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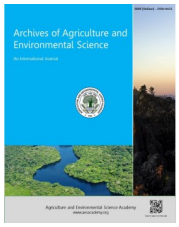

REVIEW ARTICLE

Agro-ecological characteristics and ethanobotanical significance of safflower (*Carthamus tinctorius* L.): An overview

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ABSTRACT

Safflower (*Carthamus tinctorius* L.) is one of the oldest crops. It is native to the old world. It occurs naturally in Mediterranean Region, North Eastern Africa and South Western Asia to India. It is cultivated in India mainly for oil and dye. The purpose of the present paper is to highlight the ethanobotanical properties and importance of the safflower as an ancient wonderful crop and it also focus on the environmental conditions required for the growth of safflower in India. The seeds are also used as Birdseeds. It has been grown in the past for ornamental, medicinal and cosmetic purposes. Presently it has become important mainly due to edible oil, which is obtained from its seeds. The oil is helpful in lowering blood cholesterol. It is specifically relevant to India being the largest producer of Safflower in the world. The safflower is mainly grown in India for its valuable edible oil which has many important properties related to health. The present paper also highlights the other uses of safflower beyond edible oil. The safflower oil is valuable as it content omega-6 fatty acids which are beneficial for our body. It maintains a balance of cholesterol in the body and reduces the chances of developing atherosclerosis. The various studies have shown that moderate safflower seed consumption is good for cardiovascular health. The consumption of safflower seed is also efficient in reducing belly fat. The safflower oil also lowers high blood pressure. The medicinal properties of safflower have been discovered as early as the Middle Ages, where the juice of safflower plant is mixed with chicken stock or sweetened water to relieve constipation and respiratory problems.

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INTRODUCTION

A wide range of plants have been under cultivation for various purposes. There are more than 6000 such crop species, but only a few are used as staple crops. In spite of major contribution of these crops, contribution of some minor species cannot be ignored. Safflower (*Carthamus tinctorius* L.) is one such oldest crop (Dajuem and Mündel, 1996; O'Brien, 2008; Lei *et al.,* 2016). It continued to remain a minor crop grown on small plots for personal use. The Ethnic names of safflower are Kusum, Zaffrone, Alazor, Azafran, Benibana, Qurtum, HeangLan, Hung Hua, Hung LanHua, etc. It occurs in Mediterranean region, North Eastern Africa and South Western Asia (Lei *et al.,* 2016; Srinivasa *et al.,* 2017). It is cultivated in India mainly for oil obtained from its seeds and reddish orange dye which is obtained from flowers. From the ancient times, safflower flowers had been used in preparations of Ayurvedic medicines in India, Europe, Japan and China. Its medicinal uses in China became more widely known all over the world, because it is grown there in large scale exclusively for flowers which are used to cure many diseases (Lei *et al.,* 2016). The flowers are also used as tonic tea. To meet the requirement of increasing demand for food and fodder and to ensure food security (Dajuem and Mündel, 1996; O'Brien, 2008), it is important to increase the production potential through soil health improvement in rainfed agro-ecological regions besides the irrigated regions. Degrading soil health because of decrease in soil organic carbon (SOC) and resultant decline in overall soil fertility in rainfed areas is a major threat to sustenance of

crop and fodder productivity (O'Brien, 2008; Srinivasa *et al.,* 2017).

In this review, after illustrating the fatty acid composition of safflower seed oil as well as the genetic characteristics of safflower and their relationships with agronomic traits, a brief analysis of the current worldwide situation and future prospects of safflower utilization are presented (Lei *et al.,* 2016). This led to the revival of this ancient crop in the last few decades. Safflower seeds are used in food industry for the production of oil (Armah-Agyeman *et al.,* 2002; Aurora Dobrin and Doru Ioan Marin, 2015).

Knowledge of species relationship is essential for crop improvement. The wild and weedy relatives of *Carthamus tinctorious* have been investigated to ascertain the cytogenetic and taxonomic relationships between them (Dwivedi *et al.,* 2005; Singh, 2007; Srinivasa *et al.,* 2017). But still information is lacking about the donor parents of carthamus tinctorious and the genetic distances among possible donors in relation to the recipient. Thus, the safflower oil quality and agronomic traits could be improved simultaneously through breeding of safflower for high photosynthetic efficiency (Dajuem and Mündel, 1996; O'Brien, 2008). In addition, the results also showed significant correlation coefficients between some photosynthetic parameters and the percentage of fatty acids, which inferred that the photosynthesis rate can be used as an early selection marker in genetic improvement programs (Abd El-Lttief, 2012; Srinivasa *et al.,* 2017).

New classification system of genus carthamus: Based on the geographical distribution, anatomical and biosystematic information, a new classification system has been proposed by Lopez-Gonzalez. Accordingly newly circumscribed genus Carthamus contains only annual species with 2n=20, 22, 24, 44 or 64 including allopolyploid species (Singh, 2007). The genius Carthamus has been subdivided into sections, viz. Section Carthamus, section Odonthagnathius Hanelt and section Atractylis Reichenb. Section carthamus has 12 pairs of chromosomes (2n=24) and includes following species viz. *C. curdicus* Hanelt, *C. gypsicola*, *C. oxyacanthus* Beib, *C. palaestinus* Eig, *C. persicus* Willd and *C. tinctorios* L. Section odonthagnathius Hanelt has 20 or 22 chromosomes. Section Atractylis Reichenb, with basic chromosomes number of 11 (Singh, 2007).

Characteristics of safflower: Safflower is a drought tolerant crop. Its tap root can penetrate up to a depth of three meter, if subsoil temperature and moisture permit. It is salt tolerant too. Safflower is self-pollinated with some cross-pollinated. Dense root structure can improve soil tilth and porosity. Roots also add to organic matter, improving soil water holding capacity (Armah-Agyeman *et al.,* 2002; Aurora Dobrin and Doru Ioan Marin, 2015).

Countries growing safflower: Safflower is grown in many countries such as Australia, Bulgaria, Canada, China, Ethiopia, Germany, Mexico, Romania, Russia, Slovenia, Spain, Switzerland, Turkey and the United States of America. India is the largest producer of safflower in the world with a production of 1.57 lakh tones with average productivity of 450kg/ha^4 (Dajuem, L. and Mündel, 1996; Aurora Dobrin and Doru Ioan Marin, 2015). In India it is mainly grown in Maharastra, Karnataka and parts of Andhra Pradesh, Madhya Pradesh, Orissa, Bihar, etc. Maharastra and Karnataka are two most important safflower growing states (Dwivedi *et al.,* 2005; Srinivasa *et al.,* 2017).

Growth of safflower: It is grown in Rabi *i.e.* winter season from October/November to March/April. It is also grown in an intercrop with cereals such as wheat and sorghum. Safflower seeds have hard covering. Therefore, before sowing seeds either a moist farm seed bed should be prepared or seed soaked in water should be sown. After this, irrigation is not needed. Germination will not begin until soil temperature exceeds 5^{0}C. Each seed germinates and produces a central stem that does not elongate for two-three weeks and develops leaves near the ground in a rosette stage (Dwivedi *et al.,* 2005; Singh, 2007; Srinivasa *et al.,* 2017).

Appearance of safflower plant: Safflower is a thistle like annual herb. It has strong central glabrous-branched stem which grows to a height of 30-90 cm. The leaves are

Table 1. Characteristics of Safflower (*Carthamus tinctorius*).

Determination (% db)	Value
Moisture	9.0±0.38
Oil	43.4±3.6
Lignin	
Whole seed	11.4±0.8
Hull	13.8±1.2
Cellulose	
Whole seed	45.3±2.8
Hull	46.1±2.6
Hull/Kernel ratio	0.560±0.007

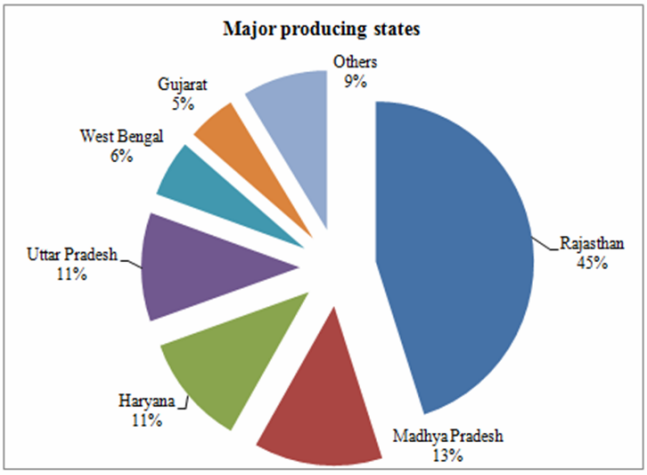

Figure 1. *Major states producing Safflower (Carthamus tinctorius) in India (Source: Ministry of Agriculture, GoI).*

alternate, sessile, and ovate-lanceolate with or without spines on the margins. Flowers are yellow or orange arranged in heads of about 2.5-25 cms across. Safflower is very susceptible to frost injury from stem elongation to maturity. The slow growth of seedlings in early winters often results in weedy crop. The strong central stems with variable numbers of branches grow from 30 cm to 1m or more depending on environmental conditions. This crop is drought resistant since it has tap root that can grow up to 3m if subsoil temperature and moisture content are suitable. Stiff spines develop on leaf margins of most varieties at about the flower bud stage so it becomes difficult to walk through the fields and later on picking flowers. Branches usually produce 1-5 flower heads, which are about 8-10mm in diameter and are usually yellow or orange in color. Seed oil content is usually between 25-45%. Seeds are enclosed in the head even after maturity, which prevents shattering before harvest and it also prevents bird damage. Safflower is ready to be harvested when most of the leaves turn brown and very little green remains on the bracts of the latest flowering heads. The stem should be dry, but not brittle and the seeds be white. It can be thrashed manually. This crop should be harvested as soon as it matures so as to avoid seed discoloration or sprouting in the head due to rains.

Storage of safflower seeds: Viability of Safflower seeds is maintained best by storing it at low moisture and low temperature. In dry environment safflower seeds are stored with 6-7% moisture. The amount of moisture should not exceed 8%. Based on the International Board for Plant Genetic Resource guidelines, medium term storage can be accomplished by storage at 4^0C and 30% relative humidity. Long-term storage can be affected at -20^0C. Ghazizade *et al.* (2012) showed salt stress affected significantly on root length, shoot length, fresh weight and dry weight of seedlings. Basiri *et al.* (2013) showed that salinity decreased length, fresh and dry weights of radical and plumule were measured and radicle was more sensitive to salinity stress than plumule. Salinity resulted from NaCl had the greater negative effect on the seedling characteristics than $CaCl_2$ salinity. Jabeen *et al.* (2013b) showed that increasing salinity stress from 3.4 to 10.8 dSm^{-1} significantly decreased length and weight of root and shoot.

Environmental requirements for safflower: This crop responds best in areas with warm temperature and sunny dry conditions during the flower and seed filling periods. Yields are lowering under humid or rainy conditions because seed set is reduced and the occurrence of leaf spot and head rot diseases increases. So areas where heavy annual rainfall is recorded or it is more than 38 cm, its cultivation is not recommended. It grows best in deep fertile, well-drained loam soil with good water holding capacity. It can also grow in coarse-textured soils of lower water holding capacity, when it is properly rainfed and moisture content is adequate. Depending on severity, soil salinity lowers germination and decreases seed yield and oil percentage. It can be grow on fallow land or in rotation with small grains. Soil tests are necessary to correctly determine wheather any additional soil nutrients are required. The amount of fertilizer needed for safflower production depends on the yield goal; rotation. Safflower roots are deeper than other crops which help plant to utilize nutrients that may be positionally unavailable to other crops such as corn, sunflower, etc.

The rapid increase in the welfare of humanity was made possible by the use of fossil fuels but the development of the industry, and to bring with it air pollution caused again this fuel causes the development of the industry to bring with it the air and environmental pollution (Mihaela *et al.,* 2013; Muciño *et al.,* 2014). Many countries encourages the efforts made on reducing addiction to the imported fuels (particularly fossil fuels) while they support the most convenient and low-cost business research of local resources to meet the growing energy demand in parallel with the developments in their economy and industry (Sajjadi, 2016 and Saluja, 2016).

Types of safflower varieties: There are two types of safflower varieties viz. with spines e.g.JSF-1, Nira etc. and without spines such as JSI-7, JSI-73, NARI-6, NARI-NH-1 etc. spineless varieties are preferred as their flowers can be easily handpicked at the time of harvesting. Safflower is poor competitor with weeds. So weed control program is required for its cultivation.

Conclusions

There is need to develop new varieties of Safflower which are spineless and resistant to diseases. Germplasm banks should be set up containing genotypes with resistance to various diseases and having high adaptability. The present paper also highlights the other uses of safflower beyond edible oil. The safflower oil is valuable as it content omega -6 fatty acids which are beneficial for our body. It maintains a balance of cholesterol in the body and reduces the chances of developing atherosclerosis. The wild species of Safflower which are closely related to cultivated varieties should be targeted for incorporating resistance to various diseases. The development of high yielding hybrids may give better results. Shoot length, shoot and root fresh weights shoot and root fresh dry weights, seedling height reduction and relative dry weight significantly affected by the interaction between cultivars and salinity concentrations, by the interaction among seed priming, cultivars and salinity concentrations.

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