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Evaluation of Safflower Genotypes in Northwest México

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Safflower (*Carthamus tinctorius* L., Asteraceae), is cultivated for the edible oil obtained from the seed. It contains a higher percentage of essential unsaturated fatty acids and a lower percentage of saturated fatty acids than other edible vegetable seed oils. The oil, light colored and easily clarified, is used in cooking oils, margarines, liqueurs, candles, and as a drying oil in paints, linoleum, varnishes, and wax cloths. Safflower oil lowers blood cholesterol levels and is used to treat heart diseases. The flowers have been the source of yellow and red dyes, largely replaced by synthetics, but still used in rouge. Meal or seedcake is used as feed for livestock, unhulled seed meal contains 18%–24% protein, hulled seed meal, 28%–50% protein. Seeds contain 32%–40% oil, 11%–17% protein, and 4%–7% moisture. One hundred g of seed contain 482 calories, 4.8 g H_2O, 12.6 g protein, 27.8 g fat, 50.5 g total carbohydrate, 25.1 g fiber, 4.3 g ash, 126 mg Ca, 310 mg P, 9.7 mg Fe, 0 µg beta-carotene equivalent, 0.59 mg thiamine, 0.14 mg riboflavin, 0.5 mg niacin, and 0 mg ascorbic acid. The oil contains 1.5% myristic (with lauric and lower acids), 3% palmitic, 1% stearic, 0.5% arachidic (with trace of lignoceric), 33% oleic, and 61% linoleic acids. Decorticated seed for animal feed contain 8.7% moisture, 10.0% fat, 45.4% protein, 20.1% carbohydrates, 8.3 fiber, and 7.5% ash (C.S.I.R. 1948–1976).

Safflower originated in southern Asia and has been cultivated in China, India, Persia, and Egypt almost from prehistoric times. During the Middle Ages it was cultivated in Italy, France, and Spain, and soon after the discovery of America, the Spanish took it to Mexico and then to Venezuela and Colombia. It was introduced into US in 1925 from the Mediterranean region and is now grown in all parts west of 100th meridian. Germplasm diversity in the World Collections of Safflower is reported by Wu and Jain (1977).

Seeds are usually pretreated with insecticides and fungicides. Same machinery used for small grains may be used for planting, cultivation, and harvesting. Seed should be planted when the soil temperature is about 4.4°C and the upper 10 cm of soil is moist. Seed germinates quickly at 15.5°C. Plant seed by solid drilling, 2.5–5 cm deep, at 9–23 kg/ha on dryland or 23–27 kg/ha when irrigation is used; seed may be broadcast (not preferred). The crop should be cultivated for weed control until just before flowering. Fertilization needs are determined by natural soil fertility and available moisture. Safflower takes the place of wheat, barley, or other feed grains in rotation, and on dry lands the highest yields follow summer fallow (Duke 1983).

BREEDING EFFORTS

In Northwest México, the weather and the soils are appropriate to grow safflower. The crop has been of interest due to its low water requirements. The first cultivars introduced to Yaqui Valley, Sonora, México, were the “Saffola” series, developed by the American seed corporation Pacific Oil Inc. The best cultivar was ‘Saffola 208’ which was grown extensively (Robles 1980). Later, Dave Rubis developed ‘Gila’, a high yielding, high test-weight cultivar, adapted to Arizona which was long popular in the Yaqui Valley, due to high grain yield, agronomic characters, excellent oil production, and disease resistance. However, ‘Gila’ was susceptible to leaf spot disease caused by the fungus *Alternaria carthami*, as a result, a Safflower Breeding Program of Yaqui Valley Experiment Field was initiated and safflower research began in Sinaloa, Tamaulipas, and Jalisco States.

The World Collection Genetic Material was obtained from the Fort Collins Seed Laboratory-USDA, which was characterized and evaluated by Ramón Gómez Jasso, continuing the research of Baldomero Rodríguez and Leodegario Quilantán, who established relationships with other researchers such as R.D. Brigham (Texas), B. Mazzani and D.G. Langham (Venezuela), A. Ashri (Israel), and C. Lessman (New México). In the 1970s Samuel Muñoz Burgos, of the Safflower Breeding Program, selected a genetic line which was released as ‘Kino 76’, the first cultivar with *Alternaria carthami* resistance. Trinidad Borbón Soto, Gilberto García Balderrama, and Edgar Haro Arias continued the safflower breeding program. During the 1980s, Gabriel Chanda Musa and Sergio Muñoz Valenzuela joined the program (Muñoz 1987).

The Safflower Genetic Breeding Program developed ‘Sahuaripa 88’ and ‘Quiriego 88’ (Musa and Muñoz-Valenzuela 1990a,b). These researchers wrote the safflower production guide for southern Sonora, México, that describes the new cultivars characteristics. In 1990, ‘San José 89’ was released for its broad adaptation to clay, sandy, and fertile soils, like the San José de Bácum region (Musa et al. 1993). In 1992 three good quality, high grain yield cultivars were released: 'San Ignacio 92', 'Sonora 92', and 'Bácum 92', with seed yield potential of 4 tonnes (t)/ha (Musa et al. 1993). In 1998 Lope Montoya Coronado, developed 'Quilantán 98', but it did not become popular because of the introduction of cultivars from other latitudes with high oleic acid for the oil industry.

DISEASE RESISTANCE

Disease resistance has been a factor in the breeding programs, because safflower is attacked by many fungi: *Alternaria carthami* (leaf spot and bud rot), *A. zinniae, Bremia lactucae, Cercospora carthami, Cercosporella carthami, Chaetomium globosum, Collectorichum capsici, Corticium solani, Ectoctroma carthami, Epicoccum nigrum, Erysiphe cichoracearum, Fusarium acuminatum, F. solani, Gloeosporium carthami, Glomerella cingulata, Leveillula compositarum, L. taurica, Macrophomina phaseoli, Macrosporium carthami, Marsonia carthami, Oidium carthami, Oidiopsis taurica, Phyllosticta carthami, Phytophthora drechsleri* (root rot)*, Ph. palmivora, Ph. parasitica, Puccinia carthami* (rust)*, Pythium debaryanum, P. oligandrum, Ramularia carthami,* and others (Duke 1983). At present, the most important disease problem of safflower in Northwest Mexico is false mildew, caused by the fungus *Ramularia carthami* (Fig. 1). This could be resolved through genetic improvement (Montoya 2005). The objective of this study was to evaluate the agronomic response, quality, disease reaction, and seed yield of new safflower experimental genotypes.

MATERIALS AND METHODS

The yield trial was conducted at the Agricultural Technological Institute (ITA) No. 21 during the winter-spring season 2005. ITA 21 (now ITVY) is located in Northwest, Sonora, Mexico between the parallels 27°00' and 28°26' N, and between the meridians 108°55' and 111°02' W, and an elevation of 40 m above sea level. The Yaqui Valley is composed of 235,000 ha of irrigated land lying between the Sierra Madre and the Gulf of California. Farms are irrigated from reservoirs on the Yaqui and Mayo Rivers and from some 700 public and private irrigation wells. Water is the lifeblood of the valley, and regional economic development has brought with it increased difficulties from water shortages, potential competition between urban and rural uses of water, and various forms of water pollution (Naylor et al. 2001). Ten safflower genotypes and two local checks, cultivars 'Bácum' and 'S-518' were used. The trial was a randomized complete block statistical design with three replications. The plots were in two rows, each 1 m wide by 6 m long. Seeding was on Feb. 12, 2005. Germination strength, bloom, and maturity date, disease reaction, plant height, lodging, grain density, oil content, and yield were measured.

RESULTS AND DISCUSSION

There were significant differences in grain yield among genotypes with a coefficient of variance of 8.12%. Grain yield varied from 2000 kg/ha (04-765) to 3418 kg/ha (02-272Y0), with an average of 2830 (Table 1). Oil content varied from 34.7% (04-765) to 40.2% (S-518). Infections by *Ramularia carthami* were observed (Fig. 1) and infection levels varied among the lines. The most resistant experimental lines were 04-787 and 04-765, which only showed traces of the disease. The lines 04-787 and 04-765 exhibited resistance to false mildew and should be used as a source of resistance to improve safflower.

REFERENCES

C.S.I.R. (Council of Scientific and Industrial Research). 1948–1976. The wealth of India. 11 vols. New Delhi.

Duke, J.A. 1983. Handbook of energy crops. www.hort.purdue.edu/newcrop/duke_energy/dukeindex.html.

Montoya, C.L. 2005. High quality and yield grain safflower varieties development in southern Sonora, México. Annual Field Day 2005. CIANO-INIFAP. Yaqui Valley Experimental Station. Ciudad Obregón, Sonora, México.

Muñoz, V.S. 1987. El mejoramiento genético del cártamo en el sur de Sonora. Conferencia impartida en la Universidad de Sonora, Unidad Norte. Caborca, Sonora, México.

Musa, G.L.C. and S. Muñoz-Valenzuela. 1990a. Registration of 'Sahuaripa 88' safflower. Crop Sci. 30:961.

Table 1. Agronomic and qualitative characteristics of 12 safflower experimental lines ranked by seed yield in Yaqui Valley, Sonora, México, ITVY, 2005.

Line	Days to bloom	False mildew severity	Plant height (cm)	Specific weight (kg/hL)	Oil content (%)	Seed yield (kg/ha)
02-272Y0	88	10	100	56.7	37.5	3418a
Bácum[z]	81	60	75	55.7	35.2	3287a
04-386	83	60	100	57.8	36.9	3132a
04-387	84	60	95	59.9	35.6	3095a
S-719	83	80	90	58.4	40.0	3065a
04-787	82	0	75	59.3	35.1	2900a
04-372	84	60	120	56.1	36.2	2845a
S-555	83	80	100	55.6	39.7	2807a
98-473	87	50	90	56.5	39.7	2697
S-518[z]	82	80	70	56.5	40.2	2493
S-345	88	60	110	51.7	39.8	2217
04-765	85	0	80	57.1	34.7	2000

[z]Local check

Fig. 1. False mildew caused by *Ramularia carthami*, the main safflower disease in Yaqui Valley, Sonora, Mexico.

Musa, G.L.C. and S. Muñoz-Valenzuela. 1990b. Registration of 'Quiriego 88' safflower. Crop Sci. 30:961–962.

Musa, G.L.C., S. Muñoz-Valenzuela, and R.D. García-Pérez. 1993. Registration of 'San José 89' safflower. Crop Sci. 33:207.

Musa, G.L.C., S. Muñoz-Valenzuela, R.D. García-Pérez, and O. Leal-Acosta. 1993. 'San Ignacio 92', 'Sonora 92', y 'Bácum 92': Nuevas variedades de cártamo para el noroeste de México. Folleto técnico No. 21. CEVY-CIRNO-INIFAP-SARH. Ciudad Obregón, Sonora, México.

Naylor, R.L., W.P. Falcon, and A. Puente-González. 2001. Policy reforms and Mexican agriculture: Views from the Yaqui Valley. CIMMYT Economics Program. Paper 01-01. México, D.F.: CIMMYT.

Robles, S.R. 1980. Producción de oleaginosas y textiles. Editorial Limusa. Noriega Editores. Monterrey, N.L. México.

Wu, K.K. and Jain, S.K. 1977. A note on germplasm diversity in the world collections of safflower. Econ. Bot. 31:72–75.