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A Review on Parthenocarpy Vegetable Importance and Approaches

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Parthenocarpy (literally meaning a virgin fruit) is the natural or artificially induced production of fruit without fertilization of ovules. Seedlessness is a desirable trait in edible fruits with hard seeds (pineapple, banana, orange, grapefruit) also desirable in fruit crops that may be difficult to pollinize or fertilize. In dioecious species (e.g., Persimmon), pathenocarpy increases fruit production as staminate trees do not need to be planted to provide pollen. Increases shelf life due to reduced ethylene generated by seeds. Improves processing quality & ultimately increases profitability. The biological function of the fruit is the protection of embryos and seeds during their development and the facilitation of seed dispersal after maturation. The onset of fruit development from the ovary, the so-called fruit set, occurs after fertilization of the ovules. Fertilization of the ovule generally triggers the ovary development into fruit (Nancy, 2015) [35] . The processes of seed and fruit development are intimately connected, synchronized and controlled by phytohormone (Pandolfini, 2009) [38]. Thus, the signaling processes are required for the development of the fertilization products necessary for the initiation of seed and fruit development (Raghavan, 2003) [41]. Various phytohormone, especially gibberellins, cytokinins and auxins, are involved in the signalling processes that follow pollination and fertilization and these are the main requirements for further growth and development of seeds and the fruit (Fos et al., 2001) [14]. Developing seeds are source of phytohormone and stimulate the fruit growth and development (Ozga et al., 2002) [37]. However, in some vegetables presence of seeds in fruit are undesirable due to hard or leathery texture, bitter taste and presence of toxic compounds, allergens and effect on the palatability (Dalal et al., 2006) [10]. Seedless fruits are desirable for improving the quality of fresh as well as of the processed fruit and it has been observed in cucumber, eggplant watermelon and tomato (Denna, 1973; Varoquaux et al., 2000; Yin et al., 2006) [12, 65, 72] . Therefore, replacing the seeds and seed cavities with edible fruit tissue is an attractive offer to the consumers and challenge to the researchers.

Parthenocarpy is the growth of ovary into seedless fruit in the absence of pollination and fertilization. It may occur naturally or can be induced artificially by exogenous application of hormones or their enhanced endogenous level. Parthenocarpy improves the yield, quality and processing attributes of vegetable crops like cucumber, eggplant and watermelon, where seed is a limiting factor during consumption. Parthenocarpic vegetables increase profitability for processing industries. It may occur naturally or can be induced artificially by exogenous application of hormones or their enhanced endogenous level. This trait proved highly useful to develop fruits under environmental conditions that are unfavorable for successful pollination and fertilization, particularly in green house cultivation and especially in cross-pollinated crops. In the ever-changing global scenario of the world, security for the nutrition in the country is the important issue for agricultural sector. Vegetables occupy an important place in diversification of agriculture and have played a vital role in food and nutritional security of evergrowing population of our large vegetarian

society. Vegetable consumption per capita in India is very low and that is only around 230.4 g per day against minimum of about 300 g recommended by dieticians so there is a great demand for production of more quantities of vegetables with high quality and reduces postharvest loss by increase a storage life as well as processing. The absence of seed is usually appreciated by consumers and producers because it increases fruit quality and fruit shelf life. It is an established fact that phytohormones play important role in fruit setting and their genetic manipulation can lead to seedlessness. Therefore, present review is focused on importance, approaches and potential of parthenocarpy in vegetable crops

Types of Parthenocarpy

Natural or genetic Parthenocarpy: Genetic Parthenocarpy is called obligatory, when expression of the Parthenocarpic trait is not influenced by external factors and is facultative, if occurs only under adverse conditions for pollination and fertilization. Elevated level of endogenous hormones in the ovary in the absence of pollination and fertilization causes the natural Parthenocarpy (Nitsch, 1970; Gillaspy et al., 1993) [36, 16]. It has been reported in various crops like grape (Wong, 1941) [68] , tomato (Groot et al., 1987) [19], mandarins (Talon et al., 1992) [57], banana (Gustafson, 1939) [20] , pointier (Weiss et al., 1993) [67] , Pepion (Prohens et al., 1998) [40], eggplant (Yoshida et al., 1998) [73], cucumber (Yan et al., 2010) [71] and capsicum (Tiwari et al., 2011) [63]. Genetic parthenocarpy can solve the problem of low pollen viability and poor pollen release, which often occurs under low light, low or high temperatures under open and greenhouse conditions.

Artificial parthenocarpy: It involves the stimulation for the growth of a fruit using both natural and artificial plant hormones. The induction of parthenocarpy is a common agricultural practice for some horticultural species (Schwabe and Mills, 1981) [48] . The exogenous use of irradiated pollen, natural or synthetic auxins and gibberellins increased IAA content during ovary development (Tsao, 1980) [64]. This resulted in elevated levels of endogenous phytohormones during parthenocarpic fruit set and development from sources other than seeds (Talon et al., 1992) [57]. Therefore, in Arabidopsis and a variety of agricultural species the parthenocarpy can be induced with exogenous application of auxin, cytokinins, or GAs (Smith and Koltunow, 1999; Ramin, 2003; Serrani et al., 2007) [42, 49]. Nitsch (1970) [36] defined that a plant is Parthenocarpic, if it exceeds a threshold in the concentration of growth regulators during a critical period at anthesis. In eggplant, the first increase takes place during the first five days after an thesis, while a major peak of IAA appears at 20 days after an thesis in both pollinated and auxin treated flowers (Lee et al., 1997).

Exploitation of parthenocarpy in vegetable crops

Parthenocarpy is an economically valuable trait in number of horticultural crops. Consumers often prefer seedless fruit for aesthetic and quality reasons, because many such fruit have more attractive appearance, added convenience in terms of preparation, consumption and processing. Parthenocarpic cucumber does not require pollination, even though, it is a cross-pollinated crop. Combination of parthenocarpy and gynoecism gave added advantage of yield and palatability of cucumber (Denna, 1973) [12]. In eggplant, parthenocarpy improves fruit quality and reduces the labour needed for its out-of-season cultivation. Since the commercial ripeness of eggplant fruits precedes its physiological maturity, the presence of seeds considerably depreciates the value of fruits for both fresh and processed market. The negative effects associated with the presence of seeds have a faster and more intense browning of the fruit flesh upon cutting, increased saponin and solasonin compounds causing bitter taste and hard flesh. The absence of seeds increased the shelf life of the fruits for better conservation (Aubert et al., 1989) [3]. This effect was also observed in watermelon, where seeds are the origin of fruit deterioration (Varoquaux et al., 2000) [65] . Further, in tomato seedless fruits

are tastier than the seeded variety. The Parthenocarpic tomato does not require removal of seed during processing. Seedless tomatoes have 1% more dry matter, more sugars, less acidity, less cellulose and more soluble solids than seeded cultivars (Lukyanenko, 1991) [30]. An important advantage of Parthenocarpic plants is that they set and develop fruits under environmental conditions that are unfavourable for successful pollination and fertilization, particularly greenhouse cultivation (Yin et al., 2006; Gorguet et al., 2008) [72, 18] .

Cucumber: Cucumber is a predominant greenhouse crop, which can be grown throughout the year, especially during offseason under protected condition that fetches higher price in very short span (Panghal et al. 2016) [39]. There is a constant demand throughout the year for cucumber, especially the smooth skinned seedless fruit because of its popular use in salad dish, sandwich, pizza and other preparations (Bisht et al., 2011) [7] . In fact, gynoecious and Parthenocarpic cucumber hybrids have revolutionized greenhouse industry throughout the world. However, the popularity of each hybrid has its own specificity depending on adaptability to particular growing conditions such as stability regarding pistillate flowering (More 2002), and local market demands for specialized fruits. The precocity or earliness for fruit bearing and harvest is the desired characters for early summer production that fetches high price. Additionally, the cultivar may have high yield potential and good commercial quality that relates to consumers preference. Special emphasis is to be laid for commercial exploitation of greenhouse for off-season cultivation of selected vegetables such as Parthenocarpic cucumber (Cucumis sativus L.), as this despite providing good yield and quality, is more remunerative (Yadav et al. 2014) [70]. Parthenocarpy has long been known to occur within the species of (Cucumis sativus L.) and parthenocarpic fruit development has long been recognized as an important characteristic for greenhouse cucumbers (Sturtevant 1890). Most greenhouse cultivars of slicing cucumbers grown today can set Parthenocarpic fruit, and Parthenocarpic pickling cultivars are of major importance in Europe (Tatlioglu, 1992) [58]. Response of fertilizers and training systems on Parthenocarpic cucumber var. Dinamik under NVPH. They reported that combination of 150% RDF (where, RDF i.e., 90 kg N, 75 kg P2O5 & 75 K2O) through fertigation and single stem training in Parthenocarpic cucumber gives higher yield as well as more LAI after 30 and 60 days respectively Kumar et al. (2014). Kumar et al. (2015) observed hybrid KPCH-1 was best in term of days to harvest, no. of fruits per plant, yield per plant, yield/100 m2 and parthenocarpy.

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