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# Effect of Integrated Nutrient Management (INM) practices on Growth, Yield and Oil Yield of Safflower (*Carthamus tinctorius* L.)

**Ripan Chandra Das[1]*, G. Somanagouda[2] and Bheiru Singh[1]**

[1]Department of Agronomy, UAS, Dharwad, Karnataka- 580005, India
[2]Department of Agronomy, ARS, Annigari, UAS, Dharwad, Karnataka- 580005, India
**Corresponding author*

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**A B S T R A C T**

A field experiment was conducted at Agricultural Research Station, Annigeri, University of Agricultural Sciences, Dharwad during *rabi* season of 2015-16 under rainfed condition to study the effect of integrated nutrient management (INM) practices on growth, yield and oil yield on safflower. Results revealed that all integrated nutrient management (INM) practices significantly influenced the growth and yield of safflower. Among the different INM combinations tested, application of RDF (40:40:12 kg $ha^{-1}$ NPK) + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$@ 10.0 kg $ha^{-1}$ ($T_{10}$) recorded significantly highest plant height (75.14 cm), Capsules (28.27 $plant^{-1}$), Seed weight (21.45 $plant^{-1}$), seed yield (989 kg $ha^{-1}$), Oil content (28.65 %) and oil yield (283.32 kg $ha^{-1}$). However, $T_7$ (50 % RDF + 1.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$@ 10.0 kg $ha^{-1}$) recorded significantly the highest net returns (Rs. 9,853 $ha^{-1}$) and B:C ratio (1.61). This study indicated that despite drought year, integrated nutrient management (INM) practices helped in improving the seed and oil yield of safflower. Thus, such study needs to be continued to see the long-term effect on crop performance and resilience to climatic variability.

## Introduction

Safflower (*Carthamustinctorius* L.) is one of the oldest crop cultivated for its edible seed oil and is known for salt as well as drought tolerance crop due to partially xerophytic nature, in addition to deep and extensive root system making efficient use of reserved soil moisture. The average productivity of safflower is low in India (627 kg $ha^{-1}$) while it is relatively better in Karnataka (822 kg $ha^{-1}$). As the crop is mainly cultivated under rainfed condition during post-rainy season on receding soil moisture, results in inadequate supply of both water and nutrients to the crop. Application of limited quantity of nutrients (NPK) only through chemical fertilizer creates multiple-nutrients deficiencies in the soil which is considered as one of reason for limiting the crop production (Tiwari *et al.*, 2002). Hence, there is need to be improved the soil fertility for better yield. Thus, soil fertility as well as crop production can be improved by application of nutrients through organic sources and/or integration of different organic sources of nutrients (Reddy 2005; Akbari *et al.*, 2011; Basak *et al.*, 2012). Therefore, combined application of organic manure and chemical fertilizers may enhance the productivity and economic profitability of safflower. In this regard, a study was conducted to test the effect of combined

application of inorganic fertilizers with organic manures including microbial sources on productivity of safflower under dryland conditions.

## Materials and Methods

A field experiment was conducted at the Agricultural Research Station, Annigeri, University of Agricultural Sciences, Dharwad, during *rabi* season of 2015-16. The experiment was laid out in a randomized complete block design (RCBD) with three replications and ten treatments comprising, $T_1$ - RDF (40:40:12 kg $ha^{-1}$ NPK) + FYM (5.0 t $ha^{-1}$), $T_2$ - RDF (40:40:12 kg $ha^{-1}$ NPK) alone, $T_3$ - 50% RDF + 1.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB, $T_4$ - RDF + 1.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB, $T_5$ - 50% RDF + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB, $T_6$ - RDF + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB, $T_7$ - 50% RDF + 1.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg $ha^{-1}$ $T_8$ - RDF + 1.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg $ha^{-1}$, $T_9$ - 50% RDF + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg $ha^{-1}$ and $T_{10}$- RDF + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg $ha^{-1}$. The soil of the experimental field was clayey in texture and soil in low, low and high rating for available nitrogen (224 kg N $ha^{-1}$) (Kjeldal method), available phosphorus (20.86 kg $P_2O_5$ $ha^{-1}$) (Olesen's method) and available potassium (342 kg $K_2O$ $ha^{-1}$) (Flame photometric method), respectively. The soil was found slightly alkaline (pH 7.95) (Potentiometric method) with normal electric conductivity. Urea, single super phosphate, muriate of potash and zinc sulphate as chemical sources of nutrients, and FYM, Vermicompost, *Azspirillum*, and PSB as organic and biofertilizer sources were used in different combinations to make 10 treatments as mentioned above. The chemical fertilizers were applied as basal at the time of sowing and for seed treatment the seeds of safflower were coated with *Azospirillum* and PSB one hour before sowing and they were air dried under shade whereas the organic manures were applied three weeks before sowing of safflower. Safflower variety- Annigeri-1 was sown in the second week of October and harvested in the third week of February. Rainfall received during 2015-16 was 507.20 mm which was 67.24 % lower than the long-term average of 754.90 mm. During the crop growth period from October to February only 38 mm rainfall received in October month at the time of sowing. Further, no rainfall was received during the crop growth period. The oil content of safflower seed was estimated by using Nuclear Magnetic Resonance (NMR).

## Results and Discussion

### Effect of INM on growth, yield and quality parameters

The experimental results showed significantly effect of INM approach on growth parameters *viz*. plant height, primary and secondary branches of safflower over only chemical method at harvest (Table 1). Results indicated that among different INM approach, application of RDF + 2.0 t $ha^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0kg $ha^{-1}$ ($T_{10}$) recorded significantly highest plant height (75.14 cm), primary (12.07 $plant^{-1}$) and secondary branches (15.87 $plant^{-1}$), but integrated nutrients management treatments $T_6$, $T_7$, $T_8$ and $T_9$ found to be at par with $T_{10}$. This was due to adequate combined application of organic manure and inorganic fertilizers which were directly involved in cell multiplication and vigorous root system development for effective absorption of applied nutrients, whereas zinc sulphate resembles nitrogen in being able to improve cell division, cell elongation as well as having a favourable effect in chlorophyll synthesis. The results corroborate with the finding of Babalad (1999) and Kumar *et al.*, 2015.

**Table.1** Effect of INM practices on growth parameters, yield attributes, yield and quality as influenced by different treatments at harvest of safflower

| | Growth parameters | | | Yield attributes | | | | | | Quality parameters | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **Plant height (cm)** | **Primary branches** | **Secondary branches** | **Capsules (plant$^{-1}$)** | **Seed weight (g plant$^{-1}$)** | **100 seed weight (g)** | **Seed yield (kg ha$^{-1}$)** | **Stalk yield (kg ha$^{-1}$)** | **Harvest index** | **Oil content (%)** | **Oil yield (kg ha$^{-1}$)** |
| $T_1$ | 68.82 | 9.27 | 11.73 | 24.40 | 18.02 | 5.13 | 831 | 2763 | 0.23 | 27.11 | 225.12 |
| $T_2$ | 68.29 | 9.13 | 11.40 | 24.20 | 17.36 | 5.02 | 773 | 2628 | 0.23 | 27.06 | 209.33 |
| $T_3$ | 69.23 | 9.73 | 12.73 | 24.87 | 18.32 | 5.23 | 834 | 2867 | 0.23 | 27.41 | 229.04 |
| $T_4$ | 69.11 | 9.33 | 12.40 | 24.73 | 18.19 | 5.21 | 833 | 2769 | 0.23 | 27.35 | 226.54 |
| $T_5$ | 70.83 | 10.07 | 13.20 | 25.07 | 19.00 | 5.30 | 850 | 2923 | 0.23 | 27.73 | 235.16 |
| $T_6$ | 71.59 | 11.27 | 14.67 | 26.20 | 20.54 | 5.51 | 904 | 3082 | 0.23 | 28.41 | 256.55 |
| $T_7$ | 72.77 | 11.47 | 14.80 | 27.60 | 20.78 | 5.94 | 935 | 3146 | 0.23 | 28.48 | 266.46 |
| $T_8$ | 73.45 | 11.53 | 15.53 | 27.73 | 20.95 | 6.01 | 945 | 3169 | 0.23 | 28.52 | 269.84 |
| $T_9$ | 74.60 | 11.67 | 15.60 | 28.13 | 21.04 | 6.06 | 950 | 3204 | 0.22 | 28.57 | 271.47 |
| $T_{10}$ | 75.14 | 12.07 | 15.87 | 28.27 | 21.45 | 6.11 | 989 | 3316 | 0.23 | 28.65 | 283.32 |
| S.Em± | 2.12 | 0.31 | 0.47 | 1.05 | 0.81 | 0.25 | 41.31 | 116.20 | 0.01 | 0.81 | 13.18 |
| C.D (P=0.05) | 4.11 | 0.93 | 1.41 | 3.12 | 2.39 | 0.76 | 122.75 | 345.25 | NS | NS | 39.17 |

**Table.2** Effect of INM practices on economics of safflower

| Treatments | Cost of cultivation (Rs. ha$^{-1}$) | Gross returns (Rs. ha$^{-1}$) | Net returns (Rs. ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|
| $T_1$ - RDF (40:40:12 kg ha$^{-1}$ NPK) + FYM (5.0 t ha$^{-1}$) | 17555 | 23266 | 5711 | 1.33 |
| $T_2$ - RDF (40:40:12 kg ha$^{-1}$ NPK) | 15055 | 21657 | 6602 | 1.44 |
| $T_3$ - 50 % RDF + 1.0 t ha$^{-1}$ VC + *Azospirillum* + PSB | 15769 | 23363 | 7594 | 1.48 |
| $T_4$ - RDF + 1.0 t ha$^{-1}$ VC + *Azospirillum* + PSB | 17115 | 23333 | 6218 | 1.36 |
| $T_5$ - 50 % RDF + 2.0 t ha$^{-1}$ VC + *Azospirillum* + PSB | 17769 | 23808 | 6039 | 1.34 |
| $T_6$ - RDF + 2.0 t ha$^{-1}$ VC + *Azospirillum* + PSB | 19115 | 25299 | 6184 | 1.32 |
| $T_7$ - 50 % RDF + 1.0 t ha$^{-1}$ VC + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$ | 16309 | 26186 | 9877 | 1.61 |
| $T_8$ - RDF + 1.0 t ha$^{-1}$ VC + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$ | 17655 | 26446 | 8791 | 1.50 |
| $T_9$ - 50 % RDF + 2.0 t ha$^{-1}$ VC + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$ | 18309 | 26606 | 8297 | 1.45 |
| $T_{10}$ - RDF + 2.0 t ha$^{-1}$ VC + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$ | 19655 | 27689 | 8034 | 1.41 |
| S.Em ± | -- | 1157 | 1157 | 0.07 |
| C.D (P= 0.05) | -- | 3437 | 3437 | 0.21 |

Yield and quality parameters of safflower *viz*. capsules plant$^{-1}$, seed weight plant$^{-1}$, 100 seed weight, seed yield, stalk yield, oil content and oil yield significantly varied among various nutrients management treatments (Table 1). Results indicated that combined application of organic and inorganic fertilizers which helped in improvement of yield and quality parameters of safflower. Among different INM approach, application of RDF + 2.0 t ha$^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg ha$^{-1}$ ($T_{10}$) recorded significantly highest capsules (28.27 plant$^{-1}$), seed weight (21.45 g plant$^{-1}$),100 seed weight (6.11 g), seed yield (989 kg ha$^{-1}$), stalk yield (3316 kg ha$^{-1}$) and oil yield (283.32 kg ha$^{-1}$) but integrated nutrients management treatments $T_6$, $T_7$, $T_8$ and $T_9$ found to be at par with $T_{10}$. However, harvest index and oil content did not show any significant differences (Table 1). The higher yield and quality parameters of safflower in these treatments might be due to combination with organic sources which helped in sustaining nutrient supply and maintaining the residual soil moisture during dry period of crop growth, resulted in better utilization of applied nutrients through improved microbial activities that involved in nutrient transformation and fixation. Similar findings were reported by Malligawad (2010), Jalilian *et al.,* (2012) and Yogesh (2013).

## Economics

Economics significantly influenced by integrated nutrients management (Table 2). Among different INM treatments, treatment $T_7$ (application of 50 % RDF + 1.0 t/ha Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$) recorded significantly highest net returns ( 9877 ha$^{-1}$) and B:C ratio (1.61) net returns due to lower cost of cultivation of this treatment and better utilization of resources. Results are in line with the findings by Naik (2008). However, application of RDF + 2.0 t ha$^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg ha$^{-1}$ ($T_{10}$) recorded significantly highest gross returns ( 27689 ha$^{-1}$), but, lower net returns and B:C ratio due to highest cost of cultivation of this treatment.

Based on results of the field experiment, it seems quite logical to conclude that, potential and effective yield of safflower by integrated nutrients management Practices can be achieved by application of RDF + 2.0 t ha$^{-1}$ Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ @ 10.0 kg ha$^{-1}$ ($T_{10}$), but economical yield can be achieved by application of 50 % RDF + 1.0 t/ha Vermicompost + *Azospirillum* + PSB + $ZnSO_4$ 10.0 kg ha$^{-1}$.

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