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# Chilli an Important Vegetable and Spice Crop: A Review on Biology, Cultivation, Breeding and Biotechnology

Mali Ram Nehra

Lecturer, Agriculture , Botany, S.C.R.S. Government College, Sawai Madhopur (Rajasthan), India

**ABSTRACT:** Chilli (*Capsicum annuum* L.) is an important vegetable spice crop in many respects. Various types of chilli peppers are cultivated and used for various purposes such as vegetables, brine, spice, and condiment in daily life. Chilli is an important ingredient in many cuisines around the world. The pungency, red color and oleoresin content of chilli peppers are of particular importance for processed foods as well as for export purposes. Capsanthin coloring matter and oleoresin content are of particular importance in the food and spice industries. Adds flavor, aroma and texture, pungency, color and spiciness. The pungency of hot peppers is due to the accumulation of capsaicinoids, a group of alkaloids native to the genus *Capsicum* (Sun *et al.*, 2015). Capsaicinoids are synthesized in placental tissue localized inside the fetus, and the seed is attached with the same structure (Wahyuni *et al.*, 2013) Naga Jolokia, the world's hottest chilli, is grown in India's Assam region. Farmers grew chilli alongside their staple crop to protect it from the damage the birds could cause. It became popular in America as a flavoring agent. In the 16th century, chilli peppers were popular in Asia and the local Asian climate was well suited to the crop. Chile has many healing properties and is used in the Ayurveda system of traditional Indian medicine. India has become the world's largest producer and exporter of chilli peppers. It accounts for 25% of the world's chilli production.

**KEYWORDS:** Chilli, Breeding, Origin, Botany, Nutritional value

### I. INTRODUCTION

Chillies belong to the genus *Capsicum* (Solanaceae family), which is one of the most cultivated groups of species in the world. These diverse species are grown worldwide for vegetable, spice, ornamental, medicinal, and lachrymator uses and are a significant source of vitamins A and C. *Capsicum* is native to the tropical and subtropical Americas, and the majority of the genetic diversity is concentrated in Bolivia, Peru, Brazil, and Mexico. This genus comprises over 30 species, and *C. annuum* is the most widely cultivated and economically important one. *Capsicum annuum* was domesticated in Mexico thousands of years ago and includes both sweet and spicy fruits, with a myriad of shapes, colors, and sizes.

The remnants of wild chili peppers recovered at various locations in Coxcatlan cave in the Tehuac, Mexico and those identified in the GuilaNaquit cave in the Oaxaca, Mexico indicate that chillies were harvested in the wild in Mexico more than 8,000 years ago, and their domestication and cultivation for the first time in Mesoamerica occurred approximately 6,000 years ago. It is believed that seed dispersal was performed by wild birds, while selection and domestication by humans gave rise to various types of fruit morphology and degrees of pungency. The chilhuaclechilli is an endemic crop of the Canada Region in the State of Oaxaca, Mexico the only place in the world where it is produced.

Common hot chilli (*Capsicum annuum* L., Solanaceae,  $2n=2x=24$ ) is one of the vegetables or spices known and used all over the world for its green fruits and pungency. Popularly called "*capsicum*", it is actually a non-pungent sweet pepper or SimlaMirch with a blocky fruit shape. The word *capsicum* has been derived from the Greek word *Kapsimomeaning* Capsaicin ( $C_{18}H_{27}NO_3$ ) is responsible for the pungency in chilli, it is a condensation product of 3-hydroxy-4-ethoxybenzylamine and decylenic acid. The red color of chili is due to the presence of Capsanthin, which is actually a mixture of esters of capsanthin, capsorubin, zeaxanthin, cryptoxanthin and other carotenoids. The chilli fruit contains an

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essential oil Oleoresin that is used in pharmaceutical, food, and beverage industries for the preparation of value-added products

## II. ORIGIN AND DISTRIBUTION

Christopher Columbus discovered the pepper in tropical America and introduced it to Europe in 1493. The pepper, which is thought to be native to Mexico and Peru, was widely used in Central and South America before Columbus' discovery. It spread so quickly that three types of pepper were brought to India in 1542. Since most European languages refer to paprika as a type of pepper, attempts have been made to distinguish it from pepper by creating new words for it. Batavian physician Jacob de Bondt coined the term *Piper chilensis* in 1630. Pepper traders in Java also tried to give it a different name from pepper, but that didn't come up. Some types of peppers are also called peppers. Pepper species are divided into two types: *Capsicum annuum* L. and *Capsicum frutescens* L. The fruits of *Capsicum frutescens*, also known as capsicum, are sharper than paprika. *Capsicum annuum* is also known as sweet pepper. Capsicum is an easy-to-grow herb that is grown commercially in almost all tropical countries. The most common red peppers in Singapore are small peppers, thin peppers and long, thick green peppers. Pepper bushes are perennial and short-lived. They can reach 1.5 m in height. The stems are woody, fleshy, erect or semi-prostrate at the bottom. The bush has one taproot and many lateral roots. The leaves can grow up to 12 cm long and 7.5 cm wide and are pointed, unevenly shaped. Pepper flowers appear singly or in small clusters of two to three flowers. They are small, hermaphrodite, and each has five or six leaves. *Capsicum annuum* has white-green flowers while *Capsicum frutescens* has yellow or white-green flowers. Pepper fruit is hollow and contains many seeds. They come in different colors such as green, orange, white, yellow and red. Sharpness varies from one breed to the next. Capsicum gets its color from a pigment called capsanthine and has a pungent flavor due to a chemical called capsaicin. Not to mention that small peppers also contain capsaicin.

### Morphology

Chilli (*Capsicum annuum* L.) Herbaceous or semi-woody annual plant in early growth stage, but later becomes woody. Old branches become brittle and break easily with age. It has a straight, woody stem and ovate leaves with pointed, pointed tips, up to 15 cm in size, dark green above and pale green below. The leaves are simple, alternate, pubescent, oval, lanceolate, and glossy. The leaf area and leaf length of one plant are 1000-3000 sq. cm and 0.5-2.5 cm. Chilli plants have strong rectilinear roots that usually break or stop during transplantation, resulting in the development of many branched lateral shoots up to 1 m long. The entire root system is more active, although confined to the topsoil to a depth of 30 cm. Nutrient roots are found at a depth of up to 10 cm at the base of the plant.

### Botany

In most cultivated chilli species, the diploid number of chromosomes is  $2n = 24$ . It is called a self-pollination crop through Chilli and some texts report up to 62% cross-pollination, with insects mainly responsible for natural mating. As such, it can be treated very well as a cross-pollinated or often cross-pollinated crop. The flowers are bisexual and protist. Flowering, fecundity, and sigma receptivity of anthers are maximized on the day of flowering. The stigma is sensitive 24 hours before and after flowering. Fruits are berry-like and vary considerably in color, shape, size, and pungency.

### Nutritional value

Chilli peppers are known to be one of the major sources of carotenoids, precursors of vitamin A and ascorbic acid (vitamin C). They contain high levels of carotenoids and L-ascorbic acid at maturity, having 0.33–336 RE/100 g RDA for vitamin A and 124–338% of the vitamin C activity. Among various vitamins, ascorbic has strong antioxidant properties towards free radicals because of its reducing power due to its enediol structure, which is conjugated with the carbonyl group in a lactone ring. Thus, it is often involved in the study of degenerative or chronic diseases prevention, as free radicals are major factors in these diseases. The concentration of vitamin C is dependent on fruit maturity and pungency. Ripe chili pepper fruit with high pungency levels possesses a high content of vitamin C

### Climate and soil

Chilli is a diurnal crop, suitable for year-round cultivation in tropical and subtropical climates, but does not tolerate prolonged frosts. A temperature range of 15 to 35°C is optimal for satisfactory growth rates and yields. Sweet peppers

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require a slightly milder climate. For peppers, plant growth slows down when the soil temperature is below 100°C. During fruit ripening, low temperatures delay color development. At temperatures above 40°C, fruit set is poor and flowers and fruits drop severely. Chilli requires 600-1200 mm of precipitation. Peppers suffer from unstable temperature regimes, insufficient watering, heavy rains and dry winds, especially during flowering, can cause buds, flowers, fruits to fall, leaves to fall, and plant rot. Crops can grow in a variety of soils, but aerated, well-drained, organic-rich loam works best, and crops grow best in a soil pH of about 6.5. Plant growth and yield are higher in heavy soils, but fruit quality is better in light soils

### Genetic and Breeding

#### Breeding Objectives

- Desirable fruit shape and size, fruit shape, □wrinkleness, fruit colour, seed content and pungency in Indian context.
- Superior fruit quality i.e., pleasing flavor, high sugar/acid ratio, high pigment content and vitamin C in bell pepper and high capsaicin, a fat soluble, □flavourless, odourless and colourless compound.
- High □oleoresin in chilli.
- Resistance to diseases i.e., fruit rot, cercospora leaf spot, powdery mildew, bacterial □leaf spot, phytophthora root rot, root knot, common leaf-curl virus.
- Resistance/tolerance □to insects i.e., thrips, mite, aphid, fruit borer.
- Resistance/ □tolerance to abiotic stresses i.e., heat, water stress, salinity.
- Rejuvenation □ability after winter in hot pepper in north India.
- High yield Colour retention in dry Chillies on drying.

The choice of pepper breeding method depends on the purpose of breeding and the initial plant material. The goal of pepper breeding is to produce superior plants with superior genetic yield potential, protection from production hazards and improved quality. Traditional selection includes mass selection, pedigree method, single-seed origin method - SSD method, backcrossing method, and repeated selection. Molecular selection methods: molecular markers, transformation.

■ Bulk Selection: Seeds from the best plants are saved for the next growing season. Oldest method. This method should be used for highly heritable traits as well as populations with genetic variability and selection in the environment in which the trait appears (Nsbyeraet *al.*, 2013) .

■ Pedigree method: Keep records of matings and their offspring. This includes selection and self-pollination of individual plants (Oliveira *et al.*, 2015)

■ Single Seed Method - SSD: This method involves advancing generations without selection. It is also used in the development of recombinant inbred lines. Advancement of generation can be performed in greenhouseutilized this method to obtain lines restant to bacterial spot.

■ Backcross: Used particularly for traits controlled by one or few genes, which involves selection of individual plants and successive crosses to a recurrent parent (Prakashet *al.*, 2014).

■ Recurrent selection involves selection individuals from a population followed by intercrossing to form a new population (Singh *et al.*, 2014).

■ Molecular breeding Modern plant breeding uses techniques of molecular biology to select, or in the case of genetic modification, to insert, desirable traits into plants. Marker Assisted selection: Different genes can influence a desirable traits in plant breeding. Thousands of genes can be mapped using tools such as molecular markers or DNA fingerprinting. Isoenzyme and molecular markers were applied to the peppers. A saturation isoenzyme and restriction fragment length polymorphism (RFLP) map of chili peppers has been reported. This map contains 192 chili pepper genomic DNA clones with 19 linkage groups with a total span of 720 cm. This area of research is rapidly expanding our knowledge of chili peppers and will be important in the tissue culture in vitro clonal.

### Biotechnology

Propagation is a key tool in biotechnology that exploits the totipotency of plant cells, a concept introduced by Haberlandt (1902). Tissue culture combined with molecular techniques is used to incorporate specific traits through gene transfer. Highly efficient and reproducible pepper plant regeneration potential. Regeneration has been achieved to

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some extent through organogenesis, and other methods such as regeneration of protoplasts into plants are also being explored. Gunay and Rao (1978) reported that cotyledons as explants in a combination of BA& IAA hormones are indirect somatic organogenesis of *Capsicum annum* and *Capsicum frutescens* species, hypocotyls, epidermis, stem leaves, roots, shoot apex and embryos for explants. Seed were used as explant for organogenesis in the hormone combination BA(2.22uM)+NAA(0.54uM) by Ebida and Hu in 1993. Harini and Lakshmisita (1993) studied direct and indirect somatic embryogenesis of mature and immature zygotic embryos. Ms-media supplemented with auxin and tidiosuran (TDZ) for both direct and indirect somatic embryogenesis recorded green and brilliant reproduction, and this combination was proposed by Venkataiah et al., (2003).

### III. CONCLUSION

Plant tissue culture and genetic transformation are powerful tools that can complement traditional breeding methods and can be used in the improved production of capsicum. Molecular markers are used to characterize the genetic structure of individuals and populations. Plant breeders also use it as a tool in selection process, Via marker-assisted selection provides more detailed information of relationship and evolution about more than 20 alkaloids involved in process that gives pungency solely in *Capsicum* genus. Furthermore, the complete pepper genome sequencing allows advancement of new associations between genomic studies and important characteristics such as fruit size, fruit production, pungency, abiotic stress tolerance, nutritional content and disease resistance. Thus, the usage of new technologies will continue to advance becoming an essential tool, combined with traditional techniques of selection and crosses already established in *Capsicum* peppers genetic breeding. The most important aspect of chilli breeding is to incorporate pest, disease resistance varieties, while retaining high yield capacity.

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