Concept Paper

Techniques of hybrid seed production in cucurbitaceous vegetables

ASHISH KUMAR and RAHUL KUMAR*

Division of Genetics, *Division of Vegetable Science
Indian Agricultural Research Institute, Pusa 110012 New Delhi, India
Email for correspondence: rahulvegiari@gmail.com

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ABSTRACT

The exploitation of hybrid vigor through the use of hybrid varieties is one of the major achievements of plant breeding. The introduction of hybrid crop varieties has enabled the farmers to increase productivity owing to hybrid vigor and increased uniformity. To produce hybrid seeds a pollination control system is needed to prevent unwanted self-pollination. The availability of quality seed is of utmost importance for increasing the vegetable production. Vegetable growers recognize quality seed of improved varieties as the most strategic resource for higher and better vegetable yield. Although India ranks second in vegetable production in the world after China, the quality vegetable seed production in the country has been insufficient. Over the decade new pollination control systems have been developed with the aid of genetic engineering mainly based on the generation of nuclear encoded male sterility. The successful application of these systems for large scale hybrid seed production depends on whether the male-sterile female parent line can be multiplied efficiently and economically. Further low inbreeding depression, high heterosis percentage, large number of seeds per fruit and low seed rate requirement per unit area give distinct advantage in commercial exploitation of heterosis in cucurbitaceous vegetables. The increase in vegetable production is limited due to continued decrease of landholdings. Hybrid vegetable technology is one of the better options to fulfill country's requirement of food and nutritional security and poverty alleviation. Tremendous efforts have been made by both public and private sectors for developing hybrid seeds in several vegetables including cucurbitaceous vegetable crops.

Keywords: Seed; cucurbits; production; vegetables; hybrid; breeding; technology

INTRODUCTION

India is the second largest producer of fruits and vegetables in the world. Total area under vegetable crops is 9.36 Mha and production is 162.89 MT. India produces 14 per cent of world's vegetables on 15 per cent of world area under vegetables. Productivity of vegetables in India (17.3 tonnes/ha) is less than the world average productivity (18.8 tonnes/ha) (Anon 2014). With current level of vegetable production (162 MT) in the country, population (1210 million) and considering 25 per cent postharvest losses and 5 per cent export and processing value, per capita consumption of vegetables in our country is 230 g as against 300 g recommended dietary allowance (RDA).

Heterosis (hybrid vigor) in plants is defined as the increase in vigor and productivity resulting from differences in parental gametes. Hybrid (F_1) varieties are produced by controlled crosses between two distinct groups of parents usually inbred lines. Hybrid varieties of crop plants are used when the increased yield from heterosis is more than to be paid for their development and the extra cost of seed production involved. Chen (1988) reported that although heterosis has been observed in nearly every crop the use of hybrids has been limited to those crops for which there is availability of an economically viable and effective means of pollination control (practices that are used to prevent self- or sib-pollination of the female parent thereby ensuring hybridization between the female and male parents). The two most widely used methods of pollination control are the manual emasculation of the male flower or flower parts and the incorporation of genetic mutations that prevent normal pollen development.

Cucurbits are important group of vegetables in whole of the world and are consumed as salad (cucumber, gherkin, long melon), sweet (ash gourd, pointed gourd), pickles (gherkin, bitter gourd, ivy gourd), desserts (melons) and as vegetables (all except melons). The family Cucurbitaceae consists of about 118 genera and 825 species. The major cucurbits grown in India are cucumber, watermelon, pumpkin, squashes, muskmelon, ash gourd, snake gourd, ridge gourd, smooth gourd, bottle gourd, round gourd, bitter gourd, pointed gourd, ivy gourd and gherkin. They exhibit wide range of variability since they have either originated or domesticated in India. Among the vegetable crops cucurbits are distinct group where sex mechanism is unique and can be easily manipulated for production of F_1 hybrids. Different methods are being employed for the production of hybrid seeds in cucurbits.

Bagging of female flowers and hand pollination: This has been most common method employed in cucurbits like pumpkin because of its large showy flowers. A day prior to anthesis the female flowers on the plants of female parent are covered by butter paper bags or petals are tied with rubber band or clip. In the afternoon hours of the same day male flowers on the plants of female parent which will open next day are protected from pollen contamination by bagging or tying the petals. In the next day morning (6.30-11 am) pollens are applied on the stigma of the protected female flowers. After hand pollination the female flowers are again bagged or petals are tied. This practice is applicable in most of the cucurbits but not in muskmelon because of its andromonoecious nature of sex expression. F_1 seed is collected from the mature fruits harvested from the plants of female parent.

Emasculation and hand pollination: This method is exclusively practiced in muskmelon where andromonoecious sex form is predominant. In the plants of female parent the hermaphrodite flowers are emasculated a day prior to anthesis and protected by bagging. The male flowers on the plants of intended male parent are also protected and pollination is done in the early morning of next day. Hybrid seed is collected from the mature fruits harvested from the plants of female parent. Here emasculation of male part is tedious.

Pinching of male flowers: Production of hybrid seeds by this method is the most simple and economical and can easily be adopted by the growers who can identify male or female flowers. F_1 hybrid production in different gourds can economically be done on large scale by pinching all the male flowers before opening from the female parent and allow the male parent to grow side by side of female parent for natural cross-pollination. One row of male parent can be down after every three rows of female parent as suggested by Choudhary and Singh (1971) for producing F_1 hybrid seeds on large scale in bottle gourd. All the fruit set in female parent would be possible necessarily through cross-pollination by insects. Therefore as a precaution there should not be a single male bud in female parent as it will promote self- or sib-pollination within the female parent. Anthesis of the flowers of bottle gourd is taken in afternoon; the pinching operation should therefore be done in the forenoon. Isolation distance between different varieties should be kept about 400 metres. As the male flowers in bottle gourd, pumpkin and squash are quite big, showy and having long pedicels the pinching operation can easily be performed. But in luffa where male flowers are produced in racemes pinching of male buds will not be complete and effective. For maximum fruit set and seed yield availability of pollination is prerequisite. One or two medium size bee colonies per hectare would be enough in seed production block.

Use of gynaecious sex form: Gynoecy is the condition where all the flowering nodes in the main, secondary and tertiary branches produce pistillate flowers in the leaf axils and is by far the most important sex form which has made phenomenal exploitation of hybrid vigour possible in cucumber and also in muskmelon. Frankel and Galun (1977) and Loy et al (1979) advocated the use of gynoecious lines in hybrid seed production. It is observed that gynaecious sex forms are stable only under moderate regimes of temperature and photoperiodic conditions. When temperature exceeds more than 30°C the stability of gynoecious sex expression is affected and irregularity in sex form can be obserbed. Homozygous gynoecious lines are maintained by using GA3 1500 ppm (Peterson and Anhder 1960) or at silver nitrate 200-300 ppm (Owen et al 1980) or silver thiosulphate 400 ppm (Beyer 1976) to induce staminate flowers when sprayed at two and four true-leaf stage. Hybrid seed of cucumber Pusa Sanyog is being produced by using gynoecious female parent. Muskmelon cultivar named MHL-10 a cross between W1 998 x Punjab Sunheri was released for commercial cultivation in Punjab and WI 998 was used as female parent which was an introduced gynoecious line (Lal and Dhaliwal 1993). At IARI, New Delhi two gynoecious lines in bitter gourd (*Momordica*

charantia L) have been isolated from indigenous source and named as DBGy-201 and DBGy-202 which could help in future hybrid seed production in bitter gourd (Behera et al 2006.)

Utilization of male sterility in muskmelon: Five recessive nuclear male sterile genes (ms-1, ms-2, ms-3, ms-4 and ms-5) are known till date. The ms 1 (Bohn and Whitaker 1949) is quite popular and most utilized till date. The genetic male sterile line ms-1 (genotype ms-1) of muskmelon was introduced in India long before by Punjab Agriculture University. Punjab hybrid (MS-1) is the result of cross between a male sterile (ms) line and a cultivar named Hara Madhu which was used as male parent. The male sterile line is to be removed from the female line. For this purpose anthers of anthesis flowers from each plant of the female parent are pierced with needle in the early morning. Male fertile flowers give light yellow powdery mass while in male sterile plants anthers produce sticky green immature pollen grain. Identified male sterile plants are tagged every day.

Use of monoecious line: Considering the problems associated with the use of male sterile gene(s) for production of muskmelon hybrid (maintenance of single recessive gene in heterozygous condition and problem of identifying and rouging of 50% male fertile plants from the female row at the time of flowering and also to overcome the andromonoecious forms) the scientists at IARI, New Delhi took keen interest in developing true breeding monoecious lines viz M1, M2, M3 and M4. Pusa Rasraj is developed by utilizing M3 as female parents with male parent Durgapura Madhu. It was found to have outstanding performance and has been released for commercial cultivation.

Chemical suppression of male flowers and open pollination: Sex modification with the help of growth regulating substances has given very significant results in cucurbits. It has now been possible to prove that the two true-leaf stage is the most responsive stage for application of chemicals for sex modification. Specific chemicals are known to induce femaleness or maleness as desired. In cucurbits like bottle gourd, pumpkin and squash female flowers can be increased by the application of ethrel (2-chloroethyl-phosphoric acid) at the rate of 200-300 ppm at two true-leaf and four-leaf stages. Ethrel helps in suppressing the staminate flowers and initiating pistillate flowers successively in the first few flowering nodes on the female parent (Singh and Choudhary 1985). The row of male parent is grown by the side of female parent and allowed natural cross pollination. In the absence of insect pollinators hand pollination is possible when two sexes are separate. Four to five fruit-sets at initial nodes containing hybrid seed would be enough for sufficient seed yield. Complete suppression of male flowers in squash can be achieved at higher concentration of 400-500 ppm ethrel applied twice to make hybrid seed production comparatively easier.

Future thrusts

India is centre of origin of several cucurbitaceous vegetables. High genetic variability present in these crops has not been fully utilized in our country. This genetic variability can be successfully utilized in hybrid breeding programmes. Hybrid seed production technology must be popularized in riverbed areas covering major part of total cultivable area of cucurbits in India. Therefore farmers can be ready to adopt the competitive costs of hybrid technology. Higher and early yield and uniform and superior fruit quality from hybrid technology in riverbed cultivation can give the farmers a premium price of their produce by fetching early market. Reported male sterile lines and gynoceious lines in different cucurbits have poor stability and they generally breakdown under high temperature conditions. Efforts should be made to develop stable tropical gynoecious and male sterile lines linked with market and their proper utilization in heterosis breeding programme so that hybrid seed becomes cheaper and is within the reach of average vegetable grower. Hybrids in low value crops like summer squash, pumpkin etc have to be developed. Efforts should be made to develop F_1 hybrids which can suit the requirement of international market. Attempts should be made to develop multiple disease resistant hybrids more particularly for muskmelon and cucumber which are highly susceptible to several diseases. There is an urgent need for efficient management of hybrid seed production and strengthening of extension network so that hybrid technology of cucurbits in a package can be transferred to the farmers along with the supply of hybrid seeds.

REFERENCES

Anonymous 2014. Indian horticulture database 2014. National Horticulture Board, Ministry of Agriculture, Government of India, 289p.

Behera TK, Dey SS and Sirohi PS 2006. DBGy-201 and DBGy-202: two gynoecious lines in bitter gourd (*Momordica charantia* L) isolated from indigenous source. Indian

Journal of Genetics and Plant Breeding **66(1):** 61-62.

Beyer Jr EM 1976. Silver ion: a potent antiethylene agent in cucumber and tomato. HortScience **11:** 195-196.

Bohn GW and Whitaker TW 1949. A gene for male sterility in the muskmelon (*Cucumis melo* L). American Society for Horticultural Science **53:** 309-314.

Chen SR 1988. Vegetable breeding. Agriculture Press, Beijing, China, 122p.

Choudhury B and Singh B 1971. Pusa Meghdoot and Pusa Manjari, two high yielding bottle gourd hybrids. Indian Horticulture **16:** 15-16.

Frankel R and Galun E 1977. Pollination mechanisms, reproduction and plant breeding. Springer-Verlag, Berlin, Heidelberg and New York.

Lal T and Dhaliwal MS 1993. Performance of selected muskmelon hybrids over environments. In: Symposium on Heterosis Breeding in Crop plants: Theory and Application, Ludhiana, Punjab, India, pp 34-35.

Loy JB, Natti TA, Zack CD and Fritts SK 1979. Chemical regulation of sex expression in a gynomonoecious line of muskmelon. Journal of the American Society for Horticultural Science **104:** 100-101.

Owen KW, Peterson CE and Tolla GE 1980. Production of hermaphrodite flowers on gynoecious muskmelon by silver nitrate and aminoethyoxyvinylglycine. HortScience **15:** 654-655.

Peterson CE and Anhder LD 1960. Induction of staminate flowers on gynoecious cucumbers with gibberellin A_3. Science **131:** 1673-1674.

Singh RK and Chaudhary BD 1985. Biometrical methods in quantitative genetics analysis. Kalyani Publishers, Ludhiana, Punjab, India, 318p.