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Effect of Micronutrients on Incidence, Damage Severity of Sucking Insect Pests of Sunflower and its Impact on Yield and other Arthropods

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in a field on $23^0$74/N latitude and $90^0$35/E longitude at the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from November 2021 to April 2022. The experiment of eight treatments as follows: T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses (RD) of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+

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$ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = RD of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= RD of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= RD of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water; T_5 RD of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180 gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 8 treatments and 3 replications. The overall result indicates that the combination of different micronutrients decreased the incidence of sucking insect pests of sunflower and increased the abundance of beneficial arthropods compared to T_8 treatment. In T_1 treatment, the lowest leaf infestation percentage caused by aphid 17.49 and 19.50 %; Jassid 14.19 and 14.89 % and White fly 26.18 and 30.83 % at the vegetative and reproductive stages respectively. The highest number of beneficial arthropods per plot of lady bird beetle both adults and grubs ((3.63 and 5.53 respectively); honey bee (22.36), ant (3.55), spider (1.42) was also recorded in T_1 treatment. The highest yield contributing characters of sunflower, the highest of head/ capitulam diameter (9.75cm), height of plant per plot (179.73 cm), leaf width (14.24 cm), leaf length (21.05 cm), area of leaves per plant (62.29 cm) and number of leaf per plant (21.93), number of total head per plot (29.83), number of seed per head (725.56), weight of single seed (1.03 mg), and weight of seed per head (54.96 gm) of sunflower were observed in T_1 treatment which was statistically different from among all other treatments. The highest sunflower yield (1.92 kg /plot) and oil content (0.93 liter/2kg and 46.5%) were also observed from T_1 treatment. Among the different micronutrient treatment combinations, different micronutrients using in T_1 treatment were more effective for the reducing the incidence of sucking insect pests on sunflower. In the term of effect of micronutrients, T_1= Recommended doses of Urea, TSP and MoP + Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot; was an eco-friendly pest management practice for sunflower by which one can significantly reduce pest infestation without use of any chemical insecticides.

Keywords: Micronutrients; incidence; damage severity; sucking insect pests of sunflower; yield and other arthropods.

1. INTRODUCTION

"Sunflower (*Helianthus annuus* L., Family: Compositae) is one of the four most important cholesterol free edible oils annual crops in the world which contains 39 to 49 per cent oil in the seed. It does not contain harmful erucic acid but possesses linoleic acid which is beneficial to humen health" [1]. "It is an essential element of butter and margarine. The linoleic acid obtained from sunflower oil shows anti-carcinogenic effects" [2]. "Oilseed crops contribute much more to our national economy. Among the oilseeds, sunflower (*Helianthus annus* L.) commonly known as 'Surajmukhi' is one of the potential oil yielding crops gaining popularity. Over 150 phytophagous insect species have been reported from cultivated and native sunflower. However, only a few insect species have adapted to cultivated sunflower and have become economic pests" [3]. The key insect pests attacking the sunflower capitulum borer (*Helicoverpa armigera* Hubner), green semilooper (*Thysanoplusia orichalcea* Fab.), Bihar hairy caterpillar (*Spilosoma = Spilarctia obliqua* Walker), tobacco caterpillar, *Spodoptera litura* Fab., cabbage semilooper (*Trichoplusia ni* Hubner), cutworm (*Agrotis* spp.) and leafhopper (*Amrasca biguttula biguttula* Ishida), aphids (*Aphis spp*), white flies (*Bemicia tabaci*) and hemipteran stink bug, *Nezara viridula* (L.) are of major economic importance" [4-7] Marin 1992; Reddy et al. 1991). "Rape and mustard oil seed crops are the most important sources of vegetable oil grown during the winter season. The activities of insect pests (aphids, leaf miner, leaf folder), predator (ladybird beetles, Syrphids), and parasitoids (*Diaretialla, Aponteles*) were recorded on mustard from sowing till maturity of the crop" [8]. "Insect pollinators also play a vital role in crop plant" [9,10]. "Many insect species are seen as active pollinators on flowers of plants" [11]. Environmental factors also play a vital role in the biodiversity of insect pests in a particular agroecosystems Aheer et al. [12], there are numerous factors which affect the speedy increase and decrease of insects population. Both the physical and biological factors are much vital causing the variations in the densities of insect's aphid population. "Application of micronutrients plays a major role in increasing seed setting percentage and influence on growth and yield" [13]. "There are positive effects of micronutrient application on the growth of sunflower, in terms of plant height, number of leaves and dry matter production per plant" [14].

"The heads consist of many individual flowers which mature in to seeds on are ceptacle base" [15]. "Boron, as a foliar spray has been found to increase thousand seed weight and seed oil content [16].

In Bangladesh Sunflower has been newly introduced as an oil seed crops. "Sunflower is primarily a winter plant but nowadays it is available also in summer. They are grown in homestead and farmer's field for oil production purposes as well as in larger plots for commercial purpose" (Umar et al. 2013). "In Bangladesh, per unit area of Sunflower production is comparatively the low with the other countries. However, low yield may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties, delayed sowing, fertilizer management, disease and insect infestation and improper or limited irrigation facilities. A major and common one is the high incidence of insect pests and management practices. Sunflowers are infested with various insect pest rights from the primordial stages of the crop to harvesting of the product. The main pests of sunflower are controlled by different cultural and biological methods but the growers in Bangladesh often use chemical insecticides" [17]. In Bangladesh farmers solely rely on chemical pesticides for the control of these obnoxious insect pests but they often fail, and in most cases, the use of these chemicals results to environmental damage. The application of insecticides, however, can cause several problems such as development of insecticide resistance pest insects, induction of resurgence of target pests, outbreak of secondary pests and undesirable effect on non-target organisms as well as serious environment pollution.

Considering the hazardous impact of high level chemical pesticides on non-target organism as well as environment this study was undertaken to assess the efficacy of different micronutrients in controlling of insect pest and an eco-friendly and sustainable pest management system in Sunflower so that farmers can get satisfactory yield and consumers can get non-toxic fresh oil.

2. MATERIALS AND METHODS

The experiment was carried out at the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka, Bangladesh from November 2021 to April 2022. The Sunflower Mayabi (hybrid) variety was selected for the experiment. The seeds were soaked in water for 12 hours before sowing in the experimental field. This was to ensure rapid and uniform germination. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 8 treatments and 3 replications. The field with good tilth was divided into 3 blocks. Each block was sub-divided into 8 sub plots, each measuring 3.5m × 4.0 m. The distance between plots was 1.0 m and between rows was 0.5m and between plants was 30 cm. Each treatment was allocated randomly within the block and replicated three times. Manures and fertilizers were applied as per recommended doses (DAE, 2019)]. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. The total amount of cow dung, Urea, TSP and MP was applied as basal dose at the time of land preparation. Urea was applied in three installments. Half of urea was applied at the time of land preparation as a first installment. Rest of urea was divided into two parts, first part was applied at 20-25 days after seedling (DAS) and second part was applied at 40-45 DAS (before flower blooming) with proper intercultural practices, gap filling and earthling up soil around base of the plant. The eight treatments for reducing several sucking insect pests were,T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control. The data were recorded in the field for the evaluation of efficiency performance of different micronutrients on infestation level of insect pest complex of sunflower, and others yield contributing characters of plant as well as impact of these management practices on the population of pollinators such as honey bee, bumble bee, predatory ladybird beetle, and other arthropods through direct visual counts from the sunflower field. The sunflower was harvested at 105 DAS when all plants were fully matured and ripped. The yield of each treatment was recorded separately. The seed were dried, cleaned and

weighed for eachplot. The weight was adjusted to 12% moisture content. The recorded data included Number of Whitefly, Aphid and Jassid after applying different treatments; Leaf infestation and reduction status of whitefly, aphid and Jassid; Number of healthy leaves per plants; Number of healthy petal, calyx per plants; Number of healthy and infested head (capitulam) per plot; diameters and width of head; soil pH; Chlorophyll content of sunflower as measured by Portable SPADO meter; Number of seeds per head; Number of seed; Weight of single seed; Weight total seeds per head; Yield per plot; Yield per hectare; Increase percentage of yield over control and Percentage of oil contained in seeds.. Statistical analysis of data was done with the help of computer software Statistics 10.

3. RESULTS AND DISCUSSION

The research was conducted to study the effect of micronutrients on incidence, damage severity of insect pests of sunflower and its impact on yield and other arthropods during the study period different sucking insect pest population per plot were observed at 15 days interval with clean observation.

Data revealed that for different treatment practices abundance of different insect pests varied significantly under the present trial.

3.1 Incidence of Jassid at the different days after seedling (DAS) of Sunflower

3.1.1 At the 22 Days After Seedling (DAS)

Number of Jassid at 22 DAS showed statistically significant differences due to different doses of micronutrients (Table 1). The highest number of Jassid per plant (5.04) was recorded in T_8 (untreated control) treatment which was statistically different from the rest of treatment. This was followed by T_7 (2.84) and T_6 (2.68) treatments respectively. The lowest number of Jassid per plant (1.88) was found inT_1 treatment, which was statistically similar to T_5 (2.12), followed by T_2 treatment (2.40). As a result, the trend of order of effectiveness of the treatments applied against jassid per plant at the different days after seedling (DAS) of sunflower including untreated control in terms of reducing number was (T_1> T_5>T_2> T_4>T_3> T_6> T_7> T_8).

3.1.2 At 37, 52, 67 and 82 Days After Seedling (DAS)

Similar trends in the number of Jassid at 37, 52, 67 and 82 DAS of sunflower was observed. The highest percentage of reduction over control (68.51) was obtained in T_1 treatment, which was followed by T_2 (63.39) treatment and T_5 (62.30) treatment, which were statistically similar. On the other hand, the lowest percentage of reduction over control was obtained from T_4 (44.33) treatment which was followed by T_7 (53.21) treatment.

3.2 Incidence of Aphid at the Different Days after Seedling (DAS) of Sunflower

3.2.1 At the 22 Days After Seedling (DAS)

Number of Aphid at the different days after seedling (DAS) of Sunflower showed statistically significant differences due to different doses of micronutrients as treatments in aphid (Table 2). The highest number of aphid per plant (2.92) was recorded from T_8 treatment which was statistically different from the rest of the treatment. This was followed by T_7 (2.40), whereas the lowest number of aphid per plant (1.77) was found from T_1 treatment, which was statistically similar to T_5 (1.81) followed by (1.95, 1.99, 2.00 and 2.13 respectively) T_2, T_4, T_3, and T_6 treatments respectively. As a result, the trend of order of effectiveness of the treatments applied against aphid per plant at the different days after seedling (DAS) of sunflower including untreated control in terms of reducing number was (T_1>T_5>T_2> T_4> T_3> T_6> T_7>T_8).

3.2.2 At the 37, 52, 67 and 82 Days After Seedling (DAS)

Similar trends in the number of Aphid at 37, 52, 67 and 82 DAS of sunflower was observed. The highest percentage of reduction over control (67.66) was obtained in T_1 treatment which was closely followed by T_5 (65.16) treatment and they were statistically similar. On the other hand, the lowest percentage of reduction over control was obtained from T_6 (60.86) treatment which was followed by T_7 (61.80) treatment.

3.3 Incidence of White Flies at the Different Days after Seedling (DAS) of Sunflower

3.3.1 At the 22 Days After Seedling (DAS)

Number of white fly at the different days after seedling (DAS) of Sunflower showed statistically significant differences due to different doses of micronutrients as treatment in white fly (Table 3). The highest number of white fly per plant (3.20)

was recorded from T_8 (untreated control) treatment which was statistically different from the rest of the treatment. This was closely followed by T_3 (2.58), T_7 (2.02) and T_6 (1.96) treatments respectively, whereas the lowest number of white fly per plant (1.13) was found from T_1 treatment which was statistically similar to T_5 (1.37) followed by (1.33 and 1.82) T_2, and T_4 treatments respectively. As a result, the trend of order of effectiveness of the treatments applied against white fly per plant at the different days after seedling (DAS) of sunflower including untreated control in terms of reducing number was **(**T_1>T_5>T_2> T_4> T_3> T_6> T_7> T_8). Similar result was also observed by Nayak et al. [18] and Geetha and Hegde [19].

3.3.2 At 36, 48, 62, and 76 Days After Seedling (DAS)

From Table 3, it was observed that, more or less similar trends of results also observed that in terms of number of white fly at the different days after seedling (DAS) such as 36 DAS, 48 DAS, 62 DAS and 76 DAS of sunflower per plant. However, the highest percentage of reduction over control (73.31) was obtained from T5 treatment which was closely followed by T1

Table 1. Effect of micronutrients on the a incidence of Jassid at the different days after seedling (DAS) of Sunflower

Treatments	Number of Jassid at the Different Days after Seedling (DAS)/ Plant						
	22 DAS	37 DAS	52 DAS	67 DAS	82 DAS	Mean	Reduction Over Control
T_1	1.88 d	4.39 cd	4.76 c	5.07 d	6.96 h	4.61 f	68.51
T_2	2.40 b-d	3.89 d	6.13 c	6.56 cd	7.85 g	5.36 e	63.39
T_3	2.63 bc	4.54 cd	5.47 c	8.09 c	9.89 d	6.12 d	58.20
T_4	2.52 bc	5.97 b	8.25 b	11.14 b	12.86 b	8.15 b	44.33
T_5	2.12 cd	4.20 d	5.24 c	7.17 cd	8.88 e	5.52 de	62.30
T_6	2.68 bc	4.64 cd	5.81 c	6.44 cd	8.21 f	5.56 de	62.02
T_7	2.84 b	5.14 bc	6.30 bc	9.13 bc	10.87 c	6.85 c	53.21
T_8	5.04 a	9.34 a	12.83 a	21.56 a	24.42 a	14.64 a	--
$LSD_{(0.05)}$	**0.61**	**0.93**	**2.01**	**2.74**	**0.76**	**0.68**	**--**
CV (%)	**12.56**	**10.04**	**16.70**	**16.63**	**11.54**	**5.49**	**--**

Table 2. Effect of micronutrients on the incidence of aphid at the different days after seedling (DAS) of Sunflower

Treatments	Number of Aphid at the Different Days after Seedling (DAS)/ Plant						
	22 DAS	37 DAS	52DAS	67 DAS	82 DAS	Mean	Reduction Over Control
T_1	1.77 c	3.33 b	4.59 c	4.48 d	5.17 c	4.14 e	67.66
T_2	1.95 bc	3.75 b	4.79 bc	5.47 b-d	6.50 bc	4.54 c-e	64.53
T_3	2.00 bc	3.78 b	5.23 bc	6.63 bc	6.76 b	4.85 b-d	62.11
T_4	1.99 bc	3.77 b	4.90 bc	6.46 bc	6.55 bc	4.69 b-d	63.36
T_5	1.81 c	3.45 b	4.76bc	5.35 cd	6.06 bc	4.46 de	65.16
T_6	2.13 bc	4.34 b	5.28 bc	6.90 b	6.70 b	4.89 bc	60.86
T_7	2.40 ab	4.22 b	5.50 b	6.54 bc	7.45 b	5.01 b	61.80
T_8	2.92 a	9.17 a	10.80 a	15.13 a	25.94 a	12.80 a	--
$LSD_{(0.05)}$	**0.55**	**1.18**	**0.80**	**1.44**	**1.42**	**0.43**	**--**
CV (%)	**14.84**	**15.07**	**7.98**	**11.57**	**9.10**	**4.27**	**--**

In a column, numeric value represents the mean of 3 replications; each replication is derived from 10 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability
[T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

Table 3. Effect of micronutrients on the incidence of white fly at the different Days After Seedling (DAS) of Sunflower

Treatments	Number of White Flyat the Different Days after Seedling (DAS)/ Plant						
	22 DAS	36 DAS	48 DAS	62 DAS	76 DAS	Mean	Reduction Over Control
T_1	1.13 e	3.00 cd	1.47 f	3.33 c-e	3.33 d	2.57 cd	69.51
T_2	1.33d	2.47 d	2.88 de	3.11 ef	3.49 d	2.72 b-d	67.73
T_3	2.58 b	3.21 bc	3.56 b	4.11 b	4.43 bc	3.59 b	57.41
T_4	1.82 cd	3.24 b	3.55 b	3.78 bc	4.45 bc	3.41 bc	59.55
T_5	1.37 d	1.59 e	1.85 ef	2.91 f	3.41d	2.25 d	73.31
T_6	1.96 bc	2.61d	3.12 cd	3.41 cd	3.77 cd	2.96 b-d	64.89
T_7	2.02 bc	2.55 d	2.84 de	3.74 cd	4.73 b	3.09 b-d	63.35
T_8	3.20 a	7.25 a	8.53 a	11.67 a	12.78 a	8.43 a	--
$LSD_{(0.05)}$	**0.63**	**0.45**	**0.79**	**0.61**	**0.85**	**0.92**	**--**
CV (%)	**4.37**	**9.22**	**11.03**	**6.81**	**9.59**	**4.52**	**--**

Table 4. Effect of micronutrients on the abundance of Mealybug at the different days after seedling (DAS) of Sunflower

Treatments	Number of Mealybug at the Different Days after Seedling (DAS)/ Plant						
	35 DAS	45 DAS	55 DAS	65 DAS	75 DAS	Mean	Reduction Over Control
T_1	00 d	00 d	00 e	0.45 e	1.33 f	0.36 e	94.59
T_2	00 d	0.88 c	1.07 c	1.17 cd	1.96 d-f	1.02 cd	84.66
T_3	1.00 c	1.00 bc	1.98 b	2.34 b	4.76 b	2.22 b	66.62
T_4	1.00 c	1.00 bc	1.23 c	1.45 c	2.84 cd	1.50 c	77.44
T_5	00 d	00 d	0.52 d	0.73 de	1.77 ef	0.60 de	90.98
T_6	1.00 c	1.02 bc	1.12 c	1.25 cd	2.54 c-e	1.39 c	79.10
T_7	1.47 b	1.52 b	1.87 b	2.11 b	3.21 c	2.04 b	69.32
T_8	3.78 a	3.02 a	6.57 a	9.92 a	9.98 a	6.65 a	--
$LSD_{(0.05)}$	**0.36**	**0.61**	**0.36**	**0.66**	**0.93**	**0.51**	**--**
CV (%)	**9.91**	**12.96**	**11.33**	**5.42**	**7.05**	**8.68**	**--**

In a column, numeric value represents the mean of 3 replications; each replication is derived from 10 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability [T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

(69.51) treatment and T_2 (67.73) treatment, which were statistically similar. On the other hand, the lowest percentage of reduction over control was obtained from T_3 (57.41) treatment, this was followed by T_4 (59.55) treatment.

3.4 Incidence of Mealybug at the Different Days After Seedling (DAS) of Sunflower

3.4.1 At the 35 Days After Seedling (DAS)

Number of Mealybug at the different days after seedling (DAS) of Sunflower per plant during study period showed statistically significant differences due to different doses of micronutrients as treatments in Mealybug (Table 4) at 35 DAS. The highest number of Mealybug per plant (3.78) was recorded from T_8 (untreated control) treatment which was statistically different from the rest of the treatment and followed by T_7 (1.47), whereas the lowest number of Mealybug per plant (1.00) was found from T_3, T_4 and T_6 treatments respectively. There is no Mealybug per plant (0.00) was found in T_1, T_2 and T_5 treatments respectively. As a result, the trend of order of effectiveness of the treatments applied against Mealybug per plant at the different days after seedling (DAS) of

sunflower including untreated control in terms of reducing number was (T_1= T_5=T_2> T_3 = T_4=T_6> T_7> T_8).

3.4.2 At the 45, 55, 65 and 75 Days After Seedling (DAS)

From Table 4, it was observed that, more or less similar trends of results also observed in terms of number of Mealybug at the different days after seedling (DAS) such as 45 DAS, 55 DAS, 65 DAS and 75 DAS of sunflower. Overall, the highest percentage of reduction over control (94.59) was obtained from T_1 treatment. This was followed by T_5 (90.98) treatment. On the other hand, the lowest percentage of reduction over control was obtained from T_3 (66.62) treatment, which was followed by T_7 (69.82) treatment.

3.5 Abundance of Beneficial Insect

During the study period beneficial insect populations in each plot were observed at 7 days interval with clean observation and lady bird beetle, Honey Bee, black ants and Spider was counted. Data revealed that for different micronutrients practices abundance of beneficial insects varied significantly under the present trial.

3.5.1 Lady bird beetle

The highest number of adults and grubs (3.63 and 5.53 respectively) was recorded in T_7 treatment which was statistically similar (5.12) to T_1 treatment, incase of grubs. This was followed (2.83) by T_1 treatment of adult lady bird beetle; while the lowest number of lady bird beetle (1.58) was found from T_6 treatment which was followed (1.73) by T_4 treatment (Fig. 1).

3.5.2 Honey Bee

The highest number of adults honey Bee (22.36) was recorded in T_1 treatment which was statistically similar (21.52) to T_5 treatment and followed by T_7 and T_4 treatments (19.57 and 18.37) respectively, while the lowest number of honey Bee (12.20) was found in T_8 treatment which was followed by T_6 (14.28) treatment in (Fig. 1).

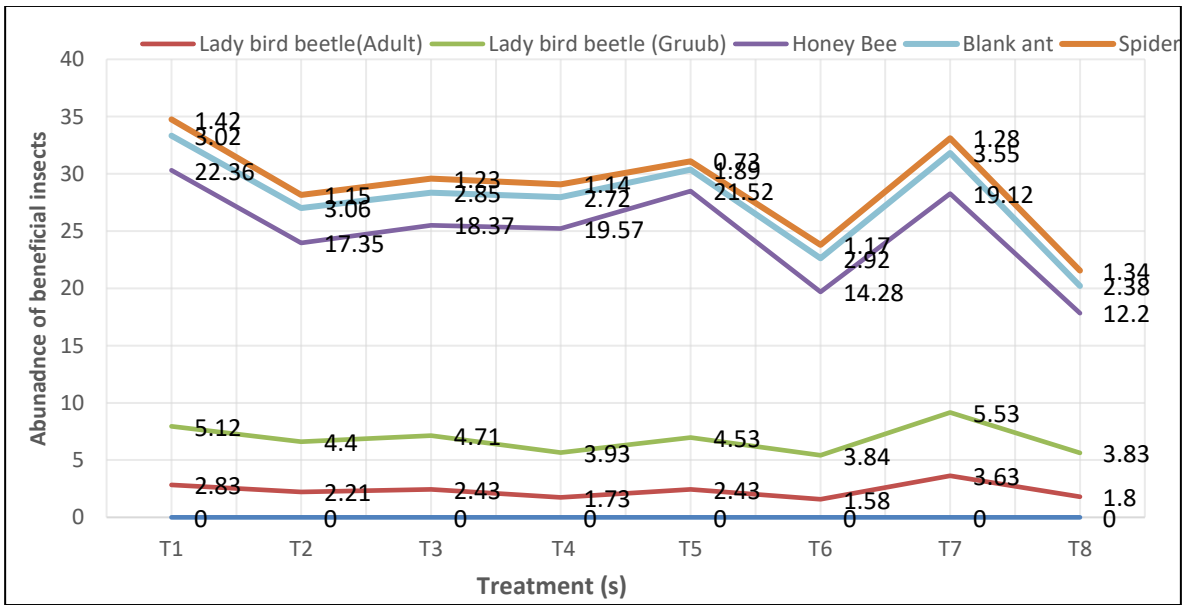

Fig. 1. Efficacy of micronutrients on the abundance of beneficial insects of Sunflower during study period

[T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

3.5.3 Blank ant

The highest number of adults blank ant (3.55) was recorded in T_7 treatment which was closely followed by T_1, and T_2 treatments (3.02 and 3.06 respectively); while the lowest number of blank ant (1.89) was found in T_6 treatment which was followed by T_8 (2.38) treatment in (Fig. 1).

3.5.4 Spider

The highest number of spider (1.42) was recorded in T_6 treatment which was statistically similar to T_3, T_7 and T_8 treatments (1.23, 1.28, and 1.34 respectively) in Fig. 1.

3.6 Infestation Status

During the study period number of healthy and infested leaves for different insect pests of 10 selected plants /plot was observed at 7 days interval. This was then converted into per plant as healthy and infested leaves and % of infestation and infestation reduction over control was estimated. Data revealed that healthy and infested leaves and infestation over control by different insect pest showed statistically significant variation due to different management practices.

3.6.1 Damage severity of leaves at the different growing stages of sunflower by aphid

At the vegetative stage, number of healthy leaves, infested leaves and percent leaf infestation of sunflower by aphid showed statistically significant differences due to different management practices (Table 5).

In case of percentage of infestation, the lowest infestation of leaves/plant (17.49 %) was recorded in T_1 treatment which was statistically different from all other treatments. While the highest infestation (48.00%) was recorded in T_8 treatment which was followed by T_7 and T_6 treatments (29.18 % and 27.43 %) respectively in Table 5. It was also observed that the highest percentage of reduction over control (63.56%) was recorded in T_1 treatment, which was followed (53.79%) by T_2 treatment, while the lowest percentage of reduction over control (39.21%) was recorded in T_7 treatment for aphid.

As a result of different management practices, the trend in the order of effectiveness of the micronutrients applied against aphid per plot including untreated control in terms of reducing number was T_1> T_2>T_4> T_2> T_6> T_7> T_3>> T_8.

Table 5. Efficacy of micronutrients on the percent leaf infestation and reduction over control due to insect pests of Aphid at the vegetative and reproductive stages of Sunflower

Treatments	At the Vegetative Stage		At the Reproductive Stage	
	% of Infestation	Reduction Over Control	% of Infestation	Reduction Over Control
T_1	17.49 d	63.56	19.50 d	57.69
T_2	22.18 c	53.79	23.44 c	49.14
T_3	29.69 b	38.15	29.78 b	35.39
T_4	22.30 c	53.54	24.91 c	45.95
T_5	22.33 c	53.48	23.40 c	49.23
T_6	27.43 b	42.85	28.85 b	37.41
T_7	29.18 b	39.21	28.82 b	37.47
T_8	48.00 a	--	46.09 a	--
$LSD_{(0.05)}$	**2.38**	**--**	**2.75**	**--**
CV (%)	**8.48**	**--**	**7.05**	**--**

In a column, numeric value represents the mean of 3 replications; each replication is derived from 10 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability [T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

At the reproductive stage, the lowest infestation of leaves/plant (19.50%) was recorded in T_1 treatment which was statistically different from all other treatments; While the highest infestation (46.09%) was recorded in T_8 treatment which was followed by T_6 and T_7 treatments (28.85 % and 28.82%) respectively (Table 5). It was also observed that the highest percentage of reduction over control (57.69%) was recorded in T_1 treatment, which was followed (49.23%) by T_5treatment, while the lowest percentage of reduction over control (37.41%) was recorded in T_7 treatment for aphid throughout the study period in sunflower field. As a result of different management practices, the trend in the order of effectiveness of the micronutrients applied against aphid per plot including untreated control in terms of reducing number was T_1> T_5>T_2>T_4> T_6> T_7 > T_3> T_8.

3.6.2 Damage severity of leaves at the different growing stages of sunflower by Jassid

At the vegetative stage, number of healthy leaves, infested leaves and percent leaf infestation of sunflower by jassid showed statistically significant differences due to different management practices (Table 6). The lowest infestation of leaves/plant (14.19%) was recorded in T_1 treatment which was statistically different from all other treatments. While the highest infestation (39.62%) was recorded in T_8 treatment which was followed by T_4 and T_7 (26.34% and 25.25%) treatments respectively (Table 6). it was also observed that the highest percentage of reduction over control (64.18%) was recorded in T_1 treatment, which was followed (55.15%) by T_2 treatment, while the lowest percentage of reduction over control (33.52%) was recorded in T_4 treatment for jassid throughout the study period in sunflower field. As a result, of different management practices, the trend in the order of effectiveness of the micronutrients applied against Jassid per plot including untreated control in terms of reducing number was T_1 > T_2 >T_3>T_5> T_6> T_7 > T_4> T_8.

At the reproductive stage, the lowest infestation of leaves/plant (14.89%) was recorded in T_1 treatment which was statistically different from all other treatments and the highest infestation (42.43%) was recorded in T_8 treatment which was statistically difference from all other treatments (Table 6). It was also observed that the highest percentage of reduction over control (64.91%) was recorded in T_1 treatment, which was closely followed (55.17%) by T_5 treatment, while the lowest percentage of reduction over control (42.71%) was recorded in T_7 treatment for Jassid. As a result of different management practices, the trend in the order of effectiveness of the micronutrients applied against jassid per plot including untreated control in terms of reducing number was T_1>T_5>T_2> T_3>T_6> T_4> T_7> T_8.

Similar findings were also reported by Shamimuzzaman [20] and Faisal et al [21].

3.6.3 Damage severity of leaves at the different growing stages of sunflower by white fly

At the vegetative stage, number of healthy leaves, infested leaves and percent leaf infestation of sunflower by white fly showed statistically significant differences due to different management practices (Table 7). Percentage of infestation due to white fly, the lowest infestation of leaves/plant (26.18%) was recorded in T_1 treatment which was statistically different from all other treatments and the highest infestation (56.54%) was recorded in T_8 treatment which was followed by T_7 and T_3 treatments (37.39 % and 36.42 %) respectively. it was also observed that the highest percentage of reduction over control was recorded in T_1 treatment (53.70%), which was closely followed by T_6 treatment (46.96%), while the lowest percentage of reduction over control was recorded in T_7 treatment (33.87%) for white fly throughout the study period in sunflower field. As a result different management practices, the trend in the order of effectiveness of the micronutrients applied against white fly per plot including untreated control in terms of reducing number was T_1> T_6>T_5> T_2> T_4> T_3> T_7> T_8.

At the reproductive stage, the lowest infestation of leaves/plant (30.83%) was recorded in T_1 treatment which was statistically different from all other treatments and the highest infestation (60.47%) was recorded in T_8 treatment which was statistically difference from all other treatments in Table 9. It was also observed that the highest percentage of reduction over control was recorded in T_1 treatment (57.69%), which was closely followed (49.02%) by T_1 treatment, while the lowest percentage of reduction over control was recorded in T_3 (30.38%) treatment for white fly throughout the study period in sunflower field. As a result different management practices, the trend in the order of effectiveness of the

micronutrients applied against white fly per plot including untreated control in terms of reducing number was (T_1< T_5<T_2< T_6< T_4< T_7< T_3< T_8).

3.7 Effect of Micronutrients on the Soil pH and Yield Attributes of Sunflower

3.7.1 Soil pH

Significant variations were observed among the yield attributes of sunflower (Table 8). The lowest soil pH was recorded in T_1 (5.80) treatment which was statistically identical from all other treatments.

3.7.2 Chlorophyll content of sunflower

Chlorophyll content varied significantly with increasing amount of different level of micronutrients application of sunflower (Table 8). The maximum chlorophyll content (46.42 %) was recorded from T_3 treatment which was statistically identical to T_5 (41.15 %) treatment, while the minimum chlorophyll content (35.64 %) was obtained from T_8 (control) treatment.

3.7.3 Area of leaves and capitulam diameter

The highest area of leaves and capitulam diameter per plant of sunflower was observed in of T_1 (62.29 cm and 9.75cm) treatment, which is significantly different from all other treatments. On the other hand, the lowest were observed in case of T_8 (57.04 cm and 8.79 cm respectively) treatment (Table 8).

This results are in conformity with Saad and Al-Doori [22], Raghu et al*.* [23] and Sepehr et al*.* [24].

3.7.4 Diameter of flower with petal

Diameter of flower with petal varied significantly with increasing amount of different level of micronutrients application of sunflower (Table 9). The maximum diameter of flower with petal (22.23 cm) was recorded from T_1 treatment which was statistically identical to T_2, T_5, T_4 and T_6 (21.52, 21.49, 20.98 and 20.63 cm) treatment, while the minimum diameter of flower with petal (19.30 cm) was obtained from T_8 (control) treatment. This results conform to the findings of Asad et al*.* [25,26] who also reported that sunflower growing on boron deficient soils responds to B application by increasing both vegetative and reproductive mass and B concentration in several parts of the plant shoot.

3.8 Seed Related Yield Attributes, Yield and Percentage of Oil Content

Significant variations were observed among yield contributing characters of sunflower in terms of number of seed per head and weight of seed per head of sunflower (Table 9).

Table 6. Efficacy of micronutrients on the percent leaf infestation and reduction over control due to insect pests of Jassid at the vegetative and reproductive stage of Sunflower

Treatments	At the Vegetative Stage		At the Reproductive Stage	
	% of Infestation	Reduction Over Control	% of Infestation	Reduction Over Control
T_1	14.19 d	64.18	14.89 e	64.91
T_2	17.77 cd	55.15	19.35 d	54.40
T_3	18.41 c	53.53	20.35 cd	52.04
T_4	26.34 b	33.52	25.33 b	40.30
T_5	19.27 c	51.36	19.02 d	55.17
T_6	23.19 b	41.47	23.80 bc	43.91
T_7	25.25 b	36.27	24.31 b	42.71
T_8	39.62 a	--	42.43 a	--
$LSD_{(0.05)}$	**3.69**	**--**	**3.62**	**--**
CV (%)	**9.16**	**--**	**8.73**	**--**

In a column, numeric value represents the mean of 3 replications; each replication is derived from 10 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability

[T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

Table 7. Efficacy of micronutrients on the percent leaf infestation and reduction over control due to insect pests of White fly at the vegetative and reproductive stage of Sunflower

Treatments	At the Vegetative Stage		At the Reproductive Stage	
	% of Infestation	Reduction Over Control	% of Infestation	Reduction Over Control
T_1	26.18 e	53.70	30.83 e	49.02
T_2	31.23 b-e	44.76	37.62 cd	37.79
T_3	36.42 bc	35.59	42.48 b	29.75
T_4	35.09 b-d	37.94	40.80 bc	32.53
T_5	30.73 c-e	45.65	36.51 d	39.62
T_6	29.99 de	46.96	37.70 cd	37.66
T_7	37.39 b	33.87	42.10 b	30.38
T_8	56.54 a	--	60.47 a	--
$LSD_{(0.05)}$	**6.19**	**--**	**3.30**	**--**
CV (%)	**9.98**	**--**	**4.59**	**--**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

Table 8. Effect of micronutrients on the Soil P^H and Yield contributing characters in terms of Chlorophyll content (%), Leaf area plant^{-1}, Head/capitulam diameter, Diameter of flower with petal of Sunflower

Treatments	Yield Contributing Characters				
	Soil P^H	Chlorophyll Content (%)	Leaf Area Plant^{-1} of Sunflower (cm)	Head/ Capitulam Diameter (cm)	Diameter of Flower with Petal
T_1	5.80 b	41.14 a	62.29 a	9.75 a	22.23 a
T_2	6.42 a	39.89 a	62.27 a	9.74 a	21.52 ab
T_3	6.22 ab	46.42 a	61.47 a	9.33 a	20.13 ab
T_4	6.42 a	38.79 a	60.35 a	9.63 a	20.98 ab
T_5	6.39 a	45.57 a	59.80 a	9.25 a	21.49 ab
T_6	6.58 a	38.27 a	58.64 a	9.44 a	20.63 ab
T_7	6.53 a	35.77 a	61.11 a	8.97 a	20.01 ab
T_8	6.52 a	35.64 a	57.04 a	8.79 a	19.30 b
$LSD_{(0.05)}$	**0.47**	**11.33**	**11.77**	**1.60**	**2.44**
CV (%)	**4.26**	**12.10**	**11.14**	**6.71**	**6.71**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

3.8.1 Seed related yield attributes

In terms of number of seed per head, the highest number of seed per head was observed (725.56) in T_1 treatment, which is significantly different from all other treatment followed by T_5 treatment (676.22). On the other hand, the lowest number of seed per head was observed in T_8 (562.67),

which were followed by T_6 (580.89) treatment (Table 9). In case of number of seeds per head of sunflower, it was observed that the following trend including untreated control was T_1> T_5>T_3> T_2> T_4> T_7>T_6> T_8.

From Table 9, it was observed that, the highest weight of seed per head of sunflower was observed in T_1 (54.96 gm) treatment, which is significantly different from all other treatments. On the other hand, the lowest weight of seeds per head of sunflower was observed in T_8 (18.93 gm) treatment. In case of weight of seed per head of sunflower, observed that the following trend including untreated control was T_1> T_5>T_3> T_7> T_2> T_4 >T_6> T_8 (Table 9).

Similar findings have been reported by Ravikumar et al. (2021) who found that foliar application of Zn @ 0.5%and B @ 0.3% along with S @ 40 kg ha^{-1} and RDF recorded the highest percentage of dry matter production (44.4%), number of filled seeds (30.1%) and yield (32.4%) of hybrid sunflower.

Faisal et al. [21] a field trial was executed to evaluate the impact of foliage applied micronutrients (zinc 0.5%, boron 0.7% and manganese 0.7%) solely and in co-application, on agro-morphological traits and achene yield of sunflower.

More or less similar result was observed from Keerio et al. [27] in case of head diameter (19.71 cm), number of seeds $head^{-1}$ (1300.0), seeds weight $head^{-1}$ (62.74 g), seed yield (1927.8 kg ha^{-1}) and oil content (41.92%) were observed under 2.00% Zn, while and head diameter (12.65 cm), number of seeds $head^{-1}$ (715.3), seeds weight $head^{-1}$ (35.53 g), seed yield (1062. 7 kg ha^{-1}) and oil content (29.28%) was recorded under control [28,29]. It was concluded on the basis of these findings that the foliar application of Zn in 2.0% concentration can be employed to increase the sunflower yield and oil content [30,31].

Zn fertilization with 10 to 20 kg per hectare increases oil content of the sunflower seed. In contrast, increasing in Zn concentration reduced oil content of the sunflower seeds [32].

3.8.2 Seed yield and percentage of oil contain of sunflower

Statistically significant variation was recorded in yield (kg/plot) of Sunflower for different treatments which has been presented in Table 9. The highest seed yield was recorded in case of T_1 treatment (1.92 kg/plot or 2.47ton ha^{-1}), which was statistically different from other treatments

Table 9. Efficacy of micronutrients on the Yield contributing characters, in terms of number of total head per plot, number of seed per head, weight of seed per head of Sunflower, yield and percentage of oil content

Treatments	Number of Seed Per Head	Weight of Seed Per Head (gm)	Weight of Total Seed Per Plot (kg)	Total Yield Ton ha^{-1}	% Of Oil Contain
T_1	725.56 a	54.96 a	1.92 a	2.47 a	46.5 a
T_2	657.90 c	26.92 d	1.25 cd	1.95 c	40.5 b
T_3	659.89 c	30.44 c	1.41c	1.85 cd	37.5 b
T_4	640.56 d	24.57 e	1.26 cd	1.86 cd	40.5 b
T_5	676.22 b	35.52 b	1.70 b	2.21b	44 ab
T_6	580.89 f	23.29 f	1.07d	1.40 d	37.5 b
T_7	602.90 e	27.23 d	0.93 e	1.55de	38 b
T_8	562.67 g	18.93 g	0.85e	1.36 e	21.5 c
$LSD_{(0.05)}$	**7.90**	**1.03**	**0.07**	**0.21**	**0.12**
CV (%)	**7.03**	**8.93**	**3.33**	**9.29**	**7.98**

In a column, numeric value represents the mean of 3 replications; each replication is derived from 10 plants per treatment; in a column means having similar letter(s) are statistically identical at 0.05 level of probability [T_1 = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ $ZnSo_4$ @ 8.4 gm/ Plot ;T_2 = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T_3= Recommended doses of Urea, TSP and MoP +Spraying 0.2% $ZnSo_4$ @ 2gm/ L of water; T_4= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T_5 Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% $ZnSo_4$ @ 2gm/ L of water; T_6 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% $ZnSo_4$ @ 5gm/ L of water; T_7 = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ $MgSo_4$ @ 12 gm/ Plot and T_8= control]

and statistically similar to T_5 treatment (1.70 kg/plot or 2.21 ton ha^{-1}). On the other hand, the lowest yield was recorded in T_8 treatment (0.85 kg/plot or 1.36 ton ha^{-1}), which was statistically similar to T_7 treatment (0.93 kg/plot). As a result, the order of effect of micronutrients management practices in terms of increasing the yield was T_1>T_5>T_3> T_4 > T_2> T_6> T_7 > T_8 [33-35].

In terms of oil content in sunflower, the highest percentage of oil (46.5%) was observed in case of T_5 treatment, which is significantly different from all other treatments. On the other hand, the lowest height of plant per plot was observed in T_8 treatment (21.5%).

So, in case weight of single seed of sunflower, we found the following trend including untreated control was T_1>T_5>T_2& T_4> T_7> T_3 & T_6> T_8 (Table 9).

Similar findings have been reported by Ebrahimian et al*.* [36], Eslami et al*.* [37], Brighenti and Castro [38], Sharma et al. [39], Siddiqui et al. [14], Reddy et al. [40], Oyinlola [41], Rahimi [42] and Rahimi et al. [43] which the present findings.

4. CONCLUSION

According to the findings remarkably different sucking insect pest jassid, whitefly, aphid, mealybug and beneficial insects were observed in the study. Among different treatments, T_1 showed the best performance, second highest T_5 treatment, where as the lowest performance in T_8 (Untreated control) for reducing incidence and infestation of major sucking insect pests of Sunflower and increasing yield and yield attributes. The overall result indicates that, the order of rank of study the efficacy of micronutrients against incidence and damage severity by major sucking insect pests of sunflower was T_1> T_5> T_2> T_4> T_3> T_6> T_7 > T_8.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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