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# Effect of combined foliar application of micronutrient and nitrogen on quality parameter of safflower in *Vertisol* of Chhattisgarh

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**Abstract**
The present investigation was conducted to access quality parameters of safflower through foliar spray of micronutrients and nitrogen combinations along with General Recommended dose during *rabi* 2013-14 and 2014-15 at the Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh in randomized block design with three replications and twelve treatments namely absolutely control, 100% GRD (without spray), 100% GRD with tap-water spray, 100% GRD+ 1% N foliar spray, 100% GRD+ 0.2% Fe foliar spray, 100% GRD+ 0.5 % Zn foliar spray, 100% GRD+ 0.3% Mn foliar spray, 100% GRD+Fe 0.2% + Mn 0.3% foliar spray, 100% GRD+ Fe 0.2% + Zn 0.5% foliar spray, 100% GRD+ Mn 0.3% + Zn 0.5% foliar spray, 100% GRD+Fe 0.2% + Mn 0.3% + Zn 0.5% foliar spray and 100% GRD + Fe 0.2% + Mn 0.3% + Zn 0.5% + 1% urea foliar spray.
The treatments 100% GRD + Fe 0.2% + Mn 0.3% + Zn 0.5% + 1% urea foliar spray was a sound combination of nutrients to get highest oil yield (529.78 kg ha$^{-1}$) followed by Fe 0.2% + Mn 0.3% + Zn 0.5% with GRD (508.33kg ha$^{-1}$) were superior to application of GRD alone (393.15kg ha$^{-1}$) and increase in oil yield was by 34.75 and 29.30% percent over GRD alone respectively.

**Keywords:** GRD, foliar application, micronutrients, oil yield, Safflower

## 1. Introduction
Safflower (*Carthamus tinctorius* L.) is an important annual winter oilseed crop grown in dry and semi dry lands with ability to withstand drought, salinity and cold stress of Southern Asia and India. India stands first in area (51%) and production (37%) in the world. Its average productivity is 498 and 286 kg/ha in India and Chhattisgarh state, respectively (Annual Research work shop on safflower, 2013). The lower crop yields are also responsible for low oil yields.
The availability of good quality seeds of the variety with high production potential and support for purchasing seed by by the farmers for its commercial uses can be effective in country's oil demand. Therefore, necessity of nutrient management is desired in turn to enhance oil yield of the crop. In rainfed, arid and semiarid regions, foliar application of nutrients is a more suitable option compared with soil fertilization when the roots are unable to provide necessary nutrients and quick compensation of nutrient deficiency and application of lesser rates and thus, preventing nutrients fixation in the soil.
The micronutrients are not micro in their role, rather play major role in enhancing efficiency of other nutrients there by enhance physiological processes of growth and development (Shukla *et al*., 2009) [15], yield and quantitative parameters of crops (Tavassoli *et al*., 2010; Paygozar *et al*., 2009) [16, 11] and manganese and zinc can play an important role in nutrition of oil plants, production of biomass, grain yield, quality and quantity of oil.
Therefore the experiment was conducted with the objective to assess quality parameters of safflower through foliar spray of micronutrients and nitrogen combination along with general recommended fertilizer dose.

## Methods and Materials
Field experiment was carried out during *rabi* seasons of 2013-2014 and 2014-2015 at the Research Farm, Indira Gandhi Agricultural University, Raipur (C.G.). The experimental soil is clayey with pH 7.2, available N, P, K and S levels were 228, 22.7, 478 and 23 kg ha$^{-1}$, micronutrients viz., Fe, Mn and Zn were 8.83, 8.37 and 0.8 mg kg$^{-1}$, respectively.

The fertilizer doses GRD was 50-25-20 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$ respectively applied in all the treatments. Phosphorus and potash were applied as basal through di-ammonium phosphate and muriate of potash, respectively. Urea foliar spray as per treatments applied thrice, first at 45 days after sowing (i.e. during branching stage), followed by the second and third at 15 days interval. Micronutrients were foliarly applied at branching stage only (45 DAS) though individual EDTA salt.

The safflower seeds with hull were dried at 40 °C for 4 hours under vacuum to less than 5% moisture content and then milled to desired particle size by a mortar. Oil was extracted from 15 grams of each seed powder in Soxhlet extractor for 6 hours using hexane as a solvent, following the AOCS method Ba 3-38 (AOCS 1993) [4].

The fatty acid composition was determined by the conversion of the oil to fatty acid methyl esters according to the AOCS 1997 method. The fatty acid methyl esters (FAMEs) were prepared by adding 7 ml of 50 µl sodium methoxide (0.5 M) to 350 mg of oil. The mixture was heated in the bath at its boiling temperature for 10 min followed by adding 5ml of boron trifluride (BF3) as catalyst and heated again for 2 min. Then 6 ml of GC-grade hexane was added and heated for 2 min. Finally, 50 ml of saturated saline water was added and well were shaken at room temperature for 1 min. The top layer (0.5 µl) was injected on to a gas chromatography. The system was equipped with a flame ionizing detector (FID) and a fused silica capillary column (BPX70, 50ml × 0.32mm i.d) with the film thickness of 0.25µm. This process was operated at an oven temperature of 120 °C which was then raised to 220 °C at a rate of 3.5 °C/min and then kept at 220 °C for 15 min. The injector and detector temperatures were set at 250 °C. Helium was used as the carrier gas at a flow rate of 1 ml min-1. Identification and quantification of FAMEs were performed by comparing the relative retention times with individual standard FAME of linoleic (C18:2), oleic (C18:1), stearic (C18:0), and palmitic, (C16:0), acids purchased from Merck (Darmstadt, Germany). The relative in percentage of the fatty acid was calculated on the basis of the peak area of a fatty acid species to the total peak area of all the fatty acids in the oil sample.

Initial and after harvest soil sample were collected and analyzed for soil pH, EC, macro and micronutrients status by adopting standard laboratory methods.

## Results and Discussion

### Percent oil content

Effect of nitrogen and micronutrients foliar spray on percent oil content is presented in table 1 and fig.1 which showed that it was significantly higher when compared with GRD alone. The highest percent oil content was recorded in T11GRD+ Fe 0.2% +Zn 0.5% +Mn 0.3%, T9 (Fe 0.2% + Zn 0.5%, followed by T10 GRD + Mn 0.5% + Zn 0.3%, T12 GRD + Fe 0.2% + Zn 0.5% + Mn 0.3% +N 1%, T6 GRD+ Zn 0.5%, T8 GRD+ Fe 0.2% +Mn 0.3%,, T7 GRD + Mn 0.3%, and T1 N0:P0:K0. The effect of different micronutrient foliar spray treatments on percent oil content was significantly higher when compared with control treatment GRD alone, while the highest oil percent increased in T11GRD+ Fe 0.2% +Zn 0.5% +Mn 0.3% i.e 4.69 % over GRD alone followed by similar trends as oil content. Kaya and Higgs, 2002) also reported that zinc plays an important role in the production of biomass, grain yield, quality and quantity of oil, micronutrients application increased leaf area index and thereby more light absorption and dry matter accumulation and economic yield Ravi *et al*. (2008) [12].

**Table 1:** Effect of nitrogen and micronutrients foliar spray on oil content of safflower.

| Treatments | Oil content (%) | | Oil content (%) pooled | % increase in oil Content |
|---|---|---|---|---|
| | 2013-14 | 2014-15 | | |
| T1- Absolutely control | 34.19 | 34.30 | 34.24 | 2.31 |
| T2- GRD (Without spray ) | 33.48 | 33.46 | 33.47 | 0.000 |
| T3- GRD with tap-water spray | 33.12 | 33.14 | 33.13 | -1.02 |
| T4- GRD+ 1% Urea Foliar spray | 33.03 | 33.07 | 33.05 | -1.26 |
| T5- GRD+ 0.2% Fe Foliar spray | 33.60 | 34.27 | 33.94 | 1.40 |
| T6- GRD+ 0.5 % Zn Foliar spray | 34.60 | 34.55 | 34.58 | 3.3 |
| T7- GRD+ 0.3% Mn ) Foliar spray | 34.40 | 34.36 | 34.38 | 2.72 |
| T8- GRD+ (Fe + Mn) Foliar spray | 34.50 | 34.57 | 34.53 | 3.18 |
| T9- GRD+ (Fe + Zn) Foliar spray | 34.77 | 34.85 | 34.81 | 4.00 |
| T10-GRD + (Mn + Zn) Foliar spray | 34.78 | 34.79 | 34.78 | 3.92 |
| T11-GRD + (Fe + Zn+Mn) Foliar spray | 35.15 | 34.93 | 35.04 | 4.69 |
| T12-GRD + (Fe+Zn+Mn+Urea) Foliar spray | 34.97 | 34.28 | 34.63 | 3.456 |
| CD (5%) | 0.28 | 0.14 | 0.24 | |
| SEm | 0.09 | 0.43 | 0.083 | |

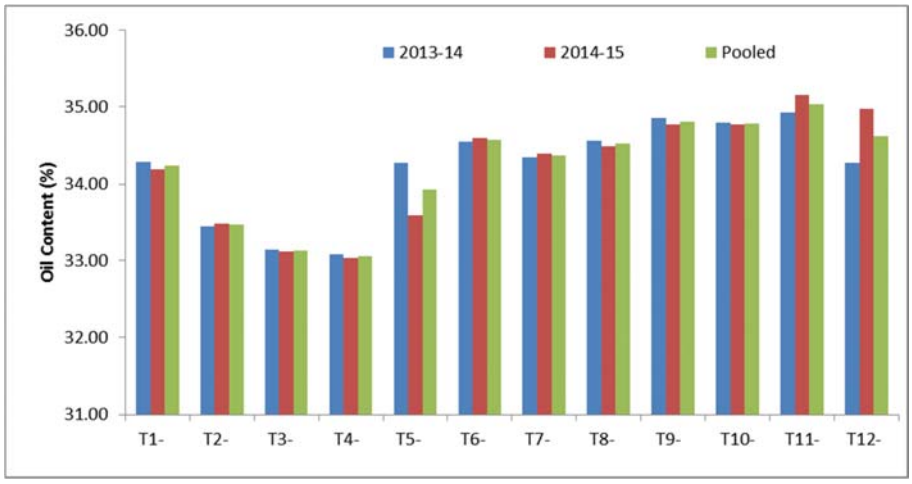


**Fig 1:** Effect of nitrogen and micronutrients foliar spray on percent oil content

Results on pooled oil yield as influenced by the treatments imposed are presented in table 2 and fig.2. Averaged oil yield was at par with each other but significantly superior with combination of T12 GRD + Fe 0.2% +Zn 0.5% +Mn 0.3% + N1%, produced highest oil yield (529.78 kg ha$^{-1}$), and T11 GRD+ Fe 0.2% +Zn 0.5% +Mn 0.3% (508.33kg ha$^{-1}$) compared with GRD alone (393.15kg ha$^{-1}$).

The highest percent oil yield increased with T12GRD + Fe 0.2% +Zn 0.5% +Mn 0.3% + N1%(34.75%), followed by T11 GRD+ Fe 0.2% +Zn 0.5% +Mn 0.3%(29.30%), T9 GRD +Fe 0.2% + Zn 0.5%(22.85%), T10 GRD + Mn 0.5% +Zn 0.3% (19.80%), T4 GRD+ 1% N (19.71%), T8 GRD+ Fe 0.2% +Mn 0.3% (19.05%), T7 GRD + Mn 0.3% (18.03%), T6 GRD+ Zn 0.5%(17.32), and T5 GRD+ Fe 0.2% (11.51%),while minimum percent oil yield increase with T3 GRD+ tap water spray (10.90%) compared with GRD alone.

The increase of seed yield of safflower and ultimately oil yield due to zinc foliar application has been reported by Movahhedi- Dehnavi *et al*. (2009) [9].

**Table 2:** Effect of nitrogen and micronutrients foliar spray on oil yield of safflower

| Treatments | Oil yield kgha$^{-1}$ | | Pooled oil kg ha$^{-1}$ | Percent increase oil yield |
|---|---|---|---|---|
| | 2013-14 | 2014-15 | | |
| T1- Absolutely control | 195.70 | 211.41 | 208.21 | |
| T2- GRD (Without spray ) | 358.54 | 394.33 | 393.15 | 0.00 |
| T3- GRD with tap-water spray | 411.83 | 434.63 | 436.00 | 10.90 |
| T4- GRD+ 1% Urea Foliar spray | 450.00 | 467.15 | 470.63 | 19.71 |
| T5- GRD+ 0.2% Fe Foliar spray | 398.16 | 471.84 | 438.41 | 11.51 |
| T6- GRD+ 0.5 % Zn Foliar spray | 446.24 | 481.10 | 461.26 | 17.32 |
| T7- GRD+ 0.3% Mn ) Foliar spray | 451.06 | 477.62 | 464.04 | 18.03 |
| T8- GRD+ (Fe + Mn) Foliar spray | 471.51 | 464.42 | 468.06 | 19.05 |
| T9- GRD+ (Fe + Zn) Foliar spray | 488.46 | 491.89 | 482.99 | 22.85 |
| T10-GRD + (Mn + Zn) Foliar spray | 466.74 | 495.15 | 471.00 | 19.80 |
| T11-GRD + (Fe + Zn+Mn) Foliar spray | 542.25 | 516.94 | 508.33 | 29.30 |
| T12-GRD + (Fe+Zn+Mn+Urea) Foliar spray | 547.12 | 541.36 | 529.78 | 34.75 |
| CD (5%) | 112.37 | 96.93 | 95.41 | |
| SEm | 38.31 | 33.05 | 32.53 | |

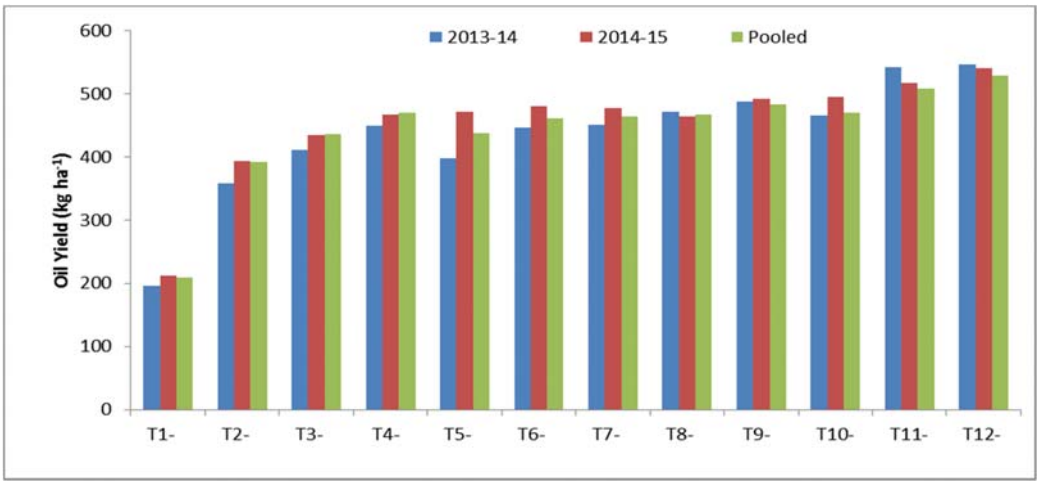


**Fig 2:** Effect of nitrogen and micronutrients foliar spray on oil yield safflower

Shahrajabian *et al*., (2011) [13] observed more leaf area index, plant height and crop biomass with the foliar application of Zn+Fe+Mn. Ravi *et al*. (2008) [12] concluded that combinations of Fe and Zn foliar spray in safflower recorded the highest yield, dry leaf and dry stem yield.

**Fatty acid profile**

Results on fatty acid profile observed are presented in table (3) and fig. (3) clearly indicates that application of micronutrients combinations and nitrogen foliar spray with GRD increased the total unsaturated fatty acid (i.e.Palmitic, steiric, oleic and linoleic). Application of foliar spray of micronutrients at critical growth stage provide nutrients along with water increased positive fatty acid profile. Its makeup was about 99.14% of safflower oil made of four fatty acid i.e. steiric (1.88%), palmitic (6.78%), oleic (17.50%) and linoleic (72.98%). The results were in agreement with the findings of Mohsen movahhedi dehvani *et al*, 2009 [9] and Ngaraj and Anjani, 1997, they also concluded that 99.5% fatty acid profiles of safflower oil was made of stearic (2%), palmitic (8.3 %), oleic (17.3 %) and linoleic (71.9 %).

**Table 3:** Effect of nitrogen and micronutrients foliar spray on fatty acid profile of safflower.

| Treatments | Fatty Acid profile (%) | | | |
|---|---|---|---|---|
| | Steiric | Palmitic | Oleic | Linoleic |
| T1- Absolutely control | 1.83 | 6.99 | 17.84 | 72.95 |
| T2- GRD (Without spray ) | 1.87 | 6.6 | 17.5 | 72.99 |
| T3- GRD with tap-water spray | 1.87 | 6.95 | 17.72 | 72.97 |
| T4- GRD+ 1% Urea Foliar spray | 1.85 | 6.62 | 17.59 | 72.89 |
| T5- GRD+ 0.2% Fe Foliar spray | 1.85 | 6.81 | 17.57 | 72.91 |
| T6- GRD+ 0.5 % Zn Foliar spray | 1.89 | 6.87 | 17.29 | 72.96 |
| T7- GRD+ 0.3% Mn ) Foliar spray | 1.92 | 6.71 | 17.29 | 73.16 |
| T8- GRD+ (Fe + Mn) Foliar spray | 1.85 | 6.45 | 17.55 | 72.96 |
| T9- GRD+ (Fe + Zn) Foliar spray | 1.85 | 6.82 | 17.29 | 73.01 |
| T10-GRD + (Mn + Zn) Foliar spray | 1.94 | 7.04 | 17.51 | 72.97 |
| T11-GRD + (Fe + Zn+Mn) Foliar spray | 1.91 | 6.69 | 17.49 | 73.06 |
| T12-GRD + (Fe+Zn+Mn+Urea)Foliar spray | 1.94 | 6.88 | 17.47 | 73.04 |
| CD (5%) | NS | NS | NS | NS |
| $SEm_{\pm}$ | 0.028 | 0.09 | 0.13 | 0.06 |

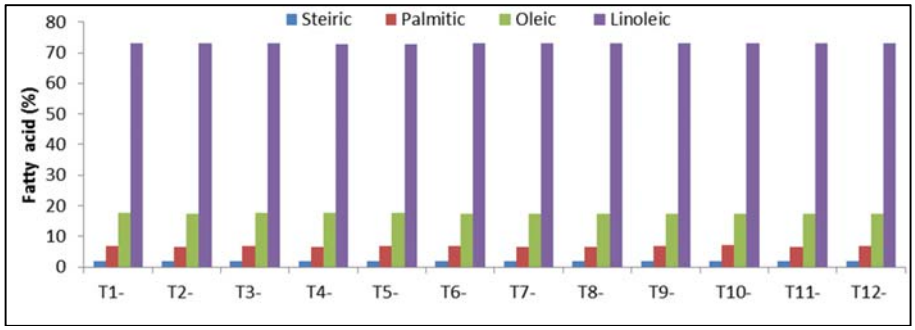


**Fig 3:** Effect of nitrogen and micronutrients foliar spray on fatty acid profile of safflower

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