FOREWORD

The present issue of *Capsicum and Eggplant Newsletter* is published late because of many commitments by the Editor during the past months. However, starting with the next issue, we will do our best to have the Newsletter published in the summer.

The twentieth issue of the journal includes an interesting invited paper. It has been written by L.M. Oelke and P.W. Bosland and deals with *Fusarium* disease of Capsicum. We thank these authors for their efforts to increase the scientific value of our publication. In addition, we would like to remind you that any suggestions on the topics and/or authors to be considered for invited papers in future issues of *Capsicum and Eggplant Newsletter* are welcomed.

We remind our readers that *Capsicum and Eggplant Newsletter* has its own mail address: **capsicum@agraria.unito.it**. One can send messages as well as **submit contributions for publication** to this address. In addition, the Website Home Page, **http://www.agraria.unito.it/dip/divapr/geneti/cenl** has all the information about the Newsletter.

The papers have been printed as received continuing the tradition of not modifying the accepted contributions. Therefore, the authors, not CENL, are responsible for the scientific content of their reports.

Please remember that this Newsletter is highly dependent on the financial support of the recipients. Therefore, a subscription fee is appreciated. The subscription fee is the same as last year: 30 EURO for normal and 150 EURO for supporter subscribers. Remember that to make the payment less time-consuming and to reduce bank costs, we have introduced the option of a 3-year subscription. It is possible (and encouraged!) to order your own personal copy to quicken its delivery to you. Just fill in the order form on page 139 and send it to us, together with a copy of the payment order, which must always be made out to Eucarpia. In case you decide to pay by credit card, please use the voucher on page 141. Because of the lower banking costs, credit card payment is preferred.

The deadline for submission of articles to be included in the next issue of the Newsletter (No. 21, 2002) is **February 28, 2002**. Please note that starting with next issue **contributions will be accepted only if submitted through electronic mail** (as attached file) **or on computer disk.** Suitable formats are as follows: operating system Windows 95-98-2000; word processing systems Word; floppy disk sizes 3½ inches or CD 650 Mb. **Please, note that EUCARPIA Secretary has moved from Wageningen to Vienna: you can find the new address and bank coordinates in page 3 of this volume.**

We regret to report that many papers had to be rejected because of inadequate scientific rigor or lack of attention paid to the instructions for submission. Moreover, we would like to remind everyone that submitted articles must deal with genetic and breeding of pepper or eggplant. Reports on cultural practices (fertilisation, space between plants, etc.) will no longer be accepted. Most of the accepted articles had poor English grammar and syntax. Please, before submitting a manuscript, have it proofed by someone capable of editing in the English language. **It is imperative that you follow the submission instructions very carefully. Otherwise your contribution will not be accepted.**

Luciana Quagliotti
(Director)

Piero Belletti
(Editor)

Turin, 30 October 2001

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THE CULTIVATED SPECIES OF *CAPSICUM* IN VENEZUELA

Eliseo Castellano

Fundación Jardín Botánico UNELLEZ, Apartado 214, Barinas 5201-A, Venezuela
ecastell@telcel.net.ve

INTRODUCTION

Venezuela is the northernmost country of South America. It is an Amazonian, Caribbean and Andean country with a very rich flora. However, there is a rather limited knowledge of the taxonomy of cultivated plants. Most of the agronomic manuals have serious errors in the taxonomy of the common species cultivated in this country. The genus *Capsicum* is no exception. The First National Report on Biological Diversity (MARN 2.000), in its section on agro biodiversity, reports four species, two of which are right, one doesn't exist in Venezuela and the other is a synonym, whereas it fails to mention the two most consumed species.

In this paper I present a list of the species of *Capsicum* cultivated in Venezuela, with comments on their use and importance, whether they are fully domesticated and the germplasm conservation status. Fruits were collected from plantations and markets all over the country; the seeds were germinated in the UNELLEZ Botanic Garden nursery and transplanted to our experimental plots. The plants were identified in the field with the IBPGR key (IBPGR 1983; Castellano 1996). Herbarium samples were collected and stored in our herbarium.

THE SPECIES

Capsicum annuum L.

Two varieties were found, *C. annuum* L. var. *annuum* and *C. annuum* var. *glabriusculum* (Dunal) Heiser & Pickersgill. The first is represented by domesticated cultivars, grown from imported seeds, mainly sweet, although some pungent cultivars are occasionally sold in markets and shops. There are also some very local cultivars, which probably were brought to Venezuela by European immigrants. The sweet pods are consumed fresh or as condiments and the hot cultivars are used for sauces.

The other variety is supposed to be the wild relative of the species. It is not a domesticate, but is occasionally grown in gardens and backyards. It is spread by birds, and is not very common.

Capsicum frutescens L.

This species is very common all over the country. It is also spread by birds. Three cultivars were identified (see Table 1), all of them pungent and widely used, either fresh or in sauces, including the Tabasco sauce. The "wild" type is cultivated in some parts of the country, although usually the pods are collected from plants growing in gardens, backyards, cultivated fields, public gardens and almost every available place. The "Tabasco" cultivar's was brought to Venezuela by that company and is grown commercially, although it is highly sensible to mosaic virus. The third cultivar's is grown in the eastern part of the country and is used by the local industries in hot sauces.

Table 1. - Fruit characteristics of three cultivars of *C. frutescens* grown in Venezuela. (All the fruits are red when ripe and pungent).

CULTIVAR	SIZE / SHAPE[1]	PERSISTANCE[1]	FRUIT POSITION
"Wild"	Small/Triangular	Slight	Erect
"Tabasco"	Small/Triangular	Persistent	Erect
"Eastern"	Medium/Triangular	Persistent	Pendant

[1] Descriptors from IPGRI (1995).

Capsicum pubescens R. & P.

This species is grown in the Andes and the Coastal Cordillera, as it needs cool, freeze free environments and long growing seasons. Usually the pods are red in colour, but yellow fruits aren't uncommon. It is used fresh and as hot sauces and is sold all over the country.

Capsicum chinense Jacq.

This is the most widely used species in Venezuela, replacing sweet *C. annuum* as condiment in stews, soups and almost any dish in the Venezuelan kitchen. The hot cultivars are not grown in this country and when a plant bearing pungent fruits is found, it is immediately removed from the field, as it ruins the whole crop for the market. I believe that this sweet form was a protodomesticate from the Indians in the eastern part of the region, which spread to the whole country during this century. I selected descriptors for vegetative and reproductive parts and calculated Shannon Index (H') for both. It was found that the vegetative characters had very little variation, whereas the reproductive parts showed great variation. This seems to indicate an early selection of this line of cultivars, probably by a spontaneous mutation selected by man in a process of protodomestication. There is no particular ecogeographic pattern of differentiation of primitive cultivars, perhaps because of the great exchange of seeds between growers, in the search of plants with greater yield and quality. It is possible to find plants, bearing sweet pods, growing spontaneously in gardens and in cultivated areas.

GERMPLASM CONSERVATION

The potential genetic erosion of these species can be considered as slow. However there are signals that this situation can change rapidly, especially in the case of *C. chinense*, because this species is at the doors of a process of modernization of the cultivation techniques. The problem is that we lack adequate facilities for the preservation of germplasm. A possible solution would be an *in situ* conservation program, although there are ethical restraints, as this means to keep the peasants in a production system with low technology (Castellano 1991). There is also the need for the creation of an infraspecific classification system, in order to ease the development of ecogeographic studies.

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Capsicum and Eggplant Newsletter 20 (2001): 14-15.

Comparative investigation of different growth mediums of green pepper plants

T. Tornyai – T. Kassai
Department of Horticultural Technologies at Szent István University, Gödöllő, Hungary
2100 Gödöllő, Páter K. u. 1.

Today in Hungary the most important forced vegetable species is the green pepper, it is grown on close to 50 % of the total vegetable forcing areas. Besides the fruit production most of the growers also deal with growing seedlings. A lot of growers realized that high quality seedling is an essential condition of the successful forcing process. The application of different mediums and ingredients, used for growing green pepper seedlings, has been changed for the last couple of years. According to the actual opinion sphagnum peat is used prominently among the modern growing mediums – besides (or instead of) the conventionally used calcarious peats.

In our experiments 12 different plant growing mediums were investigated, some of them were conventional, some of them very up-to-date soil mixes. The starting nutrient capacity and the starting pH of each soil mixes were optimal. We wanted to know if there is any perceptible difference between the conventional and modern soil mixes and under typical Hungarian circumstances which medium ensures the highest quality seedlings, meeting the most important requirements of the growers. Considering the best soil mix recipes the following basic requirements were worked up:

- After pricking out the application of nutrient solutions should be unnecessary
- The mix should not contain any manure
- The ingredients of the soil mix should be easy to access
- The mix should ensure consistent, dynamic plant development

Materials and methods

The experiment was made on the Experimental Field of the Department of Horticultural Technologies at Szent István University, Gödöllő. The test variety of the experiment was 'Ciklon' F_1 that is a widespread Cecei (sweet yellow wax) type forcing green pepper variety. In the experiment 12 different soil mix recipes were investigated in 4 repetitions – each repetition included 50 plants. Among the 12 recipes 2 were the control recipes (they are often used in the practice of Hungarian pepper producers).
The soil mixes are introduced considering their ingredients:

1. Sphagnum peat + manure + sand + lignite powder + ground zeolite + ground lime stone
2. Sphagnum peat + ground pine bark + manure + lignite powder + ground zeolite + ground lime stone
3. Sphagnum peat + ground pine bark + manure + sand
4. Control: Sphagnum peat + 4 kg/m^3 superphosphate + 1,5 kg/m^3 Buviplant A (slow release fertilizer) + ground lime stone
5. Control: 33 % manure + 33 % calcarious peat + 33 % sand + 1,5 kg/m^3 Buviplant A
6. Sphagnum peat + calcarious peat + superphosphate + Buviplant A

7. Sphagnum peat + ground pine bark + superphosphate + Buviplant A + ground lime stone
8. Sphagnum peat + ground pine bark + sand + superphosphate + Buviplant A + ground lime stone
9. Sphagnum peat + ground pine bark + sand + 1,5 kg/m^3 Osmoform (slow release fertilizer)
10. Sphagnum peat + ground pine bark + sand + 3 kg/m^3 Osmoform (the rate of ingredients in the mix was different)
11. Sphagnum peat + ground pine bark + sand + 2 kg/m^3 PG Mix (slow release fertilizer)
12. Sphagnum peat + sand + alginit + 2 kg/m^3 PG Mix

The plants were grown in 7,5 cm diameter pots in the same forcing equipment.

Measured data: stem diameter (mm) 1 cm above the cotyledon, plant length (cm), weight of the fresh green parts (g), weight of the dried roots (g)
The rate and the total amount of the green parts and roots and the rate of stem diameter and plant length were measured too. The statistical evaluation of the experimental data was made by Microsoft Office 97 Excel Software – using the method of one factor analysis of variance.

Results and Discussion

Total amount of the green parts and roots: the high total amount was considered as positive result. The treatments 6 and 12 were significant better comparing to the others. Just like treatments 7 and 10 – in case of these treatments the measured data were demonstrably smaller comparing to the others. The results of the control treatments were equal to the expected average results.

Weight ratio of the green parts and roots: the smallest ratio was considered as the best result (if it was measured together with a green weight value that was above a certain value). The treatments 1, 4 and 12 showed significantly bigger (more unfavorable) ratio comparing to the others.

Stem diameter: the large stem diameter was considered as positive result. The measured values of treatment 6 were demonstrably larger comparing to all the other treatment results. The treatments 1, 2, 12 differed from treatments 6 and treatments 1, 3, 5, 7, 11. The significantly worst results were measured in treatment 10. The treatment 5 (control) was significantly weaker comparing to treatments 1 and 2. This control treatment (5) was significantly better comparing to treatments 7,4,11. The other control treatment (4) was significantly weaker comparing to treatments 1,5,6,12. This control treatment (4) was significantly better comparing to treatments 7,10.

Plant height: the large plant height was considered as positive result.(if it was measured together with a large stem diameter value). In treatments 5 and 6 were observed the highest green pepper plants, the smallest plants were measured in treatment 10.

Taking the most important factors collectively into consideration and investigating if the measured data meet the basic growing requirements the best quality soil mixes were chosen.

According to these conditions the treatments 12 and 6 were evaluated as best and second best soil mixes.

In further experiments we would like to investigate the behavior of the plants that were grown in different soil mixes (observing mainly the vegetative-generative balance of the plants and the fruit formation process).

Capsicum and Eggplant Newsletter 20 (2001): 16-18.

Studies on standardization of inter & inter row spacings in newly evolved cultivars of chilli

K.S.Sandhu, Daljit Singh, M.S.Sandha and Jaswinder Singh
Dept. of Vegetable Crops
PAU, Ludhiana

ABSTRACT

There newly released varieties of chillies namely hybrid CH-1 & varieties Pb. Surkh and Pb. Guchhedar released by Punjab Agricultural University, Ludhiana for growing in Punjab (India) were grown at different inter & intra row spacings for four years (1995-1998.) taking into consideration the different growth behaviour of all the three varieties. Hybrid CH-1 gave the highest yield of red ripe chilli when seedlings were transplanted in rows at 60 x 60-75 cm spacings. In case of varieties namely Pb. Surkh and Pb. Guchhedar yields were maximum when seedlings were transplanted at 60 cm between the rows and 30-45 cm between the plants.

INTRODUCTION

Chilli is an important vegetable crop grown throughout India. In Punjab state, area under chilli cultivation has increased considerably due to release of new cultivars by Punjab Agricultural University, Ludhiana. During recent years, three varieties of chilli have been released for cultivation under Punjab plains namely hybrid CH-1 (Hundal & Khurana, 1993) and varieties Pb. Surkh (Hundal *et al.*, 1995) and Pb.Guchhedar (Hundal *et al.*, 1996). These new hybrids/varieties have much higher yield potential than the existing varieties and have different growth and development habits. The existing plant spacing recommendation in chilli are 45 cm between rows and 30-45 cm between the plants (Anon., 1999). These recommendations were for short saturated and low yielding varieties. Therefore, there was a need to standardize the existing inter and intra row spacings for newly evolved hybrids/varieties of chilli for fully exploiting the genetic potential of these varieties.

METHODS AND MATERIALS

Investigations to standardize inter and intra row spacings in newly evolved varieties in chilli were conducted at vegetable Research Farm, Ludhiana (India) for four years (1995-1998). Seeds of chilli cultivars namely hybrid CH-1 and varieties Pb. Surkh and Pb. Guchhedar were sown in November and seedlings were raised under low plastic tunnels to protect from severe winter during the months of December-February. During 1st week of March, the seedlings were transplanted in field at a distance of 60 cm between two rows and 30, 45, 60 and 75 cm between the plants. Recommended cultural practices were followed to raise a healthy crop of chillies. Observations on effect of different inter and intra row spacings on yield of red ripe chillies were recorded.

RESULTS AND DISCUSSION

Data on effect of different inter and intra row spacing can yield of red ripe chillies during four years of studies from 1995-98 are presented in Table 1. On the basis of these investigation, it was found that chilli hybrid CH-1 gave the highest yield of red ripe chilli when seedlings were transplanted in rows drawn 60 cm apart and plant to plant spacing was also kept at 60 cm during all the years. These results were at par with 60 cm row and 75 cm plant spacing. It is further observed that variety Pb. Surkh produced maximum, fruit yield of red ripe chillies at 60 cm spacing between rows and 30 cm spacing between plants during all the years. These values were at par with 60 cm row and 45 cm plant spacings. In variety Pb. Guchhedar highest yield of red ripe chillies was recorded at 60 cm row spacing and 45 cm plant spacing during all the year. These yields were at par with the yield recorded in 60 cm spacing between rows and 30 cm spacing between plants.

CONCLUSIONS

For getting maximum fruits yields, plant chilli hybrid CH-1 at 60 cm between the rows and at 60-75 cm between the plants. In case of varieties namely Pb. Surkh and Pb. Guchhedar transplant the seedlings at 60 cm between the rows and 30-45 cm between the plants.

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Table 1. Effect of different inter and intra row spacings on the red ripe fruit yield of different varieties/hybrids in chilli.

Treatment	Fruit yield (q/ha)				Mean
	1995	1996	1997	1998	
CH-1 60 x 30 cm	141.6	146.8	137.6	176.7	150.7
CH-1 60 x 45 cm	155.6	157.5	142.3	192.5	162.0
CH-1 60 x 60 cm	190.2	193.4	169.8	219.9	193.3
CH-1 60 x 75 cm	187.8	189.6	161.7	211.4	187.6
PS 60 x 30 cm	176.3	180.5	158.3	152.3	166.5
PS 60 x 30 cm	166.8	168.3	146.8	140.2	155.5
PS 60 x 30 cm	142.3	145.4	121.3	121.3	132.6
PS 60 x 30 cm	125.1	126.9	109.5	106.5	117.0
PG 60 x 30 cm	130.0	131.8	109.5	118.7	122.5
PG 60 x 30 cm	137.6	136.5	116.4	126.4	129.2
PG 60 x 30 cm	98.4	100.4	99.1	109.5	101.9
PG 60 x 30 cm	85.9	87.0	81.4	98.3	88.2
CD at 5% level	21.4	20.7	13.8	15.1	-

CH-1 Chilli Hybrid-1
PS Punjab Surkh
PG Punjab Guchhedar

Capsicum and Eggplant Newsletter 20 (2001): 19-22.

Capsaicin and ascorbic acid content of chilli as influenced by cultural practices

S.C. Panchal, R. Bhatnagar*°, R.A. Momin and N.P. Chauhan**

*Department of Biochemistry, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand-388 110, Gujarat, India
** Deptt. of Agronomy, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand-388 110, Gujarat, India.
° For correspondance

INTRODUCTION

Chilli (*Capsicum annum* L.) is one of the important spice crops grown in India, with an area of about 930 thousand hectares and a production of 800.1 thousand tonnes(Anonymous, 1996). It has good industrial as well as medicinal values, which entirely depends upon its quality. It is a rich source of ascorbic acid, considered as a good nutritional quality parameters. Capsaicin responsible for the pungency of fruit is another important quality parameter in terms of internal consumption as well as for export potential.

Inspite of great importance of this crop, very little efforts have been made for its quality assessment and improvement by agronomical practices. In present study an attempt was made to investigate the influence of different levels of irrigation, mulch and nitrogen levels on ascorbic acid and capsaicin contents of chilli fruit at two different growth stages, i.e. green mature fruit and red mature fruit.

MATERIALS AND METHODS

An experiment was carried out at the College Agronomy Farm, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand-388 110, during October, 1995 to May, 1996. 'Jwala' variety of chilli was grown in a replicated trial under split plot design taking irrigation as a main plot treatment and combinations of mulch and nitrogen levels as sub-plot treatments. The various levels of irrigation were drip irrigations at 40% (I_1), 60% (I_2), 80% (I_3) replenishment of PE and surface irrigation at 0.7 IW/CPE ratio (I_4). The mulch treatments were no mulching (M_0) and mulching with black polythene sheet (M_2). The nitrogen levels were 75 (F_1), 100 (F_2) and 125 (F_3) kg N ha^{-1}.

The samples (fruits) of green mature stage (S_1) and red mature stage (S_2) were collected separately, stored and analyzed for ascorbic acid (A.O.A.C., 1980) and capsaicin(Quagliotti, 1971). The laboratory analytical data were subjected to statistical analysis of variance for split plot design(Snedecor *et al.*, 1967).

plants receiving black polythene mulch treatment. Higher doses of nitrogenous fertilizer slightly increased the capsaicin content. Nelson (1920) showed capsaicin to be the amide of vanillyl amine and isodecenoic acid.

Thus, nitrogen being a constituent of capsaicin, addition of nitrogen to crop increased the capsaicin content of chilli fruit. Subbiah *et al.* (1980) reported that addition of nitrogen alone lowered the capsaicin content of NDU-1 chilli. The capsaicin content was increased as the chilli fruit ripened. These findings are in accordance with those reported by Nisar Ahmed *et al.* (1987) and Xiao *et al.* (1991).

Table 1: Ascorbic acid (mg/100 g) and capsaicin (mg/g) content on dry wt. Basis of chilli fruits as influenced by different levels of irrigation, mulch, fertilizer and stages

Treatment	Ascorbic acid content (mg/100 g)	Capsaicin content (mg/g)
Irrigation (I)		
I_1	723.18	0.76
I_2	724.74	0.78
I_3	744.45	0.77
I_4	781.34	0.86
S.Em.	0.49	0.01
C.D. at 5%	1.70	0.01
Mulch (M)		
M_0	752.93	0.82
M_1	733.93	0.76
S.Em.	0.33	0.01
C.D. at 5%	0.93	0.01
Fertilizer (F)		
F_1	740.89	0.76
F_2	705.29	0.79
F_3	784.11	0.82
S.Em.	0.41	0.01
C.D. at 5%	1.14	0.01
Stage (S)		
S_1	858.30	0.59
S_2	628.55	0.99
S.Em.	0.33	0.01
C.D. at 5%	0.93	0.01
C.V. %	0.38	2.88

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POLYMORPHISM AND LOW NIGHT TEMPERATURE INDUCED ABNORMALITIES IN PEPPER (*Capsicum annuum* L.) FLOWERING.

JEMMALI A., TARCHOUN N*. and MEZGHANI N.
Institut National Agronomique de Tunisie (INAT), 43 av. Charles Nicolle 1082 Tunis mahrajène -Tunisia
* Corresponding author: ntarchoun@yahoo.fr

1. Introduction

Pepper is very sensitive to cold. The optimum night temperature for flowering and fruit setting is 18°C (Ali and Kelly, 1993; Hennart, 1996), and most studies reported a 15 °C limit (Rylski, 1986; Mercado et al., 1997).

It was reported that under optimal night temperature the flowers are small, whereas under low night temperatures they are large and have larger ovaries (Pressman et al., 1998). In addition, these authors observed a decreasing in style length accompanied by a parallel increase in ovary size, when night temperatures decreased from 20°C to 12 or 10 °C. In these circumstences, ovaries push the anthers away from the stigmas which are shorter, thereby preventing self pollination (Kato,1989). Some similar effects have been observed for other horticultural species (Salveit and Morris, 1990; Fernandez-Munoz et al., 1995).

This paper describes floral polymorphism observed in greenhouse and abnormalities induced by low night temperatures regime in some cultivars of hot and sweet pepper cultivated in a growth chamber .

2. Material and Methods

Culture and sampling data in greenhouse

This trial concerns plants cultivated since October, under uncontrolled greenhouse conditions. Seeds of hot (Baklouti), sweet (Froidure) pepper cultivars and their F1 hybrid have been germinated in alveolated plates containing fertilized peat and seedlings with 6 to 8 true leaves were transferred into plastic pots containing 3 l of the same substrate.

To study the floral polymorphism through these three cultivars, observations were simultaneously made in December using a Leica stereomicroscope that provides more details among the different floral structures.

Culture and sampling data in growth chambers

This trial concerns two hot (Beldi, B26) and two sweet (Clace, Froidure) pepper cultivars. Seedlings at the stage of 6-8 leaves were transferred in to plastic pots containing 3 l of fertilized peat (NPK, 12-14-24) and placed in growth chambers wich were illuminated during 14 hours a day with fluorescent tubes providing a PAR (Photosynthetic Active Radiation) of approxymately 230 $\mu mol.m^{-2}.s^{-1}$.

Plants were submitted, either to a low night temperatures regime (LTR=25/12°C, day/night) or to an optimum night temperatures regime (0TR=25/20°C). Plants were watered when needed and fertilized with NutriChem solution (N:P:K 22:5:11).

Effects of low nigth temperatures on the floral parts were recorded at the anthesis stage. They were evaluated by style and stamen length, and ovary diameter. In each growth chamber, three successive samplings of 10 flowers each, were carried out at 7 day intervals and the results represent the average of these samplings.

Data analysis was perfomed by the procedure of general linear model (GLM) in SAS system. Means were compared using Duncan test at the 5% level.

3. Results and Discussion

Floral polymorphism

According to figure 1, the sweet pepper cv. Froidure has the biggest flower bud wheareas the hot pepper cv.Baklouti has the smallest one. Their hybrid is intermediate. From Figure 2(a,b), Froidure flower shows a heterostyly-like phenomenon that is characterized by the stigma emergency out of stamens. This phenomenon is less pronounced in Baklouti and F1 hybrid.

Anthers also seem to be polymorphic. Indeed, Froidure anthers are the mostly elongated, but they are largest in the case of Baklouti and intermediate in F1 (Fig.3a). Pistil illustrated by Figure 3b shows significant polymorphism in shape and size between cultivars. Froidure ovary has the largest diameter but it is cone-shaped. The two other cultivars have oblong ovary. Style and stigma are the largest in Froidure, and intermediate in the hybrid.

Polymorphisms reported here, seemingly are cultivar- related parameters. Then they may play an important role in the floral biology and subsequently in fruit setting. The fact that stigma emerged out of stamens makes them aside from each other and reduces chance to stigma to be well pollinated especially if pollen vectors are absent as in greenhouse. Indeed, fruit deformation caused by deficient fertilization was observed in some fruits of Froidure (Fig.4). Similar abnormalities were previously reported (Polowick and Sawhney, 1985, Mercado et al., 1997).

Abnormalities induced by low night temperatures

Floral morphology especially, ovary diameter, style and stamen length varies according to the cultivar type (hot or sweet pepper) and within the same cultivar as influenced by temperatures regime. Indeed, low night temperature of 12°C induced several changes in the morphogenesis of pepper flowers, more specifically in sweet pepper cultivars. A significant increase in ovary diameter and a parallel significant decrease in style length for sweet pepper (Froidure, Clace) flowers were recorded (table I). These cultivars presented the biggest ovary diameter (>6mm) and the shortest style length (3.8 mm). These results agree with findings of Polowick and Sawhney (1985) and Pressman et al.(1998). Length of stamens did not vary with temperature regimes, nevertheless, a slight increase was noted under low night temperature.

4. Conclusion

Flower polymorphism observed in December between hot and sweet pepper cultivars grown under greenhouse may be considered a cultivar-related character that was accentuated by the influence of low night temperatures occuring in this period. This hypothesis has been verified in artificial culture conditions where sweet pepper appeared to be more floral sensitive to temperature decreasing. Style emergency out of stamens of sweet pepper cv. Froidure may be explained by ovary height increasing (data not shown) than style lengthening.

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***Table I*:** Effect of low night temperature on ovary diameter, style and stamen length of four pepper cultivars grown at optimal (25/20°C, day/night) or at low (25/12°C) night temperature regimes.

Cultivars	ovary diameter (mm)		style length (mm)		stamen length (mm)	
	25/20°C	25/12°C	25/20°C	25/12°C	25/20°C	25/12°C
Clace	4.3bc	6.7 a	6.2 a	3.8 c	5.9 ab	6.3 a
Beldi	3.5 d	3.9 bcd	5.4 b	5.3 b	5.0 b	5.6 ab
Froidure	4.3 b	6.3 a	5.6 ab	3.8 c	6.0 ab	6.3 a
B26	3.7 cd	4.3 bc	6.0 ab	5.5ab	5.5 ab	6.2 a

Means followed by the same letter are not significantly different according to the Duncan test, P= 0.05.

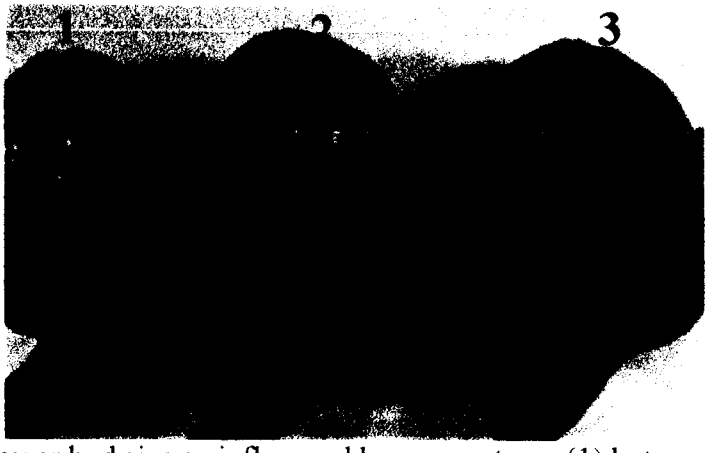

Figure 1: Flower bud size as influenced by pepper type: (1) hot pepper cv. Baklouti; (2) F1 Hybrid (Bak x Froid); (3) sweet pepper cv. Froidure.

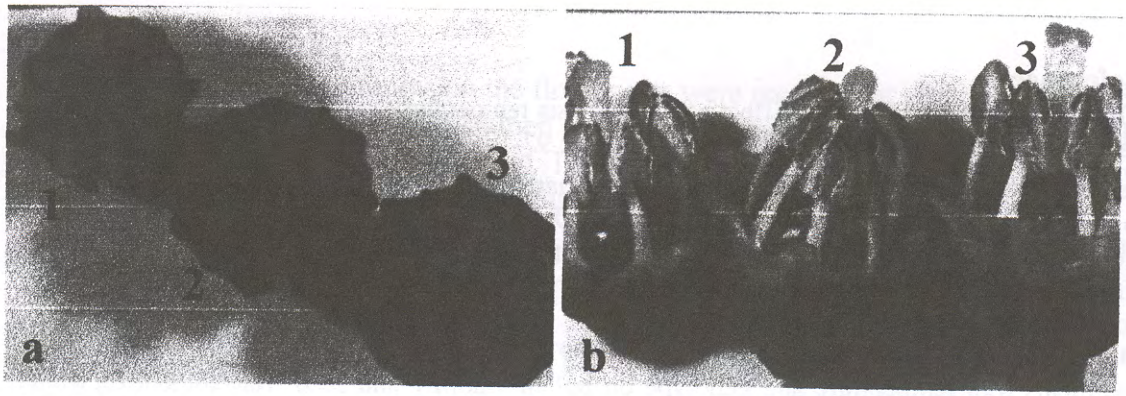

Figure 2: Style polymorphism in sweet pepper (3) compared to hot pepper (1) and their hybrid (2). a: bud stage; b: anthesis stage.

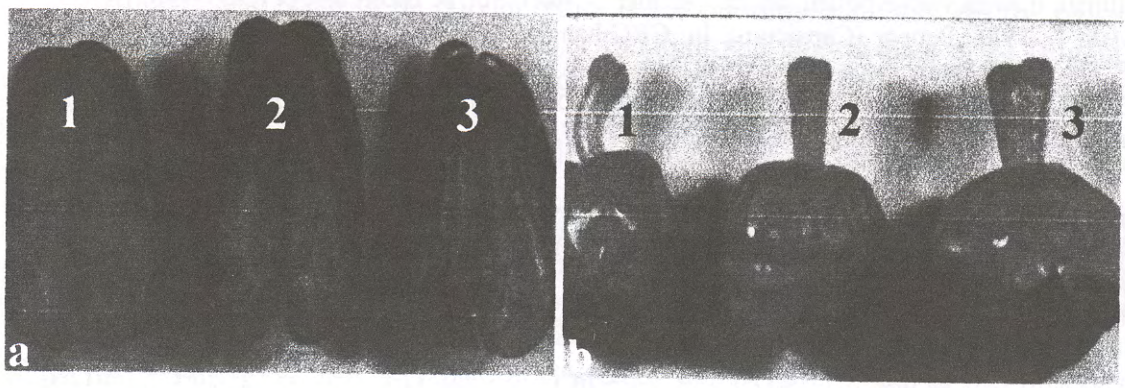

Figure 3: Anther and pistil polymorphis related to pepper type: (1) hot pepper, (2) F1 Hybrid; (3) sweet pepper. a: anthers, b: pistil

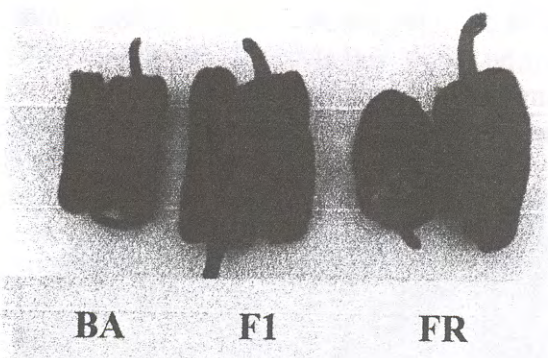

Figure 4: Fruit set showing slight deformation on sweet pepper cv. Froidure (FR) compared to Baklouti (BA) and their hybrid (F1).

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CAPSICUM GERMPLASM WITH FRUITING ABILITY UNDER HIGH TEMPERATURE STRESS

Subodh Joshi and A. D. Munshi
Division of Vegetable Crops, Indian Agricultural Research Institute,
New Delhi-110012

Sweetpepper, Paprika and chillies of *Capsicum* species are one of the most popular vegetable crops consumed as salad, cooked, processed, colouring spice and pungent seasonings of food recepies and is indispensable in every kitchen. Although peppers are available fresh for consumption almost round the year in our country but falls under expensive commodity due to short supply and high transportation cost. Peppers are grown commercially in sub-tropical climate of north India mostly during rainy season and gets severe losses due to disease infection. In summer season cultivation in difficult as fruit setting in severely hampered due to high temperature. The optimum temperature requirement for different phases of development in capsicum ranges between 25 ± 5-7°C (Somos, 1984). Therefore the present study was based on to study the feasibility of growing peppers during summer season. The objective of the study in to identify suitable genotype/s that can produce fruits under high temperature environment. The genotypes will be further used in breeding varieties that can borne fruits under high temperature stress.

Material and Methods

The experimental material consisted of 82 germplasm of Capsicum sps. Among this 10 lines were of sweet pepper, 12 paprika and 60 chillies. The seedlings were raised in polyhouse and a set of 10, 12 and 6 genotypes representing sweet pepper, parprika and chillies respectively were planted in observational rows inside the polyhouse in a spacing of 60 x 45 cm. Three separate experiments were laid out in RBD with three replications, comprising 10

numbers in sweet pepper, 12 nos. in parprika and 60 nos. of chilli germplasm. Spacing between row to row and plant to plant was kept 60 cm. Fertilizer dose were applied as per recommendation.

Other plant protection measures were followed as per standard. Observations were recorded in plant growth, generative phase and fruit setting and other desirable traits required for the different group. Selfed mature fruits were harvested to extract seeds of the genotypes which borne fruits under high temperature stress during the months of April and May

Result and Discussion

The seedlings which were planted inside the polyhouse established well and its growth was satisfactory. Flowering was observed in all the genotypes (Table 1) in the month of February and March except E.C.218694 and E.C.218688 which flowered in April belongs to *C. baccatum.* Fruit setting was found in all the genotypes but only 20 genotypes could attend biological maturity of the fruits. The seed of these genotypes were harvested in second week of May. According to Somos (1984) the optimum temperature requirement for the different phases of development of capsicum ranges between the limit values of 25 ± 5-7°C. The temperature (Table 2) of the cropping period fall under the above statement to a great extent.

The genotypes flowered heavily but due to flower and fruit drop no fruit could attain maturity and desired shape. Fruit drop was observed after 6-10 days of flowering with the symptoms of shrinking and yellowing of the pedicels. This may be due to high temperature, Singh (1993) has also mentioned that capsicums are the species of vegetables that demand mild temperature for its good growth.

Under open field condition plant stand remained almost dormant with only 4-6 leaves developed after their establishment due to low temperature (Table 2). Growth started after February when the temperature was suitable for vegetative phase. The optimum temperature required is 27 ± 2°C (Singh *et al.,* 1993). Flower

initiation took place in only 8 genotypes that could develop till fruit maturity and fruit were harvested for seeds on 25.5.2000.

Table 1: Germplasm performance under polyhouse

Genotypes	Date of flowering	Mature fruits harvested for seed extraction
A. Sweet pepper	3.6.2K	+
EG	29.2.2.K	+
EC 203591	3.3.2K	+
EC 114360	29.2.2K	+
Bell Organe P1-1	3.3.2K	+
19 x YW	6.3.2K	+
RY	2.9.2K	+
Kandaghat-Sel	7.3.2K	-
YRY-P1-3-F_4	8.3.2K	-
Sel. 8	8.3.2K	-
B. Parprika		
Caynne Long	29.2K	+
EC 252137	3.3.2K	+
Arka Abir	17.3.2K	-
Kt-P1-8	25.2.2K	+
Kt-P1-18	6.3.2K	+
Kt-P1-19	29.2.2K	+
Ancho 101	3.3.2K	+
Jalopeno	25.2.2K	+
Anaheim	6.3.2K	+
102	13.3.2K	+
VNR-1	29.2K	-
VNR-10	6.3.2K	-
C. Chilli		
EC 173372	6.3.2.K	+
Cluster purple	21.3.2K	+
Cluster Green	25.3.2K	+
EC 218694	30.3.2K	-
EC 218688	7.4.2K	-
Bolivian Rainbow	14.3.2K	+

+ = Ability of fruiting - = No fruit setting

Table 2: Temperature during the cropping season

Months	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall Total In mm
Dec. 1999	23.1	6.5	0.0
Jan. 2K	19.3	8.0	25.2
Feb. 2K	21.6	8.2	53.5
March 2K	29.0	12.9	6.7
April 2K	38.0	20.0	1.5
May 2K	42.2	27.2	6.7

The genotypes that were found suitable to set fruits under high temperature were EG and Sel. 2 in sweet pepper, Ancho-101, Jalapeno, Kt-Pt-8 in parprika and Cluster green, Cluster Purple, Caynne Long, LCA-334 in chillies. Fruit size decreased to a great extent in sweet pepper and parprika. Cochran (1936) also found that at temperature ranging between 32-38°C no fruit set at all in capsicum, but fruit set gradually increased when temperature was 21-27°C. The observation was also observed in the present study. These promising genotypes will be utilized in the breeding as has been suggested by Greenleaf (1986) for improving the quality and other desired horticultural traits. The suitable varieties if developed that can borne fruits under high temperature can open avenues for farmers to earn high price for their produce by supplying nutritionally rich vegetable to consumers.

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PHENOLOGICAL DEVELOPMENT OF VARIETIES OF RED PEPPER FOR GRINDING (*CAPSICUM ANNUUM* L.) OF DIFFERENT ECOLOGICAL ORIGIN

Tencho Cholakov, Velichka Todorova, Yordan Todorov
Institute of Horticulture and Canning , 4003 Plovdiv, Bulgria

INTRODUCTION

The significance of the information about the phenological development of plants grows all the time. The investigations in this direction are needed not only for selection but also for the introduction of foreign varieties. The phenological data is also regularly used for timely planning and for the conduction of the necessary during the vegetation period agrotechnical activities. Phenological researches are also the first step to forecasting the development of agricultural crops.

The experiment aimed at investigating the phenological development of pepper varieties with different ecological origin and morphology.

MATERIAL AND METHODS

The comparative variety trial was carried out in the field of the former The Maritsa Vegetable Crops Research Institute, Plovdiv in the period 1995-1999. This trial comprised the following varieties: 'Gorogled 6' and 'Buketen 50' from Bulgaria, 'Negral' and 'Belrubi' from Spain, 'Mihaliteleki' and 'Kalocsai 801' from Hungary. These are some of the basic varieties for the production of red pepper for grinding in the corresponding countries. The seedlings were grown in a plastic greenhouse and were planted from 15 to 30 May in the fields on a furrow surface at a distance of 70/15 cm.The trials were set in four replications following the schemes of Barov (1982). The plants are grown according to the worked out in the Institute technology (Veselinov *et al.* 1984).The phenological observations were made every other day in accordance with the requirements of Ganeva/1984/.The attention was directed towards recording the phases of budding, anthesis, fruit set and on recording the dates with botanical ripeness 50, 70 and 90% of the fruits. The data about the air temperature from the meteorological station set 300m away from the trial was processed according to the methods of Gulinova(1974).

RESULTS AND DISCUSSION

The analysis of the phenological data shows, that budding, which is the first basic phase after the planting out of the plants in the field comes earliest in the Hungarian varieties /table 1/.The average duration of the period: emergence-budding in 'Kalocsai 801' and 'Mihalyteleki' is 53 and 55 days. The Bulgarian and the Spanish varieties during this period develop with almost the same rate but the emergence of the flower buds in these are 3-7 days late. The accelerated development of the varieties from the Hungarian selection in the beginning of the vegetation is probably a result of the better climatic conditions in Bulgaria.

The following interphase period: budding-anthesis is again the shortest in 'Kaloscai 801' /8 days/. The average duration of the considered period is greater with 2 days in 'Gorogled 6' and 'Buketen 50'. The anthesis in the varieties from Spain

comes 4 to 5 days later in comparison with 'Kaloscai 801'. The shortest -10 days is the duration of the period from anthesis to the formation of the fruit set in the case of 'Belrubi'. Except 'Negral' the formation of fruit set in the rest of the varieties takes place from 1 to 2 days later. For 'Negral' the interphase period is with 6 days longer in comparison with 'Belrubi'. It is observed from the average values in Table 1 that in the case of 'Negral' the development runs the most slowly till the appearance of the fruit set. During this part of the vegetation period the quickest develop the Hungarian varieties. Among the rest three varieties / 'Gorogled 6', 'Buketen 50' and 'Belrubi'/ the differences are 1-2 days.

A characteristic peculiarity of the next stage of the phenological development: fruit set-botanical ripeness of 50% of the fruits, is that it passes away most quickly for the varieties from Spain. In this case the average duration of the period in 'Negral' is hardly 44 days and in 'Belrubi' 49 days. Most slowly during this period ripen the fruits of 'Mihalyteleki' and 'Gorogled 6'. In comparison with 'Negral' the ripening of 50% of the friuts in these varieties is 11 to 13 days late. The rate with which 'Negral' ripens stays the greatest till reaching botanical ripeness of 70% of the fruits. The duration of the period: fruit set-70% botanically ripe fruits for 'Negral' is 55 days. Regardless of the great rate of ripening of the fruits of 'Negral', 'Kaloscai 801' appears to be the variety with the quickest phenological development. This Hungarian variety has the shortest duration of the period equal to 133 days at the climatic conditions of Bulgaria from emergence till botanical ripeness of 70% of the fruits. It is followed by the Bulgarian variety 'Buketen 50' with 139 days. In the case of the variety 'Gorogled 6' the phenological development is the slowest which in comparison with 'Kaloscai 801' is averagely 20 days late.

From the data received can be seen that in the cases of the investigated varieties the phenological development runs irregularly. The varieties from Hungaria develop quicker in the beginning of the vegetation. After the formation of the fruit set, however, quicker ripen the fruits of the Spanish variety 'Negral'. This variety has relatively high biological potentialities but in Bulgaria its yield greatly varies /Todorov at all 1998/. A reason for this are the insufficient thermal resources which are significantly more restricted in comparison with these in Spain. During 1996 and1997 barely 80% of the formed fruits in 'Negral' reached botanical ripeness. Analogical development showed 'Gorogled 6' during these two years. Unlike 'Negral' it is well adapted to the regional conditions and every year it produces a relatively high yield / Todorov J. 1987/.

Among the investigated varieties with the shortest vegetational period /150 days/ from the emergence till botanical ripeness of 90% of the fruits 'Buketen 50' and 'Kaloscai 801' are the most notable. The Hungarian variety has the quickest development after emergence and in the case of 'Buketen 50' the ripening of the fruits takes place a little bit more intensively. The other Hungarian variety 'Mihalyteleki' also shows accelerated phenological development till the appearance of the fruit set. The slower ripening of fruits in it is probably connected with the morphology of the plant and its greater productivity. Hungarian varieties have quicker development during the first half of the vegetational period as a result of the better thermal resources in the region of Plovdiv (Hershkovich *et al.* 1971). The Spanish varieties have slower development during the first half of the vegetation but their fruit ripening is more intensive. Our observations showed that after the ripening of 70% of the fruits the process of ripening is slowed down. Usually this happens during autumn

and it coincides with the reduction of the average twenty-four-hour air temperatures below 14-15°C. The restrictive influence of the thermal factor is a cause for the vegetation period of the Spanish varieties to be extended. A good example of this are the two years:1996-1997 during which nearly 80% of the fruits of 'Negral' managed to reach botanical ripeness. In 1998 there was a similar case with 'Belrubi'. This variety however manifests better adaptiveness to the conditions of Bulgaria. From all the investigated varieties the phenological development of 'Gorogled 6' is the slowest. During 1997 the amount of the ripe fruits of this Bulgarian variety hardly reached 80% also because of the lower average twenty-four-hour temperatures in autumn.

CONCLUSIONS

In 'Mihalyteleki' and 'Kaloscai 801' the phase of fruit set comes 3-17 days earlier than in other varieties as a result of the better thermal conditions in Bulgaria. 'Kaloscai 801' preserves its quicker phenological development during the entire vegetation.

The Spanish varieties show the slowest rates of development till anthesis but the growth and the ripening of the fruits /to 70%/ of these varieties passes very quickly. 'Negral' comes ahead of all the varieties during this period. The insufficient thermal resources at the end of vegetation in Bulgaria restrict the development of the Spanish varieties.

The phenologocal development of 'Gorogled 6' is the slowest but this variety has won recognition because of its good adaptation to Bulgarian conditions.

'Kaloscai 801' and 'Buketen 50' are varieties with the shortest vegetation period /150 days/ and they can be used in the selection as sources of genes of early ripening.

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Table 1

AVERAGE DURATION OF THE PERIODS IN DAYS (n)

Varieties	Emergence - Bud Formation		Bud Formation - Anthesis		Anthesis - Fruit set		Fruit set - Botanical ripeness of the fruits						Germination - Botanical ripeness 70% of the fruits	
							50%		70%		90%			
	n	σ	n	σ	n	σ	n	σ	n	σ	n	σ	n	σ
Gorogled 6	60	6.3	10	3.8	12	4.6	57	17.4	71	20.9	-	-	153	20.1
Buketen 50	58	6.1	10	2.9	12	3.9	50	11.6	59	14.5	70	16.2	139	12.5
Belrubi	59	5.9	12	4.7	10	5.6	49	12.8	63	17.6	70 *	16.9	144	15.6
Negral *	60	7.1	13	7.3	16	5.8	44	10.4	55	14.0	-	-	144	14.0
Mihalyteleki *	55	4.3	11	2.9	11	2.4	55	14.4	70	17.0	84	12.6	146	14.1
Kalocsai 801	53	6.8	8	4.8	11	4.4	51	13.7	61	14.2	78	18.7	133	11.5

* - the data is from four-year investigations

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EXTENT OF NATURAL CROSS POLLINATION WITH GMS LINES IN CHILLI (*Capsicum annuum* L.)

J. A .Patel*. M.J.Patel*, A.S.Bhanvadia*, R.R.Acharya* and M.K.Bhalala*

*Main Vegetable Research Station,Gujarat Agricultural University,Anand-388 110, Gujarat, India

As for other self pollinated crops, heterosis breeding in chilli has also been rewarding (Pearson, 1983). At Gujarat Agricultural University, Anand Patel *et al.*(1997) identified a high heterotic combinations, which exhibited up to 202.30 and 29.10 per cent heterobeltiosis and standard heterosis, respectively. However, the commercial exploitation of such hybrids would only be possible if economically viable and practically feasible production technology is developed for hybrid seeds. At present hand emasculation and hand pollination is the most common method employed for hybrid seed production in this crop.

Though, chilli has been classified under self pollinated crops, some report suggest geographical differences in the degree of out crossing and which has been reported to be as high as 66.4 per cent (Singh *et al.*, 1994). At Anand Patel *et al.*(1998) observed up to 26.20 per cent out crossing with normal fertile chilli plants, however, the percentage of out crossing could be increases with male sterile plants. Therefore, a simple field experiment was conducted to study the extent of natural out crossing with GMS lines at GAU, Anand during the year 1999-2000.

The hybrid seed production work can be made easy with male sterile lines by taking advantage of natural out crossing, leading to reduction in the cost of hybrid seeds. Gill and Gill(1995) also advocated for use of natural open pollination for economically viable hybrid seed production in chilli. The cytoplasmic genetic male sterility is unstable in fluctuating environment and hence cannot be relied upon to produce F1 hybrid seeds (Greenleaf, 1986). Therefore, hybrid seed production is restricted to genetic male sterility only. The use of genetic male sterility, controlled by a single recessive gene can greatly help in making a F1 hybrid because tideous and costly hand emasculation of individual flower bud can be avoided. However, a limited use of genetic male sterility has been made to produce F1 hybrid seeds because of poor fruit set even after hand pollination (<15%). The probable reasons for low fruit set on GMS lines apart from environmental factors are

1. The stigma injuries during removal of petals and hand pollination.
2. Selection of under or over developed flower buds for pollination resulted in a non receptibility of stigma.
3. Use of unviable pollens for pollination.
4. Due to pollination and fertilization constraints, crossed fruit with hand pollination has less fruit length and less number of seeds per fruit.
5. Mechanical injuries caused by labours while working and movement in crossing block for pollination.

Kohli *et al* (1981) also observed the stigma injuries and non receptibility of stigma for lower fruit set with hand pollination.

At Main Vegetable Research Farm, G.A.U., Anand, the extent of out crossing was studied with morphologically differed six GMS lines. Five sterile plant of each sources surrounded by their fertile counter parts were selected and observation of fruit setting were recorded, where as total number of fruit set on five fertile plants of each source were also counted to estimate the extent of out crossing. Simultaneously per cent fruit set on GMS plants with hand pollination was also estimated. The findings are presented in Table-1.

The number of fruits per plant on sterile and fertile plants of various sources as well as per cent fruit set on sterile plants with hand pollination were significant. The physiological behaviour of plants varied flower morphology may be probable reason for all these differences. However, in natural out crossing average fruit set with male sterile plants varied from 30.22 per cent to 35.99 per cent with 32.79 per cent mean value which was about about 118.6 per cent higher than per cent fruit set on GMS lines with hand pollination (14.44 per cent). The great extent of out crossing with GMS lines would reduce the production cost of hybrid seeds, in addition to production cost the quality of seeds would also be maintained as there will not be any scope for pollen contamination.

It would be worth wise to capitalize on the GMS system with the advantage of natural out crossing for hybrid seed production. It would be pertinent to look for marker in male sterile sources to distinguish male sterile and male fertile plants in the vegetative phase, such identification mechanism with seedling stage is more preferred, this will permit transplanting of any sterile plants. Recessive marker or pleotropic gene action with female line can also be utilized for identification of male sterile plants. The good general combiner lines for green fruit yield, particularly having a large fruit length and girth may be converted as GMS lines with incorporation of recessive marker gene. That would be more beneficial for economically commercial hybrid seed production and for development of higher heterotic hybrids.

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Table 1 : Number / Per cent fruit set on sterile and fertile plants.

GMS line	Range of fruit set		Av.Fruits/ plant		Range of percent fruit set on GMS line		Mean percent fruit set on GMS line	
	Sterile	Fertile	Sterile	Fertile	Natural out crossing	Hand Pollination	Natural out crossing	Hand Pollination
$ACMS_2$ -1-1-1	24-32	65-110	28.20	86.40	27.78-37.04	12.5-15.0	32.64	13.82
$ACMS_2$ -1-1- 4	21-36	82-103	27.80	92.00	22.82-39.13	12.8-15.0	30.22	14.08
$ACMS_2$ - 5-1-1	39-72	107-192	54.20	150.60	25.90-47.81	14.6-15.0	35.99	14.82
$ACMS_2$ - 5-1-5	21-36	70-98	28.20	82.00	25.61-43.90	12.8-14.9	34.39	14.00
$ACMS_2$ - 6-1-1	51-68	140-257	59.40	193.60	26.34-35.12	14.2-15.0	30.68	15.34
$ACMS_2$ - 6-1-3	32-45	103-136	38.40	117.00	27.35-38.46	13.9-15.0	32.82	14.60
Av.fruits / plants	-	-	39.36	120.26	-	-	-	-
S.Em	-	-	3.39	11.08	-	-	-	0.35
Av. of mean percent fruit set on GMS lines	-	-	-	-	-	-	32.79	14.44

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Expression of Heterosis in Hot Pepper (*Capsicum annuum* L.)

Rajesh Kumar[1] and Gulshan Lal
Department of Vegetable Science, GBPUA&T, Pantnagar

Introduction

Chilli (syn. hot pepper) is one of the important crops which is consumed in various forms (Bosland, 1999). In India although most of the area under chilli cultivation is covered by open pollinated variety, in recent pest cultivation of hybrids is increasing rapidly. However, private seed companies are marketing seeds of most of the hybrid varieties. In the public sectors, now major emphasis is being laid on the development of hybrid varieties because of several inherent advantages of hybrids. In heterosis breeding, identification of superior cross combinations for yield is first step followed by economization of cost of hybrid seed production through use of male sterility systems and manipulation of cultural practices in hybrid seed production field. This report highlights identification of few promising lines for the development of heterotic hybrids in hot pepper for various market types.

Materials and Methods

Eight genotypes were crossed in all possible combinations excluding reciprocals (half – diallel). The eight parental materials viz., PC1 (Pant Chilli 1), Punjab Surkh, BC 24, HC 28, Pant Sel 13, LCA 304, JCA 283 and Sel 1 along with their 28 F_1 hybrids were transplanted on April 15, 1999 in a Randomized Block Design with two replications at Vegetable Research Centre, GBPUA&T, Pantnagar, India. The row to row and plant to plant distance were maintained at 50 cm each. Of the parents, Punjab Surkh was chosen as the standard parent for its better yield and popularity. The recommended agronomic practices were followed to raise the crop. The following ten traits were recorded from ten randomly selected plants per line: days to first harvest, fruit length, fruit width, plant height, number of fruits per plant, fresh fruit yield/plant, dry fruit yield/plant, ascorbic acid content, number of seeds per fruit and 1000 seed weight. The estimation of ascorbic acid content in green fruit juice was done according to Rangana (1977). Observation on dry fruits was taken after drying the red ripe fruits in oven for 72 hours at 50°C.

The heterotic effects were computed as the proportion of deviation of F_1 means values from the mid parent (MP), better parent (BP) and Standard Parent (SP) for relative heterosis, heterbeltiosis and standard heterosis, respectively. The significance of difference among the average values of hybrids was determined by Students 't' criterion. The better parents were established individually for each character based on their superior mean performance. For days to first harvest and plant height, the parents and crosses exhibiting low means and negative heterosis were considered desirable while for the rest of the traits higher mean values and positive heterosis were considered desirable.

Results and Discussion

The range of mean performance of parental lines, crosses and heterotic affects in crosses over MP, BP and SP are presented in Table 1. The study revealed maximum range of mean performance for parents and crosses for fresh and dry fruit yield per plant, number of

[1] Present Address: Indian Institute of Vegetable Research, 1, Gandhi Nagar (Naria), P.B. No. 5002, P.O. BHU, Varanasi (U.P.), India.

fruits per plant and ascorbic acid content. Number of seeds per fruit, fruit length and plant height also had high range.

The magnitude of heterosis for different characters varied in different crosses. Some of them manifested significant positive heterosis while others exhibited low positive or negative values heterosis, which resulted mainly due to the varying extent of genetic diversity between parents of different crosses for the component characters. One of the major objectives of plant breeding is to get higher yield and regarding, in the present investigation, considerable extent of heterosis over MP, BP and SP was observed for number of fruits per plant, fresh and dry fruit yield per plant and number of seeds per fruit. The three top ranking hybrids for dry market purpose were Pant Sel 13 x Sel 1 and BC 24 x Pant Sel 13 and Pant Sel 13 x HC 28. These results are in accordance with that of Mishra *et al.*, (1989) who reported that the hybrid Pusa Jwala x Sindhur showed heterosis over the better parent for dry fruit yield per plant and performed best for such traits as number of seeds per fruit, seed weight per fruit and dry and fresh weight of fruit. The present of heterosis for yield in chilli have also been reported by Meshram and Ghangade (1995) and Patel *et al.*, (1997). For days to harvest (an index for the development of early maturing genotype), the mean performance of crosses ranged from 63.3 to 75.9 days with PC1 x BC 24 and BC1 x LCA 304 as superior ones. But these two crosses could not rank in the top three crosses for yield and its component characters. Sekar and Arumugam (1986) also recorded similar observations. With respect to ascorbic acid content the best cross identified was PC1 x Punjab Surkh. Not many crosses expressed significant heterosis for ascorbic acid content. However, this trait is generally governed by partial dominance and over dominance type of gene action, the isolation of desirable recombinants from advance generations may be adopted (Gupta *et al.*, 1990).

In the present investigation, none of the crosses was consistent for all the characters studied. Considerable amount of heterosis was observed in desired direction in majority of the crosses. On the basis of expression of heterosis for yield in different crosses undertaken, it may be expected that high yielding hybrids Pant Sel 13 x Sel 1 and BC 24 x Pant Sel 13 and Pant Sel 13 x HC 28 may be further tested in replicated trials over location and year before recommended for the cultivation.

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Performance of parental lines and their F_1 hybrids for various characters

Character	Range					No. of F_1s showing significant desirable heterosis		
	Per Se performance *		Heterosis (%)					
	Parents	Crosses	Mid parent	Better parent	Standard parent	MP	BP	SP
Days to first harvest	65.0 to 81.5 (PC 1) (PS 13)	63.3 to 75.9 (PC 1 x BC 24) (HC 28 x Sel 1)	-17.02 to 6.87 (PS13 x Sel 1) (PC1 x PS 13)	-14.65 to 9.92 (PS13 x Sel 1) (PC 1 x PS 13)	-9.57 to 8.43 (PC1 x BC 24) (HC 28x Sel 1)	15	3	11
Fruit length (cm)	6.2 to 11.8 (PC 1) (HC 28)	7.1 to 11.6 (BC 24 x JCA 283) (PS 13 x Sel 1)	-13.18 to 30.02 (LCA 304 x Sel 1) (PC 1 x LCA 304)	-34.49 to 15.67 (LCA 304 x JCA 283) (PC1 x JCA 283)	-24.49 to 33.69 (BC 24 x JCA 283) (PS 13 x HC 28)	15	6	9
Fruit thickness (cm)	0.86 to 1.11 (PC1)(Pb. Surkh)	0.77 to 1.20 (PS13 x JCA 283) (PS 13 x HC 28)	-15.38 to 26.98 (PS 13 x JCA 283) (PS 13 x HC 28)	-17.20 to 25.0 (Pb. Surkh x JCA 283) (PS 13 x HC 28)	-30.63 to 8.10 (PS 13 x JCA 283) (PS 13 x HC 28)	5	2	0
Plant height (cm)	46.6 to 72.8 (JCA 283) (Sel 1)	52.7 to 76.2 (Pb. Surkh x JCA 283) (PS 13 x HC 28)	-20.31 to 28.54 (Pb. Surkh x JCA 283) (BC 24 x Sel 1)	-23.76 to 12.45 (Pb. Surkh x Sel 1) (HC28x LCA 304)	-20.75 to 3.15 (Pb. Surkh x JCA 283) (HC 28 x LCA 304)	3	5	1
Fruits per plant	100.3 to 285.6 (HC 28) (PC 1)	86.4 to 242.0 (Pb. Surkh x JCA 283) (BC 24 x Sel 1)	-45.80 to 75.48 (PC1 x Sel 1) (BC 24 x LCA 304)	-61.45 to 64.80 (PC1 x Sel 1) (PS 13 x Sel 1)	-16.92 to 132.7 (Pb. Surkh x JCA283) (BC24 x Sel 1)	9	7	18
Fresh fruit yield per plant	206.9 to 408.5 (Sel 1) (Pb. Surkh)	213.2 to 721.0 (Pb. Surkh x JCA283) (PS 13 x Sel 1)	-31.87 to 158.80 (Pb. Surkh x JCA 283) (PS 13 x Sel 1)	-48.00 to 105.87 (BC24 x JCA 283) (PS13 x Sel 1)	-50.50 to 76.49 (BC24 x JCA 283) (PS 13 x Sel 1)	11	7	4
Dry fruit yield per plant (g)	44.6 to 89.2 (Sel 1) (BC24)	52.7 to 155.2 (Pb. Surkh x JCA 283) (PS13 x Sel 1)	-37.41 to 162.20 (Pb. Surkh x JCA 283) (PS13 x Sel 1)	-38.10 to 110.30 (Pb. Surkh x JCA 283) (PS13x Sel 1)	-36.80 to 82.40 (LCA 304 x Sel 1) (PS13 x Sel 1)	12	10	9
Ascorbic acid content	93.7 to 165.8 (LCA 304) (Sel 1)	80.8 to 214.7 (Pb. Surkh x PS 13) (PC 1 x Pb. Surkh)	-28.6 to 79.10 (BC 24 x JCA 283) (PC 1 x Pb. Surkh)	-33.80 to 78.60 (Pb. Surkh x Sel 1) (PC 1 x Pb. Surkh)	-32.80 to 78.60 (Pb. Surkh x PS13) (PC 1 x Pb. Surkh)	4	1	4
Seeds per fruit	24.4 to 51.8 (PC 1) (Pb. Surkh)	33.8 to 71.2 (BC 24 x Sel 1) (PS 13 x HC 28)	-24.2 to 66.35 (BC 24 x Sel 1) (PS 13 x HC 28)	-32.70 to 60.24 (BC 24 x Sel 1) (PC 1 x Sel 1)	-31.46 to 37.45 (JCA 283 x Sel 1) (PS 13 x HC 28)	12	5	1
1000 seed weight (g)	4.43 to 6.53 (PC 1) (Sel 1)	4.10 to 7.31 (PC 1 x BC 24) (Pb. Surkh x LCA304)	-29.6 to 43.3 (Pb. Surkh x Sel 1) (Pb. Surkh x LCA304)	-36.90 to 41.40 (Pb. Surkh x Sel 1) (Pb.Surkh x LCA304)	-20.70 to 41.40 (PC 1 x BC 24) (Pb. Surkh x LCA304)	13	6	16

* in parenthesis names of parents and hybrids showing respective range values have been indicated.
PC1 = Pant Chilli 1 PS 13 = Pant Sel 13 Pb. Surkh = Punjab Surkh

Table 2: Average performance of three best heterotic crosses for yield and other traits

Cross /parameters	Days to first harvest	Fruit length	Fruit width	Plant height	Fruits per plant	Fresh fruit yield per plant	Dry fruit yield per plant	Ascorbic acid content	Seeds per fruit	1000 seed weight
Pant Sel 1 3 x Sel 1										
Mean	65.8	11.63	0.93	62.4	207.0	721.0	155.2	125.1	55.0	6.01
Heterosis MP	-10.2	20.95	8.14	-14.05	68.08	158.84	162.16	-5.40	39.35	-2.19
BP	-14.65	13.72	0.00	-14.28	64.80	105.88	110.29	-24.41	38.46	-7.96
SP	-6.00	24.06	-16.21	-6.16	99.03	76.49	82.37	4.07	4.24	16.24
BC 24 x Pant Sel 13										
Mean	66.6	9.66	1.03	59.7	191.1	710.7	119.1	128.3	49.7	5.56
Heterosis MP	-9.38	3.31	7.85	-9.95	30.76	92.36	46.01	14.60	12.06	1.92
BP	1.68	-5.29	5.10	-17.54	14.63	82.84	33.40	2.72	0.99	3.47
SP	-4.85	3.31	-7.20	-10.22	83.75	73.97	39.83	6.73	4.05	7.54
Pant Sel 13 x HC 28										
Mean	66.8	12.45	1.20	76.2	114.2	318.3	13.06	95.6	71.2	6.05
Heterosis MP	-14.52	13.63	26.98	14.58	1.10	-10.24	74.72	-6.36	66.35	2.02
BP	-10.69	5.93	25.00	5.24	-9.07	-11.31	76.96	-9.12	51.16	-0.82
SP	-4.57	33.69	8.10	14.58	9.80	-22.10	53.46	-20.46	37.45	17.02

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HETEROSIS AND CORRELATION STUDIES FOR EARLINESS, FRUIT YIELD AND SOME ECONOMIC CHARACTERISTICS IN SWEET PEPPER

Mamedov M.I., Pyshnaja O.N.

Russian Research Institute of vegetable breeding and seed production, 143080, Moscow reg., 0dintsov dis., p/o Lesnoj gorodok, Russia

Introduction

Sweet pepper (*Capsicum annuum* L.) is a high value crop grown in almost all parts of Russia for its fruits which are used as vegetable and spice. But agroclimatic condition in the most part of Russia does not ensure high yield each year not only in open field, but in plastic film greenhouses too. The essential ecological factor limiting growing of sweet pepper in plastic greenhouses and in open field of central regions is lower temperatures (especially at the beginning and the end of vegetation), insufficient total quantity of temperature in plant growth season and short growing period (in an open field since June 10 to September 1, in plastic greenhouses since April 20 to September 1). In Russian central regions a sum of daily average positive temperatures for plant growth period from April 15 to September 15 is 2000°C and the sum of effective temperatures (> 15°C) is 1500°C.It is less than 2 times the plant requirement.

Breeding earliness sweet pepper varieties and hybrids has the large economic significance to promoting culture to northern regions and in southern areas for early production.

Alpatjev (1963) considers, that each phases of earliness is controlled by the separately gene system, and it is possible to plan during breeding process combination of two most short phases at the expense of an appropriate selection of the parent forms.

Material and Methods

The experimental material comprised of six parents - L-Zdorovje, L-Rub, L-Sir, L-Bond, L-Top, L-Sar and their diallel crosses excluding reciprocals. The resulting 21 entries (6 parents and 15 F_1 hybrids) were evaluated under plastic film greenhouses in a randomized block design with three replication at Experimental Station of Russian Research Institute of Vegetable Breeding and Seed Production during 1998-99. The experimental unit was a single row plot of fifteen plants spaced 70 x 30 cm apart for each entry. The observations on fresh fruit yield and its components were recorded on 10 plants for F_1's and parents. Combining ability was done by Method 2, Model 1 of Griffing (1956).

Discussion

Manifestation of heterosis over BP was observed for all traits and the number of hybrids showing significant heterosis over BP are shown in Table 1. The number of crosses, which exhibited significant desirable heterosis over BP were 15 for early yield, 15 for total yield, 5 for germination-flowering, 5 for germination-technical

ripening, 7 for fruit weight, 12 for fruit number per plant, 9 for fruit length, 4 for fruit girth, 8 for pericarp thickness.

The increase of earliness of sweet pepper hybrids F_1 can be reached at the expense of reduction of phases germination-flowering and flowering-technologically mature. The analysis of parameters of trait germination-flowering shows, that 5 F_1's were earlier than BP. They excel of the best parent on 1,5-4,8 %. At three hybrid combinations – F_1L-Bond x L-Sar, F_1L-Bond x L-Sir and F_1 L-Sir x L-Zdorovje is marked negative overdominance on trait germination-flowering - Hp > -1,17; - 1,5; -5 respectively, at one hybrid combination – F_1L-Rub x L-Bond negative dominance Hp ≥-1, and at a hybrid combination F_1L-Top x L-Zdorovje - intermediate inheriting - Hp ≥-0,5.

In unfavorable 1998 sweet pepper plants differ by fast passing of phase germination-technologically mature as parent lines and as hybrids. On the trait germination-technologically mature on 1997 allocated only 3 F_1's. At hybrid combinations F_1L-Bond x L-Sar and F_1Bond x L-Top is observed negative overdominance - Hp >-1,86 and Hp >-3,0 respectively. These hybrids were earlier than best parent line about 7-12 days. One hybrid combination on a trait germination-technologically mature has appeared at level of the best parent – F_1L-Top x L-Sar (110 days), where the degree of dominance carries character negative dominance Hp = -1.

In conditions of 1997 most earlier hybrid was F_1L-Sir x L-Zdorovje (100 days). The degree of dominance of trait germination-technologically mature at this hybrid combination is characterized by negative overdominance - Hp > -3.

In 1998 only 2 F_1's were earlier than BP - F_1L-Rub x L-Top, F_1L-Rub x L-Bond. F_1Rub x L-Top was earlier of the best parent on 6,6 % and degree of dominance is characterized by negative overdominance - Hp >-5,7. At other hybrid F_1L-Rub x L-Bond the degree of dominance of trait germination-technologically mature is characterized also by negative overdominance - Hp >-2, though it was earlier of the best parent only on 0,9% or tree days.

Agroclimatic conditions influences significant to a duration of phases as beginning of flowering up to setting and as from setting up to technologically mature.

Phenophases germination-flowering and flowering-technologically mature sharply differ on years. The phase germination-flowering is exhibited more stable in various conditions, than flowering-technologically mature. A character of manifestation of these two traits do not depend from each other. The correlation coefficient between them r = + 0,47. The correlation coefficient between phases germination-flowering and germination-technologically mature - r = + 0,84 were established.

The analysis of the trait of early yield shows, that in all 15 combinations is observed desirable heterosis effect and the degree of dominance on all hybrid combinations carries a character overdominance - Hp > 1.

The best hybrid combinations on early yield have appeared the following: F_1 L-Rub x L-Zdorovje, F_1 L-Sir x L-Sar, F_1 L-Top x L-Zdorovje, F_1 L-Sir x L-Zdorovje. In both years of research dependence between early yield and germination-flowering and germination-technologically mature carries negative character, that specifies a possibility of breeding of hybrids combining earliness and high early yield. Short vegetation period is inherited dominance and overdominance.

Yeld-main parameter of a variety or hybrid. The separation of total yield of sweet pepper on components, such as number of fruits in plant, fruit weight, length, girth and pericarp thickness are very useful, as each of them differently responds on

breeding and environmental factors. Total yield on all hybrid combinations is observed heterosis effect and the degree of dominance is characterized by overdominance - Hp > 1.

By results of two-years investigations on total yield the following hybrid combinations were selected: F_1 L-Rub x L-Zdorovje, F_1 L-Rub x L-Sar, F_1 L-Bond x L-Sar, F_1 L-Bond x L-Sir, F_1 L-Sir x L-Sar, F_1 L-Top x L-Sar, F_1 L-Top x L-Zdorovje, F_1 L-Sar x L-Zdorovje.

The analysis of correlation parameters shows, that between traits total yield and germination-flowering, germination-technologically mature, average fruit weight the dependence is absent; between total yield-early yield (r = + 0,82) and total yield-number fruits per plant (r = + 0,81) - high correlation. The high correlation is observed between traits total yield-fruit length (r = + 0,74), the significant correlation with an average fruit weight (r = + 0,61).The total yield of sweet pepper in the greater degree depends on number of fruits per plant, than from their weight.

On average fruit weight heterosis effect is observed at 8 F_1's (53,3 %). At 7 F_1's heterosis effect is characterized by overdominance and at one - negative dominance. The heterosis effect on average fruit weight has made 3,3-29,7%.

Among 15 crosses, 8 crosses revealed highest pericarp thickness of 6,4 mm (L-Top x L-Zdorovje), 6,6 mm (L-Rub x L-Bond), 6,5 mm (L-Rub x L-Top) and others.

Trait the average fruit weight has high positive correlation with germination-flowering (r = + 0,75) and germination-technical ripening (r = + 0,67); negative correlation with early yield (r = -0,22), does not correlate with total yield. Average fruit weight has high positive correlation with fruit length and pericarp thickness (r = + 0,83; r = + 0,84) respectively, with fruit girth (r = + 0,61).

Heterosis effect on number of fruits per plant was observed at 12 F_1's, where the degree of dominance is characterized by overdominance. Correlation between traits number of fruit per plant with germination-flowering, germination-technologically mature and traits of fruit (length, girth, pericarp thickness) is absent or very low. Between total yield and number of fruit per plant there is high correlation (r = + 0,81), with early yield (r = + 0,78).

Heterosis on yield-outcome of interaction of various components: a size of plant, early flowering, fruit weight, pericarp thickness, number of fruits per plant. In some combinations the increase of yield is stipulated only by average fruit weight. Is established, that the degree of genetic variety of the parent forms is proportional to range of heterosis effect.

The limited manifestation of heterosis effect under the various factors, influencing to yield, for example (F_1 L-Top x L-Zdorovje), 4,5% - on average fruit weight and 12,8% on number of fruits per plant results in 44,5% heterosis on yield.

References: ALPATJEV A.V., 1963. Breeding of vegetables for earliness and cold tolerance. Genetic, Moscow, p. 529-534.

Table 1. Number of hybrids showing significant heterosis and five best hybrids for each character on the base of heterosis (%) over BP.

Character	No. of hybrids showing significant heterosis BP	Five best hybrids on the base of heterosis over BP
Early yield (kg/m^2)	15	2x1 (203.9), 5x6 (195.3), 4x1(231.1), 5x1 (186.9), 3x1 (194.2)
Total yield (kg/m^2)	15	2x5 (154.1), 5x6 (181.2), 2x1(161.3), 5x1 (150.9), 3x5 (143.8)
Germination flowering	5	2x3 (103.0), 3x6(101.5), 3x5 (101.7), 5x1 (103.5), 4x1 (104.8)
Germination tech. Mature	5	3x4 (102.7), 3x6 (102.6), 2x3 (100.9), 2x4 (106.6)
Fruit weight (g)	7	2x3 (123.7), 2x4 (111.3), 2x6(I14.4), 3x2 (129.7), 4x1 (104.5)
Fruit number	12	3x1 (120.2), 5x4 (183.6), 5x1(140.4), 4x6 (139.3), 4x1 (112.8)
Fruit length (cm)	9	2x3 (103.8), 2x6 (116.3), 3x6(114.3), 5x4 (112.0), 5x1 (112.5)
Fruit girth (cm)	4	2x5 (102.6), 3x5 (105.3), 3x1 (100.8), 5x6 (104.0)
Pericarp thickness (mm)	8	2x3 (108.2), 3x4 (103.4), 2x4 (104.8), 4x6 (106.7), 5x1 (104.1)

Lines: 1. Zdorovje, 2. L-Rub, 3. L-Bond, 4. L-Top, 5. L-Sir, 6. L-Sar.

Table 2. Correlation coefficients for different traits in sweet pepper (*Capsicum annuum* L.).

Traits	Early yield	Total yield	Germination flowering	Germination tech. mature	Fruit weight	Fruit number	Fruit length	Fruit girth	Pericarp thickness
Early yield	1.0	0.82	-0.31	-0.26	-0.2 2	0.78	0.08	-0.09	0.21
Total yield		1.0	0.04	0.05	0.05	0.81	0.74	0.33	0.54
Germination flowering			1.0	0.84	0.82	-0.57	0.63	0.43	0.63
Germination tech. mature				1.0	0.84	0.19	0.78	0.53	0.68
Fruit weight					1.0	-0.57	0.83	0.62	0.84
Fruit number						1.0	0.59	0.21	0.32
Fruit length							1.0	0.40	0.74
Fruit girth								1.0	0.42
Pericarp thickness									1.0

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Seedling analysis for the prediction of heterosis and combining ability in chilli (*Capsicum annuum* L.)

DOSHI, K. M.*, SHUKLA, M. R. AND KATHIRIA, K. B.

Vegetable Research Station, Gujarat Agricultural University, Anand 388 110, India.
* Present address: Department of Fruit Tree Breeding, Bet-Degan-50250, Israel.

INTRODUCTION

The study was carried out with the objective of identifying good combiners and assessing the magnitude of heterosis at the seedling stage, and also to assess the predictability of heterosis and combining ability for yield at seedling stage in chilli , where F_1 hybrids have been commercialized. Such information is not available in literature, although it would be extremely helpful if few seedling characters can be identified which could form a dependable basis to predict heterosis for green fruit yield.

MATERIALS AND METHODS

Ten parental line viz., 'S-49', 'Jwala', 'Arkalohit', 'BC-14-2', 'RHRC- 50-1', 'RHRC-16-5', 'SG-5', 'Guchhedar', 'ACS-92-3' and 'Balochpur' were used in present investigation. Forty five F_1s were developed through half diallel approach. Thirty seeds of each entry (F_1s and parents) were sown on raised beds with spacing in three replication at Vegetable Research Station, GAU, Anand on 20.06.1998. On 20th and 40th day after sowing (DAS), seedling height and leaves per plant were recorded on 10 randomly selected plants in all the entries of three replications. Growth rate and leaf production per weak were calculated as follow:

$$\text{Growth rate (mm/day)} = \frac{\text{Height at 40 DAS} - \text{Height at 20 DAS}}{20}$$

$$\text{Leaf production per week} = \frac{\text{leaves per plant at 40 DAS} - \text{leaves per plant at 20 DAS}}{20} \times 7$$

The beds were drenched with water at 40 DAS and seedlings were carefully uprooted with complete root frame. The roots were thoroughly washed in water and basal roots per plant arising from tap root were counted. Remaining 20 seedling from each beds and each replication were transplanted to the field in randomized block design with three replications keeping the spacing of 60 x 60 cm. Observation for green fruit yield per plant was recorded on ten randomly selected plants in each replication.

Replication means for various characters were subjected to diallel analysis (Griffing, 1956). Heterosis over mid parent and better parent was worked out as per standard procedure given by Turner (1953) and Fonesca and Patterson (1968), respectively. Simple correlation co-efficient was also worked out between different characters using mean values.

RESULTS AND DISCUSSION

Significant variability was observed among entries (including parents and crosses) for all the characters except leaf production per week. Most of the hybrids were significantly superior to parents in all these characters. Maximum heterosis was observed over mid parent and better parent for seedling height at 40 DAS (52.3%, 27.8%), leaves per plant at 40 DAS (38.6%, 21.4%), growth rate (67.1%, 33.1%), leaf production per week (18.4%, 14.0%) and basal roots per plant (64.2%, 28.8%) at seedling stage (Table 1), indicated expression of heterosis even at early development stages. For green fruit yield per plant, maximum heterotic values on mid parent and better parent basis were 77.9% and 64.2%, respectively. The green fruit yield per plant of the best hybrid 'Jwala' x 'Arkalohit' was 32.6% higher as compared to the best line 'Arkalohit' (Table 2).

The correlation studies revealed that green fruit yield per plant was significantly correlated with all the characters (Table 3). This indicated that heterosis expressed at seedling stage gives better idea of green fruit yield. This is in agreement with the finding of Mulge and Anand (1997). The hybrids 'Arkalohit' x 'Guchhedar' and 'Jwala' x 'Arkalohit' expressed significant heterosis over the better parent for seedling height at 40 DAS, leaves per plant at 40 DAS, growth rate, leaf production per week and basal roots per plant. These two crosses also expressed significant heterosis over the better parent for green fruit yield per plant (Table 4). The other cross combination 'BC-14-2' x 'RHRC-16-5' showed significant heterosis over better parent for leaves per plant at 40 DAS, growth rate, leaf production per week along with green fruit yield per plant. Thus, expression of heterosis was maintained right from seedling stage to reproductive phase (Table 1,4). These results suggest that heterosis for green fruit yield can be predicted using the seedling characters.

Identification of good hybrids for green fruit yield per plant is possible at seedling stage, if there is association between seedling and yield characters for their specific combining ability effects (Moentono , 1988). The sca effects for seedling height at 40 DAS (rp=0.56**) and growth rate (rp=0.48**) were significantly correlated with sca effects for green fruit yield per plant (Table 5), indicating that good specific combiners for green fruit yield per plant can be identified at seedling stage. The results of this study confirms that hybrids with high sca effects for green fruit yield per plant can be identified at seedling stage. This technique can help in rejection of inferior hybrids at initial stage of evaluation.

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Table 1 : Magnitude of heterosis for seedling traits and green fruit yield in chilli

Character	Maximum heterosis (%) over	
	Mid Parent	Better Parent
Seedling height at 40 DAS	52.3	27.8
Leaves per plant at 40 DAS	38.6	21.4
Growth rate	67.1	33.1
Leaf production per week	18.4	14.0
Basal roots per plant	64.2	28.8
Green fruit yield per plant	77.9	64.2

Table 2 : Yield potential of best five hybrids and three parents in chilli

Genotype	Green Fruit Yield per plant (g)
Hybrids	
1. 'Jwala' x 'Arkalohit'	1140.3
2. 'Arkalohit' x 'Guchhedar'	1118.1
3. 'Arkalohit' x 'ACS 92-3'	1035.3
4. 'Jwala' x 'Balochpur'	980.1
5. 'S-49' x 'Arkalohit'	963.1
Parents	
1. 'Arkalohit'	860.0
2. 'S-49'	780.0
3. 'Jwala'	753.3
CD at P = 0.05	78.15

Table 3 : Correlation coefficients among different characters of seedling and green fruit yield in chilli

Character	Leaves per plant at 40 DAS	Growth rate	Leaf production per week	Basal roots per plant	Green fruit yield per plant
Seedling height at 40 DAS	0.48**	0.71**	0.24**	0.21**	0.38**
Leaves per plant at 40 DAS		0.67**	0.64**	0.05	0.39**
Growth rate			0.37**	0.23**	0.41**
Leaf production per week				0.06	0.20**
Basal roots per plant					0.26**

Table 4 : Heterosis (%) over better parent for seedling and green fruit yield in selected crosses of chilli

Cross	Seedling height at 40 DAS	Leaves per plant at 40 DAS	Growth rate	Leaf production per week	Basal roots per plant	Green fruit yield per plant
Arkalohit x Guchhedar	19.4**	21.4**	12.6**	12.4**	28.8**	64.2**
Jwala x Balochpur	11.0	2.6	-8.3	6.9	-9.4	61.3**
BC-14-2 x RHRC-16-5	10.1	20.2**	33.1**	13.5**	10.1	58.6**
Jwala x Arkalohit	27.8**	17.0**	24.4**	14.0**	17.3**	49.8**
BC-14-2 x SG-5	18.3**	9.4	6.7	-4.7	-8.6	47.9**

Table 5 : Correlation coefficient for seedling characters with fruit yield per plant for sca effects

Character	Sca effects of green fruit yield per plant
Seedling height at 40 DAS	0.56**
Growth rate	0.48**

*, ** Significant at P = 0.05 and 0.01, respectively

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POLLEN FERTILITY OF PEPPER CULTIVARS AND THEIR HYBRIDS ON MALE STERILITY BASIS

Nikolova V.[1], Todorova V.[1], Daskalov S.[2], Todorov Y.[1] and Stoeva V.[1]
[1] Institute of Horticulture and Canning, 4003, Plovdiv
[2] Institute of Genetics, 1113, Sofia

Abstract

During the year 2000 at the Institute of Horticulture and Canning, Plovdiv pollen fertility of pepper (*Capsicum annuum L.*) was studied in order to be realized breeding program for creation of new male sterile lines. There were tested: P_1 - 1647 'Zm' (*ms* 8), P_2 - cultivars 1644 'Kurtovska kapja', 523 'Victoria' and their F_1 and F_2 hybrids. Lethality in part of homozygous recessives (*msms*) was established and the segregation in F_2 fertile: sterile plants instead of expected 3:1 ratio was 6:1 in 1647 x 1644 'Kk' combination and 10:1 in 1647 x 523 V. Incomplete domination of *Ms* gene was found in heterozygotes *Msms* in fertile plants of the female line, F_1 and F_2 generations. As a result the pollen fertility is with a high variability.

In the studied cultivars the same variability of pollen fertility was set up too.

Introduction

Pepper hybrid seed production on male sterility basis is carrying out in France, Hungary, Italy, Bulgaria, Israel etc. (Pearson, 1983). Seed productivity of different male-sterile forms pollinated by insects and additional hand pollination was studied (Pochard, 1972, Daskalov 1973 *et al.*).

Segregation of sterile and fertile plants in maintaining of male-sterile female line and also the high pollen fertility in father components are of great importance for the hybrid seed production.

The aim of the current study is to analyse the expression of pollen fertility in parents, F_1 and F_2 generations and type of segregation - fertile:sterile plants.

Materials and methods

The male-sterile line 1647 'Zlaten medal' *ms* 8 developed by Daskalov (1973) and the cultivars 1644 'Kurtovska kapja' and 523 'Viktoria' were used as parent components. Expression of the pollen fertility in: fertile plants of 1647 'Zm', father cultivars and their F_1 and F_2 hybrids was studied by pollen grain staining with 4% acetocarmine and glycerin in 1:1 ratio. The parent components, F_1 and F_2 hybrids were cultivated in field conditions and with the exception of F_1 under plastics greenhouse-isolators. The vegetation period was characterized with extremely high temperatures - over 45°C during the experimental year - 2000.

Results and discussions

Data of the results confirm that the male sterility of mother line 1647 'Zm' *ms* 8 is genetically determinated and it is not effected by the conditions of growing. The ratio sterile:fertile plants is approximately 1:1 in open field and greenhouse conditions (Table 1). It was established that in fertile plants of the mother line, the pollen fertility varies from 0.1 to 60% in the open field and from 20 to 100% under cover. Therefore the dominant gene - *Ms* in heterozygous genotypes probably does not ensure complete dominance of fertility.

Most plants - 73.3% under greenhouse and 85.7% in open field conditions, from the father cultivar 1644 'Kk', demonstrated good pollen fertility. The pollen fertility in tested plants of 1647 x 1644 'Kk' F_1 generation significantly varies (0.1 - 100%). The segregation fertile:sterile plants is 6:1 in F_2 generation. It is known that this sterility is monogenic and expected segregation should be 3:1. To explain our results we suppose that nearly 50% of recessive homozygotes (*msms*) are lethal in this combination.

The high variation of pollen fertility in F_1 and F_2 plants confirms again that the dominant gene *Ms* in the heterozygotes does not ensure complete fertility dominance.

The trends in the second combination 1647 x 523 'V' are nearly the same as in the first one (Table 1).

The pollen fertility in cultivar 523 'Viktoria' significantly varies both in open field and under greenhouse conditions.

In F_2 generation only 4, from 44 tested plants were sterile as a results of degenerative processes during the microsporo and microgametogenesis. The value of lethality in recessive homozygotes are higher in the second

combination. The results of our study show that the lethality of recessives *msms* depend on genotype of father parents in a great degree. Incomplete domination of the gene *Ms* in F_1 and F_2 generations is also observed in 1647 x 523 'V'. Therefore this facts have to be taken into consideration in breeding of new male-sterile lines.

Pollen fertility of the tested cultivars has been reduced probably as a result of extremely high temperatures during the year of investigation. That is why the experiments should be continued.

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Table 1. Pollen fertility in pepper (%)

Parents and hybrids	Total plants number	Sterile plants		Fertile plants									
				0.1 - 20%		20 - 40%		40 - 60%		60 - 80%		80 - 100%	
		number	%	number	%	number	%	number	%	number	%	number	%
In open field													
1647 Zm (ms)	22	10	45.5	7	31.8	1	4.5	4	18.2				
1644 Kk	14					2	14.3	9	64.3	3	21.4		
1647 x 1644 Kk F_1	22			2	9.1	1	4.5	4	18.2	9	40.9	6	27.3
1647 x 1644 Kk F_2	9	2	22.2	1	11.1			1	11.1	2	22.2	3	33.3
523 V	10			4	40.0	3	30.0	3	30.0				
1647 x 523 V F_1	5							5	100.0				
1647 x 523 V F_2	7	3	42.9					3	42.9	1	14.2		
In plastics greenhouse - isolators													
1647 Zm (ms)	31	15	48.4			2	6.4	4	12.9	7	22.6	3	9.7
1644 Kk	15					4	26.7	7	46.6	4	26.7		
1647 x 1644 Kk F_2	62	8	12.9	1	1.6	7	11.3	13	21.0	22	35.5	11	17.7
523 V	20			2	10.0	1	5.0	3	15.0	6	30.0	8	40.0
1647 x 523 VF_2	37	1	2.7	1	2.7	5	13.5	13	35.1	11	29.7	6	16.2

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PERFORMANCE OF THE 9th INTERNATIONAL CHILLI PEPPER NURSERY AT MELKASA, ETHIOPIA

Geleta Legesse
Ethiopian Agricultural Research Organization
Melkasa Center, P.O. Box 436, Nazareth, Ethiopia

Introduction

Hot pepper (*Capsicum annuum* L.) is the first priority spice and vegetable crop in Ethiopia. It is the major food item consumed in every day diet mainly for its pungency, color and flavor. Hot pepper is also processed into paprika oleoresin for export. The demand for hot pepper in Ethiopia is increasing with ever-increasing population, however the productivity of the cultivars currently under production is very low because of their low yielding ability and susceptibility to diseases. To over come this problem, our pepper breeding program introduces materials from international institutions and collects the local land races to develop varieties with high yield, disease resistance and desirable horticultural characteristics. As a collaborator, Ethiopia receives International Chilli and Sweet Pepper Nurseries form the Asian Vegetable Research and Development Center (AVRDC) every year and sends feedback to the organization. This report summarizes the results of the AVRDC 9th International Chilli Pepper Nursery at Melkasa Agricultural Research Center.

Materials and Methods

Twenty-one hot pepper genotypes (Table 1) were evaluated at Melkasa Agricultural Research Center during 1999 in a randomized complete block design with three replications. Ten seedlings were transplanted per row and double row made up a replicate. The spacing was 70 cm between rows and 30 cm between plants within the row. Guard plants bordered the experimental plants. All cultural practices were applied as per recommended for pepper production in Ethiopia. The observations were recorded for yield and some important economic characters (Table 1). Fruit weight, length and girth were average of 10 ripe fruits of the second harvest. Fruit number per plant, plant height, plant width and arial fresh biomass were average of five plants randomly taken from the central rows. Data on days to 50% anthesis and fruit yield were recorded at plot basis.

Results and Discussion

Marked differences were observed among the various genotypes for yield and some economic characters (Table 1). As indicated in the table, statistically ($P<0.05$) the highest fruit yield was obtained from cultivars 9852-54, PBC 308, 985-100, PP97-7644, 9852-173, 9852-170 and PBC 142 as compared to the local check (Bako Local). The highest yield was generally attributed to the combination of fruit number per plant, fruit

size and resistance to virus diseases. Very good performance in terms of days to anthesis, fruit number, fruit length, fruit weight, fruit girth, plant character and disease resistance was also observed in appreciable number of genotypes as compared to Bako Local. The ICPN9 materials that revealed better performance for yield and other economic characters will be used to introduce desirable genes such as disease resistance to the local cultivars through standard breeding methods and to directly release the most promising varieties for production after further evaluation under different environments.

Table 1. Performance of the 9th International Chilli Pepper Nursery for Yield and some important economic characters at Melkasa, 1999

Entry	Days to anthesis (DAS)♠	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Fruit no./ plant	Plant height (cm)	Plant width (cm)	Arial fresh biomass (g)	No. of virus infected plants*	Bacterial leaf spot*♣	Fresh fruit yield, t/ha.
9852-15	105.3	8.9	9.9	1.5	74	41.3	32.3	61.1	0	3	11.6
9852-17	88.7	10.4	11.9	1.3	17	38.1	21.6	30.4	0	2	4.8
9852-18	94.7	10.8	10.1	1.3	37	36.9	28.7	45.7	0	3	10.2
9852-19	100.7	8.2	10.5	1.6	27	31.5	30.1	45.7	0	2	6.0
9852-51	99.3	3.6	5.0	1.1	38	52.6	42.6	73.2	0	4	4.3
9852-54	86.7	3.4	7.7	1.0	179	39.3	48.1	99.3	0	3	17.6
9852-61	100.0	3.3	7.5	1.2	160	39.0	43.3	111.2	0	2	10.0
9852-77	90.3	9.1	10.5	1.4	44	30.9	28.8	27.5	0	5	7.6
9852-78	89.3	8.5	10.9	1.7	55	40.4	39.1	73.8	0	4	10.5
9852-79	86.3	10.0	11.3	1.4	50	34.1	39.4	46.9	0	6	11.4
9852-100	90.7	6.7	8.1	1.3	126	46.2	44.0	76.7	0	5	15.2
9852-110	101.7	4.1	6.6	1.2	76	46.2	42.9	70.1	0	1	8.0
9852-170	95.7	8.1	9.2	1.4	52	52.6	48.6	78.6	0	2	12.2
9852-173	94.0	10.3	9.7	1.6	69	47.0	44.6	99.7	0	3	12.6
PBC 142	98.3	2.2	5.4	0.8	179	50.9	47.1	74.9	0	1	12.0
PBC 308	87.3	14.0	11.1	1.7	50	40.2	38.8	52.6	0	2	17.3
PP97-7114	95.7	8.4	8.7	1.4	19	34.4	31.5	47.8	0	5	4.4
PP97-7127	100.3	11.1	10.7	1.8	44	40.9	39.6	67.4	2	2	10.8
PP97-7195-1	106.7	9.0	10.0	1.3	40	50.8	41.6	84.5	0	3	11.3
PP97-7644	104.0	6.3	10.4	1.2	68	54.0	45.3	78.0	0	2	14.0
Bako Local	99.3	10.9	9.2	1.9	9	57.0	42.5	85.9	3	2	4.7
LSD0.05	*14.7*	*2.9*	*1.5*	*0.3*	*51*	*10.0*	*8.4*	*28.2*			*7.0*
CV, %	*9.3*	*22.1*	*10.1*	*15.1*	*46.2*	*14.1*	*13.1*	*25.0*			*41.2*

♠ Days after sowing, * average of three replications, ♣ 1-9 ratings score: 1-3 = resistant/tolerant, 4-6 = moderately susceptible, 7-9 = highly susceptible

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EXOCARP THICKNESS VARIATION IN SOME RED PEPPER CULTIVARS FOR GRINDING

PETKOVA VALENTINA., TODOROVA VELICHKA
Maritsa Vegetable Crops Research Institute, 4003 Plovdiv, Bulgaria*

Abstract

The exocarp thickness variation has been examined in 6 varieties of red pepper for grinding: 'Gorogled 6', 'Buketen 50' (Bulgarian), 'Negral', 'Belrubi' (Spanish), 'Kalocsai 801' and 'Mihalyteleki' (Hungarian). It was established that the fruits of 'Mihalyteleki' and 'Buketen 50' featured the thickest exocarp respectfully 56.6 μ and 55.9 μ, while the Spanish ones are with the thinnest. The variation of this feature for the period expressed via relative range Rm_n, is considerably highest with 'Gorogled 6' (0.19) and 'Belrubi' (0.16), while the lowestis with 'Kalocsai 801' (0.08) and 'Buketen 50'(0.07). The lowest variation measured in variety index is with 'Kalocsai 801', and the highest – 'Mihalyteleki' (CV=20.2%-21.0%). Generally for the investigation period all cultivars showed heterogeneous variation (CV=10.9%-21.0%).

Introduction

The pepper fruit exocarp is of great significance for the quality and the preservation of the production. The problem of pepper exocarp is dealt with in a limited number literature sources. Tenov and Christov (1966) characterize 24 pepper varieties by chemico-technological properties, pointing out the exocarp of the cultivars 'Shipka', 'Kozi roga' and red pepper for grinding is thicker. Fisher (1974) reported that Hungarian red pepper varieties for grinding are characterized with a considerably thicker exocarp and determines the influence of ecological conditions in this respect. Fisher & Fari (1983) examine the anatomical structure of the pepper exocarp and the methods for its measuring. Todorov and Genchev (1985), Omar & Lippert (1975) (by Milkova, 1979) also investigated the pepper exocarp thickness and its variation. Fisher (1992) categorizes pepper varieties according to the exocarp thickness in the following groups: under 40 μ - determinate white varieties; from 40 to 80 μ - indeterminate varieties; above 80 μ - red pepper varieties for grinding. The author reports that the thicker exocarp is dominant and assumes that 1-2 genes determine this feature.

The relatively small number of researching on this problem was the reason that prompted us to investigate this study.

Material and Methods

The following varieties 'Gorogled 6', 'Buketen 50' (Bulgarian), 'Negral', 'Belrubi' (Spanish), 'Kalocsai 801' and 'Mihalyteleki' (Hungarian) have been investigated in Maritsa Institute, Plovdiv for the period 1996 - 1997. The plants have been grown under identical conditions in plastic greenhouses. Sawing was done in second and third decade of March, planting – second and third decade of May, on furrow surface 70/15 cm.

The field trials have been carried out in four replications of 4.8 m^2 recorded area, 40 plants grown under standard technology. Exocarp thickness (μ) has been measured ocular – micrometer. Prior to this crosscuts were made in the middle part of each fruit with a manual microtom.

Fruits of twenty plants, chosen at random, were analyzed individually to establish the feature variation.

The evaluation of differences among average values was made according to smallest considerable difference (FPLSD) and is determined under standard methods /Lidanski, 1988/. The

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importance of the three levels of variation is marked with [1] when P 5%, [2] when P 1%, [3] - P 0.1% and [0] – insignificant. The relation of the valuables to total number of differences between average values is registered by the indicator frequency of significant differences – fsd /Lidanski and Noveva, 1990/.

Results and Discussions

General evaluation of researched feature in years show that investigated cultivars for grinding are with different genetic heritage (table 1).

Table 1.
Dispersion analysis of exocarp thickness

Variation	Degree of freedom	1996		1997	
		σ^2	F	σ^2	F
Genotype	5	1224,00	13.43[3]	553,50	7.45[3]
Random	114	91,60		74,25	
Total	119				
F table P 5% =2.3; P 1% = 3.2; P 0.1% = 4.5					

The fruits of Hungarian and Bulgarian cultivars have thicker exocarp compared to the Spanish ones (table 2). During 1996 this feature varies from 36.8 μ to 57.8 μ. The thinnest exocarp was established in the Spanish varieties 'Belrubi' and 'Negral'. The highest values were registered with the fruits of 'Buketen 50' and 'Mihalyteleki'. 'Negral' and 'Kalocsai 801' fruits show close performance to the control ones. As a rule the frequency of significant values within the examined variants is high (fsd = 80%).

The lack of rainfall in last decade of August, September and twice reduced rainfall in the first decade of October in 1997compared to the climate regulars, benefited formation of fruits with thicker exocarp (x_r=51.8μ). Exocarp thicknesses of 'Mihalyteleki', 'Gorogled 6' and 'Buketen 50' fruits are with highest values and have insignificant differences. Again 'Belrubi' fruits show the thinnest exocarp.

Table 2.
Exocarp thickness

Variety	1996		1997		LSD 1%	x_n	Rm_n
	x	Rm	X	Rm			
'Gorogled6'	47.2	1.00	56.2	0.67	8.39	51.8	0.19
'Buketen50'	57.8[3]	0.67	54.0[0]	0.56	8.98	55.9	0.07
'Negral'	44.2[0]	1.00	50.2[1]	0.33	6.62	47.2	0.14
'Belrubi'	36.8[3]	0.50	42.8[3]	0.43	5.77	39.8	0.16
'Kalocsai 801'	50.2[0]	0.50	50.2[1]	0.33	5.87	50.2	0.00
'Mihalyteleki'	56.2[2]	0.67	57.0[0]	0.67	9.95	56.6	0.01
x_r	48.8		51.8		3.05	50.2	
Rm_r	0.57		0.33			0.42	
LSD 5% =	5.98		5.40				
LSD 1% =	7.91		7.14				
LSD 0.1% =	10.18		9.18				

Fisher (1992) report's that the varieties for grinding are characterized with thickest exocarp – above 80 μ, was not confirmed with none of the examined in our study cultivars. Neither were

confirmed the results of Christov and co., (1984), reporting much thicker exocarp of 'Gorogled 6' and 'Buketen50' fruits, respectfully 94.5μ and 105.0μ.

According to our study results the 'Mihalyteleki' fruits have thickest exocarp (56.6μ) and 'Buketen 50' - (55.9μ), while the Spanish cultivars show thinnest results. The established mean values are close to the ones of the general groups (Ps = 2.45 - 4.69 %).

The variation of this feature for the considered period, measured by the correlated range Rm_n, is comparatively the highest with 'Gorogled 6' (0.19) and 'Belrubi' (0.16), and the lowest with 'Kalocsai 801' (0.08) and 'Buketen 50' (0.07).

The lowest variation measured by variation coefficient shows 'Kalocsai 801', while highest is registered by 'Mihalyteleki' (CV=20.2 - 21.0%) (figure 1). Generally for the study period the variation of all cultivars proves to be heterogeneous (CV=10.9 - 21.0%).

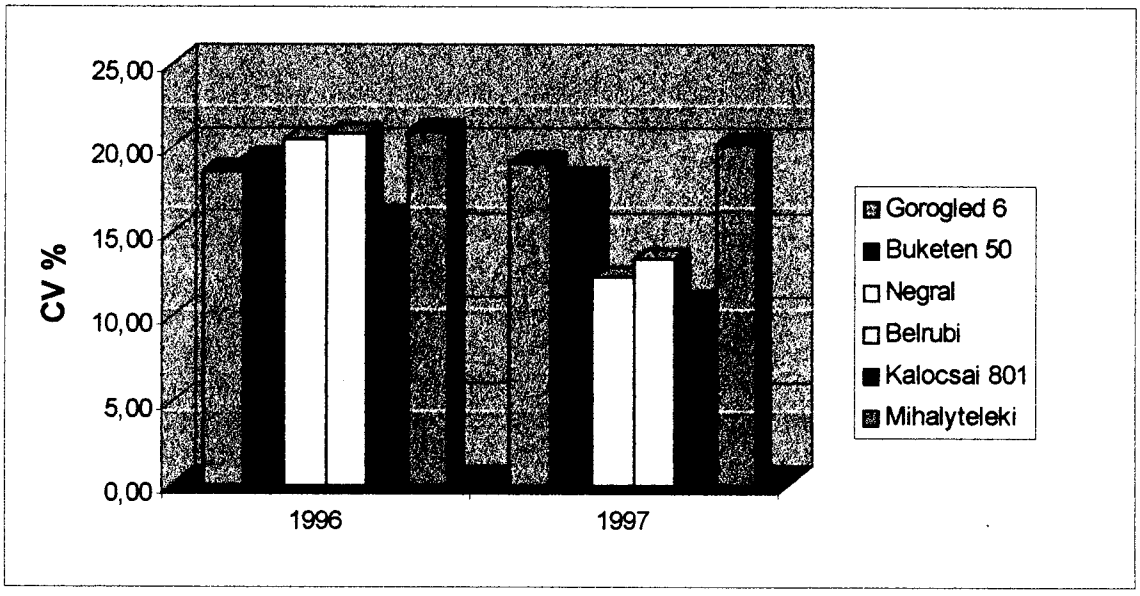

Figure 1. Variation coefficient of exocarp thickness

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ALLELIC TEST FOR CLOSED FLOWER TRAIT IN CAPSICUM

Yayeh Zewdie and Paul W. Bosland

Agronomy and Horticulture Department
New Mexico State University
Las Cruces, NM 88003
U.S.A.

Introduction

A mutant (UFBG 8209-1) with a closed flower trait in chile pepper was reported for the first time by Subramanya and Ozaki (1984). The trait is controlled by a single recessive gene, *cf*, and is expressed by having the flower remain closed during anthesis. The closed flower has the appearance of a "balloon." From a plant breeding point-of-view the closed flower trait favors self-pollination. High rates of outcrossing has been reported in chile pepper (Tanksley, 1984). Consequently, maintaining genetic purity is laborious and expensive (Bosland, 1993).

Dr. Csillery of Hungary observed some mutants with a closed flower trait in his breeding materials and retained the lines. Because of the different genetic backgrounds, different genes might control the closed flower trait in Csillery's material and in the UFBG 8209-1. To determine the allelic relationship among Hungarian mutants and that of the original mutant, a series of test crosses was performed. The results are summarized in this report.

Material and Methods

The seed of the mutant PBC 079, which originated from UFBG 8209-1, was obtained from the Asian Vegetable Research Development Center (AVRDC), Taiwan. The nine Hungarian mutants, 3610/6, 3610/1, 11882/4, 1099/1, 3617/4, 3617/3, 1144/2, 1144/1,and 1139/1, were obtained from Dr. Csillery, Hungary. All the mutants were grown and were evaluated for allelisim in a greenhouse at New Mexico State University in 2000. Four of the mutants, 3617/4, 3617/3, 1144/2, and 1144/1 were found to be open flower types under greenhouse conditions. Two other lines, 3610/1 and 11882/4, were found to be mixtures of plants with closed flower and open flower types. Mutants 3610/6, 1099/1, and 1139/1 had closed flower trait. Except for flower size, no visual variation was observed among the parents in the phenotype of the closed flower, all had the "balloon" phenotype.

To analyze for allelisim of the mutants, 3610/6, 1099/1, 1139/1 and plants with the closed flower trait from the lines 3610/1 and 11882/4 were hybridized with PBC 079. Except for mutant 1139/1 and PBC 079 that had erect fruit type, the fruit position for all the mutants was pendant. The pendant *vs.* erect fruit position present in the parents was used as a visible genetic marker for the verification of true hybrid seeds. If the progeny is a true hybrid derived from pendant vs. erect fruit type parents, the fruit position will be pendant.

Results and Discussion

Results of the tests for allelisim are presented in Table 1. The fruit position of the F_1's derived from the hybridization of parents with erect vs. pendant type was pendant (Table 1), indicating that the F1's were true hybrids. All F_1 progenies had closed flower, demonstrating that the gene governing the closed flower trait in the Hungarian mutants is allelic to *cf.* There was no variation between the F_1 progeny and the parents in the phenotype of the closed flower. This confirms that the genes in the PBC 079 and the Hungarian mutants for a closed flower trait are identical. Although these new mutants were derived from genotypes markedly different in genetic backgrounds, the results showed that the same recessive gene controlled the trait.

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Table 1. Tests of allelism for closed flower trait between the new five mutants and the original known mutant in chile pepper.

Mutant generation	Number of plants	Phenotype of flower	Fruit position
PBC 079 P_1 (original)	15	closed	erect
3610/6 P_2	16	closed	pendant
3610/1 P_3	6	closed	pendant
11882/4 P_4	3	closed	pendant
1099/1 P_5	2	closed	pendant
1139/1 P_6	3	closed	erect
$P_1 \times P_2$ F_1	37	closed	pendant
$P_1 \times P_3$ F_1	11	closed	pendant
$P_1 \times P_4$ F_1	7	closed	pendant
$P_1 \times P_5$ F_1	13	closed	pendant
$P_1 \times P_6$ F_1	7	closed	erect
$P_6 \times P_1$ F_1 (reciprocal)	1	closed	erect

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GENETIC DIVERSITY OF *CAPSICUM PUBESCENS* REVEALED VIA RAPD ANALYSIS

E. J. Votava and P. W. Bosland
Agronomy and Horticulture Department
New Mexico State University, Las Cruces, New Mexico, 88003, USA

Introduction

A unique opportunity to evaluate genetic diversity in an *ex situ* collection containing landrace accessions exists in the species *Capsicum pubescens* Ruiz and Pav. *Capsicum pubescens* is a domesticated *Capsicum* species grown exclusively as landraces at elevations between 1400 - 2900 meters along the Andes mountains of South America (Bosland and Votava, 2000). First described by Ruiz and Pavon (1790) from cultivated plants in Peru, it may be one of the oldest domesticated plants in the Americas, having been domesticated nearly 8,000 years ago (Heiser, 1976). The species has pubescent leaves, purple flowers with large nectaries, and thick-walled round to oval fruit containing reticulated dark brown to black seeds. Facultative self-fertility appears to be prevalent in *C. pubescens* (Eshbaugh, 1970). *C. pubescens* is enigmatic in that wild relatives within this species are unknown. It is thought to be closely related to the wild species *Capsicum eximium* Hunz. and *Capsicum cardenasii* Heiser & P. G. Sm. (Eshbaugh, 1970). Random amplified polymorphic DNA (RAPD) molecular markers have been used to measure genetic diversity in *Capsicum* (Prince *et al.*, 1995; Paran *et al.*, 1997; Rodriguez *et al.*, 1999). RAPD molecular markers were used to measure the genetic diversity contained within and among accessions of *C. pubescens*.

Materials and Methods

Plant material came from either the New Mexico Capsicum Accession (NMCA)collection, New Mexico State University or from the United States Department of Agriculture (USDA) National Plant Germplasm System Plant Introduction Station, Griffin, GA , USA (Table 1). A total of 13 accessions of *C. pubescens* were studied. Additionally, one accession each of *C. annuum*, *C. eximium*, and *C. cardenasii* were included. Two plants from each accession were sampled.

The protocols for growing plants, DNA extraction, and RAPD analysis, are described in Votava (2000). A total of seven primers (Operon Technologies, Alameda, CA, USA) were used for RAPD analysis. These primers were OPA-04, OPAB-14, OPAD-09, OPAE02, OPAK-10, OPV-03, and OPV-17.

Results

Seven primers produced 108 polymorphic and monomorphic RAPD bands. The number of bands generated by each primer ranged from 8 (OPAD-09) to 26 (OPV-17), with an average of 15.4 bands per primer. Of the 108 total bands, 94 (87%) were polymorphic across the 32 DNA samples. Only scorable and reapeatable bands were used for data analysis. This data generated a table of genetic similarities and a dendogram showing the relative genetic similarities of the samples (Fig. 1).

The majority of accessions contained intra-accessional genetic diversity Only three accessions of the 13 revealed no intra-accessional genetic diversity. These accessions were NMCA 80009 (Mexico), NMCA 80019 (Guatemala), and NMCA 80020 (Guatemala). The accession from Costa Rica (PI235047) had relatively little intra-accessional genetic diversity . The greatest intra-accessional distance was observed between the two samples from La Paz, Bolivia (PI 590503). Intra-accessional diversity was seen in the wild species *C. cardenasii* and *C. eximium*.

Table 1. Accessions of *C. annuum, C. cardnasii, C. eximium, and C. pubescens* from the NMCA or USDA collections.

Plant Identifier	Species	Original source
NMCA 11007-1*,-2	*Capsicum annuum*	Arizona, USA
PI 590507-1,-2	*Capsicum cardenasii*	La Paz, Bolivia
NMCA 90021-1,-2	*Capsicum eximium*	letje W. Boukema
PI 235047-1,-2	*Capsicum pubescens*	Costa Rica
PI 355811-1,-2	*Capsicum pubescens*	Ecuador
PI 585277-1,-2	*Capsicum pubescens*	Carchi, Ecuador
NMCA 80058-1,-2	*Capsicum pubescens*	Ecuador
NMCA 80059-1,-2	*Capsicum pubescens*	Ecuador
PI 590504-1,-2	*Capsicum pubescens*	La Paz, Bolivia
PI 590503-1,-2	*Capsicum pubescens*	La Paz, Bolivia
NMCA 80017-1,-2	*Capsicum pubescens*	La Paz, Bolivia
NMCA 80004-1,-2	*Capsicum pubescens*	Peru
NMCA 80005-1,-2	*Capsicum pubescens*	Peru
NMCA 80019-1,-2	*Capsicum pubescens*	Guatemala
NMCA 80020-1,-2	*Capsicum pubescens*	Guatemala
NMCA 80009-1,-2	*Capsicum pubescens*	Michoacan, Mexico

*Dashed numbers indicate plant sample number.

Discussion

Landrace accessions of *C. pubescens* contain a relatively high amount of genetic diversity not only among accessions but also within accessions. This is in contrast to studies of other *Capsicum* species which tend to show relative homogeneity within accessions based on geographical origin (Loiza-Figueroa *et al.,* 1989). Every primer used in this study produced some polymorphic loci. Levels of intra-accessional diversity appear to follow geographic source with less genetic diversity found in countries further from the center of domestication. The greatest intra-accessional genetic distance was found between two samples from La Paz, Bolivia (PI 590503), substantiating Bolivia as the center of domestication for *C. pubescens* (Eshbaugh 1970). Concordantly, the four *C. pubescens* accessions that showed no or little intra-accessional genetic diversity were accessions from Mexico, Guatemala, and Costa Rica and may represent founder's effects due to recent introductions of realatively small founding seed samples.

Taxonomic assumptions for *Capsicum* were validated in this study. *C. annuum* was genetically the most distant from the accessions of *C. pubescens*, while accessions of *C. cardenasii* and *C. eximium* were genetically more similar to *C. pubescens*.

This research supported the concept that greater genetic diversity is obtained by collecting in a crop's center of domestication. In addition, collecting fewer samples from more geographically separated areas outside the center of domestication, rather than collecting intensively within a few small areas, may be a preferred method of obtaining genetically varied germplasm.

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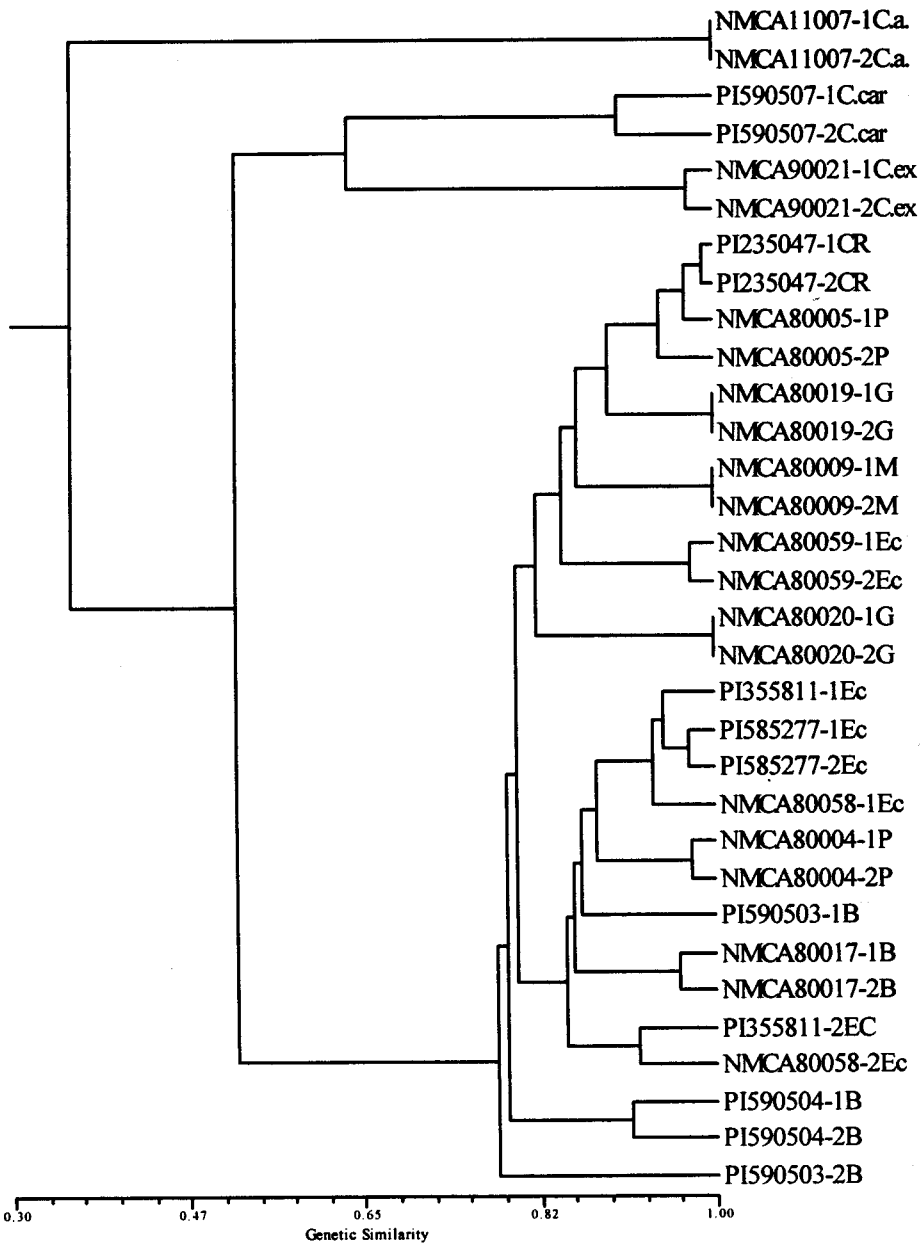

Figure 1. UPGMA dendogram based on Nei and Li's similarity index among 32 *C. annuum*, *C. cardenasii*, *C. eximium*, and *C. pubescens* samples. Labels refer to plant identifier numbers in Table 1.

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CYTOLOGICAL MECHANISMS OF MALE STERILITY IN A NUCLEAR-CYTOPLASMIC LINE OF CHILLI PEPPER (*CAPSICUM ANNUUM* L.)

Sanjeet Kumar, S.K. Rai, M.K. Banerjee and G. Kalloo

Indian Institute of Vegetable Research, 1, Gandhinagar, Post Box # 5002, Varanasi-221 005, India
E-mail: sanjeetk1@123india.com

Abstract

Meiotic analyses of a stable male sterile (CCA-4261) and maintainer (PBC-534) lines of chilli pepper (*Capsicum annuum* L.) were conducted. Although male sterile plant produced very little amount of stainable pollen, pollen failed to dehisce from anthers. Hence CCA-4261 line has been classified as a sporogenous male sterile line, which also shares features of functional male sterility. Results on male meiotic analyses of male sterile and male fertile (maintainer) plants revealed that meiosis was irregular in male sterile plant, especially at telophase II (TII). The results indicated non-dehiscence of pollen as a major mechanism and irregular meiosis at TII as an additional mechanism that provides support to the former in relation to complete expression of male sterility in CCA-4261 line.

Introduction

The phenomenon of male sterility has always been of long-term interest for the plant breeders to produce hybrid seeds. In *Capsicum,* although several nuclear (gms) and nuclear-cytoplasmic (cms) male sterile lines have been reported, only few of them are actually being utilized at commercial scale. Hitherto, gms is being predominantly utilized, despite of the fact that the use of cms is more advantageous (Shifriss, 1997; Kumar *et al.*, 2000). The major bottlenecks in utilization of cms line are unstable expression of male sterility and lack of restorer allele(s) in long fruited sweet pepper lines. Nevertheless, in recent past, few seed companies in Korea have taken initiative in utilizing stable cms line to produce hot pepper hybrids (Shifriss 1997). Since distribution of maintainer and restorer allele(s) are more frequent in sweet pepper and hot pepper lines, respectively, restorer (in sweet pepper) and maintainer (in hot pepper) breeding programs are becoming an integral part of cms based hybrid development in *Capsicum.* In *Capsicum*, certain modifiers and its sensitiveness to temperature also condition expression of male sterility (Shifriss, 1997), therefore, knowledge about the expression stage(s) of male sterility and its kind are imperative to transfer maintainer or restorer gene(s) in desirable genotypes. Hence, a study was conducted to identify particular stage(s) of expression of male sterility at cytological level.

Materials and Methods

Male sterile line (CCA-4261) possessing Peterson's sterile cytoplasm and its maintainer line (PBC-534) were evaluated. Expression of male sterility was found to be complete and stable (Kumar *et al.*, 2001). For meiotic study, flower buds of

appropriate size from one plant each of CCA-4261 and PBC-534 lines were fixed in 3:1 (alcohol : acetic acid) fixative, to which few crystals of ferric chloride were added and after 24 h, materials were stored in 90% alcohol. Slides were prepared in 2.0% carmine in 45% acetic acid and the pollen mother cells (PMCs) showing metaphase I (MI), anaphase I (AI) and AII, telophase I (TI) and TII stages were screened under compound microscope. Frequencies of meiotic configurations were recorded at MI and that of laggards at TI and TII.

Results and Discussion

Male sterility type

Visual comparison between flowers of male sterile and maintainer plants revealed that unlike anther of maintainer plant, there was complete absence of pollen on the anther of male sterile plant (Fig. 1a). However, cytological examination revealed presence of very little amount of stainable pollen in male sterile plant. Further, at later stage unlike anther wall of male fertile (maintainer), anther wall of male sterile plant remained intact and gradually anther became shriveled.

In male sterile plant, although very little amount of normal pollen was produced, they failed to dehisce from the anther, resulting in complete failure of self-fertilization. Hence, CCA-4261 represents an example of sporogenous sterility, which also shares features of functional sterility. This kind of blending of more than one mechanism leading to male sterility has actually been proposed by Kaul (1988). More recently, a similar kind of cms line (Niujiaojio No.21 A) has been utilized to tag fertility restoration (*Rf*) gene (Baoxi *et al.,* 2000).

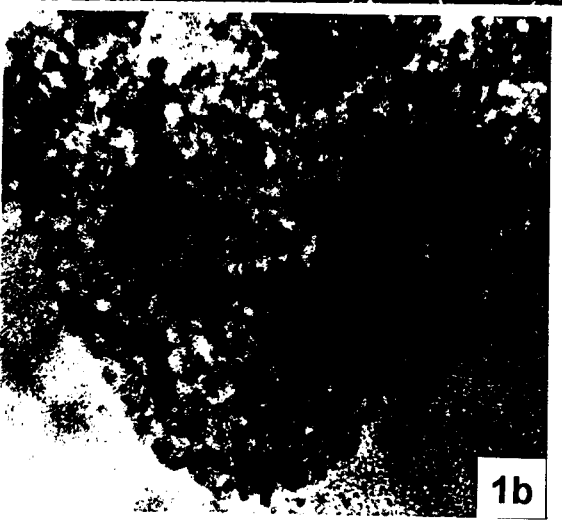
Meiosis and mechanisms

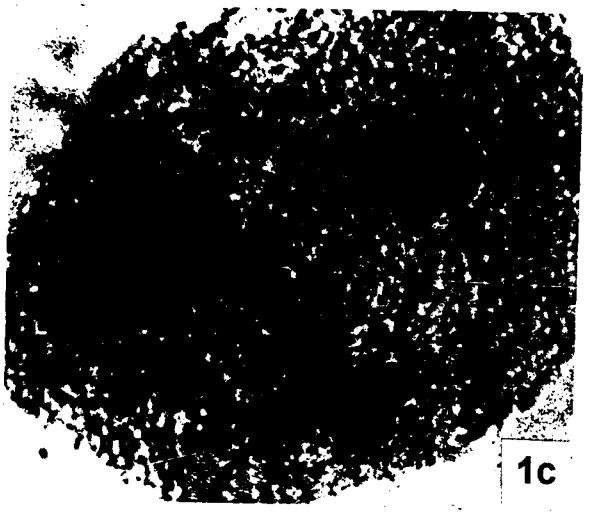
In male sterile plant, percentage of PMCs with univalent(s) and laggard(s) at MI and TII (Fig. 1b) varied from 0.03% and 30.0%, respectively, thereby indicating irregular male meiosis at TII. Further, 5.06% PMCs at TII were tripolar (Fig.1c) in male sterile plants. In maintainer plant, normal bivalents at MI in all PMCs examined and a very few laggards were observed at TII, which was significantly lower than that in male sterile plants. Average laggards (3.05) per PMC at TII in male sterile plant were significantly higher than that in male fertile plant (0.02). These results clearly demonstrated that in male sterile plant meiosis was abnormal especially at TII.

In male sterile plants of *Capsicum*, many meiotic irregularities have been reported during the prophase I (PI) to TII, however, meiosis was not completely arrested (Kaul 1988). Novak (1971) reported irregular meiosis and abnormal tapetum development in cms line of pepper. In contrast, although Horner and Rogers (1974) presented evidence of mistiming of callose dissolution and activity of the tapetum, they argue against the irregular meiosis in cytoplasmic male sterile line. Hence irregular meiosis at TII observed during this study is in agreement with the Novak (1971). However, present result does not confirm majority of reports where breakdown of microspores has been observed after tetrad formation (Shifriss, 1997) but is in agreement with one recent report, wherein normal release of little amount of pollen has been observed in cms line of pepper (Baoxi *et al.,* 2000). The discrepancies in the results of cytological analyses of cms line derived from same cytoplasm (i.e. Peterson's) are difficult to explain. Selection and examination

of male sterile plant(s) with incomplete expression of male sterility may be one of the factors for such differences. For example, Horner and Rogers (1974) did not described degree of male sterility expression in male sterile plant/line studied by them. Instead, it was mentioned that plants of both the lines (normal and cms) produced abundant fruits. Such statement does not specify degree of male sterility expression rather creates confusion that, whether male sterile plants produced selfed fruits or chance out crossed fruits?

Figures 1a-c. Flowers of male sterile and male fertile plants (1a); laggards (1b) and tripolar (1c) PMCs at TII in male sterile plant





The results obtained during this investigation, revealed involvement of irregular meiosis at TII and non-dehiscence of pollen in the complete expression of male sterility. Hence it may be suggested that in CCA-4261 line, complete expression of male sterility is operating through two mechanisms. The first mechanism operates during microsporogenesis and is associated with irregularities in male meiosis at TII, which leads to formation of very little amount of pollen. The second mechanism operates after the release of pollen from the tetrad and is associated with failure of pollen dehiscence, which leads to non-availability of pollen for self-fertilization. The first mechanism (irregular meiosis at TII) does not completely avoid chance of selfing because it does allow formation of little amount of stainable pollen. Therefore, second mechanism (non-dehiscence of pollen) is actually the exact stage of complete male sterility expression in CCA-4261. Although complete failure of pollen dehiscence would essentially be required for avoidance of any chance of selfing, formation of very little amount of pollen (via irregular meiosis at TII) might be playing supportive role to non-dehiscence mechanism in relation to the complete expression of male sterility. This supportive role could be in

minimizing selfing risk otherwise involved due to regular meiosis in male sterile plants, leading to huge (normal) amount of pollen formation and increased chance of pollen dehiscence. In these views, non-dehiscence of pollen may be a major mechanism, which gives complete male sterility expression only in the presence of irregular meiosis at TII. Hence both these mechanisms detected at cytological level are complementary for the complete expression of male sterility in CCA-4162 line and one would expect complementary gene ratio for fertility restoration as reported by Novak *et al.* (1971).

The cytological mechanisms proposed in this paper are based on the results of meiotic analyses of a stable male sterile and a male fertile maintainer plant. Further detailed cytological investigations involving various plant materials including plants with complete and intermediate male sterility expression along with genetics of fertility restoration are needed to test validity of proposed mechanisms.

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PLANT REGENERATION AND *AGROBACTERIUM*-MEDIATED GENETIC TRANSFORMATION IN FOUR *CAPSICUM* SPECIES

P VENKATAIAH, T CHRISTOPHER and K SUBHASH
Mutation Breeding and Tissue Culture Lab, Department of Botany,
Kakatiya University, Warangal – 506 009, INDIA.

ABSTRACT

Adventitious shoot buds developed from three explants, hypocotyl, cotyledon and leaf explants of four *Capsicum* species viz., *C. annuum* cv G_4, *C. baccatum, C. frutescens* and *C. praetermissum* on MS medium containing various concentrations of BAP and IAA. *Agrobacterium tumefaciens* pCAMBIA 1304 MVR 240299 with gus and hpt genes was used for transformation studies using three explants of four *Capsicum* species.

INTRODUCTION

The prerequisite for genetic transformation of pepper (*Capsicum* spp.), a spice and vegetable crop of Solanaceae is the development of an efficient and reproducible regeneration system from tissue cultures. Many reports on regeneration of plants *in vitro* from various explants of pepper via organogenesis (Phillips and Hubstenberger, 1985, Agrawal et al. 1989; Valera-Montero and Ochoa-Alejo, 1992; Szasz et al. 1995) and somatic embryogenesis (Binzel et al. 1996) are available. However, the intervarietal differences in regeneration from various explants and species are highly pronounced. Therefore, cultivars, species and tissue specific media have been devised to optimize regeneration for various species and cultivars (Fari, 1986; Fari and Andrasfalvy, 1994; Christopher and Rajam, 1996; Ramirez-Malagon and Ochoa-Alejo, 1996).

The objective of the present communication is to develop plant regeneration procedure from tissue cultures of four *Capsicum* spp. and to utilize the regeneration protocol in developing *Agrobacterium*-mediated genetic transformation method.

MATERIALS AND METHOD:

Plant Material: Seed of *Capsicum baccatum* PI 260434, *C. frutescens* PI 586675 and *C. praetermissum* PI 342947, were obtained from Regional Plant Introduction Station, Griffin, USA and *C. annuum* cv G_4 from Lam Farm Chillies Research Station, Guntur, India. Seeds were imbibed in sterile distilled water for 24 h, then surface sterilized with 0.1% $HgCl_2$ for 3-5 min, rinsed in several changes in sterile distilled water and germinated aseptically on MS basal medium (Murashige and Skoog, 1962). The axenic seedlings provided cotyledon, hypocotyl (from three week-old) and leaf explants (from six week-old).

Culture Media and Culture conditions: Shoot regeneration was tested on MS basal medium supplemented with various concentrations of BAP (2.0 – 10.0 mgl^{-1}) in combination with IAA (0.5 or 1.0 mgl^{-1}). Regenerated shoots were rooted on MS medium fortified with IAA, IBA and NAA (1.0 mgl^{-1}) individually. All media were adjusted to pH 5.8 before addition of 0.8% agar and autoclaved at 103.4 kPa for 20 min. Media were dispensed into culture tubes and each tube inoculated with one explant were incubated under a 16 hr photoperiod (of cool while fluorescent tubes) with 40-60 $\mu mol\ m^{-2}s^{-1}$ at 25 $\pm$ 1°C. Data were scored for 24 explants per treatment after 4 weeks of culture. All the experiments were repeated at least twice.

Bacterial Strain and Culture: The transformation experiment was conducted using *Agrobacterium tumefaciens* strain pCAMBIA 1304 MVR 240299 (provided by Dr. M.V. Rajam, Department of Genetics, University of Delhi, South Campus, New Delhi). The plasmid contains hygromycin phosphotransferase (hpt) gene, which provides resistance to hygromycin was used as a selectable marker and the β-glucuronidase (GUS) gene was used as reporter gene. The bacterial strain is maintained on Luria-Bertani (LB) medium plates

containing 50 mgl^{-1} Kanamycin + 50 mgl^{-1} streptomycin + 10 mgl^{-1} Rifampicin. For inoculation a single colony was transferred to 30 ml liquid LB medium containing appropriate antibiotics and cultured for 48 h at 28°C on a shaker (100 rpm) and collected in the log phase, when the absorbance at 550 nm was between 0.4 and 0.8.

Transformation and Regeneration: For transformation 100 explants for each treatment from all the four species were precultured on the suitable regeneration media for 4 days. Then, the explants were infected with 10 min with *Agrobacterium*-suspension, blotted dry with Whatman No. 1 filter paper and returned to the regeneration medium for co-cultivation. Following the 48 h co-cultivation, the explants were washed with MS liquid medium. Subsequently, the explants were placed on selection medium, which is the regeneration medium as described above, complemented with 25 mgl^{-1} hygromycin and 500 mgl^{-1} cefotaxime. The explants were transferred to fresh selection medium after 15 days of culture. The explants with putative transgenic shoot buds were transferred to rooting medium with 10 mgl^{-1} hygromycin and 250 mgl^{-1} cefotaxime.

Histochemical GUS assay: The histochemical GUS assay was conducted in explants with shoot buds as described by Jefferson *et al* (1987). The tissues were cleared through ethanol series to remove chlorophyll. The number of blue coloured shoot buds per explant were scored as an indication of transformation.

RESULTS AND DISCUSSION

The adventitious shoot bud formation from hypocotyl, cotyledon and leaf explants of *C. annuum, C. baccatum, C. frutescens* and *C. praetermissum* occurred on BAP (2.0 – 10.0 mgl^{-1}) in combination with IAA (0.5 or 1.0 mgl^{-1}). Maximum number of adventitious shoots buds produced by hypocotyl, cotyledon and leaf explants varied significantly for four *Capsicum* species (Fig. 1, A, B, C & D). In *C. annuum* the optimal media for maximum number of adventitious shoot bud formation for all the three explants was BAP 3.0 mgl^{-1} in combination with IAA 1.0 mgl^{-1}, while in the remaining three *Capsicum* species optimal shoot regeneration occurred on BAP 5.0 mgl^{-1} in combination with IAA 1.0 mgl^{-1}. Variation for adventitious shoot bud regeneration for the three explants within the species was observed, but was not significant. Earlier studies also report the variation in the concentrations of BAP and IAA for plant regeneration from various explants of different *Capsicum* species and cultivars (Phillips and Hubstenberger, 1985; Agrawal et al. 1989; Valera-Montero and Ochoa-Alejo, 1992; Szasz et al. 1995; Christopher and Rajam, 1996, Ramirez-Malagon and Ochoa-Alejo 1996). Leaf explants are more amenable to adventitious shoot formation followed by cotyledon and hypocotyl. Similar observations were also made in *Capsicum* by Agrawal et al. (1989) and Christopher and Rajam (1996) i.e., leaf explants were more regenerable than hypocotyl or cotyledon.

Adventitious shoots from three explants and four species were isolated and transferred to media containing various auxins. Optimal rooting with shoot elongation was observed on medium containing with IAA (1.0 mgl^{-1}) in all four species tested, these results also supports the earlier findings in *Capsicum* (Christopher and Rajam, 1996). Percent rooting of shoots in these four species ranged from 80 – 90%. Complete plantlets measuring a height of 3-5 cm were transferred to vermiculite mix and grown in green house.

For *Agrobacterium*-mediated genetic transformation 100 explants for each treatment were maintained for each species. All the explants were precultured for 4 days on suitable regeneration media, then co-cultivated with *Agrobacterium* for 48 h and placed on regeneration medium fortified with 25 mgl^{-1} hygromycin and 500 mgl^{-1} cefotaxime. Various stages of shoot bud differentiation occurred after 2-4 weeks of culture. In four *Capsicum* species studied leaf explant exhibited maximum transformation percentage (5-22%), followed by cotyledon (2-16%) and hypocotyl (0 – 6%) (Table 1). The transformation efficiency certainly depends upon the regeneration efficiency of explants tissue and species as well as the vector system. This observation shows that explants and *Agrobacterium* compatibility plays a very important role in the development of transformation methods in pepper. Similar observations were also made in *Capsicum* (Liu *et al.* 1990, Siregar and Sudarsono 1997).

Another observation in histochemical staining for GUS gene express was the presence deep blue spots all the injured regions of the explants and scanty callus which developed along with margins. Organogenesis via callus is currently being explored. Shoot buds regenerated (putative transformants) on hygromycin supplemented medium showed the expression of GUS gene. It is also supports the conclusions of Jefferson *et al.* (1987) that the distribution of GUS (β-glucuronidase) gene activity in transgenic plant tissue can be used as a rapid and sensitive marker for transformation. Histochemical staining of transformed shoot buds (GUS activity) provided the preliminary evidence for successful transformation in *Capsicum* species. For *Agrobacterium*-mediated transformation cotyledons were generally preferred as the target explants, and NPT II (coding for resistance to kanamycin) was the selective tool in all cases (Manoharan et al. 1998; Steinitz *et al.* 1999 and references there in).

In the present study we report the use of the GUS and hpt marker genes and hypocotyl, cotyledons and leaf explants were targetted in four *Capsicum* species to produce transgenic plants.

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Figure 1 : Adventitious shoot bud formation from various explants on MS medium supplemented with different concentrations of BAP and IAA in four *Capsicum* species

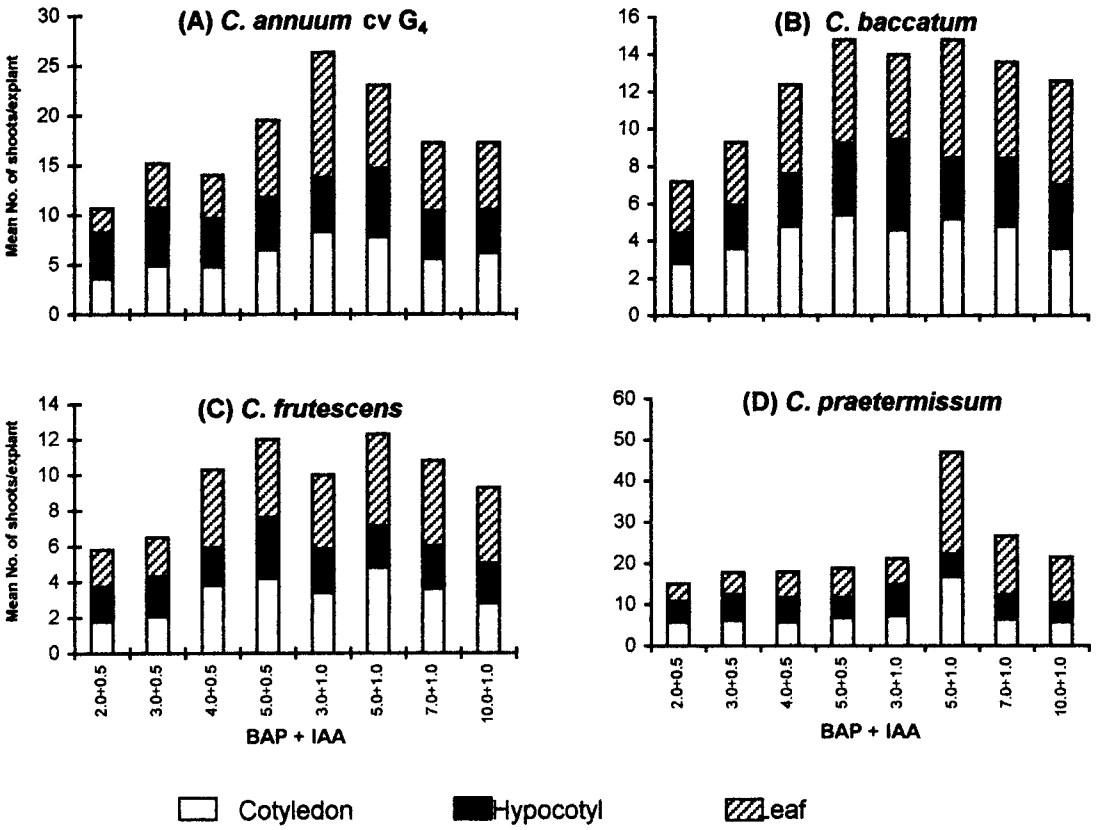

Table - 1 : *Agrobacterium*-mediated genetic transformation using various explants of four *Capsicum* species

Species	Explant	% cultures showing responding	No. of cultures showing callus	No. of cultures showing shoot buds	Total No. of shoot buds showing GUS expression*
C. annuum cv G_4	Hypocotyl	8	6	2	6
	Cotyledon	22	12	10	14
	Leaf	34	20	14	20
C. baccatum	Hypocotyl	2	2	--	--
	Cotyledon	10	8	2	2
	Leaf	19	14	5	6
C. frutescens	Hypocotyl	4	4	--	--
	Cotyledon	12	9	3	3
	Leaf	18	14	4	8
C. praeterunissum	Hypocotyl	16	10	6	9
	Cotyledon	32	16	16	18
	Leaf	48	26	22	38

* Only explants with shoot buds have been used for GUS assay. 100 explants were used for each treatment.

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INDUCED MORPHOLOGICAL MUTATIONS IN *CAPSICUM ANNUUM* L

O. Aniel Kumar, V. Anitha, K. Roseline Subhashini and K.G.Raja Rao
Department of Botany, Andhra University, Visakhapatnam-530003.

Summary:

Seeds of *Capsicum annuum* L Var 'PC 1' were exposed to five doses of gamma rays (10, 20, 30, 40 and 50 KR). Sixteen morphological mutants classified under four categories were isolated from several M2 and M3 progenies. The isolated mutants are described and inheritance pattern genetically analysed.

Keywords: *Capsicum annuum* L; Gamma-rays; Morphological mutations

Introduction:

The induced mutations are of considerable value for comprehensing evolution and accelerating the process of plant improvement. Reports are available on induced mutations in different crops. However, Chili pepper has received only limited attention of mutation breeders (Joshi, 1962; Venkata Rajam and Subhash, 1986). Therefore an attempt has now been made to induce mutations through gamma-rays in cultivar 'Pc 1' of *Capsicum annuum* L. The data on frequency and spectrum of morphological mutations and their inheritance are documented in this communication.

Materials and methods:

One hundred seeds each of cultivar 'Pc 1' of *Capsicum annuum* L were exposed to 10 KR, 20 KR, 30 KR, 40 KR and 50 KR doses of gamma radiation at centre for Nuclear techniques, Andhra University, Visakhapatnam which has a source for ^{60}co. Seeds of M1 plants were harvested separately and sown in M2 on a plant to progeny basis. Several morphological mutations were identified. A few heterozygous plants were taken randomly from lines segregating for mutations in M2 and the seeds of these were sown for M3. Both in M2 and M3 the frequencies of mutants were determined in terms of mutants for 100 plants.

Results:

The frequencies and spectrum of various morphological mutations isolated in M2 and M3 generations are summarised in table-1.

I Plant height mutants:

Mutants showing remarkable variation from the normal plant height of control plants were placed under this category. In the control plants the height ranged from 45-75 cm.

Stunted mutant: Height 7.0-9.15cm. Fewer leaves, flowers, and fruits. Highly sterile.

Dwarf mutant: Height 10-20 cm. Size of leaf, flower, fruit and seeds reduced. Partly fertile. Seeds of various sizes.

Semidwarf mutant : Height 21-40 cm. Size of leaf, flower, fruit and seed slightly reduced compared to control. Partly sterile.

Tall mutant: Height 65-80 cm. Fewer branches, flowers and fruits, seeds shriveled.

II Leaf mutants:

Mutants showed remarkable variation in shape and size of the leaf.

Narrow leaf: Leaves narrow reduced branches, flowers and fruits. Poor Seed set.

Broad leaf: Leaves larger, broader, profused branching. Seed set very low.

Small leaf: Leaves small, fewer flowers and fruits. Seed set poor. Partially sterile.

Curved leaf: Leaves have curved leaf blades with long petioles, fewer branches, flowers and fruits. Seed set poor.

Folded leaf: leaves folded upward, giving boat shaped appearance. Prominent in the seedlings, weak, partially fertile.

Round leaf tip: Leaf tip rounded. Fewer branches, flowers and fruits. Seed set very poor.

Leaf dimorphism: Small, narrow, thin and light green leaves at the top. Long broad, thick and dark green leaves at the lower portions of the plant. Partially fertile. Seed set poor.

Elongated petiole: Narrow and long petiole. Irregular flower opening. Shriveled seeds.

III Maturity mutants:

Early flowering: Flowering 20-25 days ahead of the control. Seed set poor.

Late flowering: Flower initiation 20-30 days later than in control. Partially fertile.

Flowerless mutant: Profuse vegetative growth but without flowers. Totally sterile.

IV Fruit mutant:

Dark green fruit: Fruits elongated and dark green in colour. Partly fertile.

Seeds of heterozygous plants in different M1 and M2 lines were sown and the progenies segregated in M2 and M3 lines and their inheritance pattern was analysed.

Discussion

Enhancement of the frequency and spectrum of mutations is predictable manner and thereby achieving desired plant characters through mutagenesis is an important goal of mutation research (Swaminathan, 1969). In the present study leaf mutations occurred in a higher frequency than other mutant types. However, some mutations viz., stunted growth, semidwarf, elongated petiole and early flowering types were not realised in some M2 doses. In general, the total mutation frequency is higher in M3 generation than M2 generation (Table-1). The mutation frequency encountered now envisages a linear relationship between the dosage of the mutagen and the frequency and spectrum of morphological mutants with a few exceptions. Such a dose dependent relationship was reported in

morphological mutations induced earlier in crops such as *Lathyrus* (Kumar and Dubey 1998) and Chillies (Zubrzycki and Vonder Pahlen 1973).

Various leaf mutants isolated in M2 and M3 generations were possibly due to the gamma-rays causing serious cellular damage resulting in the alteration of metabolism which ultimately lead to leaf abnormalities. A similar postulation was also made in the leafy mutants of *Lathyrus* (Kumar and Dubey 1998). The occurrence of early flowering mutation was possibly due to the disturbances in auxin balance which consequently reduced photoperiodic cycle, a view also shared in induced mutants by Kumar and Dubey (1998) and Sparrow (1966).

The segregation ratios in heterozygous lines generally indicate the genetical structure of M1 plants raised from mutagenized seeds. The segregation pattern of different morphological mutants studied both in M2 and M3 imbreed lines showed that majority of the mutants segregated into normal and mutated phenotypes in a ratio of 3:1 and are controlled by a single recessive gene in each case. However, the progenies of mutant phenotype viz., stunted and semi dwarfs raised from M1 and M2 lines displayed anomalous genetic ratios suggsting their origin from M1 chimaric plant. A similar result was also recorded in mutants of *Vigna mungo* (Raisinghani and Mahna 1994).

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Table-1 Frequency and spectrum of morphological mutations in M2 and M3 generations induced by Gamma-rays in *Capsicum annuum* Var PC 1

Mutant type	M2 generation					M3 generation				
Gamma-rays dose (KR)	10	20	30	40	50	10	20	30	40	50
Total plants studied	260	210	190	160	130	580	540	480	430	410
No. of plants mutated	69	61	60	53	46	158	160	157	150	152
Plant height mutants:										
Stunted	0.38	0.48	-	0.62	-	0.34	0.55	-	0.23	-
Dwarf	1.92	2.85	2.64	3.12	3.07	2.20	2.32	2.29	2.32	3.14
Semi Dwarf	0.38	0.48	0.52	0.62	-	-	0.18	0.42	0.46	0.65
Tall	1.92	1.42	2.10	2.74	3.07	2.07	2.13	2.29	2.82	3.14
Leaf mutants:										
Narrow leaf	1.92	2.22	2.58	2.76	2.90	2.45	2.77	3.20	3.55	3.95
Broad leaf	2.19	2.38	2.64	2.50	2.77	2.36	2.63	2.89	3.10	3.19
Small leaf	1.92	2.40	2.60	2.88	3.16	2.24	2.68	2.78	2.32	2.33
Curved leaf	1.80	2.40	2.56	2.35	2.60	2.08	2.08	2.17	2.40	2.46
Folded leaf	1.65	2.38	1.78	2.50	3.07	1.67	2.30	2.46	2.50	2.70
Round leaf tip	1.92	2.32	2.10	2.32	2.40	1.97	2.45	2.57	2.60	2.38
Leaf dimorphism	1.92	2.46	2.24	2.26	2.08	2.28	2.10	2.37	2.82	2.92
Elongated petiole	1.64	2.40	2.58	-	2.30	1.78	1.48	1.67	1.86	2.42
Maturity mutants:										
Early flowering	1.58	1.56	2.40	2.87	-	1.87	2.03	2.50	2.32	1.95
Late flowering	1.95	0.95	1.76	2.50	2.54	1.37	1.29	1.87	1.86	1.70
Flowerless mutant	2.30	1.42	1.58	2.06	2.30	1.55	1.67	2.08	2.10	2.19
Fruit mutants:										
Dark green fruit	1.14	1.42	1.57	1.87	2.08	1.03	0.97	1.08	1.62	1.95
Total frequency	26.53	29.04	31.57	33.12	35.38	27.24	29.63	32.71	34.88	37.07

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EVALUATION OF HOT PEPPER VARIETIES AGAINST LEAF CURL AND POWDERY MILDEW.

P.A. Fugro,
Central Experiment Station, Wakawali-415 711
Dapoli – Ratnagiri (India)

Abstract

Fourteen varieties of hot pepper (*Capsicum annum* L.) were evaluated against mixed infections of leaf curl and powdery mildew diseases under natural conditions in the field for two successive years. 'RHR-16-5' recorded the lowest incidence of leaf curl (7.96%) and was susceptible to powdery mildew (24.67%) 'PMR-3' recorded the lowest incidence of powdery mildew (08.0%) but was susceptible to leaf curl (29.03%). The varieties 'BC-14-2' and 'BC-21-2' though showed moderate resistance to both the diseases, recorded significantly superior yield of red hot pepper.

Key words : hot pepper, leaf curl, powdery mildew, resistant, susceptible.

Introduction

Virus incited leaf curl and powdery mildew caused by the fungus *Leveillula taurica* are quite important disease of hot pepper and often produce mixed infections in the crop at this location (Konkan region of Maharashtra, India). some insecticides belonging to organophosphorus group and systemic fungicides have been reported to be useful in reducing the incidence of leaf curl and powdery mildew, respectively (Singh, 1985). However, the use of disease resistant/tolerant varieties can always be economical to farming community. It was therefore, decided to screen some promising indigenous varieties of hot pepper against two major diseases of this region.

Materials and methods

An experiment was laid down in randomized block design for two successive years with three replications and fourteen treatments (varieties) in a plot size of 3.6 x 2.8 m and at a spacing of 60 x 60 cm. Recommended doses of manures and fertilizers were applied. The varieties, 'CA-219' and 'Pusa Sadabahar' were planted as susceptible checks for leaf curl and powdery mildew, respectively. Observations for disease incidence were recorded based on scales adopted by Large (1966) and Datar (1980) for powdery mildew and leaf curl, respectively. Disease incidence and yield data were computed and statistically analysed.

Results and discussion

Data presented in Table indicated that the two varieties of hot pepper viz, 'BC-14-2' and 'BC-21-2' though moderately resistant to leaf curl and powdery mildew, recorded significantly superior yields 24.0 and 20.0 q/ha of red hot pepper. 'RHR-16-5' though

resistant to leaf curl (07.96%) was susceptible to powdery mildew (24.67%) while 'PMR-3' though resistant to powdery mildew (08.0%) was susceptible to leaf curl (29.03%). 'PMR-3' was also reported to be resistant to powdery mildew at different locations in India. However, yield potential of this variety varied from place to place depending upon soil and climatic conditions (Annonymous, 1996).

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Table : Performance of hot pepper varieties against leaf curl and powdery mildew.

(Data pooled over 2 years)

Variety	Mean Leaf curl incidence (%)	Mean Powdery mildew incidence (%)	Mean Yield of red hot pepper (q/ha)
'BC-14-2'	14.61 (11.63)	20.00 (22.61)	24.0
'BC-21-2'	18.11 (19.91)	21.43 (24.00)	20.7
'PKM-1'	11.67 (13.05)	25.05 (27.11)	19.1
'Phule Jyoti'	18.81 (20.12)	25.61 (28.01)	18.4
'Konkan Kirti'	18.09 (20.00)	14.78 (16.51)	17.6
'PMR-2'	24.08 (26.11)	09.68 (12.13)	17.3
'PMR-3'	29.03 (31.71)	08.00 (10.41)	17.0
'LCA-304'	25.60 (27.13)	23.81 (26.01)	16.0
'JCA-305'	29.67 (32.13)	30.63 (33.14)	13.0
'LCA-305'	28.02 (31.01)	21.63 (23.61)	11.0
'RHRC-16-5'	07.96 (10.10)	24.67 (27.81)	10.0
'Arka Lohit'	21.22 (23.42)	31.00 (33.56)	08.2
'CA-219 ' Sus.check)'	51.11 (48.11)	26.01 (28.90)	06.7
'Pusa Sadabahar' (Sus.check)	11.02 (13.41)	59.11 (53.65)	05.8
SE ±	**0.61**	**0.32**	**0.076**
CD at 5%	**1.84**	**0.96**	**0.223**

(Figures in parentheses indicate arc sin value)

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Development of F_1 hybrids with resistance to Cucumber Mosaic Virus (CMV) in Chilli (*Capsicum annuum* L.).

Narasimha Prasad, B.C., Madhavi Reddy, K and Sadashiva,A.T.

Indian Institute of Horticultural Research, Hessaraghatta, Bangalore-560 089.

ABSTRACT

Among thirty-six F_1 hybrids produced from 9x9 half diallel mating design, VR-2 x VR-55 (153g. /plant) was found to be the best yielder followed by VR-47 x VR-55 (136g. /plant) and VR-27 x VR-47 (115g. /plant). When the entries were screened for Cucumber Mosaic Virus (CMV) resistance under artificial conditions, two parents *viz;* VR-42 and VR-55 and a hybrid VR -42 x VR- 55 were completely free from infection under artificial conditions. This was further confirmed through ELISA.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important commercial crop of India grown for its green fruits as vegetable and red ripe form as spice. Chilli is known for its flavor and pungency, which are due to capsaicin. Many food industries have extracted the oleoresin from chilli and are being used in the preparation of processed products and in pharmaceutical preparation. In India, chilli is grown in an area of 956 thousand hectares with an annual production of 945 million tones with a productivity of 0.9t/ha (Peter, 1999). Even though India ranks first in area and production, productivity is very less as compared to other foreign countries like Japan (3.6t/ha) and Korea (2.0t/ha). This low productivity of chilli is due to fact that many diseases attack it, which are caused by fungus, virus and bacteria. About 42 viruses are known to attack chilli, which cause yield loss to the extent of 42-80% (Villalon, 1981). Among these 42 viruses, the major are Pepper Vein Banding Virus (PVBV), Potato Virus Y (PVY), Cucumber mosaic Virus (CMV), Tobacco Mosaic Virus (TMV), Pepper Vein Mottling Virus (PVMV) and Tobacco Etch Virus (Horvath, 1986). In the absence of effective conventional plant protection measures, it is necessary to develop resistant varieties/hybrids to combat this problem. Therefore, an attempt was made to develop hybrids with resistance to Cucumber Mosaic Virus at Indian Institute of Horticultural Research, Hessaraghatta, Bangalore.

MATERIAL AND METHODS

The experimental material consisted of nine parents *viz;* Arka Gaurav (Susceptible Parent), VR-1, VR-2, VR-42, VR-14, VR-17, VR-27, VR-47 and VR-55. These parents were crossed according to diallel mating design to get 36 F_1 hybrids. All the nine parents, thirty six hybrids and two commercial checks *viz.*, CH-104 (Pro Agro Seed Company), and Tejaswini (Maharastra hybrid seed company) were sown on 11th January, 1999 and planted on 1st March, 1999 in Randomized Complete Block Design (RCBD) with three replication. Observations were recorded on days to 50% flowering, fruit length (cm), fruit width (cm), number of fruits per plant and dry fruit yield per plant (g).

One more set of parents, hybrids and checks were sown under glass house to screen them for Cucumber Mosaic Virus resistance. Fifteen-day-old seedlings were sap inoculated with pure culture of Cucumber Mosaic Virus maintained on cucumber plants. First observation on percent infection was recorded after fifteen days of inoculation followed by the second observation after fifteen days of first observation.

RESULTS AND DISCUSSION

Mean performance of all the parents and hybrids are presented in the table1. Arka Gaurav was found best for days to fifty percent flowering and fruit width, VR-55 for fruit length, VR-17 for number of fruits per plant and VR-47 for dry fruit yield per plant.

Among hybrids VR-17 x VR-27 (40.57) was found to be the best for days to fifty per cent flowering, VR-17 x VR-55 (8.65cm) for fruit length, Arka Gaurav x VR-2 (2.58cm) for fruit width, VR-1 x VR-2 (169.87) for number of fruits per plant and VR-2 x VR-55 (153.66g. /plant) for dry fruit yield per plant.

When the entries were screened for resistance to Cucumber Mosaic Virus, two parents *viz;* VR-42 and VR-55 and a hybrid VR –42 x VR- 55 were completely free from CMV infection under artificial conditions (Table 2). Where as the susceptible parent Arka Gaurav recorded 88.46 per cent of infection. This was confirmed through ELISA test also. Even though the entries did not show any symptoms, most of the entries had taken the virus but could not express.

The present investigation thus revealed that the most of inbred lines of chilli used for screening against virus were resistant but they were symptom less carriers. Considering the total yield per plant and resistance to virus, outstanding parents and hybrids are;

Parents: VR-17, VR-47 and VR-55.

Hybrids: VR-2 x VR-55, VR-47 x VR-55, VR-27 x VR-47 and VR-42 x VR-55.

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Table 1: Mean of parents, hybrids and checks in chilli for various characters.

Parents/ Hybrid	Days to 50% flowering	Fruit length (cm)	Fruit width (cm)	No. of fruits / plant	Dry fruit yield / plant (g)
ARKA GAURAV	42.06	3.00	3.87	10.54	22.53
VR-1	43.60	4.75	1.00	71.41	65.96
VR-2	48.27	6.09	1.11	83.18	62.14
VR-42	45.70	6.90	1.37	43.42	52.88
VR-14	46.47	7.45	0.81	67.47	56.19
VR-17	50.00	7.17	1.18	92.81	71.17
VR-27	43.20	6.34	0.89	52.21	65.62
VR-47	45.60	6.10	1.12	90.89	86.80
VR-55	46.60	8.32	1.14	35.12	43.20
ARKA GAURAV x VR-1	42.73	6.33	2.27	28.92	44.35
ARKA GAURAV x VR-2	44.40	7.03	2.58	22.00	62.81
ARKA GAURAV x VR-42	43.23	5.26	2.54	24.46	62.81
ARKA GAURAV x VR-14	44.23	7.72	2.30	15.41	35.55
ARKA GAURAV x VR-17	41.03	7.07	2.16	21.50	32.70
ARKA GAURAV x VR-27	43.63	6.64	2.09	24.48	44.70
ARKA GAURAV x VR-47	42.93	8.00	2.12	27.11	55.08
ARKA GAURAV x VR-55	44.40	6.81	2.30	21.19	46.87
VR-1 x VR-2	47.30	7.90	1.20	169.87	113.62
VR-1 x VR-42	46.10	8.00	1.28	98.47	99.50
VR-1 x VR-14	49.53	6.22	0.75	85.75	54.02
VR-1 x VR-17	44.27	6.91	0.98	126.69	114.31
VR-1 x VR-27	51.27	7.70	1.35	76.72	73.91
VR-1 x VR-47	51.67	6.32	1.12	151.85	86.44
VR-1 x VR-55	41.80	6.04	0.87	92.05	62.86
VR-2 x VR-42	45.33	7.34	1.21	74.31	52.67
VR-2 x VR-14	43.67	7.92	0.94	102.71	79.74
VR-2 x VR-17	42.17	8.13	1.21	132.52	86.04
VR-2 x VR-27	43.77	7.81	1.26	53.80	78.05
VR-2 x VR-47	41.43	8.40	1.07	110.40	84.54
VR-2 x VR-55	42.00	7.42	1.15	100.70	153.66
VR-42 x VR-14	45.27	8.07	1.34	90.90	87.14
VR-42 x VR-17	43.68	7.77	1.04	113.07	96.02
VR-42 x VR-27	42.58	8.33	1.14	74.70	102.22
VR-42 x VR-47	42.85	6.67	0.98	113.90	90.29
VR-42 x VR-55	44.57	7.69	1.09	94.66	89.30
VR-14 x VR-17	44.93	7.41	1.12	122.57	84.96
VR-14 x VR-27	43.97	8.28	1.17	93.58	96.25
VR-14 x VR-47	43.60	7.04	1.28	77.87	81.96
VR-14 x VR-55	44.64	6.77	1.08	66.65	61.61
VR-17 x VR-27	40.57	6.92	1.21	66.34	61.92
VR-17 x VR-47	45.60	7.38	1.17	106.24	85.81
VR-17 x VR-55	50.93	8.34	1.13	91.23	96.81
VR-27 x VR-47	48.77	7.31	1.17	95.20	115.54
VR-27 x VR-55	47.23	7.02	1.41	148.28	100.99
VR-47 x VR-55	40.67	7.52	1.15	153.84	136.07
Tejaswini	**45.00**	**9.00**	**1.15**	**102.24**	**78.64**
CH-104	**48.33**	**8.65**	**1.04**	**108.64**	**75.74**
SEm±	**0.61**	**0.30**	**0.12**	**7.45**	**4.72**
CD at 5 %	**1.20**	**0.59**	**0.28**	**14.60**	**9.25**
CD at 1 %	**1.58**	**0.78**	**0.32**	**19.20**	**12.16**

Table 2: Performance of Parents, Hybrids and Checks for CMV resistance Under Artificial Conditions.

Parents/Hybrids/checks	Incidence (%)	Elisa test
Arka Gaurav (Susceptible parent)	88.46	+
VR-1	0.00	+
VR-2	0.00	+
VR-42	**0.00**	−
VR-14	0.00	+
VR-17	0.00	+
VR-27	0.00	+
VR-47	0.00	+
VR-55	**0.00**	−
ARKA GAURAV x VR-1	0.00	+
ARKA GAURAV x VR-2	0.00	+
ARKA GAURAV x VR-42	0.00	+
ARKA GAURAV x VR-14	0.00	+
ARKA GAURAV x VR-17	13.34	+
ARKA GAURAV x VR-27	25.00	+
ARKA GAURAV x VR-47	40.00	+
ARKA GAURAV x VR-55	0.00	+
VR-1 x VR-2	0.00	+
VR-1 x VR-42	0.00	+
VR-1 x VR-14	0.00	+
VR-1 x VR-17	0.00	+
VR-1 x VR-27	0.00	+
VR-1 x VR-47	0.00	+
VR-1 x VR-55	0.00	+
VR-2 x VR-42	0.00	+
VR-2 x VR-14	0.00	+
VR-2x VR-17	0.00	+
VR-2 x VR-27	0.00	+
VR-2 x VR-47	0.00	+
VR-2 x VR-55	0.00	+
VR-42 x VR-14	0.00	+
VR-42 x VR-17	0.00	+
VR-42 x VR-27	0.00	+
VR-42 x VR-47	0.00	−
VR-42 x VR-55	**0.00**	+
VR-14 x VR-17	0.00	+
VR-14 x VR-27	0.00	+
VR-14 x VR-47	0.00	+
VR-14 x VR-55	0.00	+
VR-17 x VR-27	0.00	+
VR-17 x VR-47	0.00	+
VR-17 x VR-55	0.00	+
VR-27 x VR-47	0.00	+
VR-27 x VR-55	0.00	+
VR-47 x VR-55		
Pusa Jwala (Resistant check Op)	**0.00**	+
CH-104 (Resistant Check F_1)	**0.00**	+
Tejaswini (Resistant Check F_1)	**0.00**	+

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REACTION OF DIFFERENT CHILLI (*Capsicum annuum*) GENOTYPES TO BACTERIAL WILT

A.G.Fatima and Salikutty Joseph
Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Kerala, India

Introduction

Chilli *(Capsicum annuum) is* an important spice cum vegetable grown throughout the country. Despite, favourable climatic conditions, cultivation of chilli in Kerala is threatened by many diseases and pests; the most damaging being bacterial wilt caused by *Ralstonia solanacearum* (Smith) Yubuuchi *et al.* The warm humid tropical climate and acidic soil conditions in Kerala are more congenial for the incidence of bacterial wilt. Crop losses up to 100 per cent occur due to this disease. None of the high yielding varieties is resistant to the disease. Chemical control measures have not been successful/economical in controlling the disease. Good drainage, liming and crop rotation programmes of three to five years are helpful in minimizing the disease, but the most efficient method of control is the use of resistant varieties. The research conducted in this direction in Kerala Agricultural University, Vellanikkara, Kerala has resulted in the identification of two chilli varieties viz., Manjari and Ujawala resistant to the disease. But these varieties are small fruited having high seed content and high pungency with less market acceptability. So this experiment was carried out to identify the chilli genotypes (long / medium long) with resistance to bacterial wilt.

Material and Methods

The present investigation has been undertaken at the Vegetable Research Farm of the Department of Olericulture, College of Horticulture, KAU, Vellanikkara between 1996-98. Chilli germplasm maintained in the Department of Olericulture, collections made from other State Agrl Universities and abroad formed the basic experimental material. Fifty three accessions were raised in Randomised Block Design with two replications in the bacterial wilt sick soil. There were 16 plants per accession per replication. Spot planting with a well known bacterial wilt susceptible variety Pusa Jwala was done to study host reaction to the bacteria. The wilt incidence was confirmed through ooze test. The number of plants wilted at weekly intervals was recorded and percentage of wilt incidence was worked out. Then the accessions were grouped in to resistant, moderately resistant, moderately susceptible and susceptible as per Mew and Ho (1976).

Results and Discussion

The percentage of wilt incidence at vegetative, flowering and the harvesting stages were observed (Table 1). The chilli accessions showed different levels of resistance to wilt. The wilt incidence ranged from 8.34 to 88.88 per cent. The check variety Pusa Jwala completely succumbed to wilt at the vegetative stage itself. Fifteen accessions were found resistant to the wilt, with the wilt incidence below 20 per cent.

Minimum wilt incidence was noticed in the accessions CA 745 (PBC 535) (8.34%) followed by CA 731 (Perennial) (8.40%), CA 219 (Ujwala) (8.53), CA 738 (PBC 204) (8.54%), CA 337 Punjab Lal) (8.59%), CA 715 (PBC 385) (8.69%), CA 739 (PBC 375) (9.19%), CA 517 (IIHR 819) (9.40%), CA 714 (PBC 473) (9.76%), CA 740 (PBC 384) (10.84%), CA 716 (PBC 066) (11.27%), CA 33 (Manjari) (12.04%), CA 744 (PBC 518) (13.78%), CA 53 (Pant C-1) (17.86%) and CA 746 (PBC 716) (18.91). Resistance of Ujwala (CA 219) and Manjari (CA 33) to bacterial wilt was reported by Gopalakrishnan and Peter (1991) and Jyothi *et al.* (1993). Resistance of accessions namely CA 745, CA 738, CA 740, and CA 715 was also confirmed by Jawfen and Berke (1997).

Sixteen accessions were moderately resistant with wilt incidence ranged between 20 and 40 per cent. Another thirteen accessions were rated as moderately susceptible with disease incidence varied between 40 and 60 per cent. Remaining nine accessions were found to be highly susceptible with more than 60 per cent of wilt incidence. The accessions CA 87 and CA 153 were severely affected by this dreadful disease (68.80 and 88.88% respectively).

Based on fruit length the above mentioned 15 resistant accessions were classified into short, medium long and long according to Smith *et al.* (1987). Nine accessions namely CA 337, CA 53, CA 731, CA 33, CA 219, CA 517, CA 738, CA 739 and CA 746 were found short in fruit length (5.0-7.5 cm). The accession CA 745 had medium long fruits (7.5-10.0 cm). Remaining five accessions viz., CA 714, CA 715, CA 716, CA 740 and CA 744 were rated as long fruited genotypes (10.15 cm).

Abstract

Fifty three chilli accessions collected from various parts of the country and abroad were evaluated in the bacterial wilt sick soil. The level of resistance to bacterial wilt varied with the accessions. Out of the 53 accessions tested 15 were resistant, 16 were moderately resistant, 13 were moderately susceptible and the remaining nine were highly susceptible. Among the 15 resistant accessions nine were short fruited, five were long fruited and remaining one was medium long fruited.

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Table 1. Evaluation of 53 chilli genotypes for bacterial wilt resistance.

Accessions No.	Incidence of bacterial wilt			
	Vegetative Stage	Up to flowering and fruiting	Up to final harvest (total)	Score
CA 33	3.74	8.48	12.04	R
CA 53	6.54	13.76	17.89	R
CA 66	10.00	14.81	25.92	MR
CA 87	40.00	60.42	68.80	S
CA 94	4.44	15.55	28.88	MR
CA 153	44.44	66.66	88.88	S
CA 186	9.40	25.92	37.03	MR
CA 219	1.63	5.77	8.53	R
CA 337	2.00	5.74	8.59	R
CA 451	8.84	32.80	45.72	MS
CA 452	8.34	33.25	47.37	MS
CA 517	3.50	5.78	9.40	R
CA 5 91	11.11	15.76	22.22	MR
CA 644	13.34	39.81	61.84	S
CA 695	11.10	20.00	33.00	MR
CA 696	11.10	33.33	44.44	MS
CA 698	4.44	11.10	24.44	MR
CA 699	25.00	50.00	50.00	MS
CA 701	25.00	38.00	63.00	S
CA 702	29.25	45.00	69.72	S
CA 703	30.00	41.11	67.40	S
CA 710	8.33	27.24	38.64	MR
CA 714	2.54	6.32	9.76	R
CA 715	2.30	5.84	8.69	R
CA 716	3.49	8.41	11.27	R
CA 725	2.46	11.11	22.20	MR
CA 727	10.00	33.52	48.00	MS
CA 728	10.28	18.51	25.92	MR
CA 729	11.11	33.33	44.44	MS
CA 730	10.20	22.22	22.22	MS
CA 731	3.50	4.76	8.40	R
CA 733	14.76	33.33	44.44	MS
CA 734	30.50	48 46	70.56	S
CA 737	8.59	27.54	38.84	MR
CA 738	2.46	5.37	8.54	R
CA 73 9	2.82	6.42	9.19	R
CA 740	3.27	6.82	10.84	R
CA 744	5.94	7.61	13.78	R
CA 745	2.41	5.72	8.34	R
CA 746	6.73	11.57	18.91	R

Accessions No.	Incidence of bacterial wilt			
	Vegetative stage	Up to flowering and fruiting	Up to final harvest (total)	Score
CA 748	16.66	50.00	66.66	S
CA 750	14.81	33.33	44.44	MS
CA 751	17.77	22.22	42.22	MS
CA 752	11.11	28.66	51.11	MS
CA 753	11.11	22.22	44.44	MS
CA 754	20.37	31.11	53.33	MS
CA 755	11.67	20.00	37.77	MR
CA 756	11.11	11.11	22.22	MR
CA 757	10.24	20.00	22.22	MR
CA 758	13.46	22.22	33.33	MR
CA 759	29.47	48.32	65.92	S
CA 760	11.11	33.33	48.14	MS

R – Resistant (< 20% wilt)
MR – Moderately Resistant (20% - 40%)
MS – Moderately Susceptible (40% - 60%)
S - Susceptible (>60%)
(Mew and Ho, 1976)

Capsicum and Eggplant Newsletter 20 (2001): 86-89 (invited paper).

FUSARIUM DISEASES OF CAPSICUM

L.M. Oelke and P.W. Bosland
Department of Agronomy, New Mexico State University, Las Cruces, NM 88003

The fungal genus, *Fusarium* Link ex. Fr., is found worldwide and causes serious crop losses in many economically important crops, including cereals, vegetables, and ornamentals (Snyder and Hansen, 1940). As a pathogen of chile (*Capsicum* spp.), *Fusarium* causes wilts, root rots, foliar blight and fruit rot, and storage rot. The goal of this paper is to clarify the status of *Fusarium* as a pathogen of chile.

Fusarium taxonomy

Fusarium taxonomy is very complex and imprecise in differentiating between species. Most fungal pathogens are classified by morphological and physiological characteristics of the organism. *Fusarium* species vary greatly in morphological and physiological traits that would normally be used to classify at the species level (Snyder and Hansen, 1940). Wollenweber et al. (1925) developed a system of classifying *Fusarium* species based on macroconidia and microconidia structures, including their shape, presence of septate, number of septate, color of conidia, presence or absence of chlamydospores, and other measurable traits of mycellial cultures. Snyder and Hansen (1940) demonstrated that by doing a single spore culture of *Fusarium*, the resulting cultures could fall into more than one species based on the Wollenweber system of morphological and physiological traits. The Snyder and Hansen system simplified the Wollenweber system by grouping *Fusarium* into species based on morphology and creating forma specialis based on the pathogenicity of the isolate or strain. This system of taxonomy is the current system used by mycologists and plant pathologists.

Fusarium annuum

Fusarium annuum Leonian was the first *Fusarium* organism described as a pathogen of chile (Leonian, 1919). Based on greenhouse and field experiments, Leonian incorrectly reported *F. annuum* as the causal agent of chile wilt. Three years later, Leonian correctly reported *Phytophthora capsici* Leon. as the causal agent of chile wilt in the southwestern United States (Leonian, 1922). Since then, references have been made to both of Leonian's reports causing confusion to the true causal agent responsible for root rot and wilt diseases of chile (Doolittle, 1953; Walker, 1932). Walker (1952) questioned whether *F. annuum* was actually a causal agent of wilt of chile because the symptoms given for Fusarium wilt of chile were so similar to Phytophthora root rot of chile.

F. annuum has been mistakenly reported as a major pathogen of chile repeatedly based on Leonian's 1919 publication. *F. annuum* along with *P. capsici* were reported as pathogens of chile in the southwestern United States in the 1953 *Yearbook of Agriculture*. *F. annuum* was later reclassified as *Fusarium oxysporum* (Schlecht.) Snyd. and Hans. by Snyder and Hansen (1940). *F. oxysporum* (Schlecht.) var. *vasinfectum* (Atk.) Snyd. and

Hans. was reported as the causal agent of Fusarium wilt of chile in *Vegetable Diseases and Their Control* by Sherf and MacNab (1986). This *Fusarium* was described as "more of a root rotting organism" when compared to other Fusarium wilts such as Fusarium wilt (*F. oxysporum* var. *vasinfectum*) of cotton (*Gossypium hirsutum* L.). Several researchers have reported isolating *Fusarium* from wilted chile plants in Peru, Chile, Spain, and Italy (Bozza Barducci, 1938; Ministerio de Agricultura, Chile, 1941; Benlloch and Dominquez, 1933; Baldacci and Corradini, 1952), but Koch's Postulate, a step-by-step method for proving pathogenicity of an organism, was not completed., The *Fusarium* isolated could have been a contaminant and not the causal agent of disease (Agrios, 1997). Many organisms may be associated with and repeatedly isolated from a diseased plant. The organism may be a saprophyte, feeding on the already killed portion of the host, or may be a secondary invader, following the primary causal organism.

***Fusarium* of chile**

After the initial confusion of misidentifying root rot for a *Fusarium* disease, researchers have clarified that *Fusarium* species are pathogenic on chile. However, the symptoms of *Fusarium* diseases can easily be confused with other fungal diseases.

Fusarium fruit rot symptoms are similar to other fruit rots. Fusarium fruit rot of chile can occur anytime after harvest from transport to the shelves at the market. Lesions form on the fruit, starting out pale in color, quickly turning brown. Under humid conditions, white or pink mycelium will develop on the surface of the fruit. The fruit eventually rots. Under low humidity, the fruit will dry out and shrivel (Micosa, and Ilag, 1977).

Fusarium fruit rot of chile has been identified in field production and under greenhouse production. Micosa and Ilag (1997) identified and described two species of *Fusarium* as fruit rots of *C. annuum*. *F. oxysporum* and *F. solani* (Mart.) (Appel and Wr.) Snyd. and Hans. (forma specialis not given) were isolated from infected fruit, identified and their pathogenicity tested on *C. annuum*. In greenhouse production, *F. solani* has been identified as the causal agent of stem and fruit rot of sweet pepper in Great Britain (Fletcher, 1994). The telomorph of *F. solani*, *Nectria haematococca* Berk. and Br., was identified as a stem and fruit rot causing organism of chile in Ontario, Canada (Jarvis et al., 1994). *N. haematococca* entered the chile plant through wounds and could be controlled by careful pruning and general sanitation in the greenhouse.

While pathogenic *Fusarium* are generally considered wilt pathogens, Fusarium root rot has been identified in beans (*Phaseolis vulgaris*) and peas (*Pisum sativum* L.) (Sherf and Macnab, 1986). Fusarium root rots can be confused with Phytophthora root rot (*P. capsici*) due to the similar symptoms of the two diseases. The symptoms of Phytophthora root rot of chile are severe wilting, collapse of the plant, decay or disintegration of the root system and death of the plant (Goldberg, 1995). *P. capsici*, unlike *Fusarium*, is able to infect any part of the chile plant, including the roots, stems, foliage, and pods.

Govindswamy (1963) conducted a survey of root rot diseases of chile, eggplant, and tomato in India. The symptoms described were consistent with root rots rather than wilts. Govindswamy isolated 35 isolates of *Fusarium* from chile, primarily *F. solani* and *F. solani* (Mart.) v. *minus* Appel et. Wollen. Four isolates of *F. solani* (Mart.) v. *martii* Appel et. Wollen. were also isolated. Pathogenicity tests of these *Fusarium* species were

conducted on chile, tomato and eggplant. Isolates from eggplant and tomato caused 20-90% mean mortality on chile plants. The isolates from chile resulted in 0-50% mean mortality rates on eggplant and tomato plants. These results indicated that *Fusarium* isolated from chile, tomato, and eggplant were not host specific. Fusarium wilts of chile can also be misidentified as Verticillium wilt (*Verticillium dahliae* Kleb. and *V. albo-atrum* Reinke and Berthold) and vice versa. However, the symptoms are distinctly different. The symptoms of a Fusarium wilt can be generalized as vascular discoloration, yellowing of leaves wilting, and death of the plant. The symptoms of Verticillium wilt are leaves turning yellow, stunting, leaf drop, vascular discoloration and death of the plant. No crown or root rot occurs with Verticillium wilt (Goldberg, 1995).

F. oxysporum (Schlect.) f. sp. *capsici* Bl. and Riv., a Fusarium wilt pathogen, was identified for the first time in the United States on Avery Island, Louisiana (Rivelli, 1989). *F. oxysporum.* f. sp. *capsici* was isolated from a tabasco plant (*Capsicum frutescens* L.). Pathogenicity tests by root immersion were done at 2 to 4 weeks after emergence of the seedlings. Pathogenicity tests showed host specificity to *Capsicum*, while excluding cotton, okra (*Abelmoschus esculentus* W.), tomato (*Lycopersicum esculentum* Mill.), eggplant (*Solanum melongena* L.), watermelon (*Citrullis lanatus* L.), cantaloupe (*Cucumis melo* L.), cucumber (*Cucumis sativus* L.) and cabbage (*Brassica oleracea* L.) as susceptible hosts. This is the first confirmed *Fusarium* pathogen of chile independent of Leonian's report found in the United States. Rivelli (1989) described the wilt symptoms as yellowing of the foliage, vascular discoloration, and wilting of the plant with the leaves still attached. These symptoms are typical of Fusarium wilt diseases.

Joffe and Palti (1974) investigated the *Fusarium* species associated with root rots and wilts of several crops grown in Israel, including chile, but no differentiation was made between wilt and root rot and no symptomology was given. Based on the information in the paper and the range of hosts utilized in the experiment, the Fusarium diseases investigated were probably Fusarium wilts. In the report, isolates of *Fusarium* associated with chile wilts and root rots were *F. oxysporum*, *F. solani*, *F. equiseti* Corda, and *F. semitectum* Berk. The *Fusarium* species capable of causing the highest mortality rates in chile were *F. solani* (53%), *F. oxysporum* (24%), *F. equiseti* (36%), and *F. javanicum* Koord. (40%). *F. avenaceum* (Fr.) Sacc., *F moniliforme* (Sheldon) Snyd. and Hans., and *F. culmorum* (W.G. Smith) Sacc. also killed chile seedlings at rates of 17%, 6%, and 10%, respectively. An interesting observation from this study was that *F. javanicum* while isolated primarily from marrow, was capable of killing 40-86% of seedlings in five other crops, including chile. *F. javanicum* had never been isolated from chile previously, but under greenhouse conditions was capable of killing chile seedlings. Some *Fusarium* diseases not present under field conditions can cause disease and mortality under greenhouse conditions. Joffe and Palti (1974) reported that these results might be due to higher inoculum level killing plants in the greenhouse and a more robust root system. In addition, field irrigation practices and general cropping practices in Israel may have prevented the plants from dying in the field.

Conclusion

Fusarium is a serious pathogen of chile. Several *Fusarium* species are able to infect chile causing wilts, root rots, and/or fruit blight. *Fusarium* diseases of chile have been confirmed in most chile producing regions throughout the world.

Contrary to earlier reports, *Fusarium* has not been documented as a pathogen of chile in the southwestern United States. The actual distribution of *Fusarium* diseases of chile worldwide waits for better clarification. Using Koch's Postulates will allow for an unambiguous diagnosis of the causal agent. Conformation of the correct causal agent in chile production areas will determine if *Fusarium* is causing yield losses, previously blamed on other chile pathogens. With correct information, breeding programs can begin to breed for *Fusarium* disease resistance in chile.

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A SURVEY OF "TRISTEZA" OF PEPPER IN GALICIA AND THE FUNGAL PATHOGENS CAUSING THE DISEASE.

Pomar, F., Bernal, M.A., Collar, J., Díaz, J., Caramelo, C., Gayoso, C., Novo, M., Prego, C., Saavedra, A., Silvar, C. y Merino*, F.

Departamento de Bioloxía Animal, Bioloxía Vexetal e Ecoloxía. Facultade de Ciencias. Universidade da Coruña, 15071 A Coruña. SPAIN.
* e-mail: fuenme@mail.udc.es

Introduction

Pepper is an important crop in Galicia (NW Spain) with the annual production of pepper fruits being 20.000 Tm in a total area of 950 Ha. The most relevant cultivar cultivated in Galicia is Padrón. The fruits are harvested and commercially available when immature and their flavor is moderately hot, as they contain only small levels of capsaicin (Estrada et al., 1997). This low capsaicinoid content of the fruit is the most important trait in terms of its quality. The Padrón pepper is highly appreciated for fresh market consumption.

As with other crops, pepper suffers losses in production due to the attack of several pathogens. However the most serious and well-known disease in Galicia is the so-called "tristeza". "Tristeza" is a Spanish generic term applied in a broad sense to plant wilt. *Phytophthora capsici* Leon. and *Verticillium dahliae* Kleb. are the fungal pathogens usually associated with the collective term "Tristeza", but the name is also applied to the wilt caused by flooding and the subsequent hypoxia in the roots. The major symptoms of "Tristeza" are the withering of the plant, the loss of the green colour in the aerial organs, and the reduction in the total size of the plant (Palazón & Palazón, 1989).

In spite of the commercial importance of the Padrón pepper, there is very little information on the incidence of "tristeza" and the pathogens causing the disease on Galician farms (Saavedra, 1993).

Considering the above facts, in 1998 a survey was carried out on Galician farms to evaluate the epidemiological situation of "Tristeza" and, in particular, to determine the fungi causing the disease at each location.

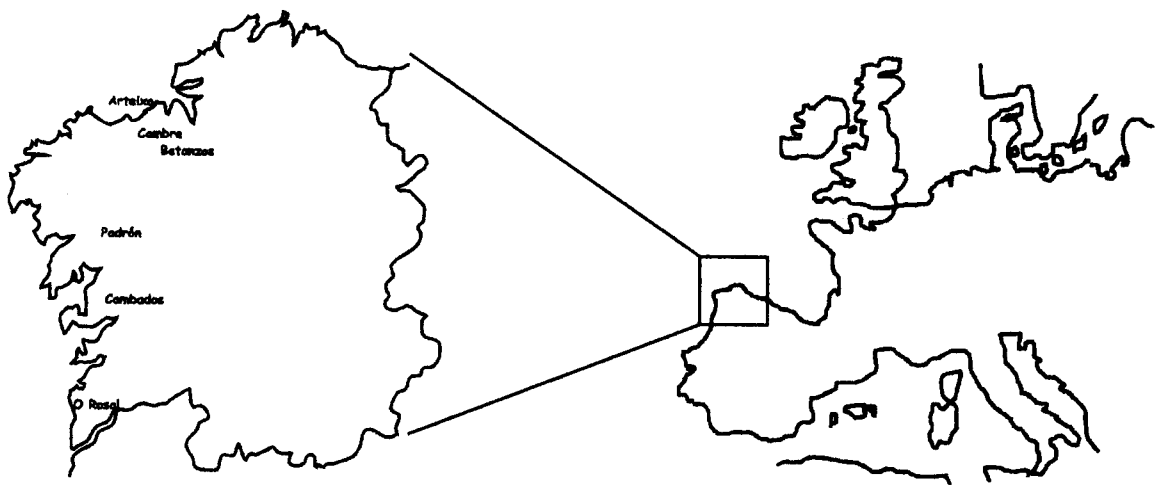

Figure 1.- Location of the surveyed area.

Material and Methods

The survey was conducted at different locations in Galicia (Fig. 1.), grouped into three mayor areas: the Northern area, including Arteixo, Betanzos and Cambre; the Central area covering the locality of Padrón and lastly the Southern area, comprising Cambados and O Rosal.

Samples were collected in 1998. The survey was conducted during two different crop stages: the first collection of samples took place between 15th May and 24th June, and the second, between 28th July and 24th September. This survey was targeted, seeking out farms where growers had observed some signs of disease which might be "tristeza".

The number of farms surveyed in each area was proportional to the relative abundance of the crop. In the Northern area, only five farms were studied, because in recent years the traditional pepper crop has been replaced by other crops. However, in the Central and the Northern areas the Padrón pepper is the major crop, therefore 24 and 16 farms were surveyed respectively. During each stage of the survey, 5-10 pepper plants were sampled at each farm.

Visible symptoms were recorded in the laboratory. Pathogens were isolated from the roots and stems of diseased plants. The plant material was surface sterilized with 10% sodium hypochlorite, and small pieces were transferred to Petri dishes with PDA and Ponchet medium (Ponchet et al., 1972). The dishes were incubated at 25°C, and fungal colonies appeared within few days. The fungi were identified and, in the case of *Phytophthora capsici* and *Verticillium dahliae*, field isolates were subcultured and preserved for further studies.

In order to demonstrate the pathogenicity of the *Phytophthora capsici* and *Verticillium dahliae* isolates, pepper plants were inoculated. Briefly, the inoculum from each isolate was prepared by grinding a PDA culture in 400 ml of sterile distilled water. The inoculation was carried out by dipping the roots for 20 min. into the inoculum, then the plants were transferred to potting soil, and finally each plant was watered with 40 ml of the inoculum.

Results and Discussion

Table I shows the fungi isolated from the different samples. A total of 37 different fungi were found in addition to *Verticillium dahliae* and *Phytophthora capsici*. Some of these are also considered to be pathogens of pepper, namely *Botrytis cinerea*, *Fusarium roseum*, *Fusarium solani*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*.

With regards to the presence of *Phytophthora capsici*, we found that, in the first stage of the survey, 40% of the farms were affected in the Northern area, 50% in the Central zone and 50% in the Southern area (Table II). The second sampling stage of the survey yielded the following results: the percentage of affected farms was 0% in the Northern area, 45.8% in the Central area, and 18.8% in the Southern area.

A wide-spread presence of *Phytophthora capsici* has been previously reported in other zones of Spain, specially in Mediterranean locations such as Tarragona, Valencia, Alicante and Murcia (Bartual et al., 1991). Likewise, *Phytophthora capsici* is cited in other countries, namely the USA, Brazil, Japan, Italy, Argentina, Korea, Taiwan and China (Erwin & Ribeiro, 1996; Huang & Kim, 1995; Wang & Wang, 1996), where it is the factor having the most negative effect on the pepper crop. In many of these countries, *P. capsici* causes both blight in the aerial parts and roots and crown rot. We observed the root and crown rot form of the disease, eventually causing the whole plant to wilt, but no cases of blight were recorded.

Table I. Mycoflora isolated from plants showing "tristeza" symptoms.

Alternaria sp.	*Gloeosporium* sp.
Aspergillus sp.	*Heteroconium* sp.
Aureobasidium sp.	*Mucor* sp.
Botryotichum sp.	*Papularia* sp.
Botrytis cinerea Pers.:Fr.	*Penicillium* sp.
Cephalosporium sp.	*Pestalotia* sp.
Cladosporium sp.	*Phialophora* sp.
Colletotrichum sp.	*Phoma* sp.
Curvularia sp.	*Phomopsis* sp.
Cylindrocarpon sp.	*Phytophthora capsici* Leon.
Chaetomium sp.	*Pithomyces* sp.
Epicoccum sp.	*Pythium* sp.
Fusarium moniliforme Sheldon	*Rhizoctonia solani* Kühn
Fusarium oxysporum Schlecht.:Fr.	*Rhizopus* sp.
Fusarium roseum Link	*Sclerotinia sclerotiorum* (Lib.) de Bary
Fusarium solani (Mart.) Sacc.	*Stemphylium* sp.
Geotrichum sp.	*Trichoderma* sp.
Gliocadium sp.	*Verticillium dahliae* Kleb.

The fungus *Verticillium dahliae*, was also detected on many farms. In the first stage of the survey, *V. dahliae* was isolated from the samples of 20% in the farms in the Northern area, 20.8% in the Central area and 50% in the Southern area. In the second stage of the survey, we found this fungus in 20% of the farms belonging to the Northern area, 12.5% in the Central zone, and 37.5% in the Southern area.

Table II. Presence* of *Phytophthora capsici* and *Verticillium dahliae* on the farms surveyed.

		Stage of the survey			
		1st stage		**2nd stage**	
Area	**Locality**	***P. capsici***	***V. dahliae***	***P. capsici***	***V. dahliae***
Northern	Arteixo	0.0	0.0	0.0	0.0
	Betanzos	33.3	33.3	0.0	33.3
	Cambre	100.0	0.0	0.0	0.0
	Northern total	40.0	20.0	0.0	20.0
Central	Padrón	50.0	20.8	45.8	12.5
Southern	Cambados	25.0	37.5	0.0	62.5
	O Rosal	75.0	62.5	37.5	12.5
	Southern total	50.0	50.0	18.8	37.5
Total		48.9	31.1	31.1	22.2

* expressed as % of farms in which these species were detected.

Verticillium dahliae has been reported as the principal infect-agent of pepper in other areas of Spain such as the Ebro Valley (Palazón & Palazón, 1989), and also causes significant losses on farms in the USA (Bosland & Lindsey, 1991), Bulgaria (Fari, 1986) and Israel (Tsor et al., 1998).

Our data showed that the "Tristeza" was widely distributed in Galicia, and both *V. dahliae* and *P. capsici* were present in the three areas of the survey. Lastly, we were able to prove that all the isolates of *Phytophthora capsici* and *Verticillium dahliae* were pathogens. Further characterization of the virulence, compatibility type and the sensitivity of the isolates to fungicides are currently underway.

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GENETIC ANALYSIS OF EARLINESS AND PLANT STATURE IN BRINJAL

J. KAUR* , J.A.PATEL**, M.J.PATEL**, R.R.ACHARYA**AND A.S.BHANVADIA**
* Flat No. : 86, Godavari Appartment, Alaknanda, New Delhi-110 019
** Main Vegetable Research Station, G.A.U., Anand Campus, Anand 388 110, INDIA

INTRODUCTION

The knowledge of combining ability helps in identifying best combiners, which may be hybridized either to exploit heterosis or to accumulate fixable genes through selection. Such information which forms a backbone of any breeding programme limited is for developmental traits in brinjal.

MATERIAL AND METHODS

The experimental material comprised of 35 F_1s and 12 parents (7 lines & 5 testers) were evaluated in a RBD with three replications at Vegetable Research Farm , GAU, Anand during *Kharif* 1996-97. The single row plot of twelve plants were spaced at 90 x 60 cm for each entery. The observations for earliness and plant stature (Table-1) were recorded from five randomly selected competitive plants from each treatment. The phenological trait, days to flower was recorded on population basis. Combining ability analysis was computed according to Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among all parents and hybrids for all the characters, indicating presence of considerable amount of genetic variability. The hybrid V_S parents comparisons was significant for all the traits revealing the occurrance of hetrotic effects. Apparently both additive and non additive gene effects were at work for the inheritance of the components of earliness, viz., days to flower, days to first picking and economic fruiting period. Among component traits of plant stature, only non additive gene effect was important for plant height and primary branches. Whereas, none of the genetic variance was significant for secondary branches and plant width. The estimates of protonce ratio of additive to non additive genetic variance revealed equal importance of both the gene effects for days to flower and economic fruiting period , but for days to first picking preponderance of additive gene effect was detected. The results are in accordance with Verma(1996) for days to flower & days to first picking, Joshi and Chadha (1991) for economic fruiting period & plant height, Singh *et al.* (1991) for days to first picking & plant height and Padmabham and Jagdish (1996) for primary branches & secondary branches.

General combining ability estimates are presented in Table-2. For earliness and staggering fruit harvest the parents 'DBR-8', 'PLR-1', 'Bombay Gulabi' and 'DBSR-44' had significant gca effects. Where as, for plant stature (tall and profused branches) the parent 'DBSR-44', 'PBS-12' and 'Morvi 4-2' had significant gca effects. However, the parent 'DBSR-44' may be extensively used for future breeding programme aimed at earliness and tall-bushy plant stature.

The estimates of specific combining ability (desired) are narrated in Table-3. About one third hybrids depicted significant desired sca effect for days to flower, days to first picking and economic fruiting period. The hybrid 'Surati Ravaiya' X 'DBSR-44', 'Bombay Gulabi' X 'PBS-12' and 'H-8 X 'PBS-12' depicted significant sca effect for all component traits of earliness , which had been reflected in heterotic effects. For the plants stature, the crosses 'DBR-8' X 'DBSR-44', 'H-8' X 'DBSR-44', 'Surati Ravaiya' X 'DBSR-44' and 'AB-1' X 'Aruna' depicted significant desired sca effects for most of the component characters, which had been evidenced through high magnitude of heterosis. These crosses involved good X poor and/or poor X poor combing parents confirming the importance / preponderance of dominant gene effect.

The hybrid 'Surati Ravaiya' X 'DBSR-44 may be directly recommended or may be advanced for beneficial transgrasive segrigants aimed at breeding for early and tall-bushy hybrid/genotype.

Table:1 Analysis of variance and estimate of combining ability variance for earliness and plant stature in brinjal

Source	d.f.	Days to flower	Days to first picking	Economic fruiting period	Plant height (cm)	Primary branches	secondary branches	Plant width (cm)
A. Replication	2	32.88**	10.15	39.71	822.48**	0.295	15.73**	1230.70**
B. Genotypes	46	985.03 **	1355.86**	3543.68**	2066.87**	10.57**	51.14**	3518.70**
a.Parents	11	650.53**	515.83**	794.98**	390.20**	3.05**	6.83**	456.58**
i)Females	6	742.08**	783.44**	1290.32**	477.95**	4.79**	8.83**	375.92**
ii)Males	4	244.77**	23.40**	25.66	355.61**	1.03*	3.55	690.56**
iii)Females Vs Males	1	1724.33**	880.00**	900.18**	2.08	0.667	8.03**	4.60
b. Hybrids	34	196.84**	206.90**	262.08**	238.72**	1.87*	7.45**	202.40**
c. Parents Vs Hybrids	1	137.66**	633.13**	2486.62**	1437.95**	5.65**	36.86**	2859.42**
C. Error	92	5.31	8.46	22.41	29.60	0.23	1.54	58.53
σ^2 gca	08	12.64*	20.13**	17.78*	8.37	0.02	0.19	1.22
σ^2 sca	24	40.46**	37.15**	50.08**	59.02*	0.53**	1.81	44.79
Error	68	5.60	5.96	21.60	30.63	0.25	1.50	57.10
σ^2 sca/σ^2 gca		0.95	1.67	1.09				

Table:2 General combining ability effect and *per se* performance (in parenthesis) of parents for developmental characters in brinjal

Parents	Days to flower	Days to first picking	Economic fruiting period	Plant height (cm)	Primary branches	secondary branches	Plant width (cm)
LINES							
AB-1	5.28** (107.3)	3.08** (130.7)	-3.31** (108.7)	-3.69** (89.7)	0.45** (4.5)	0.41 (11.3)	-4.08** (90.0)
S.Ravaiya	9.21** (145.0)	0.01 (172.3)	-3.98** (55.0)	2.77** (65.2)	-0.39** (2.2)	-0.32 (6.7)	1.87 (70.7)
Morvi 4 -2	-2.59** (104.0)	5.28** (132.3)	-5.51** (114.3)	3.69** (84.1)	-0.08 (5.3)	-0.19 (11.3)	2.44 (92.2)
PN-1	-1.79** (105.7)	1.74** (137.0)	-1.58 (106.0)	0.96 (84.4)	-0.20* (3.7)	-0.28 (8.1)	-6.11** (88.9)
Bombay Gulaby	-3.12** (126.7)	-3.86** (153.7)	10.02** (82.3)	1.61 (95.0)	0.23* (4.1)	-0.12 (9.0)	1.68 (91.8)
H-8	-3.32** (111.3)	-2.39** (134.0)	1.62 (93.3)	-3.14** (71.3)	0.01 (6.1)	-0.63* (10.5)	0.52 (93.9)
DBR-8	-3.66** (102.0)	-3.86** (127.7)	2.75** (106.7)	-2.19** (62.3)	-0.02 (5.1)	-0.12 (9.5)	4.41** (66.9)
S. Em. (gi)	0.47	0.50	0.96	1.14	0.10	0.25	1.56
TESTERS							
DBSR-44	9.15** (108.0)	-5.93** (128.7)	6.36** (109.3)	-2.07* (92.9)	0.57** (3.7)	0.95** (9.1)	1.96 (59.8)
JB 64-1-2	2.94** (85.0)	3.59** (134.3)	-3.92** (107.0)	0.93 (85.8)	-0.32** (5.3)	0.63** (11.9)	3.09* (92.2)
PLR-1	-10.94** (101.0)	-2.08** (127.7)	1.89* (104.3)	-2.61** (66.5)	-0.06 (4.8)	-0.10 (9.7)	-2.38 (83.7)
PBS-12	10.39 (104.0)	5.11** (132.3)	-3.02** (104.3)	-5.03* (76.2)	0.02* (4.8)	0.94** (10.8)	-0.02 (100.3)
Aruna	-5.66** (104.7)	-0.70 (132.3)	-1.30 (101.7)	8.77** (70.5)	-0.39** (4.8)	-1.61** (10.7)	-2.66* (84.8)
S. Em. (gi)	0.38	0.41	0.78	0.93	0.08	0.21	1.27

Table : 3 Crosses showing desired (Significant) sca effect and their *per se* performance

Sr. No	Character	Crosses	sca effect	Mean value	Relative hetrosis	Hetero-beltiosis	S.Em.±
1	Days to Flower	AB-1 X JB 64-1-2	-2.94**	107.3	11.61**	26.27	0.94
		AB-1 X PLR-1	-10.94**	103.0	-1.12	1.98	
		AB-1 X Aruna	-5.66**	101.0	-4.72**	-3.50	
		Surati Ravaiya x DBSR-44	-10.78**	104.0	-17.79**	-3.70*	
		PN-1 X PLR-1	-6.54**	100.3	2.90	-0.66	
		Bombay Gulabi X DBSR-44	-3.11**	99.3	-15.34**	-8.02**	
		Bombay Gulabi X PBS-12	-3.88**	104.7	-9.23**	0.64	
		H-8 X PLR-1	-2.01*	103.3	-2.67	2.31	
		H-8 X PBS-12	-5.34**	103.0	-4.33**	-0.96	
		DBR-8 X JB 64-1-2	-6.68**	94.7	1.25	11.37**	
		DBR-8 X PBS-12	-4.34**	103.7	0.65	1.63	
		DBR-8 X Aruna	-4.39	93.3	-9.66**	-8.50**	
2	Days to first picking	AB-1 X DBSR-44	-5.93**	120.0	-3.60*	-2.85	1.01
		AB-1 X PLR-1	-2.08*	129.3	0.13	1.31	
		Surati Ravaiya x DBSR-44	-4.87**	123.0	-18.27**	-4.40*	
		Surati Ravaiya x JB 64-1-2	-2.68**	130.7	-14.78**	-2.73	
		Morvi-4-2 X DBSR-44	-2.13*	131.0	0.38	1.81	
		Morvi-4-2 X PLR-1	-4.28**	129.3	-0.51	1.31	
		Morvi-4-2 X Aruna	-3.23**	130.7	-1.26	-1.26	
		PN-1 X DBSR-44	-2.60**	127.0	-4.39**	-1.30	
		PN-1 X JB 64-1-2	-2.79**	132.3	-2.46	-1.49	
		PN-1 X PLR-1	-3.79**	126.3	-4.53**	-1.04	
		PN-1 X PBS-12	-12.54**	156.3	16.09**	18.14**	
		PN-1 X Aruna	-3.36**	127.0	-5.69**	-4.03**	
		Bombay Gulabi X PBS-12	-10.29**	128.0	-10.49**	-3.27	
		H-8 X PBS-12	-5.75**	134.0	0.63	1.26	
		DBR-8 X JB-64-1-2	-3.81**	125.7	-4.07**	-1.57	
		DBR-8 X PBS-12	-13.95**	124.3	-4.36**	-2.61	
3	Economic Fruiting Period (days)	AB-1 X DBSR-44	6.36**	115.0	5.50	5.18	1.92
		Surati Ravaiya x DBSR-44	9.03**	117.5	42.39**	7.01*	
		Surati Ravaiya x Aruna	4.70**	128.0	40.85**	8.52	
		Morvi-4-2 X DBSR-44	4.56**	111.0	-0.75	-2.92	
		Morvi-4-2 X PLR-1	6.09**	112.7	3.05	-1.46	
		PN-1 X JB 64-1-2	6.68**	116.7	9.55	9.03	
		PN-1 X Aruna	4.30**	112.3	8.19**	5.97	
		Bombay Gulabi X PBS-12	16.65**	126.7	35.71**	21.41**	
		H-8 X PBS-12	9.71**	111.3	12.65**	6.71	
		DBR-8 X PBS-12	6.91**	109.7	3.95	2.81	
4	Plant Height (cm)	AB-1 X Aruna	8.77**	84.6	5.57	-5.72	2.28
		Surati Ravaiya x PLR-1	5.10*	93.3	41.67**	40.32**	
		Surati Ravaiya x PBS-12	15.08**	112.0	58.42**	46.98**	
		Bombay Gulabi X JB-64-1-2	5.13*	93.1	2.99	-2.00	
		Bombay Gulabi X Aruna	8.54**	89.7	8.34	-5.61	
		H-8 X DBSR-44	7.11**	88.5	7.73	-4.77	
		H-8 X PBS-12	7.22**	98.2	33.17**	28.92**	
		DBR-8 X DBSR-44	8.76**	91.1	17.38**	-1.97	
		DBR-8 X PLR-1	7.59**	90.8	41.07**	36.61**	

Sr. No	Character	Crosses	sca effect	Mean value	Relative hetrosis	Hetero-beltiosis	S.Em.±
5	No. of Primary	Surati Ravaiya x DBSR-44	1.49**	6.67	124.72**	78.57**	0.21
	Branches	Morvi-4-2 X PLR-1	0.94**	5.80	14.47*	8.75	
		PN-1 X DBSR-44	0.94**	4.43	19.82*	18.75	
		PN-1 X JB 64-1-2	0.96**	5.43	20.74*	1.88	
		PN-1 X Aruna	0.46*	4.86	14.51*	0.69	
		Bombay Gulabi X Aruna	0.83**	5.67	26.39**	17.24**	
		H-8 X DBSR-44	0.42*	6.00	22.45**	-1.10	
		H-8 X PLR-1	0.82**	5.77	6.13	-4.25	
		DBR-8 X DBSR-44	1.18**	6.73	52.45**	32.03**	
6	No. of Secondary	AB-1 X PLR-1	2.09**	13.47	27.85**	18.82*	0.51
	Branches	AB-1 X Aruna	1.15*	11.47	4.24	1.18	
		Surati Ravaiya x DBSR-44	1.10*	12.80	62.03**	40.66**	
		Morvi-4-2 X Aruna	1.35**	11.07	0.91	-1.78	
		PN-1 X JB 64-1-2	1.06*	11.23	12.33	-5.87	
		PN-1 X PBS-12	1.47**	13.20	39.68**	21.85**	
		PN-1 X Aruna	1.01*	10.63	13.52	-0.31	
		Bombay Gulabi X JB-64-1-2	1.62**	11.93	13.83	0.00	
		H-8 X DBSR-44	1.79**	14.43	47.03**	37.03**	
		DBR-8 X DBSR-44	1.77**	13.67	46.69**	43.36--	
		DBR-8 X Aruna	1.10*	10.88	7.76	2.03	
7	Plant Width	AB-1 X Aruna	13.20**	100.7	15.18	11.85	3.12
		Surati Ravaiya x DBSR-44	10.10**	108.8	66.89**	54.00**	
		PN-1 X PBS-12	10.66**	99.5	5.14	-0.86	
		DBR-8 X DBSR-44	13.70**	99.8	81.58**	71.98**	

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SUPERIORITY OF BRINJAL HYBRIDS FOR QUALITY TRAITS

J. KAUR*, J. A. PATEL**, M. J. PATEL**, M. N. PATEL**, A. D. PATEL** AND A. S. BHANVADIA**

* Flat No. 85, Godavari Apartment, Alaknanda, New Delhi - 110 019
** Main Vegetable Research Station, Gujarat Agricultural University Anand Campus, Anand- 388110, INDIA

INTRODUCTION

High total soluble sugars, low total phenols, low glycoalkaloid and low total dry matter are considered as desirable quality characters of superior brinjal variety. To maintain the fruit quality with increased yield, development of hybrid varieties is need of present era.

MATERIAL AND METHODS

The investigation was carried out with 35 F_1 hybrids (Line X Tester : 7 X 5) (Table 1). All the 35 F_1 S and 12 parents were evaluated in RBD having three replications during the *kharif* 1996-97 at Vegetable Research Farm, G.A.U., Anand. The experimental unit was consist of 7.2 m single row, spaced at 90 X 60 cm inter and intra row distance.

The biochemical analysis for the quality traits viz., Total Soluble Sugars (mg/100 g of fresh wt.), Total Phenol Content (mg/100 g of fresh wt.), Total Glycoalkaloids (O.D/ g of fresh wt.) and Dry matter of fruit per cent was carried out from a composite fruit sample of each genotype from each replication of the 7^{th} picking. The magnitude of heterosis as the differences in F_1 s performance over mid parents and better parent in percentage was computed as suggested by Turner (1953) and Fonseca and Patterson (1968), respectively.

RESULTS AND DISCUSSION

The mean value of parental genotypes is given in Table 1. Wide range of variability was exhibited by parental lines for Total Soluble Sugars (7.17 to 27.86 mg/100g of fresh wt.), Total Phenol Content (0.63 to 3.94 mg/100g fresh wt.), Glycoalkaloids (0.16 to 1.40 O.D/g of fresh wt.) and Dry Matter (7.76 to 12.80 % of fresh fruit wt.). The lines and testers also differed significantly among each group for all the quality traits under study. The mean values and range of mean values of F_1S as well as range of different heterotic effects, and number of superior hybrids are presented in Table 2. Whereas, the value of relative heterosis (RH) and heterobeltiosis (HB) of hybrids for different characters are narrated in Table 3.

Heterosis over the mid parent for TSS ranged from -54.93 to 100.02 %, while over the better parent it was varied from -70.00 to 75.64 per cent. Total number of superior hybrids in comparison to mid parent and better parent were 16 and 12, respectively, of which the top five were 'Morvi 4-2' X 'Aruna' (75.64 % HB), 'Morvi 4-2' X 'PBS-12' (64.33 % HB), 'S. Ravaiya' X 'JB 64-1-2' (40.02 % HB), 'AB-1' X 'PBS-12' (28.43 % HB) and 'DBR-8' X 'PBS-12' (20.50 % HB).

For total phenol content the relative heterosis and heterobeltiosis ranged from -93.31 to 382.38 and -85.29 to 840.38 per cent, respectively. The cross combination 'PN-1' X 'PBS-12' (-85%) depicted the maximum heterobeltiosis in desired direction, followed by 'S. ravaiya' X 'DBSR-44' (-78.06 %), 'H-8' X 'PLR-1' (-71.45 %), 'H-8' X 'JB 64-1-2' (-57.17 %) and 'Morvi 4-2' X 'Aruna' (-49.92 %). The heterotic effect for glycoalkaloid content over mid parent value and better parent value varied from -87.76 to 1195.55 and -78.57 to 2900 per cent, respectively. The top five superior

crosses were 'B. Gulabi' X 'JB 64-1-2' (-78.57 % HB), 'AB-1' X 'Aruna' (-73.25 % HB), 'DBR-8' X 'Aruna' (-65.38 % HB), 'H-8' X 'Aruna' (-63.86 % HB) and 'B. Gulabi' X 'Aruna' (-62.50 % HB).

For dry weight of the fruit the relative heterosis and heterobeltiosis ranged from -31.01 to 18.73 and -27.28 to 25.32 per cent, respectively. Total 25 and 16 hybrids showed their superiority in comparison to mid parent and better parent value, respectively. The top five ranking hybrids were 'DBR-8' X 'DBSR-44' (-27.28 % HB), 'AB-1' X 'Aruna' (-23.27 % HB), 'DBR-8' X 'Aruna' (-16.84 % HB), 'PN-1' X 'Aruna' (-15.38 % HB) and 'DBR-8' X 'JB 64-1-2' (-14.50 % HB).

These findings are in accordance with Dahiya *et al.* (1984) for TSS and Dry matter, Chadha *et al.* (1990) for Total Phenol content and Patel (1994) for Total Phenol content and Glycoalkaloid content.

The higher estimate for heterobeltiosis in both the direction as well as very close estimates of both the heterotic effects with most of the cross combinations suggest the involvement of dominance gene effect, particularly over dominance for inheritance of all the characters under study. Hence, heterosis breeding is suggested for development of better quality brinjal varieties.

The pollen parent 'Aruna' contributed for beneficial heterotic effects in most of the cross combinations for all the above quality characters, therefore, it is suggested to use in future crop improvement programme. The hybrids, 'AB-1' X 'Aruna', 'Morvi 4-2' X 'Aruna', 'PN-1' X 'Aruna' and 'B.Gulabi' X 'JB 64-1-2' may directly exposed for commercial cultivation and those hybrids may also be advanced for desirable transgressive segregants, as all the parents involved in these crosses are higher yielding varieties and may poses better genetic profile for higher fruit yield.

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Table : 1 Mean Performance of Parents in Brinjal

Parents	Total Soluble Sugar mg/100g fruit wt.	Total Phenols mg/100g fruit wt.	Total Glycoalkaloids O.D/g	Dry matter of fruit %
Lines				
AB-1	12.38	0.79	0.71	8.41
Surti Ravaiya	19.90	0.71	0.18	7.76
Morvi 4-2	17.90	0.63	0.56	7.89
PN-1	17.51	1.57	1.16	8.77
Bombay Gulabi	8.36	1.69	0.56	8.80
H-8	27.86	2.20	0.58	8.11
DBR-8	19.90	2.52	0.61	9.32
Mean of lines	17.69	1.44	0.62	8.44
Testers				
DBSR-44	7.17	3.94	0.20	10.33
JB 64-1-2	7.96	7.08	1.40	12.80
PLR-1	19.90	1.73	0.16	8.15
PBS-12	11.94	2.36	0.76	10.10
Aruna	14.30	1.57	0.67	8.98
Mean of testers	12.25	3.34	0.64	10.07
Mean of parents	15.45	2.23	0.63	9.12
S.Em. Lines	0.031	0.005	0.017	0.009
Testers	0.026	0.004	0.014	0.008

Table : 2 Range of hybrids for Mean Performance and Heterotic effects

Character	Range of Mean value	Av. Mean value	Relative Heterosis		Heterobeltiosis		S.E.	
			Range (%)	No. of Superior Crosses	Range (%)	No. of Superior Crosses	RH	HB
Total Soluble Sugar (mg/100g fruit wt.)	6.37 to 31.44	15.36	-54.93 to 100.02	16	-70.00 to 75.64	12	0.112	0.129
Total Phenols (mg/100g fruit wt.)	0.16 to 12.42	3.20	-93.31 to 382.38	16	-85.29 to 840.38	08	0.011	0.013
Total Glycoalkaloids (O.D/g)	0.12 to 5.01	1.14	-87.76 to 1195.55	10	-78.57 to 2900.00	08	0.043	0.05
Dry wt. of fruit (%)	4.58 to 9.72	8.27	-31.01 to 18.73	25	-27.28 to 25.32	16	0.023	0.026

Table 3: Per cent heterosis over mid-parent and better parent

Crosses	Total soluble sugar		Total phenol content		Glycoalkaloids		Dry matter	
	RH	HB	RH	HB	RH	HB	RH	HB
AB-1 X DBSR-44	42.52**	12.52**	153.32**	659.97**	97.15**	350.00**	20.64**	11.58**
AB-1 X JB 64-1-2	-29.56**	-42.13**	88.01**	840.38**	-50.78**	-27.07**	19.87**	1.06
AB-1 X PLR-1	-6.29**	-24.00**	-6.20**	50.06**	174.91**	650.00**	0.67**	2.30**
AB-1 X PBS-12	30.79**	28.43**	275.03**	650.06**	90.48**	96.35**	-9.56**	-0.46
AB-1 X Aruna	4.42**	-2.59	-60.02**	-40.03**	-74.03**	-73.25**	25.77**	23.27**
S. Ravaiya X DBSR-44	-20.63**	-46.02**	-93.31**	-78.06**	184.21**	200.00**	-5.56**	10.11**
S. Ravaiya X JB 64-1-2	100.02**	40.02**	-23.22**	322.49**	-39.24**	166.67**	16.56**	10.60**
S. Ravaiya X PLR-1	-37.98**	-37.98**	351.74**	678.11**	723.53**	775.00**	10.82**	13.62**
S. Ravaiya X PBS-12	39.96**	11.98**	207.72**	566.98**	28.07**	223.33**	20.17**	-8.72**
S. Ravaiya X Aruna	16.39**	0.02	244.81**	455.70**	195.43**	600.00**	16.17**	25.32**
Morvi 4-2 X DBSR-44	-31.55**	-52.07**	1.49**	268.20**	-5.39	80.00**	17.89**	-5.20**
Morvi 4-2 X JB 64-1-2	-30.55**	-49.83**	-22.43**	375.52**	22.39**	113.90**	-8.82**	19.75**
Morvi 4-2 X PLR-1	-26.30**	-30.00**	20.08**	125.28**	50.07**	238.13**	18.73**	20.66**
Morvi 4-2 X PBS-12	97.15**	64.33**	5.31**	150.29**	0.00	17.47**	5.38**	20.15**
Morvi 4-2 X Aruna	95.28**	75.64**	-71.40**	-49.92**	55.59*	71.12**	-6.88**	-0.46
PN-1 X DBSR-44	-22.59**	-45.45**	14.29**	100.00**	-23.53**	160.00**	-1.63**	7.12**
PN-1 X JB 64-1-2	-7.42**	-32.67**	-63.64**	0.00	-36.72**	-30.17**	24.85**	-7.57**
PN-1 X PLR-1	27.67**	20.00**	-4.63**	0.13	293.94**	1525.00**	-0.10	3.72
PN-1 X PBS-12	-32.43**	-43.18**	179.98**	249.98**	422.90**	562.09**	-7.42**	-0.39
PN-1 X Aruna	17.95**	7.14**	-85.29**	-85.29**	-34.53**	-10.85**	16.37**	15.38**
B. Gulabi X DBSR-44	-17.97**	-23.81**	-7.65**	53.76**	57.89**	200.00**	14.82**	-7.41**
B. Gulabi X JB 64-1-2	12.20**	9.52**	-67.69**	-16.10**	-87.76**	-78.57**	21.38**	-3.47**
B. Gulabi X PLR-1	-54.93**	-68.00**	61.05**	63.06**	11.11	150.00**	-5.60**	-1.82**
B. Gulabi X PBS-12	1.96	-13.33**	24.35**	49.08**	82.23**	114.29**	15.68**	-9.43**
B. Gulabi X Aruna	-41.90**	-53.97**	382.38**	400.00**	-65.94**	-62.50**	-2.68**	-1.68**
H-8 X DBSR-44	-20.46**	-50.00**	121.70**	208.76**	617.03**	1300.00**	-2.65**	10.68**
H-8 X JB 64-1-2	-53.33**	-70.00**	-79.67**	-57.17**	41.34**	140.96**	10.51**	15.39**
H-8 X PLR-1	-38.32**	-47.13**	-68.01**	-71.45**	1195.55**	2900.00**	-2.34**	-2.12**
H-8 X PBS-12	50.00**	7.14**	203.44**	214.25**	79.37**	106.54**	4.99**	17.88**
H-8 X Aruna	3.84**	-21.43**	16.68**	40.03**	-66.51**	-63.86**	10.00**	15.89**
DBR-8 X DBSR-44	17.61**	-20.00**	-31.69**	-12.47**	271.90**	650.00**	31.01**	27.28**
DBR-8 X JB 64-1-2	62.81**	13.97**	54.11**	193.80*	-16.28**	38.46**	27.95**	14.50**
DBR-8 X PLR-1	-29.77**	-29.77**	-3.69**	18.20**	395.65**	1087.50**	0.15	7.38**
DBR-8 X PBS-12	50.63**	20.50**	95.61**	102.12**	5.60	18.68**	14.16**	10.54**
DBR-8 X Aruna	-53.43**	-60.00**	-7.72**	19.95**	-67.18**	-65.38**	18.41**	16.84**
C.D. at 5%	0.219	0.252	0.021	0.025	0.084	0.098	0.044	0.051
1%	0.289	0.333	0.028	0.033	0.110	0.129	0.058	0.067

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HETEROSIS FOR FRUIT YIELD AND ITS COMPONENTS IN BRINJAL (*Solanum melongena* L.)

J. KAUR*, J. A. PATEL**, M. J. PATEL**, A. S. BHANVADIA** AND R. R. ACHARYA**

* Flat No. 85, Godavari Apartment, Alaknanda, New Delhi - 110 019
** Main Vegetable Research Station, Gujarat Agricultural University, Anand 388 110 (Gujarat) INDIA

INTRODUCTION

The exploitation of hybrid vigour is a potent method of enhancing the yield, the exploitation of hybrid vigour in any crop depends on substantial heterosis for yield coupled with an economical and easy method of hybrid seed production. In brinjal, there is a bright scope for heterosis breeding, larger flower bud size and more number of seeds per fruit provide this opportunity.

MATERIALS AND METHOD

An experimental material comprised of 35 F_1s from7 lines and 5 testers (Table 2). The F_1 seedings alongwith parents and one check hybrid (ABH-1) were planted in RBD with three replications at Vegetable Research Farm, G.A.U., Anand during *kharif* 1996-97. Each experimental unit had single row plot of 7.2 m. length with 90 x 60 cm. inter and intra row spacing. Five competitive plants (except border plants) from each entry were selected at random and observations for fruit yield and its four important components were recorded. Heterosis over mid parent, better parent and check hybrid (ABH-1) were worked out as per the standard procedure given by Turner (1953) and Fonseca and Patterson (1968), respectively.

RESULTS AND DISCUSSION

The estimates of mean squares due to genotypes were highly significant for all the characters suggesting large amount of variability among the genotypes studied (Table 1). Contrast comparison of parents with hybrids was significant with all the characters revealing presence of hybrid vigour for all the characters under study.

The female parent 'AB-1' and 'Morvi 4-2' as well as male parent 'DBSR-44' and 'PBS-12' proved to be promising by giving high heterotic effects in all the cross combinations for fruit yield and other one and/or more yield contribuiting component characters.

The range of hybrids for mean value and heterotic effects as well as number of superior crosses are narrated in Table 2. For fruit yield the value of heterosis was varied from -17.15 to 151.50 and -47.61 to 50.95, per cent over mid parent and better parent as well as check hybrid, respectively. Total 19 hybrids were significantly superior for their heterobeltiotic effect, of which four hybrids 'S. Ravaiya' x 'PBS-12' (23.80%), 'AB-1' x 'PBS-12' (22.38%), 'S. Ravaiya' x 'DBSR-44' (20.23%) and 'Morvi 4-2' x 'DBSR-44' (17.62%) were identified as promising in comparison to check hybrid for fruit yield. In consideration to standard heterosis, the parents 'S. Ravaiya' and 'DBSR-44' performed better for giving promising cross combinations. The crosses showed high and significant heterosis over better parent involved H x H (1 cross), H x M (3), H x L (6), M x L (3), M x M (1) and L x L (5 crosses) yielding parents, all the above crosses except H x H and H x M indicated presence of over dominance gene effect for fruit yield.

The extent of heterosis for number of fruits exhibited by the hybrids over their mid parent and better parent value varied from -26.86 to 168.85 and -51.40 to 93.25 per cent, respectively. For fruit length, the range of relative heterosis and heterobeltiosis was -18.01 to 39.97 and -19.40 to 38.40 per cent, respectively. The heterosis over mid parent and better parent for fruit girth varied from -29.90 to 15.53 and –31.96 to 15.5 per cent, respectively. For average fruit weight the relative heterosis and heterobeltiosis ranged from -35.29 to 59.25 and -57.80 to 15.55 per cent respectively.

The hybrid 'S. Ravaiya' x 'DBSR-44' depicted maximum heterobeltiosis as well as significant positive standard heterosis for fruit yield, which exhibited desired significant heterobeltiosis/standard heterosis only for number of fruits per plant, thus indicating number of fruits as a major component of fruit yield (Table 3). The cross 'Morvi 4-2' x 'DBSR-44' and 'AB-1' x 'PBS-12' depicted significant and positive heterobeltiosis for most of the yield contributing component characters. Above all the hybrids may directly be recommended for commercial cultivation and/or may be advanced for useful transgressive segregants.

Those above findigs are in accordance with the earlier research workers; Bhutani *et al.* (1980, Fr. No and Fr. yield), Chadha and Sidhu (1982, Fr. length and Fr. Girth); Patel *et al.* (1984, Fr. Yield and Fr. No); Ponnuswami and Irulappan (1992, Fr. Yield Fr. No and Av. fr. wt.) and Prakash *et al.* (1993, Fr. Length and Fr. Girth).

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Table 1 : Analysis of variance for five characters in brinjal.

Source	d.f.	No. of fruits per plant	Av. fruit length (cm.)	Av. fruit girth (cm.)	Av. fruit wt. (g)	Fruit yield per plant (kg)
Replication	2	90.03	0.365	0.297	98.29	0.66*
Genotypes	46	3855.63**	11.49**	44.59**	3648.02**	29.92**
Parents	11	1591.48**	2.49*	18.33**	2753.50**	0.69**
Line	6	151.11**	1.53	13.21**	1532.53**	0.51*
Tester	4	1486.51**	3.59*	4.98	248.49**	1.13**
Line Vs Tester	1	9213.60**	3.91*	102.46**	20099.44**	0.06
Crosses	34	314.54**	4.90**	6.30**	510.24**	1.95**
Parents Vs Crosses	1	1949.61**	4.10**	19.96**	384.28**	27.28**
Error	92	37.44	1.06	2.56	88.71	0.17

* 5 % level of significance ** 1% level of significance

Table 2 : Range of Hybrids for Mean Performance and Heterotic effects

Character	Range of mean value	Av. of mean value	Relative Heterosis		Heterobeltiosis		Standard Heterosis		S. Em.	
			Range (%)	No. of superior crosses	Range (%)	No. of superior crosses	Range (%)	No. of superior crosses	RH	HB/SH
No. of fruits per plant	30.77 to 78.05	50.40	-26.86 to 168.85	15	-15.49 to 93.25	04	-56.83 to 24.38	02	4.32	4.99
Fruit length (cm)	8.50 to 15.00	10.27	-18.01 to 39.97	08	-19.40 to 38.04	04	-24.11 to 31.25	01	0.731	0.844
Fruit girth (cm)	5.73 to 19.97	17.31	-29.90 to 15.53	02	-31.96 to 12.90	01	-17.53 to 29.22	10	1.13	1.31
Av. fruit wt. (g)	46.12 to 100.03	70.53	-35.29 to 59.25	08	-57.80 to 15.55	07	-29.36 to 44.63	07	6.65	7.69
Fruit yield per plant (kg)	2.06 to 5.14	3.62	-6.13 to 158.36	25	-17.75 to 151.50	19	-47.61 to 50.95	05	0.292	0.337

Table 3: Hybrids exhibited significant heterobeltiosis (≥ 40) for fruit yield, their per se performance and top five ranking hybrids for other traits

Characters	Hybrids	Heterosis over			Mean values			Desired heterobeltiosis for other traits			
		M. P.	B. P.	CH	Hybrid	B. P.	CH	Fr. No.	Fr. L.	Fr. G.	Av. Fr. wt
Fruit yield per plant	AB-1 x PLR-1	59.70**	49.89**	---	4.56	3.04	---	Fr. No.	---	Fr. G.	Av. Fr. wt.
	AB-1 x PBS-12	71.91**	69.08**	22.38**	5.14	3.04		---	Fr. L.	Fr. G.	Av. Fr. wt.
	S. Ravaiya x DBSR-44	158.36*	151.50*	20.23**	5.05	2.01		No. Fr.	---	---	---
	S. Ravaiya x PBS-12	*	*	23.89**	5.47	2.94		No. Fr.	---	Fr. G.	---
	S. Ravaiya x Aruna	26.68**	--	50.95**							
	Morvi 4-2 x DBSR-44	----	---	17.85	4.95	2.39		No. Fr.	Fr. L.	Fr. G.	Av. Fr. wt.
	Morvi 4-2 x PLR-1	130.79*	107.26*	---	3.78	2.67		No. Fr.	---	---	---
	Morvi 4-2 x Aruna	*	*	---	3.64	2.39		No. Fr.	Fr. L.	---	---
	PN-1 x PLR-1	49.60**	41.75**	---	4.11	2.67		No. Fr.	Fr. L.	---	Av. Fr. wt.
	PN-1 x Aruna	55.78**	52.61**	---	4.54	2.29		No. Fr.	Fr. L.	---	---
	B. Gulabi x JB 64-1-2	67.39**	54.00**	16.67**	4.90	3.51		---	---	---	---
	H-8 x DBSR-44	100.59*	98.54**	---	3.92	2.52		No. Fr.	---	---	Av. Fr. wt.
		*	39.73**								
		56.72**	55.42**								
		77.22**									
No. of fruits per plant	S. Ravaiya x DBSR-44	168.85*	93.25**	24.38**	78.05	40.39	63.56	Fr. Y.	---	---	---
	Morvi x DBSR-44	*	41.32**	---	57.07	40.39		Fr. Y.	Fr. L.	---	Av. Fr. wt.
	B. Gulabi x DBSR-44	73.99**	33.23**	---	53.81	40.39		Fr. Y.	---	---	---
	AB-1 x DBSR-44	73.98**	28.61**	---	51.94	40.39		Fr. Y.	---	---	---
	PN-1 x Aruna	36.61**	---	---	59.19	49.65		Fr. Y.	Fr. L.	---	---
		49.65**									
Fruit length	S. Ravaiya x PRL-1	39.97**	38.04**	31.25**	15.00	10.87		---	---	---	---
	AB-1 x PBS-12	29.88**	24.50**	---	12.53	10.07		Fr. Y.	---	Fr. G.	Av. Fr. wt.
	Morvi 4-2 x PBS-12	23.77**	23.10**	---	11.37	9.23		Fr. Y.	---	---	Av. Fr. wt.
	Morvi x DBSR-44	19.63**	18.98**	---	10.87	9.13		Fr. Y.	Fr. No.	---	Av. Fr. wt.
	AB-1 x Aruna	24.49**	---	---	11.27	10.07		Fr. Y.	---	---	---
Fruit girth	DBR-8 x PLR-1	14.31*	12.90*	26.62**	19.83	17.57	15.40	Fr. Y.	---	---	Av. Fr. wt.
	AB-1 x PBS-12	15.53*	---	29.22**	19.97	18.23		Fr. Y.	---	Fr. L.	Av. Fr. wt.
Av. fruit wt.	DBR-8 x PLR-1	59.25**	15.55**	15.42**	100.07	86.69	66.07	Fr. Y.	---	---	Fr. G.
	DBR x DBSR-44	38.30**	9.58**	44.63**	94.99	86.69		Fr. Y.	---	---	---
	H-8 x DBSR-44	31.10**	7.05**	27.28**	84.04	78.51		Fr. Y.	Fr. No.	---	---
	PN-1 x JB 64-1-2	41.66**	5.05**	---	79.96	76.12		Fr. Y.	---	---	---
	AB-1 x PBS-12	36.34**	4.50**	---	68.49	75.21		Fr. Y.	---	Fr. L.	Fr. G.

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STUDIES ON THE EFFICIENT SEED PRODUCTION TECHNOLOGY IN BRINJAL F_1 HYBRID 'COBH 1' (EP 45 X CO 2)

V. SANKAR*, P. JANSIRANI, V.A. SATHIYAMURTHY* and D. VEERARAGAVATHATHAM*****

* Ph. D Scholar
** Assistant Professor
*** Professor and Head, Dept. of Vegetable Crops,
Horticultural College and Research Institute, Tamilnadu Agric. University, Coimbatore –641003.

The hybrid seed production is very much influenced by several factors such as environment, soil, irrigation, pest and diseases, availability of isolation distance, pollen viability, synchronization of flowering of parental line and ratio of male and female parents. Among the several factors that affect hybrid seed production, the choice of ratio of parental lines is important factor one which influence the pollination by the production of pollen. This is important to stabilize the seed yield. The optimum ratio of pollen parent to seed parent for maximising seed set and yield is to be determined. With this objective the detailed studies were undertaken for standardizing the optimum-planting ratio of F1 hybrid seed production in COBH - 1 Brinjal.

Materials and Methods

The experiment was conducted at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during Summer 1999. The pollen and seed parental lines viz, Co-2 and EP 45 of the COBH –1 Hybrid brinjal were grown at different planting ratio proportions. The pollinator to seed parent ratio viz, 1:1,1:2,1:3,1:5,1:7 and 1:10 were tried. The experiment was laid in RBD with four replications. A spacing of 75 x 60 cm was adopted and crossing block was maintained for the production of hybrid (Fo).

In the seed parent, healthy, long or medium styled flower buds alone were retained for emasculation and the rest of the flowers were removed. Emasculation was carried between 3.00 and 5.30 PM in the flower buds which were about to open the next morning. Immediately after emasculation, the buds were bagged with black butter paper covers. Simultaneously, in the pollen parents also, the unopened flower buds were bagged with white butter paper covers, a day prior to anthesis, to avoid contamination by foreign pollen.

The next day morning, between 7.00 and 8.00 AM, pollen from the bagged flowers of the pollen parents from the each treatments were collected and dusted on to the stigma of the emasculated flowers of the respective ovule or seed parents. The flowers were labeled and bagged with white butter paper covers. The covers were removed after ensuring proper fruit set. The crossed fruits were harvested at fully ripe stage and seeds were extracted by fermentation method, shade dried to eight percent moisture content and stored in butter paper covers for later use. The data on percentage of fruit set, number of fruits per plant, fruit yield per plant, ripe fruit yield per plot, number of seeds per fruit, 1000 seed wet weight, 1000 seed dry weight, seed yield per fruit, seed yield per plant were collected. The estimated ripe fruit yield and seed yield per hectare was arrived at. The data collected were subjected to statistical analysis.

Results and Discussion

The present investigation revealed that biometric attributes such as plant height, days to first flowering, fifty per cent flowering, complete flowering and number of flowers per plant were not significantly influenced by the different planting ratios .Since the season, spacing and agronomic practices being the same. Similar findings are reported in sunflower hybrids by Balamurugan (1993). Days to first fruit set and fruit set percent was significantly influenced by adopting various planting ratios. The male and female planting ratios of 1:1 showed the highest per cent of fruit set (85.32) while 1:10 and recorded lowest per cent of fruit set (75.70). Seed set per cent decreased as the ratio increased from 1:1 to 1:10. This might be due to the adequate supply of pollen grains enhanced the fruit set per cent up to 1:3 ratio and insufficiency of pollen when the ratio was widened. These results are confirmed with those earlier findings of Seetharam (1980), Seetharam and Sathyanarayana (1984) and Vimala (1997).

The data on number of fruits per plant and yield per plant was significantly influenced by different planting ratios. The number of fruits per plant ranged from 24.40 to 28.13. Among the different planting ratios, the 1:1 ratio produced the highest mean number of fruits as against in 1:10. Increased ripe fruit yield may be due to increase in fruit setting per cent. Among the various planting ratios 1:1 registered the highest fruit yield per plant (1.81 Kg) which was on par with the 1:2 ratio (1.78 Kg). While the lowest yield were recorded in 1:10 (1.60 Kg) ratio. Number of fruits per plant and single plant yield were significantly different for all planting ratios. It may be seen from the data that though plant yield decreased in general, as ratio of male to female increased and decreasing trend was observed. Similar results were documented by Angamuthu (1996) and Periyasamy (1994). The result on the estimated ripe fruit yield per hectare showed significant difference among the treatments. Among the planing ratios, 1:10 recorded the highest ripe fruit yield per hectare followed by 1:7, which was on par with 1:5. The lowest estimated ripe fruit yield per hectare was noticed in 1:1 ratio.

The increased seed number per fruit was seen at 1:1 ratio while the least at 1:10 ratio. There was no significant relationship / difference was observed in seed wet weight, dry weight and seed yield per fruit. The data on seed yield per plant was highest in 1:1 ratio and the lowest in 1:10 ratio. However the seed yield per plot was higher in 1:10 ratio due to higher ripe fruit yield. The results suggested that seed yield per plot and seed yield per hectare was good when ratio was increased from 1:1 to 1:10. Pollen and seed parent ratio of 1:10 recorded significantly the highest seed yield per hectare than the other ratios and also which was on par with 1:7 ratio and the lowest seed yield was noticed in 1:1 ratio.

The proportion of planting ratio of male: female parent is an important factor in hybrid seed production. In the present study the ripe fruit yield and hybrid seed yield were increased as the proportion of female parent plant increased from 1:1 to 1:10. Similar increase in hybrid seed yield was due to increase in proportion of seed parents has also been reported by Kathavate (1996) in sorghum and Patel and Vaishnavi (1976) in castor, Prabhakaran (1996) and Angamuthu (1996) in rice, Periyasamy (1994) in pearl millet and Balamurugan (1993) in sunflower.

Summary

Experiments conducted at HC & RI, TNAU, Coimbatore to study the optimum planting ratio of pollinator to seed parent for obtaining higher yields of hybrid seeds in COBH -1 brinjal. There were no significant differences observed from single fruit weight, 1000 seed weight and number of seeds per fruit. Fruit set percentage and number of fruits per plant were significantly affected by various planting ratios. The estimated fruit yield and seed yield per hectare were the highest at 1:10 ratio and the lowest were noticed 1:1 ratio. The increased fruit yield and seed yield was mainly due to increased population of seed parent.

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Table 1. Effect of different planting ratio (Male: Female) for Ripe fruit yield, seed yield and seed characters of 'COBH 1' Brinjal

Treatments	Estimated ripe fruit yield (Kg/ha)	Number of seeds per fruit	1000 seed weight (Wet) (g)	1000 seed weight (Dry) (g)	Seed yield per fruit (g)	Seed yield per plant (g)	Estimated seed yield (Kg/ha)
T1-1:1	19912	1632.5	7.54	2.34	1.065	29.55	325.3
T2-1:2	24962	1597.5	7.50	2.35	0.982	27.38	395.5
T3-1:3	28965	1592.5	7.44	2.32	0.975	25.75	411.9
T4-1:5	32368	1589.7	7.11	2.28	0.950	24.60	419.3
T5-1:7	32495	1586.7	6.92	2.28	0.950	24.42	424.9
T6-1:10	33094	1577.0	6.80	2.23	0.930	23.45	429.3
SE d	0.2696	0.5188	0.0804	0.0314	0.0164	0.2103	2.3537
CD	0.5747	0.1105	NS	NS	NS	0.4482	5.0158

Table 2. Effect of different planting ratio (Male: Female) for flowering, fruit set and Ripe fruit yield in 'COBH 1' Brinjal

Treatments	Plant height (cm)	Days to first flowering	Days to 50% flowering	Complete flowering	Number of flowers per plant	Days to first fruit set	Fruit set per cent	Number of fruits per plant	Ripe fruit Yield per plant (Kg)
T1-1:1	82.77	47.9	121.2	150.6	56.0	4.05	85.32	28.13	1.81
T2-1:2	83.10	47.7	120.7	150.7	57.2	4.35	83.83	27.15	1.78
T3-1:3	82.82	47.9	120.7	150.8	58.0	4.85	82.20	26.30	1.75
T4-1:5	82.85	47.7	121.1	150.1	58.0	5.20	80.17	25.70	1.71
T5-1:7	83.07	47.8	121.2	150.7	57.7	5.55	78.42	24.95	1.63
T6-1:10	82.80	48.2	120.2	150.3	55.0	5.95	75.70	24.40	1.60
SE d	0.4246	0.2351	0.5576	0.6597	4.7123	0.0856	0.431	0.1945	0.0133
CD	NS	NS	NS	NS	NS	0.1824	0.9188	0.4146	0.0284

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PERFORMANCE OF THREE SOLANUM GILO (RADDI) STRAINS IN IKANGBA, OGUN STATE, NIGERIA.

O. O. Oloruntoba*[1] and J. O. Sanwo*[1]
Department of Crop Production
Ogun State University,
P. M. B. 2002, Ago-Iwoye, Nigeria.
*[1] Research student and plant breeder respectively in the Crop Production department.

INTRODUCTION

Solanum gilo (Raddi) is cultivated in Nigeria, mainly for it's edible fruit which is botanically a berry. Variations in fruit shapes and sizes, stripes and color of immature fruit exist. These differences were attributed to intra and inter-specific genetic variability and the free exchange of genes among strains (Omidiji, 1981). S. gilo genotypes and genotype x environment interactions have additionally accounted for the variations observed in the yield and other phenotypic characteristics (Aliyu et al., 1994).

The present study is aimed at determining the response of three strains of Solanum gilo (Raddi) introduced from the Savannah zone into the rainforest belt of South Western Nigeria at three plant population densities and three fertilizer levels.

MATERIALS AND METHODS

Brief descriptions of S. gilo strains used are:

Accession 1: Fruits are round in shape and green in color with dark green stripes when unripe; Accession II: Immature fruits are ivory in color with green stripes. The fruits are also smallest in size and oblong in shape; Accession III: fruits are round, pulpy and relatively largest with minimal seeds. Unripe fruit is ivory in color with no stripes.

Nursery raised seedlings were transplanted to the field at 8 weeks at Ikangba (Longitude 03°58'E; Latitude 06°47'N). The soil type prevalent in this area is generally of sedimentary origin, classified as the oxic tropudalfs with rather deep non leached soils under forest vegetation initially(Ojo-Atere et al., 1990). The experimental plot which was chosen for uniformity in slope and soil type was divided into three blocks. Each block was given a superimposed fertilizer (NPK = 15:15:15) treatment to accentuate unseen block variations at rates of 0kg/ha, 200kg/ha and 400kg/ha respectively. Transplanting was at spacings of 1m x 1m, 0.75m x 0.75m and 0.75m x 0.6m in each block, involving an experiment with a total of 27 plots, each of 3m x 3m. The experiment is a split – plot in a randomized complete block design, in which fertilizer level was confounded with the blocks; strains constituted the main plots and spacing, the subplots. Mean comparison and correlation between traits inter se were carried out. Traits observed were: Mean plant height (cm), percentage of surviving plants per plot, percentage of flowering plants per plot, percentage of insect damaged plants per plot, total fruit number, total fruit weight (g) and mean fruit weight (g).

RESULTS AND DISCUSSION

Plant density of 20,000plts/ha gave the highest total fruit number and weight (g) (Table 1(i). Accession II had greater ability to survive in the environment (Table 1(ii)). Mean plant height (cm) was similar in accessions II and III but significantly higher than accession I (Table (ii)). Differences in the surviving ability and mean plant height (cm) of the strains could partly be ascribed to differences in the strains genotypes (Table 1). Accession III was the most susceptible strain to insect damage (Table 1(ii)). Afolami et al (1988) reported similar trends for nematode susceptibility in S. gilo R. Despite the high mean fruit weight of accession III, accession II produced the highest total fruit number and total fruit weight (g). Olufolaji (2000) had earlier reported similar observations in an accession of S. gilo, morphologically similar to accession II.

Results showed that fertilizer application confounded with unpartitioned block effect had significant influence on mean plant height (cm) in S. gilo R and subsequently its yield (Table 1 (iii)). Positive and high correlations exist between mean plant height (cm) and each of the yield traits (total fruit number ($r = 0.98^{**}$); total fruit weight (g) ($r = 0.99^{**}$); and, mean fruit weight ($r = 0.97^{**}$)). Aliyu et al. (1994), and Sanwo (1996) had earlier reported similar observations.

The findings from this study show that of the three introduced strains, accession II was the best yielder under Ikangba environment in the South Western part of Nigeria. Plant population densities of 15,000 and 20,000 plants/ha statistically yielded similarly but were higher than 10,000 plants/ha. Although confounded with unaccountable minor soil variations, fertilizer application appears like a profitable venture in eggplant cultivation in the South Western part of Nigeria. Data suggest more experimental work to determine the economic threshold of such application.

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Table 1: Means[*2] showing the effects of Plant densities (i), Strains (ii) and Fertilizer (iii) on the vegetative and yield traits of S. gilo (Raddi)

(i) Plant Population densities (pts/ha)	Surviving plants	Insect damaged plants	Flowering plants	Mean plant height (cm)	Total fruit number	Total fruit weight (g)	Mean fruit weight (g)
10,000	15.45a	9.31a	14.26b	98.80a	960b	22,581.0b	3.97b
15,000	15.29a	10.25a	15.03a	107.40a	1416a	30,786.5ab	5.15a
20,000	15.42a	8.79a	15.22a	105.00a	1855a	40,627.1a	4.90a
(ii) Strains							
Accession I	15.22b	7.73b	14.83a	91.83b	1268b	26,645.9b	2.59b
Accession II	15.75a	9.49ab	15.21a	111.50a	2698a	40,010.9a	1.97c
Accession III	15.19b	11.14a	14.47a	107.90a	310c	27,338.1b	9.46a
(iii) Fertilizer levels (Kg/ha)							
0	15.35a	7.83a	13.51b	71.63c	290c	4,806.6c	2.53c
200	15.36a	10.62a	15.39a	100.23b	1517b	30,266.6b	4.97b
400	15.45a	9.91a	15.61a	139.37a	2469a	58,921.7a	6.52a
Se.	0.05	0.95	0.25	3.98	14.12	3254.4	1.56

[*2] Column means within each (i), (ii), (iii) followed by different letters are significantly different at P = 0.05.

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SOURCES OF RESISTANCE TO BACTERIAL WILT IN EGG PLANT

P.A. Fugro,
Central Experiment Station, Wakawali-415 711
Dapoli – Ratnagiri (India)

Abstract

Wilt caused by *Pseudomonas solanacearum* E.F. Smith is a very severe soil borne disease of egg plant in Konkan region of Maharashtra (India). Twenty two promising varieties/cultivars were screened against bacterial wilt under field conditions (Sick plots) for two successive years. 'IHR-12', 'IHR-21', 'IHR-54', 'BB-44', 'BB-7', 'DPL-B-1', 'SM-6-6' and 'BB-60–C' were found to be highly resistant. Bandhtiware-1, Bandhtiware (Local), 'CHES-243', 'CHES-249', and 'DPL-B-3-91-1 'were moderately resistant. The variety 'BB-44' produced the maximum yield of 26.77t/ha followed by 'DPL-B-1' (25.98t/ha), 'BB-7' (24.14t/ha) and 'BB-60–C' (24.08 t/ha). These sources have been used in breeding programme for bacterial wilt resistance in egg plant at this location.
Key words : wilt, egg plant, resistant, susceptible.

Introduction

The lateritic soils of most of the vegetable growing belts in Konkan region of Maharshtra (India) are highly infested with wilt pathogen, *Psendomonas solanacearum* E.F. Smith. The disease causes heavy losses in yield of egg plant and has become a limiting factor in cultivation of the crop. The disease was first reported from Bengal by Das and Chattopadhyaya (1955). Soil is the potential source of primary inoculum and the pathogen may survive in the soil for more than two years (Hingorani *et al.*, 1956). Disease is very difficult to manage by any chemical or agronomical manipulation. Most of the local cultivars and improved varieties and hybrids are susceptible to bacterial wilt. Therefore, the identification of bacterial wilt resistant sources has become quite imperative.

Materials and methods

The experiment was conducted at Central Experiment Station, Wakawali, Konkan Krishi Vidyapeeth, Dapoli (India). Twenty two egg plant cultivars/varieties were screened under field conditions in wilt sick plots. The seedlings of highly susceptible variety, Manjari Gota were planted at every fifth row. Twenty five days old seedlings were artificially inoculated by root clipping and dipping in bacterial suspension (O.D.=0.1) for 10 minutes before transplanting. The inoculated seedlings were then transplanted in bacterial wilt sick plots using Randomised Block Design with 4 replications in a plot size of 3.6 × 3.0 and at a spacing of 60 × 30 cm. Observations on wilt incidence were

recorded at an interval of 30 days after transplanting upto 120 days of crop growth. The disease intensity was graded as resistant (R), moderately resistant (MR), Susceptible (S) and highly susceptible (HS) with 0, 0.1 to 10.0, 10.1 to 20.0 and 20.1 to 100 per cent mortality, respectively.

Results and discussion

Results presented in Table 1 indicate that, the highly susceptible variety, Manjari Gota was wiped out within 60 days of transplanting. Based on per cent mortality, the cultivars/ varieties were grouped into following categories (Table 2).

Resistant : 'Arka Nilkantha', 'Arka Keshav', 'BB-44', 'BB-7', 'SM-6-6', 'BB-60-C' 'DPL-B-1' and 'IHR-54'.

Moderately resistant : 'Bandhtiware-1', 'Bandhtiware (Local)', 'CHES-243', 'CHES-249' and 'DPL-B-3-91-1'.

Susceptible : 'DPL-B-2', 'Bandhtiware-7', BB-13-1, 'DPL-B-3, BB-1' and 'WCG'.

Highly susceptible : 'Manjari Gota', 'HOE-44' and 'Pant Samrat'.

The variety 'BB-44' produced the maximum yield of 26.77 t/ha followed by 'DPL-B-1' (25.98 t/ha), 'BB-7' (24.14 t/ha) and 'BB-60-C' (24.08 t/ha), 'IHR-12', 'IHR-21' and 'IHR-54' have already been released as wilt resistant varieties of egg plant in Karnatka State of India (Anonymous, 1991). 'BB-7' and 'BB-44' have been reported to be resistant to bacterial wilt from different locations in India with varying yields (Anonymous, 1990). This might be due to genotype and environment interaction. 'SM-6-6', 'DPL-B-1' and 'BB-60-C' are new egg plant genotypes with attractive coloured fruits and high resistance to bacterial wilt. However, these genotypes do not fulfil consumers' requirement as regards to fruit shape and size. Most of the high yielding, resistant varieties reported at this location (Table-2) also lack in one or the other character preferred by the consumers in Konkan region of this State. Hence, these varieties/ cultivars have been incorporated in breeding programme for bacterial wilt resistance in egg plant.

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Table 1 : Periodic incidence of bacterial wilt in brinjal cultivars/varieties.

Sr. No.	Variety	Per cent wilt incidence at 30 days interval after transplanting			
		30	60	90	120
1	'IHR-12'(Arka Nilkantha)	-	-	-	-
2	'IHR-54'	-	-	-	-
3	'DPL-B-3'	-	5-21	9.0	11.0
4	'BB-1'	2.18	3.6	17.12	17.12
5	'SM-6-6'	-	-	-	-
6	'IHR-21' (Arka Keshav)	-	-	-	-
7	'BB-7'	-	-	-	-
8	'W.C.G.'	4.13	9.0	18.6	18.6
9	'DPL-B-2'	4.0	12.0	22.0	22.0
10	'DPL-B-1'	-	-	-	-
11	'DPL-B-3-91-1'	-	5.0	6.98	6.98
12	'Bandhtiware – 1'	-	6.0	8.52	8.52
13	'Bandhtiware – 7'	-	8.38	11.0	16. 78
14	'Bandhtiware (Local)'	-	-	8.3	3.33
15	'BB-44'	-	-	-	-
16	'CHES-243'	-	-	-	6.98
17	'CHES-249'	-	-	2.62	7.62
18	'BB-60-C'	-	-	-	-
19	'BB-13-1'	-	5.0	11.11	15.53
20	'HOE-44'	30.00	60.0	100.00	100.00
21	'Manjari Gota'	20.00	100.00	100.00	100.00
22	'Pant Samrat'	-	40.0	60.0	70.0

Table 2 : Yield performance and reaction of brinjal varieties/cultivars to bacterial wilt.

Sr. No.	Variety	Wilt Incidence (%)	Reaction to bacterial Wilt	Yield (t/ha)
1	'IHR-12'(Arka Nilkantha)	Nil	R	23.50
2	'IHR-54'	Nil	R	23.87
3	'DPL-B-3'	11.0	S	19.63
4	'BB-1'	17.12	S	14.77
5	'SM-6-6'	Nil	R	20.87
6	'IHR-21' (Arka Keshav)	Nil	R	14.95
7	'BB-7'	Nil	R	24.14
8	'W.C.G.'	18.60	S	23.56
9	'DPL-B-2'	19.00	S	19.97
10	'DPL-B-1'	Nil	R	25.98
11	'DPL-B-3-91-1'	6-98	MR	11.21
12	'Bandhtiware – 1'	8.52	MR	10.85
13	'Bandhtiware – 7'	16.78	S	8.70
14	'Bandhtiware (Local)'	3.33	MR	8.11
15	'BB-44'	Nil	R	26.77
16	'CHES-243'	6.98	MR	13.73
17	'CHES-249'	7.62	MR	16.22
18	'BB-60-C'	Nil	R	24.08
19	'BB-13-1'	15.53	S	9.21
20	'HOE-44'	100.00	HS	00.00
21	'Manjari Gota'	100.00	HS	00.00
22	'Pant Samrat'	70.00	HS	1.98
	S. E. ±			0.8
	C. D. at 5%			2.33

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Evaluation of Eggplant (*Solanum melongena* L.) Lines for Bacterial Wilt Resistance

A.T. Sadashiva, K. Madhavi Reddy, Girija Ganeshan and B.C. Narasimha Prasad.

Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore 560 089

ABSTRACT

Twelve bacterial wilt resistant (BWR) eggplant lines were evaluated in wilt-infested soil followed by artificial inoculations with bacterial suspension for three years during 1998 to 2000. Of the twelve entries, only two lines *viz;* EG 191 and TS-3 had 100 per cent survival in all the three years. Where as seven entries *viz;* EG190, EG192, EG193, EG203, EG219, TS-7 and TS-69 recorded less than 5% mean wilt incidence. Susceptible checks EG 064 and IIHR 228 succumbed to complete wilt.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is an important vegetable cultivated in tropical and sub-tropical regions of the world. Bacterial wilt disease is a major limiting factor caused by *Ralstonia solanacearum* (Yabucchi *et al.*, 1995) has been the most ubiquitous and serious bacterial disease throughout the tropical, sub-tropical and temperate regions of the world (Hayward, 1991). Developing commercially acceptable brinjal varieties and hybrids with resistance to bacterial wilt has been a goal of many breeding programmes. Eggplant has a variable consumer preference in terms of fruit colour, shape and size. In view of this, the present study was undertaken to identify stable source of resistance to bacterial wilt from a set of 12 BWR lines received from different sources under South Asian Vegetable Network (SAVERNET) programme.

MATERIAL AND METHODS

The experimental material consisted of 12 BWR lines *viz;* EG 190, EG191, EG192, EG193, EG195, EG203, EG219, TS-3, TS-7, TS-69, TS-75 & TS87. All the 12 entries along with the two susceptible checks (EG 064 and IIHR 228) were evaluated for 3 years during 1998 (May to September), 1999 (January to July) and 2000 (June to September). Forty-day-old seedlings were planted at a spacing of 90 cm between rows and 40 cm between plants. Experiment was laid out in RCBD with 3 replications accommodating 12 plants per replication per treatment. Experiment was conducted in bacterial wilt sick soil (10^7 c.f.u. /g soil) maintained at IIHR, Bangalore. Regular cultural practices were followed to raise the crop. Seedlings were artificially inoculated with bacterial suspension (0.7 OD) by following pinprick method at 3rd leaf axil as suggested by Winstead and Kelman (1957). Data on percent survival and yield per plant were recorded and statistically analyzed. Observations were also recorded on fruit colour& shape

RESULTS AND DISCUSSION

Results of evaluation for all the 3 years are presented in table 1. During 1998, four entries *viz*; EG191, EG195, EG219 and TS-3 were completely free from wilt incidence and in the remaining entries wilt incidence ranged from 2% in EG193 and TS-7 to 8% in EG 190. Susceptible check EG 064 succumbed to wilt with 83% incidence. During 1999, ten entries showed no wilt incidence, which include EG 190, EG 191, EG 192, EG 193, EG 195, EG 203, EG219, TS-3, TS-7 and TS-69. Where as the susceptible check EG064 succumbed to complete wilt. During 2000, six entries *viz*; EG190, EG191, EG193, EG203, TS-3 and TS-7 recorded complete survival and in the remaining entries wilt incidence ranged from 4 to 27%. Susceptible check IIHR 228 succumbed to complete wilt. Mean values for all the 3 years revealed that only two entries viz; EG191 and TS-3 were resistant with no wilt incidence. Wilt incidence less than 5% was noticed in entries EG190, EG192, EG193, EG 203, EG219, TS-7 and TS69. Resistance to wilt was confirmed by the absence of bacterial ooze. EG190 (1.34kg/pt.) followed by EG193 (1.32kg. /pt,) and EG192 (1.25kg. /pt.) were the top yielders over 3 years. Among the 12 entries evaluated, 3 had purple long fruits (EG 191, EG192 & EG193), 3 had green long fruits (EG190, EG219 & TS-75), 2 had pink long fruits (TS-7 & TS-87) and the remaining 4 entries had variable fruit shape & colour which include green oval (EG195), purple oval (EG203), green round (TS-3) and green small flat round (TS-69).

Among the 12 BWR entries evaluated for 3 years in bacterial wilt sick soil the most promising entries were EG190, EG191, EG192, EG193, EG203, EG219, TS-3, TS-7 and TS-69. These entries with stable resistance (<5% wilt incidence) can be further exploited for future breeding programme.

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Table 1: Performance of Eggplant lines for bacterial wilt resistance.

Entries	1998		1999		2000		Mean		Remarks
	Yield (Kg/pt.)	Witt Incidence (%)	Yield (Kg/pt.)	Wilt Incidence (%)	Yield (Kg/pt.)	Wilt Incidence (%)	Yield (Kg/pt.)	Wilt Incidence (%)	
EG 190	0.83	8.33	1.50	0.00	1.68	0.00	1.34	2.77	Light green fruits
EG 191	0.89	0.00	1.47	0.00	1.35	0.00	1.24	0.00	Shiny purple long fruits
EG 192	0.98	4.00	1.31	0.00	1.47	4.16	1.25	2.72	Dark purple, medium long fruits
EG 193	1.06	2.00	1.42	0.00	1.48	0.00	1.32	0.67	Dark purple, medium long fruits
EG195	0.81	0.00	1.17	0.00	1.39	26.67	1.12	8.89	Green oval fruits
EG 203	0.88	4.34	1.35	0.00	1.42	0.00	1.21	1.44	Purple oval fruits
EG 219	0.87	0.00	1.28	0.00	1.34	8.34	1.16	2.78	Green, medium long fruits with white stripes.
TS-3	0.91	0.00	1.20	0.00	1.28	0.00	1.13	0.00	Green round fruits
TS-7	0.90	2.00	1.25	0.00	1.34	0.00	1.16	1.12	Pink, medium long fruits
TS-69	0.73	6.00	1.17	0.00	1.19	4.66	1.03	3.55	Small flat, round green fruits
TS-75	0.74	12.34	1.14	8.00	1.22	4.12	1.03	8.15	Green long fruits
TS-87	0.68	13.34	1.15	11.00	1.36	16.2	1.06	13.5	Pink long fruits
EG 064	0.20	83.34	0.00	100.00	-	-	0.10	91.67	Purple long fruits
IIHR 228	-	-	-	-	0.00	100.00	0.00	100.00	Manjarigota type.
SEm±	**0.10**	**6.31**	**0.18**	**3.19**	**0.08**	**1.78**	-	-	-
C.D. @ 5%	**0.28**	**17.48**	**0.87**	**8.85**	**0.48**	**4.95**	-	-	-
C.D. @ 1%	**0.32**	**22.87**	**0.91**	**11.59**	**0.76**	**6.48**	-	-	-

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Breeding for Bacterial Wilt Resistance in green long Egg plant (*Solanum melongena* L.).

A.T. Sadashiva, K. Madhavi Reddy, Girija Ganeshan and B.C. Narasimha Prasad
Indian Institute of Horticultural Research, Bangalore 560 089.

ABSTRACT

Five bacterial wilt resistant (BWR) lines with green long fruits have been developed through pedigree method involving the resistant parents Arka Keshav and IIHR 124. All the five lines were resistant to bacterial wilt when tested in bacterial wilt sick soil (10^7 c.f.u. /g. of soil) followed by artificial inoculation with bacterial suspension. Most promising were 96-2-1(1.68kg. /pt.) and 96-4-3 (1.63kg. /pt.). All the five lines and resistant checks *viz*; Arka Keshav and Shwetha had cent percent survival, where as the susceptible check succumbed to complete wilt.

INTRODUCTION

Bacterial wilt caused by *Ralstonia solanacearum* is a serious disease in eggplant causing yield losses upto 80 per cent in India (Rao *et.al*, 1976). Though several sources of resistance to bacterial wilt have been reported in eggplant (Sadashiva *et. al.*, 1993), none of the resistant lines had green long fruit type for commercial cultivation. A systematic breeding programme was under taken to develop green long eggplant lines with bacterial wilt resistance for commercial cultivation.

MATERIAL AND METHODS

Two bacterial wilt resistant lines *viz*; Arka Keshav (purple long) and IIHR 124 (green oval) were involved in hybridization during 1991 to develop green long eggplant lines. Resistant F_1 (purple medium long) was advanced by selfing and a large F_2 population was raised in bacterial wilt sick soil. Twenty eight individual plant selections with green long fruits were selected in F_2 and advanced further in wilt sick soil. Five advanced breeding lines stabilized for resistance to bacterial wilt with green long fruits were selected in F_8 generation (Fig. 1) and tested for yield and quality parameters. Screening for bacterial wilt resistance was done in bacterial wilt sick soil (10^7 c.f.u. /g.) by stem puncturing method as suggested by Winstead and Kelman (1952). Resistance in selected plants was further confirmed by ooze test. All the 5 breeding lines *viz*; 96-1-1, 96-1-2, 96-2-1, 96-4-1 & 96-4-3 along with resistant checks (Arka Keshav and SM 6-6) and a susceptible check IIHR 228 were evaluated during summer, 2000 for yield and wilt resistance in wilt sick soil. Experiment was conducted by following Randomized Complete Block Design (RCBD) with 3 replications. Data on yield per plant, percent survival, average fruit weight, fruit length and fruit width were recorded and statistically analyzed.

RESULTS AND DISCUSSION

A systematic breeding programme was under taken at Indian Institute of Horticultural Research, Bangalore to develop bacterial wilt resistant egg plant lines with green long fruit type by following pedigree method of breeding. Arka Keshav, a bacterial wilt resistant variety with profuse branching having purple long fruits developed at IIHR, Bangalore and IIHR 124, a

bacterial wilt resistant line with green oval fruits received from Kerala were involved in hybridization to pool the resistant genes from different sources and to get desirable recombinants such as green long fruits with profuse branching. High levels of resistance to bacterial wilt were achieved due to the involvement of both resistant parents. Five resistant breeding lines were selected in F_8 with required fruit quality attributes. All the selected lines were also found to be good for cooking qualities. Evaluation for yield, bacterial wilt resistance and fruit quality attributes (Table 1) revealed that all the 5 lines including both the resistant checks *viz*; Arka Keshav and Shwetha (bacterial wilt resistant variety released form Kerala Agricultural University, Vellanikkara, Kerala with med. long fruits having cream colour) had 100 % survival, where as the susceptible check IIHR 228 succumbed to complete wilt. 96-2-1(1.68 kg. /pt.) and 96-4-3 (1.63 kg. /pt.) were found to give significantly higher yields than both the resistant checks. Both the resistant lines had appreciable fruit weight (> 60g.). 96-2-1 had highest fruit length (20 cm.) followed by 96-1-2 and 96-4-3 (>15 cm.). At present none of the commercially available eggplant varieties / hybrids in green long fruit types are resistant to bacterial wilt. Newly developed lines are found to be promising for further commercial exploitation.

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Fig.1: Development of BWR lines- *schematic representation*

Arka Keshav (Purple long) **x** **IIHR 124 (Green oval)**

↓

F_1 (BWR-purple medium long)

↓

↓

F_2 (All BWR but fruits Purple / green)

↓

↓

↓

↓

F_8 (8 families)

MOST PROMISING WERE:

96-1-1 - white small
96-1-2 - green small
96-2-1 - green long
96-4-1 - green small
96-4-3 - green medium long

Table 1:Performance of Bacterial Wilt Resistant green long eggplant lines.

Entries	Yield (Kg. / pt.)	Average fruit weight (g.)	Fruit length (Cm)	Fruit width (Cm)	Remarks
96-1-1	1.43	58.00	16.00	2.20	White medium Long.
96-1-2	1.50	70.00	17.00	2.70	Green medium Long.
96-2-1	1.68	66.00	20.00	2.60	Green long with excellent cooking qualities
96-4-1	0.98	93.00	16.00	2.70	Green small, calyx non-fleshy
96-4-3	1.63	62.00	15.00	2.70	Green med. long Excellent cooking qualities
Arka Keshav (Resistant. Check)	1.40	-	-	-	Purple long
Shwetha (Resistant. Check)	1.53	54.00	12.00	2.30	Light green med. long
IIHR-228 (Susceptible. Check)	0.00	-	-	-	Manjarigota
SEm±	0.03	4.53	0.53	0.09	-
C.D. @5%	0.07	12.50	1.48	0.25	-
C.D. @ 1%	0.10	16.50	1.94	0.33	-

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Performance of Bacterial wilt Resistant F_1 Hybrids in Green Long Eggplant (*Solanum melongena* L.)

M. Anuroopa, A.T. Sadashiva, K. Madhavi Reddy and B.C. Narasimha Prasad
Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore 560 089

ABSTRACT

Thirty two green long bacterial wilt resistant (BWR) eggplant F_1 hybrids obtained by crossing 8 line x 4 tester mating design were evaluated in wilt infested soil followed by artificial inoculations with bacterial suspension. All the 32 hybrids were resistant to bacterial wilt with the percent survival ranging from 80 to 100%. Commercial green long F_1 hybrid *viz;* MEBH-9 used as susceptible check succumbed to complete wilt. Promising hybrids with cent percent survival were 99-4-3-7 x SM 6-6 (2.3 kg. /pt.), 99-4-3-6 x SM 141 (2.2 kg. /pt.) and 99-2-1 x BB44 (2.2 kg. /pt.).

INTRODUCTION

Eggplant (*Solanum melongena* L.) is an important vegetable crop grown in India and through out the world belonging to the nightshade family *Solanaceae*. Successful cultivation of brinjal crop has been hindered due to attack of many insect pests and devastating diseases. Among these, bacterial wilt disease is a major limiting factor caused by *Ralstonia solanacearum* (Yabucchi *et al.*, 1995) has been the most ubiquitous and serious bacterial disease throughout the tropical, sub-tropical and temperate regions of the world (Hayward, 1991). Developing commercially acceptable brinjal varieties and hybrids with resistance to bacterial wilt has been a goal of many breeding programmes.

Exploitation of heterosis has become a potential tool in the improvement of brinjal. Although several resistant varieties / hybrids have been released in different fruit types like purple long, purple oval, green long, purple round with stripes and green round, none of the released varieties or hybrids in green long fruit type are resistant to bacterial wilt. At IIHR, Bangalore, inbred lines in brinjal with resistance to bacterial wilt have been developed in green long fruit type to cater the needs of consumers. The present study was undertaken to develop F_1 hybrids in brinjal with resistance to bacterial wilt in green long fruit type using green long bacterial wilt resistant inbreds.

MATERIAL AND METHODS

The experimental material consisted of 32 F_1 hybrids developed by crossing 8 BWR green long eggplant inbred lines developed at IIHR, Bangalore viz; 99-1-1, 99-1-2, 99-2-1, 99-4-1, 99-4-3, 99-4-3-6, 99-4-1-4 and 99-4-3-7 and four BWR green long testers (S-75, BB44, SM 141 and SM 6-6). All the 32 F_1 s along with the green long susceptible check MEBH-9 were transplanted during May, 2000 in 4.0 m rows at a spacing of 90 cm between rows and 40 cm between plants accommodating 10 plants per

treatment per replication in a randomized block design with three replications in bacterial wilt sick soil (10^6 colony forming unit/g soil) maintained at IIHR, Bangalore. A basal dose of 60 Kg N, 50 Kg P_2O_5 and 30 Kg K_2O per hectare was applied before transplanting. The crop was top dressed with 60 Kg N, 50 Kg P_2O_5 and 30 Kg K_2O 36 days after transplanting. A second top dress with 60 Kg N was given after 60 days of transplanting. Regular cultural and plant protection measures were taken up to control pests and other diseases. On the 30^{th} day after planting, seedlings were artificially inoculated with bacterial culture (0.7 OD) by following pinprick method at 3^{rd} leaf axil as suggested by Winstead and Kelman (1952). Data on percent survival (at monthly interval), number of fruits per plant, average fruit weight, fruit length, fruit width and yield per plant were recorded and statistically analyzed.

RESULTS AND DISCUSSION

Mean performance of hybrids along with check for percent survival is presented in table 1. Of the 32 F_1 hybrids evaluated for bacterial resistance 19 hybrids had 100% survival even after 120 days of planting. Nine hybrids had 90% survival and the remaining 4 hybrids had 80% survival. Susceptible check MEBH 9 succumbed to complete wilt by 60^{th} day indicating the severity of disease in causing complete yield loss. At present no commercial hybrid in green long fruit type has bacterial wilt resistance. Hybrids with 100% survival indicated that these hybrids could be commercially exploited further.

Highest yield per plant (table 2) was recorded by 99-4-3-7 x SM 6-6 (2.3 kg.) followed by 99-4-3-6 x SM 141 (2.2 kg.) and 99-2- x BB 44 (2.2 kg.). Six hybrids recorded more than 2 kg. /plant with 100% survival. Maximum fruit number was recorded by 99-4-3-7 x SM 6-6 (36) followed by 99-1-1 x SM 6-6 (28) and 96-4-3-6 x SM 141 (28). Fruit length was highest in 99-4-3 x S-75 (23.5 cm) followed by 99-4-3-6 x S-75 (23 cm.) and 99-2-1 x S-75 (22.8cm.). Fruit girth was maximum in 99-1-1 x BB44 (3.4cm), followed by 99-4-1 x BB44 (3.3cm.) and 99-1-2 x BB44 (3.15cm.). Highest average fruit weight was recorded by 99-1-2 x S-75 (148g.) followed by 99-1-1 x S-75 (113g.) and 99-4-1 x BB44 (105g.). By considering the yield and yield components the most promising BWR hybrids for further commercial exploitation include 99-4-3-7 x SM 6-6, 99-4-3-6 x SM 141, 99-2- x BB 44, 99-4-1-4 x S-75, 99-4-1 x SM 6-6 and 99-2-1 x BB 44.

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Table 1: Mean performance of hybrids for per cent survival against Bacterial Wilt

Entries	30DAT	60DAT	90DAT	120DAT
99-1-1 x S-75	100	100	100	100
99-1-1 x BB-44	100	80.0	80.0	80.0
99-1-1 x SM-141	100	90.0	90.0	90.0
99-1-1 x SM 6-6	100	100	100	100
99-1-2 x S-75	100	100	100	100
99-1-2 x BB-44	100	100	100	100
99-1-2 xSM-141	100	100	100	100
99-1-2 x SM 6-6	100	100	100	100
99-2-1 x S-75	100	90.0	90.0	90.0
99-2-1 x BB-44	100	100	100	100
99-2-1 x SM-141	100	90.0	90.0	90.0
99-2-1 x SM 6-6	100	90.0	90.0	90.0
99-4-1 x S-75	100	80.0	80.0	80.0
99-4-1 x BB-44	100	100	100	100
99-4-1 x SM-141	100	90.0	90.0	90.0
99-4-1 x SM 6-6	100	100	100	100
99-4-3 x S-75	100	90.0	90.0	90.0
99-4-3 x BB-44	100	100	100	100
99-4-3 x SM-141	100	80.0	80.0	80.0
99-4-3 x SM 6-6	100	90.0	90.0	90.0
99-4-3-6 x S-75	100	90.0	90.0	90.0
99-4-3-6 x BB-44	100	100	100	100
99-4-3-6 x SM-141	100	100	100	100
99-4-3-6 x SM 6-6	100	100	100	100
99-4-1-4 x S-75	100	80.0	80.0	80.0
99-4-1-4 x BB-44	100	100	100	100
99-4-1-4 x SM-141	100	90.0	90.0	90.0
99-4-1-4 x SM 6-6	100	100	100	100
99-4-3-7 x S-75	100	100	100	100
99-4-3-7 x BB-44	100	100	100	100
99-4-3-7 x SM-141	100	100	100	100
99-4-3-7 x SM 6-6	100	100	100	100
MEBH-9 (Susceptible check)	50.0	0.0	0.0	0.0

Table 2: Per se performance of bacterial wilt resistant green long eggplant hybrids for yield and its components

Hybrids	Number of fruits per plant	Fruit length (cm.)	Fruit width (cm.)	Average fruit weight (g.)	Yield per plant (kg.)
99-1-1 x S-75	17.00	16.35	2.77	113.7	1.94
99-1-1 x BB-44	15.33	14.67	3.39	86.10	1.32
99-1-1 x SM 141	22.67	16.98	2.77	77.53	1.75
99-1-1 x SM6-6	27.67	16.08	2.67	75.80	2.10
99-1-2 x S-75	11.00	21.16	2.82	148.77	1.62
99-1-2 x BB-44	16.33	15.14	3.15	103.87	1.65
99-1-2 x SM 141	20.67	16.36	2.55	81.17	1.67
99-1-2 x SM6-6	22.67	17.22	2.68	77.87	1.77
99-2-1 x S-75	13.33	22.89	2.65	85.10	1.13
99-2-1 x BB-44	22.00	14.18	2.95	97.43	2.20
99-2-1 x SM 141	21.67	20.35	2.93	97.97	2.12
99-2-1 x SM6-6	22.67	17.65	2.60	67.23	1.52
99-4-1 x S-75	17.0	20.22	2.88	79.50	1.33
99-4-1 x BB-44	15.0	14.48	3.28	105.27	1.57
99-4-1 x SM 141	17.33	16.06	3.04	91.43	1.60
99-4-1 x SM6-6	25.67	15.61	2.62	79.7	2.03
99-4-3 x S-75	17.0	23.57	2.78	97.43	1.67
99-4-3 x BB-44	16.67	16.53	3.03	84.27	1.38
99-4-3 x SM 141	21.0	18.20	2.72	76.57	1.61
99-4-3 x SM6-6	25.33	16.57	2.76	73.53	1.87
99-4-3-6 x S-75	18.0	23.33	2.65	89.40	1.57
99-4-3-6 x BB-44	22.0	15.43	2.80	92.47	2.02
99-4-3-6 x SM 141	27.67	17.97	2.56	78.62	2.20
99-4-3-6 x SM6-6	27.33	18.13	2.60	71.53	1.97
99-4-1-4 x S-75	22.67	20.47	2.72	98.67	2.15
99-4-1-4 x BB-44	19.0	14.47	3.06	99.87	1.89
99-4-1-4 x SM 141	17.67	15.52	2.79	100.23	1.75
99-4-1-4 x SM6-6	26.67	17.93	2.63	75.33	1.77
99-4-3-7 x S-75	15.67	21.93	2.61	103.53	1.63
99-4-3-7 x BB-44	22.67	15.83	2.96	87.50	1.98
99-4-3-7 x SM 141	22.33	18.76	2.94	81.57	1.82
99-4-3-7 x SM6-6	36.00	17.99	2.61	64.10	2.30
SE±	**2.486**	**1.139**	**0.171**	**8.176**	**0.257**
CD@5%	**4.972**	**2.278**	**0.342**	**16.352**	**0.514**
CD@1%	**6.613**	**3.029**	**0.455**	**21.478**	**0.683**

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99-4-3 x S-75	100	90.0	90.0	90.0
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99-4-1-4 x SM 6-6	100	100	100	100
99-4-3-7 x S-75	100	100	100	100
99-4-3-7 x BB-44	100	100	100	100
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Relative resistance to shoot and fruit borer *(Leucinodes orbonalis* Guen.) in eggplant and related *Solarium species*

Ravinder Kumar and S.S.Gupta
Division of Vegetable Crops
Indian Agricultural Research Institute
New Delhi-110002
India

Introduction

The shoot and fruit borer *(Leucinodes orbonalis* Guen.) is the most serious insect pest in eggplant throughout India and the Indian sub-continent. The borer starts its attack in eggplant from nursery (young seedling) stage and continue through all phases of plant growth and fruiting period. Its attack particularly to the fruits, results into a considerable loss to the grower of the crop. The loss in yield as reported in northern states of India was higher, i.e. 63%, in Haryana (Dhankhar *et al.*, 1977) and 61% in Punjab (Singh arid Guram, 1967). In southern states the loss reported was 54% in Tamil Nadu (Srinivasan *et al.*,1959) and 37 % in Karnatka (Krishnaiah *et al.*, 1978).

High resistance to shoot arid fruit borer at cultivars level is a rare possibility as evident from the literature. However, high resistance to the insect has been reported by several workers at *Solanum* species level. The initial field work done at the Division of Vegetable Crops, Indian Agricultural Research Institute, New Delhi have shown that resistance to shoot and fruit borer in eggplant is not available at *Solanum melongena* L. level. It can only be possible in related *Solanun* species like *S. gilo, S. anomalum, S. incanum* etc. (Tejavathu *et. al.*; 1991).

Material and Methods

The rearing of shoot and fruit borer and screening of plant material against borer were done in laboratory having controlled conditions (temperature and R. H.) with necessary light arrangements for growing the plants. The technique given by Patil (1990) was adopted for mass rearing of the insect pest. The plant material used for screening against the borer consisted of *S. gilo, S.indicum, S.incanum, S. anomalum, S. sisymbrifolium* and *S. melongena* cv. Pusa Uttam (control).

The screening experiments namely 'no choice test' and 'choice/preferebce test' were conducted in the laboratory and in the field as given by Smith *et al.* (1994). The seeds of the plant material as stated above were divided into three parts. Two parts of parts were used for experimentation under controlled conditions of the laboratory and the third part in open under natural conditions of the field.

Screening Tests

1. No Choice Test: Five plants of each Solarium species named above and control, Pusa Uttam were screened against the insect larvae in laboratory using one species plants at a time. In this experiment, the borer, insect-larvae were

given 'no choice' of different species and their plants. Four larvae (2-3 day old) were released on each plant (4 week old) and their reaction was recorded every day for three days.

2. Choice/preference test: The second experiment was designed to screen 13 plants (4 week old) each of *Solanum* species along with *Solanum melongena* (Control). The plants of all species and that of control were transplanted in randomised design in large trays and allowed to establish for a few days. The established plants were placed under insect-proof net of controlled conditions of laboratory. Six adults of insect, shoot and fruit borer were released twice in the net over the plants at three days interval. This experiment provided choice or preference of plants of different species to the insect for mating arid egg-laying. The hatched larvae ultimately also feed on the plant material of their choice or those plants which were susceptible to insect.

3. Field Experiment: The third part of the seeds *of* all *Solanum* species including *Solanum melongena* (Control) were sown in the nursery. Thirty plants (4 week old) of each species along with control were transplanted in a 'randomized block design' in the field under three replications (each replication consisted of 10 plants). After the establishment of the plants, observations on shoot infestation of borer were recorded on each plant at an interval of two weeks. On every harvesting of fruits, number of fruits, infested with borer and also the total number of fruits were recorded. These records of infestation on shoots and fruits were finally considered for the percentage of plants infested with borer.

Results and Discussion

1. No choice test: The results of screening under 'no choice test' were recorded for three days on each plant of each *Solanum* sp. individually and these observations are given in Table 1.

Table 1. Plants of *Solanum* species and control screened under 'no choice test'.

Solanum species	No. of test plants	No. of plants infested	% age of infestation	Remarks
Solanum gilo	5	5	100	Main shoot and leaf Petioles were badly damaged
Solanum indicum	5	5	100	
Solanum incanum	5	5	100	- do -
Solanum anomalum	5	5	100	- do -
Solanum sisymbrifolium	5	5	100	- do -
Solanum melongena	5	5	100	- do -

The perusal of the data given have shown that all five plants of each *Solanum* species namely *Solanum gilo, S.indicum, S.incanum, S. anomalum, S. sisymbrifolium* and *S. melongena* (control) were badly infested by the larvae of the shoot and fruit borer. The damage to central shoot and leaf petioles of the test

plants as well as that of control was 100 per cent. Such experiments in crop plants have shown that plant genotypes classified as resistant in a 'choice test' may be susceptible in a 'no choice test' (Tingey, 1986). Plants of all *Solanum* species screened under 'no choice test' therefore, behaved as susceptible like that of *S. melongena* (control).

2. Choice/preference test: The results of the screening of *Solanum* species along with control plants under choice test of screening against shoot and fruit borer were recorded. The data on infestation by the larvae are given in Table 2.

Table 2. Data showing percentage of infestation in test plants of *Solanum* species with a control.

Solanum species	No. of test plants	No. of plants infested	% age of infestation	Remarks
Solanum gilo	13	5	38.5	This sp. is crossable with *S. melongena*
Solanum indicum	13	6	46.1	- do -
Solanum incanum	13	7	53.8	- do -
Solanum sisymbrifolium	13	8	61.5	Highly susceptible
Solanum anomalum	13	11	84.6	- do -
Solanum melongena	13	11	84.6	- do -

The perusal of the data on resistance indicated that the highest infestation (84.6%) of a shoot and fruit borer was seen in *Solanum melongena* (control) and *S. anomalum* followed by *S. sisymbrifolium* (61.5%), *S. incanum* (46.1%) and *S. indicum* (46.1%). The least percentage of infestation (38.5%) was found in case of *S. gilo*. This shows that resistance to shoot and fruit borer is available in *S. gilo, S. indicum* and *S. incanum*.

3. Filed Experiment: As stated earlier, the *Solanum* species under this experiment were screened under natural conditions of the field. The observation made on infestation by shoot and fruit borer are given in Table 3.

Table 3. Showing percentage of combined infestation on shoots and fruits of borer in field.

Solanum species	No. of test plants	No. of plants infested	% age of infestation
Solanum gilo	30	5	16.7
Solanum indicum	30	6	20.0
Solanum incanum	30	7	23.3
Solanum sisymbrifolium	30	7	23.3
Solanum anomalum	30	8	26.7
Solanum melongena	30	18	60

The perusal of data in Table 3 indicate that the highest infestation (60%) of shoot and fruit borer in the field was seen in *Solanum melongena* (control) and the lowest (16.7%) in *S. gilo*. The infestation in *S. indicum* was 20 % and 23.3% in case of *S. incanum*. Such infestation indicated that the pattern of resistance found in field was similar to that found in the laboratory in these *Solanum* species.

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