Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2017; SP1: 1145-1148

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# Response of seed yield, nutrient uptake and nitrogen use efficiency to different sources of vermicompost and inorganic fertilizer in sunflower (*Helianthus annuus* L.) cultivation

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**Abstract**
Field experiment was carried out at the Annamalai University, Experimental Farm, Department of Agronomy, Annamalai Nagar, Tamil Nadu to study the response of seed yield, nutrient uptake and nitrogen use efficiency to different sources of vermicompost and inorganic fertilizer in sunflower cultivation during February – May 2013. The experiment was laid out in randomized block design (RBD) with eleven treatments includes control, recommended dose of fertilizer, graded dose of fertilizer along with different sources of vermicompost + foliar application of boron and zinc on different dates (20 and 40 DAS). The treatments were replicated thrice. The results revealed that crop raised with pressmud vermicompost registered higher seed, stalk yield and harvest index. The vermicompost treatments had significant influence on the nutrient uptake, nitrogen use efficiency (NUE), Agronomic Efficiency (AE), Apparent nitrogen recovery (ANR), Physiological efficiency (PE) and Internal efficiency (IE) over control and recommended dose of fertilizer by the crop at harvest. Among the treatments, pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF (recommended dose of fertilizer) + foliar spray of $ZnSO_4$ @ 0.5 % + Borax @ 0.2% on 40 and 60 DAS to sunflower hybrid registered the higher NPK uptake, nitrogen use efficiency ( NUE), Agronomic Efficiency (AE), Apparent nitrogen recovery (ANR), Physiological efficiency (PE) and Internal efficiency (IE) values at harvest. From the above experimental results, it could be concluded that with application of pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF + foliar spray of $ZnSO_4$ @ 0.5 % + Borax @ 0.2% on 40 and 60 DAS not only resulted in higher seed yield but also superior in respect of nutrient uptake and nitrogen economy under sunflower cultivation.

**Keywords:** Sunflower, seed yield, nutrient uptake, nitrogen use efficiency (NUE), Agronomic Efficiency (AE), apparent nitrogen recovery (ANR), Physiological efficiency (PE) and Internal efficiency (IE).

## Introduction
Sunflower ranks third next only to groundnut and soybean in total production of oilseeds in the world. Sunflower is cultivated on an area of 23.70 million hectares with an annual production and productivity of 31.33 million tonnes and 1322 kg per hectare, respectively in the world (Hegde, 2012) [5]. Research evidences clearly show that vermicompost is a potential organic input which would impart consistent environment and soil physico-chemical properties, biological activity, nutrient availability which ultimately improves nutrient uptake, growth and yield components and yields of oilseed crops. Foliar nutrition is a simple and cheaper technology which ensures the supply of nutrients to the crops directly where they are needed without spending energy for their transport, application and without any losses in transit. Among micronutrients, boron can influence photosynthesis and respiration and activate a number of enzymatic systems of protein, nucleic acid metabolism and play an important role in seed setting and yield of sunflower. (Ramulu *et al*., 2011) [11]. Zinc is another micronutrient, plays multiple important role in various physiological and metabolic processes of plants (Gitte *et al.*, 2005) [3]. Vermicompost made from different organic sources along with foliar nutrition in sunflower is almost meagre. Therefore, the present experiment was planned to develop a sustainable nutrient management concept to achieve a higher seed yield and conserve the nitrogen in sunflower hybrid cultivation under tail end area of Cauvery deltaic zone of Tamil Nadu.

## Materials and methods
Field experiment was carried out at the Annamalai University, Experimental Farm, Department of Agronomy, Annamalai Nagar, Tamil Nadu to study the response of seed yield, nutrient uptake and nitrogen use efficiency to different sources of vermicompost and inorganic

fertilizer in sunflower cultivation (*Helianthus annuus* L.) during February – May 2013. The experimental soil was deep clay, low in available soil nitrogen (198 kg $ha^{-1}$), medium in available soil phosphorus (23 kg $ha^{-1}$) and high in available soil potassium (282 kg $ha^{-1}$). The experiment was laid out in randomized block design (RBD) with eleven treatments *viz*., Control - ($T_1$), 100 % RDF - ($T_2$), 75 % RDF + FYM vermicompost @ 2.5 t $ha^{-1}$ ($T_3$), 75 % RDF + Pressmud vermicompost @ 2.5 t $ha^{-1}$ ($T_4$), 75 % RDF + Sewage sludge vermicompost @ 2.5 t $ha^{-1}$ ($T_5$), 75 % RDF + Water hyacinth vermicompost @ 2.5 t $ha^{-1}$ ($T_6$), $T_2$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_7$), $T_3$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_8$), $T_4$+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_9$), $T_5$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_{10}$) and $T_6$+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS - ($T_{11}$). The treatments were replicated thrice.

Vermicompost was prepared using heap method. After 3 months, matured vermicompost was applied to experimental plots as per the treatment schedule. The sunflower hybrid (sunbred) was chosen for the study. The recommended seed rate for sunflower hybrid @ 4 kg $ha^{-1}$ was adopted and seeds were dibbled at a depth of 3 cm with a spacing of 60 cm x 30 cm. A recommended fertilizer schedule of hybrid sunflower *viz.*, 60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$ was adopted. Nitrogen, phosphorus and potassium were applied as per treatment schedule. 50 per cent of recommended N was applied as basal and the remaining 50 per cent was applied at 30 DAS. Entire dose of $P_2O_5$ and $K_2O$ were applied as basal. As per treatment schedule, Zinc (0.5%) and Borax (0.2%) was sprayed at 40 and 60 DAS by using of hand operated knapsack sprayer. All other improved recommended package of practices were followed to sunflower hybrid as per the Crop Production Guide (2012) [1]. Observations on seed and stalk yield were recorded. Plants were also analyzed for N, P and K uptake after harvest. Assessing of nitrogen use efficiency by following methods.

**Assessing nitrogen efficiency**

**Nitrogen use efficiency (NUE)**

In this approach, nitrogen use efficiency was calculated in terms of seed yield $kg^{-1}$ of nitrogen fertilizer applied. It was computed using the formula as given below:

$$NUE = \frac{Seed\ \ yield\ \ (kg\ ha^{-1})}{Amount\ \ of\ \ nitrogen\ \ applied\ \ (kg\ ha^{-1})}$$

**Agronomic Efficiency (AE)**

In this approach, agronomic efficiency was calculated in terms of seed yield obtain from fertilized plot and unfertilized plot to $kg^{-1}$ of nitrogen applied. It was computed using the formula as given below:

$$AE = \frac{\text{Grain yield in fertilized plot (kg ha}^{-1}\text{)} - \text{Grain yield in unfertiliz ed plot (kg ha}^{-1}\text{)}}{\text{Amount of nitrogen applied (kg ha}^{-1}\text{)}}$$

**Apparent N recovery (ANR) (%)**

Apparent N recovery efficiency is defined as the quantity of nitrogen absorbed per unit of nitrogen applied. It was computed as per the formula suggested by Pillai and Vamadevan (1978) [10].

$$ANR = \frac{Y_t - Y_o}{N_t} \times 100$$

$Y_t$ = Uptake of N in particular treatment (kg $ha^{-1}$)

$Y_o$ = Uptake of N in unfertilized plot (kg $ha^{-1}$)

$N_t$ = Quantity of N applied for the treatment (kg $ha^{-1}$)

**Physiological efficiency (PE)**

The physiological efficiency is defined as the grain yield obtained per unit of nitrogen adsorbed. It was computed as follows (Yoshida, 1981) [12].

$$PE = \frac{Grain\ \ yield\ \ in\ \ fertilized\ \ plot\ \ (kg\ ha^{-1}) - Grain\ \ yield\ \ in\ \ unfertiliz\ \ ed\ \ plot\ \ (kg\ ha^{-1})}{N\ \ uptake\ \ in\ \ fertilized\ \ plot\ \ (kg\ ha^{-1}) - N\ \ uptake\ \ in\ \ unfertiliz\ \ ed\ \ plot\ \ (kg\ ha^{-1})}$$

**Internal efficiency (IE)**

Internal efficiency was calculated kg grain $kg^{-1}$ N uptake. It was computed using the formula as given below:

$$IE = \frac{Grain\ \ yield\ \ (kg\ ha^{-1})}{Total\ \ N\ uptake\ \ (kg\ ha^{-1})}$$

The data on various studies recorded during the investigation were subjected to statistical scrutiny as suggested by Gomez and Gomez (1984) [4].

**Results and Discussion**

**Effect of INM treatments on seed and stalk yield**

All the treatments exerted significant influence on the seed yield of sunflower hybrid. Among the treatments, pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF + foliar spray of $ZnSO_4$ @ 0 .5% + Borax @ 0.2% on 40 and 60 DAS ($T_9$) significantly registered the higher seed yield of 2241.34 kg $ha^{-1}$ and stalk yield of 4912.45 kg $ha^{-1}$(Table 1). The next order of ranking was $T_8$ (75% RDF + FYM vermicompost @ 2.5 t $ha^{-1}$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS).

The aforesaid increased yields due to vermicompost might be due to the fact that pressmud vermicompost offer a balanced nutritional release pattern to plants, providing nutrients such as available N, soluble K, exchangeable Ca, Mg and P that can be taken readily by plants (James Pitchai *et al*., 2009) [7] and greater microbial diversity and activity resulting in higher seed and stalk production (Edwards, 2004) [2]. Studies have revealed that boron not only improved the nutrients uptake, it also augmented the conversion, translocation of starch to sink region. Hence, the availability of these nutrients with this treatment might have increased seed and stalk yield of sunflower. These findings of Gitte *et al.* (2005) [3] lend support to the present results. The treatment control ($T_1$) registered the lowest seed yield of 624.78 kg $ha^{-1}$ and stalk yield of 1625.17 kg $ha^{-1}$. In respect of harvest index, the treatments which receive pressmud vermicompost along with 75% RDF + foliar spray of $ZnSO_4$ @ 0 .5% + Borax @ 0.2% on 40 and 60 DAS ($T_9$) recorded superior values. This might be due to higher availability of both native and applied nutrients and better soured and sink relationship, which contributed to higher harvest index. The least values were recorded in absolute control ($T_1$).

**Effect INM treatment on crop nutrient uptake**

Sunflower crop with different sources of vermicompost registered higher nutrient uptake and was significantly superior to recommended dose of fertilizer alone and absolute control. The date on the effect of different sources of vermicompost show that, pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS ($T_9$) excelled other treatments by recording the highest nutrient uptake of 92.85 kg of N, 18.18 kg of $P_2O_5$ and 83.51 kg of $K_2O$. This could be due to steady and sustained availability of nutrients in pressmud vermicompost in the forms that are readily available to plants, which match the uptake pattern of different physiological growth phases of crop (Kavitha *et al*., 2008) [8]. The presence of these essential nutrient elements (B, Zn and S) could have facilitated enhanced root proliferation and effective absorption of soil available nutrients to a maximum extent. Similar results were reported by Jayaramaiah *et al.* (2005) [8]. The least uptake of N, P and K were registered under $T_1$ (control).

**Assessing nitrogen use efficiency**

In respect of Nitrogen use efficiency (NUE), Agronomic Efficiency (AE), Apparent nitrogen recovery (ANR) (%), Physiological efficiency (PE) and Internal efficiency (IE) significantly registered under pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS ($T_9$) as nitrogen use efficiency of 49.81, agronomic efficiency of 35.92, Apparent nitrogen recovery (%) of 62.77, Physiological efficiency of 24.24 and Internal efficiency of 30.42. This might be due to increased availability of nitrogen in vermicompost in the form of mucous, nitrogenous excretory substances which were not present in other organic sources. Nitrogen fixing bacteria were also found to be more in this vermicompost which might have reduced the loss of nitrogen from the soil and increased the use efficiency of inorganic fertilizers applied (Ihseen *et al*., 2003) [6]. The aforesaid parameters lowest value was observed in 100% RDF alone ($T_2$) plots.

Thus from the result of the experiment, it can be concluded that application of pressmud vermicompost @ 2.5 t $ha^{-1}$ along with 75% RDF + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS produces higher seed and stalk yield, increases nutrient uptake along with conserving nitrogen in sunflower soils which pave way for sustainability in sunflower cultivation.

**Table 1:** Influence of different sources vermicompost along with inorganic fertilizer and micronutrients on seed and stalk yield, harvest index and NPK uptakes in sunflower

| Treatments | Seed yield (kg $ha^{-1}$) | Stalk yield (kg $ha^{-1}$) | Harvest index | Nitrogen Uptake (kg $ha^{-1}$) | Phosphurus Uptake (kg $ha^{-1}$) | Potassium uptake(kg $ha^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$ | 624.78 | 1625.17 | 27.77 | 26.17 | 6.01 | 22.75 |
| $T_2$ | 1202.78 | 2909.64 | 29.25 | 50.92 | 10.77 | 43.64 |
| $T_3$ | 1849.19 | 4202.62 | 30.56 | 79.43 | 15.55 | 71.44 |
| $T_4$ | 1926.67 | 4345.17 | 30.72 | 82.12 | 16.08 | 73.87 |
| $T_5$ | 1813.75 | 4138.07 | 30.47 | 78.21 | 15.31 | 70.35 |
| $T_6$ | 1742.90 | 4008.36 | 30.30 | 75.76 | 14.83 | 68.14 |
| $T_7$ | 1422.76 | 3345.00 | 29.84 | 63.22 | 12.38 | 56.87 |
| $T_8$ | 2135.78 | 4722.82 | 31.14 | 89.26 | 17.47 | 80.29 |
| $T_9$ | 2241.34 | 4912.45 | 31.33 | 92.85 | 18.18 | 83.51 |
| $T_{10}$ | 2096.23 | 4647.36 | 31.08 | 87.84 | 17.20 | 79.01 |
| $T_{11}$ | 2021.36 | 4520.39 | 30.90 | 85.44 | 16.73 | 76.85 |
| SEd CD (p=0.05) | 26.45<br>52.76 | 54.74<br>108.82 | 0.06<br>0.14 | 1.05<br>2.26 | 0.21<br>0.42 | 0.99<br>1.98 |

**Treatments details:** ($T_1$) 100 % RDF - ($T_2$), 75 % RDF + FYM vermicompost @ 2.5 t $ha^{-1}$ ($T_3$), 75 % RDF + Pressmud vermicompost @ 2.5 t $ha^{-1}$ ($T_4$), 75 % RDF + Sewage sludge vermicompost @ 2.5 t $ha^{-1}$ ($T_5$), 75 % RDF + Water hyacinth vermicompost @ 2.5 t $ha^{-1}$ ($T_6$), $T_2$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_7$), $T_3$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_8$), $T_4$+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_9$),$T_5$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS- ($T_{10}$) and $T_6$+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS and $T_6$+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS – ($T_{11}$)

**Table 2:** Influence of different sources vermicompost along with inorganic fertilizer and micronutrients on nitrogen use efficiency, Agronomic Efficiency, Apparent nitrogen recovery, Physiological efficiency and Internal efficiency in sunflower

| Treatments | Nitrogen use efficiency | Agronomic efficiency | Apparent nitrogen recovery % | Physiological efficiency | Internal efficiency |
|---|---|---|---|---|---|
| $T_1$ | _ | _ | _ | _ | 25.63 |
| $T_2$ | 20.05 | 9.63 | 40.67 | 20.05 | 27.56 |
| $T_3$ | 41.09 | 27.21 | 51.41 | 22.99 | 29.33 |
| $T_4$ | 42.81 | 28.93 | 51.94 | 23.27 | 29.56 |
| $T_5$ | 40.31 | 26.42 | 51.06 | 22.85 | 29.22 |
| $T_6$ | 38.73 | 24.85 | 50.31 | 22.55 | 28.99 |
| $T_7$ | 23.71 | 13.30 | 47.62 | 21.53 | 28.36 |
| $T_8$ | 47.46 | 33.58 | 61.79 | 23.95 | 30.15 |
| $T_9$ | 49.81 | 35.92 | 62.77 | 24.24 | 30.42 |
| $T_{10}$ | 46.58 | 32.70 | 61.41 | 23.86 | 30.07 |
| $T_{11}$ | 44.92 | 31.04 | 61.12 | 23.56 | 29.81 |

**Treatments details**:($T_1$) 100 % RDF - ($T_2$), 75 % RDF + FYM vermicompost @ 2.5 t $ha^{-1}$ ($T_3$), 75 % RDF + Pressmud vermicompost @ 2.5 t $ha^{-1}$ ($T_4$), 75 % RDF + Sewage sludge vermicompost @ 2.5 t $ha^{-1}$ ($T_5$), 75 % RDF + Water hyacinth vermicompost @ 2.5 t $ha^{-1}$ ($T_6$), $T_2$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_7$), $T_3$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_8$), $T_4$+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - ($T_9$),$T_5$ + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS- ($T_{10}$) and $T_6$+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS

* Data statistically not analysed

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