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Review Article

Lentil (*Lens culinaris* Medik.): A Current Review

Dürdane MART[1*] (Orcid ID: 0000-0002-2944-1227)
[1]Eastern Mediterranean Agricultural Research Institute, Adana
*Corresponding author: durdanemart@yahoo.com

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Abstract

Lentil was first cultivated 8000–10,000 years ago and is a protein-rich crop. It is an important dietary component in many Mediterranean and Asian countries but allergic reactions to lentil intake was reported in some countries. Lentil yield is a key and difficult trait to enhance for crop genetic improvement. Several biotic and abiotic variables such as drought, high temperature, salinity, mineral deficiency and fungal diseases limit the production of lentils. Landraces and wild relatives are more tolerant to adverse environmental conditions. Molecular tools to assist breeding efforts in lentil are less well developed in comparison with other crops. Due to its excellent and balanced nutritional composition, the use of lentil flour in bakery, extruded and other products is gaining attention from food technologists and industry. In this review, some valuable information related to lentil is extracted from international articles published in last two years and presented here.

Keywords: Lentil, *Lens culinaris*, breeding, agronomy, food

INTRODUCTION

After chickpea and pea, lentil (*Lens culinaris* Medik. subsp. *culinaris*) is the world's third most significant cool-season grain legume (Sehgal et al., 2021). Lentil was first cultivated 8000–10,000 years ago in Southwest Asia. Archeological evidence is inconclusive as to how many times it was separately domesticated in Southwest Asia regions, and if wild species in the Lens genus contributed to the cultivated gene pool (Liber et al., 2021). Due to its great nutritional content, particularly protein, the lentil is an important dietary component in many Mediterranean and Asian countries. However, allergic reactions to lentil intake have been reported in a number of nations (Halima et al., 2022). Lentil is a popular Mediterranean legume crop used for its nutritious seeds and soil fertility improvement. Because it is influenced by a variety of factors that have negative effects on seed yields and seed quality features, lentil yield is a key and difficult trait to enhance for crop genetic improvement (Sellami et al., 2021). Several biotic and abiotic variables limit the production of lentils (drought, high temperature, salinity, and mineral deficiency). The development of stress tolerance in lentils is hampered by its limited genetic base. Studies are being undertaken to identify lentil germplasm with superior root system architecture, water use efficiency, transpirational cooling, mineral use efficiency, reproductive function, yield, and quality, especially under stress. Many linkage maps have been developed, and QTL for biotic and abiotic stress tolerance in lentils have been found, which could help in the production of improved varieties. To boost lentil yield in various agro-climatic areas, several agronomic approaches to improve water usage efficiency, nutrition requirements, canopy management, and root architecture are being explored (Sehgal et al., 2021). In recent years, it has been shown that the green sections of lentils contain a wide range of acylated flavonoids. This suggests that lentil aerial portions could be used as a source of bioactive compounds (Zuchowski et al., 2021). The lentil seed coat is a byproduct that is nevertheless high in phenolic chemicals, particularly condensed tannins. The use of ultra-high-pressure liquid chromatography linked to quadrupole-time-of-flight mass spectrometry (UHPLC-ESI/QTOF-MS) allowed the identification of over 500 chemicals in lentil seed coat extracts, mostly flavonoids and phenolic acids (Galgano et al., 2021).

Breeding lentil

Lentil (*Lens culinaris* Medik.) is a self-pollinated annual legume crop in the *Fabaceae* family with a diploid chromosome number of 2n = 2X = 14 and a diploid chromosomal number of 2n = 2X = 14. (Ogutcen e al., 2018). Lentil variants are typically farmed close to their origins. Higher temperatures and alterations in lentil crop production zones are expected as a result of future climate change scenarios, necessitating increased breeding efforts. Lentil is grown in a variety of habitats, resulting in a wide range of phenological adaptations and a loss in genetic variability within breeding programs due to a lack of willingness to use genotypes from other environments (Wright et al., 2021). In semiarid places, lentil has the ability to improve soil colonized by nitrogen-fixing symbiotic bacteria while also giving income to local farmers. Several landraces and traditional variations have been established throughout the centuries, giving a wealth of genetic material for lentil cultivation and use by local populations around the world. However, present improved lentil varieties face numerous biotic and abiotic problems, and future cultivars should take advantage of the *Lens* gene pool's vast genetic potential. Landraces and wild relatives are more tolerant to adverse environmental conditions and can provide valuable genes to develop improved varieties in modern agriculture, adapted to environmental abiotic and biotic stresses, suitable as well for other industrial non-food uses, such as biomass production and use as energy crop. Molecular tools to assist breeding efforts in lentil are less well developed in comparison with other crops, although progress has been made in germplasm characterization using molecular markers. Genomic research is delayed by the large (4.3 GB) lentil genome size, and progress towards the release of the complete lentil genome sequence is expected to accelerate breeding efforts (Polidoros et al., 2022). Growth and yield can be decoupled in lentil whereby excessive vegetative growth leads to self-shading, reduced pod and seed set, low harvest index and higher risk of disease and lodging. Selection for harvest index would improve yield across environments whereas selection for growth rate could further improve yield under stress (Lake & Sadras, 2021).

Agronomy

Lentil is a cool-season grain legume grown largely in the Mediterranean and temperate parts of the world, where water and heat stress during important maturation periods limit yield. Stress has a different influence on yield depending on when it occurs, how intense it is, and how long it lasts (Lake et al., 2021). In semi-arid areas, coupled heat and drought stress may pose a threat to lentil cultivation (Hosseini et al., 2021). During the mid-to-late reproductive phases, lentils are extremely sensitive to sudden temperature rises, resulting in substantial biomass and seed yield reductions (Kumar et al., 2021). High temperature and water deficit are among the major limitations reducing lentil yield in many growing regions. In addition, increasing atmospheric vapor pressure deficit due to global warming causes a severe challenge by influencing the water balance of the plants, thus also affecting growth and yield (El Haddad et al., 2021). Grain production is reduced by extreme temperatures during important developmental stages. Heat stress is reduced by a combination of planting date and cultivar that favors rapid development, but frost is increased at critical stages. Despite warming trends, adaptation to frost during the key period for yield is critical for pulses. Increased frost tolerance can boost yield while also helping to lessen the danger of heat and drought later in the season (Lake et al., 2021). Drought is one of the primary restrictions, accounting for up to 50% of lentil production losses. The use of silicon (Si) has been demonstrated to be a potential approach for increasing drought resistance. The effects of Si on drought stress tolerance of lentil genotypes were studied by Biju et al., (2021). At the start of the reproductive stage, seven lentil genotypes with varied levels of drought tolerance (tolerant, moderately tolerant, and sensitive) were treated to mild and severe drought stress. Different drought stress treatments dramatically reduced above-ground biomass, water status, and chlorophyll pigment concentrations, while Si supplementation of drought stressed lentil genotypes considerably improved the same parameters, regardless of their drought tolerance levels. On the other hand, Si effect on osmoregulation leads to a decline in the membrane damage and osmolytes (proline and glycine betaine) concentration in drought-stressed lentil. Application of Si to drought-stressed lentil plants significantly maintained the nitro-oxidative homeostasis by balancing the concentrations of reactive oxygen/nitrogen species, superoxide anion, hydrogen peroxide and nitrous oxide, thereby reducing the oxidative damage caused due to drought stress. Although Si showed the same regulatory mechanisms in all the studied genotypes to protect lentil plants from moderate and severe drought stress, the defensive role of Si against drought stress was more conspicuous in drought sensitive genotypes than in the tolerant ones. Thus, this study suggests the protective role of Si on drought-stressed lentil genotypes through the modulation of nitro-oxidative homeostasis and antioxidant defence responses. The optimum time of sowing and foliar spray of micronutrients may be helpful to alleviate the soil moisture and heat stress for the sustainability of lentil production in the subtropical regions (Venugopalan et al., 2021). Soil salinity impairs crop's physiological and biochemical processes, putting future food security at risk. In plants, sodium nitroprusside, a nitric oxide contributor, has the ability to reduce abiotic stress effects and enhance tolerance. Exogenous sodium nitroprusside application could be developed as a beneficial technique for increasing lentil plant performance in salinity-prone regions (Yasir et al., 2021). Transient waterlogging can be caused by a combination of poorly drained soils and excessive rainfall, reducing lentil yield. However, there are genotypes that are consistently more resistant to waterlogging. The end-of-recovery biomass ratio between waterlogged and control plants was linked to growth rate during recovery and biomass at the end of waterlogging (Lake et al., 2021). In acid soils, aluminum toxicity hinders root elongation and growth, resulting in reduced water and nutrient uptake by the root system, lowering crop yields (Kulkarni et al., 2021). Under acidic soils, aluminum stress reduces lentil yield. To improve its yield, more knowledge of aluminum tolerance qualities is required. On aluminium-toxic fields, aluminium-resistant cultivars had much higher seed yield than Al-sensitive cultivars, indicating that tolerance is maintained in lentils until reproductive stage (Singh et al., 2021). Worldwide, Fusarium wilt (*Fusarium oxysporum*) is one of the most important soil-borne diseases of lentil. Biological control by means of microorganisms represents an important aspect of sustainable agriculture and food production for organic crops. *Bacillus velezensis*, *Glomus* spp., *Trichoderma* spp, *Streptomyces* spp. *Bacillus subtilis*, *Pichia pastoris* and *Streptomyces griseoviridis* were evaluated for the control of Fusarium wilt of lentil by Campanella & Miceli, (2021) and found successful to improve Fusarium wilt management as well as increase lentil yields. Anthracnose, caused by *Colletotrichum lentis*, is one of the most damaging diseases of lentil in western Canada (Gela et al., 2021). *Ascochyta lentis* (syn. *Ascochyta fabae* f. sp. *lentis*) is the causal organism of ascochyta blight in lentil. The disease causes considerable reduction in grain quality and yield due to stem girdling, flower and pod abortion, and seed staining (Henares et al., 2022).

Lentil is an important pulses crop but it's short stature and slow growth rate make it vulnerable to weed competition, limiting crop productivity (Grewal et al., 2022).

Lentil as a protein food

Substituting plant-based proteins for animal proteins is a possible strategy to reduce the harmful impact of animal husbandry on the environment. Pulse consumption has long been touted as a healthy way to boost protein intake (Boeck et al., 2021). Lentil is a protein-rich crop (Joehnke et al., 2021). Due to its red-colored proteins, quantity, high protein, and low cost, red lentils (*Lens culinaris*) are an appealing raw material for meat mimics (Lee et al., 2021). Plant-based proteins were used in a variety of food products, either in their totality or as partial substitutions, due to their excellent nutritional value and rising consumption patterns. There is indeed a growing need to produce plant-based proteins as alternatives to dairy-based proteins that have good functional properties, high nutritional values, and high protein digestibility. Among the plant-based proteins, lentil proteins received a lot of attention in recent years as dairy-based protein alternatives (Alrosan et al., 2022). Due to its excellent and balanced nutritional composition, the use of lentil flour in bakery (bread, cake, crackers), extruded (pasta, snacks), and other products (dressings, soups, dairy and meat products) is gaining attention from food technologists and industry, as well as popularity among consumers. Our understanding of lentil flour's nutritional and functional qualities (solubility, emulsification, gelation, and foaming) has grown, revealing its technological potential for the manufacture of high-quality foods (gluten free bakery, yogurt and meat products). However, addition of lentil flour may introduce technological problems and novel allergens (Romano et al., 2021). Inclusion of pulses flour in bread formulation has important nutritional effects but its successful implementation is challenging and requires a good understanding of the effect of flour functionality, granulometry and substitution level on bread quality. Particle size affected physico-chemical properties of flours. Substitution level was the dominant factor affecting dough rheology. Coarse fraction has lower impact on dough rheology than finer fractions (Marchini et al., 2021). Lentil, a cool-season food legume, is high in protein and minerals, as well as a variety of prebiotic carbohydrates such raffinose-family oligosaccharides, fructooligosaccharides, sugar alcohols, and resistant starch, all of which contribute to the health advantages of lentil. Beneficial bacteria in the colon ferment prebiotic carbohydrates, providing health advantages to the user. These carbohydrates are also important for lentil plant health, since they help with carbon transport, storage, and abiotic stress tolerance. As a result, lentil prebiotic carbohydrates could be a nutritional breeding target for strengthening crop resilience to climate change while also improving global nutritional security (Johnson et al., 2021). Infant formula is a human milk substitute that is given to babies during the first few months of their lives. The protein in these goods is usually derived from dairy. Alternative protein sources, such as those derived from plants, are gaining popularity as a result of dairy allergies, intolerances, and ethical and environmental concerns. Lentils have a high protein content (20–30%), a decent amino acid composition, and strong functional characteristics. Lentil proteins are a good alternative to other plant proteins (e.g., soybean and rice) in baby nutritional products from a nutritional and physicochemical standpoint (AlonsoMiravalles et al., 2021). One of the major challenges limiting lentil proteins' utilization in food applications is their low solubility (Alrosan et al., 2021). Lentil lectin strongly inhibit infection of SARS-COV-2 variants, which should provide valuable insights for developing future anti-SARS-CoV-2 strategies (Wang et al., 2021).

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