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Conventional and Biotechnological Approaches for Sex Manipulation in Cucurbits

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SUMMARY

Sex manipulation is attributed to alter the ratio of male to female flowers within the individuals. A wide range of variation in sex forms ranging from primitive hermaphrodite to gynoecious advanced sex form is observed in cucurbitaceous vegetable crops. Sex expression in cucurbitaceae family is regulated by environmental, genetic and hormonal factors. In general, female sex expression is promoted by low temperature and short photoperiod, which may influence the level of endogeneous hormones (ethylene, auxin and GA) which in turn influence the sex expression. Sex inheritance plays an important role in breeding programme. The reduction in sex ratio, stabilizing the gynoecious character and development of stable gynoecious inbred parents is the main objective of cucurbit breeding programs. Identification of sex expression in the initial stage of the crop with the help of biotechnological tools like marker assisted selection (MAS) may be employed.

INTRODUCTION

The cucurbit vegetables are the largest and diverse group comprised of 900 species classified under 130 genera (Jeffrey, 1964; 1980) belongs to the family Cucurbitaceae. The members of Cucurbitaceae family exhibit a fascinating range of sex namely staminate, pistillate and hermaphrodite flowers resulted in evolution of several types of sex forms like monoecious (staminate and pistillate flowers produces in the same plant), gynoecious (pistillate flowers producing plants), andromonoecious (staminate and hermophrodite flowers in the same plant), gynomonoecious (pistillate and hermaphrodite flowers produces in the same plant), androecious (plant with staminate flowers only), trimonoecious (staminate, pistillate and hermophrodite flowers produces in the same plant), gynodioceous (pistillate and hermaphrodite plants segregate separately from base population), dioecious (staminate and pistillate flowers are produced in separate plant).

A wide range of variation in sex forms owed to evolve from primitive sex form hermaphrodite could lead to evolution of predominant sex form i.e. monoecious and advanced sex form i.e. gynoecious (Robinson and Decker-Walters, 1999). Sex manipulation is the process of altering male and female flower ratio within the individuals of a species, the sex modification leads to alteration in the sequence of flowering phenology by modifying beneficial sex ratio in order to enhance the economic yield.

Sex inheritance plays an important role in cucurbit breeding, sex expression mainly influenced by genetical and environmental factors. The monoecious plants are characterized by three phases of flowering, i.e. an initial period where only male flowers are produced, secondly equal proportionate of male and female flowers are produced for maximum period and finally predominate in female flowers production.

Evolution of Sex Expression in Cucurbitaceae

The original and primitive sex form of cucurbits are assumed to be hermaphrodite nature, and evolutionary changes had been occurred in later generations might be due to the

vagaries of environmental factors, the dominant mutation effect may lead to the modification of sex from hermaphrodite to the intermediate sex forms like andromonoecious, trimonoecious and gynomoecious, furthermore advancement in the evolutionary genetic and environmental changes might cause for modification of androecious, monoecious and gynoecious (Robinson and Decker-Walters, 1999). Sex expression in cucurbits is easily manipulated by controlling the environmental conditions as well as genetic factors, hence these two factors are major effect on sex manipulation. The nongenetic factors like environmental effect, cultural practices, plant growth regulators, and genetic factors like breeding behaviour and genetic constitution plays a significant role in altering the sex expression of cucurbits with the aid of conventional breeding methods and intervention of biotechnological approaches.

Non-Genetic Factors

Influence of environmental effect on sex expression

Sex expression mainly influenced by environmental factors, attributing female sex expression is promoted by low temperature, short photoperiod and high moisture availability, (Atsmon and Galun, 1962; Atsmon, 1968), which intern encourages the buildup of carbohydrates. The high temperature and long photoperiod results in male flower production (Cantliffe, 1981). The phenomenon of sex expression is influenced by environmental factors on production of endogenous hormones especially ethylene, auxin, gibberellic acid and chemical composition, may cause for different expression of sex forms, the ratio of staminate to pistillate flowers greatly varies when the monoecious plants are grown under different environmental conditions (Robinson and Decker-Walters, 1997; Achakzai; Kayani, 2002; Achakzai, 2012). Positive correlation between ethylene release and percentage of nodes and number of female flowers were recorded highest at 28°C/ (6h 18°C+6h 12°C) day/night temperatures. The enhanced female flowers in monoecious cucurbits is not directly regulated by low temperature or low night temperature, but these conditions lead to accumulation of the glucose and sucrose in the shoot apex under certain temperatures, through hexokinase-mediated sugar signalling pathway (Miao *et al*., 2011).

Influence of cultural practice on sex expression

Cultural practices like irrigation, nutrient application and season of planting plays a minor role in sex manipulation, unfavourable growing conditions such as lack of water can cause a slowdown in flower production, higher application of nitrogen results in more vegetative growth intern reduces reproductive stage and lead to the delayed flowering. Mineral nutrients might alter sex expression in plants through effects on hormonal balance (Salisbury and Ross, 1969). The season of planting during higher rainfall results in lesser flower production, whereas planting during hot seasons produces more male flowers and less female flower production. Sub-optimal application of nitrogen, phosphorus, potassium nutrients has been reported to depress flowers and encourage male flowers rather than female flowers (Kraup *et al.,* 2002).

Role of growth regulators on sex expression

Growth regulators have tremendous effects on sex expression and flowering in various cucurbits lead to suppression of male flowers or an increased number of female flowers (AlMasoum and Al-Masri, 1999), without imposing any deleterious effect on environment and human health. Growth regulators can alter the sex ratio and sequence if applied at the two- or four-leaf stage, which is the critical stage at which the suppression or promotion of either sex is possible (Hossain *et al.,* 2006). The male to female flower ratio of cucumber plants is also regulated by plant hormones, ethylene and auxin promote the formation of female flowers, whereas gibberellins promote the formation of male flowers.

Genetic Factors

Breeding for sex manipulation traits

A wide range of variation in sex forms ranging from hermaphrodite to monoecious forms is observed in cucurbitaceous vegetable crops (Robinson and Decker-Walters 1997). Among these the gynoecious sex (only female flowers) form has been commercially exploited worldwide for cucurbit breeding programme. Development of hybrids in any crop is expensive (Behera, 2004). However, the utilisation of gynoecy is economical and easier for exploiting hybrid vigour in many cucurbitaceous crops. Hybrid varieties of cucurbits are predominantly used in the production system, the proportion of hybrid varieties is continuously increasing and thus, gynoecious lines in cucurbits are important for economic production. Development of hybrids in cucurbits is expensive because of hand pollination. However, it can be made inexpensive by the utilisation of gynoecy which is economical and easier for exploiting hybrid vigour.

Different sex forms in cucurbits

Sex forms	Cucurbits
Monoecious (♀ and ♂)	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 (♀ and ♂ in separate plant)	Pointed gourd, Ivy gourd,
Andromonoecious (♂ and in same plant)	Muskmelon, Water melon, Cucumber
Gynomonoecious (♀ and in same plant)	Cucumber, Musk melon, Ridge gourd
Trimonoecious (♂, ♀and in same plant)	Cucumber
Hermaphrodite	Ridge gourd (Satputia)

Biotechnological Intervention in Sex Manipulation

The monoecious (M-ff) cucumbers hypothesized to produce two types of flower buds namely one produces more ethylene and the other produces less ethylene (Yamasaki *et al.*, 2001). Development of male and female specific markers at early identification of male and female plants and efficiency in improving of dioecious vegetables (Ivy gourd, Pointed gourd, Spine gourd and Asparagus etc.) as well as transferring the desirable gene governing sex character in to the required plants adapting tissue culture techniques for mass multiplication of gynoecious lines and biotechnological approaches import a crucial role in which RAPD marker associated with gynoecious trait (gy-1 gene) in bitter gourd had been revealed namely, OPZ 13 marker of 700 bp produced specific band in gynoecious lines makes easy identification of gynoecious lines in bitter gourd (Mishra *et al.*, 2014).

CONCLUSION

Sex manipulation in cucurbits plays an important role in the reduction of sex ratio. Gynoecious lines acts as a male sterile line in cucurbitaceous vegetables. Henceforth, stabilization of gynoecious trait and development of stable gynoecious inbred parents will be helpful in hybrid development programs. The mechanism affecting sex expression and identification of the genes governing the sex character is possible through specific molecular markers. In dioecious crops, the molecular markers linked to gynoecious trait are useful in early identification of sex at earlier stage of the crop.

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