Safflower (*Carthamus tinctorius* L.) – an underutilized leafy vegetable

Safflower (*Carthamus tinctorius* L.) is an important oilseed crop producing quality oil rich in polyunsaturated fatty acids which helps in reducing cholesterol level in blood. Safflower also produces flowers which are used as a natural source of edible colours and exhibit several medicinal properties to cure chronic diseases like hypertension, cardiovascular diseases, arthritis, spondylosis, menstrual cycle and fertility disorders[1]. Besides, tender leaves and shoots of safflower at early stages of growth are used as pot-herb and salad locally in and around the area of production in India and some neighbouring countries[2,3]. Safflower leaves are a good source of fibre, minerals, vitamins[3–5] and antioxidants. Despite being a highly nutritious leafy vegetable, safflower could not attain commercial status because of lack of information about the performance of different varieties, monetary returns in different seasons and nutritional benefits accrued from them. Therefore, in order to popularize safflower as a leafy vegetable it is critical to create awareness on diet-related health benefits of this neglected but precious crop. Promotion of safflower as a leafy vegetable will not only impart health benefits to consumers, but will also significantly enhance the income of safflower growers.

The main purpose of this study was to evaluate the performance of safflower varieties/genotypes for fresh vegetable yield, nutritional qualities and monetary returns in different seasons. We expect this study to generate interest in further research on the subject.

In a trial study, 15 safflower entries consisting of released varieties as well as stem-fasciated genotypes were planted in a randomized block design with two replications during winter 2014–15, summer 2015 and monsoon 2015 at the Nimbkar Agricultural Research Institute (NARI), Phaltan. Each entry was sown in six rows of 5 m length with inter- and intra-row spacings of 30 and 10 cm respectively. The experiment was provided a basal fertilizer dosage of 30 : 30 : 30 kg/ha of N, P_2O_5 and K_2O respectively during sowing. Irrigation was done during sowing for seed germination. The fresh vegetable yield was recorded on whole-plot basis at 30 days after sowing (DAS) during all three seasons.

Quality parameters such as fat %, protein %, ash %, vitamin C and concentration of phenolic compounds were estimated on a dry matter basis for each safflower entry of the trial grown in summer 2015. Vegetable samples of fenugreek and spinach obtained from the local market were used along with safflower for quality parameter analysis. The fat content of the samples was estimated by Soxhlet method[6] (SOCS PLUS system, Pelican Instruments, Chennai). The protein content of leaf samples was estimated by Kjeldahl mehod (Kjeloplus system, Pelican Instruments, Chennai). Percentage ash content was calculated by the standard method, while 2, 6-dichorophenol-indophenol visual titration method[7] was used to estimate vitamin C content in leaf samples. Total phenolics in a leaf sample were determined using Folin–Ciocalteu method[8].

The observations recorded during different seasons were subjected to analysis of variance (ANOVA) to test the significance of differences between the genotypes for fresh vegetable yield and other quality parameters, according to the method of Panse and Sukhatme[9].

Evaluation of safflower genotypes for leafy vegetable yield at 30 DAS during winter 2014–15, summer 2015 and monsoon 2015 showed the differences due to genotypes to be significant for winter 2014–15 and summer 2015. However, during monsoon 2015 no significant variation among genotypes for vegetable yield was observed, probably because no moisture stress was experienced by the genotypes.

Evaluation of safflower genotypes during the three seasons also revealed that sowing in monsoon 2015 recorded maximum average leaf yield, followed by crops raised in summer 2015 and winter 2014–15. This suggests that apart from regular winter season, safflower as a vegetable crop can also be suitably grown in both summer and monsoon seasons; thus regular round-the-year supply of safflower as a leafy vegetable for consumers can be assured.

Fresh leafy vegetable yield of safflower entries screened in winter 2014–15 varied from 656 to 4744 kg/ha; for summer 2015-sown entries it was in the range 427–7767 kg/ha and monsoon 2015-sown crops showed a range 5175–8331 kg/ha (Table 1). Overall, the average yield performance during monsoon 2015 was better (7008 kg/ha) than that for crops grown in summer 2015 (3313 kg/ha) and winter 2014–15 (3960 kg/ha).

Similarly, gross income, net income and benefit cost ratio (B : C ratio) were found to be higher in monsoon 2015 than in summer 2015 and winter 2014–15.

In safflower leaves, fat content ranged from 1.15% to 2.85% and protein content varied from 21.00% to 29.75%. Estimates of vitamin C showed the highest content of 18.99 mg/100 g and lowest content of 8.06 mg/100 g. Phenolic compounds were found to be maximum of 234.87 mg/100 g of gallic acid equivalent (GAE) and minimum of 76.00 mg/100 g of GAE (Table 2).

In safflower, average fat content (2.01%) and protein content (26.27%) were found to be higher than those for fenugreek (1.27% and 21.83% respectively) and spinach (1.12% and 23.84% respectively). Concentration of vitamin C and phenolic compounds was also found to be higher in safflower (12.66 mg/100 g and 146.12 mg/100 g of GAE respectively) than in spinach (10.91 mg/100 g and 99.91 mg/100 g of GAE respectively). However, concentration of vitamin C and phenolic compounds was less than those for fenugreek (18.25 mg/100 g and 218.58 mg/100 g of GAE respectively). Evaluation of quality parameters revealed that nutritional value of safflower as a leafy vegetable is as good as fenugreek and spinach. Similar results have been reported in an earlier study for safflower leaves in comparison with three other common leafy vegetables in India[4].

The high returns from safflower as a leafy vegetable in a short period of 30 DAS coupled with its high nutritional quality should be publicized to popularize it. This will increase the demand for safflower as a vegetable which can be easily met from the regular safflower grown as an oilseed during winter season, as thinning is carried out to remove the excess plants at 30–35 DAS. The removed plants instead of being used as a fodder for animals can be marketed as a leafy vegetable and give additional income to the farmers. Also, the lower 3–4 leaves of each plant may be removed

Table 1. Fresh vegetable yield of safflower, fenugreek and spinach

Crop	Season		
	Winter (2014–15)	Summer (2015)	Monsoon (2015)
	Fresh vegetable yield (kg/ha)		
Safflower	656–4744	427–7767	5175–8331
Fenugreek*	10,000–12,900	1800–2100	5000–7000
Spinach*	11,600–14,000	8000–9000	9000–12,000

*Source: Data provided by local farmer irrigated fields (single cutting @ 35–40 DAS).

Table 2. Nutritional parameters of vegetable safflower, fenugreek and spinach in summer 2015

Crop	Fat (%)	Protein (%)	Vitamin C (mg/100 g)	Phenolic compounds (mg/100 g of GAE)
Safflower (range)	1.15–2.85	21.00–29.75	8.06–18.99	76.00–234.87
Safflower (general mean)	2.01	26.27	12.66	146.12
Fenugreek (general mean)	1.27	21.83	18.25	218.58
Spinach (general mean)	1.12	23.84	10.91	99.91

during the rosette stage (30–40 DAS) without adversely affecting the productivity of the crop as an oilseed[10,11]. Thus the income generated from thinned plants and removal of the lower 3–4 leaves/plant at 30–40 DAS can meet the entire cost of production of the crop in advance. This can help the farmers in meeting all future input needs of the crop. The earnings likely to be obtained from the seeds and flowers would be a net income in his hands. However, in order to achieve this it is important to promote safflower as a nutritious leafy vegetable among the masses. This will not only enhance income of safflower farmers, but would also help in ensuring nutritional security of the consumers.

High vegetable yield under summer and monsoon conditions has revealed the suitability of safflower for two growing situations in which it is conventionally not grown. The promotion of safflower as a leafy vegetable will provide an additional nutrient source to the consumers and a source of remuneration to the farmers.

1. Li, D. and Mundel, H-H., In *Safflower–Carthamus tinctorius* L. *Promoting the Conservation and Use of Underutilized and Neglected Crops*, 7. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy. 1996, p. 83.
2. Knowles, P. F., *Econ. Bot.*, 1969, **23**, 324–329.
3. Nimbkar, N., *Times Agric. J.*, 2002, **2**, 32–36.
4. Sahasrabudde, D. L., Bombay Bulletin No. 124, Department of Health, Bombay, 1925, p. 38.
5. Awasthi, C. P. and Tandon, P. K., *Narendra Deva J. Agric. Res.*, 1988, **3**(2), 161–164.
6. Soxhlet, F., *Dingler's Polytech. J.* (in German), 1879, **232**, 461–465.
7. Ranganna, S., In *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw Hill, New Delhi, 2008, 2nd edn, pp. 105–106.
8. Singleton, V. L., Orthofer, R. and Lamuela-Raventós, R. M., *Methods Enzymol.*, 1999, **299**, 152–178.
9. Panse, V. G. and Sukhatme, P. V., In *Statistical Methods for Agricultural Workers*, ICAR, New Delhi, 1961, 2nd edn, p. 328.
10. Patil, V. A. and Jadhav, B. B., *Indian J. Agric. Sci.*, 1976, **46**, 415–417.
11. Urie, A. L., Leininger, L. N. and Zimmer, D. E., *Crop Sci.*, 1968, **8**, 747–750.

Received 10 May 2016; accepted 9 June 2016

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Temporal variation of phytoplankton assemblage in estuarine waters: implication of cyclone *Phailin*

Physical forcing of cyclonic phenomenon on water quality often exerts stress on marine and estuarine ecosystems due to their unpredictability. The post-cyclonic changes in phytoplankton biomass have been reported in the Bay of Bengal[1]. In addition, cyclones also intensify physical processes resulting in entrainment of nutrient-rich water from deeper depths into surface leading to regional phytoplankton blooms[2]. These blooms can bring out either positive or negative responses in the phytoplankton community which in turn exert effects on the food chain. However, changes in water quality parameters largely depend on cyclone intensity along with residence period.

A very severe cyclonic storm, *Phailin*, was developed in the Bay of Bengal and made landfall at Gopalpur coast of Odisha on 12 October 2013 (ref. 1). The present study area, Rushikulya estuary, was in close proximity (~20 km) to the landfall point. The Rushikulya estuary is a shallow aquatic ecosystem influenced by semi-diurnal tides and experiences tropical monsoonal climate[3]. The present study was carried out to decipher the phytoplankton community structure in Rushikulya estuary with reference to the cyclone *Phailin*.

The Rushikulya estuary has been seasonally monitored. Hence, water quality