REVIEW ARTICLE

DIFFERENT SYSTEM OF HYBRID DEVELOPMENT IN OKRA AND CUCURBITACEOUS VEGETABLES

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Abstract: Okra (*Abelmoschus esculentus*) is a monotypic genus under the family Malvaceae having a significant place in the Indian vegetable market and export market. Cucurbitaceae is the largest family of vegetable crops consisting of about 800 species in around 130 genera with dominance in production and consumption among Indian people. In both of the above vegetable families several hybrids have been developed which played a major role in increasing the area and production of these crops. Heterosis or hybrid vigour has been exploited in its full potential in several vegetables of these two vegetable families. Presence of Genetic male sterility (GMS) in okra and gynoecy, monoecy and dioecy in cucurbits has been provided a convenient and cost-effective method of mass hybrid seed production in those crops. Here we have discussed several hybrids developed and their method of development in okra and major cucurbits like cucumber, bitter gourd, bottle gourd, musk melon, pumpkin, sponge gourd, squashes and water melon.

Keywords: Cucurbits, Hybrid, Male sterility, Okra, Vegetable

INTRODUCTION

Due to ever-increasing demand of vegetables, the use of hybrids become popular to full fill the recommended consumption level of 300g vegetables per capita per day. The introduction of hybrids in public and private sector has greatly contributed to the vegetable production in our country. In most of vegetable crops the open pollinated varieties are being replaced by the hybrids. Hybrid varieties play a vital role in increasing vegetable production due to their high yield potential, early maturing, superior quality, disease and pest resistance attributes.

Different ICAR research institutes have contributed considerably to develop hybrid varieties. In India, more than 100 hybrid varieties of 15 vegetables have been developed in the public sector. The private seed companies have done commendable work in popularizing the hybrid varieties in India.

High cost of F1 hybrid seed is one of the major handicaps of successful hybrid vegetable technology. This is because under-utilization of available genetic tools for economic F1 seed production. In the entire country, mostly hand emasculation and hand pollination technique are being followed (with very little exception) to develop F1 hybrid seeds in most of vegetable crops.

Only about 10 per cent of vegetable area is under hybrids, of which tomatoes cover 36 per cent, cabbage 30 per cent, brinjal 18 per cent, okra 7 per cent, melons and gourds 5 per cent each, cauliflower 2 per cent and chilli 1 per cent. With awareness of advantages for cultivation of F1 hybrids, the area is bound to extend (Singh, 2004).

Hybrid development in okra

Okra has hermaphrodite flowers and often-cross-pollinated crop. Hybrid vigor is exploited in this crop. 60 % increased yield by Joshi *et al*., (1958). Hybrids developed by hand emasculation & pollination as no pollination control mechanisms were available earlier. 30-76 % heterosis for earliness, yield, no. of fruit/plant and fruit length. F_1 hybrids resistant to YVMV.

IARI, New Delhi

Pusa Sawani –IC-1542 X Pusa Makhmali. Developed through pedigree selection for YVMV resistance but later it became susceptible.

DOH-2, DOH-4 & DOH-6

IIHR, Bengaluru

Arka Anamika & **Arka Abhay** (Dutta & Singh, 1990) *A. esculentus* (IIHR 20-31) X *A. tetraphyllus var tetraphyllus* followed by back cross. Resistant to YVMV.

IIVR, Varanasi

Kashi Mahima (DVR-4) - resistant to YVMV & OLCV.

OTHERS SAUs

Manjima – released from KAU, Trissur (2006). (Gowreesapattom local X NBPGR/TCR-874). High yielding (16t/ha), early maturing, YVM resistant variety.

Punjab 7: *A. esculentus* (Pusa sawani) X *A. caillei* followed by backcross with Pusa sawani. Released from PAU by Harbajan Singh (1952).

Panjab Padmini: *A. esculentus* (Reshmi) X *A. caillei*. Released from PAU (Thakur and Arora 1986)

Parbhani Kranti: *A. esculentus* (Pusa sawani) X *A. manihot.* Released from Parbhani. (Jambhale & Nerkar, 1986)

Hyb-7 & 8 (TNAU)

GOH-3 & 4 (Gujarat AU)

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Hybrid released from Private sectors tolerant to YVMV

Sl. No.	Name of the varieties	Sources
1.	Sarika, Sonal, Shakthi	Nunhems
2.	Varsha, Vijay and Vishal	IAHS seeds
3.	No-10, No- 64	Mahyco seeds
4.	NS-811, NS-810, NS-801, 866	Namdhari seeds
5.	US -7109	US agri seeds
6.	Mona, Teja	Adventa seeds
7.	Avanthika	Bio-seed

Emasculation & pollination by hand may not be an economic proposition due to less number of seeds per fruit. Use of male sterility will be effective for commercial hybrid seed production.

Male sterility controlled by Single recessive gene in homozygous condition. stable and not influenced by the environmental factors. (ms1 and ms2). It can be induced by Gamma rays (500-600 Gy) and maintained by sib matting (Pitchaimuthu *et al*., 2012).

Arka Nikita - GMS-4 X IIIHR-299-14-11-585. It is developed using GMS line.

It has been identified for release by the Institute VTIC during 2017. Produces dark green, medium, smooth and tender fruits. Excellent cooking quality, nutritionally rich in antioxidant activity, high mucilage content (1.08 % (FW) and high edible fiber content (8.85 % (DW). It is rich in minerals like potassium (3.7 %), calcium 997 mg /100 g) and magnesium. Rich in iodine content (33.31µ g/kg). Yields 21-24 t/ha in 125 -130 days duration.

Hybrid development in cucurbits

Large and diverse group of vegetable crops in the family cucurbitaceae. Consists of 130 genera & 800 species (Jeffrey, 2005). Cross pollinated crops, no inbreeding depression. Significant heterosis in desirable directions for yield and yield attributed traits like sex ratio, days to first picking, number of fruits per plant, yield per plant and vine length have been reported in these crops.

Hybridization is relatively easier due to presence of big size of flowers and production of separate male and female flower in monoecious, dioecious plants and only female flower in gynoecious plants. No need of emasculation, male flower can be pinched off.

Sex Forms in Cucurbits

SEX FORMS	CUCURBITS
Monoecious	Cucumber, Musk melon, Pumpkin, Summer squash, Winter squash, water melon, Sponge gourd, Round melon, Bottle gourd, Bitter gourd
Gynoecious	Cucumber, Bitter gourd, Musk melon, Watermelon, Ridge gourd
Androecious	Cucumber, Musk melon
Dioecious	Pointed gourd, Ivy gourd,
Andromonoecious	Water melon, Musk melon
Gynomonoecious	Cucumber, Musk melon, Ridge gourd
Trimonoecious	Cucumber
Hermaphrodite	Satputia (Ridge gourd), Cucumber

(Genetics, Genomics and Breeding of Cucurbits, 2011)

These sex forms are interchangeable with application of growth regulators. Male sterility reported in musk melon and ridge gourd. These systems can aid the hybrid seed production in different cucurbits.

Hybrid seed production mechanism

The manual pollination method of seed production on commercial scale is only feasible in the development of hybrids of vegetables like tomato, eggplant, and cucurbits (bottle gourd, watermelon, pumpkin etc.) where large number of F_1 seeds can be obtained per pollination.

The hybrid seeds of bottle gourd, bitter gourd and pumpkin through protection of female flower and hand pollination (Flemine, 2010; Jat, 2011; Behera *et. al*, 2015); cucumber through natural pollination in case of gynoceious seed parent (Munshi *et al*., 2015)

The hybrids of cucumber are produced mainly by crossing gynoecious lines with monoecious lines. The other systems of producing gynoecious hybrid seed are gynoecious × gynoecious but gynoecious × monoecious hybrids are still widely grown hybrids because this offers advantages like earliness, high degree of female sex expression, with uniform and concentrated fruit formation, which was especially advantageous for mechanical harvest.

Ethrel 200-300 ppm at two and four true leaf stage and another at flowering is useful for inducing the pistilate flower in bottle gourd, pumpkin and squash for F1 seed production. The row of male parent is

grown side by the side of female and natural cross pollination is allowed.
Different methods of hybrid development in cucurbits are -
Pinching of staminate flowers and hand pollination – Bitter gourd, bottle gourd, pumpkin, watermelon and muskmelon
GMS + bee pollination – Musk melon
CGMS + natural pollination – Ridge gourd
Gynocecism and natural pollination – Cucumber, bitter gourd
PGR and natural pollination – Squash
Emasculation and hand pollination – Satputia – ridge gourd

Male msterility in cucurbits

Crop	Salient features of male sterility
Watermelon	Recessive mutant has been reported; linkage of ms gene with delayed-green (dg) seedling marker gene. MSDG-1 and MSDG-2 - Male sterile lines with delayed green seedling marker (Zhang et al., 1996) 93JMSB-1, 93JMSB-1-1, and 93JMSF3-2- male sterile lines with Juvenile albino seedlings. (Zhang *et al*., 1996)
Muskmelon	5 Recessive non-allelic genes have been reported; ms-1 is commercially utilized. linkage of ms 1 gene with red stem and ms 2 with yellow green leaf.
Cucumber	Monogenic recessive gene has been reported; limited scope of utilization because of the availability of gynoecious lines.
Ridge gourd	cytoplasmic male sterility with two dominant male fertility restorer nuclear genes
Summer squash	Monogenic recessive gene has been reported; very limited scope of utilization because of the availability of sex regulating mechanism using PGR, particularly ethephon.

Male sterility in Ridge gourd

Male sterile lines in Ridge gourd- IIHRRGMS-1 & IIHRRGMS-2. Rudimentary male flowers which do not open. Pollen sterility and no fruit set on selfing, if male flower is opened. Male sterile flower buds are smaller in size compared to the male fertile lines. Crosses were made with RGGP-4, RGGP-5 & RGGP-6. All F1 plants were male sterile in MS x RGGP-5 and RGGP-6 - Cytoplasmic male sterility-recessive gene control. In MS x RGGP-4: 16% male fertile.
Back-cross populations/F2 populations are developed to find out the genetics of inheritance of male sterility. Efforts are under way to identify the restorer lines - two dominant restorer genes were identified in ridge gourd. (Pradeep kumar *et al*., 2012)
These male sterile lines can be used for hybrid seed production.

Gynoecious lines reported in cucurbits for hybreed seed production (HSP)

Crop	Salient features of Gynoecious lines
Cucumber	Shogoin (PI-220860) Peterson and Anhder (1960) DCH-1, DCH-2 – Tropical gynoecious lines identified in IARI. Gyc- 1, Gyc-2, Gyc-3 - gynoecious lines identified in IARI Gyc - pkg-1 - gynoecious parthenocarpic line identified in MPKV, Rahuri.
Summer squash	NJ-34 – gynoecious line. It carries gene B for precocious fruit pigmentation.
Bitter gourd	Gy 263 B- Ram *et al.* (2002) DBGy-201, DBGy-202 Behera *et al.*, (2006) IIHRBTGy-491 and IIHRBTGy-492 Varalakshmi *et al.* (2014)

Muskmelon	Wisconsin 998 (WI 998) Peterson *et al*., 1983 86-104, 105, 118 More *et a*l., 1987 GH 3-2, 5E-1, 7-7, 4D, 5D, 6C-4 and 6E-7 - More *et al*., 1991

1. HYBRIDS IN CUCUMBER

IARI, New Delhi

Pusa Sanyog – Japanese Gynoecious line X Green Long Naples. High yielding, fruits are 28-30 cm long, dark green with yellow stripes, matures in 50 days.

OTHER SAUs

Solan Khira Hybrid 1 – 1983 G X K90. Gynoecious based early maturing F1 hybrid, bears 10-12 cm long fruits, ready for harvesting in 65 days, yields 30-40 t/ha.

Solan Khira Hybrid 2 – 2780G X K90. Gynoecious based F1 hybrid, vines reach up to 5 m with 4-5 lateral branches, and fruits are cylindrical, 20-23 cm in length, black spine. Average yield 55-60 t/ha. Suitable for low temperature areas.

Public and private sector hybrids in cucumber

Crops	Hybrids	Source
Public sectors	Pusa Sanyog PCUCH-1 AAUC-1, AAUC-2 Solan Khira Hybrid 1, 2& KH-1 Phule Prachi Pant Shankar Khira-1 Harith and Shubra	IARI, New Delhi GBPUAT, pant Nagar AAU, Assam UHF, Solan MPKV, Rahuri GBPUAT, pant Nagar KAU, Trissur
Private seed companies	Priya Superior Slicer Liberty Aman Malini	Mahyco IAHS Suttons PROAGRO Seminis

2. HYBRIDS IN WATERMELON

IARI, New Delhi

Pusa Bedna – Tetra-2 X Pusa Rasal. Triploid seedless hybrid.

IIHR, Bengaluru

Arka Jyoti – IIHR.20 X Crimson Sweet. Released from IIHR, Bengaluru.

Arka Manik – IIHR.21 X Crimson Sweet. Resistant to powdery mildew, Downey mildew and anthracnose.

Arka Madhura - Triploid seedless watermelon variety. High yield 50-60 t/ha, T.S.S 13-14 %. Unique type, sweet, juicy and fully seedless. Longer shelf life and transport quality. Suitable for year-round production under protected condition.

Arka Akash - High yielding F1hybrid. Dark green with light green broken specks slightly deep foliage, oblong fruit red flesh, with TSS of 12-13% (brix), average fruit weight 6.5kg.

Arka Aiswarya - Green with Dark green deeply lobbed foliage, round to oval fruit, Dark green with light green broken stripes, red flesh, with TSS of 13-14% (brix), average fruit weight 7.5kg with 1-2 fruit per vine. Duration 95-100 days. Fruit yield 75 to 80 t/ha.

Other SAUs

Shonima – KAU, 2015. Red fleshed seedless triploid hybrid, rind colour is dark green with light green stripes. Avg wt is 3.92 kg.

Swarna – KAU, 2015. Bright Yellow fleshed seedless triploid hybrid, rind colour is green with yellow stripes. Avg wt is 3.18 kg.

HYBRIDS IN MUSKMELON

IARI, New Delhi

Pusa Rasraj – Monoecious - 3 × Durgapura Madhu. Monoecious based hybrid, developed from IARI. Fruits have 11-120 B TSS. Suitable for both garden and riverbeds. Yields 25 tonnes/ha.

Other SAUs

MHY-10 – gynoecious based hybrid

Punjab Hybrid – ms -1 × Hara Madhu. Male sterility-based hybrid using ms-1, developed from PAU. Early maturing with orange flesh and netted skin. Suitable for long distance transportation.

Punjab Anmol – ms -1 × Punjab Sunheri. Male sterility-based hybrid using ms-1, developed from PAU. It takes 70 days from transplanting to first picking. The fruit is oval-round, light brown, non-sutured and intensely netted. Flesh is thick, orange coloured, medium in juiciness and flavoursome with TSS content of 11.5 per cent. The fruits develop "full slip" stage. The average fruit weight is 7109. Fruits have better shelf life and are suitable for distant transportation.

HYBRIDS IN BITTER GOURD

IARI, New Delhi

Pusa Hybrid-1 IARI, New Delhi

Pusa Hybrid-2 IARI, New Delhi

Pusa Hybrid-4 - First gynoecious based bitter gourd hybrid developed by ICAR- IARI, New Delhi and released in 2018, for commercial cultivation. It has predominately gynoecious habit with high female: male flower ratio (2:1). Fruits are dark green, medium long and medium thick with 5-6 dis-continuous narrow ridges and first harvest after 45-50 days of sowing. The average fruit weight is 60g and its average yield is 22.26 t/ha.

Other SAUs

COBgoH.1 – It is a hybrid between MC.84 x MDU.1 from TNAU. Yield potential is 52 tonnes/ha in a crop duration of 115 -120 days. Fruits have high momordicin content (2.99mg/g). Fruits are white in colour.

Private organisations

Indam Kohinoor - released by Indo-American hybrid Seed Company. Vigorous plants, can withstand heat, wider adaptability, Green fruits, tubercles, length-17cm and 4.3cm diameter, good for transport, shiny 90-100gm fruits, high yielding with heat set. Matures in 50-55days after sowing, can be maintained up to 180days.

From World Vegetable centre – Taiwan, bitter gourd hybrid AVBG1601 (released as '**NBH-Figo**' by Noble Seeds Pvt. Ltd). This hybrid is high yielding, powdery mildew and virus tolerant.

HYBRIDS IN BOTTLE GOURD

IARI, New Delhi

Pusa Meghdoot - PSP Long × Sel. 2 Relatively early, fruits are long, light green and attractive. Suitable for cultivation in spring summer season.

Pusa Manjari - PSP Round × Sel. 11 It recorded 48% higher early yield and 106% total yield over PSP Round.

Pusa Hybrid-3

IIVR, Varanasi

Kashi Bahar – Straight fruit light green colour, medium size, 10-12 fruits per plant, 800-900 g fruit weight.

Other SAUs

Gujarat Anand Bottle Gourd Hybrid-1 (**GABGH-1**) - 2017 AAU, Anand - The fruits are medium in size and cylinder in shape with attractive light green colour.

Pant Sankar Lauki -1 - GBPUAT, Pantnagar.

Narendra Sankar-1 - NDUAT, Faizabad

HYBRIDS IN RIDGE GOURD

IIHR, Bengaluru

Arka Vikram - This hybrid has been identified for release by the institute VTIC during 2016. It takes 40 days for the first female flower appearance and 46 days for first picking of fruits produces green, long, tender fruits. Excellent cooking quality, nutritionally rich in antioxidant activity and minerals like potassium, calcium, iron, zinc and manganese. Yields 34.0 t/ha in 120-135 days duration.

HYBRIDS IN PUMPKIN

IARI, New Delhi

Pusa Hybrid-1 – high yielding, suitable for growing in both summer and kharif season.

HYBRIDS IN ASH GOURD

IARI, New Delhi

Pusa Shreyali - released in 2016 for commercial cultivation.

Pusa Urmi – is an excellent variety for commercial cultivation

HYBRIDS IN SUMMER SQUASH

IARI, New Delhi

Pusa Alankar - EC 207050 × Sel. 1. Developed from IARI, New Delhi. Green fruits with light coloured stripes, early maturing in 45 -50 days. Yields 20-30 tonnes/ha.

Diseases Resistance Hybrids of Different Vegetable Crops (Private Seed Companies)

Okra YVMV - No.7, No.8, No.10, Panchalik, Adhunik, Tara, Supriya, Uphar, Varsha, Vijay, Vishal

Ridge gourd Powdery mildew – Surekha

Watermelon Fusarium wilt – Amrit, MHW-6

Muskmelon Downey mildew – Madhuma

Future Strategies

To increase vegetable production not only to meet requirement of population but also increase per capita income of marginal farmers. The public and private sectors should exchange the inbred lines in liberal way to develop elite hybrids and their seed multiplication at cheap rate. The Govt. should support financially to the SAUs/ Institutions/vegetable growers to strengthen teaching, research and extension activities. Application of biotechnological approaches for production of high yielding and disease resistant hybrid vegetables.

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