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Importance of Oilseed Crop Sesame (*Sesamum indicum* L.) : A review

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ABSTRACT

Demand to sesame in the market increases. Fatty acids composition of sesame oil determines its commercial value. Both potential and actual yield levels are needed to be increased by breeding and agronomy to obtain high yielding sesame crops with high quality worldwide. The properties of sesame that have been studied in the last 10 years in the world mainly on topics of oil, protein, processing, breeding, genetic, agronomy and allergy are briefly given in this review.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an erect annual plant which is a member of *Pedaliaceae* family (Sharma et al., 2021). Growth habit of sesame plants is indeterminate, generally tall and branched (Tripathy et al., 2019). The cultivation history of sesame starts 5000 years ago (Miao et al., 2021). Its seed oil is a part of the daily edible oil for half of the global population (Wei et al., 2014). Sesame oil presence increases in Western diet (Nachshon et al., 2019). Fatty acids composition of its oil determines its commercial value (Kadkhodaie et al., 2014). Sesame seeds are rich in folic acid (Kapoor et al., 2015). These seeds are used for the decoration of bread and cookies, to produce paste, to add to dishes and to produce tahin. Sesame oil is a salad and cooking oil (Elleuch et al., 2011). Antibacterial activity of sesame seeds for *Staphylococcus* and *Streptococcus* was also reported (Anilakumar et al., 2010). Seed sprouts are vegetables consumed in Asian folk (Liu et al., 2011).

2. SESAME OIL

Demand for vegetable oils is rising with increasing world population (Islam et al., 2016). Sesame has high oil content and quality. Unsaturated fatty acids, proteins and antioxidants in its seeds are attractive and increasing consumption of sesame seed products (Zhang et al., 2019). The lignans (sesamin, sesamol etc.) adds pharmaceutical properties to its oil (Dutta et al., 2021). The *γ*-tocopherol is the most abundant tocopherol in its oil (Wan et al., 2015). Sesame oil has antioxidant properties which prevents oxidative decay and improves storage quality (Islam et al., 2016). A germplasm set of 54 indigenous sesame varieties from India was analysed for fatty acid and lignan content and composition of their seed oil by Bhunia et al., (2015). The varieties varied for composition of fatty acid and lignan. Detected values range were 10–22% for palmitic, 5–10% for stearic, 38–50% for oleic, 18–43 for linoleic and lower than 1% for α-linolenic acids. Also 3–37% sesamol, 27–67% sesamin and 20–59% sesamolin shared total lignan content. The highest α-linolenic acid percentage was 1.3% of the total fatty acids (Bhunia et al., 2015).

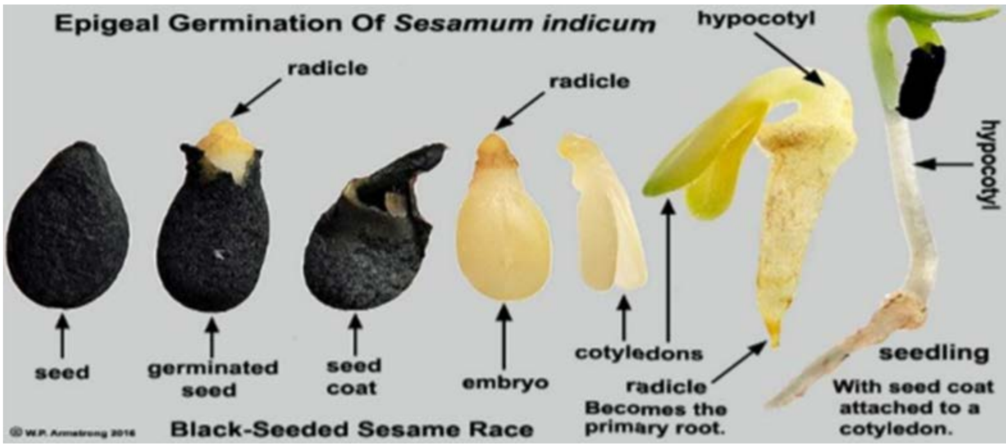

Fig. 1. Germination of sesame seed (Khatoon et al., 2019)

3. EXTRACTION OF SESAME SEEDS

Increasing demand to sesame in the market is triggering the development of sesame industry (Zhang et al., 2021). Significant amount of waste (bran) is produced as a result of processing plants of sesame that may be used as animal feed (Görgüç et al., 2019). The oil of sesame seeds can be extracted by simple solvent extraction and expelling processes. Alternatively, supercritical extraction can also be used which is more technologic (Nagendra Prasad et al., 2012). Sesame seed processing industry generates high quantities of phenolic-rich by-products as a natural sources of antioxidants (Mohdaly et al., 2013). Sesame oil flavor significantly depends on roasting conditions and volatile concentrations content. Concentration of aroma volatiles (pyrazines, furans, and sesamol) increase with increasing seed roasting temperature. Instead, alcohols and aldehydes decrease with increasing roasting temperature. Acceptable sesame oil aroma requires appropriate processing (Xu-Yan et al., 2012).

4. SESAME PROTEİNS

Plant proteins are cheaper compared to animal proteins (Sharma et al., 2016). An important by-product of sesame seed pressing is sesame seed meal (sesame oil cake). It is a good source of protein (Omer et al., 2019). It is rich in sulfur-containing amino acids (methionine). Nearly 15–25% of the dry weight of sesame seeds (30–50% of the defatted sesame cake mass) are proteins. Two storage proteins are abundant; 11S globulin ratio is 60–70% and and 2S albumin ratio is 15–25% of total sesame proteins (Tzen, 2021). Pulses and other crops are deficient in methionine, tryptophan and valine but seeds of sesame are rich for those (Sharma et al., 2021). Their seeds are also rich in phytates compared to soybeans (Sharma et al., 2021). Sesame seed cake is generally used as cattle feed in many countries (Sarkis et al., 2014).

5. SESAME ALLERGY

Sesame is an increasing allergen (Saf et al., 2020). As an allergen, it is affecting approximately 0.1% of the population in North America. In the Middle East, it is one of main reason for anaphylaxis (Adatia et al., 2017). In another study, Warren et al., (2019) estimated that 0.5% of the US population reported sesame allergy in past. Sesame seed food allergy was increased worldwide during past 20 years. It is estimate that sesame seed food allergy affects 0.1–0.2 % of the population where sesame is consumed. This ratio is relatively low (nearly ½ of cow’s milk allergy) (Dalal et al., 2012). European Union was added sesame in the allergens food list and sesame added products require information on labels (Mühlenbein & Pfützner, 2018).

6. GENETICS

In wide agro ecological zones in the world, many different varieties of sesame exist (Nagendra Prasad et al., 2012). Sesame is not transformed genetically yet (Yadav et al., 2010). Low yield is a major constraint for its cultivation (Jayaramachandran et al., 2020). Inherently low genetic yield potential and susceptibility to biotic and abiotic stresses are the reasons for low productivity of sesame. Development of stress tolerant high yielding varieties is needed (Jyothi et al., 2011). The gap between the potential and realized yields in sesame is very high due to capsule shattering and sensitivity to a biotic and abiotic stresses (Tripathy et al., 2019). Sesame plant leaf shape affects development of plantlets and seed yields. Leaf and capsule regulation by breeding and high harvest mechanization adaptation may improve yields in sesame (Zhang et al., 2018).

Figure 2. Pods (upper photos) and corresponding seeds (lower photos) of sesame harvested at different stages of development (Stage 1 is early, Stage 5 is mature) (Chandra et al., 2019)

Genomic studies on sesame have started late but during 2010-2015, extensive progresses were experienced on this crop in genomics. Functional markers, genes and QTLs linked to important agronomical traits and association analysis were generated by linkage mapping but much of these data are ununified and distributed in different publications (Dossa et al., 2016). Mutagenesis, interspecific hybridization, somaclonal variation and somatic hybridization can be used for sesame breeding. Identification of candidate genes and QTLs (quantitative trait loci) and monitoring them in breeding cycles by molecular markers can be used for sesame improvement. Crop's biosystematics and floral biology are also needed attention (Tripathy et al., 2019). Plant architecture modification is required to increase harvest index. Selection for medium plant height (approximately one meter) with high capsule density starting from 15-20 cm above the soil level is needed (Tripathy et al., 2019). Male sterility is an effective phenotype for sesame hybrid production (Zhou et al., 2019). Most of the 20,000 sesame germplasm accessions exist in the world is mainly in South Korea, China, India and in a few African countries. Sesame is the sole cultivated *Sesamum* species for seed production. Narrow genetic base prevents acceleration in sesame breeding but absence of enough number of elite accessions also reduces improvements. Mutagenesis was succesfully applied to develop new sesame germplasm and varieties in past (Ju et al., 2021).

7. AGRONOMY

Sesame production is common in marginal and semi-marginal lands (Pandey et al., 2017). Its cultivation is between latitudes 30 S to 43 N (Langham et al., 2021). Sesame crop is widely grown in tropical and subtropical countries as a major oil and protein source (Wang et al., 2014). It is grown typically by smallholders mainly in developing countries. Inappropriate fertilizers usage is among the major constraints for its production (Zenawi & Mizan, 2019). Seed yield and quality siginificantly get affected from drought stress (You et al., 2019). Genotype and drought stress affect quality and quantity of extractable oil (Kadkhodaie et al., 2014). Sesame is commonly cultivated in marginal areas under diversified stress factors in the world. Crop yield loss is high especially under waterlogging, chilling, salinity and heavy metals stress (Islam et al., 2016). Research to improve traditional seed harvest methods and postharvest processes are needed to improve agronomic capacity of crop (Mushtaq et al., 2020).

Sesame has wide diversity in root morphology. High root biomass helps plant to improve aboveground biomass and seed yield which are determined by multi-environmental trials (Su et al., 2019). Eighteen lines were evaluated by correlation analysis to determine the major traits effecting seed yield of sesame in a study of Ramazani (2016). Significant negative correlations were determined between seed yield and number of capsules/plant and number of seeds/capsule parameters. Number of seeds/capsule produced highest negative direct effect on sesame seed yield. Indirect highest negative effect on sesame seed yield was related to the capsule number/plant through the seed number/capsule (Ramazani, 2016).

Many abiotic and biotic stress factors reduce the biomass accumulation and rainfed sesame seed yield (Mehmood et al., 2021). Sesame is tolerant to drought and poor soils but affected from diseases and waterlogging. High and stable yield is prerequisite but increasing mechanization level for harvest will increase global sesame production (Zhang et al., 2019).

8. CONCLUSIONS

Demand to sesame in the market increases. Fatty acids composition of sesame oil determines its commercial value. Both potential and actual yield levels could be increased by,

- increasing harvest index
- modification of plant leaves and capsules
- hybrid variety production
- utilisation and unification of new developed genomic tools
- researches on plant biosystematics, floral biology, root morphology and biomass production
- breeding activities via interspecific hybridization, somaclonal variation, mutagenesis and somatic hybridization.
- obtain crops with medium plant height (approximately one meter) and high capsule density starting from 15-20 cm above the soil level via by agronomic applications or breeding.
- reduced capsule shattering
- reduced susceptibility to biotic and abiotic stresses (drought, waterlogging, chilling, salinity and heavy metals stress)
- improve traditional seed harvest methods and postharvest processes
- non-allergen varieties.

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