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

ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2021 to April 2022. The experiment consists of eight treatments such as 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+ $ZnSo_4$ @ 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 @ 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 experiment was laid out in Randomized Complete Block Design (RCBD) with three 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 (without used of micronutrients). 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 stage respectively; the highest number of beneficial arthropods per plot like as adults and grubs of lady bird beetle ((3.63 and 5.53 respectively), honey bee (22.36), ant (3.55), spider (1.42) were also recorded in T_1 treatment. The highestyield contributing characters of sunflower, the highestof 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 sunflowerwere 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. So, among the different micronutrients combinations as a treatment, different micronutrients were more effective for the reducing of sucking insect pests of sunflower. So, 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 chemicals insecticides.

Key words: *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 annualcrops 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 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 our national economy. Among 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 (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 (*Bemicia tabaci*) and hemipteran stink bug, *Nezara viridula* (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.

Applicationofmicronutrientsplaysamajorrolei ninincreasingseedsettingpercentageandinfluence growthandyield(Kumbhar*etal*.2017).Thereare positiveeffectsofmicronutrientapplicationonth e growthofsunflower,interms ofplantheight,numberof leaves anddrymatterproductionperplant(Siddiqui*etal*. 2009).Theheadsconsistofmanyindividualflow erswhichmatureintoseeds onareceptaclebase(Seghatoleslami*etal*.2012). Boron, asafoliarspraywasfoundtoincreasethousandsee dweightandseedoilcontent(KastoriandGrujie 1992).

In Bangladesh the Sunflower is newly introduced as an oil seed crops.Sunflower is

primarily a winter plant but now-a-days it is available also in summer. They are grown in homestead to 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 Sunflower production is comparatively 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 right from the primordial stages of the crop to harvest of the product. The main pests of oil crops sunflower are controlling by different methods of the pest but the growers in Bangladesh frequently use chemical insecticides (Younas *et al*. 2016). In Bangladesh farmers solely rely on chemical pesticide for their welfare against this obnoxious insect pest and fail at most of the cases and damage the ecological balance. The application of insecticide, 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 my study will be undertaken to asses the efficacy of different micronutrients to get rid of insect pest and aiming at eco-friendly and sustainable pest management system in Sunflower so that farmer can get satisfactory yield as well as consumer can get non-toxic fresh oil. However, the proper management is a burning issue in respect of agro socio economic and environmental aspect.

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) was selected for the experiment as a planting material. After collecting seeds were soaked for 12 hours in water before sowing in the experimental field for rapid and uniform germination.The study was conducted with eight treatments with three (3) replications. The experiment was laid out in a Randomized Complete Block Design (RCBD). The field with good tilth was divided into 3 blocks. Each block was sub-divided into 8 sub plots, each of which was of 3.5 m × 4.0 m maintaining plot to plot distance 1.0 m and row to row distance 0.5mand plant to plant distance was 30 cm. Each treatment was allocated randomly within the block and replicated three times.Manures and fertilizers were applied in the experimental plot [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 cowdung, Urea, TSP and MP was applied as basal dose at the time of land preparation. Urea was applied at three installments. Half of urea was applied at the time of land preparation as a first installment. Rest of urea was divided two parts, first part was applied at the time of 20-25 days after seedling and second part was applied at the time of 40-45 days after seedling (before flower blooming) with proper intercultural practices, gap filling and earthling up soil around base of the plant. The eight treatments for reducing severalsucking 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. 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. Yield of each treatment in all replications were recorded separately. The seed were dried, cleaned and weighed for individual plot. The weight was adjusted to 12% moisture content. The recorded data were 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 seed Weight of single seed; weight total seeds per head; Yield per plot; Yield per hectare and Increase percentage of yield over control and percentage of oil contain. 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 Jassidat the different days after seedling (DAS) of Sunflower during study periodin the sunflower research field

At the 22days after seedling (**DAS):** Number of Jassidat 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 jassid (Table 1) at 22 DAS.The highest number of jassid per plant (5.04) was recorded from T_8 (untreated control) treatment which was statistically different from rest of the treatment and followed by T_7 (2.84) and T_6 (2.68) treatments respectively, whereas the lowest number of jassid per plant (1.88) was found from T_1 treatment which was statistically similar to T_5(2.12) followed by (2.40)T_2treatment. 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).**

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 of number of jassidat the different days after seedling (DAS) such as 37 DAS, 52 DAS, 67 DAS and 82 DAS of sunflower per plant during study period.Incase of jassid, the highest percentage of reduction over control (68.51) was obtained from 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 in table 1.

3.2Incidence of Aphidat 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 Aphidat 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 T_8 (untreated control) treatment which was statistically different from rest of the treatment and 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, andT_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).

At the 37, 52, 67 and 82days 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 Aphidat 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 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 in table 2.

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

At the 22 days after seedling (DAS): Number of white flyat 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 T_8 (untreated control) treatment which was statistically different from rest of the treatment and 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 respectively)T_2, andT_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.* (2022) and Geetha and Hegde (2018).

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.

[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 36, 48, 62, and 76days 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 flyat 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 T_5 treatment which was closely followed by T_1 (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 which was followed by T_4 (59.55) treatment in table 3.

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

At the 35 days after seedling (DAS): Number of Mealybugat 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 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 andT_6 treatments respectively. There is no Mealybug per plant (0.00) was found in T_1, T_2 andT_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)

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 T_1 treatment which 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 in table 4.

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 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 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						
	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]

3.5Abundance 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 T_7 treatment which was statistically similar (5.12) to T_1 treatment incase of grubs, and followed (2.83) by T_1 treatment incase 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 (Figure 1).

3.5.2 Honey Bee: In case of 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_5treatment and followed (19.57 and 18.37) T_7 by and T_4 treatments 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 (Figure 1).

3.5.3 Blank ant: In case of blank ant, the highest number of adults blank ant (3.55) was recorded in T_7 treatment which was closely followed (3.02 and 3.06 respectively) by T_1, and T_2 treatments respectively, while the lowest number of blank ant (1.89) was found from T_6 treatment which was followed by T_8 (2.38) treatment in (Figure 1).

3.5.4 Spider: In case of spider, the highest number of spider (1.42) was recorded in T_6 treatment which was statistically similar (1.23, 1.28, and 1.34 respectively) to T_3, $T_7$and T_8treatments respectively in (Figure 1).

3.6 Infestation status

During the study period healthy and infested leaves for different insect pests of 10 selected plants /plot were observed at 7 days interval 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 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).

Incase 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 throughout the study period in sunflower field.

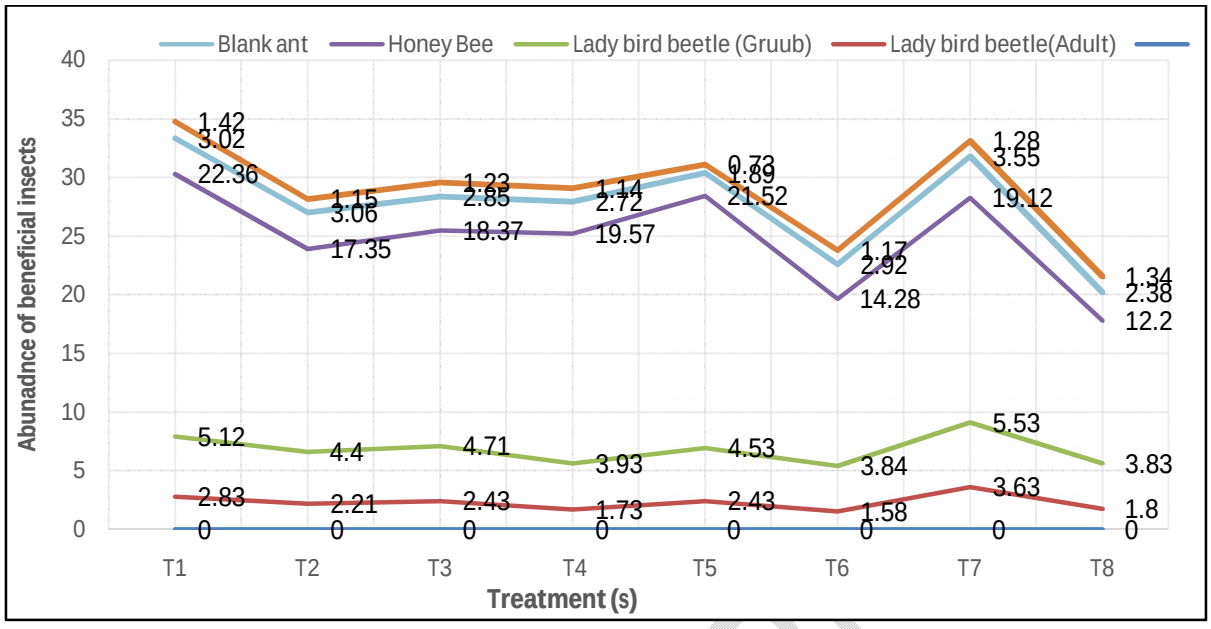

Figure 1: Efficacy of micronutrients on the abundance of beneficial insects of Sunflower during study

[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]

As a result, the trend of 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).

At the reproductive stage, Incase of percentage of infestation, 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 in 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, the trend of 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).

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.

[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]

3.6.2 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). Incase of percentage of infestation, 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 (26.34% and 25.25%) by T_4 and T_7 treatments respectively in 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_2treatment, 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, the trend of order of effectiveness of the micronutrients applied against grasshopper 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, Incase of percentage of infestation, 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 in 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 throughout the study period in sunflower field. As a result, the trend of order of effectiveness of the micronutrientsapplied 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 (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.

[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]

3.6.3 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_3treatments (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_6treatment (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, the trend of 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, percentage of infestation, 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 (57.69%) was recorded in T_1 treatment, which was closely followed (49.02%) by T_1treatment, while the lowest percentage of reduction over control (30.38%) was recorded in T_3 treatment for white fly throughout the study period in sunflower field. As a result, the trend of 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 P^H and Yield contributing characters of Sunflower

The significant variations were observed among yield contributing characters of sunflower throughout the growing period of sunflower in the field (Table 8). Incase of soil P^H, from results it was releaved that the lowest soilP^H was recorded in T_1 (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 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.

In terms of,area of leaves and capitulam diameter per plant, the highest area of leaves and capitulam diameter per plant of sunflower was observed (62.29 cm and 9.75cm) in case of T_1 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 in table 8.

This research results more or less similar to Saad and Al-Doori (2017). They was a field 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).

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.

[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 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 toRaghu *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:Diameter of flower with petal varied significantly with increasing amount of different level of micronutrientsapplication of sunflower (Table 11). 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 research results more or less similar to Asad *et al.* (2002, 2003) also reported that sunflower growing on boron deficient soils responded to B application by increasing both vegetative and reproductive mass and B concentration in several parts of the plant shoot.

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 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 headand weight of seed per headthroughout the growing period of sunflower in the field (Table 9).

In terms of number of seed per head, the height number of seed per head was observed (725.56) in case of 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 case of T_8 (562.67), which were followed (580.89), by T_6treatment(Table 9). So, in case number of seed per head of sunflower, we found 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 headof sunflower was observed (54.96 gm) in case of T_1 treatment, which is significantly different from all other treatments. On the other hand, the lowest weight of seed per headof sunflower was observed in case of T_8 (18.93 gm) treatment. So, in case weight of seed per head of sunflower, we found 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.

More or less similar results observed from different researchers such as, Ravikumar *et al.* (2021) 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.

Keerio *et 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 $head^{-1}$ increased by 41.5%, 88.5%, 55.8% and 81.7%, respectively on applying highest concentration of Zn. While, seeds weight $head^{-1}$, seeds index, seed yield, and oil content ascended by 76.6%, 37.2%, 81.4%, and 43.2%, receptively 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).

Seedyield 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 (1.92 kg/plot or 2.47ton ha^{-1}) treatment, which was statistically different from other treatments and statistically similar to T_5 (1.70 kg/plot or 2.21 ton ha^{-1}) treatment. On the other hand, lowest yield was recorded in case of T_8 (0.85 kg/plot or 1.36 ton ha^{-1}) treatment, which was statistically similar to T_7 (0.93 kg/plot) treatment and incase of ton ha^{-1}statistically similar to T_6. 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 contain of sunflower, the highest percentage (%) of oil contain of sunflower was observed (46.5%) 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 case of T_8 (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 headof 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]

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).

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 Rahimi*et al*. (2012) which supported 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 $T_1 > T_5 > T_2 > T_4 > T_3 > T_6 > T_7 > T_8$.

5. REFERENCES

Aheer GM, Ahmad KJ and Ali A. Impact of weather factors on population of wheat aphids at Mandi Baha-ud-din District. J. Agric. Res. 2007; 45(1): 61-68.

Ahmed KN. Use of bio-pesticide in the control of the pests of oilseeds in pre-harvest and postharvest conditions. Research Report submitted to the Ministry of Science and Information and Communication Technology on 1.12.2002; Bangladesh.

Asad A, Blamey FPC and Edwards DG. Effects of Boron Foliar Applications on vegetative and reproductive growth of sunflower. Annals of Bot., 2003; 92(4):656-570.

Asad A, Blamey FPC and Edwards DG. Effects of boron foliar application on vegetative and reproduction growth of sunflower. *Annals of Botany*, 2002; 92: 1- 6.

Bauman DE, Barbano DA, Dwyer DA and Giriinari JM. Technical Note: production of butter with enhanced conjugated linoleic acid for use in biomedical studies with animal models. J. Dairy Sci.2000; 83: 2422-25.

Brighenti A. M., and Castro. "Boron foliar application on Sunflower (*Helianthus annuus* L.) associated with herbicides." Helia, 2008; 31(48): 127-36.

Charlet LD and Glogoza PA. Insect problems in the sunflower production regions based on the 2003 sunflower crop survey and comparisons with the 2002 survey. Proc. 26th Sunflower Research Workshop, Natl. Sunflower Assoc., Fargo, ND, 14-15 January 2004.

De Grandi-Hoffman G. and Chambers M. Effects of honey bee (Hymenoptera: Apidae) foraging on seed set in self-fertile sunflowers *Helianthus annuus*, L. Environ. Entomol. 2006; 35(4): 1103-1108.

Ebrahimian E, Bybordi A, and Eslam BP. Efficiency zinc and iron application methods on sunflower. J. Food Agric. Envin.,2010; 8(3&4): 783-789.

Eslami M, Deghanzadeh H, and Najafi F. The effect of drought stress on oil percent and yield and type of sunflower (*Helianthus annus* L.) fatty acids. Agric. Sci. Development, 2015; 4:4-6.

Faisal M, Iqbal MA, Aydemir SK, Hamid A, Rahim N, Sabagh A, Khaliq A, and Siddiqui MH. Exogenously foliage applied micronutrients efficacious impact on achene yield of sunflower under temperate conditions. Pak. J. Bot., 2020; 52(4): 1215-1221. DOI: http://dx.doi.org/10.30848/PJB2020-4(33).

FAO. Production Year Book. Food and Agricultural of the United Nations Rome, Italy. 1988; 42: 190-193.

Gomez KA, and Gomez AA. Statistical procedure for agricultural research, (2eds.), Wiley, New York, USA. 1984; pp. 680.

Grasso S, Omoarukhe E, Wen X, Papoutsis K. and Methven L. The use of upcycled defatted sunflower seed flour as a functional ingredient in biscuits. Foods. 2019; 8(8): 305. https://doi.org/10.3390/foods8080305

Hadi, F., Mohammad, H.S., Gholamreza, A. and Mostafa, A. (2014). Effect of different micronutrients on growth parameters and oil percent of Azargol sunflower cultivar in Jiroft region. *Bull. Env. Pharmacol. Life Sci.* **3**(7): 97-101.

Hegde MG and Geetha S. Incidence of insect pests and natural enemies in sunflower crop ecosystem. Int. J. Curr. Microbiol. App. Sci. 2018; 7(9): 1593-1601.

Hill, D.S. Agricultural Insect Pests of the Tropics and their Control. 2nd Ed. Cambridge Univ. Press. 1983; p. 746.

Horvath Z. Biological control methods and breeding for resistance against the sunflower moth (*Homoeosoma nebulellum* Hb.) (In Bulgarian). *Novenyvedelen*. 1993; 29: 259-63.

Hugar PG, Anandhi P, Varma SSL. Seasonal incidence of important insect pests of sunflower and their natural enemies in relation to weather parameters, *in Allahabad region Department of Plant Protection*, 2008; AAI-DU, Allahabad - 211 007, U.P, India.

Kastori R, and Grujie S. Institute *Dichimica agarina*, University delistudi. 1992; pp. 507-518.

Keerio RA, Soomro NS, Soomro AA, Siddiqui MA, Khan MT, Nizamani GS, Kandhro MN, Siddiqui M, Khan H, and Soomro FD. Effect of foliar spray of zinc on growth and yield of sunflower (*Helianthus annuus* L.). Pakistan J. Agric. Res., 2020; 33(2): 264-269.

Kumbhar CS, Indulkar BS, and Wagh CB. Effect of micronutrients application on availability of Zn, Fe and B of sunflower (*Helianthus annus* L.) in Inceptisol. Inter. J. Cur. Microb. App. Sci. 2017; 6(11): 438-442.

Mirzapour MH, and Khoshgoftar AH. Zinc Application Effects on Yield and Seed Oil Content of Sunflower Grown on a Saline Calcareous Soil. 2006.

Müller A, Diener S, Schnyder S, Stutz K, Sedivy C, and Dorn S. Quantitative pollen requirements of solitary bees: implications for bee conservation and the evolution of bee-flower relationships. Bio. Conservation. 2006; 130: 604-615.

Nayak SK, Khura N, and Moharana RL. Seasonal abundance of insect pests and natural enemies in sunflower in the Western Undulating zone of Odisha. Pharma Innov. J. **SP**-2022; 11(5): 245-248.

Oyinlola EY. Effect of boron fertilizer on yield and oil content of three Sunflower cultivars in the Nigerian savanna. J. Agric., 2007; 6(3): 421- 426.

Perrin RM. Pest management in multiple cropping systems. *Agro ecosystems.* 1977; 3: 93-118.

Raghu MS, Chari MK, Tuppad GB, and Upperi SN. Effect of secondary and micronutrients on growth, yield parameters and nutrient uptake of sunflower (*Helianthus annuus* L.). Int. J. of Medicinal Plants Res., 2017; 6(3): 328-331.

Rahimi MM. Effect of micronutrients and varieties on yield and yield component of sunflower. Int. J. Bio., 2014; 5: 91-96.

Rahimi A, Arslan Kiralan M. and Day S. Effects of micronutrients on oil quality of sunflower (*Helianthus annuus* L.). Academic Food J., 2012; 10(3): 51-56.

Rana JS. and Sheoran RK. Evaluation of sunflower *Helianthus annuus* L. hybrids against insect pests in semi-arid tropics. J. Oilseeds Res. 2004; 21(2): 374-375.

Ravikumar C, Karthikeyan A, Senthilvalavan P. and Manivannan R. Effect of sulphur, zinc and boron on the growth and yield enhancement of sunflower (*Helianthus annuus* L.). J. Applied and Natural Sci.,2021; 13(1): 295-300.

Reddy SS, Yadahalli YH, Kumar VKK, Kumara O. and Naik AHK. Effect of fertilizer, gypsum and boron application on yield and economics of sunflower hybrids. Crop Res., 2002; 23(3): 450-453.

Rikabder FH. Oilseeds Crop Production Technology. Agriculture Information Service, Ministry of Agriculture, Dhaka-1000. 1987; p. 21.

Saad A. and Al-Doori M. Effect of zinc and boron foliar application on growth, yield and quality of some sunflower genotypes (*Helianthus annuus* L.) Mesopotamia. J. of Agric., 2017; 54(1): 299-318.

Sepehr E, Malakouti MJ, and Rasouli MH. The effect of K, Mg, S, and micronutrients on the yield and quality of sunflower in Iran. 17th The World Congress of Soil Science (WCSS), Thailand. 2002; DOI: 10.13140/RG.2.2.22290.91849.

Sharma KR, Srivastara PC, Ghosh D. and Gangwar MS. Effect of boron and farmyard manure application on growth, yield and boron nutrition of sunflower. Journal of Plant Nutrent. 2008; 22(4 and 5): 633-640.

Siddiqui MH, Oad FC, Abbasi MK and Gandahi AW. Zinc and born fertility to optimize physiological parameters nutrient uptake and seed yield of sunflower. Sarhad J. Agric., 2009; 25(1): 53-57.

Seghatoleslami MJ, Bradaran R, Ansarinia E. and Mousavi SG. Effect of irrigation and nitrogen level on yield, yield components and some morphological traits of sunflower. Pakistan J. Bot.2012; 44(5): 1551-1555.

Shamimuzzaman M. Effects of Mg, S, Zn, Mn and B on growth, yield and oil content of sunflower. MS thesis. 2021; Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka-1207.

Shankergoud I, Shadakshari YG, Parameshwarappa KG, Chandranath HT, Katti, and Mesta RK. Sunflower and Castor Research in Karnataka – An Overview, University of Agricultural Sciences, Dharwad. 2006; pp. 1-41.

Thapa RB. Honeybees and other insect pollinators of cultivated plants: *J. Inst. Agric. Anim. Sci*. 2006; 27: 1-23.

Younas A, Khan Z, Waqil W, Shaaban M. and Prager SM. The efficacy of *Beauveria bassiana*, jasmonic acid and chlorantraniliprole on larval populations of *Helicoverpa armigera* in chickpea crop ecosystems. Pest Manage. Sci. 2016; doi: 10.1002/ps.4297.