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Effect of spacing and foliar application of iron on yield, yield attributes and economics of safflower (*Carthamus tinctorious* L.)

Pitcheri Narendra Hirwani, Rajesh Singh and Ekta Singh

Abstract
A field experiment was conducted during Rabi 2020 at CRF (Crop Research Farm), Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field is sandy loam in texture, nearly neutral in soil reaction (pH 7.4). The treatments consisted of Spacing *viz*., 30x10cm, 45x10cm and 60x10cm and Foliar application of iron *viz*., Iron (0.1%), Iron (0.3%), Iron (0.6%) whose effect is observed in safflower (ISF-764). The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The results showed that *viz*.: number of capitulum per plant (29.33), seeds per capitulum (33.68) and test weight (51.37 g) were significantly recorded with the application of (60 cmx10cm + 0.6% Fe/ha). Maximum seed yield (1.91 t/ha), stover yield (4.73 t/ha) and harvest index (29.49%) were significantly recorded with the application of 30cm x10cm + 0.3% Fe/ha compared to all other treatments. However, the maximum gross returns (88929.60 INR/ha), net returns (63013.07 INR/ha) and B:C ratio (2.43) was significantly recorded significantly with the application of 30cm x10cm +0.3% Fe/ha as compared to all other treatments.

Keywords: Safflower, foliar application of iron, spacing, yield and economics

Introduction
Safflower is an important oilseed crop of the world. In India, it is grown in winter season and accounts for about 8.0% of the value of total oilseeds produce. Safflower has a deep root system and thus, can capture leached nutrients below the rooting-zone of other crops. In northern India, sowing of safflower gets delayed due to late harvesting of long-duration rice crop as well as in areas where moisture from rice fields cannot be receded out in time. Late sown safflower is exposed to high temperature during the reproductive phase, along with reduced growing season and consequently, results in reduced growth and productivity. India ranks first in area (41%) and production (29%) of safflower grown across the world. In India, safflower is grown on 1.5 lakh ha with the production of 1.09 lakh tons with an average productivity of 726 kg/ha. In India, the crop is largely grown in Maharashtra, Karnataka, Gujarat and Andhra Pradesh. Indian yield levels are very low compared to world productivity (820 kg/ha) (FAO, 2013). In Telangana, safflower is grown in an area of 35,000 acres with production of about 8,000 tonnes and productivity of about 350 kg/ha (Vyavasaya Panchangam, 2015-16). In recent years, nutrient management is one of the critical inputs in achieving high productivity of safflower.

Generally, safflower is produced on marginal lands that are relatively dry and deprived of the benefits of fertilizer inputs. Attempts to improve seed yield and quality by developing agronomic practices are underway throughout the world; safflower can be a candidate crop in dry land Agro-ecosystems, due to its potential for growth under water stress and the economic value in terms of both oil and seed.

Plant spacing is one of the agronomic practices that influence crop growth and development. Besides, plant spacing is among the factors affecting safflower yield and seed oil percentage. Optimization of plant density positive affects the absorption of nutrients and the amount of plant exposure to light and lead to higher yield. In addition, plant density of safflower crop is an important factor and increasing plant density provides to control of weeds and the end of result, yield and yield components was to higher (Naghavi, 2012). Moatshe *et al*. (2016) [4] reported that seed yield significantly increased as plant density increased from 62.500 to 100.000 plants per hectare. Propagation, Sowing and Spacing in Safflower Cultivation. Propagation is done by seeds. In India, usually this is sown as Rabi season crop from October to November. Avoid late sowing as this may result in low yield due to high temperatures before maturity of the crop. Actually, sowing time depends on the region/states.

When it comes to spacing for pure or solo crop, row spacing of 45-50 cm x 20-25 cm and for mixed crop or intercrop, row spacing of 20-25 cm x 20-25 cm and for rainfed crop, a row spacing of 60 cm x 30-35 cm should be followed. Safflower is usually planted at a depth of 30 to 45 mm. On an average, 10 kg of seeds are enough for covering 1 hectare land. Again seed rate depends on the area and variety. Healthy seeds of improved varieties should be selected for sowing. Find the high yielding cultivar for your region from agriculture department.

Iron (Fe) is a cofactor for approximately 140 enzymes that catalyze unique biochemical reactions. Carthamus tinctorius is a traditional Chinese medicine widely used to improve blood circulation extending the coagulation time in mice and exhibiting a significant antithrombotic effect**.** However, Carthamus tinctorius is used not only for its traditional medicinal purposes but is also effective for treating breast cancer**.** The oil extracted from the seed of Carthamus tinctorius is reported to contain alkane-6, 8-diols, which have the activity to inhibit 12- tetradecanoylphorbol-13-acetate-induced tumor promotion in two-stage carcinogenesis in mouse skin. In addition, Nferuloylserotonin and N-(p-coumaroyl) serotonin strongly inhibit the melanin production of Streptomyces bikiniensis and B16 melanoma cells**.** These compounds are suggested to have potential antitumor effects.

Materials and Methods

The experiment was carried out during *Rabi* season of 2020 at the CRF (Crop Research Farm), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The CRF is situated at 25º24‘41.27” N latitude, 81°50‘56” E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the Yamuna River by the side of Prayagraj - Rewa road about 12 km from the city. The experiment laid out in Randomized Block Design which consisting of ten treatments with T1: 30cm x 10cm + 0.1% Fe/ha, T2: 30cm x10cm + 0.3%Fe/ha, T3: 30cm x 10cm + 0.6% Fe/ha, T4: 45cm x10cm + 0.1% Fe/ha, T5: 45cm x 10cm + 0.3% Fe/ha, T6: 45cm x10cm + 0.6% Fe/ha, T7: 60cm x 10cm + 0.1% Fe/ha, T8: 60cm x 10cm + 0.3% Fe/ha, T9: 60cm x 10cm + 0.6% Fe/ha, T10: Control. The Experiment was laid out in Randomized Block Design, with ten treatments which are replicated thrice. Date of sowing was on 13th November 2020 with the seed rate of 7-20 kg/ha. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, branches per plant and plant dry weight are recorded. The yield parameters like capitulim per plant, seeds per capitulum, seeed yield, test weight (1000 seeds), stover yield and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results

Yield attributes

Data in table 1 tabulated that Application of 60cm x10cm + 0.6% Fe/ha resulted higher number of capitulum per plant (29.33), number of seeds per siliquae (33.68) and test weight (51.37g) which was significantly higher. 60cm x10cm + 0.3% Fe/ha and 45cm x10cm + 0.6% Fe/ha recorded capitulum per plant (28.93), seeds per capitulum (33.52 and 32.99) and test weight (50.47 and 49.83) respectively which were statistically at par with 60cm x 10cm + 0.6%.

Table 1: Effect of spacing and foliar application of iron on yield attributes of safflower

S. No	Treatments	capitulum/plant	Seeds/capitulum	Test weight (g)
1.	30cm x 10cm + 0.1% Fe/ha	24.13	29.92	42.77
2.	30cm x 10cm + 0.3% Fe/ha	24.93	30.57	44.37
3.	30cm x 10cm + 0.6% Fe/ha	26.20	31.22	46.63
4.	45cm x 10cm + 0.1% Fe/ha	25.37	30.94	45.13
5.	45cm x 10cm + 0.3% Fe/ha	27.63	32.48	48.27
6.	45cm x 10cm + 0.6% Fe/ha	28.30	32.99	49.83
7.	60cm x 10cm + 0.1% Fe/ha	27.30	31.67	47.70
8.	60cm x 10cm + 0.3% Fe/ha	28.93	33.52	50.47
9.	60cm x 10cm + 0.6% Fe/ha	29.33	33.68	51.37
10.	Control	22.30	29.38	40.77
F- test		S	S	S
S. EM (±)		0.37	0.36	0.53
C. D. (P = 0.05)		1.10	1.08	1.56

Yield and Yield attributes

Data in table 2 tabulated that Application of 60 kg/ha Sulphur + 40×20 cm resulted maximum seed yield (1.60 t/ha), stover yield (5.92 t/ha) and harvest index (22.38%) which are recorded maximum with the application of T_7 which is (60 kg/ha Sulphur + 40×20 cm) which was significantly higher. Sulphur (S) 60, 45 $kgha^{-1}$ + 40×20 cm, 50×20 cm recorded seed yield (1.57, 1.54 t/ha) and stover yield (5.74, 5.64 t/ha) respectively which were statistically at par with (60 kg/ha Sulphur + 40×20 cm).

Table 2: Effect of spacing and foliar application of iron yield and yield attributes safflower.

S. No	Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	30cm x 10cm + 0.1% Fe/ha	1.70	4.32	28.25
2.	30cm x 10cm + 0.3% Fe/ha	1.86	4.65	28.56
3.	30cm x 10cm + 0.6% Fe/ha	1.91	4.73	28.92
4.	45cm x10cm + 0.1% Fe/ha	1.64	3.93	29.44
5.	45cm x 10cm + 0.3% Fe/ha	1.77	4.49	28.55
6.	45cm x 10cm + 0.6% Fe/ha	1.81	4.57	28.41

7.	60cm x 10cm + 0.1% Fe/ha	1.50	3.78	28.47
8.	60cm x 10cm + 0.3% Fe/ha	1.56	3.85	28.77
9.	60cm x 10cm + 0.6% Fe/ha	1.67	4.01	29.49
10	Control	1.39	3.61	27.81
F- test		S	S	NS
S. EM (±)		0.04	0.06	0.59
C. D. (P = 0.05)		0.12	0.17	-

Economics

Data in table 3 tabulated Experimental results revealed that application of 30cm x10cm + 0.6% Fe/ha recorded higher gross returns (88929.60 INR) net returns (63013.07 INR) and benefit: cost ratio (2.43) and minimum gross returns (64718.40 INR), minimum net returns (39436.75 INR) and minimum benefit: cost ratio (1.55) were recorded with the treatment of control plot.

Table 3: Effect of spacing and foliar application of iron on economics of safflower

S. No	Treatments	Cost of Cultivation (INR/ha)	Gross return (INR/ha)	Net Return (INR/ha)	B:C ratio
1.	30cm x 10cm + 0.1% Fe/ha	25387.45	79152.00	53764.55	2.11
2.	30cm x 10cm + 0.3% Fe/ha	25599.07	86601.60	61002.53	2.38
3.	30cm x 10cm + 0.6% Fe/ha	25916.53	88929.60	63013.07	2.43
4.	45cm x 10cm + 0.1% Fe/ha	25387.45	76358.40	50970.95	2.00
5.	45cm x 10cm + 0.3% Fe/ha	25599.07	82411.20	56812.13	2.21
6.	45cm x 10cm + 0.6% Fe/ha	25916.53	84273.60	58357.07	2.25
7.	60cm x 10cm + 0.1% Fe/ha	25387.45	69840.00	44452.55	1.75
8.	60cm x 10cm + 0.3% Fe/ha	25599.07	72633.60	47034.53	1.83
9.	60cm x 10cm + 0.6% Fe/ha	25916.53	77755.20	51838.67	2.00
10.	Control	25281.65	64718.40	39436.75	1.55

Discussion

The maximum number of capitulum per plant and seed/capitulum was observed in T_9 (60cm x 10cm + 0.6% Fe/ha) (29.33). However, 28.93 was recorded in T_8 (60cm x 10cm + 0.3% Fe/ha). Which were statistically at par with T_9 (60cm x 10cm + 0.6% Fe/ha). Higher number of capitulum per plant might have been possible due to more vigour and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light and supply of nutrients in balanced quantity of the plant at growing stages. Resulted into a higher of capitulum. Prasanna *et al.*, (2014) [7]. The maximum test weight was observed in T_9 (60cm x 10cm + 0.6% Fe/ha) (51.37 g). However, 50.47 g was recorded in T_2 (30cm x 10cm+ 0.3% Fe/ha) and 49.83g was recorded in T_6 (45cm x 10cm + 0.6% Fe/ha). Which were statistically at par with T_9 (60 cmx10cm + 0.6% Fe/ha).Dry matter production related to grain productivity contributes an important factor in source-sink relationship. The increase in dry matter is indicator to increase production of yielding attributes. The iron has significantly increased on the number of capsules per plant and test weight. Similar results were reported by Ravi and Channal (2010). The maximum seed yield was observed in T_3 (30cm x 10cm + 0.6% Fe/ha) (1.91 t/ha). However, 1.86 t/ha was recorded in T_2 (30cmx10cm+ 0.3% iron Fe/ha) and 1.81 t/ha was recorded in T_6 (45cm x 10cm + 0.6% Fe/ha). Which were statistically at par with T_3 (30cm x 10cm + 0.6% Fe/ha). Galavi *et al.* (2012) [3] experiments revealed that spraying safflower plants with micronutrient Fe ($FeSO_4$) 2 ml/lit significantly increased seed yield (1346 kg/ha). The increase of plant population resulted in increasing number of head per area unit which ultimately leads to high yield. The maximum stover yield was observed in in T_3 (30cm x 10cm + 0.6% Fe/ha) (4.73). However, 4.65 was recorded in T_2 (30cm x 10cm+ 0.3% iron Fe/ha) and 4.57 Was recorded in T_6 (45cm x 10cm + 0.6% Fe/ha).The increase in stover yield was due to increase in respiration and photosynthesis, indirectly affected on source and sink relation by application of Iron reported by Ravi *et al.* (2010). The maximum gross return, net profit and benefit cost ratio (88929.60 INR/ha, 63013.07 INR/ha and 2.43) was recorded in treatment (T_3) in which (30cm x 10cm + 0.6% Fe/ha) followed by treatment (T_2) in which (30cm x 10cm + 0.3% Fe/ha). The minimum gross return, net profit and benefit cost ratio were recorded in treatment (64718.40 INR/ha, 39346.75 INR/ha and 1.55) which is (control).

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