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Why does sesame still yield less? Challenges and opportunities for enhancing productivity

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Intricacies of the subject

Sesame (*Sesamum indicum* L.) occupies first position in oil content among the major oilseed crops and it is regarded as "Queen of Oilseeds". It also possesses higher nutritional and economic benefits. Despite being the producer of higher oil content, its productivity has remained stagnant for decades completely contrast to the yield gains achieved in other oilseeds. This article examines the most common constraints responsible for low yield such as capsule shattering, indeterminate growth, narrow genetic diversity, biotic and abiotic stress and rainfed cultivation and further deliberates how modern breeding approaches ranging from utilization of wild relatives and landraces to genome editing are transforming sesame improvement. Integrating traditional breeding with advanced genomic tools and following appropriate crop management practices, creating awareness among farmers helps in breaking the long-standing yield barriers in sesame.

Introduction

Sesame is one of the oldest cultivated oilseed crops in the world. Global sesame consumption is steadily increasing due to high demands related to its unique nutritional values such as higher contents of antioxidants (lignans, flavonoids, phenolics, tocopherol and melatonin), Vitamins (A and E), minerals, dietary fibres, and healthy fatty acids (oleic acid, linoleic acid) besides carbohydrates and protein. With the increasing knowledge on the dietary and health benefits of sesame, the market demand for its seed and oil is likely to increase. Some of the benefits like lowering of cholesterol levels, hypertension and reducing the incidence of certain cancers promotes use of sesame oil as a cooking medium. Improving the production and productivity of this oilseed crop is, hence, paramount to alleviate the alarmingly growing demand for oil and seeds. Over period of time, major oilseed crops in India have experienced more productivity driven by high-yielding cultivars, improved crop management practices and policy initiatives like the Technology Mission on Oilseeds (TMO). While sesame productivity has grown at a significantly lower rate. Since the 1960s, average groundnut yields in India have increased from roughly 700-800 kg/ha to over 1,700-1,860 kg/ha, while rapeseed and mustard productivity more than doubled from around 500-600 kg/ha to 1,400-1,500 kg/ha. Similarly, soybean, after its major commercial expansion in the late 1970s and 1980s, established average yields around 1,000-1,200 kg/ha. In contrast, Indian sesame productivity stagnated for decades, moving from an average of 200-250 kg/ha in the 1960s to only about 450-520 kg/ha today.

Why is sesame productivity low?

Shattering of capsules: This is one of the most unique challenges of sesame. The capsules which are matured, split open very easily resulting in the falling of seeds onto the ground either before or during harvest, consequently leading to lower yields.

Indeterminate growth: Cultivated sesame still has some wild characters including indeterminate growth habit and asynchronous capsule ripening leading to poor seed yield.

Cultivation under rainfed conditions: Mostly, sesame is cultivated under rainfed conditions and the crop depends entirely on the rainfall. If there is delayed onset of monsoon or a prolonged dry spell, it leads to soil moisture deficit. Moisture stress during flowering and capsule formation often reduces seed formation, thereby reducing yields.

Susceptibility to pest and diseases: Sesame is affected by several pests such as leaf roller, Gall fly, sesame leafhopper, Hawk moth and Bihar hairy caterpillar. Maggots feed inside the floral buds, leading to the formation of a gall like structure which do not develop into flower / capsule. The affected buds wither and drop, resulting in yield loss. Sesame is also affected by several diseases such as phytophthora blight, stem and root rot, bacterial blight, bacterial leaf spot, cercospora leaf spot, powdery mildew and phyllody. Due to phyllody, all the floral parts are transformed into green leafy structures and such plants generally do not bear capsules, but even if capsules are formed on the lower portion of the plant, they do not yield quality seed.

Narrow genetic diversity: Although sesame has been cultivated for a long time, it possesses a narrow genetic base. This is majorly due to domestication (Bottleneck effect), repeated selection of a few elite genotypes, limited use of wild relatives and the self-pollinating nature of the crop. It leads to a reduction in genetic diversity and limits progress in breeding programs.

Modern breeding approaches: The breeding Approaches to prevail over these multiple challenges, there is necessity for combining classical breeding along with modern genomic tools, which is paving a new way for sesame breeding.

Utilisation of wild relatives and landraces: Wild relatives and landraces contain valuable genes for improving the cultivated sesame. S. alatum reduces the yield loss caused by the diseases phyllody and powdery mildew by providing resistance genes. *S. angustifolium* helps in producing stable yields under higher temperature and moisture stress conditions by providing genes for heat and drought tolerance. The use of these wild species in breeding programs, either through pre breeding or introgression helps in extending the genetic base and assists in the development of high yielding, disease resistant and climate resilient varieties (Bedigian, 2015; Yadav *et al.*, 2022).

Marker assisted selection: MAS is an efficient tool for improving sesame breeding by allowing the early selection of plants that contain desirable genes. Recent studies have identified markers that are linked to important agronomic traits such as capsule indehiscence, flowering time, plant height, oil content and lignan content. The turning point was the discovery of SiCD locus controlling capsule indehiscence, where 76.8% of the phenotypic variance was explained by the major QTL, this helps in the development of non shattering sesame varieties with reduced seed loss during harvest (Teboul *et al.,* 2022). More recently, CAPS markers linked to the major lignan QTLs (qLIGN-1 and qLIGN-8) have been validated for improving sesamin and sesamolin content, which helps in the development of nutritionally superior sesame cultivars (Kim *et al.,* 2023).

Mutation breeding: Mutation breeding can add new genetic variation to the existing germplasm and can broaden the genetic base. Artificial mutation can be induced to make changes at the genetic level, thereby increasing productivity and earliness. An extra early maturing mutant TVS 1401 was identified that reached physiological maturity on 70 DAS and recorded 683 kg/ha of seed yield, which was 21.96% higher yield than the popular check TMV 7 (Jayaramachandran *et al.,* 2020).

Genome editing: It is an emerging area in sesame improvement. The candidate genes controlling oil biosynthesis and capsule shattering are identified and these genes can be targeted using CRISPR-Cas technology to improve productivity and reduce harvest losses.

The road ahead: Conducting research on non-shattering, determinate growth habit, disease resistance, specifically phyllody and drought tolerance are essential for future progress. Wider adoption of improved varieties and modern production technologies can help in bridging the yield gap. Enhanced crop management and farmer awareness plays a key role in getting maximum benefits rather than relying entirely on genetic improvement.

Conclusion: Sesame has enormous potential to contribute to nutritional, economic and oilseed security, yet its productivity is repressed by capsule shattering, indeterminate growth, narrow genetic diversity, biotic and abiotic stress and rainfed cultivation. Modern technologies such as the use of landraces and wild relatives, MAS, mutation breeding, and genome editing can be used for developing high yielding, climate resilient and non-shattering varieties. Still, genetic improvement alone is not sufficient and there is a need for integrating improved varieties with sustainable crop management practices, quality seed availability and farmer awareness for bridging the yield gap and realize the full potential of sesame.

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