GYNOECIOUS AND PARTHENOECARPIC CUCUMBER BREEDING

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INTRODUCTION

Cucumber (Cucumis sativus L.) belongs to family Cucurbitaceae, which distributed throughout the warmer parts of the world (Gopala krishnan, 2007). This is commercially grown all over the world in open fields and small gardens, even under polyhouses or glasshouses. Cucumber fruit is characterized by low energy, high fiber and high water containing vegetable. Its immature fruits are known as good appetizer to have cooling effect. Cucumber is also a good source of Vitamin B and C, carbohydrates, calcium and phosphorus (Yawalkar, 1985). Cucumber is both a leading commercial crop Exploitation of Gynoecious Lines in Cucumber (Cucumis Sativus L.) for Heterosis Breeding.

Hybrid varieties of cucumber are predominantly used in the production system of many developed and developing countries. The proportion of hybrid varieties is continuously increasing and thus, gynoecious hybrids for open field cultivation and parthenocarpic cucumbers for polyhouse cultivation are important for commercial cultivation. Sex inheritance plays an important role in cucumber hybrid breeding. Several researchers have worked on sex expression of cucumbers and reported that it was genetically determined but could be modified by growth substance application and also environmental factors (Krishnamoorthy, 1975; Lower and Edwards, 1986; Kalloo, 1988). Considering the above factors many combinations of hybrid seed production have been proposed and recommended using gynoecious parents. Despite of all efforts, sex expression variation of commercial hybrids is still a problem in cucumber cultivation (Lower and Edwards, 1986). At present, interesting in stabilizing the gynoecious character and development of stable parthenocarpic & gynoecious inbred parents have been intensified and become a common goal of numerous hybrid breeding programs. Therefore this study was conducted with the following objectives.

a) Breeding parthenocarpic cucumber lines and to develop F1 hybrids adapted to greenhouse/plastic house cultivation.

b) Understand and familiarize breeding Gynoecious cucumber lines and F1 hybrids suitable for open field condition.
Cucumber breeder should have following knowledge

* Market potential
* Types / segments to work on
* Clearly defined objective/ market requirement
* Germplasm base
* Traits of inheritance
* Application of breeding methods with respect to traits of improvement
* Breeding and testing locations etc

**Major Types/Segments of Cucumbers for breeding**

### Slicing cucumber

- **Plant:** Very strong, high branching & longevity
- **Fruit type:** Mottle green, white with light green tinge & dark green colour with cylindrical uniform fruits
- **Quality:** High keeping quality, transportability, hallow & bitter free
- **Sex type:** Gynoecious, Predominantly female & monoecious types
- **Parthenocarpic bearing habit**
- **Disease resistance:** DM, PM, GSB, CMV & ZyMV

### Pickling cucumber

- **Plant:** Very strong, less branching & high plant longevity
- **Fruit type:** Mottle green to dark green & glossy green colour with cylindrical uniform fruits, intermediate cluster bearing type
- **Quality:**
- **Sex type:**
- **Parthenocarpic bearing habit**
- **Disease resistance:**
Slicing cucumber & traits of interest

- Quality: Crispy taste, processing quality, hallow & bitter free
- Sex type: Gynoecious & predominantly female types
- Parthenocarpic or Non parthenocarpic bearing habit
- Disease resistance: DM, PM, GSB, CMV & ZyMV

Conventional Breeding methods

- Routine pedigree breeding
- Routine back cross breeding
- Use of sex inheritance & chemicals in breeding
- Use of MAS in line development
- Use of DH tech in line development

Cucumber gynoecious line development

Beit alpha cucumber & traits of interest

- Plant: Very strong, medium branching & high plant longevity
- Fruit type: Dark green to glossy green colour with cylindrical uniform fruits, intermediate cluster bearing type
- Quality: Good keeping qty & transportability, hallow & bitter free
- Sex type: Gynoecious type
- Parthenocarpic bearing habit
- Disease resistance: DM, PM, GSB, CMV & ZyMV
Gynoecious cucumber

Breeding for higher yields is an important objective of cucumber breeding programmes (Wehner, 1987). Yield of cucumber can be improved through breeding to develop resistance against pest-diseases (Peterson, 1975); improvement in cultural practices (Cargill et al., 1975); qualitative traits improvements like gynoecious sex expression, colour of fruit and yield (Wehner, 1987) or development of high yielding varieties or hybrids. Moreover, cucumber crop is predominantly monoecious in nature but gynoecious sex form has also been reported (Pati et al., 2015) which facilitates hybridization by reducing labour cost for crossing. The gynoecious hybrid cultivars often bear a high proportion of female flowers, resulting in earliness, good yield and give many fruits in a single harvest. Exploitation of Gynoecious Lines in Cucumber (Cucumis Sativus L.) for Heterosis Breeding.

Flowers

Male Staminate

Female Staminate

Genetics of sex expression:

<table>
<thead>
<tr>
<th>Acr</th>
<th>acr</th>
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<tbody>
<tr>
<td>M:</td>
<td>m:</td>
</tr>
<tr>
<td>Gynoecious</td>
<td>Hermaphrodite</td>
</tr>
<tr>
<td>Monoecious</td>
<td>Andromonoecious</td>
</tr>
<tr>
<td>Androecious</td>
<td>Androecious</td>
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</table>

Sex expression is greatly influenced by environmental factors like nutrition, day length, light intensity & stress factors

Gyno plant grown

Male flower appeared in Gyno plant
Selfed fruit

Revert back to gyno plant

Gynoecious fruit setting

Pedigree Breeding

<table>
<thead>
<tr>
<th>% Homozygosity</th>
<th>Generation</th>
<th>Cycles</th>
<th>Years</th>
<th>Generation</th>
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<tbody>
<tr>
<td>50</td>
<td>F2</td>
<td>Season -2</td>
<td>Year 1</td>
<td>F2</td>
</tr>
<tr>
<td>75</td>
<td>F3</td>
<td>Season -3</td>
<td></td>
<td>F3</td>
</tr>
<tr>
<td>87.5</td>
<td>F4</td>
<td>Season -1</td>
<td>Year 2</td>
<td>F4</td>
</tr>
<tr>
<td>93.75</td>
<td>F5</td>
<td>Season -1</td>
<td></td>
<td>F5</td>
</tr>
<tr>
<td>96.875</td>
<td>F6</td>
<td>Season -1</td>
<td></td>
<td>F6</td>
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</tbody>
</table>

Population size

<table>
<thead>
<tr>
<th>Generation</th>
<th>Plant No. to grow</th>
<th>PI No. to select</th>
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</thead>
<tbody>
<tr>
<td>F1</td>
<td>10-20</td>
<td>Bulk</td>
</tr>
<tr>
<td>F2</td>
<td>200-300</td>
<td>15-20</td>
</tr>
<tr>
<td>F3</td>
<td>50-100</td>
<td>10-15</td>
</tr>
<tr>
<td>F4</td>
<td>50-100</td>
<td>8-10</td>
</tr>
<tr>
<td>F5</td>
<td>30-50</td>
<td>5-8</td>
</tr>
<tr>
<td>F6</td>
<td>20-30</td>
<td>5-8</td>
</tr>
</tbody>
</table>

Procedure to develop gynoecious cucumber inbreds

Select best Gyno F1 or DCF1 or ?

Grow F2 100-200 Population, (it segregates to Gyno, Mono, PF, Andro.. etc) Select gyno plants at 3-5 leaves stage, tag them, spray GA3 than self

Grow early generation material/ population at different temperature and day length to confirm stable gynoecious nature

Similarly grow F3, F4, F5 & so on, depends on background of origin it will get fix at different generation (F4 to F8)
DOUBLE CROSS METHOD for Gynoecious LDP

Gynoecious X Fruit uniformity
(Line -1) (Line -2)
F1

Plant longevity X DMR
(Line -3) (Line -4)
F1

No. of generations will be cut shorted if DH technology is available

DH (Andro or Gynogenesis)

Progenies of doubled chromosomes

Check & screen for Gynoecious, Parthenocarpic & CMV resist.

DCF1

Select gyno plant with other desirable traits

DCF2

Pythopathology scoring at every generation

Colchicine

IPS upto F6-F8

Select gyno plant with other desirable traits at every generation
BACK CROSS METHOD (Gynoecious, parthenocarpic & CMV resist.)

Gynoecious & parthenocarpic (Line -1)  X  CMV resist (Line -2)

F1  X

BC1F1

BC1F2  Screening for resistance

BC2, BC3, BC4, BC5F2, F3

Finally line with Gynoecious & Parthenocarpic with CMV resistance
BACK CROSS METHOD (Gynoeocious, parthenocarpic & CMVR)

Gynoeocious & parthenocarpic

(Line -1)

CMV resist

(Line -2)

No. of generations will be cut shorted if DH technology is available

F1

X

BC1F1

X

BC1F2

Screening for resistance

Application of molecular markers to speed up programme

BC2, BC3, BC4, BC5F2,F3

Finally, The line with Gynoeocious & Parthenocarpic with CMV resistance

DH (Andro or Gynogenesis)

Colchicine

Progenies of doubled chromosomes

Check & screen for Gynoeocious, Parthenocarpic & CMV resist.
**Molecular Markers Linked to Gynoecious Loci**

Based on different ecological type materials of cucumber, F1, F2, BC1 and BC2 population were constructed, and the inheritance law of sex was study; RAPD and AFLP markers linked to gynoe- cious loci were attained, these markers could be utilized for marker assist selecting (MAS) of cucumber gynoecious lines.

**Use of DH tech in line development**

**Gynoecious**

Culture of unpollinated ovaries and ovules represent an alternative for the production of haploid plants in species for which anther culture has failed

Not used as much as androgenic methods:

- Problems in dissection of unfertilized ovules/ovaries
- Successful in Onion, melon, cucumber and sugar beet

**Homozygous frequency**

<table>
<thead>
<tr>
<th>X</th>
<th>Frequency of homozygous</th>
<th>X</th>
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</thead>
<tbody>
<tr>
<td>F₁</td>
<td>0%</td>
<td>F₁</td>
</tr>
<tr>
<td>F₂</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>F₃</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>F₄</td>
<td>87.5%</td>
<td></td>
</tr>
<tr>
<td>F₅</td>
<td>93.75%</td>
<td></td>
</tr>
<tr>
<td>F₆</td>
<td>96.88%</td>
<td></td>
</tr>
<tr>
<td>F₇</td>
<td>98.44%</td>
<td></td>
</tr>
<tr>
<td>F₈</td>
<td>99.22%</td>
<td></td>
</tr>
</tbody>
</table>

DH lines 100% homozygous

**Main features of DH:**

Double haploids are completely homozygous & homogeneous population, hence is highly uniform

DH can be produced both in auto and allogamous species

It's a rapid method of producing pure lines from heterozygous parents in one generation, conventional takes 3-5 years

DH helps fixation of hybrid vigour or heterosis in hozygous lines.

Example: genotypes; AAbb X aaBB

Haploid ; AB

AB genotype fixed as DH ; AAbb
Growing Conditions of Donor Plants

Should be grown under good conditions without stress

Must be healthy and vigorous

location, season, soil and water quality is important, esp. if plant material is grown in GH/field

Pesticides/insecticides/fungicides can also cause stress or reduction in embryogenesis!

Improperly controlled growth of donor plants could lead to inconsistent DH plant production efficiencies

Gynogenesis (Female Gamete culture)

Donor plant growth

Ovary culture

Rooting

Embryogenesis

Ploidy analysis & diplodization

Hardening & Selfing

Observations:

Qualitative Parameters:

1. Plant vigour (Strong, medium and week)
2. Plant Branching habit: (High, medium, poor)
3. Sex type (Monoecious, Gynoecious, PF, Androecious, Gynomonoecious, Andromonoecious, Gynoandromonoecious, Hermaphrodite)
4. Parthenocarpy: Parthenocarpic or non parthenocarpic
5. Fruit colour: (Dark green, Mottle green, White with light green tinge & White)
6. Spine colour on fruit: (white, brown, black, nonspiny)
7. Fruit shape: (Cylindrical, tapering end, elliptical, globular round)
8. Fruit Bitterness: (free, little, severe)
9. Hollowness / Cavity: free, little, severe)
**Observations:**

**Qualitative Parameters:**

1. Days to 50% female flower after planting
2. Days to first harvest after planting
3. Length & Diameter (Cm)
4. Yield (Kg/plant)

**Disease Interpretation:**

1. Downy mildew incidence score (1-9 scale, 1=immune 3 = high resistance 5=intermediate 7= susceptible)
2. Powdery mildew
3. Cucumber mosaic virus (CMV)/ZYMV/PRSV (Based on prevalence)
4. Gummy stem blight (GSB)

**Parthenocarpic cucumber futures:**

The tendency to produce parthenocarpic fruit in response to controlled variations in photo-period, temperature and nutrient uptake differed according to variety Must be healthy and vigorous

Parthenocarpic variety must be gynoe-cious and solitary to multi-pistillate flowering habit

Tendency to set fruit without pollination will have no seed in fruit and must have seed with pollination.

Usually cultivated in controlled condition, its ability to bear more number of fruits per plant but needs high management

Its very succulent and susceptible to pest, disease and harsh weather.

**Cucumber gyno & parthenocarpic line development breeding**

![Cucumber gyno & parthenocarpic line development breeding](image_url)
Multi-pistillate flower

Procedure to develop parthenocarpic cucumber inbreds

**Case-I**

1. **Parthenocarpic F1**
2. Grow F2 200-300 Population in net house or polyhouse (divide of pollinators), Select gynoecious plant with good fruit setting
3. F3 100-200 plants, F4 50 plants and so on
4. Grow F5- F6 plants at different temperature and day length to confirm stable gynoecious & Parthenocarpic type

**Case-II**

1. **Parthenocarpic F1 X Nonparthenocarpic F1**
2. Grow F2 300-400 Population at control condition. Select gyno with good fruit setting without pollination, it will be continued till attain purity
3. Similarly it will be continued for any kind of population, if it is having parthenocarpic or gyno gene
Some Relationships of Seed Production with Parthenocarpy and Relative Humidity in the Cucumber

Nick E. Fanourakis and Eva E. Tzifaki

An important advantage of the cucumber plant that makes it suitable for breeding and genetic studies is its ability to produce many seeds in each pollinated fruit. A mature, hand-pollinated fruit containing more than 150 seeds is not rare. However, with parthenocarpic plants the situation is different. We have observed that the strong parthenocarpic beit alpha type produce generally fewer seeds per pollinated fruit than the non-parthenocarpic. Since commercial seeds of parthenocarpic cultivars are produced by hand pollination, seed cost is dependent on the number of seeds produced per pollination

Strongly parthenocarpic cucumber plants produced much fewer seeds than the non-parthenocarpic. However, wide variation was observed within lines. Cross-pollination of the parthenocarpic flowers did not always provide more seeds than self-pollination. The increase of RH during pollination could affect positively the number of seeds per fruit
Development of hybrids for stable fruit colour, wider adaptable and resistance to DM & CMV is an opportunity.

Development of hybrid for poly house cultivation, as its area is growing.

Use of DH technology to fast track line development program.

References


