Concept Paper

Breeding cucumber for quality improvement

RAHUL KUMAR, JITENDRA KUMAR MEENA* and NEERA YADAV*

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

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ABSTRACT

Cucumber quality traits like fruit colour, shape, size and its nutritional quality are of prime importance for breeders to improve the crop. Quality in vegetables is a complex character influenced by both genetical and environmental factors. Breeding for quality has been unsystematic and often empirical but significant progress has been made in several vegetable crops. Conventional breeding in conjunction with biotechnology has bright prospects of developing vegetable varieties high in nutraceuticals, edible colours and bioactive compounds suitable for fresh market as well as for food industry. The final goal of cucumber breeding programmes is to develop new improved varieties having elite combinations of many desirable horticultural characteristics. Consumers are seeking new nutritionally rich vegetable varieties/hybrids for new nutrient rich cuisines, different quality attributes and improved convenience and are ready to pay a premium for such produce if their expectations are met and under these circumstances cucumber rich in quality aspect is most demanding.

Keywords: Cucumber; quality; breeding; crop improvement

INTRODUCTION

There are around 795 million (Anon 2015) undernourished people around the world today meaning thereby that one in nine people does not get enough food to lead a healthy and active life. Vegetables are considered essential protective food for well-balanced nutritional diets. Cucumber (*Cucumis sativus* L) is a member of Cucurbitaceae family comprising 90 genera and 750 species (Whitaker and Davis 1962).

Cucumber being originated in India has wide morphological variation in terms of growth habit, fruit size, colour etc (Staub and Bacher 1997). The chief evidence for this is the presence of *C hardwickii* Royle, a cucumber-like plant in the foot-hills of the Himalayas in India. Since *C hardwickii* crosses freely with *C sativus* this has led to the conclusion that *C hardwickii* is either a feral or progenitor form of the cultivated cucumber (Deakin et al 1971).

Cucumber cultivars are currently classified as either pickling or slicing types. Total production of cucumber in the world is 57.55 MT of which India's share is 15.17 MT (26%) (Anon 2015). The productivity of cucumber in India is 6.34 MT/ha as compared to the average world productivity of 30.23 MT/ha. The flesh of cucumber is very good source of vitamins A, C and folic acid. The hard skin is rich in a variety of minerals including calcium, potassium and magnesium. Cucumber has got cooling effect so fruits are often used as cooling vegetable. It is ideal for people suffering from jaundice and allied diseases and also very much useful in preventing constipation. Its seeds contain oil which is helpful for brain development and body smoothness. Hence it is being used in Ayurvedic preparations (Robinson and Decker-Walters 1999). Besides the whole fruit is used in cosmetic and soap industries.

Floral biology, crop behavior and sex expression

Cucumber is an annual and day neutral plant. Within *C sativus* staminate, pistillate and hermaphroditic flowers occur in various arrangements. Cucumbers are primarily monoecious ie bearing separate staminate and pistillate flowers on the same plant. Male flowers occur in clusters with each flower on a slender stem and having three stamens. Female flowers are usually solitary with stout and short pedicel and have an inferior distinguishable large ovary.

Anthesis takes place around 5.00 AM to 7.30 AM and dehiscence of anther around 4.00 AM to 5.00 AM. Pollen remains fertile for 7 to 8 hours after anthesis. Honeybees are the major pollinating agents of cucumber. The optimum time for pollination is between 9:00 AM to 12:00 noon. Cucumber pollen is sticky and not actively collected by bees. To ensure adequate pollination bees should visit the flowers at least 12 to 15 times for normal fruit development.

The normal and common cucumber in India is a semi-vining to vining type having green to pale green fruits, bitter near the stem end, monoecious plant having a female-male sex ratio of 1:15 to 1:30. The crops require 18-25°C temperature for seed germination while best plant growth and fruiting are at 20-30°C and best fruit set when pollination done between 17-25°C.

Breeding methods followed in cucumber for quality improvement

Breeding method in any crop for quality improvement depends upon the breeding system and genetic architecture resulting from natural selection as well as human selection during the course of evolution. The genetic architecture or the pattern of inheritance of characters is another important aspect while determining the appropriate breeding method applicable to any crop.

The choice of breeding method is largely guided by the crop's nature of gene action and relative magnitude of additive genetic variance, dominance variance and epistasis in a breeding population. Earlier selections from local material in India like Balam Khira and Poona Khira or introductions like Poinsette, Japanese Long, Green and Straight Eight were most popular cultivars among farmers. Cucumber does not show inbreeding depression. Therefore several breeding methods are applicable to this crop. Mass selection can be commonly practiced in cucumber wherein the best individual plants are selected on the basis of phenotypic characters and their open pollinated seeds are mixed for raising the succeeding generations. Since mass selection is made exclusively on the phenotypic performance of the mother plant without any progeny test the success of selection depends largely on the heritability of the character under selection. This method is effective in improving simply inherited and highly heritable qualitative characters like skin color, fruit shape, spine colour and other quality traits in cucumber.

Inbreeding and individual plant selection through pedigree breeding can also be practiced effectively in cucumber. Cucumber has been identified as a crop with limited genetic variability. Populations derived from adapted breeding lines have been found to contain little genetic variability. Therefore selection within adapted would be expected to progress slowly. Because of the narrow genetic base a source population with broad genetic base should be more responsive to selection for quantitative and qualitative traits.

Population improvement approach based on recurrent selection theoretically allows greatest long term gain and may be required to improve traits of low to moderate heritability substantially. However population having narrow genetic base may exhibit little response to such breeding procedure. Since most of the adapted cucumber breeding lines and varieties have a very narrow genetic base, population improvement within adapted material is not likely to give expected return. So enrichment and incorporation of unadapted and exotic germplasm in the breeding population is the need of the hour for improvement of desirable quantitative and qualitative characters in cucumber.

The phenomenal success in heterosis breeding in cucumber is mainly due to manipulation of sex expression to the desired direction. The genetic control of sex mechanism in cucumber especially of the gynoecious sex form has made it possible to exploit heterosis. Attractive fruit skin colour like light green/ green, uniformly long cylindrical fruits with smooth surface without prominent spines, prickles, crookneck and crispy with tender flesh are the primary objectives of breeding for the quality characters in cucumber. The wild relatives like *C hardwickii, C setosus*, *C callosus* and *C hystrix* add variability for different qualitative and quantitative traits. Fruits free from carpel separation and bitterness and with less seed at edible maturity are the major objectives of the breeder.

Efforts were also made in the development of cultivar with bunching fruit habit producing multiple pistillate flowers on individual nodes for harvesting finger size fruits to suit whole fruit canning for export a novel character available in its wild progenitor, *C hardwickii* Royle. Newly developed multiple branching cultivars which are also known as little leaf types produce more fruits at the same stage of maturity. Besides pickling cucumber cultivars have also been bred to withstand carpel separation in order to prevent bloating during the brining process.

Breeding for high carotenoid content

The carotenoid pigments which are present in fruit colour of cucumber are an important source of vitamin A. In contrast to other cucurbits fruits of cucumber typically lack mesocarp or placental pigmentation.

A distinct group of cultivars known as Xishuangbanna gourd classified as *C sativus* var *xishuangbannesis* (Qi and Yuan 1983) is the new source for high carotenoid content to breed cucumber. The rind of this variety is white, yellow or brownish-orange sometimes with distinct netting, smooth with yellow to orange flesh colour which is rich in provitamin A carotenes. An effort was made to improve the nutritional value of cucumber by the introgression of β-carotene (orange flesh) genes from Xishuangbanna gourd into pickling cucumber from US. Three varieties namely Early Orange Mass 400, Early Orange Mass and Late Orange Mass 404 were produced from the cross between US pickling cucumber lines and orange-fruited Xishuangbanna cucumber (PI 509549) from China (Simon and Navazio 1997). Progeny segregations indicate that two recessive genes control the β-carotene content in the mesocarp while one recessive gene controls β-carotene content in the endocarp (Cuevas et al 2010).

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