. Seed Sci. Tęch.* 22: 51-57.

Wunderlin, Richard, P., Hansen, Bruce, F., Delaney, Kris, R., Nee, Michael, Mullahey, J., and Jeffrey. 1993. *Solanum viarum* and *S. tampicense* (Solanaceae): two weedy species new to Florida and the United States. *Sida.* 15(**4**): 605-611.

Wysocka-Owczarek, M. 1993. Zapylaniepomi dorówszklarnio wychprzy wykorzy staniutrz mielazie mnego. *Now. Warz.* 24: 31–40.

Yadhav, D. S., Jadhav, D. S., and Sharma, M. M. 2005. Evaluation of brinjal genotypes for resistance aginst shoot borer *Leucinodes orbonalis Guinee. Indian. J. Entomol.* 67(**2**): 129-132.

Yupsanis, T., Mocstakas, M., and Karakoli, S. 1992. Seed protein electrophoresis for varietal identification in rice (*Oryza sativa* L.). *J. Agron. and Crop Sci.* 168(**2**): 95-99.

Zeven, A. C. and Zhukovsky, P. M. 1975. Dictionary of cultivated plants and their centres of diversity, Wageningen. 219 p.

# BREEDING BIOLOGY AND CROSS COMPATIBILITY OF CLOSE WILD RELATIVES OF BRINJAL
(*Solanum melongena* L.)

By
**NEERAJA PUTHIAMADOM**
**(2014-11-112)**

**ABSTRACT OF THE THESIS**

**Submitted in partial fulfillment of the requirement for the degree of**

MASTER OF SCIENCE IN AGRICULTURE

***Faculty of Agriculture***
***Kerala Agricultural University***

**Department of Plant Breeding and Genetics**
**COLLEGE OF HORTICULTURE**
**VELLANIKKARA, THRISSUR - 680 656**
**KERALA, INDIA**
**2016**

## ABSTRACT

The present study entitled "Breeding biology and cross compatibility of close wild relatives of brinjal (*Solanum melongena* L.)" was carried out in the Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara, during 2014 – 2016. The objective of the study was to elucidate the reproductive biology of the related wild species of brinjal and to ascertain their cross compatibility with the cultivated species.

Four wild species variants of *Solanum viz., viarum, gilo, incanum and indicum,* collected from NBPGR, RS, Vellanikkara along with *S. melongena* varieties Haritha and Surya formed the material for the study. These genotypes were evaluated for various vegetative, floral and fruit characters following the descriptor developed by IPGRI (1988) and clustering was done.

Study of the reproductive biology revealed that flowering was profuse in *S. viarum*, *S.incanum* and *S. gilo.* However *S. indicum* did not flower during the entire experiment period and hence could not be utilized in the programme.

The flowers of *Solanum* species were found to be positively geotropic with a floral formula of $\varphi\nearrow K_{(5)}C_{(5)}\overline{A}_{(5)}\underline{G_{(2)}}$. In all the species evaluated, flowers were pedicellate, zygomorphic, bisexual and complete. Irrespective of species, long, medium and short styled flowers were observed. However, the frequency of medium styled flowers were very low. Unlike in the case of *S. gilo* and *S. melongena* variety Haritha, a change in colour of the corolla was observed in *S. viarum, S. incanum* and *S. melongena* variety Surya on the day prior to anthesis.

The time of anther dehiscence was found to vary with the species. The pollen grains dehisced nearly two to five hours after flower opening in *S. viarum* and *S. incanum*. However, in the cultivated varieties, Haritha and Surya, anther dehiscence commenced along with the opening of flowers. Among the different

species protandry was observed only in *S. gilo*. The dehiscence continued for three days in all the species. Irrespective of species, pollen grains were remained fertile for three days.

The change in the colour of the stigmatic surface from glossy green to deep yellow, at the time of initiation of stigma receptivity was a unique feature of *S. gilo*. In all the other wild species of *Solanum* as well as the cultivated varieties Haritha and Surya, the colour of the stigmatic surface was glossy green at the time of receptivity. The colour was found to fade with the decline in receptivity.

Studies to assess the mode of pollination revealed that cross pollination is the rule in *Solanum* species.

Cross compatibility studies were undertaken between the three wild species which flowered and the two cultivated types under *S. melongena.* Among the twelve crosses attempted, Surya x *S. viarum*, *S. viarum* x Surya, Surya x *S. incanum*, Haritha x *S. incanum*, *S. incanum* x Haritha, *S. viarum* x Haritha were the successful ones. Out of these, the progeny of three crosses *viz.,* Surya x *S. viarum*, *S. viarum* x Surya and Surya x *S. incanum* established in the field. The progeny of the cross Surya x *S. viarum* was found to be superior with respect to fruit weight as well as absence of prickles on leaf and fruit pedicel. Even though one of the parents of this cross, Surya was susceptible to most of the common pests and diseases of brinjal, no incidence of pests and diseases was noticed in the progeny population.

# *APPENDIX*

## Annexure 1

## IPGRI descriptor for brinjal

| Vegetative characters | | | |
|---|---|---|---|
| **SL. NO** | **Character** | **Code** | **Trait** |
| 1 | Cotyledon colour | 3 | Green |
| | | 5 | Light violet |
| | | 7 | Violet |
| 2 | Plant growth habit | 3 | Upright |
| | | 5 | Intermediate |
| | | 7 | Prostrate |
| 3 | Plant branching (no of primary branches per plant) | 1 | Very weak (~2) |
| | | 3 | Weak (~5) |
| | | 5 | Intermediate (~10) |
| | | 7 | Strong (~20) |
| | | 9 | Very strong (>30) |
| 4 | Plant height (at flowering stage) | 1 | Very short (<20 cm) |
| | | 3 | Short (~30 cm) |
| | | 5 | Intermediate (~60 cm) |
| | | 7 | Tall (~100 cm) |
| | | 9 | Very tall (>150 cm) |
| 5 | Plant breadth (at flowering stage) | 1 | Very narrow (<30 cm) |
| | | 3 | Narrow (~40 cm) |
| | | 5 | Intermediate (~60 cm) |
| | | 7 | Broad (~90 cm) |
| | | 9 | Very broad (> 150 cm) |
| 6 | Leaf blade length | 3 | Short (~10 cm) |
| | | 5 | Intermediate |

| | | | |
|---|---|---|---|
| | | | (~20 cm) |
| | | 7 | Long (~30 cm) |
| 7 | Leaf blade width | 3 | Narrow (~5 cm) |
| | | 5 | Intermediate (~10 cm) |
| | | 7 | Wide (~15 cm) |
| 8 | Leaf blade lobing | 1 | Very weak |
| | | 3 | Weak |
| | | 5 | Intermediate |
| | | 7 | Strong |
| | | 9 | Very strong |
| 9 | Petiole length | 0 | None |
| | | 1 | Very short (<5 mm) |
| | | 3 | Short (~10 mm) |
| | | 5 | Intermediate (~30 mm) |
| | | 7 | Long (~50 mm) |
| | | 9 | Very long (>100 mm) |
| 10 | Petiole colour | 1 | Green |
| | | 3 | Greenish violet |
| | | 5 | Violet |
| | | 7 | Dark violet |
| | | 9 | Dark brown |
| 11 | Leaf blade colour (upper surface) | 1 | Light green |
| | | 3 | Green |
| | | 5 | Dark green |
| | | 7 | Greenish violet |
| | | 9 | Violet |
| 12 | Leaf blade tip angle | 1 | Very acute (<15°) |
| | | 3 | Acute (<45°) |
| | | 5 | Intermediate (~75°) |

| | | | |
|---|---|---|---|
| 13 | | 7 | Obtuse (~110°) |
| | | 9 | Very obtuse (>160°) |
| | Leaf prickles (number of leaf prickles on upper surface of leaf) | 0 | None |
| | | 1 | Very few (1-2) |
| | | 3 | Few (3-5) |
| | | 5 | Intermediate (6-10) |
| | | 7 | Many (11-20) |
| | | 9 | Very many (>20) |
| **Floral characters** | | | |
| 14 | Corolla colour | 1 | Greenish violet (Methuen 30A2) |
| | | 3 | White (Methuen 1A1) |
| | | 5 | Pale violet (Methuen 18A3) |
| | | 7 | Light violet (Methuen 18A5) |
| | | 9 | Bluish violet (Methuen 18A7) |
| 15 | Average no of prickles per calyx | 0 | None |
| | | 1 | Very few (<3) |
| | | 3 | Few (~5) |
| | | 5 | Intermediate (~10) |
| | | 7 | Many (~20) |
| | | 9 | Very many (>30) |
| **Fruit characters** | | | |
| 16 | Fruit length | 1 | Very short (< 1 cm) |
| | | 3 | Short (~2 cm) |
| | | 5 | Intermediate |

| | | | |
|---|---|---|---|
| | | | (~5 cm) |
| | | 7 | Long (~10 cm) |
| | | 9 | Very long (>20 cm) |
| 17 | Fruit breadth (diameter at the broadest part) | 1 | Very small (<1 cm) |
| | | 3 | Small (~ 2 cm) |
| | | 5 | Intermediate (~ 3 cm) |
| | | 7 | Large (~ 5 cm) |
| | | 9 | Very large (> 10 cm) |
| 18 | Fruit curvature | 1 | None (fruit straight) |
| | | 3 | Slightly curved |
| | | 5 | Curved |
| | | 7 | Snake shaped |
| | | 8 | Sickle shaped |
| | | 9 | U shaped |
| | | | |
| 19 | Fruit cross section | 1 | Circular, no grooves |
| | | 3 | Elliptic, no grooves |
| | | 5 | Few grooves |
| | | 7 | Many grooves |
| | | 9 | Very irregular |
| 20 | Fruit shape (position of widest part of fruit) | 3 | About ¼ way from base to tip |
| | | 5 | About ½ way from base to tip |
| | | 7 | About ¾ way from base to tip |
| 21 | Fruit apex shape | 3 | Protruded |
| | | 5 | Rounded |
| | | 7 | Depressed |
| | | | |

| | | | |
|---|---|---|---|
| 22 | Fruit colour at commercial ripeness | 1 | Green (Metheun 27D8) |
| | | 2 | Milky white (Metheun 1A2) |
| | | 3 | Deep yellow (Metheun 3A8) |
| | | 4 | Fire red (Metheun 7A8) |
| | | 5 | Scarlet red (Metheun 9A8) |
| | | 6 | Liliac grey (Metheun 16C3) |
| | | 7 | Purple (Metheun 16D-E8) |
| | | 8 | Purple black (Metheun 15F5-8) |
| | | 9 | Black |
| 23 | Fruit colour distribution at commercial ripeness | 1 | Uniform |
| | | 3 | Mottled |
| | | 5 | Netted |
| | | 7 | Striped |
| 24 | Fruit colour at physiological ripeness | 1 | Green (Metheun 27D8) |
| | | 2 | Deep yellow (Metheun 3A8) |
| | | 3 | Yellow orange (Metheun 5A8) |
| | | 4 | Deep orange (Metheun 6B8) |
| | | 5 | Fire |

| | | | |
|---|---|---|---|
| | | | red(Metheun 7A8) |
| | | 6 | Poppy red (Metheun 8A8) |
| | | 7 | Scarlet red (Metheun 9A8) |
| | | 8 | Light brown (Metheun 7D8) |
| | | 9 | Black |
| 25 | Fruit flesh density | 1 | Very loose (spongy) |
| | | 3 | Loose (crumbly) |
| | | 5 | Average density |
| | | 7 | Dense |
| | | 9 | Very dense |
| 26 | Fruit position | 1 | Erect |
| | | 3 | Semi- erect |
| | | 5 | Horizontal |
| | | 7 | Semi – pendant |
| | | 9 | Pendant |
| 27 | Fruit pedicel prickles | 0 | None |
| | | 1 | Very few (<3) |
| | | 3 | Few (~5) |
| | | 5 | Intermediate (~10) |
| | | 7 | Many (~20) |
| | | 9 | Very many (>30) |


DESCRIPTORS
FOR EGGPLANT

# DESCRIPTORS FOR EGGPLANT

IBPGR
ROME 1988

The International Board for Plant Genetic Resources (IBPGR) is an autonomous international scientific organization under the aegis of the Consultative Group on International Agricultural Research (CGIAR). IBPGR was established by CGIAR in 1974. The basic function of IBPGR is to promote and coordinate an international network of genetic resources centres to further the collecting, conservation, documentation, evaluation and use of plant germplasm and thereby contribute to raising the standard of living and welfare of people throughout the world. Financial support for the core programme is provided by the Governments of Australia, Austria, Belgium, Canada, China, Denmark, France, FRG, India, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK and the USA, as well as the World Bank

Citation:
IBPGR. 1988. Descriptors for Eggplant. International Board for Plant Genetic Resources, Rome

ISBN 92-9043-131-8

IBPGR Headquarters
c/o FAO
Via delle Terme di Caracalla
00100 Rome
Italy

# CONTENTS

# PREFACE

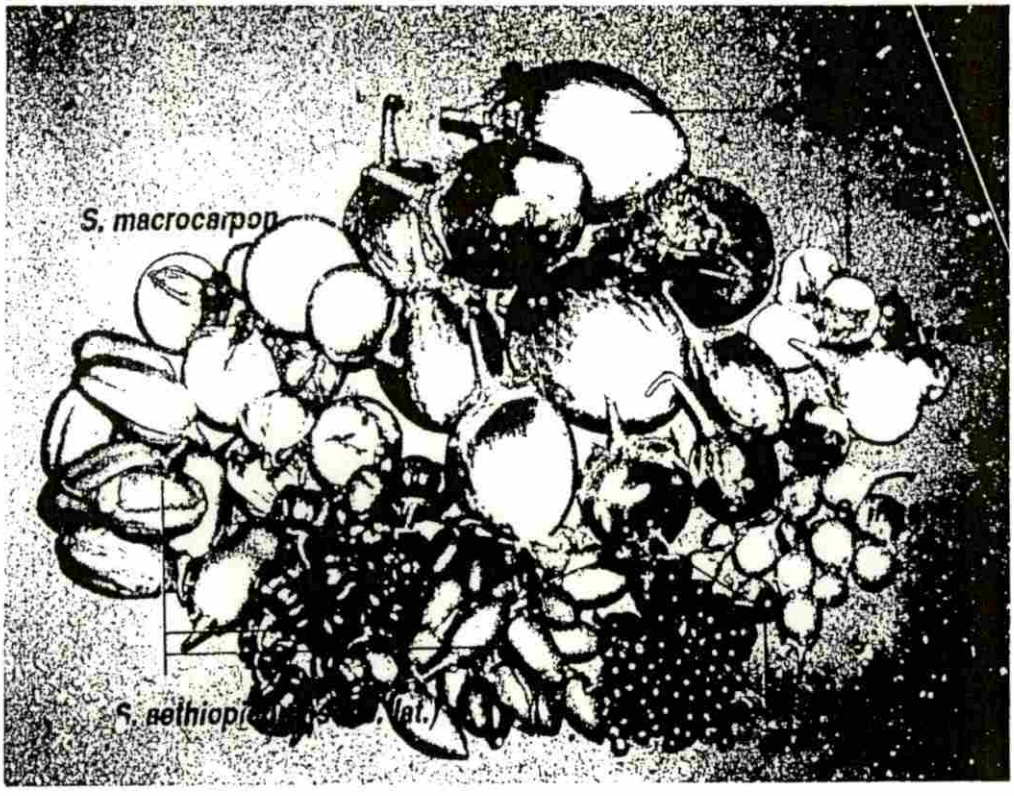
This descriptor list has been prepared in an IBPGR standard format by R.N. Lester and L. Niakan following advice on descriptors and descriptor states from crop experts throughout the world, and after consulting the Russian COMECON Descriptors for Solanum melongena.

The descriptors have been designed for the fruit and leaf vegetables Solanum melongena (Brinjal eggplant or aubergine), S. aethiopicum (scarlet eggplant) and S. macrocarpon (Gboma eggplant) and their wild relatives. Since these plants encompass a wide range of morphological diversity, this descriptor list applies to almost all other Solanum species utilized for fruit (e.g. S. quitoense), leaf vegetable (e.g. S. scabrum) or alkaloid production (e.g. S. aviculare, S. viarum). Only pinnate-leaved vines (e.g. S. muricatum) are not accommodated: for such species the IBPGR Descriptors for Tomato or Potato are more appropriate.

IBPGR encourages the collection of data on the first four categories of this list: 1. Accession; 2. Collection; 3. and 4. Characterization and preliminary evaluation. IBPGR endorses the information in categories 1-4 as the minimum that ideally should be available for any one accession. Other descriptors are given in categories 5 onwards that will enable the simple encoding of further characterization and evaluation data and which can serve as examples for the creation of additional descriptors in the IBPGR form by any user.

Although the suggested coding should not be regarded as the definitive scheme, this format has the full backing of IBPGR and is promoted worldwide. The descriptor list given here provides an international format and thereby produces a universally understood 'language' for all plant genetic resources data. The adoption of this scheme for all data encoding, or at least the production of a transformation method to convert other schemes to the IBPGR format, will produce a rapid, reliable and efficient means for information storage, retrieval and communication. This will greatly assist the utilization of germplasm throughout the international plant genetic resources network. It is recommended, therefore, that information should be produced by closely following the descriptor list with regard to: ordering and numbering descriptors; using the descriptors specified; and using the descriptor states recommended.

Any suggestions for modifications will be welcomed by IBPGR Headquarters, Rome.




*Solanum* cultigens and ancestors

# DESCRIPTOR LIST FOR EGGPLANT

IBPGR now uses the following definitions in genetic resources documentation:

(i) passport data (accession identifiers and information recorded by collectors);

(ii) characterization (consists of recording those characters which are highly heritable, can be easily seen by the eye and are expressed in all environments);

(iii) preliminary evaluation (consists of recording a limited number of additional traits thought desirable by a consensus of users of the particular crop).

Characterization and preliminary evaluation will be the responsibility of the curators, while further characterization and evaluation should be carried out by the plant breeder. The data from further evaluation should be fed back to the curator who will maintain a data file.

The following internationally accepted norms for the scoring or coding of descriptor states should be followed as indicated below:

(a) measurements are made according to the SI system. The units to be applied are given in square brackets following the descriptor;

(b) many descriptors which are continuously variable are recorded on a 1-9 scale. The authors of this list have sometimes described only a selection of the states, e.g. 3, 5 and 7 for such descriptors. Where this has occurred the full range of codes is available for use by extension of the codes given or by interpolation between them - e.g. in Section 8 (Pest and disease susceptibility) 1 = extremely low susceptibility and 8 = high to extremely high susceptibility;

(c) presence/absence of characters are scored as + (present) and 0 (absent);

(d) for descriptors which are not generally uniform throughout the accession (e.g. mixed collection, genetic segregation) mean and standard deviation could be reported where the descriptor is continuous or mean and 'x' where the descriptor is discontinuous;

(e) when the descriptor is inapplicable, '0' is used as the descriptor value, e.g. if an accession does not form flowers, 0 would be scored for the following descriptor

Flower colour

1 White
2 Yellow
3 Red
4 Purple

(f) blanks are used for information not yet available;

(g) standard colour charts, e.g. Royal Horticultural Society Colour Chart, Methuen Handbook of Colour, Munsell Colour Charts for Plant Tissues are strongly recommended for all ungraded colour characters (the precise chart used should be specified in the NOTES descriptor, 11);

(h) dates should be expressed numerically in the format DDMMYYYY, where

DD - 2 digits to represent the day
MM - 2 digits to represent the month
YYYY - 4 digits to represent the year

# PASSPORT

## 1. ACCESSION DATA

1.1 ACCESSION NUMBER

This number serves as a unique identifier for accessions and is assigned by the curator when an accession is entered into his collection. Once assigned this number should never be reassigned to another accession in the collection. Even if an accession is lost, its assigned number is still not available for re-use. Letters should occur before the number to identify the genebank or national system (e.g. MG indicates an accession comes from the genebank at Bari, Italy; PI indicates an accession within the USA system)

1.2 DONOR NAME

Name of institution or individual responsible for donating the germplasm

1.3 DONOR IDENTIFICATION NUMBER

Number assigned to accession by the donor

1.4 OTHER NUMBERS ASSOCIATED WITH THE ACCESSION

(other numbers can be added as 1.4.3 etc.)

Any other identification number known to exist in other collections for this accession, e.g. USDA Plant Inventory number (not collection number, see 2.1)

1.4.1 Other number 1

1.4.2 Other number 2

1.5 SCIENTIFIC NAME

1.5.1 Genus

1.5.2 Species

1.5.3 Subspecies

1.5.4 Cultivar group

1.6 PEDIGREE/CULTIVAR NAME

Nomenclature and designations assigned to breeder's material

1.7 ACQUISITION DATE

The date in which the accession entered the collection

1.8 DATE OF LAST REGENERATION OR MULTIPLICATION

1.9 ACCESSION SIZE

Approximate number of seeds of accession in collection

1.10 NUMBER OF TIMES ACCESSION REGENERATED

Number of regenerations or multiplications since original collection

1.11 TYPE OF MAINTENANCE

1 Vegetative
2 Seed
3 Both vegetative and seed
4 Tissue culture

## 2. COLLECTION DATA

2.1 COLLECTOR'S NUMBER

Original number assigned by collector of the sample normally composed of the name or initials of the collector(s) followed by a number. This item is essential for identifying duplicates held in different collections and should always accompany sub-samples wherever they are sent

2.2 COLLECTING INSTITUTE

Institute or person collecting/sponsoring the original sample

2.3 DATE OF COLLECTION OF ORIGINAL SAMPLE

2.4 COUNTRY OF COLLECTION OR COUNTRY WHERE CULTIVAR/VARIETY BRED

Use the 3 letter abbreviations supported by the Statistical Office of the United Nations. Copies of these abbreviations are available from IBPGR

Headquarters and have been published in the FAO/IBPGR Plant Genetic Resources Newsletter number 49

2.5 PROVINCE/STATE

Name of the administrative subdivision of the country in which the sample was collected

2.6 LOCATION OF COLLECTION SITE

Number of kilometres and direction from nearest town, and village or map grid reference (e.g. TIMBUKTU 7S BOLA means 7 km south of Timbuktu town in Bola village)

2.7 LATITUDE OF COLLECTION SITE

Degrees and minutes followed by N (north) or S (south), e.g. 1030S

2.8 LONGITUDE OF COLLECTION SITE

Degrees and minutes followed by E (east) or W (west), e.g. 7625W

2.9 ALTITUDE OF COLLECTION SITE [m]

Elevation above sea level in metres

2.10 COLLECTION SOURCE

1 Wild
2 Farm land
3 Farm store
4 Backyard
5 Village market
6 Commercial market
7 Institute
8 Other (specify in the NOTES descriptor, 11)

2.11 STATUS OF SAMPLE

1 Wild
2 Weedy
3 Breeder's line
4 Primitive cultivar/landrace
5 Advanced cultivar (bred)
6 Other (specify in the NOTES descriptor, 11)

2.12 LOCAL/VERNACULAR NAME

Name given by farmer to cultivar/landrace/weed

2.13 ETHNIC GROUP

Name of tribe or language

2.14 NUMBER OF PLANTS SAMPLED

Approximate number of plants collected in the field to produce this accession

2.15 PHOTOGRAPH

Was a photograph taken of the accession or environment at collection?

0 No
\+ Yes

2.16 ORGAN USED

1 Fruit
2 Leaf
3 Fruit primarily and leaf secondarily
4 Leaf primarily and fruit secondarily

2.17 PRIMARY FRUIT USAGE

1 Vegetable
2 Flavouring
3 Medicine
4 Steroid alkaloids
5 Poison for vermin
6 Curdling milk
7 Other (specify in the NOTES descriptor, 11)

2.18 SECONDARY FRUIT USAGE

1 Vegetable
2 Flavouring
3 Medicine
4 Steroid alkaloids
5 Poison for vermin
6 Curdling milk
7 Other (specify in the NOTES descriptor, 11)

2.19 PRIMARY LEAF USAGE

1 Vegetable
2 Flavouring
3 Medicine
4 Steroid alkaloids
5 Other (specify in the NOTES descriptor, 11)

2.20 SECONDARY LEAF USAGE

1 Vegetable
2 Flavouring
3 Medicine
4 Steroid alkaloids
5 Other (specify in the NOTES descriptor, 11)

2.21 OTHER NOTES FROM COLLECTOR

Collectors will record ecological information. For cultivated crops, cultivation practices such as irrigation, season of sowing, etc. will be recorded

# CHARACTERIZATION AND PRELIMINARY EVALUATION

## 3. SITE DATA

3.1 COUNTRY OF CHARACTERIZATION AND PRELIMINARY EVALUATION

3.2 SITE (RESEARCH INSTITUTE)

3.3 NAME OF PERSON(S) IN CHARGE OF CHARACTERIZATION

3.4 SOWING DATE

3.5 FIRST HARVEST DATE

3.6 LAST HARVEST DATE

## 4. PLANT DATA

4.1 VEGETATIVE

4.1.1 Cotyledon colour

| | |
|---|---|
| 3 | Green |
| 5 | Light violet |
| 7 | Violet |

4.1.2 Cotyledon length/width ratio

| | | |
|---|---|---|
| 1 | Very low | (<2.0) |
| 3 | Low | (~2.2) |
| 5 | Intermediate | (~2.5) |
| 7 | High | (~3.5) |
| 9 | Very high | (>5.0) |

4.1.3 Plant growth habit

| | |
|---|---|
| 3 | Upright |
| 5 | Intermediate |
| 7 | Prostrate |

4.1.4 Leaf blade length

| | | |
|---|---|---|
| 3 | Short | (~10 cm) |
| 5 | Intermediate | (~20 cm) |
| 7 | Long | (~30 cm) |

4.1.5 Leaf blade width

The maximum width

| | | |
|---|---|---|
| 3 | Narrow | (~ 5 cm) |
| 5 | Intermediate | (~10 cm) |
| 7 | Wide | (~15 cm) |

4.1.6 Leaf blade lobing

See Fig. 1

| | |
|---|---|
| 1 | Very weak |
| 3 | Weak |
| 5 | Intermediate |
| 7 | Strong |
| 9 | Very strong |

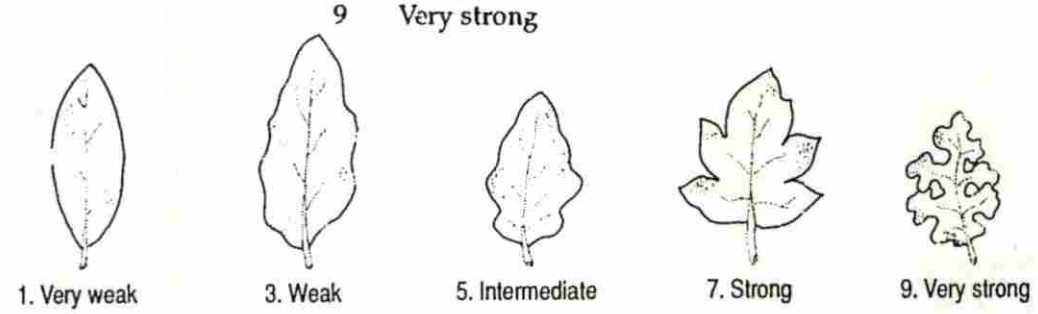



Fig. 1. Leaf blade lobing

4.1.7 Leaf blade tip angle

See Fig. 2

| | | |
|---|---|---|
| 1 | Very acute | (< 15°) |
| 3 | Acute | (~ 45°) |
| 5 | Intermediate | (~ 75°) |
| 7 | Obtuse | (~110°) |
| 9 | Very obtuse | (>160°) |

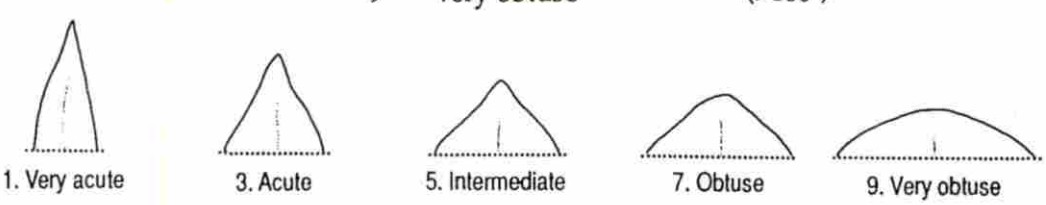



Fig. 2. Leaf blade tip angle

4.1.8 Leaf prickles

Number of leaf prickles on upper surface of the leaf

| | | |
|---|---|---|
| 0 | None | |
| 1 | Very few | (1-2) |
| 3 | Few | (3-5) |
| 5 | Intermediate | (6-10) |
| 7 | Many | (11-20) |
| 9 | Very many | (> 20) |

4.1.9 Leaf hairs

Number of hairs per $mm^2$ on lower surface of the leaf

| | | |
|---|---|---|
| 1 | Very few | (<20) |
| 3 | Few | (20-50) |
| 5 | Intermediate | (50-100) |
| 7 | Many | (100-200) |
| 9 | Very many | (>200) |

4.2 INFLORESCENCE AND FRUIT

4.2.1 Number of flowers per inflorescence

4.2.2 Corolla colour

| | | |
|---|---|---|
| 1 | Greenish white | (Methuen 30A2) |
| 3 | White | (Methuen 1A1) |
| 5 | Pale violet | (Methuen 18A3) |
| 7 | Light violet | (Methuen 18A5) |
| 9 | Bluish violet | (Methuen 18A7) |

4.2.3 Fruit length

From base of calyx to tip of fruit

| | | |
|---|---|---|
| 1 | Very short | (< 1 cm) |
| 3 | Short | (~ 2 cm) |
| 5 | Intermediate | (~ 5 cm) |
| 7 | Long | (~10 cm) |
| 9 | Very long | (>20 cm) |

4.2.4 Fruit breadth

Diameter at broadest part

| | | |
|---|---|---|
| 1 | Very small | (< 1 cm) |
| 3 | Small | (~ 2 cm) |
| 5 | Intermediate | (~ 3 cm) |
| 7 | Large | (~ 5 cm) |
| 9 | Very large | (>10 cm) |

4.2.5 Fruit length/breadth ratio

See Fig. 3

1 Broader than long
3 As long as broad
5 Slightly longer than broad
7 Twice as long as broad
8 Three times as long as broad
9 Several times as long as broad

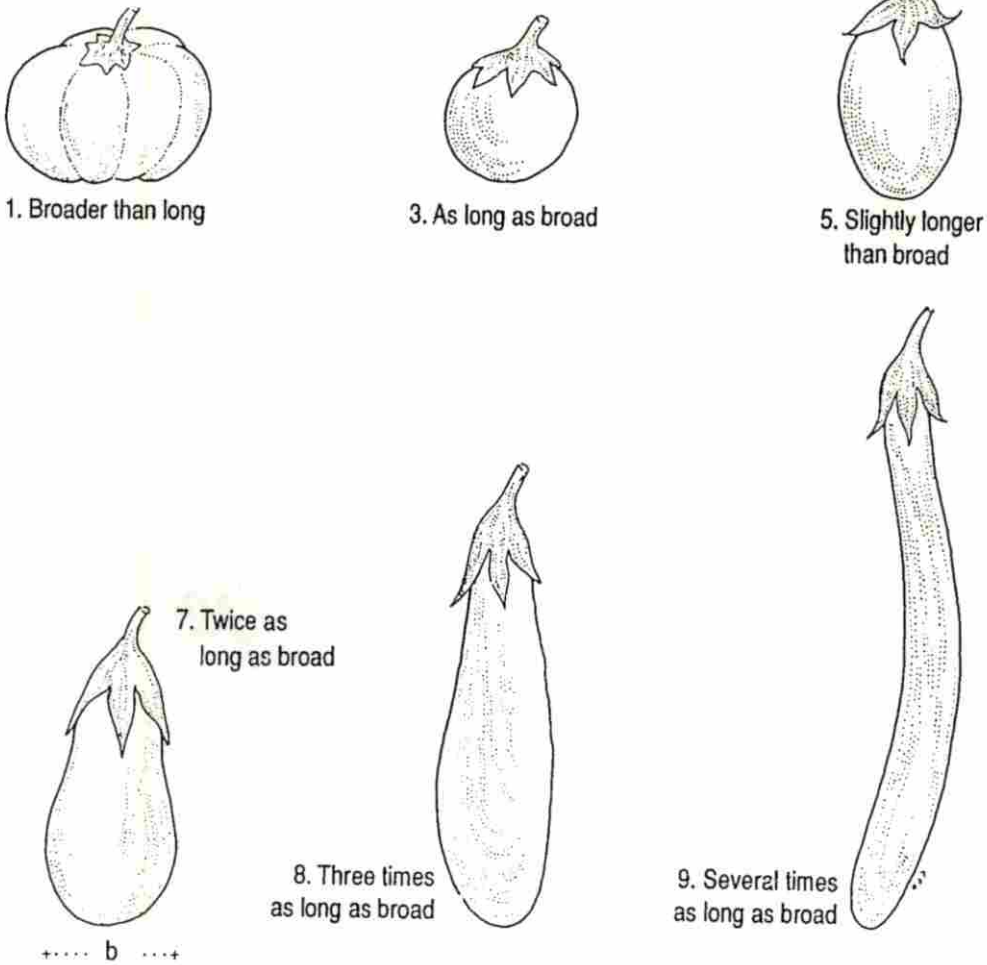



Fig. 3. Fruit length/breadth ratio

4.2.6. Fruit curvature

See Fig. 4

1 None (fruit straight)
3 Slightly curved
5 Curved
7 Snake shaped
8 Sickle shaped
9 U shaped

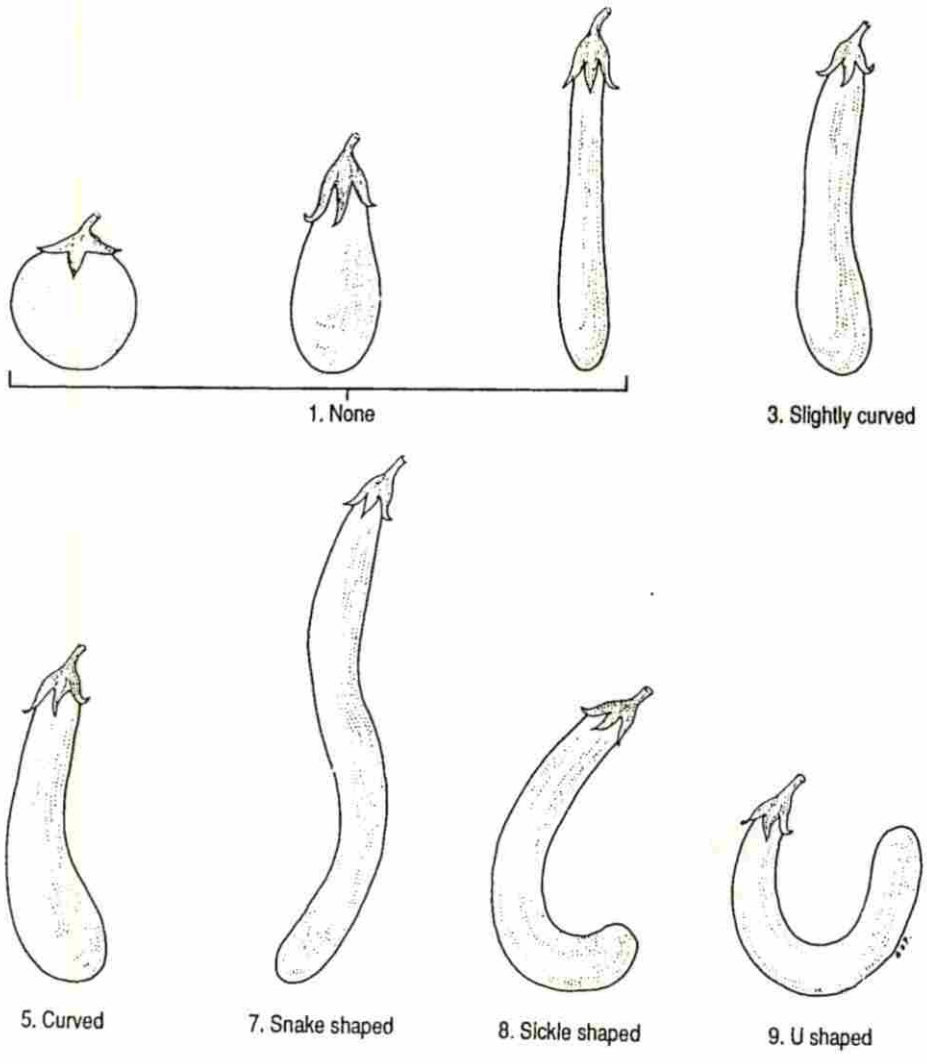



Fig. 4. Fruit curvature

4.2.7 Fruit cross section

1 Circular, no grooves
3 Elliptic, no grooves
5 Few grooves (~4)
7 Many grooves (~8)
9 Very irregular

4.2.8 Fruit shape

Position of widest part of fruit

3 About 1/4 way from base to tip
5 About 1/2 way from base to tip
7 About 3/4 way from base to tip

4.2.9 Fruit apex shape

3 Protruded
5 Rounded
7 Depressed

4.2.10 Fruit colour at commercial ripeness

| | | |
|---|---|---|
| 1 | Green | (Methuen 27D8) |
| 2 | Milk white | (Methuen 1A2) |
| 3 | Deep yellow | (Methuen 3A8) |
| 4 | Fire red | (Methuen 7A8) |
| 5 | Scarlet red | (Methuen 9A8) |
| 6 | Lilac grey | (Methuen 16C3) |
| 7 | Purple | (Methuen 16D-E8) |
| 8 | Purple black | (Methuen 15F5-8) |
| 9 | Black | |

4.2.11 Fruit colour distribution at commercial ripeness

1 Uniform
3 Mottled
5 Netted
7 Striped

4.2.12 Fruit colour at physiological ripeness

| | | |
|---|---|---|
| 1 | Green | (Methuen 27D8) |
| 2 | Deep yellow | (Methuen 3A8) |
| 3 | Yellow orange | (Methuen 5A8) |
| 4 | Deep orange | (Methuen 6B8) |
| 5 | Fire red | (Methuen 7A8) |
| 6 | Poppy red | (Methuen 8A8) |
| 7 | Scarlet red | (Methuen 9A8) |
| 8 | Light brown | (Methuen 7D8) |
| 9 | Black | |

4.2.13 Fruit flesh density

| | |
|---|---|
| 1 | Very loose (spongy) |
| 3 | Loose (crumbly) |
| 5 | Average density |
| 7 | Dense |
| 9 | Very dense |

4.2.14 Relative fruit calyx length

Measured as percentage of total fruit length

| | | |
|---|---|---|
| 1 | Very short | (<10%) |
| 3 | Short | (~20%) |
| 5 | Intermediate | (~50%) |
| 7 | Long | (~70%) |
| 9 | Very long | (>75%) |

4.2.15 Fruit calyx prickles

Average number of prickles per calyx

| | | |
|---|---|---|
| 0 | None | |
| 1 | Very few | (< 3) |
| 3 | Few | (~ 5) |
| 5 | Intermediate | (~10) |
| 7 | Many | (~20) |
| 9 | Very many | (>30) |

4.2.16 Fruit position

| | |
|---|---|
| 1 | Erect |
| 3 | Semi-erect |
| 5 | Horizontal |
| 7 | Semi-pendant |
| 9 | Pendant |

4.3 SEED

4.3.1 Number of seeds per fruit

| | | |
|---|---|---|
| 0 | None | |
| 1 | Very few | (< 10) |
| 3 | Few | (~ 50) |
| 5 | Intermediate | (~100) |
| 7 | Many | (~300) |
| 9 | Very many | (>500) |

4.3.2 Seed colour

| | | |
|---|---|---|
| 1 | White | (Methuen 1A1) |
| 2 | Light yellow | (Methuen 2A4) |
| 3 | Grey yellow | (Methuen 4B3) |
| 4 | Brownish yellow | (Methuen 5C7) |
| 5 | Brown | (Methuen 6D6) |
| 6 | Brown black | (Methuen 7E3) |
| 9 | Black | |

4.3.3 Seed size

Diameter

| | | |
|---|---|---|
| 3 | Small | (~2 mm) |
| 5 | Intermediate | (~3 mm) |
| 7 | Large | (~4 mm) |

4.3.4 100 seed weight [g]

# FURTHER CHARACTERIZATION AND EVALUATION

## 5. SITE DATA

5.1 COUNTRY OF FURTHER CHARACTERIZATION AND EVALUATION

5.2 SITE (RESEARCH INSTITUTE)

5.3 NAME OF PERSON IN CHARGE OF EVALUATION

5.4 SOWING DATE

5.5 FIRST HARVEST DATE

5.6 LAST HARVEST DATE

5.7 STANDARD CULTIVARS

The applied characteristics to be scored require standardization by comparison with recognized cultivars (e.g. Solanum melongena cv. Long Purple). The standard cultivars used will be constant at a given evaluation site or group of sites. Different Solanum crops may require a range of standard varieties for each site or group of sites

5.7.1 Cultivar 1

5.7.2 Cultivar 2 etc.

## 6. PLANT DATA

6.1 VEGETATIVE

6.1.1 Germination period

Number of days from sowing till first germination

6.1.2 Plant height

At flowering stage

| | | |
|---|---|---|
| 1 | Very short | (< 20 cm) |
| 3 | Short | (~ 30 cm) |
| 5 | Intermediate | (~ 60 cm) |
| 7 | Tall | (~100 cm) |
| 9 | Very tall | (>150 cm) |

6.1.3 Plant breadth

At flowering stage

| | | |
|---|---|---|
| 1 | Very narrow | (< 30 cm) |
| 3 | Narrow | (~ 40 cm) |
| 5 | Intermediate | (~ 60 cm) |
| 7 | Broad | (~ 90 cm) |
| 9 | Very broad | (>150 cm) |

6.1.4 Plant branching

Number of primary branches per plant

| | | |
|---|---|---|
| 1 | Very weak | (~ 2) |
| 3 | Weak | (~ 5) |
| 5 | Intermediate | (~10) |
| 7 | Strong | (~20) |
| 9 | Very strong | (>30) |

6.1.5 Petiole length

| | | |
|---|---|---|
| 0 | None | |
| 1 | Very short | (< 5 mm) |
| 3 | Short | (~ 10 mm) |
| 5 | Intermediate | (~ 30 mm) |
| 7 | Long | (~ 50 mm) |
| 9 | Very long | (>100 mm) |

6.1.6 Petiole colour

| | |
|---|---|
| 1 | Green |
| 3 | Greenish violet |
| 5 | Violet |
| 7 | Dark violet |
| 9 | Dark brown |

6.1.7 Leaf blade colour

Upper surface

| | |
|---|---|
| 1 | Light green |
| 3 | Green |
| 5 | Dark green |
| 7 | Greenish violet |
| 9 | Violet |

6.1.8 Leaf yield per plant

(Only for cultivars used as leaf vegetables)

Total fresh weight of leaves

| | | |
|---|---|---|
| 1 | Very low | (< 100 g) |
| 3 | Low | (~ 200 g) |
| 5 | Intermediate | (~ 500 g) |
| 7 | High | (~1000 g) |
| 9 | Very high | (>2000 g) |

6.1.9 Leaf flavour

(Only for cultivars used as leaf vegetables)

3 Bitter
5 Intermediate
7 Sweet

6.1.10 Leaf dry matter percentage

6.1.11 Leaf protein content [%]

Measured on a fresh weight basis

6.1.12 Leaf steroidal glyco-alkaloid content

In mg/100 g fresh weight

6.2 INFLORESCENCE AND FRUIT

6.2.1 Flowering time

Number of days from sowing till first flower opening

6.2.2 Number of hermaphrodite flowers per inflorescence

1 Only one hermaphrodite flower on each inflorescence
2 Only two hermaphrodite flowers on each inflorescence
3 Only three hermaphrodite flowers on each inflorescence

| | | |
|---|---|---|
| 4 | Four or more hermaphrodite flowers on each inflorescence; but some other flowers functionally male | |
| 5 | Four or more hermaphrodite flowers on each inflorescence; no functionally male flowers | |

6.2.3 Relative style length

In hermaphrodite flowers, the extent to which the style is longer than the stamens

| | | |
|---|---|---|
| 3 | Short | (~1 mm) |
| 5 | Intermediate | (~3 mm) |
| 7 | Long | (~5 mm) |

6.2.4 Pollen production

| | |
|---|---|
| 0 | None |
| 3 | Low |
| 5 | Medium |
| 7 | High |

6.2.5 Fruit pedicel length

| | | |
|---|---|---|
| 1 | Very short | (< 5 mm) |
| 3 | Short | (~10 mm) |
| 5 | Intermediate | (~25 mm) |
| 7 | Long | (~50 mm) |
| 9 | Very long | (>75 mm) |

6.2.6 Fruit pedicel thickness

| | | |
|---|---|---|
| 1 | Very thin | (< 1 mm) |
| 3 | Thin | (~ 2 mm) |
| 5 | Intermediate | (~ 3 mm) |
| 7 | Thick | (~ 5 mm) |
| 9 | Very thick | (>10 mm) |

6.2.7 Fruit pedicel prickles

| | | |
|---|---|---|
| 0 | None | |
| 1 | Very few | (< 3) |
| 3 | Few | (~ 5) |
| 5 | Intermediate | (~10) |
| 7 | Many | (~20) |
| 9 | Very many | (>30) |

6.2.8 Number of locules per fruit

6.2.9 Number of fruits per infructescence

6.2.10 Number of fruits per plant

6.2.11 Fruit yield per plant

| | | |
|---|---|---|
| 1 | Very low | (< 250 g) |
| 3 | Low | (~ 500 g) |
| 5 | Intermediate | (~1000 g) |
| 7 | High | (~2500 g) |
| 9 | Very high | (>5000 g) |

6.2.12 Fruit flavour

| | |
|---|---|
| 3 | Bitter |
| 5 | Intermediate |
| 7 | Sweet |

6.2.13 Fruit transportability

| | |
|---|---|
| 3 | Poor |
| 5 | Intermediate |
| 7 | Good |

6.2.14 Fruit storage suitability

Period of satisfactory storage above 20°C

| | | |
|---|---|---|
| 3 | Short | (2 weeks) |
| 5 | Intermediate | (4 weeks) |
| 7 | Long | (8 weeks) |

6.2.15 Fruit dry matter percentage [%]

6.2.16 Fruit protein content [%]

Measured as percentage of edible portion

6.2.17 Fruit steroidal glyco-alkaloid content

In mg/100 g fresh weight

6.3 SEED

## 7. STRESS SUSCEPTIBILITY

Coded on a 1-9 scale, where:

3 Low susceptibility
5 Medium susceptibility
7 High susceptibility

7.1 LOW TEMPERATURE

7.2 HIGH TEMPERATURE

7.3 DROUGHT

7.4 HIGH SOIL MOISTURE

7.5 HIGH AIR HUMIDITY

7.6 SALINITY

7.7 ACIDITY

## 8. PEST AND DISEASE SUSCEPTIBILITY

Coded on a 1-9 scale, where:

3 Low susceptibility
5 Medium susceptibility
7 High susceptibility

8.1 PESTS

| | | |
|---|---|---|
| 8.1.1 | Aphid | (Aphis gossypii) |
| 8.1.2 | Colorado beetle | (Leptinotarsa decemlineata) |
| 8.1.3 | Epilachna beetle | (Epilachna vigintioctopunctata) |
| 8.1.4 | Root-knot nematode | (Meloidogyne arenaria) |
| 8.1.5 | Root-knot nematode | (M. incognita) |
| 8.1.6 | Root-knot nematode | (M. javanica) |

| | | | |
|---|---|---|---|
| | 8.1.7 | Shoot and fruit borer | (Leucinodes orbonalis) |
| | 8.1.8 | Red spider mite | (Tetranychus cinnabarinus or T. urticae) |
| | 8.1.9 | White fly | (Trialeurodes vaporariorum) |
| | 8.1.10 | Other (specify in the NOTES descriptor, 11) | |
| 8.2 | FUNGI | | |
| | 8.2.1 | Anthracnose | (Colletotrichum gloeosporioides) |
| | 8.2.2 | Damping-off | (Rhizoctonia solani) |
| | 8.2.3 | Fusarium wilt | (Fusarium oxysporum f.sp. melongenae) |
| | 8.2.4 | Grey mould rot | (Botrytis cinerea) |
| | 8.2.5 | Leaf spot | (Cercospora melongenae) |
| | 8.2.6 | Phomopsis blight | (Phomopsis vexans) |
| | 8.2.7 | Sclerotinia disease | (Sclerotinia sclerotiorum) |
| | 8.2.8 | Verticillium wilt | (Verticillium dahliae) |
| | 8.2.9 | Other (specify in the NOTES descriptor, 11) | |
| 8.3 | BACTERIA | | |
| | 8.3.1 | Bacterial wilt | (Pseudomonas solanacearum) |
| | 8.3.2 | Canker | (Corynebacterium michiganense) |
| | 8.3.3 | Other (specify in the NOTES descriptor, 11) | |


8.4 VIRUSES etc.

8.4.1 Cucumber mosaic virus

8.4.2 Eggplant mosaic virus

8.4.3 Little leaf

8.4.4 Stolbur

8.4.4.1 Stolbur yellowing

8.4.4.2 Stolbur phyllody

8.4.5 Other (specify in the NOTES descriptor,11)

## 9. ALLOENZYME COMPOSITION AND ZYMOTYPE

## 10. CYTOLOGICAL CHARACTERS AND IDENTIFIED GENES

10.1 CHROMOSOME NUMBER

Somatic total

10.2 PLOIDY LEVEL

## 11. NOTES

Give additional information where descriptor state is noted as 'Other' as, for example, in descriptors 8.1.10, 8.4.5, etc.

Also include here any other relevant information