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Derleme Makalesi

Safflower (*Carthamus tinctorius* L.) : Utilisation, Genetics and Agronomy

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Abstract

Safflower is a deep rooted drought tolerant crop originating from Middle East deserts. It is an ancient but minor crop cultivated for its flowers (for coloring, flavoring foods, dyes, medicinal properties), for seeds (for livestock feed, biofuels and oil) in semiarid and temperate regions. 15 countries are producing safflower in the world where Kazakhstan, USA and Russia are top producers. Its oil is prefered due to higher amount of oleic and linoleic acids contents than any other oil seed crops. Safflower petals have been used for centuries as a spice and medicine in traditional Asian cultures. Safflower is poorly studied for genetics. It is a suitable oil crop for marginal areas with deep roots penetrating to uptake moisture and nutrients leached out of rhizosphere. It is also moderately tolerant to salt stress.

Keywords: Safflower, *Carthamus tinctorius* L., utilisation, genetics, agronomy

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a plant of *Compositae* family. It is a species also known as "false saffron" (Buyukkurt et al., 2021). This deep rooted drought tolerant crop originates from deserts of Middle East (Singh et al., 2016). Safflower is among oldest cultivated crops. Its cultivation is usually at small scaled fields. Safflower is cultivated for flowers (for coloring, flavoring foods, dyes, medicinal properties) (Hussain et al., 2016), livestock feed, biofuels (Shahrokhnia & Sepaskhah, 2016), as an oil seed crop in the semiarid and temperate regions of the world (Bahmankar et al., 2017). This crop is underutilized but recieving attention due to oil quality and ability to grow under extremes (high temperatures, drought and salinity) (Hussain et al., 2016). 15 countries were producing safflower in 2019 in the world. Kazakhstan, USA and Russia are top producers in the world with 200 thosands, 88 thousands and 81 thousands tonnes of production in 2019, respectively. Yield of USA (1.426 kg/ha) was double of Kazakhstan (760 kg/ha) in 2019 (Table 1) (FAOSTAT, 2021).

Table 1. Countries producing safflower, their production amounts, acreages and yields in 2019 (FAOSTAT, 2021)

Rank	Country	Seed Production (tonnes)	Acreage (ha)	Yield (kg/ha)
1	Kazakhstan	199.789	262.768	760
2	USA	88.130	61.800	1.426
3	Russia	81.189	106.952	759
4	Mexico	51.655	27.828	1.856
5	China	33.128	22.570	1.468
6	India	24.640	45.890	537
7	Argentina	24.327	28.646	849
8	Turkey	21.883	15.860	1.380
9	Tanzania	16.087	27.823	578
10	Kyrgyzstan	12.374	12.414	997
11	Ethiopia	9.571	7.561	1.266
12	Tajikistan	9.238	5.061	1.825
13	Uzbekistan	8.637	16.218	533
14	Iran Islamic Rep.	6.313	4.764	1.325
15	Australia	3.793	6.389	594

Safflower oil

Safflower is a multiple purpose crop generally grown for oil production. Its oil is prefered due to higher amount of oleic and linoleic acids contents than other oil seed crops. Safflower oil has many applications in food, pharmaceutical, cosmetics and feed industry (Khalid et al., 2017). Industry desires "High Oleic" safflower oil for its high oxidative stability to use in food, fuel, and other products (Anjani & Yadav, 2017). Two different levels of high oleic acid content (>84% and >75%) was reported in safflower (Hamdan et al., 2012). An added advantage of safflower oil is lower cost of production thus can become an

alternate option for those who cannot afford to buy olive or other functional oils. A higher stability index makes it possible to encapsulate safflower oil or used it as a carrier in bioactive functional ingredient delivery systems. Composition and distribution of phenolic contents of safflower oil has not been explored to its full potential. There is a need to conduct exclusive research on exploring the role of phenolic compounds in food and pharma industrial applications (Khalid et al., 2017). Safflower seed has highest concentration of "Linoleic acid" among 80 different oilseeds (Alizadeh et al., 2010). Its oil is a rich source of "omega 3" (Akbari et al., 2020) and "omega 6" fatty acids (Amirkhiz et al., 2021).

A traditional medicine

Safflower petals have been used for centuries as a spice, in tea blends and in traditional Asian medicine (Lewin et al., 2021).

Fig. 2. The inflorescences (upper photos) and tubular flowers of safflower (lower photos) (Chen et al., 2020)

Seed extracts of safflower have been traditionally used to treat thrombotic disorders, coronary disease, menstrual problems, cancer, depression (Kuehnl et al., 2013), diseases of the musculoskeletal system, connective tissue (Lee et al., 2013) and peptic ulcer (Mandade et al., 2011). Traditional Chinese medicine benefit its pharmacological effects (anticoagulant, antioxidant, antitumor, antiaging and regulation of gene expression) (Han et al., 2015). A possible source of this effect of safflower compounds is tryptophan-degrading activity of enzyme indoleamine 2,3-dioxygenase (Kuehnl et al., 2013). Leaves of safflower are a good source of natural antioxidants (Zaoui et al., 2016).

Feed

It is grown commercially for the production of birdseed (Mayerhofer et al., 2011). Seeds of safflower are rich in high-grade vegetable protein (<16%) (Kutsenkova et al., 2020). Powder and extract of its seeds are effective in the prevention of bone loss in ovari-ectomized animals (Choi et al., 2017).

Usage of safflower oil instead of fish oil in turbot fish (*Psetta maxima*) feed was confirmed that it did not generate any negative effects on growth, feed conversion and the values regarding the growth performance (Altundag et al., 2014). Dschaak et al., (2011) was conducted a lactation trial to see the effects of supplementing whole safflower seeds on ruminal fermentation, lactational performance, and milk fatty acid profiles of multiparous Holstein cows. Supplementing diets with whole safflower seeds 3% of dietary dry matter was an effective strategy of fat supplementation to lactating dairy cows without negative effects on lactational performance and milk fatty acid profiles.

Others

Safflower is one of the most important crop plants that has been utilized for production of oleosins (Li et al., 2011). Safflower straw is an abundant, inexpensive and renewable lignocellulosic waste as a substrate of anaerobic digestion to produce biogas. Hydrothermal pre-treatment of safflower straw was studied for biogas production in a study of Hashemi et al., (2019). The pre-treatment solid and liquid fractions were subjected to anaerobic digestion. Hydrothermal pretreatment of safflower straw significantly improved biogas yield. Maximum biogas yield was obtained at low severity pretreatment conditions. Monofloral safflower honey, produced from nectar of the *Carthamus tinctorius* was shown to have excellent nutritional value and biological activity. Safflomin A was identified as a reliable characteristic indicator. Safflomin A can be applied as a chemical marker for fingerprinting the botanical origin of safflower honey (Zhao et al., 2022). Safflower is well-known by textile conservators and restorers as the red dye source that produces a nice, though very delicate pink colour that is extremely light-sensitive (Costantini et al., 2019).

Genetics

Kumar et al. (2015) investigated genetic diversity and population structure of 531 safflower accessions from 43 countries. Far East and Egypt sourced accessions clustered in distinct groups. Near East, Iran, Afghanistan and Indian sub-continent were containing maximum diversity. American accessions showed low molecular variability. As a minor crop, safflower is poorly studied for genetics. Four types of the corolla color are distinguished in safflower (red, orange, yellow and white) (Leus, 2016).

Fig. 2. Color of the safflower corolla: a) yellow, b) orange, c) red, d) White (Leus, 2016)

Agronomic advantages and disadvantages

Deep root system of *Carthamus tinctorius* is an important adaptive trait under rainfed semi-arid agriculture conditions (Bhattarai et al., 2020). Deep roots of this species help to uptake moisture and nutrients, especially nitrogen which leaches out of rhizosphere of many of other crops (Yau & Ryan, 2010). It is a suitable oil crop for marginal areas (Poodineh et al., 2021). Safflower is also moderately tolerant to salt stress (Yeilaghi et al., 2012). Severe drought stress decrease the yield and oil quality of species (Akbari et al., 2020). In rainfed ecologies crops typically face terminal stresses. Information on safflower dry matter dynamics at the seed-filling stage and its relation to yield formation was researched by Koutroubas et al., (2021). Effects of nitrogen and sowing time on crop growth were assessed. Nitrogen rate >100 kg/ha was required to optimize achene yield grated than 4 t/ha. Higher assimilates in the source resulted with greater remobilization to sink. Dry matter at anthesis was determined as an early-season predictor of achene yield. Autumn sowing produced 28% higher achene and 20% higher oil-yield than spring sowing.

CONCLUSIONS

It is a drought tolerant and suitable oil crop for marginal areas with deep roots penetrating to uptake moisture and nutrients leached out of rhizosphere. It is also moderately tolerant to salt stress. It is a minor crop cultivated for flowers (for coloring, flavoring foods, dyes, medicinal properties), for seed (for livestock feed, biofuels and oil) in semiarid and temperate regions. Its oil is prefered due to higher amount of oleic and linoleic acids contents than other oil seed crops. Safflower petals have been used for centuries as a spice and medicine in traditional Asian cultures. Safflower is poorly studied for genetics and requires studies on nearly all agronomic aspects.

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