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Sesame (*Sesamum indicum* L.), an underexploited oil seed crop: Current status, features and importance – A review

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ABSTRACT

Sesame is important oilseed crop of tropical and sub tropical region, renowned for its high oil content (up to 60% oil), hence sesame is known as the king of oil seeds. Sesame seed oil contains 83% - 90% unsaturated fatty acids, 20% proteins and various minor nutrients such as vitamins and minerals, large amount of characteristic lignans, such as sesamin, sesamol, sesamolin and tocopherols. Sesame seeds with high amounts of nutritional components are consumed as a traditional health food for its specific antihypertensive effect, anticarcinogenic, anti-inflammatory and antioxidative activity. Besides food, sesame also finds its uses in application areas such as pharmaceutics, industrial, and as biofuel. Sesame is used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellants, and anti-tubercular agents. In spite of being a good source of "healthy oil" in terms of presence of high amounts of PUFA and high antioxidant content, it is not grown on a large extent due to very poor yields. Therefore, serious efforts are necessary for selecting varieties of good quality and high adaptive potential to the diverse climatic situations. There should be effective strategies adapted to produce climate ready sesame variety using modern biotechnological approach.

Key words: Antioxidant, Edible oil, Nutracitical, Sesamin, Sesame.

Sesame (*Sesamumindicum* L.) belonging to the order Tubiflorae, family*Pedaliaceae*is an important oil seed crop being cultivated in the tropics as well as in the temperate zone of the world (Biabani and Pakniyat, 2008) and cultivated for its high quality oil (Chung *et al.*, 2003).It is cultivated mainly in the Asia, Africa and Southern America. It was cultivated and domesticated on the Indian subcontinent during Harappan and Anatolian eras (Bedigian, 2003). Sesame contains high amount of oil (up to 60%), hence sesame is known as the king of oil seeds (Sharma *et al.,* 2014**).** It was reported that the sesame hulls possess considerable antioxidant activity due to the presence of high level of phenolic compounds (Chang *et al.*, 2002).Beside food, sesame has also many potential applications in other areas such as pharmaceutics, industrial and as biofuel. Sesame is used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellants, anti-tubercular agents (Bedigian *et al.*, 1985) and considerable source of Phosphorus, Iron, calcium, tryptophan, methionine, valine , niacin and thiamin (Ojiako *et al.,* 2010). Among the edible oils, sesame oil has the highest antioxidant content (Cheung *et al.,* 2007) and possesses plentiful fatty acids.

Status of sesame production: Sesame is cultivated on 10.56 M ha worldwide. The Asian countries like Myanmar, India and China are the world's largest producers of sesame, followed by Sudan, Tanzania (FAOSTAT, 2015). In 2014, the total world production was about 5.46 million tons that was grown on 10.56 M ha. The annual area put under it in India is about 2-3million hectares (13.1 % per cent of the world hectarage) and the total production is nearly 81lakh tones (FAOSTAT, 2015). Sesame is grown in only eight Indian states, *viz.* Uttar Pradesh, Rajasthan, Madhya Pradesh, AndhraPradesh, Maharashtra, Gujarat, Tamil Nadu and Orissa. In the remaining states including North East India, it isgrown only on a small area as a minor crop. Because of low productivity and competition from other edible oil seeds such as soybean, sunflower, peanut, the sesame could not manage its ranking over the others oil crops in developing country like India.

Taxonomy and habitat: Sesame, a member of Pedaliaceae family, is an annual shrub with white bell-shaped flowers with a hint of blue, red or yellow with or without branches (Martin and Leonard, 1967). There are different colours of sesame like, creamy-white to charcoal-black. This crop is best suited in tropical climates, sandy, well drained soil with hot climate and moderate rainfall particularly in India, China, South America and Africa. The leaves vary from ovate to lanceolate and are hairy on both sides. The flowers are purple to whitish, resembling foxglove, followed by 3 cm capsules/ fruits containing numerous seeds (McCormick, 2001). The

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India has been reported to be rich in diversity, especially in cultivated sesames. In India, besides the cultivated species *Sesamumindicum*, six more wild species have been reported. These include *S. malabaricum*, closest wild relative of cultivatedsesame (2n = 26) sharing same chromosome number with the *S. indicum*, an intermediate species complex, *S. mulayanum*(2n = 26), *S. prostratum*, *S. laciniatum*(2n = 32) and the two introduced African species, *S. radiatum*(2n = 64) and *S. alatum*(2n = 26). Two species, *S. laciniatum*and *S. prostratum*, grow in Africa and India (Pathak *et al*, 2014). The observableseed colour show range from black to pure white (Ramanujam and Joshi, 1951). Bandila *et al*., (2011) accessed the level of diversity in relation to geographical origins and morphological characteristics of a total of 60 accessions collected from different parts of the India.

Nutritional, medicinal and industrial uses of sesame: Sesame seed contains high amounts of (83% - 90%) unsaturated fatty acids, mainly linoleic acid (37% - 47%), oleic acid (35% - 43%), palmitic (9% - 11%) and stearic acid (5%-10%) with trace amount of linolenic acid (Kamal-Eldin *et al*., 1992). The high levels of unsaturated (UFA) and polyunsaturated fatty acids (PUFAs) of sesame oil enhance the quality of the oil for human consumption and plays an important role in preventing atherosclerosis, heart diseases and cancers (Miyahara *et al*., 2001). Carbohydrates in sesame seed are composed of 3.2% glucose, 2.6% fructose and 0.2% sucrose along with dietary fibers. Sesame seeds are excellent source minerals like copper, calcium, phosphorous, iron, magnesium, manganese, zinc and vitamin B1. Sesame lignans have health promoting activities as well as antioxidant properties. (Nakai *et al*., 2003). Sesame seeds contain two unique compounds, *viz*sesamin and sesamolin, which prevent high blood pressure and increase vitamin E supplies in animals (Kamal-Eldin *et al*., 1995). Sesame oil contains sesaminol and sesamolinol,that promotes the integrity of body tissues in the presence of oxidizing compounds (Morris, 2002). The total phytosterol content in sesame seeds is around 400 mg/100 g, which is higher as compared to English walnuts and Brazil nuts (113 mg/100g and 95 mg/100 g, respectively) (Phillips *et al*., 2005).

A chlorinated red naphthoquinone pigment possessing antifungal activity, named chlorosesamone has been reported from sesame root (Hasan *et al*., 2000). Three anthraquinones, Anthrasesamones A, B and C were isolated from the root of sesame (Furumoto *et al*., 2003).

Sesame can inhibit the growth of malignant melanoma *in vitro* and the proliferation of human colon cancer cells. Sesame oil heals and protects areas of mild scrapes, cuts and abrasions (Jeng and Hou, 2005). Sesame seed oil maintains good cholesterol (high density lipoprotein, HDL) and lower bad cholesterol (low density lipoprotein, LDL) (Yasumoto *et al*., 2001). Sesamin binds to and activates a receptor in the body called Peroxisome Proliferator-Activator Receptor Alpha (PPARalpha). Activation of PPARalpha increases gene expression of the fatty acid oxidation enzymes and decreases gene expression of lipogenic enzymes. In other words, sesamin increases the fat burning process and decreases the storage of fat in the body (Penalvo *et al*., 2006). Sesame seed consumption increases plasma γ tocopherol and enhances vitamin E activity, which is reported to prevent cancer and heart diseases (Cooney *et al*., 2001).

Jellin *et al*., (2000) also reported uses of sesame oil as a therapy for gum disease, treat toothaches, relieve insomnia and also used as an antibacterial mouthwash by Chinese and Indian in the history (Morris, 2002). Sesamin, one of the major components of lignan of sesame seeds, has received a great deal of interest regarding its potential as a hypocholesterolemic agent (Hirata *et al*., 1996). The chemical composition of the white sesame cultivar showed relatively high protein content (25.18%) Bahkali *et al*., (1998), which is in good agreement with few Indian sesame cultivars (25.4%) reported by Dhawan *et al*., 1972. The sesame is rich in methionine and tryptophan. Since these amino acids are absent in vegetable protein, sesame meal or flour can be added to recipes to give a better nutritional balance to health food products (Quasem *et al*., 2009).

Other application: Sesame oil has been reported as a source for biodiesel and found to give a product with fuel properties (Ahmad *et al*., 2010). Hasan *et al*., (2000) extracted chlorosesamone from roots of sesame and found it possess antifungal properties. Sesame flowers have been used to prepare perfumes in Africa (Morris, 2002). The antioxidant sesamin is used as a synergist for pyrethrum or rotenone insecticides and increases the toxicity of insecticides when sprayed against flies (Haller *et al*., 1942).

Wild relatives as genetic resources: Wild relatives of crop plants have contributed many useful genes to crop species. These modern of crop varieties contain genes from their wild relatives and are essential constituent for increasing food security and maintaining the environment. Wild sesame species are reported to possess several desirable traits such as high harvest index and other yield components, determinate growth habit with uniform ripening, early maturity, photo and thermal insensitivity, high seed retention, high nutritional quality (high oil and protein, high sesamin and sesamolin contents, reduced anti-nutritional factors and oxalic acid in seeds). *Indian*-1 and *Indian*-2 are wild relatives sesame located mainly on Indian sub continent are having good morphological and yield attributes. Wild sesame species are tolerant to many pests and diseases *i.e.* resistance to biotic (*Phytophthora*blight, *Cercospora*spot, *Alternaria*leaf spot, phyllody, leaf curl virus etc. and abiotic (waterlogging, drought and salinity) stresses (Pathak *et al*., 2014).

Conservation strategies: The aim of conservation is to conserve genetic resources for potential future research and it should support basic studies and improvement of crops. The presence of a large number of uncharacterized accessions is a limitation in effective utilization of genetic diversity (Pathak *et al.*, 2014). Core collections of sesame germplasm have been established by the National Bureau of Plant Genetic Resources (NBPGR) of India in collaboration with the International Plant Genetic Resources Institute (IPGRI). Thus, NBPGR maintains 6658 accessions of sesame where 4136 are indigenous and 2522 are from exotic sources (Bisht *et al.*, 1998).Large sesame collections are available at National Gene Bank at NBPGR, New Delhi with 9630 accessions stored for long term conservation at "20ÚC in the cold modules and 255 *Sesamum*species maintained at cryobank(NBPGR data, 2013, www.nbpgr.ernet.in). Earlier, sesame core has been developed for indigenous sesame comprising of 343 accessions (Bishit *et al.*, 1998). The Gene Bank of Rural Development Administration (RDA) located in Suwon, Korea have collected 7698 sesame accessions, that consist of 3538 exotic collections, 2660 indigenous collections, 1072 improved genetic stocks and 428 others (Kang *et al.*, 2006).

Sesame breeding: Globally, India is the largest producer, consumer and exporter of sesame. As per the Solvent Extractor's Association of India(SEAI), the area under sesamecrop is 19.81 lakh hectares with a production of 8.87 lakh tonnes during 2015-16. India ranks first in the worldwith respect to area under sesamecultivation. (Anonymous, 2016). In spite of being a good source of "healthy oil" in terms of presence of high amounts of PUFA and high antioxidant content, sesame is not grown on a large extent due to very poor yields (Furat and Uzun, 2010). Lack of improved varieties and reduced acreage under cultivation are the reasons for low seed yield. Sesame production is also limited by pests, diseases, lack of uniform maturity of capsules (Langham and Wiemers, 2002). In spite of huge sesame germplasm collections available in India, limited study efforts on the use of conventional and biotechnological methodologies have resulted in minimal success in developing biotic and abiotic stress-tolerant cultivars. The absence of efficient *in vitro* regeneration protocols further provides challenges for development of desired novel sesame genotypes (Pathak *et al.,* 2014).Therefore serious efforts are needed for selecting varieties of good quality and high adaptive potential to the current global climatic situations. Conventional sesame landraces are an important source of genetic diversity and form the backbone of sesame breeding programme, which remain largely unexplored. Genotypic diversity is tremendously important in selecting the parents for hybridization programmes. Genetic diversity in sesame can be assessed using morphological, agronomic characteristics, isozyme analysis, and DNA marker analysis (Reiter *et al.,* 1993). Only a limited number of reports are available on the use of molecular markers such SSR (Dixit *et al.,* 2005). Characterization of genetic diversity of these cultivars by molecular markers is of great value to assist parental line selection and breeding strategy blueprint (Wu *et al.,* 2014). SSRs are a valuable tool for estimating genetic diversity and analyzing the evolutionary and historical development of cultivars at the genomic level in sesame breeding programs Spandana *et al.,* (2012).These novel SSR markers are valuable tool for genetic linkage map construction, genetic diversity exposure, and marker-assisted selective sesame breeding.(Wei *et al.,* 2014).

CONCLUSION AND FUTURE SCOPE

The cultivation practice for sesame crop is simple and appropriate for various ecological conditions ranging from tropical to sub tropical area. There is a tremendous application of sesame seed as a multinutient capsule due to the presence of high oil (83% - 90%) with unsaturated fatty acids as well as proteins, vitamins, minerals and high amount of antioxidant properties. Sesame seed has a potential application as a source nutraceuticals for human to prevent malnutrition as well as global food security. Besides, there is also enough scope for development of different value added sesame products. Various effective strategies should be adapted to produce climate ready planting material to fit the current global environment using modern breeding techniques.

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