International Journal of Bio-resource and Stress Management 2016, 7(4):845-850 DOI: HTTPS://DOI.ORG/10.23910/IJBSM/2016.7.4.1632

Full Research Article

# Growth and Yield of Sunflower (*Helianthus annuus* L.) Hybrids under Different Nutrient Management Practices

**Sarthak Pattanayak[1*], Aswini Behera[2], S. N. Jena[3], Priyanka Das[4] and Suryakanta Behera[5]**

[1-4]Dept. of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha (751 003), India

[5]Dept. of Silviculture and Agroforestry, College of Forestry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha (751 003), India

**Article History**

Manuscript No. AR1632
Received in 29th June, 2016
Received in revised form 23rd July, 2016
Accepted in final form 4th August, 2016

**Correspondence to**

*E-mail: sarthakekun@gmail.com

**Keywords**

Growth, boron, sulphur, biofertiliser, yield, hybrids

**Abstract**

Field experiment conducted at Department of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, (India) under split plot design taking four nutrient management practices including combination of recommended dose of fertilizer, application of $ZnSO_4$ @ 25 kg ha$^{-1}$, boron @ 1 kg ha$^{-1}$ and biofertliser along with four genotypes including three hybrids and one local variety evaluated that application of recommended dose of fertilizer with dose of 80−60−80 kg N, $P_2O_5$, $K_2O$+$ZnSO_4$ @ 25 kg ha$^{-1}$ recorded in higher plant height (160.3 cm), number of leaves (31.1), leaf area index (3.549) and dry matter accumulation (128.90 g plant$^{-1}$) with higher crop growth rate (12.343 g m$^{-2}$ d$^{-1}$) as compared to other and also reported higher seed (2.17 t ha$^{-1}$), Stover (4.88 t ha$^{-1}$) and oil (0.91 t ha$^{-1}$) yield, which was followed by application of recommended dose of fertilizer+boron 1 k ha$^{-1}$. Hybrid Super-48 recorded higher growth and yield attributing characters as compared to others with plant height, number of leaves, leaf area index, dry matter accumulation, crop growth rate with corresponding values of 157.8 cm, 23.0, 3.572, 133.22 g plant$^{-1}$ and 13.177 g d$^{-1}$ m$^{-2}$, respectively. Application of $ZnSO_4$ 25 kg ha$^{-1}$ in hybrid Super–48 recorded the highest seed yield and oil due application of sulphur which was followed by application of boron 1 kg ha$^{-1}$.

## 1. Introduction

Sunflower is an important oilseed crop grown in India for edible oil although its average productivity is only 566 kg ha$^{-1}$ (Damodaram and Hegde, 2000). By virtue of its short duration, low photo- and thermo-sensitivity and wider adaptability to different soil types, sunflower fits well into various multiple cropping systems. These features offer a potential scope to explore the system of cropping in sequence proceeding to sunflower. The shortage of edible oils has become a chronic problem in India with increasing demographic pressure. Sunflower can play an important role in meeting out the shortage of edible oils in the country. It covers 2.34 mha and provides 1.44 mt total productions with 615 kg ha$^{-1}$ average productivity (Anonymous, 2007). The existing yield is very low, mainly because of the suboptimal soil fertility. After N, P and K, S is the fourth nutrient, whose deficiency is wide spread in India (Yadav et al., 2000; Sakal et al., 2001). Results from 12 Indian states Co-operative study from TSI, FAI and IFA in association with agronomists at national centres showed that an average 30 to 35% of cropped soils were deficient in S and another 35% potentially deficient in it, indicating widespread soil S hunger (Morris, 2006). Sulphur deficiency is observed primarily due to high crop yield and therefore higher rate of S removal by crops, and lesser use of S-containing fertilizers (Messick, 2003). Application of Boron increases the pollen-producing capacity of anthesis and pollen grain viability. Appropriate dose of boron at sowing affect positively the inner tissues of plant which lead to head seed filling due to better development of pollen tubes. Similar results were reported earlier by Silva et al. (2011); Shekhawat and Shivay (2008). Bio-fertilizers are inputs containing micro-organisms which are capable of mobilizing nutritive elements from non-available to available form through biological processes (SubbaRao, 1993). Taking this in view experiment was conducted for evaluating best nutrient management practices and hybrids interaction for sunflower production in coastal Odisha.

## 2. Materials and Methods

A field experiment was conducted at Agronomy Research Farm, Department of Agronomy, Orissa University of Agriculture and Technology, Bhubaneswar (India) during summer, 2014. The experimental site lies at 20°15′ N latitude and 85°52′ E longitude, with an altitude of 25.9 m amsl under the Agro-climatic zone of East and South Eastern plain zone. The experiment was laid in split plot design with four main plot treatments viz., $N_1$-N, $P_2O_5$, $K_2O$ @ 60-80-60 kg ha$^{-1}$ (RDF); $N_2$-RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$; $N_3$-RDF+Boron @ 1 kg ha$^{-1}$; $N_4$-RDF+*Azotobacter*+*Azospirillum*+PSB (1:1:1) and four varieties $V_1$-Super-48, $V_2$-Super-90, $V_3$-Super- 86, $V_4$-Morden and replicated three times. The soil was well drained and sandy loam in texture with pH of 5.76, Ec of 0.133 dSm$^{-1}$ and organic carbon (%) of 0.52, respectively. The available Nitrogen, phosphorus, potassium and sulphur was 235.7, 32.4, 120.4 and 25.3 kg ha$^{-1}$ and available boron of 0.334 mg kg$^{-1}$. Well decomposed FYM was incorporated into the soil at final ploughing @ 5 t ha$^{-1}$. Inorganic fertilizers @ 60:80:60 kg N, $P_2O_5$ and $K_2O$ ha$^{-1}$ were applied to all the plots through urea (46-0-0), DAP (18-46-0) and MOP (0-0-64). Full P and K + half N were applied as basal while rest were top dressed at 30 days after sowing. $ZnSO_4$ (25 kg ha$^{-1}$) and Boron (1 kg ha$^{-1}$) and *Azotobacter*+*Azospirillum*+Phosphorus solubilising bacteria (1:1:1) @ 4 kg ha$^{-1}$ each were applied as basal at the time of final land preparation. Observation on periodic growth parameter was taken at 15 days interval starting from 30 days after sowing. Leaf area index was calculated following Watson (1947). Crop growth rate is the increase in dry weight of plant per unit area of land unit$^{-1}$ change in time and expressed as g d$^{-1}$ m$^{-2}$ whereas relative growth rate is increase in dry weight per unit dry weight already present and is expressed as g g$^{-1}$ day$^{-1}$ (Radford, 1967).

## 3. Results and Discussion

### 3.1. Plant height

Plant heights (Table 1) increased significantly due to different nutrient management practices at all the stages of observations viz., 45, 60, 75 DAS and at harvest, except up to 30 days after sowing where effect of nutrients has not started to a significant level. Plant height increased at around 3.5 times from 30 to 45 DAS and rate of increase decreased with age. Highest plant height of 160.3 cm was recorded under application of RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$ which was at par with RDF+ boron @ 1 kg ha$^{-1}$ (157.5 cm) at harvest which is the result of increased metabolism due application of sulphur in addition to effect of RDF. This increased height at sulphur application is in accordance with Vijay and Selvaraju, (2001). The highest plant height of 160.0 cm was observed in local variety Morden followed by Super-48 with plant height of 157.8 cm.

Table 1: Plant height, number of leaves and leaf area index as influenced by nutrient management practices and hybrids

| Treatments | Days after sowing | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant height (cm) | | | | | Number of leaves | | | | | Leaf area index | | | | |
| NMP | 30 | 45 | 60 | 75 | Harvest | 30 | 45 | 60 | 75 | harvest | 30 | 45 | 60 | 75 | harvest |
| $N_1$ | 16.2 | 70.9 | 133.1 | 143.8 | 145.5 | 7.8 | 10 | 19.1 | 25 | 18 | 0.438 | 1.78 | 3.15 | 3.04 | 1.92 |
| $N_2$ | 17.5 | 80.2 | 142.5 | 152.6 | 160.3 | 8.5 | 15.4 | 24.1 | 31.1 | 24.1 | 0.517 | 1.95 | 3.42 | 3.549 | 2.405 |
| $N_3$ | 17.4 | 79.5 | 140.5 | 152.2 | 157.5 | 8.1 | 15.1 | 24 | 30.9 | 23.4 | 0.493 | 1.93 | 3.39 | 3.538 | 2.395 |
| $N_4$ | 16.5 | 75.1 | 136.5 | 148.2 | 151.2 | 8.3 | 15.7 | 23.5 | 29.3 | 22.2 | 0.44 | 1.86 | 3.276 | 3.263 | 2.16 |
| SEm± | 0.281 | 1.132 | 0.735 | 1.007 | 1.534 | 0.05 | 0.07 | 0.09 | 0.13 | 0.34 | 0.048 | 0.02 | 0.027 | 0.058 | 0.052 |
| CD ($p$=0.05) | NS | 3.918 | 2.543 | 3.484 | 5.308 | NS | NS | 0.261 | 0.387 | 1.009 | NS | NS | 0.095 | 0.2 | 0.18 |
| Hybrids | | | | | | | | | | | | | | | |
| $V_1$ | 17.2 | 77.9 | 140.8 | 152.5 | 157.8 | 8.8 | 16 | 24.9 | 32 | 23 | 0.524 | 1.98 | 3.363 | 3.572 | 2.377 |
| $V_2$ | 16.7 | 74 | 135.6 | 147.7 | 152.7 | 7.9 | 13.9 | 22.1 | 28 | 21.7 | 0.45 | 1.87 | 3.297 | 3.288 | 2.143 |
| $V_3$ | 15.5 | 72.6 | 133.2 | 141.4 | 144 | 7.9 | 15.1 | 23.9 | 30.5 | 22.5 | 0.48 | 1.95 | 3.338 | 3.468 | 2.335 |
| $V_4$ | 18.2 | 81.2 | 143 | 155.2 | 160 | 8.1 | 11.2 | 19.8 | 25.8 | 20.5 | 0.433 | 1.72 | 3.238 | 3.062 | 2.025 |
| SEm± | 0.365 | 1.246 | 2.034 | 1.518 | 1.152 | 0.03 | 0.08 | 0.11 | 0.19 | 0.38 | 0.023 | 0.03 | 0.026 | 0.068 | 0.034 |
| CD ($p$=0.05) | NS | 3.636 | 5.936 | 4.429 | 3.361 | NS | NS | 0.298 | 0.564 | 1.132 | NS | NS | 0.074 | 0.199 | 0.099 |

NMP: Nutrient management practices; $N_1$: RDF (60:80:60 kg N:$P_2O_5$:$K_2O$ ha$^{-1}$; $N_2$: RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$; $N_3$: RDF+Boron @ 1 kg ha$^{-1}$; $N_4$: RDF+Bio-fertiliser; $V_1$: Super-48; $V_2$: Super-90; $V_3$: Super-86; $V_4$: Morden

### 3.2. Number of leaves and leaf area index

Number of leaves (Table 1) and leaf area index (LAI) followed the same trend where both, increased upto 75 DAS and declined thereafter due to natural senescence of lower leaves. Highest number of leaves were counted when $ZnSO_4$ was applied along with RDF (31.1) which was at par with application of RDF+boron @ 1 kg $ha^{-1}$ (30.9) at 75 DAS and declined thereafter at harvest. There was 72% increase in number of leaves in the period of 30 to 45 DAS. High leaf area index (Table 3) is indicative of high mobilizable protein pools available at the beginning of the reproductive phase, greater the plant-bearing capacity later on. Highest LAI (3.549) was obtained in treatment RDF+$ZnSO_4$ @ 25 kg $ha^{-1}$ at 75 DAS and also maintained highest LAI of 2.405 at harvest confirming the results of Dev and Sarawgi (2004) and Sarkar and Mallik (2009). While, among cultivars, Super-48 recorded in highest number of leaves (32.0) and leaf area index (3.572).

### 3.3. Dry matter production

Application of sulphur (RDF+$ZnSO_4$ @ 25 kg $ha^{-1}$) increased the dry matter (128.9 g $plant^{-1}$) due to higher production of photosynthates and their translocation to sink, which ultimately increased the plant growth as reported earlier by Karthikeyan and Shukla (2008). Application of boron ($N_3$) also recorded at par dry matter production (126.2 g $plant^{-1}$) as that of Sulphur application ($N_2$). Dry matter (Table 2) also increased at a rate of around 3.5% in the period between 30 to 45 DAS that followed same trend as that of plant height. This, results were confirmed by earlier worker Rasool et al. (2013). Hybrid Super-48 recorded in highest dry matter accumulation of 133.22 which was superior over the others.

### 3.4. Crop growth rate (g $m^{-2}$ $d^{-1}$)

Crop growth rate (CGR) is the increased dry matter $unit^{-1}$ land area $unit^{-1}$ time which is affected by all the growth parameters. CGR (Table 2) increased with increase in age up to 45−60 DAS and declined thereafter till harvest with a highest value of 14.830 when RDF+$ZnSO_4$ @ 25 kg $ha^{-1}$ ($N_2$) was applied which was closely followed by RDF+boron @ 1 kg $ha^{-1}$ ($N_3$) with value of 14.675 at 45−60 DAS. This finding was supported by Sarkar and Mallik (2009). The highest crop growth rate of 14.33 was was recorded in Super-48 during the growth period of 45 to 60 days after sowing, while the lowest(13.529) was obtained in local variety morden.

### 3.5. Relative growth rate (g $g^{-1}$ $d^{-1}$)

Highest relative growth rate (RGR) was obtained at initial period of crop growth that declined gradually with age as growth increases with decreased trend with age following Mitscherlich's law. Application of RDF+boron and RDF+bio-fertiliser (Table 2) recorded highest RGR of 1.000 at 30−45 DAS while the lowest of 0.008 was recorded with only application of RDF at period of 75 days after sowing to harvest. Super-48 recorded highest RGR of 0.101 during period of 30−45 days after sowing while the lowest (0.0114) was recoded in Super-90

### 36. Yield

#### 3.6.1. Seed yield

Application of RDF+$ZnSO_4$ @ 25 kg $ha^{-1}$ (2.17 t $ha^{-1}$) resulted in the highest seed yield, which was on par with that of

Table 2: Dry matter accumulation, crop growth rate and relative growth rate as influenced by nutrient management practices and hybrids

| Treatments | Days after sowing | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry matter accumulation (g $plant^{-1}$) | | | | | Crop growth rate (g $d^{-1}$ $m^{-2}$) | | | | Relative growth rate (g $g^{-1}$ $d^{-1}$) | | | |
| NMP | 30 | 45 | 60 | 75 | harvest | 30−45 | 45−60 | 60−75 | 75-harvest | 30−45 | 45−60 | 60−75 | 75-harvest |
| $N_1$ | 7.05 | 31.24 | 66.2 | 98.8 | 115.07 | 8.966 | 12.958 | 12.084 | 6.03 | 0.0992 | 0.05 | 0.03 | 0.008 |
| $N_2$ | 7.69 | 34.09 | 74.1 | 107.4 | 128.9 | 9.786 | 14.83 | 12.343 | 7.969 | 0.0996 | 0.0517 | 0.02 | 0.0091 |
| $N_3$ | 7.56 | 33.91 | 73.5 | 106.7 | 126.2 | 9.766 | 14.675 | 12.306 | 7.228 | 0.1 | 0.0515 | 0.02 | 0.009 |
| $N_4$ | 7.25 | 32.71 | 70.1 | 102.4 | 120.6 | 9.437 | 13.859 | 11.972 | 6.746 | 0.1 | 0.0508 | 0.03 | 0.0081 |
| SEm± | 0.19 | 0.283 | 1.132 | 1.065 | 1.726 | | | | | | | | |
| CD ($p$=0.05) | NS | 0.838 | 3.351 | 3.058 | 5.074 | | | | | | | | |
| Hybrids | | | | | | | | | | | | | |
| $V_1$ | 7.77 | 35.66 | 74.34 | 109.89 | 133.22 | 10.337 | 14.33 | 13.177 | 8.647 | 0.101 | 0.049 | 0.03 | 0.0128 |
| $V_2$ | 7.36 | 32.79 | 70.62 | 103.47 | 122.69 | 9.426 | 14.022 | 12.176 | 7.124 | 0.099 | 0.0511 | 0.03 | 0.0114 |
| $V_3$ | 7.58 | 34.09 | 73.03 | 106.7 | 127 | 9.826 | 14.434 | 12.48 | 7.524 | 0.1 | 0.0504 | 0.03 | 0.0116 |
| $V_4$ | 6.84 | 29.41 | 65.91 | 95.24 | 107.86 | 8.366 | 13.529 | 10.871 | 4.678 | 0.0972 | 0.0538 | 0.02 | 0.0025 |
| SEm± | 0.173 | 0.246 | 0.974 | 0.923 | 1.385 | | | | | | | | |
| CD ($p$=0.05) | NS | 0.728 | 2.883 | 2.714 | 4.091 | | | | | | | | |

RDF+Boron @ 1 kg ha$^{-1}$ (2.12 t ha$^{-1}$), while the lowest was recorded under only RDF application (Table 3). This increased yield might be due to significant increase in yield attributes and better partitioning of photosynthates from source to sink. Application of RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$ recorded in 2.5 and 11.43% increase in yield over RDF+Boron @ 1 kg ha$^{-1}$ and RDF+Biofertiliser, respectively. Treatment containing RDF+$ZnSO_4$ @ 25 Kg ha$^{-1}$, RDF+Boron @ 1 kg ha$^{-1}$ and RDF+Biofertiliser recorded 20.05, 17.12 and 7.73% increase in yield over RDF, respectively. Increased seed yield due to Sulphur application was in conformity with Bhagat et al. (2005) and Kumar and Thenua (2012). All hybrids showed higher growth parameter as compared to varieties and performance of one hybrid vary from other at a particular situation. This finding was supported by earlier workers Reddy (2002) and Sheoran et al. (2014). Yield is the combined effect of all yield attributing characters. Super-48 also recorded in highest seed (2.25 t ha$^{-1}$), which was 14.18 % higher than Morden. Super-48 recorded significantly higher seed yield (Table 4) of 2.55 t ha$^{-1}$ when applied with RDF+ ZnSO4 25 kg ha$^{-1}$.

*3.6.2. Stover yield*

Application of RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$ produced the highest Stover yield (4.88 t ha$^{-1}$**)** and RDF+Boron @ 1 kg ha$^{-1}$ (4.82 t ha$^{-1}$) was statistically at par (Table 3). Application of RDF+ Biofertiliser (4.68 t ha$^{-1}$) recorded significantly less Stover yield. Application of recommended dose of fertilizer alone (4.54 t ha$^{-1}$**)** produced the lowest Stover yield. Treatments containing RDF+$ZnSO_4$, RDF+Boron and RDF+Biofertiliser recorded 7.55, 6.14 and 3.06% increase in Stover yield over RDF alone, respectively. Hybrid Super -48 recoded the highest stover yield of 5.10 t ha$^{-1}$ which was 6.4% higher than Morden (4.190 t ha$^{-1}$).

*3.6.3. Oil yield*

The highest oil yields were recorded with RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$ (0.91 t ha$^{-1}$) and RDF+Boron @ 1 kg ha$^{-1}$ (0.89 t ha$^{-1}$) were at par with it. This might be due to synthesis of higher amount of sulphur containing amino acids and fatty acid (conversion of acetyl Co-A to malonyl Co-A) resulting from increased activity of thiokinase enzyme due to S supply. Similar results were reported by Poonia (2000); Rasool et al. (2013) and Sheoran et al. (2014). ).95 t ha$^{-1}$ oil yield was obtained in hybrid Super-48 which was followed by Super-90 (0.83 t ha$^{-1}$). Super- 48 recoded 43.99% increased oil yield than Morden. The increased seed and oil yield in hybrids was also supported by Kaya and Kolsarici (2011) and Khan et al. (2013). Hybrid Super-48 recorded maximum oil yield (Table 5) production with application of RDF+$ZnSO_4$ @ 25 kg ha$^{-1}$ (1.03 t ha$^{-1}$) and RDF + Boron @ 1 kg ha$^{-1}$ (10.09 q ha$^{-1}$). Similar trend was observed with cv. Super-86 observed with $N_2$ and $N_3$, recording the yield of 0. 98 t ha$^{-1}$ and 0. 96 t ha$^{-1}$, respectively.

## 4. Nutrient Uptake

NPK uptake (Table 6) by sunflower was found to be statistically similar with RDF+$ZnSO_4$ or RDF+Boron. If a plant nutrient is involved in improving the vegetative growth, it would certainly improve the uptake of all nutrients, which are required to maintain growth. Higher uptake of N due to synergistic effect of N and S in sunflower, resulted in higher uptake of P and K also as reported earlier by Shekhawat and Shivay (2008). Boron improved the rational utilization of P and K and helped in transportation of these nutrients from source and sink as reported by Stoyanov (1975). RDF+Bio-fertilizer resulted higher nutrient uptake than RDF alone because of the activity of nitrogen fixing bacteria and P-solubilizing bacteria increasing the availability and uptake of N and P.

Table 3: Yield (t ha$^{-1}$) of sunflower as influenced by nutrient management practices and hybrids

| Treatment | Seed yield (t ha$^{-1}$) | Stover yield (t ha$^{-1}$) | Oil yield (t ha$^{-1}$) |
|---|---|---|---|
| Nutrient management practices | | | |
| $N_1$ | 1.81 | 4.54 | 0.73 |
| $N_2$ | 2.17 | 4.88 | 0.91 |
| $N_3$ | 2.12 | 4.82 | 0.89 |
| $N_4$ | 1.95 | 4.68 | 0.80 |
| SEm± | 0.067 | 0.64 | 0.033 |
| CD ($p$=0.05) | 0.20 | 0.19 | 0.10 |
| Hybrids | | | |
| $V_1$ | 2.250 | 5.100 | 0.95 |
| $V_2$ | 2.020 | 4.730 | 0.83 |
| $V_3$ | 2.150 | 4.890 | 0.89 |
| $V_4$ | 1.630 | 4.190 | 0.66 |
| SEm± | 0.03 | 0.065 | 0.02 |
| CD ($p$=0.05) | 0.09 | 0.19 | 0.06 |

Table 4: Interaction of nutrient management practices and hybrids in relation to seed yield

| | $V_1$ | $V_2$ | $V_3$ | $V_4$ | Mean (t ha$^{-1}$) |
|---|---|---|---|---|---|
| $N_1$ | 1.95 | 1.84 | 1.90 | 1.55 | 1.81 |
| $N_2$ | 2.55 | 2.11 | 2.32 | 1.70 | 2.17 |
| $N_3$ | 2.38 | 2.11 | 2.30 | 1.68 | 2.12 |
| $N_4$ | 2.12 | 2.01 | 2.07 | 1.59 | 1.95 |
| Mean (t ha$^{-1}$) | 2.25 | 2.02 | 2.15 | 1.63 | |
| | Fixed main plot | | Fixed sub plot | | |
| SEm± | 0.12 | | 0.10 | | |
| CD ($p$=0.05) | 0.36 | | 0.30 | | |

Sulphur application and boron application increased sulphur and boron uptake, respectively due to their higher availability at root zone. Among the different cultivars tested, Super-48 resulted in the highest N, P, K, S and B uptake due to its higher seed yield and stover yield and higher nutrient content in its dry matter, which was followed by Super-86, Super-90 and Modern.

### 5. Economics

Maximum gross returns, net returns and benefit-cost ratio were found to be maximum with RDF+$ZnSO_4$, which was on par with RDF+Boron (Table 7). This was due to higher seed and oil yield in these treatments. RDF alone recorded the least gross and net returns and benefit-cost ratio due to lower seed and oil yield. Similar results were found by Sarkar and Mallick (2009).

Among different test cultivars, the maximum gross returns, net returns and benefit-cost ratio were obtained with Super-48, which was significantly superior to Super-86 and Super-90. The lowest gross returns, net returns and benefit-cost ratio were observed with Modern. This was due to the variation in the seed yield and oil yield among the cultivars.

Table 5: Interaction of nutrient management practices and hybrids in relation to oil yield

| | $V_1$ | $V_2$ | $V_3$ | $V_4$ | Mean (t ha$^{-1}$) |
|---|---|---|---|---|---|
| $N_1$ | 0.87 | 0.71 | 0.73 | 0.61 | 0.73 |
| $N_2$ | 1.03 | 0.94 | 0.98 | 0.70 | 0.91 |
| $N_3$ | 1.00 | 0.90 | 0.96 | 0.69 | 0.89 |
| $N_4$ | 0.90 | 0.78 | 0.88 | 0.63 | 0.80 |
| Mean (t ha$^{-1}$) | 0.95 | 0.83 | 0.89 | 0.66 | |
| | Fixed main plot | | Fixed sub plot | | |
| SEm± | 0.057 | | 0.052 | | |
| CD ($p$=0.05) | 0.159 | | 0.149 | | |

Table 7: Economic analysis of sunflower as influenced by nutrient management practices and Hybrids

| Treatment | Cost of cultivation (₹ ha$^{-1}$) | Gross return (₹ ha$^{-1}$) | Net return (₹ ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|
| Nutrient management Practices | | | | |
| $N_1$ | 28000 | 67875 | 39875 | 2.42 |
| $N_2$ | 29250 | 81488 | 52238 | 2.79 |
| $N_3$ | 29100 | 79500 | 50400 | 2.73 |
| $N_4$ | 28800 | 73125 | 44325 | 2.53 |
| SEm± | | 1286.4 | 838.1 | 0.026 |
| CD ($p$=0.05) | | 3780 | 2439 | 0.064 |
| Hybrids | | | | |
| $V_1$ | 29100 | 84375 | 55275 | 2.89 |
| $V_2$ | 29100 | 75750 | 46650 | 2.60 |
| $V_3$ | 29100 | 80625 | 51525 | 2.77 |
| $V_4$ | 27500 | 61125 | 33625 | 2.22 |
| SEm± | | 1349.8 | 940.6 | 0.023 |
| CD ($p$=0.05) | | 3982 | 2756 | 0.07 |

Table 6: Nutrient uptake by grain and stover as influenced by nutrient management practices and hybrids

| Treatment | Nitrogen (kg ha$^{-1}$) | | | Phosphorus (kg ha$^{-1}$) | | | Potassium (kg ha$^{-1}$) | | | Sulphur (kg ha$^{-1}$) | | | Boron (mg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Stover | Total | Grain | Stover | Total | Grain | Stover | Total | Grain | Stover | Total | Grain | Stover | Total |
| $N_1$ | 41.68 | 22.69 | 64.37 | 12.08 | 3.56 | 15.64 | 12.84 | 70.83 | 83.67 | 7.25 | 6.81 | 14.06 | 343.85 | 1957.17 | 2301.02 |
| $N_2$ | 54.54 | 27.83 | 81.84 | 19.33 | 4.35 | 23.68 | 16.29 | 80.58 | 96.87 | 12.16 | 9.76 | 21.92 | 586.71 | 2752.39 | 3339.1 |
| $N_3$ | 53.60 | 25.45 | 79.05 | 17.10 | 4.24 | 21.34 | 15.04 | 76.82 | 91.62 | 10.51 | 8.48 | 18.99 | 601.81 | 3032.96 | 3634.74 |
| $N_4$ | 43.40 | 23.15 | 66.55 | 13.21 | 3.63 | 16.84 | 13.53 | 71.20 | 84.73 | 9.01 | 7.56 | 16.57 | 390.81 | 2407.45 | 2798.26 |
| SEm± | 0.853 | 0.754 | 1.778 | 1.157 | 0.085 | 0.959 | 1.020 | 3.851 | 1.870 | 0.523 | 0.435 | 0.836 | 3.010 | 89.250 | 94.125 |
| CD* | 2.51 | 2.21 | 5.23 | 3.38 | 0.25 | 2.82 | 2.981 | NS | 5.48 | 1.54 | 1.28 | 2.46 | 8.127 | 265 | 281.34 |
| Hybrids | | | | | | | | | | | | | | | |
| $V_1$ | 55.90 | 28.03 | 83.93 | 19.30 | 4.58 | 23.88 | 16.61 | 84.62 | 101.23 | 11.89 | 9.68 | 21.57 | 561.25 | 2808.99 | 3370.24 |
| $V_2$ | 49.99 | 24.99 | 74.98 | 17.14 | 3.70 | 20.84 | 14.71 | 75.45 | 90.16 | 9.88 | 8.33 | 18.21 | 463.86 | 2513.54 | 2977.40 |
| $V_3$ | 51.28 | 25.91 | 77.19 | 17.38 | 3.91 | 21.29 | 13.21 | 79.20 | 92.41 | 10.28 | 8.31 | 18.59 | 476.34 | 2781.84 | 3258.18 |
| $V_4$ | 36.74 | 20.25 | 56.99 | 10.66 | 3.57 | 14.23 | 10.66 | 60.77 | 71.43 | 6.43 | 6.35 | 12.78 | 396.93 | 2040.58 | 2436.91 |
| SEm± | 0.478 | 0.021 | 0.729 | 0.488 | 0.34 | 0.462 | 0.731 | 1.578 | 2.344 | 0.530 | 0.419 | 0.959 | 5.472 | 29.01 | 37.182 |
| CD* | 1.406 | NS | 2.13 | 1.43 | NS | 1.35 | 2.15 | 4.64 | 6.87 | 1.560 | 1.230 | 2.810 | 15.180 | 87.180 | 109.270 |

*: CD ($p$=0.05)

## 6. Conclusion

Application of recommended dose of fertilizer with dose of 60-80-60 kg N, $P_2O_5$ and $K_2O$+$ZnSO_4$ @ 25 kg ha$^{-1}$ may be the best nutrient management practice and coupled with hybrid Super-48 can bring forth better growth and higher seed & oil yield and also resulted in higher economic return.

## 7. References


Anonymous, 2007. Agricultural Research Data Book. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi.

Bhagat, G.J., Hamid, A., Bonde, S.P., Giri, M.D., Sajidi, M., 2005. Yield quality concentration, uptake and availability of N, phosphorus and sulfur of sunflower (*Helianthus annuus* L.) as influenced by irrigation and sulphur levels. Crop Research 30(1), 30–36.

Damodaram, T., Hegde, D.M., 2000. In Oilseeds situation: A Statistical Compendium, Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh.

Dev, C.M., Sarawagi, S.K., 2004. Balance sheet of nitrogen, phosphorous and Journal of Biotechnology 10(22), 4591–4595.

Goksoy, A.T., Demir, A.O., Toran, Z.M., Daughu, N., 2004. Responses of sunflower to potassium at different growth stages. Field Crop Research 87(3), 167–178.

Karthikeyan, K., Shukla, L.M., 2008. Effect of boron and sulphur inter action on their uptake and quality parameters of mustard and sunflower. Journal of Indian Society of Soil Science 56, 225–230

Kaya, M.D., Kolsarici, O., 2011. Seedyield and oilcontent of some sunflower (*Helianthus annuus* L.) hybrids irrigated at different growthstages. African Journal of Biotechnology 10(22), 4591–4595.

Khan, S.U., Khan, A., Gurmani, A.R., Din, J.U., 2013. Oil yield, fatty acid profile, achene yield and yield attributes of sunflower (*Helianthus annuus* L.) as influenced by autumn planting conditions in Islamabad Pakistan Journal of Botany 45(S1), 107–110.

Kumar, P., Thenua, O.V.S., 2012. Effect of sulphur on growth and yield of sunflower (*Helianthus annuus* L.) and black gram (*Phaseolus mungo* L.) in intercropping system. Annals of Agricultural Research 33(3), 102–108.

Messick, D.L., 2003. Sulphur fertilizers: A global perspective. In: Sarkar, M.C., Biswas, B.C., Das, S., Kalwe, S.P., Maity, S.K. (Eds.), Proceedings of TSI-FAI-IFA workshop on Sulphur Balanced Fertilization, 17.

Morris, R.J., 2006. Sulphur in agriculture: international perspective, In: Proceedings of TSI-FAI-IFA Symposium-cum Workshop on Sulphur in Balanced Fertilization, held at New Delhi, India, 1–8.

Poonia, K.L., 2000. Effect of planting geometry, nitrogen and sulfur on growth and yield of sunflower (*Helianthus annuus* L.). Journal of EcoPhysiology 3, 59–71

Radford, P.J., 1967. Growth analysis formulae-their use and abuse. Crop Sciences 7(1), 171–175.

Rasool, F.U., Hasan, B., Jahangir, I.A., Ali, T., Mubarak, T., 2013. Nutritional yield and economic responses of sunflower (*Helianthus annuus* L.) to integrated levels of nitrogen, sulphur and farmyard manure. The Journal of Agricultural Sciences 8(1), 18–27.

Reddy, S.S.,Yadahalli, Y.H., Kumara,V.K.K., Boraiah, B., 2002. Effect of fertilizer, gypsum and boron on growth, yield and nutrient uptake in sunflower hybrids. Crop Research 3(2), 353–358.

Sakal, R., Singh, A.P., Choudhary, B.C., Shahi, B., 2001. Sulphur status of Udifluvents and response of crops to sulphur application, Fertilizer News 46(10), 61–65.

Sarkar, R.K., Mallik, R.V., 2009. Effect of nitrogen, sulphur and foliar spray of nitrate salts on performance of sunflower (*Helianthus annuus* L.). Indian Journal of Agricultural Sciences 79(12), 986–990.

Shekhawat, K., Shivay, Y.S., 2008. Effect of nitrogen sources, sulphur and boron levels on productivity, nutrient uptake and quality of sunflower (*Helianthus annus* L.*)*. Indian Journal of Agronomy.

Sheoran, P., Sardana, V., Singh, R., 2014. Evaluating productivity potential of spring planted sunflower (*Helianthus annuus* L.) hybrids in response to sowing time under changing climate scenario. Indian Journal of Agronomy 59(1), 124–132.

Silva, C.A.T., Cagol, A., Silva, T.R.B., Noberga, L.H.P., 2011. Boron application before sowing of sunflower hybrid. Journal of Food and Agriculture Environment 9, 582–583.

Stoyanov, D.V., 1975. Interaction of K and B in light pseudopodzolic and ciunamonic forest soils. *Rastenievduinavki* 2, 64–70.

SubbaRao, N.S., 1993. Bio-fertilizers in Agriculture and Forestry. 3rd Edition. Oxford and IBM Publishing Company, Oxford.

Vijaya, K.M., Selvaraju, R., 2001. Effect of plant population and split application of nitrogen on growth and grain yield of sunflower under rainfed condition. Mysore Journal of Agriculture Sciences 35(4), 307–12.

Yadav, R.L., Dwivedi, B.S., Shukla, A.K., Kumar, V., 2000. Sulphur in balanced fertilization in alluvial soils of western Uttar Pradesh. In: Proceedings of TSI-FAI-IFA Workshop on Sulphur in Balanced Fertilization, held at New Delhi, 27–41.

Watson, J.D., 1947. Comparative Physiological Studies in the Growth of Field Crops. I. Variation in net assimilation rate and leaf area between species and varieties and within and between years. Annals of Botany 11, 41–76.