

SAFFLOWER R&D at NARI

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INTRODUCTION

1. Background

Safflower, *Carthamus tinctorius* L. is a member of the family Compositae or Asteraceae, cultivated mainly for its seeds, which yield edible oil. Traditionally, the crop was grown for its flowers, used for coloring and flavoring foods and making dyes. The medicinal uses of flower in China have become known to the rest of the world in last decade rekindling the interest in this crop. Some of the various uses of safflower have been listed in Table 1.

Table 1 : Safflower uses

Plant part	Product	Uses
(1) Seed	i) Quality edible oil containing polyunsaturated fats	Associated with lowering of blood cholesterol
	ii) Meal left after oil extraction	Used as animal feed
(2) Flowers	i) Natural food and cosmetic coloring (Carthamin dye)	Gives yellow to bright orange color to food products and cosmetics such as lipsticks
	ii) Dyes (Carthamidin and carthamin)	Give crimson, rose, pink or light pink color to cotton yarn
	iii) Medicines	Extract of florets contains nutrients and is used in treatment of many illnesses such as menstrual problems, cardiovascular disease and pain and swelling associated with trauma as well as in tonic tea
(3) Whole plant	i) Tender shoots and thinnings or nippings	Used for preparing a nutritious vegetable
	ii) Dried stalk or straw	Used as a fodder similar to cereal straw or as fuel for biomass gasifiers to produce energy and char for soil conditioning

Safflower is one of humanity's oldest crops, but has remained a minor crop with world seed production around 650,000 tons per year. Over 25 countries grow safflower, but over half the production takes place in India. The plant has a strong taproot, which enables it to thrive in dry climates.

Traditionally in India, safflower is grown only as a rainfed, winter crop on residual soil moisture. Also generally it is intercropped with cereals such as wheat and sorghum.



Safflower field at NARI farms

Despite its reputation as a drought-tolerant and hardy crop, the research carried out at NARI in the late 1960s showed that safflower gives good response to management practices such as irrigation, fertilizer application and pest control. For an example the application of one or two irrigations to safflower crop at critical growth stages could boost the seed yield by as much as 50 percent. Likewise the use of recommended fertilizers and timely management of pests also had similar effects on seed yield in safflower. Since 1975, NARI has been a center under the All India Coordinated Research Project on Oilseeds to work specifically on “irrigated safflower”.

For last 40 years, NARI has been working to popularize safflower among farmers as a pure crop to be grown under 1 to 3 irrigations depending on availability of water.

2. Highlights of work done at NARI

1) Development of high yielding and high oil containing varieties and hybrids of safflower for minimal irrigation :

- a. Ten spiny and three non-spiny genetic male sterile lines have been developed from two different genetic male sterility sources identified at NARI. In addition to these, six dwarf male sterile lines have also been developed. These make it possible to identify male sterile (MS) and male fertile (MF) plants at about 40-45 days after sowing, making rouging of MF plants relatively easy.
- b. Technology for the production of spiny and non-spiny safflower hybrids based on genetic male sterility and TGMS systems has also been developed.
- c. Developed cytoplasmic male sterility systems in safflower through mutagenesis with streptomycin treatment and by interspecific crossing.
- d. Studied genetics of flower yield and its components in safflower in order to develop varieties and hybrids producing high petal and seed yield.
- e. Developed thermosensitive genetic male sterility (TGMS) in safflower. The TGMS lines exhibit complete male sterility during winter conditions, however they are completely

fertile when grown during summer conditions. The thermosensitive genetic male sterility was observed to be digenic recessive with an inhibitory gene controlling it.

- f. Developed high oil containing and high yielding genotypes NARI-57 and NARI-52 giving an oil content of 38 and 35% respectively, in addition to the seed yield at par with the national check A-1. Both the genotypes are highly resistant to wilt and are in final stage of evaluation in multilocational coordinated varietal trials.
- g. Developed simple and short leaf chromosome technique to determine ploidy level in safflower. By following the leaf processing technique, chromosome preparations require only a period of 6-7 hours as compared to a period of 96 to 100 hours required for processing of root tissues with the regular method currently in use. Thus the development of the leaf tissue processing technique allows one to analyze the chromosomes of a field-grown plant any time during its entire vegetative period of growth.
- h. Two genotypes exhibiting apomixis were identified in safflower. The apomixis in them was categorized to be aposporic and facultative in nature since both sexual and aposporous embryo sacs were observed in the same ovule.
- i. Genetics of short duration and growth inhibition has been studied separately in safflower.

II) Development of suitable technology for growing safflower under limited irrigation

Highest seed yields could be obtained when

- i. Safflower was planted in the first week of October.
- ii. Plant population of about 100 thousands/ha was maintained.
- iii. Fertilizer containing 60 Kg/ha N (in split doses) and 30 Kg/ha P₂O₅/K₂O was applied to the crop.
- iv. Two irrigations—first at elongation (35 days after sowing) and second at flowering stage (70 days after sowing) were applied, in addition to a pre-sowing irrigation.
- v. Crop was protected against diseases such as alternaria leaf spot and wilt and insects such as aphids and heliothis.

III) Studies on safflower flowers (florets) and popularization of safflower florets as a herbal health tea

A safflower capitulum (head) is nothing but an inflorescence containing many florets arranged in several circles (Fig. 1). Safflower flowers are known to possess many medicinal properties for curing several chronic diseases such as heart disease, hypertension, male sterility, female infertility, respiratory diseases etc.



Fig. 1. Safflower florets

Table 2. Characteristics of safflower varieties/hybrids released by NARI

Sr. No.	Name of cultivar	Year of release and recommended region for production	Average seed yield (Kg/ha)	Increase in seed yield over check %	Oil content (%)	Characteristics	Area under NARI cultivars (ha)
1.	Nira (Spiny variety)	1986 Maharashtra	1576	24 Bhima	31.5	Early maturing, recommended for limited irrigations.	-
2.	NARI-6 (Non-spiny variety)	2000 All India	1074	20 JSI-7	35	Non-spiny, high oil containing tolerant to foliar and wilt diseases, produces dark red flowers.	10,000
3.	NARI-NH-1 (First non-spiny hybrid in the world)	2001 All India	1936	10 A-1	35	Non-spiny, high oil containing, tolerant to foliar and wilt diseases.	1,500
4.	NARI-H-15 (Spiny hybrid)	2005 All India	2201	19 NARI-NH-1	30	Early maturing, tolerant to aphids and wilt	100
5.	NARI-38 (Spiny variety)	2007 All India	2038	9 A-1	31	Tolerant to wilt	2000
6.	NARI-H-23 First TGMS-based spiny hybrid	2012-13 All India	1711	4 NARI-H-15	35	Higher tolerance to foliar and wilt diseases than NARI-H-15	-

In addition to their medicinal uses safflower flowers are also highly nutritious. In order to determine nutritiveness and suitability of safflower flowers of Indian cultivars for human consumption, flowers of non-spiny safflower variety NARI-6 and non-spiny hybrid NARI-NH-1, developed at NARI were analyzed for biochemical composition at CFTRI, Mysore. The flowers of both the cultivars were found suitable for human consumption and were highly nutritive. Their biochemical properties are furnished below :

Table 3. Nutritional composition of flowers of safflower variety NARI-6 and hybrid NARI-NH-1

Nutritive parameters	NARI-6	NARI-NH-1
Total sugar, % by wt.	7.36	11.81
Protein, % by wt.	12.86	10.40
Potassium, mg/100 g	3992.00	3264.00
Calcium, mg/100 g	558.00	708.00
Magnesium, mg/100 g	207.00	142.00
Iron, mg/100 g	55.10	42.50
Sodium, mg/100 g	1043.00	17.00
Manganese, mg/100 g	4.34	4.70
Zinc, mg/100 g	2.88	2.60
Copper, mg/100 g	4.73	1.10

Table 4. Amino acid composition of flowers of non-spiny safflower hybrid NARI-NH-1

Sr. No.	Amino acid	(g %)
1.	Aspartic acid	5.09
2.	Glutamic acid	9.78
3.	Serine	6.02
4.	Glycine	6.97
5.	Histidine	2.27
6.	Arginine	5.72
7.	Threonine	4.78
8.	Alanine	8.66
9.	Proline	8.96
10.	Tyrosine	2.81
11.	Valine	6.77
12.	Methionine	1.49
13.	Cysteine	0.18
14.	Isoleucine	5.63
15.	Leucine	8.63
16.	Phenylalanine	5.28
17.	Lysine	5.35
18.	Hydroxyproline	5.63

- A simple and easy to use method of color extraction from safflower flowers has been developed and the suitability and concentrations of color required to color sweets and snacks have been determined.
- A pleasant tasting safflower tea, using safflower flowers as a main ingredient which was mixed with other aromatic herbs to enhance its aroma and quality for mass acceptability, has been developed. This tea can be made in regular fashion and can be drunk with or without milk. We are popularizing this as a herbal health tea in India.
- Pharmacological investigations of safflower tea were carried out to study efficacy and safety of safflower tea, when given as an add-on therapy in patients suffering from mild hypertension by Dr. U. M. Thatte, Associate Professor, Department of Clinical Pharmacology at BYL Nair Charitable Hospital and T. N. Medical College, Mumbai. The study concluded that the addition of safflower tea (three cups a day) to the ongoing

antihypertensive monotherapy successfully reduced the blood pressure in patients of mild hypertension. It was observed that in safflower-treated group, the percentage decrease in blood pressure was more between day 0 and 15 as compared to that between day 15 and day 30. This may be attributed to one or more of the three reasons.

- The compliance of the patient might have decreased from day 15 onwards due to cumbersome method of tea preparation. The ready to dip sachets can be an alternative.
- Patients might have developed tolerance. In this case the dose of safflower may need to increase after day 15.
- The safflower may have lost potency after day 15. It is therefore recommended to conduct stability testing after regular time intervals.

It was felt that collecting florets should be able to give good remuneration to farmers. However, spiny nature of the plant was a hindrance to flower collection. For this reason, non-spiny varieties and hybrids were bred at NARI. In addition to 2500 to 3000 Kg seed, the hybrids were found to yield 250 to 300 Kg petals per hectare. This should give a net profit of about Rs. 35 to 40,000/- per hectare to the farmers from the non-spiny safflower hybrids. From spiny safflower hybrids, farmers get a net profit of about Rs. 25 to 30,000/- per hectare.

For farmers to get extra income from the petals, we have developed a [battery-operated knapsack type petal collector](#) (Fig. 2). This will enable them to increase their net profit from spiny hybrids to Rs. 35,000/- or more per hectare. These net profit figures also compare favorably with those from other winter crops such as wheat or gram, which give a net profit of about Rs. 20 to 25,000/- per ha. The battery operated petal collector has been tested in Nepal and Iran.



Fig. 2. Battery powered petal collector

During last three years we have locally sold about 100 Kg petals as herbal tea on an experimental basis. The response from the local population has been quite positive.

ONGOING R & D PROGRAM

- To develop spiny and non-spiny safflower varieties and hybrids giving high seed yield and oil content with inbuilt resistance to wilt.
- To perfect the cytoplasmic male sterility systems to develop CMS-based hybrids in safflower.
- To confirm the existence of polyembryony and apomixis in safflower.
- To develop short duration safflower for nutrient deficient soils having poor water holding capacity.

SERVICES OFFERED

- NARI can help in procurement of bulk quantity of safflower petals (florets).
- NARI can supply seed material of high seed and flower yielding, spiny and non-spiny safflower varieties/hybrids.
- NARI can transfer parental material of newly developed spiny and non-spiny hybrids to interested parties on royalty basis.
- NARI promotes herbal health tea prepared from dried florets of safflower.
- NARI can provide petal collectors for purchase and also transfer its technology to interested buyers.

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