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# Effect of Spacing and Foliar Application of Iron on Growth and Yield of Safflower (*Carthamus tinctorious* L.)

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**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., 30 × 10cm, 45 × 10cm and 60 × 10cm 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 treatment with (60 cm × 10cm + 0.6% Fe/ha) also recorded significantly higher in plant height (84.60 cm), number of branches (12.46), plant dry weight (36.80 g) . The treatment with (60 cm × 10cm + 0.6% Fe/ha) also recorded significantly higher in yield parameters *viz.*, number capitulum per plant (29.33), and Number of seeds/capitulum (33.68), test weight (51.37 g) and oil content (31.07%). The treatment with 30cm × 10cm + 0.6% Fe/ha) also recorded significantly higher in Seed yield (1.67 t/ha) and stover yield (4.01 t/ha).**

**Keywords:** Safflower, foliar application of iron, Spacing, Capitulum, dry weight and seed yield.

## 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). 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.

There are many factors that affect productivity in agriculture (Yau, 2009). Safflower growth, yield and yield composition and quality of seeds are also influenced by many factors like genotype, environment and agronomic practices (Dajue and Mundel, 1996). Agronomic practices such as row spacing and plant distance (plant density) of safflower vary considerably worldwide depending on each growing region, environmental condition, production systems and safflower cultivar, germination rate, soil fertility and water availability (Omidi *et al.*, 2009). 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) 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 × 20-25 cm and for mixed crop or intercrop, row spacing of 20-25 cm × 20-25 cm and for rainfed crop, a row spacing of 60 cm × 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, N feruloylserotonin 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 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 × 10cm + 0.1% Fe/ha, T2: 30cm × 10cm +0.3% Fe/ha, T3: 30cm × 10cm + 0.6% Fe/ha, T4: 45cm × 10cm + 0.1% Fe/ha, T5: 45cm × 10cm + 0.3% Fe/ha, T6: 45cm × 10cm +0.6% Fe/ha, T7: 60cm × 10cm + 0.1%Fe/ha, T8: 60cm × 10cm + 0.3% Fe/ha, T9: 60cm × 10cm + 0.6% Fe/ha, T10: Control were replicated thrice. The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (pH 7.4), low in Organic carbon (0.49%), medium available N (225 kg $ha^{-1}$), higher available P (21.3 kg $ha^{-1}$) and medium available K (235.8 kg $ha^{-1}$). Nutrient sources were Urea, DAP, MOP to fulfill the requirement of Nitrogen, phosphorous and potassium. Ferrous sulphate used to fulfill the requirement of Iron. The applications of fertilizers were applied as basal at the time of sowing. Nitrogen applied as split dose half as basal dose remaining as top dressing. 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 capitulum per plant, seeds per capitulum, seed 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 and Gomez 1984).

## RESULTS AND DISCUSSION

*A. Effect of spacing and foliar application of iron on plant height in safflower*

Data in Table 1, tabulated the plant height (cm) of Safflower and there was increasing in plant height was improved with the advancement of experimentation. The plant height was significantly higher in all different growth intervals with levels of spacing and foliar application of iron. At harvest, recorded maximum plant height $T_9$ (60 cm × 10cm + 0.6% Fe/ha) (84.60 cm). However, 84.27 cm was recorded in $T_8$ (60 cm × 10cm + 0.3% Fe/ha), 83.57 cm was recorded in $T_6$ (45cm × 10cm + 0.6% Fe/ha) and 83.17 cm was recorded in $T_5$ (45cm × 10cm + 0.3% Fe/ha) which were statistically at par with $T_9$ (60 cm × 10cm + 0.6% Fe/ha). The probability in increase in plant height due to widest (increased) plant spacing might be due to the fact that the increased spacing between plants resulted in enhanced space sunlight, nutrients and soil moisture for increased photosynthesis, metabolic activities, growth and development increase in plant height with higher levels of iron due to well-aerated soils iron occurs mostly in the form of $Fe^3$ oxides or hydroxides, and thus the concentration of $Fe^{3+}$ is very low in physiological pH range. As a consequence of the chemical equilibrium in aerated soils, chelated iron is the dominant form transported to the roots apoplast. Which ultimately leads to the higher values in growth parameters similar results were reported by (Lindsay and Schwab, 1982).

*B. Effect of spacing and foliar application of iron on branches in safflower*

Data in Table 1, tabulated the branches per plant of safflower and there was increasing in crop age branches was improved with the development of experimentation. The branches per plant were significantly higher in all different growth intervals with levels of Spacing and foliar application of iron. At harvest, $T_9$ (60 cm × 10cm + 0.6% Fe/ha) (12.46). However, 12.34 was recorded in $T_8$ (60 cm × 10 cm + 0.3% Fe/ha ) which were statistically at par with $T_9$ (60 cm × 10cm + 0.6% Fe/ha ). The beneficial effect might be due to interaction effect of Iron and their role in the synthesis of IAA, metabolism of auxin and formation of chlorophyll synthesis, similar results was also reported by Zareii *et al*., (2014).

*C. Effect of spacing and foliar application of iron on dry weight (g) in safflower*

Data in Table 1 tabulated the plant dry weight (g) of safflower and there was increasing in plant dry weight was improved with the development of experimentation. The plant dry weight was significantly higher in all different growth intervals with levels of Spacing and foliar application of iron. At harvest $T_9$ (60 cm × 10cm + 0.6% Fe/ha)
(36.80 g). However, 36.46 g was recorded in $T_8$ (60cm × 10cm + 0.3% Fe/ha) and 36.21 g Was recorded in $T_6$ (45cm × 10cm + 0.6% Fe/ha) which were statistically at par with $T_9$ (60 cm × 10cm + 0.6% Fe/ha). Higher dry matter production is observed in 40cm × 10cm spacing due to better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants have also resulted in higher dry weight on the plants results reported by Jangir *et al.,* (2017).

**Table 1: Effect of spacing and foliar application of iron on growth attributes of safflower.**

| Sr. No. | Treatments | Plant height (cm) | branches/plant | Dry weight (g) |
|---|---|---|---|---|
| 1. | 30 cm × 10cm + 0.1% Fe/ha | 80.43 | 11.64 | 33.05 |
| 2. | 30cm × 10cm + 0.3% Fe/ha | 80.97 | 11.69 | 33.84 |
| 3. | 30cm × 10cm + 0.6% Fe/ha | 82.43 | 11.96 | 35.01 |
| 4. | 45cm × 10cm+ 0.1% Fe/ha | 81.57 | 11.83 | 34.47 |
| 5. | 45cm × 10cm + 0.3% Fe/ha | 83.17 | 12.15 | 35.57 |
| 6. | 45cm × 10cm + 0.6% Fe/ha | 83.57 | 12.20 | 36.21 |
| 7. | 60cm × 10cm + 0.1% Fe/ha | 82.63 | 12.04 | 35.25 |
| 8. | 60cm × 10cm+ 0.3% Fe/ha | 84.27 | 12.34 | 36.46 |
| 9. | 60 cm × 10cm + 0.6% Fe/ha | 84.60 | 12.46 | 36.80 |
| 10. | Control | 79.80 | 11.51 | 32.22 |
| | F test | S | S | S |
| | SEm (±) | 0.59 | 0.07 | 0.40 |
| | CD (5%) | 1.74 | 0.21 | 1.20 |

*D. Effect of Spacing and foliar application of iron on Number of capitulum/plant, seeds/capitulum and test weight (g) in yellow mustard*

**Number of capitulum/plant.** Data in Table 2 tabulated the number of capitulum per plant of safflower and there was increasing in number of capitulum per plant was improved with the development of experimentation. Maximum number of capitulum/plant $T_9$ (60 cm × 10cm + 0.6% Fe/ha) (29.33). However, 28.93 was recorded in $T_8$ (60cm × 10cm+ 0.3% Fe/ha ) which were statistically at par with $T_9$ (60 cm × 10cm + 0.6% Fe/ha). The 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 (Kumara *et al.,* 2014).

**Number of Seeds/plant.** Data in Table 2 tabulated the no. of seeds/capitulum of safflower and there was increasing in number of seeds/capitulum was improved with the development of experimentation. The maximum number of seeds per capitulum was observed in $T_9$ (60 cm × 10cm + 0.6% Fe/ha ) (33.68). However, 33.52 was recorded in $T_8$ (60cm × 10cm + 0.3% Fe/ha) and 32.99 was recorded in $T_6$ (45cm × 10cm + 0.6% Fe/ha) which were statistically at par with $T_9$ (60 cm × 10cm + 0.6% Fe/ha).

**Table 2: Effect of Spacing and Foliar application of iron on yield attributes of Safflower.**

| Sr. No. | Treatments | Capitulum/plant | Seeds/capitulum | Test weight (g) | Seed yield (t/ha) | Stover yield (t/ha) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| 1. | 1. 30 cm × 10cm + 0.1% Fe/ha | 24.13 | 29.92 | 42.77 | 1.70 | 4.32 | 28.25 |
| 2. | 2. 30 cm × 10cm + 0.3% Fe/ha | 24.93 | 30.57 | 44.37 | 1.86 | 4.65 | 28.56 |
| 3. | 3. 30 cm × 10cm + 0.6% Fe/ha | 26.20 | 31.22 | 46.63 | 1.91 | 4.73 | 28.92 |
| 4. | 4. 45cm × 10cm + 0.1% Fe/ha | 25.37 | 30.94 | 45.13 | 1.64 | 3.93 | 29.44 |
| 5. | 5. 45cm × 10cm + 0.3% Fe/ha | 27.63 | 32.48 | 48.27 | 1.77 | 4.49 | 28.55 |
| 6. | 6. 45cm × 10cm + 0.6% Fe/ha | 28.30 | 32.99 | 49.83 | 1.81 | 4.57 | 28.41 |
| 7. | 7. 60cm × 10cm + 0.1% Fe/ha | 27.30 | 31.67 | 47.70 | 1.50 | 3.78 | 28.47 |
| 8. | 8. 60cm × 10cm + 0.3% Fe/ha | 28.93 | 33.52 | 50.47 | 1.56 | 3.85 | 28.77 |
| 9. | 9. 60cm × 10cm + 0.6% Fe/ha | 29.33 | 33.68 | 51.37 | 1.67 | 4.01 | 29.49 |
| 10. | Control | 22.30 | 29.38 | 40.77 | 1.39 | 3.61 | 27.81 |
| | F- test | S | S | S | S | S | NS |
| | S. EM (±) | 0.37 | 0.36 | 0.53 | 0.04 | 0.06 | 0.59 |
| | C. D. (P = 0.05) | 1.10 | 1.08 | 1.56 | 0.12 | 0.17 | - |

Test weight (g). Data in Table 2 tabulated the test weight of safflower and there was increasing in test weight (g) was improved with the development of experimentation. The maximum test weight was observed in $T_9$ (60 cm × 10cm + 0.6% Fe/ha) (51.37 g). However, 50.47 g was recorded in $T_2$ (30cm × 10cm + 0.3% Fe/ha) and 49.83 g was recorded in $T_6$ (45cm × 10cm + 0.6% Fe/ha) which were statistically at par with $T_9$ (60 cm × 10cm + 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 *et al.*, (2010).

*E. Effect of Spacing and foliar application of iron on yield and yield attributes in safflower*

Data in Table 2 tabulated the yield and yield attributes of safflower and there was increasing in seed yield (1.91 t/ha), stover yield (4.73 t/ha) and harvest index (29.49 %) which are recorded maximum with the application of $T_3$ (30 cm × 10cm + 0.6% Fe/ha) which was significantly higher. $T_2$ (30cm × 10cm + 0.3% iron Fe/ha), $T_6$ (45cm × 10cm + 0.6% Fe/ha) recorded seed yield (1.86.1.81 t/ha) and stover yield (4.65,4.57 t/ha) respectively which were statistically at par with $T_3$ (30 cm × 10cm + 0.6% Fe/ha). While in the harvest index maximum recorded with the in $T_9$ (60 cm × 10cm + 0.6% Fe/ha) and minimum recorded with $T_{10}$ (Control). Galavi *et al.*, (2012) experiments revealed that spraying safflower plants with micronutrient Fe ($FeSO_4$) 2ml/lit significantly increased seed yield (1346 kg/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).

**Fig. 1.** Field layout preparation before seed sowing atcrop, Spraying of foliar spray of ferrous sulphate at 60DAS of interval and crop harvesting at research farm, Department of Agronomy, SHUATS, Prayagraj, during Rabi, 2020.

## CONCLUSION

On the basis of present study, recommends that the application of resulted $T_9$ (60 cm × 10cm + 0.6% Fe/ha) highest plant height (84.60 cm), number of branches per plant (12.34 ), capitulum/plant (29.33), seeds/capitulum (33.68) where as application of $T_3$ (30 cm × 10cm + 0.6% Fe/ha) resulted maximum seed yield of (1.91 t/ha), stover yield (4.73 t/ha) and harvest index (29.49%).

## FUTURE SCOPE

Since, the findings were based on the research dine in one season under agro-ecological conditions of Prayagraj it may be repeated for confirmation and farmer recommendations

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**Conflict of Interest.** Nil.

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