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# ZINC AND BORON MICRONUTRIENTS ON YIELD AND ECONOMICS OF SUNFLOWER GROWN ON COASTAL REGIONS OF NORTHERN TAMILNADU, INDIA

**Rex Immanuel R., D. Saravanan, G.B. Sudhagar Rao* and M. Thiruppathi**
Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalainagar - 608 002, Tamilnadu, India.
*Corresponding author

## Abstract

A field experiment was carried out at Experimental Farm, Annamalai University, Annamalainagar, Tamil Nadu during summer season of 2014-15 (February to May) to study effects of soil and foliar applied micronutrients on yield and economics of irrigated sunflower. The trial includes 12 treatment combinations with recommend dose of fertilizer (RDF) with combinations of zinc and boron soil and foliar nutrition at various crop growth stages. The experiment revealed that 60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$ along with soil application of $ZnSO_4$ @ 25 kg $ha^{-1}$ and borax @ 5 kg $ha^{-1}$ and foliar application of $ZnSO_4$ @ 0.5 per cent at star bud stage and borax @ 0.2 per cent at ray floret stage was the most favourable micronutrient management practice for obtaining maximum achene yield, oil yield and higher economic returns.
***Keywords***: B: C ratio, Boron, micronutrients, oil yield, summer irrigated, zinc sulphate

## Introduction

Oilseeds attracted more interest due to an increasing demand for their healthy vegetable oils, bio fuels and other industrial uses. Additionally, the meal fractions, that part of the seed after the oil is removed, are used as an important high protein animal feed. The increased interest resulted in an 82 per cent expansion of oilseed crop cultivation areas and about a 240 per cent increase in total world production over the last three decades (Rahman and Monika, 2016).

India, the second largest consumer country in the world, and the world's top importer of vegetable oil (two third is met by import), is expected to maintain a high per capita consumption growth of 3.1per cent per annum and reach 24 kg (current consumption 17.5 kg/person/annum) per capita in 2027. India's vegetable oil consumption will reach 47 million tonnes by 2027, up from around 30 million tonnes in 2017-18. This substantial growth will be filled by both an expansion of domestic production, sourced in the intensification of oilseed cultivation and a further increase in imports. India's edible oil seed cultivation accounts for 13per cent of the gross cropped area, three per cent of the gross national product and 10 per cent value of all agricultural commodities.

Sunflower (*Helianthus annuus* L.) is an essential oil seed crop and has been considered as a promising alternative crop for the conventional cropping systems. In world, sunflower is cultivated in an area of 26.36 million ha with an annual production and productivity of 54.97 million tonnes and 2090 kg $ha^{-1}$, respectively. In India, it is cultivated over an area of about 0.23 million ha with a production of 0.17 million tonnes and productivity of 760 kg $ha^{-1}$ (USDA, 2020). Among the states Karnataka rank the first in area (66.04 %) and production (47.31 %) and Punjab ranks first in the productivity of 1842 kg $ha^{-1}$. In Tamil Nadu, currently, 0.01 million ha (3.49 %) of land area is under sunflower cultivation with an annual production of 0.01 million tonnes (4.73 %) and the productivity of 1050 kg $ha^{-1}$ (MAFWDA, 2019). This is extremely below the India's average achievable yield (1842 kg $ha^{-1}$) and potential yield of major sunflower oil seed producing countries (2600 kg $ha^{-1}$). In India, the yield gap between the farmer's practices is very high (142 %) and bridging the yield gap can increase production significantly that would concomitantly reduce the reliance on imports of edible oil besides realising higher profitability to oilseed cultivators.

Sunflower offers significantly profitable oil seed crop compared to other crops in similar maturity groups. In coastal Tamil Nadu, sunflower is mostly cultivated as a Kharif or rice fallow crop, if irrigation facilities available. With a possible introduction and increase in acreage with sunflower/ gingelly/ greengram-rice-sunflower/ blackgram/ maize/ cotton cropping systems in coastal regions of Tamil Nadu enhanced the production of oil seeds (Rex Immanuel, 2019; Rex Immanuel *et al.*, 2019a). However, its production potential is very worst due to degraded nature of coastal soils and cultivation is probably on soils where salinity problems already exist or may develop from the use of saline irrigation water during critical crop growing period (Rex Immanuel *et al.*, 2018; Rex Immanuel and Ganapathy, 2019).

Nutrient management is one of the major agronomic factors that influence sunflower achene yield and oil yield. Farmers have traditionally applied N, P and K fertilizers, resulting in overuse but insufficient micronutrients, especially in sunflower production. Micronutrient deficiency appears to be the most widespread problem resulting in severe losses in productivity of crops. India is one of the nations with the most zinc deficient agricultural soils and the average deficiency is projected to increase from the present levels of 50 per cent to an estimated 63 per cent by 2025 if the current trend continues. Under zinc deficient soils, plants exhibit a high susceptibility to environmental stresses, which in turn stimulate development of deficiencies and cause stunted growth. Zinc fertilization to soil and onto plant leaves offers a simple and very effective solution to zinc deficiency problems and significantly reduces unnecessary loss of oil seed production. It also enhances grain zinc concentration which contributes to daily zinc intake of human populations in a sustainable and environmentally responsible manner. Adequate Zn application to crops is important for the food and nutritional security of India. The level of Zn deficiency in coastal regions of Tamilnadu is > 50 per cent (Shukla and Tiwari, 2016) and application of Zn successfully increased yield of crops by improving pollen viability, kernel number and kernel weight (Liu *et al*., 2020).

In India, boron deficiency has been recognised next to Zinc. Availability B to plants is governed by soil pH, $CaCO_3$ and organic matter contents, beside total B content in soil, interactions with other nutrients, plant type or variety and environmental factors (Shukla and Tiwari, 2016). Boron deficiency in some region of Indian soils is becoming a serious constraint to sustainable agricultural productivity. In general, B deficiency was higher in eastern region of the country and has resulted due to its excess leaching. It may affect crop production substantially. The sustainable solution is to apply an adequate and balanced quantities of Zn and B to oilseed crops are essential (Rex Immanuel *et al*., 2019b & 2019c). Amendment with Zn and B in micronutrient deficit soils further helps to enhanced utilization of available N, P and K as well as augmenting the productivity of crops. With this background, the present investigation was carried out to optimize the nutrient management especially micronutrients Zn and B for augmenting productivity of sunflower more specifically during summer season under irrigated condition in northern coastal region of Tamil Nadu.

## Materials and Methods

The field experiment was conducted at the Annamalai University Experimental Farm situated at 11°24' N latitude and 79°44' E longitude and at an altitude of +5.79 m above MSL (mean sea level) and 10 kms away from the Bay of Bengal. Field experiment was conducted during summer season of (February to May) 2014-15. The maximum temperature ranges from 29.2°C to 36.4°C with a mean of 32.8°C and the minimum temperature ranges from 20.8°C to 26.5°C with a mean of 23.6°C. The cropping period received the summer shower of 5.6 mm distributed over 6 rainy days. The relative humidity ranges from 82 to 89 per cent. The soil is clay loam, saline (pH 8.1 and EC 1.14 $dSm^{-1}$), low in organic carbon (0.42 %) and available nitrogen (212 kg $ha^{-1}$), medium in available phosphorus (20 kg $ha^{-1}$) and high in available potassium (279 kg $ha^{-1}$), low in available zinc (0.47 ppm) and boron (0.21 ppm). Rice crop was grown as Rabi crop (Oct-Jan) with normal package of practices.

The treatment consisted of $T_1$ – Control (60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$ alone), $T_2$ - $ZnSO_4$ 25 kg $ha^{-1}$ (Soil application (SA)), $T_3$ - Borax 5 kg $ha^{-1}$ (SA), $T_4$ - $ZnSO_4$ 0.5 % foliar application at star bud stage (FA - SBS), $T_5$ - Borax 0.2 % foliar application at ray floret stage (FA at RFS), $T_6$ - $ZnSO_4$ 25 kg $ha^{-1}$ (SA) + Borax 5 kg $ha^{-1}$ (SA), $T_7$ - $ZnSO_4$ 25 kg $ha^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_8$ - $ZnSO_4$ 25 kg $ha^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_9$ - Borax 5 kg $ha^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_{10}$ - Borax 5 kg $ha^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_{11}$ - $ZnSO_4$ 0.5% (FA - SBS) + Borax 0.2 % (FA - RFS) and $T_{12}$ - $ZnSO_4$ 25 kg $ha^{-1}$ (SA) + Borax 5 kg $ha^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS + Borax 0.2 % FA at RFS. The experiment was laid out in randomized block design with three replications.

The commercial sunflower hybrid 'Sun-bred' was used for the study. A recommended dose of fertilizer for hybrid sunflower *viz.,* 60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ $ha^{-1}$ was adopted. Zinc sulphate ($ZnSO_4$) was used as the source of zinc (containing 36 % Zn), whereas borax (containing 11 % boron) was used as the source of boron. In without foliar fertilization plots, same quantity of water was sprinkled over the foliage. Standard package of practices were followed as per the Tamilnadu state recommendation.

The diameter of the head from the five representative samples were measured at harvest and expressed in cm. The total numbers of seeds were counted and the mean values $head^{-1}$ were worked out and recorded. The filled seeds and chaffy seeds were separated, counted and mean values were expressed as number of filled seeds $head^{-1}$. The ratio of number of filled seeds to the total number of seeds $head^{-1}$ was calculated and expressed as percentage of filled seeds $head^{-1}$. One hundred filled seeds were randomly collected from the sunflower heads of each treatment plot and their weight was recorded in grams (g).

The sunflower heads from each treatment plots were harvested, threshed, sun dried to attain 14 per cent moisture, weighed and the seed yield was expressed in kg $ha^{-1}$. The stalks from the each treatment plots were harvested and after complete sun drying the stalk yield was recorded in kg ha-$^{1}$. The harvest index for each treatment was calculated by using the equation suggested by Verma (1973). The oil content of the seed was estimated using diethyl either as extractant by Soxhlet extractor and expressed in percentage. The oil yield was worked out by multiplying the oil content with seed yield and expressed in kg $ha^{-1}$. Crude protein content of seed was calculated by multiplying the nitrogen percentage of the kernel with factor 6.25 (Humphries, 1956). The economic parameters benefit cost ratio (B: C ratio) was calculated based on prevailing market price The data on observations were statistically analyzed by adopting the procedure of Panse and Sukhastme (1978) and the critical differences were calculated at 5 per cent probability level to draw statistical conclusion.

## Results and Discussion

### Yield Attributes

The data pertaining to yield attributes recorded at physiological maturity stage of the crop are presented in Table 1. The micronutrient management was found to influence the yield attributes of sunflower. Soil application of $ZnSO_4$ @ 25 kg $ha^{-1}$ and Borax 5 kg $ha^{-1}$ and foliar application of $ZnSO_4$ 0.5 per cent at star bud stage and Borax 0.2 per cent at ray floret stage ($T_{12}$) significantly registered the highest head diameter of 21.28 cm, number of seeds $head^{-1}$ of 776.18, number of filled seeds $head^{-1}$ of 659.88, percentage of filled seeds $head^{-1}$ of 86.01 and 100 seed weight (6.12 g).

**Table 1 :** Yield attributes of sunflower as influenced by Zn and B fertilization

| Treatments | Head diameter (cm) | Number of Seeds head$^{-1}$ | Number of filled seeds head$^{-1}$ | Percentage of filled seeds head$^{-1}$ | 100 seed weight (g) |
|---|---|---|---|---|---|
| $T_1$ | 10.15 | 430.65 | 270.55 | 48.89 | 5.15 |
| $T_2$ | 13.15 | 532.15 | 360.65 | 67.77 | 5.25 |
| $T_3$ | 12.72 | 510.15 | 335.38 | 65.74 | 5.22 |
| $T_4$ | 15.19 | 593.62 | 425.52 | 71.68 | 5.48 |
| $T_5$ | 14.77 | 569.24 | 400.16 | 70.29 | 5.45 |
| $T_6$ | 20.65 | 742.20 | 627.69 | 84.57 | 6.07 |
| $T_7$ | 18.73 | 687.10 | 558.31 | 81.24 | 5.94 |
| $T_8$ | 19.58 | 710.32 | 595.50 | 83.83 | 6.00 |
| $T_9$ | 18.26 | 618.55 | 483.58 | 80.28 | 5.91 |
| $T_{10}$ | 16.10 | 667.13 | 452.62 | 75.35 | 5.65 |
| $T_{11}$ | 17.16 | 641.76 | 535.60 | 73.17 | 5.73 |
| $T_{12}$ | 21.28 | 776.18 | 659.88 | 86.01 | 6.12 |
| SEd | 0.24 | 10.60 | 13.68 | 0.34 | 0.02 |
| CD(p=0.05) | 0.50 | 22.85 | 27.19 | 0.68 | 0.04 |

[$T_1$ –Control (60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ ha$^{-1}$), $T_2$ – NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA), $T_3$ – NPK + Borax 5 kg ha$^{-1}$ (SA) $T_4$ - NPK + $ZnSO_4$ 0.5 % foliar application at star bud stage (FA - SBS), $T_5$ - NPK + Borax 0.2 % foliar application at ray floret stage (FA at RFS), $T_6$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA), $T_7$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_8$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_9$ - NPK + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_{10}$ - NPK + Borax 5 kg ha$^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_{11}$ - NPK + $ZnSO_4$ 0.5% (FA - SBS) + Borax 0.2 % (FA - RFS) and $T_{12}$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS + Borax 0.2 % FA at RFS]

Among the yield parameters, head diameter is an important feature in the sunflower seed yield structure. Sunflower head diameter has dependent on the genotype, environmental factors and interaction between these two parameters (Hladni *et al.*, 2014). However, the size of the head diameter influences the number of florets which directly influence the seed yield. As the head diameter increases by one cm, the increase in the number of seeds head$^{-1}$ was about 75 to 100 (Ramulu *et al.*, 2011). In the present study micronutrients Zn and B fertilization greatly influenced the head diameter. The number of seeds head$^{-1}$ increases with increase in head diameter and period for proper filling of seeds also increases, as result the number of unfilled seeds head$^{-1}$ reduces to maximum extent. This also persuades transport and accumulation better photosynthates due to full exposure of sunflower head and higher pollination from insects.

Likewise for determining the yield potential of the hybrid sunflower crop, the number of filled seeds head$^{-1}$ is an important yield component. It enhanced more accumulation of photosynthates in source of hybrid sunflower. Further increase in translocation of assimilates from source to sink, which ultimately increased number of seeds head$^{-1}$. These results are according to the findings as reported by Somroo *et al.* (2007) and Ravi *et al.* (2008).

The 100 seed weight is also another important parameter to increase seed yield. There is a direct relationship between yield and 100 seed weight, as the seed weight increases, yield also increases (Fig. 8). As the number of filled seeds increases, than the contribution of total number of seeds head$^{-1}$ to seed yield will be more. In the present study total number of seeds head$^{-1}$ was higher in $T_{12}$. The increase in number was mainly due to higher zinc and boron levels, which reduce the number of unfilled seed head$^{-1}$ and increase the number of bold healthy filled seeds. Similar type of synergistic effect *i.e.* significant increases in number of filled seeds head$^{-1}$, total number of seeds head$^{-1}$ and higher test weight with soil as well as foliar application of Zn and B was also reported by Patil *et al.* (2006c).

Zinc is the most soluble and available micronutrient under acid conditions. But when the pH is increased, especially in saline soils the ionic forms of Zn are changed to hydroxides or oxides, resulting in decrease of their solubility and availability to the plants as the hydroxides of Zn are insoluble. When Zn was applied through foliar nutrition during star bud stage correct the Zn deficiency and regulate the metabolic effects in photosynthesis. The raise in yield components also due to the effect of Zn in metabolism process *i.e.* chloroplast formation and photosynthesis (Alloway, 2008).

Moreover, foliar application of borax made the boron available directly on the capitulum leading to lower percentage of chaffiness, higher number of filled seeds and higher 100 seed weight. Borax at the rate of 0.2 per cent at ray floret stage has helped to meet the demand for the crop at right time when pollen tubes were to be developed.

Further micronutrients Zn and B involved in photosynthesis even at critical stages of sunflower like seed filling and facilitating the translocation of metabolites resulting in better filling of late formed florets. In this way, treatment $T_{12}$ contributed significantly to all the yield parameters. The effect of Zn and B on sunflower hybrid had a significant effect on higher head diameter, number of seeds head$^{-1}$ and 100 seed weight are in agreement with the findings of Wazilewski and Gomes (2009); Stangoulis *et al.* (2010); Suresh *et al.* (2013) and Petr (2013).

**Yield and Harvest index**

The higher achene yield and stalk yield were registered in $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 per cent FA at SBS + Borax 0.2 per cent FA at RFS treatment ($T_{12}$). It recorded the achene and stalk yield of 2194 and 4956 kg ha$^{-1}$, respectively. The highest harvest index of 30.81 was recorded in the same treatment. The oil content and oil yield of sunflower seeds was significantly influenced by micronutrient treatments. The micronutrient treatment $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 per cent FA at SBS + Borax 0.2 per cent FA at RFS ($T_{12}$) significantly registered the highest oil content of 42.92 per cent and oil yield of 941 kg ha$^{-1}$.

**Table 2 :** Yield and economics of sunflower as influenced by Zn and B fertilization

| Treatments | Achene yield (kg ha$^{-1}$) | Stalk yield (kg ha$^{-1}$) | Harvest index (%) | Oil content (%) | Oil yield (kg ha$^{-1}$) | Return rupee$^{-1}$ invested |
|---|---|---|---|---|---|---|
| $T_1$ | 1012 | 2430 | 20.06 | 40.96 | 414 | 1.71 |
| $T_2$ | 1348 | 3785 | 26.26 | 41.33 | 557 | 2.11 |
| $T_3$ | 1296 | 3680 | 26.04 | 41.15 | 533 | 2.03 |
| $T_4$ | 1520 | 4036 | 27.35 | 41.67 | 625 | 2.21 |
| $T_5$ | 1468 | 3931 | 27.17 | 41.50 | 609 | 2.13 |
| $T_6$ | 2087 | 4810 | 30.25 | 42.73 | 891 | 2.66 |
| $T_7$ | 1859 | 4563 | 28.94 | 42.38 | 787 | 2.42 |
| $T_8$ | 1981 | 4688 | 29.70 | 42.55 | 842 | 2.55 |
| $T_9$ | 1805 | 4457 | 28.82 | 41.86 | 761 | 2.38 |
| $T_{10}$ | 1610 | 4190 | 27.75 | 42.20 | 673 | 2.27 |
| $T_{11}$ | 1700 | 4312 | 28.27 | 42.03 | 714 | 2.30 |
| $T_{12}$ | 2194 | 4956 | 30.81 | 42.92 | 941 | 2.70 |
| SEd | 51 | 57 | 0.12 | 0.09 | 20 | - |
| CD(p=0.05) | 101 | 116 | 0.25 | 0.17 | 39 | - |

[$T_1$ –Control (60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ ha$^{-1}$), $T_2$ – NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA), $T_3$ – NPK + Borax 5 kg ha$^{-1}$ (SA) $T_4$ - NPK + $ZnSO_4$ 0.5 % foliar application at star bud stage (FA - SBS), $T_5$ - NPK + Borax 0.2 % foliar application at ray floret stage (FA at RFS), $T_6$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA), $T_7$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_8$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_9$ - NPK + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS, $T_{10}$ - NPK + Borax 5 kg ha$^{-1}$ (SA) + Borax 0.2 % FA at RFS, $T_{11}$ - NPK + $ZnSO_4$ 0.5% (FA - SBS) + Borax 0.2 % (FA - RFS) and $T_{12}$ - NPK + $ZnSO_4$ 25 kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 % FA at SBS + Borax 0.2 % FA at RFS]

The higher seed yield of hybrid sunflower might be due to increase in translocation of photosynthates from vegetative sources towards the reproductive organs when Zn and B were applied as foliar nutrition 0.5 per cent at star bud stage and borax 0.2 per cent at ray floret stage, respectively. Soil application of $ZnSO_4$ has an important role in regulating the ionic balance in plant system in order to decrease the water stress such that any secondary factor which leads to inaccessibility of this element for the plant indicates the yield (Khurana and Chatterjee, 2001 and Madani, 2013). Foliar nutrition of $ZnSO_4$ at the rate of 0.5 per cent at might have positively enhanced the seed yield and harvest index synergistically with its favourable effect on chlorophyll (a and b) synthesis, auxin synthesis, water uptake and photosynthesis (Patil *el al.*, 1997).

In sunflower, it was reported that there was an intense Zn translocation from the leaf, stem and capitulum to seed formation, and the highest accumulations occurred in the stem and seeds. In the seeds, such accumulation happened at 97 DAE, Zn representing an exportation of 52 per cent of all Zn absorbed by the plant (Zobiole *et al*. 2011).

Sunflower also requires greater quantities of B to satisfy its metabolic needs than other cultivated species (Brighenti and Castro, 2008). Diggs *et al.* (1992) reported that application of 1.1 to 1.4 kg B ha$^{-1}$ to sunflower plants between 40 and 50 cm height, followed by a second spray shortly before flowering increased seed yield by 20 per cent. Siyal and Bhatti (1996) observed that boron deficiency decreases the rate of water absorption and transaction of sugar in plants. Murthy (2011) reported that boron application at 0.2-0.5 per cent to capitulum at the ray floret stage in sunflower was adequate for increasing yields.

In sunflower crop, it was also reported that B accumulation in the sunflower plants was low until 28 DAE due to the lower development of the plants. From this period, the speed of B accumulation increased rapidly presenting a higher accumulation at 80 DAE. It is possible to observe that, after B maximum accumulation in the leaf at 69 DAE, there was an accentuated decrease of contents in this organ, showing an intense translocation of this element to the other organs such as the seed which presented maximum accumulation at 95 DAE (Zobiole *et al*., 2011).

Such response mainly due to dominant role played by Zn and B in improving the photosynthetic ability and assimilating capacity of crop by being a component in various enzymatic and other biochemical reactions. Better translocation of nutrients from source to sink enabling better yield parameters and finally the seed yield of sunflower. These results are in line with the findings of Oyinlola (2007); Ramulu *et al.* (2011); Takir *et al.* (2014) and Bhattacharyya *et al.* (2015).

The application of micronutrients also exhibited increase over control in stalk yield and harvest index of hybrid sunflower. Harvest index is a measure of determining productivity of a crop. Higher harvest index might be due to continuous availability of nutrients in the rhizosphere, better source and sink relationship contributed to overall performance in terms of stalk yield and harvest index. This finding is in accordance with the earlier reports of Zahoor *et al.* (2011); Shahri *et al*. (2012).

The value of sunflower produce is measured in term of seed oil contents. These results could be explained according to favourable time of Zn and B foliar application and its effect by enhancing photosynthesis activity which, in turn, resulted in seed formation, an increase in oil content and oil yield of sunflower. Ahmad *et al.* (2011) found that direct proportionality presents in Zn and B, and application time and photosynthetic rate in sunflower to the pollination, seed set, the formation of protein and oil synthesis. The significant positive relations between seed oil content with the soil and foliar application of Zn and B were also reported by Shaker and Mohammed (2011) and Tahir *et al*. (2014).

### Economics

In general, Zn and B fertilization had exhibited considerable variations in B: C ratio. The higher return rupee$^{-1}$ invested (Rs. 2.70/-) was obtained from treatment $T_{12}$ ($ZnSO_4$ 25kg ha$^{-1}$ (SA) + Borax 5 kg ha$^{-1}$ (SA) + $ZnSO_4$ 0.5 per cent FA at SBS + Borax 0.2 per cent FA at RFS). This is due to the synergistic and cumulative effect of both soil and foliar applied Zn and B micronutrient treatments followed. Micronutrients *viz*., Zn and B application effectively corrected the deficiencies and balanced the other available nutrients and the resources which ultimately enhanced the economic produce and obtained the higher B: C ratio.

## Conclusion

The head diameter, number of seeds head$^{-1}$, number of filled seeds head$^{-1}$, the percentage of filled seeds head$^{-1}$, 100 seed weight, seed yield, stalk yield and oil yield and benefit cost ratio were significantly maximum in 60 kg N, 90 kg $P_2O_5$ and 60 kg $K_2O$ ha$^{-1}$ along with soil application of micronutrients $ZnSO_4$ 25 kg ha$^{-1}$ and borax 5 kg ha$^{-1}$, foliar fertilization of $ZnSO_4$ 0.5 per cent at star bud stage and borax 0.2 per cent at ray floret stage. Hence, it can be concluded that this management practice was the optimal micronutrient management practice for obtaining maximum yield and B: C ratio on the coastal saline soils.

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