*International Journal of Plant & Soil Science*

***26(2): 1-6, 2018; Article no.IJPSS.46223***
***ISSN: 2320-7035***

# Effect of Graded Levels of Major Nutrients and Biofertilizers on Yield, Nutrient Content and Uptake of Safflower Growing in Vertisol

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author BAP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SNI and VDG managed the analyses of the study. Author VDG managed the literature searches. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2018/46223
Editor(s):
(1) Dr. Muhammad Shehzad, Department of Agronomy, Faculty of Agriculture, The University of Poonch Rawalakot, Pakistan.
Reviewers:
(1) A. Ramanjaneya Reddy, Y. S. R. Horticultural University, India.
(2) Rocky Thokchom, Pandit Deen Dayal Upadhyay Institute of Agricultural Sciences, India.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46223

***Original Research Article***

***Received 27 October 2018***
***Accepted 06 January 2019***
***Published 25 January 2019***

## ABSTRACT

Effect of graded levels of major nutrients and biofertilizers on yield, nutrient content and nutrient uptake of safflower growing in *vertisols* was investigated in field experiment carried out on clayey soil at College of Agriculture, Nagpur during rabi season using variety AKS/S-41 in 2011-12. The experiment was conducted in a Randomized Block Design (RBD) with three (3) replications and nine (9) treatments. N and P fertilizers each at 40 kg $ha^{-1}$ were applied. The sources of N and P were urea and single super phosphate. The results of the study showed that yield, nutrient content and uptake N, P, K, parameters of safflower were significantly found highest in the treatment of RDF alone or in combination with Azospirillum + PSB. The seed and straw yield of safflower was also significantly highest in the same treatments. It is concluded that combination of biofertilizer and major fertilizers significantly improved the yield, nutrient content and uptake of safflower.

*Keywords: Safflower; biofertilizer; PSB; grain; straw; yield.*

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## 1. INTRODUCTION

Safflower (*Carthamus tinctorius* L) is a herbaceous annual and a member of the Asteraceae/ Compositae family. It is native to parts of Asia, the Middle East, and Africa. It grown mainly for its flowers, which were used in making dyes for clothing and food. Today, it is grown mainly for its oil.

Safflower importance has been realized as an ideal oilseed crop due to its important character *viz*. capacity to with stand drought, low input required for its cultivation, no specific preference to any type of soil and its capacity to yield reasonably under rainfed condition. The oil contents various from 25 to 35% depending upon varieties. The safflower oil is nutritionally better because (it contain 78% linoleic acid which is helps to prevent coronary disease) It also contains A, D, E and K vitamins. While the particular linoleic acid in diet helps to prevent coronary disease [1]. The safflower oil is also used to its dyeing properties; it is used in the manufacture of paints, varnishes, resins and linoleum.

In India it was cultivated over an area of 364 thousand hectares (50% world area) and had a production of 229 thousand tones (70% world production) during 2008-09 [2]. Oilseed plays an important role in the rain-fed agro-ecosystem of Maharashtra. In Maharashtra, the total area and production of safflower was 256 thousand hectares and 101 thousand tones production with average productivity of 397 kg $ha^{-1}$. The productivity of safflower is low and unstable due to vagaries of monsoon or uncertainties of response under moisture stress condition. Among the various factors that are responsible for grain production of crops, the nutrient management plays a significant role in deciding the crop yield. The high cost of chemical fertilizer, whereas continuous use leading to an imbalance nutrient in soil, thereby creating adverse effect on soil physicochemical properties.

Oilseeds productivity in the country is one of the lowest due to their cultivation under rain fed condition (>75% area) in marginal lands (Poor soil fertility) and by response of poor farmers (low investment, low input Use.) The recurring uncertainties in rainfall pattern, epidemics of insect pest and disease, uncertain price structure and escalating input cost make oilseeds cultivation risky for investment [3]. Thus; safflower seeds production adequately depends on the rainfall situation with high degree of variation and sustainability.

Though oilseeds have higher requirement of nutrient they are grown under nutrient starvation/ imbalance of even major nutrients, while their demand and response is high for secondary and micro-nutrients. Providing optimum crop growing conditions for sustainable and profitable oilseeds production is the priority with emphasis on improved the factor productivity and reducing the cost of production. Assessment of nutrient requirement of safflower and plants aids in efficient management of nutrient for sustainable safflower production.

There is a strong need of alternative source of nitrogen, especially bio fertilizer, in order to provide the nutrient supply through chemical fertilizer as well as biofertilizers are cheaper, pollution free and renewable. Non symbiotic bacteria like *Azotobactor* and *Azospirillium,* fungus like Aspergillus have potential to fix nitrogen to number of non legume crops and phosphorus solublising bacteria (PSB) solublise the unavailable phosphorus in soil to plant. Azotobacter and azospirillum are free-living bacteria that fix atmospheric nitrogen in cereal crops without any symbiosis and they do not need a specific host plant [4]. Azotobacter abundant in well-drained, neutral soil. They can fix 15-20 kg $ha^{-1}$ N per year [4]. Azotobacter can also produce antifungal compounds to fight against many plant pathogens [5].

The proper supply of nutrients in balance amount is very essential for maximum production of safflower. Mineral fertilizers are costly and sometimes may be unavailable due to which its application in balance amount cannot be possible for most farmers. Almost all farmers are continuously use or relying on commercial fertilizers for maximum profitable yields, but there were no build-up of organic matter occurs in our soil. Mineral fertilizers when applied continuously over the years, affects the physical properties of the soil and may not have the ability to produce more yields [6]. Under such circumstance integration of mineral and organic fertilizers is very important, which plays a key role to sustain soil fertility and produce maximum yield. Kumar and Sharma [7] reported that the use of organic nutrient sources with mineral nitrogen, phosphorus and potassium fertilizers were found

more beneficial in terms of maximum yield and in providing macronutrients in safflower. Single source of nutrients such as mineral fertilizers, compost, animal manures and bio-fertilizers cannot meet the nutrient requirements of the crops for sustainable production [8]. Therefore, a suitable ratio of organic and inorganic fertilizers is necessary for higher crop yield.

Since, the productivity of safflower in Maharashtra is quite low, i.e. productivity of 397kg $ha^{-1}$ [2]. There is need to study effect of nutrient levels to maximize productivity with minimum deterioration of soil. Keeping these considerations in view present investigation was carried out for sustained safflower production.

## 2. MATERIALS AND METHODS

A field experiment was conducted during 2012 at the College of Agriculture Nagpur (located at 21˚10' North Latitude and 79˚10' East Longitude at the elevation of 321.26 m above sea level.The soil of the experimental site was clayey in nature with pH 7.75 (1:2 soil: water) [9], low in EC 0.286 $dsm^{-1}$ [9], low in organic matter content of 0.5, [10]. low in available N 174.25 kg $ha^{-1}$ [11], medium in available P 15.00 kg $ha^{-1}$ [10]. and medium in available K 340 kg $ha^{-1}$ [10] at the start of experiment. The experiment was laid out in a Randomized Block Design (RBD) with three replications having nine treatment combinations, that is, $T_1$ (control), $T_2$ (50% *RDF*), $T_3$ (50% *RDF* + *Azospirillum* + *PSB*), $T_4$ (100% RDF), $T_5$ (100% RDF + *Azosprillum* + *PSB* ), $T_6$ (150% RDF), $T_7$ (150% RDF + *Azosprillum* + *PSB*),$T_8$ (50% RDF +2% *DAP* spray at 30 and 45 DAS) and $T_9$ (100% RDF +2% *DAP* spray at 30 and 45 DAS). The fertilization N and P with biofertilizer were applied at 40: 40 kg $ha^{-1}$, respectively, while compost (FYM) was applied at 5 tons per hectare. The fertilizers were applied as per treatment details. Dose of nitrogen and phosphorous were applied through Urea and SSP, respectively. Nitrogen was applied in two split doses, 1st dose at the time of sowing and 2nd at 30 DAS. Seed treatment done with Azospirillum and PSB @ 250 g /10 kg of seed at the time of sowing. The germination was completed between 6th to 10th days after Sowing

### 2.1 Statistical Analysis

Standard method of analysis known as 'Analysis of Variance' was applied for the statistical analysis of the data, critical difference (CD) at 5 percent level of significance was worked out and used for comparison among different treatments [12].

## 3. RESULTS AND DISCUSSION

Safflower Yield is the most important goal for maximum return to farmer given in Table 1 shows the data recorded on grain and straw yield as affected by biofertilizer and inorganic fertilizers. Grain and straw yield was significantly affected by the addition of biofertilizer and inorganic fertilizer. Among the treatments, maximum safflower grain and straw (27.78 q $ha^{-1}$) and straw yield (83.65 q $ha^{-1}$) was recorded by the treatment $T_5$ receiving 100% RDF + Azospirillum + PSB which was followed by treatment $T_7$ with 150% RDF + Azospirillum + PSB *i.e.* (27.78 and 75.36 q $ha^{-1}$ grain and straw yield, respectively). Which were significantly superior over all treatments in straw yield. In grain yield treatment $T_6$ found to be at par with treatment $T_7$. Whereas, lowest yield was obtained in control plot i.e. $T_1$ (17.25 and 45.38 q ha) grain and straw respectively, The better performance of Safflower crop in terms of yield was observed when bio fertilizer was combined with inorganic fertilizers. The better performance of the Safflower plants with biofertilizer and NPK fertilizers support the results of many researchers [13,14] and [15]. Who reported that maximum nutrient availability due to integrated use of biofetilizer and inorganic fertilizers increased nutrient uptake by the plant which in turn lead to dry matter production and safflower yield. Similarly the results closely confirmative by Singh and Singh [16], Rajput et al. [17].

### 3.1 Nutrient Content of Nutrient in Safflower Grain and Straw

Table 2 shows the data regarding N, P, K uptake as affected by biofertilizer and inorganic fertilizers. The N, P, K uptake of safflower plant was significantly influenced by the integrated use of organic and inorganic nutrient sources. The highest P and K in safflower grain was observed in the treatments $T_5$ i.e. (100% RDF + Azospirillum + PSB) i.e. N 2.59%, P 0.216% and K 1.65% followed by treatment $T_7$ i.e. (150% RDF + Azospirillum + PSB) i.e. N 2.55%, P 0.20% and K 1.63%. Treatment $T_5$ significantly superior over all treatments in N, P and K content of grain and $T_8$ found to be at par with treatment

$T_7$ in N, P and K content of grain. The lowest content of N and P was found in control i.e. $T_1$ i.e. N 2.20% P 0.166% and K 1.56%. Similar results were closely reported by Zaman and Das [18].

From Table 2, highest N, P and K content in safflower straw was observed in the treatments $T_5$ i.e. (100% RDF + Azospirillum + PSB) i.e. N 0.58%, P 0.13% and K 1.57% followed by treatment $T_7$. Treatement $T_7$ and $T_8$ found to be at par with each other in N and P content of safflower straw and treatment $T_7$, $T_5$, $T_6$ and $T_8$ found to be at par with each other in K content of safflower straw. The lowest NPK content in straw was observed in i.e. control $T_1$.

### 3.2 Nutrient Uptake of Safflower Grain and Straw

From the Table 3. Various treatments significantly influenced nutrient uptake in the present study. Increasing trend in uptake of NPK by safflower was observed with the increase in RDF levels and seed treatment with Azospirillum + PSB. Highest uptake by safflower was recorded with the ($T_5$) 100% RDF with seed treatment with Azospirillum + PSB, followed by ($T_7$) 150 RDF with seed treatment with Azospirillum + PSB of NPK. Treatment $T_6$ at par with treatment $T_8$ in N and P uptake of grain. Whereas K uptake in treatment $T_8$ found to be at par with treatment $T_7$. Whereas, treatment $T_8$ found to be at par with treatment $T_7$ in straw nitrogen uptake. Treatment $T_6$, $T_7$ and $T_8$ found to be at par with each other in phosphorus straw uptake whereas, the lowest uptake of NPK was found in the results were recorded by Zaman and Das [18].

### 3.3 Total Uptake of Nutrients (kg ha$^{-1}$) by Safflower Crop

Inorganic fertilizers are concentrated forms of soil nutrients which can be transported much more readily than can bio fertilizer. Organic manures like FYM, compost released nutrients very slowly to the plants and these nutrients are judiciously absorb by the plants. Therefore, plants are unable access required amount of nutrients in the critical yield-forming period. This may be the probable reason for the higher yield produced by the inorganic fertilizer applied safflower [17]. However, the present study increasing trend in uptake of NPK was observed with the increase in RDF level and seed treatment with (Azospirillum + PSB). The highest uptake of nutrient by safflower was recorded with 100% RDF with seed treatment Azospirillum + PSB, i.e. 112.07 N kg ha$^{-1}$, 17.02 P kg ha$^{-1}$ and 171.16 K kg ha$^{-1}$, followed by 150% RDF with seed treatment Azospirillum + PSB, i.e. 101.41 N kg ha$^{-1}$, 13.79 P kg ha$^{-1}$ and 161.83 K kg ha$^{-1}$. $T_5$ was significantly superior in N, P and K uptake in over all treatment. The $T_8$ and $T_6$ found to be at par with treatment $T_7$ in P uptake of safflower crop. The Research has shown that combinations of biofertilizer and mineral fertilizers resulted in higher crop yields [19,20,21].

Total uptake of nutrients increase might be due to the combined application of inorganic fertilizers and biofertilizers. Due to these treatments, nitrogen, phosphorous and potassium might have been gained by plants through RDF and biofertilizer. These results are in agreement with the finding [22,23,16] and lowest uptake of NPK was found in control plot i.e. 56.58 N kg ha$^{-1}$, 7.06 P kg ha$^{-1}$ and 78.06 kg ha$^{-1}$.

**Table 1. Yield of safflower (q ha$^{-1}$) as influenced by various treatments**

| Treatments | | Grain yield | Straw yield |
|---|---|---|---|
| $T_1$ | Control | 17.25 | 45.37 |
| $T_2$ | 50% RDF | 18.39 | 49.44 |
| $T_3$ | 50% RDF + Azospirillum + PSB | 21.05 | 59.87 |
| $T_4$ | 100% RDF | 21.80 | 71.02 |
| $T_5$ | 100% RDF + Azospirillum + PSB | 27.78 | 83.65 |
| $T_6$ | 150% RDF | 23.40 | 80.16 |
| $T_7$ | 150% RDF + Azospirillum + PSB | 24.55 | 75.36 |
| $T_8$ | 50%RDF +2 % DAP spray at 30 and 45 DAS | 17.58 | 58.01 |
| $T_9$ | 100% RDF + 2% DAP spray at 30 and 45 days after sowing | 18.22 | 53.15 |
| | SE (m) ± | 0.452 | 0.910 |
| | CD at 5% | 1.344 | 2.705 |

**Table 2. Content of nutrients (%) in safflower grain and Straw**

| Treatments | | N | | P | | K | |
|---|---|---|---|---|---|---|---|
| | | Grain | Straw | Grain | Straw | Grain | Straw |
| $T_1$ | Control | 2.20 | 0.43 | 0.166 | 0.10 | 1.56 | 1.18 |
| $T_2$ | 50% RDF | 2.32 | 0.45 | 0.170 | 0.11 | 1.59 | 1.46 |
| $T_3$ | 50% RDF + Azospirillum + PSB | 2.42 | 0.46 | 0.183 | 0.11 | 1.62 | 1.50 |
| $T_4$ | 100% RDF | 2.38 | 0.55 | 0.200 | 0.12 | 1.57 | 1.61 |
| $T_5$ | 100% RDF + Azospirillum + PSB | 2.59 | 0.58 | 0.216 | 0.13 | 1.65 | 1.57 |
| $T_6$ | 150% RDF | 2.50 | 0.56 | 0.193 | 0.12 | 1.58 | 1.58 |
| $T_7$ | 150% RDF + Azospirillum + PSB | 2.55 | 0.54 | 0.200 | 0.12 | 1.63 | 1.60 |
| $T_8$ | 50%RDF +2 % DAP spray at 30 and 45 DAS | 2.34 | 0.53 | 0.206 | 0.11 | 1.59 | 1.59 |
| $T_9$ | 100% RDF + 2% DAP spray at 30 and 45 days after sowing | 2.26 | 0.54 | 0.196 | 0.12 | 1.61 | 1.62 |
| | SE (m) ± | 0.0197 | 0.004 | 0.004 | 0.007 | 0.007 | 0.015 |
| | CD at 5% | 0.0587 | 0.014 | 0.012 | 0.022 | 0.023 | 0.046 |

**Table 3. Uptake of nutrients (kg $ha^{-1}$) by safflower grain and straw**

| Treatments | | N | | | P | | | K | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| $T_1$ | Control | 37.93 | 18.65 | 56.58 | 2.87 | 4.19 | 7.06 | 26.89 | 51.17 | 78.06 |
| $T_2$ | 50% RDF | 42.66 | 22.24 | 64.90 | 3.12 | 4.77 | 7.89 | 29.48 | 72.16 | 101.59 |
| $T_3$ | 50% RDF + Azospirillum + PSB | 50.92 | 27.73 | 75.32 | 3.86 | 7.18 | 11.04 | 34.15 | 89.80 | 123.95 |
| $T_4$ | 100% RDF | 51.79 | 38.54 | 90.34 | 4.36 | 9.23 | 13.29 | 34.21 | 114.34 | 146.49 |
| $T_5$ | 100% RDF + Azospirillum + PSB | 63.56 | 48.51 | 112.07 | 5.32 | 11.71 | 17.02 | 39.84 | 131.33 | 171.16 |
| $T_6$ | 150% RDF | 58.50 | 44.89 | 103.39 | 4.52 | 9.61 | 14.14 | 37.05 | 126.65 | 163.70 |
| $T_7$ | 150% RDF + Azospirillum + PSB | 60.72 | 40.69 | 101.41 | 4.76 | 9.04 | 13.79 | 39.00 | 122.83 | 161.83 |
| $T_8$ | 50%RDF +2 % DAP spray at 30 and 45 DAS | 41.14 | 30.74 | 71.68 | 3.63 | 6.38 | 10.00 | 27.95 | 92.23 | 120.63 |
| $T_9$ | 100% RDF + 2% DAP spray at 30 and 45 days after sowing | 41.21 | 28.70 | 69.91 | 3.58 | 6.37 | 9.95 | 29.32 | 85.96 | 115.28 |
| | SE (m) ± | 0.424 | 0.348 | 1.325 | 0.099 | 0.462 | 0.493 | 0.276 | 0.987 | 0.966 |
| | CD at 5% | 1.259 | 1.034 | 3.935 | 0.295 | 1.373 | 1.466 | 0.822 | 2.931 | 2.870 |

## 4. CONCLUSION

It may be concluded that application of 100% RDF and seed treatment of Azospirillum + PSB had profound effect on grain yield and NPK nutrient content and uptake by safflower as compared to application of inorganic fertilizers alone. Thus, application of fertilizer along with bio fertilizer can play a vital role in achieving high yield potential of safflower through its beneficial effect on nutrients supply and soil properties.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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*The peer review history for this paper can be accessed here:*
*http://www.sdiarticle3.com/review-history/46223*