

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

ABSTRACT

The An experiment was conducted in the a field of on Longitude ----- and Latitude ----- at the Central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2021 to April 2022. The experiment consists-consisted of eight treatments such-as follows: T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses (RD) of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂ = RD of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= RD of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= RD of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water; T₅ RD of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 8 treatments and -three3 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 T₈ treatment (without used of micronutrients). In T₁ treatment, the lowest leaf infestation percentage caused by aphid were (17.49 and 19.50 %)-.%; Jassid (were 14.19 and 14.89 %;) and white-White fly were (26.18 and 30.83 %) at the vegetative and reproductive stages, respectively. T₁-the highest number of beneficial arthropods per plot like-asof adults and grubs of lady bird beetle (3.63 and 5.53 respectively), honey bee (22.36), ant (3.55), spider (1.42) werewas also recorded in T₁ treatment. The highest yield contributing characters of sunflower, the highest of head/capitulum 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 T₁ 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 T₁ treatment. So, -a Among the different micronutrients-micronutrient treatment combinations-as-a-treatment, different micronutrients were more effective for the reducing the incidence of sucking insect pests of on sunflower Sunflower. So, Effect-In terms of the effect of micronutrients, T₁= Recommended doses of Urea, TSP and MoP + Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 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 chemicals-insecticides.

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Key words: Micronutrients, Incidence, Damage Severity, Sucking Insect Pests of Sunflower, Yield and Other Arthropods

1. INTRODUCTION

Sunflower (*Helianthus annuus* L., Family: ~~Compositae~~ 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 ~~our~~ human health (Rikabder 1987). It is an essential element of butter and margarine. The linoleic acid obtained from sunflower oil shows anti-carcinogenic effects (Bauman *et al.* 2000). Oilseed crops contribute much ~~in~~ more to our national economy. Among the oilseeds, sunflower (*Helianthus annuus* 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 (Charlet and Glogoza 2004). 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 (*Bemisia tabaci*) and hemipteran stink bug, *Nezaraviridula* (L.) are

of major economic importance (Rana *et al.* 2004, Hill 1983; Horvath 1993; Ahmed 2002; Reddy *et al.* 1991; Marin 1992). Rape and mustard oil seed crops are the most important sources of vegetable oil grown during the winter season. The activities of insect pests, predator and parasitoids such as aphids, leaf miner, leaf folder, ladybird beetles, Syrphids, *Diaretialla*, *Aponteles* were recorded on mustard from sowing till maturity of the crop (Hugar *et al.* 2008). Insect pollinators also play a vital role in crop plant (Müller *et al.* 2006; Thapa 2006). Many insect species are seen as active pollinators on flowers of plants (De Grandi and Chambers 2006). Environmental factors also play a vital role in the biodiversity of insect pests in a particular agro ecosystem (Aheer *et al.* 2007), 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 insects (REF) aphid population. Application of micronutrients plays a major role in increasing seed setting percentage and influence growth and yield (Kumbhare *et al.* 2017). 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 (Siddiqui *et al.* 2009). The heads consist of many individual flowers which mature into seeds on a receptacle base (Seghatoleslami *et al.* 2012).

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Boron, as a foliar spray was found to increase thousand seed weight and seed oil content (Kastori and Grujic 1992).

In Bangladesh, the Sunflower is has been newly introduced as an oil seed crop. Sunflower is primarily a winter plant but now-a-days it is available also in summer. They are grown in homestead ~~to~~ 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 low with the other countries. However, the 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 pests right from the primordial stages of the crop to harvesting of the product. The main insect pests of oil crops sunflower are ~~controlling~~ controlled by different cultural and biological methods of the pest but the growers in Bangladesh frequently often use

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 during the period from November 2021 to April 2022. The variety of Sunflower Mayabi (hybrid) variety was selected chosen for the experiment as a

chemical insecticides (Younas *et al.* 2016). In Bangladesh farmers solely rely on chemical pesticides for ~~their welfare against the control of this these~~ obnoxious insect pests ~~and but they often fail, and in at most of the cases most cases, and damage the ecological balance~~ 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 high-level chemical pesticides on non-target organism as well as environment, my this study will be was undertaken to assess assess the efficacy of different micronutrients to get rid of in controlling insect pest and aiming at an eco-friendly and sustainable pest management system in Sunflower so that farmers can get satisfactory yield as well as and consumers can get non-toxic fresh oil. However, the proper management is a burning issue in respect of agro socio economic and environmental aspect.

~~planting material. After collecting~~ The seeds were soaked for 12 hours in water in water for 12 hours before sowing in the experimental field. This was to for ensure rapid and uniform germination. The study was conducted with eight treatments with three (3) replications. The experiment was laid out

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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 of which was measuring of 3.5 m × 4.0 m. The maintaining plot to plot distance between plots was distance 1.0 m and row to row between rows was distance 0.5 m and plant to plant distance and between plants was 30 cm. Each treatment was allocated randomly within the block and replicated three times. Manures and fertilizers were applied in the experimental plot as per recommended doses of fertilizers in sunflower field (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 at 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 the time of 20-25 days after seedling (DAS) and second part was applied at the time of 40-45 days after seedling DAS (before flower blooming) with proper intercultural practices, gap filling and earthing up soil around base of the plant. The eight treatments for reducing several sucking insect pests were, T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] + Boron @ 7.0 gm/ Plot + ZnSo₄ @ 8.4 gm/ Plot ; T₂ = Recommended doses of Urea, TSP and MoP + Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP + Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of

Urea, TSP and MoP + Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP + Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control. The data were recorded in the field for the evaluation of efficiency performance of different micronutrients on infestation level of insect pest complex on the growth and yield 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. Heads were harvested based on the attaining of mature and ripening stage. The sunflower plants were harvested at 105 DAS when all plants were fully matured and ripped. The yield of each treatment in all replications were recorded separately. The seed were dried, cleaned and weighed for individual each plot. The weight was adjusted to 12% moisture content. The recorded data were 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 (capitulum) per plot; diameters and width of head; soil pH; Chlorophyll content of sunflower was measured by Portable SPADO meter. ; Number of seeds per head; Number of

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seed; Weight of single seed; ~~weight~~ Weight total seeds per head; Yield per plot; Yield per hectare ~~and~~; Increase percentage of yield over control; and ~~percentage~~ Percentage of oil contained in seeds. Statistical analysis of data was done with the help of computer software Statistics 10.

3. RESULTS AND DISCUSSION

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 during study period in the sunflower research field

At the 22 days after seedling (DAS): Number of Jassid ~~the different days after seedling~~ (22 DAS) of Sunflower per plant during study period showed statistically significant differences due to different doses of micronutrients as treatments in jassid (Table 1) at 22 DAS. The highest number of Jassid per plant (5.04) was recorded ~~from in~~ T₈ (untreated control) treatment, which was statistically different from ~~the~~ rest of the treatment ~~and~~. This was followed by T₇ (2.84) and T₆ (2.68) treatments respectively, ~~whereas~~. The lowest number of jassid Jassid per plant (1.88) was found ~~from in~~ T₁ treatment, which was statistically similar to T₅ (2.12), followed by ~~(2.40)~~ T₂ treatment (2.40). As a result, the trend of order of effectiveness of the treatments

The research was conducted to study the effect of micronutrients on incidence, damage severity of insect pests ~~of on~~ 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.

applied against jassid per plant at the different days after seedling (DAS) of sunflower including untreated control in terms of reducing number was (T₁ < T₅ < T₂ < T₄ < T₃ < T₆ < T₇ < T₈).

At 37, 52, 67 and 82 days after seedling (DAS): ~~From table 1, it was observed that, more or less similar trends of results also observed that in terms in the of~~ number of jassid Jassid at the different days after seedling (DAS) such as 37 DAS, 52 DAS, 67 DAS and 82 DAS of sunflower per plant during study period was observed. ~~In case of jassid, the highest percentage of reduction over control (68.51) was obtained from in~~ T₁ treatment, which was followed by T₂ (63.39) treatment and T₅ (62.30) treatment, which were statistically similar. On the other hand, the lowest percentage of reduction over control was obtained from T₄ (44.33) treatment which was followed by T₇ (53.21) treatment ~~in table 1.~~

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3.2 Incidence of Aphid at the different days after seedling (DAS) of Sunflower during study period in the sunflower research field

At the 22 days after seedling (DAS): Number of Aphid 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 aphid (table 2) at 22 DAS. The highest number of aphid per plant (2.92) was recorded from T₈ (untreated control) treatment which was statistically different from rest of the treatment and followed by T₇ (2.40), whereas the lowest number of aphid per plant (1.77) was found from T₁ treatment which was statistically similar to T₅ (1.81) followed by (1.95, 1.99, 2.00 and 2.13 respectively) T₂, T₄, T₃, and T₆ 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 (T₁ < T₅ < T₂ < T₄ < T₃ < T₆ < T₇ < T₈).

At the 37, 52, 67 and 82 days after seedling (DAS): From table 2, it was observed that, more or less similar trends of results also observed that in terms of number of Aphid at the different days after seedling (DAS) such as 37 DAS, 52 DAS, 67 DAS and 82 DAS of sunflower per plant during study period. The

highest percentage of reduction over control (67.66) was obtained from T₁ treatment which was closely followed by T₅ (65.16) treatment and they were statistically similar.

On the other hand, the lowest percentage of reduction over control was obtained from T₆ (60.86) treatment which was followed by T₇ (61.80) treatment in table 2.

3.3 Incidence of White flies at the different days after seedling (DAS) of Sunflower during study period

At the 22 days after seedling (DAS): Number of white fly 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 treatment in white fly (table 3). The highest number of white fly per plant (3.20) was recorded from T₈ (untreated control) treatment which was statistically different from rest of the treatment and closely followed by T₃ (2.58), T₇ (2.02) and T₆ (1.96) treatments respectively, whereas the lowest number of white fly per plant (1.13) was found from T₁ treatment which was statistically similar to T₅ (1.37) followed by (1.33 and 1.82 respectively) T₂ and T₄ 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 (T₁ < T₅ < T₂ < T₄ < T₃ < T₆ < T₇ < T₈). Similar result was also observed by Nayak *et al.* (2022) and Geetha and Hegde (2018).

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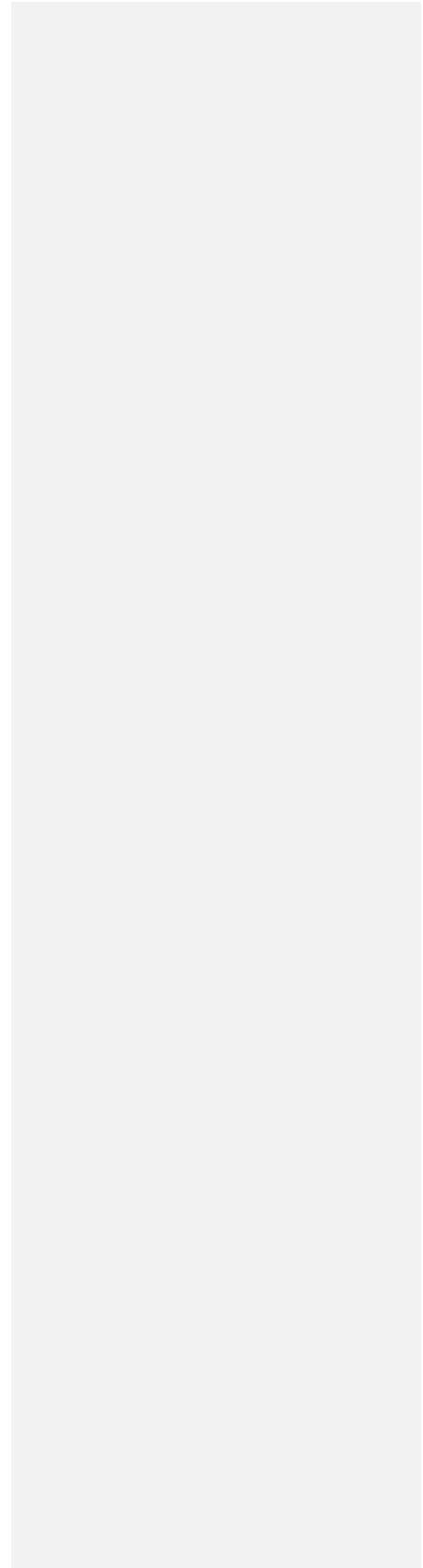


Table 01: Effect of micronutrients on the a incidence of Jassid at the different days after seedling (DAS) of Sunflower during study period

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 02: Effect of micronutrients on the incidence of aphid at the different days after seedling (DAS) of Sunflower during study period

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.

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂ = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

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 during study period. However, the highest percentage of reduction over control (73.31) was obtained from T₅ treatment which was closely followed by T₁ (69.51) treatment and T₂ (67.73) treatment, which were statistically similar. On the other hand, the lowest percentage of reduction over control was obtained from T₃ (57.41) treatment which was followed by T₄ (59.55) treatment in table 3.

3.4 Incidence of Mealybug the different days after seedling (DAS) of Sunflower during study period

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 T₈ (untreated control) treatment which was statistically different from rest of the

treatment and followed by T₇ (1.47), whereas the lowest number of Mealybug per plant (1.00) was found from T₃, T₄ and T₆ treatments respectively. There is no Mealybug per plant (0.00) was found in T₁, T₂ and T₅ 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 (T₁=T₅=T₂<<T₃=T₄=T₆<T₇<T₈)

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 per plant during study period. Overall, the highest percentage of reduction over control (94.59) was obtained from T₁ treatment which was followed by T₅ (90.98) treatment. On the other hand, the lowest percentage of reduction over control was obtained from T₃ (66.62) treatment which was followed by T₇ (69.82) treatment in table 4.

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Table 03: Effect of micronutrients on the incidence of white fly at the different days after seedling (DAS) of Sunflower during study period

Treatments	Number of white fly at the different days after seedling (DAS)/ plant						Reduction over control
	22 DAS	36 DAS	48 DAS	62 DAS	76 DAS	Mean	
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 04: Effect of micronutrients on the abundance of Mealybug at the different days after seedling (DAS) of Sunflower during study period

Treatments	Number of Mealybug at the different days after seedling (DAS)/ plant					Mean	Reduction over control
	35 DAS	45 DAS	55 DAS	65 DAS	75 DAS		
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.

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂ = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

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: ~~In case of lady bird beetle,~~ The highest number of adults and grubs (3.63 and 5.53 respectively) was recorded in T₇ treatment which was statistically similar (5.12) to T₁ treatment in case of grubs, and followed (2.83) by T₁ treatment in case of adult lady bird beetle, while the lowest number of lady bird beetle (1.58) was found from T₆ treatment which was followed (1.73) by T₄ treatment (Figure 1).

3.5.2 Honey Bee: ~~In case of Honey Bee,~~ The highest number of adults ~~honey~~ Honey Bee (22.36) was recorded in T₁ treatment, which was statistically similar (21.52) to T₅ treatment and followed (~~19.57 and 18.37~~) by T₇ by and T₄ treatments (~~19.57 and 18.37~~) respectively, while the lowest number of honey Bee (12.20) was found in T₈ treatment, which was followed by T₆ (14.28) treatment in (Figure 1).

3.5.3 Blank ant: ~~ant: In case of blank ant,~~ The highest number of adults blank ant (3.55) was recorded in T₇ treatment, which was closely followed (3.02 and 3.06 respectively) by T₁, and T₂ treatments respectively, while the lowest number of blank ant (1.89) was found ~~from~~ in T₆ treatment, which was followed by T₈ (2.38) treatment in (Figure 1).

3.5.4 Spider: ~~In case of spider,~~ The highest number of spider (1.42) was recorded in T₆ treatment, which was statistically similar (~~1.23, 1.28, and 1.34 respectively~~) to T₃, T₇ and T₈ treatments (~~1.23, 1.28, and 1.34~~) respectively in (Figure 1).

3.6 Infestation status

During the study period, number of healthy and infested leaves for different insect pests of 10 selected plants/plot were 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 ~~statistical~~ 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~~ In case of percentage of infestation, the lowest infestation of leaves/plant (17.49 %) was recorded in T₁ treatment, which was statistically different from all other treatments. While the highest infestation (48.00%) was recorded in T₈ treatment, which was followed by T₇ and T₆ 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 T₁ treatment, which was followed (53.79%) by T₂ treatment, while the

lowest percentage of reduction over control (39.21%) was recorded in T₇ treatment for aphid ~~throughout the study period in sunflower field.~~

UNDER PEER REVIEW

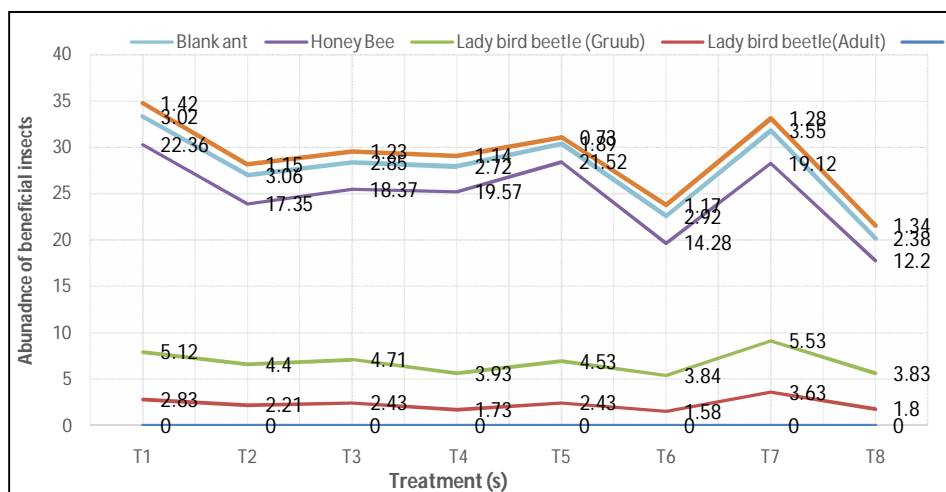


Figure 1: Efficacy of micronutrients on the abundance of beneficial insects of Sunflower during study

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂ = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

As a result of different management practices, the trend of in the order of effectiveness of the micronutrients applied against aphid per plot including untreated control in terms of reducing number was (T₁< T₂<T₄< T₂< T₆< T₇< T₃< T₈).

At the reproductive stage, Incase of percentage of infestation, the lowest infestation of leaves/plant (19.50%) was recorded in T₁ treatment, which was statistically different from all other treatments, w. While the highest infestation (46.09%) was recorded in T₈ treatment,

which was followed by T₆ and T₇ treatments (28.85 % and 28.82%), respectively in (Table 5). It was also observed that the highest percentage of reduction over control (57.69%) was recorded in T₁ treatment, which was followed (49.23%) by T₅treatment, while the lowest percentage of reduction over control (37.41%) was recorded in T₇ treatment for aphid throughout the study period in sunflower field. As a result of different management practices, the trend of in the order of effectiveness of the micronutrients applied against aphid per plot

Comment [FO33]: Delete all

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

UNDER PEER REVIEW

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

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂= Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

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

At the vegetative stage, the number of healthy leaves, infested leaves and percent leaf infestation of sunflower by jassid Jassid showed statistically significant differences due to different management practices (Table 6).

In case of percentage of infestation, the lowest infestation of leaves/plant (14.19%) was recorded in T₁ treatment, which was statistically different from all other treatments, while the highest infestation (39.62%) was recorded in T₈ treatment, which was followed (26.34% and 25.25%) by T₄ and T₇ treatments (26.34 % and 25.25 %) respectively in (Table 6). It was also observed that the highest

percentage of reduction over control (64.18%) was recorded in T₁ treatment, which was followed (55.15%) by T₂ treatment (55.15%), while the lowest percentage of reduction over control (33.52%) was recorded in T₄ treatment for jassid throughout the study period in sunflower field.

As a result of the different management practices, the trend of effectiveness of the micronutrients applied against grasshopper per plot including untreated control in terms of reducing number was (T₁ > T₂ > T₃ > T₅ > T₆ > T₇ > T₄ > T₈).

At the reproductive stage, increase of percentage of infestation, the lowest infestation of leaves/plant (14.89%) was recorded in T₁ treatment, which was

Comment [FO34]: Delete all

Comment [FO35]: Why grasshopper? Is the heading is relating to Jassid?

statistically different from all other treatments and the highest infestation (42.43%) was recorded in T₈ treatment, which was statistically difference from all other treatments in (Table 6). It was also observed that the highest percentage of reduction over control (64.91%) was recorded in T₁ treatment, which was closely followed (55.17%) by T₅ treatment, while the lowest percentage of reduction over control (42.71%) was recorded in T₇ treatment for jassid throughout the study period in sunflower field.

As a result of the different management practices, the trend of in the order of effectiveness of the micronutrients applied against jassid per plot including untreated control in terms of reducing number was (T₁ < T₅ < T₂ < T₃ < T₆ < T₄ < T₇ < T₈).

Similar findings were also reported by Shamimuzzaman (2021) and Faisal *et al.* (2020).

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

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂= Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water; T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

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

At the vegetative stage, the number of healthy leaves, infested leaves and percent leaf infestation of sunflower by white-White

fly showed statistically significant differences due to different management practices (Table 7). In terms of percentage percentage of infestation due to white-White fly, the lowest infestation of leaves/plant (26.18%) was recorded in T₁ treatment, which was statistically different from all

other treatments and the highest infestation (56.54%) was recorded in T₈ treatment, which was followed by T₇ and T₃ treatments (37.39 % and 36.42 %), respectively. It was also observed that the highest percentage of reduction over control was recorded in T₁ treatment (53.70%), which was closely followed by T₆ treatment (46.96%), while the lowest percentage of reduction over control was recorded in T₇ treatment (33.87%) for white fly throughout the study period in sunflower field.

As a result, the trend of in the order of effectiveness of the micronutrients applied against white fly per plot including untreated control in terms of reducing number was (T₁ < T₆ < T₅ < T₂ < T₄ < T₃ < T₇ < T₈).

At the reproductive stage, percentage of infestation, the lowest infestation of leaves/plant (30.83%) was recorded in T₁ treatment, which was statistically different from all other treatments and the highest infestation (60.47%) was recorded in T₈ treatment, which was statistically difference from all other treatments in (Table 9). It was also observed that the highest percentage of reduction over control (57.69%) was recorded in T₁ treatment, which was closely followed (49.02%) by T₁ treatment, while the lowest percentage of reduction over control (30.38%) was recorded in T₃ treatment for white fly throughout the study period in sunflower field.

As a result, the trend of in the order of effectiveness of the micronutrients applied against white fly per plot including untreated

control in terms of reducing number was (T₁ < T₅ < T₂ < T₆ < T₄ < T₇ < T₃ < T₈).

3.7 Effect of micronutrients on the Soil P^H and Yield contributing characters attributes of Sunflower

The significant variations were observed among yield contributing characters attributes of sunflower throughout the growing period of sunflower in the field (Table 8). In case of soil P^H, from results it was the study revealed that the lowest soil P^H was recorded in T₁ (5.80) treatment, which was statistically identical from all other treatments.

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 T₃ treatment, which was statistically identical to T₅ (41.15 %) treatment, while the minimum chlorophyll content (35.64 %) was obtained from T₈ (control) treatment.

In terms of area of leaves and capitulum diameter per plant, the highest area of leaves and capitulum diameter per plant of sunflower (62.29 cm and 9.75cm) was observed (62.29 cm and 9.75cm) in case of T₁ treatment, which is significantly different from all other treatments. On the other hand, the lowest were observed in case of T₈ (57.04 cm and 8.79 cm respectively) treatment in (Table 8).

This research results more or less similar to results are in conformity with Saad and Al-Doori (2017), Raghu *et al.* (2017) and Sepehr *et al.* (2002). They was a field

Comment [FO36]: Separate this subtopic into two subtopics as follow: 3.7.1 Effect of micronutrients on soil pH and 3.7.2 Effect of micronutrients on yield attributes of Sunflower

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experiment was conducted during spring and autumn growing seasons of 2009 to study the effect of foliar application of zinc and boron on growth characters, yield components and quality of some sunflower genotypes (*Helianthus annuus* L.).

The experiment was carried out according to the factorial experiment in a randomized completely block design, consisting of three zinc application (0, 6, 12 mg.L⁻¹) and three boron application (0, 4 and 8 mg.L⁻¹) with three sunflower genotypes (Myogen, Isaanka and Ginmus).

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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 reproductivestage 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, 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.

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂= Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

The main findings could be summarized as follows: - Foliar application of zinc to the leaves with concentration 12 mg·L⁻¹ showed a significant increase in plant height, stem diameter, leaf area, head diameter. Also pertinent to Raghu *et al.* (2017) and Sepehr *et al.* (2002) a field experiment was carried out to study the effect of secondary and micronutrients on growth, yield parameters and nutrient uptake of sunflower (*Helianthus annuus* L.).

Diameter of flower with petal: The diameter of flower with petal varied significantly with increasing amount of different level of micronutrients application of

sunflower (Table 11). The maximum diameter of flower with petal (22.23 cm) was recorded from T₁ treatment, which was statistically identical to T₂, T₅, T₄ and T₆ (21.52, 21.49, 20.98 and 20.63 cm) treatment respectively, while the minimum diameter of flower with petal (19.30 cm) was obtained from T₈ (control) treatment. This research results more or less similar to conform to the findings of Asad *et al.* (2002, 2003), who also reported that sunflower-Sunflower growing on boron deficient soils responded-responds to B application by increasing both vegetative and reproductive mass and B concentration in several parts of the plant shoot.

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Table 8: Effect of micronutrients on the Soil P^H and Yield contributing characters in terms of Chlorophyll content (%), Leaf area plant⁻¹, Head/capitulum 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/capitulum 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

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂ = Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

3.8 Seedrelated yield attributes, yield and percentage of oil content

The significant variations were observed among yield contributing characters of sunflower in terms of number of seed per head and weight of seed per head throughout the growing period of sunflower in the field (Table 9).

In terms of number of seed per head, the highest number of seed per head was observed (725.56) in case of T₁ treatment, which is significantly different from all other treatment followed by T₅ treatment (676.22). On the other hand, the lowest number of seed per head was observed in case of T₈ (562.67), which was followed

(580.89), by T₆ treatment (580.89) (Table 9). In case of number of seeds per head of sunflower, it was found that the following trend including untreated control was T₁ > T₅ > T₃ > T₂ > T₄ > T₇ > T₆ > T₈.

From Table 9, it was observed that the highest weight of seed per head of sunflower (54.96 gm) was observed in case of T₁ treatment, which is significantly different from all other treatments. On the other hand, the lowest weight of seed per head of sunflower was observed in case of T₈ (18.93 gm) treatment. In case of weight of seeds per head of sunflower, it was found that the following trend including untreated control

was $T_1 > T_5 > T_3 > T_7 > T_2 > T_4 > T_6 > T_8$ (in Table 9). Similar findings have been reported by

~~More or less similar results observed from different researchers such as, Ravikumar *et al.* (2021), who experimental trials were conducted to study the effect of sulphur, zinc and boron application on the growth, yield components and yield of hybrid sunflower and from their experimental results, they 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.* (2020) 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.

Keerioet *al.* (2020) the experiment was conducted at field of Oil Seeds Section, Agriculture Research Institute (ARI), Tandojam, Sindh using RCBD design with three replications. The maximum plant height (203.33 cm), stem girth (11.67 cm), head diameter (19.71 cm), number of seeds head⁻¹ (1300.0), seeds weight head⁻¹ (62.74 g), seeds index (60.12 g), seed yield (1927.8 kg ha⁻¹) and oil content (41.92%) were observed under 2.00% Zn, while and minimum plant height (143.67 cm), stem girth (6.19 cm), head diameter (12.65 cm), number of seeds head⁻¹ (715.3), seeds weight head⁻¹ (35.53 g), seed index (43.82 g), seed yield (1062.7 kg ha⁻¹) and oil content (29.28%) was recorded under control (no foliar spray of Zn). Thus,

the plant height, stem girth, head diameter, and number of seeds per head⁻¹ increased by 41.5%, 88.5%, 55.8% and 81.7%, respectively on applying highest concentration of Zn. While, seeds weight per head⁻¹, seeds index, seed yield, and oil content ascended by 76.6%, 37.2%, 81.4%, and 43.2%, respectively as compared to the control. 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.

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 (Mirzapour and Khoshgoftar, 2006).

Seed yield and percentage of oil content 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 T₁ treatment (1.92 kg/plot or 2.47 ton ha⁻¹) treatment, which was statistically different from other treatments and statistically similar to T₅ treatment (1.70 kg/plot or 2.21 ton ha⁻¹) treatment. On the other hand, the lowest yield was recorded in case of treatment T₈ (0.85 kg/plot or 1.36 ton ha⁻¹) treatment, which was statistically similar to T₇ treatment (0.93 kg/plot) treatment and increase of ton ha⁻¹ statistically similar to T₆. As a result, the order of effect of micronutrients management practices in terms of increasing the yield was $T_1 > T_5 > T_3 > T_4 > T_2 > T_6 > T_7 > T_8$.

In terms of oil content of sunflower, the highest percentage (%) of oil (46.5%) contain of sunflower was observed (46.5%) in

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case of T₅ treatment, which is significantly different from all other treatments. On the other hand, the lowest height of plant per

plot was observed in ~~ease of treatment T₈~~ (21.5%) ~~treatment.~~

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.

[T₁ = Urea @ 210 gm/plot + TSP @ 84gm/plot + MoP @ 98gm/plot [recommended doses of Urea, TSP and MoP] +Boron @ 7.0 gm/ Plot+ ZnSo₄ @ 8.4 gm/ Plot ;T₂= Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax @ 2gm/ L of water; T₃= Recommended doses of Urea, TSP and MoP +Spraying 0.2% ZnSo₄ @ 2gm/ L of water; T₄= Recommended doses of Urea, TSP and MoP +Spraying 0.5% Borax @ 5gm/ L of water T₅ Recommended doses of Urea, TSP and MoP +Spraying 0.2% Borax + 0.2% ZnSo₄ @ 2gm/ L of water; T₆ = Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot + Spraying 0.5% ZnSo₄ @ 5gm/ L of water; T₇= Urea @ 210 gm/plot+ TSP @ 180gm/plot+ MoP @ 150gm/plot+ MgSo₄ @ 12 gm/ Plot and T₈= control]

~~So, in~~ case weight of single seed of sunflower, ~~we found it was observed that~~ the following trend including untreated control was ~~observed: T₁>T₅>T₂& T₄> T₇> T₃& T₆> T₈~~ (Table 9). ~~Similar findings have been reported by~~

~~More or less similar results observed from different researchers such as, Ebrahimian et al. (2010), reported that oil content increases by use of Zn microelement and soil application of Zn micronutrients is more beneficial to oil biosynthesis. In addition, they concluded that foliar application of Zn microelement significantly increased POD (peroxidase) and SOD (superoxide dismutase) but decreased significantly CAT~~

~~(catalase) activity and Zn foliar application significantly increased palmitoleic, linolenic, oleic and myristic acid content in sunflower. In another study, conducted by Eslami et al. (2015), spraying zinc sulfate to sunflowers effected oil content of the plants.~~

~~Brighenti and Castro (2008), demonstrated that oil yield were increased by B consumption, and stated that B consumption increased the pollen fertility.~~

~~Similar result was also observed by Sharma et al. (2008), Siddiqui et al. (2009), Reddy et al. (2002), Oyinlola (2007), Rahimi (2014) and Rahimiet al. (2012), which supported the present findings.~~

4. CONCLUSION

According to the findings, remarkably different sucking insect pest Jjassid, whitefly Whitefly, aphid Aphid, mealybug Mealybug and other beneficial insects were observed in the study. Among the different treatments, T₁ showed the best performance, second followed by highest T₅ treatment, where as the The lowest performance was observed in treatment T₈ (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 in this study was in the order T₁> T₅> T₂> T₄> T₃> T₆> T₇> T₈.

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