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INFLUENCE OF MICRONUTRIENTS AND THEIR METHOD OF APPLICATION ON YIELD AND YIELD COMPONENTS OF SUNFLOWER

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Abstract

The sunflower (*Helianthus annuus* L.) has been recognized as a crop with high potentials that can successfully meet future oil requirements of the country. Formulation of micronutrients (MN) based fertilizer, in terms of application rate and method, and uptake of MN by sunflower has the ability not only to ensure nutrients availability to plants particularly in MN-limiting environments but also can manipulate the environmental hazards associated with over inorganic fertilization. To support this view, clear experimental evidence is still lacking. In addition, the current experiments aimed to evaluate the influence of MN and its method of application on yield and yield components of sunflower cultivars/hybrids. Three sunflower cultivars (HO-1, Hysun-39 and Ausigold-62) along with three MN (Z, B and Fe) and two application methods (soil and foliar) were used in the experiment. Three Zn application rate (3, 5 and 8 kg ha^{-1}) along with 0.75 kg ha^{-1} B and 0.30 kg Fe ha^{-1} were used in four combinations such as 0-0-0, 0-0.75-0.30, 0-0.75-0.30, 3-0.75-0.30, 5-0.75-0.30, 8-0.75-0.30 kg Z, B and Fe ha^{-1}, respectively. A control (no MN) treatment was also included for comparison. Two year averaged study exhibited that foliar application of Zn, B and Fe at rate of 8-0.30-0.75 kg ha^{-1} increased stem girth, head diameter, number of seeds $head^{-1}$, seed weight $head^{-1}$, seed index, oil content and seed yield by 21%, 27%, 13%, 34%, 19%, 24 and 31%, respectively over control. Among cultivars/hybrids, the hybrids HO-1 and Hysun-39 had taller plants, seed weight $head^{-1}$, seeds $head^{-1}$ and earlier in flowering and maturity. Flowering and maturity was delayed in Ausi Gold-62 with higher seed index and oil content. It is concluded that foliar application of micronutrients at the rate of 8+0.75+0.30 Zn, B and Fe kg ha^{-1} had substantially improved yield and yield related traits of sunflower cultivars HO-1, Hysun-39 and Ausi gold-62.

Key words: Sunflower, Cultivars, Micronutrients agronomic traits and method of application.

Introduction

The gap between production and consumption of edible oil in Pakistan has been widening at an alarming pace due to various reasons. The ever increasing populations and urbanization has further widened the gap between the productivity and demand (Munir *et al*., 2007). The total requirements of edible oil during 2009 was about 3.07 m t, in which 0.83 million tons (27%) was produced locally and the remaining quantity was fulfilled by imports. That's why Pakistan is ranked the third largest importer of the world in edible oil (Anon., 2009). Due to this reason, there is a huge burden on national economy of Rs 84000 billion and 13756.83 billion for 1290 and 723.96 thousand tons of edible oil and oilseeds, respectively (Anon., 2013). A developing country like Pakistan cannot afford such a mounting import bill. Thus the situation warrants for increasing the oilseed production in the country. Inadequate fertilizer application, lack of high yielding cultivars/hybrids, in appropriate use of micronutrients and lack of modern production technologies like appropriate methods of fertilizer application are the major constraints for low productivity and hindrance in increasing the yield of the crop to feed ever increasing population of the country. The productivity of sunflower can largely be influenced by cultivation of suitable and high yielding cultivars/hybrids, recommended amount and appropriate methods of micro nutrients application and improved production technology. Sunflower hybrids/cultivars have remarkable genetic differences in terms of flowering, maturity and plant height (Andrade *et al.,* 2002).

The best option would be through the plant breeding strategies or application of micronutrients to the crops to enhance their uptake. Likewise, the application of micronutrients will not only meet the national diet to the starving people but will also improve the yield of the crop (Welch & Graham, 2002). Application of micronutrients increase the uptake of all the plant nutrients and enhance the mechanism against disease and pest thus consequently improve yield and plant growth (Anuprita *et al*., 2005). Zinc is recognized among the important nutrients considered as essential for the plant growth and development and is found one of the limiting factors for crop yields (Cakmak, 2008).

Boron is involved in cell wall synthesis, maintenance, sugar translocation and membrane integrity (Dordas & Brown, 2001) and its requirement is higher for seed production than vegetative production. The use of boron has increased the vegetative and reproductive growth of the sunflower (Asad *et al*., 2003). Iron (Fe) is also one of the important nutrient involved in the formation of chlorophyll and light reaction of electron transport chain and thus can enhance the growth and yield of crop (Kakar *et al.,* 2000; Tariq and Mott, 2006). Similarly, it has important role in the synthesis of cell wall and anions absorption, viability of pollen and carbohydrates and fats metabolism (Oyinlola, 2007). Similarly, El-Fouly *et al.* (2001) found that number of leaves and the leaf area of sunflower were increased with application of Zn, Fe, Mn and Boron. Chitdeshwari & Duraisami (2005) reported an increase in seed yield by the application of B and Zn and also

resulted in greatest Zn and B availability in soil after harvest and Zn, B and Fe uptake by plants. Madan Kumar & Söll (2000) and Schuster (2008) reported that Fe was needed for increasing chlorophyll content, and reduction in the chlorosis.

Micronutrients application such as zinc, boron and iron each as broadcast as well as foliar application had enhanced yield, yield components and seed oil (Alloway, 2008; Zou *et al*., 2001). Foliar applications of micronutrient have been effective (Savithri *et al*., 1999) and especially significance in case of rapid absorption of the required nutrients (Kinaci & Gulmezoglu, 2007). Foliar application also promoted root absorption of the same or other plant nutrients by increasing growth of roots and uptake of nutrients (Saqib *et al*., 2006). Kołota & Osinska (2001) reported that foliar application was a successful method of nutrients supply during exhaustive periods of plant growth for the growth and crop yield. Foliar application of minerals like Zn, B, and Fe are considered more realistic as compared to soil application due to its adsorption with soil particles and lesser contact with the roots of crop (Wissuwa *et al*., 2008). Recently, the application of micronutrients is extensively used both as broadcast and foliar for increasing the productivity of crops, therefore, application of micronutrients may need to be examined by the appropriate method and dosage for enhancing the seed and oil yield of sunflower.

The present investigation was therefore, undertaken to find out the effect of micro nutrients Zn, B and Fe, using suitable methods of application under the Agro-climatic conditions of Tandojam (Sindh) on the agronomic traits of sunflower cultivars.

Material and Methods

Soil characteristics of experimental site: The soil of the experiment area (before sowing) was clay loam in texture, non-saline, EC (0.94 dSm^{-1}), alkaline in reaction pH 8.3, calcareous ($CaCO_3$ 9.7%), low in organic matter (0.56%), total nitrogen content was 0.06% available phosphorus 3.06 mg kg^{-1}, but high in exchangeable potassium (165 mg kg^{-1}), available zinc (0.32 mg kg^{-1}) available boron (0.64 mg kg^{-1}) and available iron (000) respectively.

Treatments and design: The factorial experiment was carried out in randomized complete block design with three replications .The plot size was 4 m × 3m having four rows 4 meters long with row to row and plant to plant spacing of 75 and 30 cm, respectively. The experiment was conducted on three sunflower cultivars i.e. HO-1, Hysun-39 and Ausigold-62, micronutrients levels (0-0-0, 0-0.75-0.30, 0-0.75-0.30, 3-0.75-0.30, 5-0.75-0.30, 8-0.75-0.30 kg Z, B and Fe ha^{-1}, respectively) and methods of nutrients application i.e., placement and foliar application. For foliar application of fertilizers, the required amount of the fertilizer was weighed and mixed with 20 liters of water and put in Knapsack sprayer before use. For placement method of application, the required amount of the fertilizer was thoroughly mixed with 5 kg of soil. These were prepared on the same day. Seeds of three sunflower cultivars collected from ARI Tandojam and were sown by drilling at the recommended seed rate of 8 kg ha^{-1} in spring season during the years 2011 and 2012. After sowing the plant to plant distance of 30 cm was maintained by thinning. The recommended dose of NPK (120-50-50 kg ha^{-1}) was applied to each plot. The nitrogen was applied in the form of urea, phosphorus as single super phosphate and potassium as sulphate of potash. Micro-nutrients fertilizers (zinc, boron and iron) were applied in the form of $ZnSO_4$, Solubor/Borex and Indiplex, respectively (in chelated form). The full dose of phosphorus and potassium with the half nitrogen was applied at the time of sowing, whereas, remaining amount of nitrogen was applied in two equal splits at 1st and 2rd irrigations. Other agronomic practices like irrigations; weeding, thinning and intercultural practices along with plant protection measures were followed uniformly to all plots as per recommendations.

Data recording procedure: Germination percentage of sunflower was recorded when 80% emergence of seedling was completed in each plot. Data on plant height was determined by randomly selected 15 plants in each plot and the height was measured from base to tip of disk of each plant and then average was calculated. Days to flowering and maturity were recorded as the difference between sowing date and the date on which 75% of the plants produced flowers in each plot. Stem girth was recorded by measuring the top, middle and bottom of stem of 15 plants randomly selected in each plot at physiological maturity and then the average was worked out. Data on head diameter was recorded by selecting 15 heads at random in each plots and the radius was measured by measuring tape and then was converted to diameter and averaged. Data on seeds $head^{-1}$ was determined by counting number of seeds in ten randomly selected heads for each experimental unit and then was calculated. Seed weight $head^{-1}$ data was noted by taking 10 randomly selected heads and their seeds were threshed and weighed and was calculated. Seed index data was recorded by weighing 1000 seeds from the seed lot of each experimental unit with the help of electronic balance. For seed yield data, three central rows in each plot were harvested and the heads were separated, dried in the open sun for few days and then were threshed and seeds obtained after separation from the straw were weighed and converted to kg ha^{-1}.

Statistical analysis: The experiment was arranged in randomized complete blocks design having three factors. Data were analyzed statistically through Genstat software by using procedure appropriate for the said design of both years separately and combine over year. The LSD test was performed as mean comparison test when the F test was found significant at a probability of ≤ 0.05 (Jan *et al*., 2009).

Results

Micronutrients levels: Data regarding agronomic traits of sunflower are presented in Table 1. All agronomic traits were significantly influenced by application of zinc (Zn) boron (B) and iron (Fe) except germination percentage, days to flowering and maturity. Application of micronutrients at the rate of 8-0.30-0.75 kg Z-B-Fe ha^{-1} had higher stem girth (8.4 cm), head diameter (16.33cm), number of seeds $head^{-1}$ (441.5), seed weight $head^{-1}$ (32.9 g), seed index (74 g), oil content (39.05%) and seed yield (1913 kg ha^{-1}) of sunflower followed by treatment (5-0.30-0.75 kg Zn-B-Fe ha^{-1}) however, the seed yield and oil content were statistically similar with each other. The plots where no micronutrients was applied (control) had the smallest stem girth (5.84 cm), head diameter (8.55 cm), number of seeds $head^{-1}$ (388.1), seed weight $head^{-1}$ (16.8 g), seed index (43 g), oil content (38.17%) and seed yield (1390 kg ha^{-1}). This was followed by the plots where only boron and iron were applied at the same rates.

Sunflower cultivars: Data regarding agronomic, physiological and nutrient contents and uptake of nutrients are shown in Table 2. The analysis of the data showed that significant differences were recorded among sunflower cultivars for all agronomic traits except seed yield under micronutrient nutrition. It is pertinent from the mean values that the sunflower cultivar HO-1 and Hysun-39 produced plants with higher heights (119. 6 cm and 119.2 cm), heavier seed weight $head^{-1}$ (23.7 g and 23.4 g), more number of seeds $head^{-1}$ (425.5 and 432.3) and earlier flowering and maturity (63.2 and 94.7 days) whereas, the cultivar HO-1 was superior in germination (85.3%) and head diameter (12.9 cm). Higher stem girth (7.43 cm) was recorded for the hybrid Hysun-39. Flowering and maturity was delayed (66 and 96 days) in Ausi Gold-62 with higher seed index (58.1g) and oil content (39.4%). However, the seed yield remained similar for both the hybrids and local cultivar.

Application methods: Data regarding agronomic traits are shown in Table 3. The statistical analysis showed that effect of fertilizer application methods was significant for all agronomic parameters except germination, flowering and seed yield. Data showed that higher plant height (124.2 cm), stem girth (7.4 cm), head diameter (13 cm), seed weight (24.1 g), seed index (59.6 g) and oil content (38.7%) were recorded in plots where foliar spray was made whereas short stature plants(111.8 cm), stem girth (6.6 cm), head diameter (10.6 cm), seed weight (21.9 g), seed index (50.7 g) and oil content (38.2%) was recorded when micronutrients were applied by placement method, however number of seeds $head^{-1}$ of sunflower was higher (419.1) in placement method of application as compared to foliar spray (403.5).

Table 1. Effect of zinc, boron and iron on yield and yield components of sunflower cultivars.

Traits	Micronutrients (Zn + B + Fe kg ha^{-1})					$LSD_{0.05}$
	0-0-0	0-0.75-0.30	3-0.75-0.30	5-0.75-0.30	8-0.75-0.30	
Germination (%)	83.38	84.16	84.10	84.63	85.20	ns
Days to flowering	63.83	64.08	64.36	64.64	64.92	ns
Days to maturity	95.75	95.19	95.33	94.86	95.94	ns
Plant height (cm)	86.90 e	98.87d	115.26c	134.07b	154.80a	4.26
Stem girth (cm)	5.84 e	6.41d	6.86c	7.26b	8.40a	0.19
Head diameter (cm)	8.55 e	9.35d	10.97c	13.99b	16.33a	0.52
Seeds $head^{-1}$	388.11 c	394.5 bc	419.7 ab	412.7 bc	441.5 a	24.12
Seed weight $head^{-1}$(g)	16.8 e	18.0 d	20.8 c	26.5 b	32.9 a	0.61
Seed index (g)	43.0 e	45.2 d	49.8 c	63.7 b	74.0 a	1.9
Oil content (%)	38.17b	38.19b	38.48ab	38.44ab	39.05a	0.62
Seed yield (kg ha^{-1})	1390 d	1473 c	1615 b	1905 a	1913 a	57

In each row, means followed by common letter are not significantly different at 5% probability level

Table 2. Agronomic traits of various cultivars of sunflower during the year 2011 and 2012.

Traits	Cultivars			$LSD_{0.05}$
	HO-1	Hysun-39	Ausi Gold 62	
Germination (%)	85.25 a	83.37 b	84.26 b	1.29
Days to flowering	63.17 b	63.92 b	66.02 a	1.02
Days to maturity	94.68 b	95.60 b	95.97 a	1.00
Plant height (cm)	119.58 a	119.15 a	115.20 b	3.30
Stem girth (cm)	6.70 b	7.43 a	6.73 b	0.15
Head diameter (cm)	12.93 a	11.65 b	10.93 c	0.40
Seeds $head^{-1}$	425.45 a	432.33 a	376.14 b	18.69
Seed weight $head^{-1}$(g)	23.72 a	23.41 a	21.87 b	0.47
Seed index (g)	52.88 c	54.40 b	58.11 a	1.47
Oil content (%)	37.56 c	38.49 b	39.35 a	0.48
Seed yield (kg ha^{-1})	1648	1657	1674	Ns

In each row, means followed by common letter are not significantly different at 5% probability level

Table 3. Effect of micronutrient application method on agronomic traits of sunflower.

Parameters	Methods		$LSD_{0.05}$
	Foliar	Placement	
Germination (%)	84.2 a	84.4 a	Ns
Days to flowering	64.3 a	64.5a	Ns
Days to maturity	96.1 a	94.7 b	0.82
Plant height (cm)	124.2 a	111.8 b	2.70
Stem girth (cm)	7.4 a	6.6 b	0.12
Head diameter (cm)	13.0 a	10.6 b	0.33
Seeds $head^{-1}$	403.5 b	419.1 a	15.26
Seed weight $head^{-1}$ (g)	24.1 a	21.9 b	0.38
Seed index (g)	59.6 a	50.7 b	1.20
Oil content (%)	38.7 a	38.2 b	0.39
Seed yield (kg ha^{-1})	1659	1660	Ns

Means of each row followed by different letters are significantly different from each other at 5% level of probability

Table 4. Interactive effect between micronutrient application methods and cultivars on agronomic traits of sunflower.

Traits	$LSD_{0.05}$	Placement methods x cultivars					
		Foliar			Placement		
		HO-1	Hysun-39	Ausi Gold 62	HO-1	Hysun-39	Ausi Gold 62
Stem girth (cm)	0.21	6.97bc	8.01a	7.10b	6.43d	6.86c	6.36d
Head diameter (cm)	0.57	14.47a	12.74b	11.90c	11.40c	10.56d	9.97e
Seeds $head^{-1}$	26.43	434.83b	400.58cd	375.19d	416.06bc	464.07a	377.08d
Seed weight $head^{-1}$ (g)	0.66	24.72a	24.88a	22.75b	22.71b	21.95c	20.99d
Seed index (g)	2.08	56.65b	61.55a	60.48a	49.10c	47.25c	55.74b

Application methods and cultivars: Data regarding agronomic parameters of sunflower as influenced by the interactive influence of cultivars and fertilizer application methods are shown in Table 4. Statistical analysis of the data indicated that stem girth, head diameter, seed $head^{-1}$, seed weight $head^{-1}$ and seed index was significantly influenced by the interaction between application methods of micronutrients and sunflower cultivars/hybrids whereas there were no significant variations in plant height, germination, days to flowering and maturity, seed yield and oil content of sunflower for the interactive effect of both factors. All the cultivars showed differential response with the method of micronutrient application for all the significant traits. Stem girth, head diameter, seed weight $head^{-1}$ and seed index of all the cultivars decreased when the micronutrients was applied as placement as compared to foliar spray of the micronutrients however, more number of seed $head^{-1}$ was recorded in Hysun-39 when the micronutrients were applied as Placement compared to foliar spray. Bulky stems of the hybrid Hysun-39 were recorded under foliar method of micronutrient application followed by both Ausi Gold and HO-1 which were statistically similar with each other whereas, it was lower for the cultivar Ausi Gold-62 under the placement method of micronutrients application. Likewise, higher seed index was produced by the hybrid Hysun-39 under foliar method of micronutrient application which was at par with the cultivar Ausi Gold-62 under the same methods of fertilizer application. The seed index was lower for the same cultivars when fertilized through placement method. Bigger heads and higher seed weight $head^{-1}$ was recorded for HO-1 when fertilized as foliar followed by the Hysun-39 whereas lower diameter and seed weight $head^{-1}$ was recorded for the cultivars Ausi Gold-62 when fertilized as placement.

Micronutrient application methods and levels: Significant variations in plant height, stem girth, head diameter, seed $head^{-1}$, seed weight and seed index of sunflower were recorded for the interaction between micronutrients levels and methods of application whereas, the remaining traits were found non- significant. The effectiveness of micronutrients levels were increased for all the significant traits when the application of those nutrients was done as foliar as compared to the placement method of application except number of seed $head^{-1}$. Plant height, stem girth, head diameter, seed weight and seed index of sunflower were improved at treatment (8-.75-0.30 kg Z- B- Fe ha^{-1}) applied as foliar spray followed by the same treatment when applied as placement (Table 4). The number of seeds $head^{-1}$was higher in the treatment when Zn, B and Fe were applied as placement at rate of 8-0.75 and 0.30 kg ha^{-1}, respectively producing almost similar number of seeds $head^{-1}$ which was also at par with the treatments where zinc was applied both foliar as well as placement up to 3 kg ha^{-1} with the same amount of B and Fe in combination.

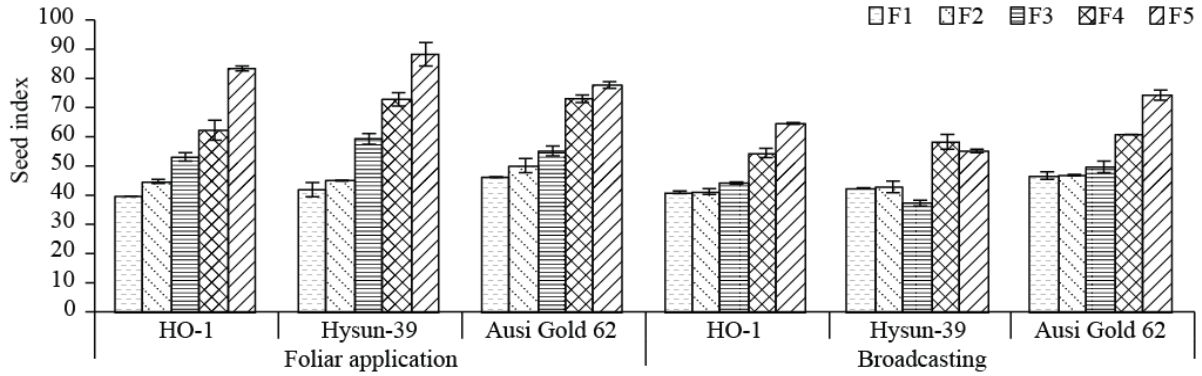

Fig. 1a. Interaction between methods of application and fertility levels of various sunflower cultivars for seed index.

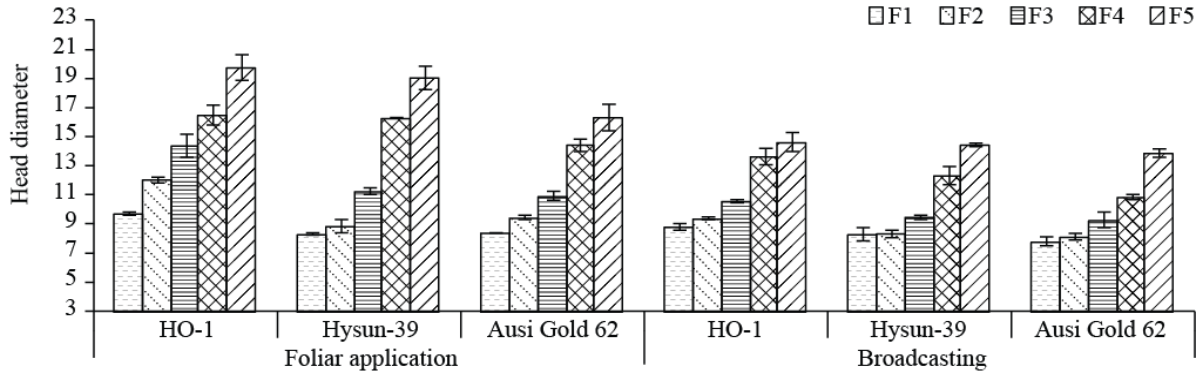

Fig. 1b. Interaction between methods of application and fertility levels of various sunflower cultivars for head diameter.

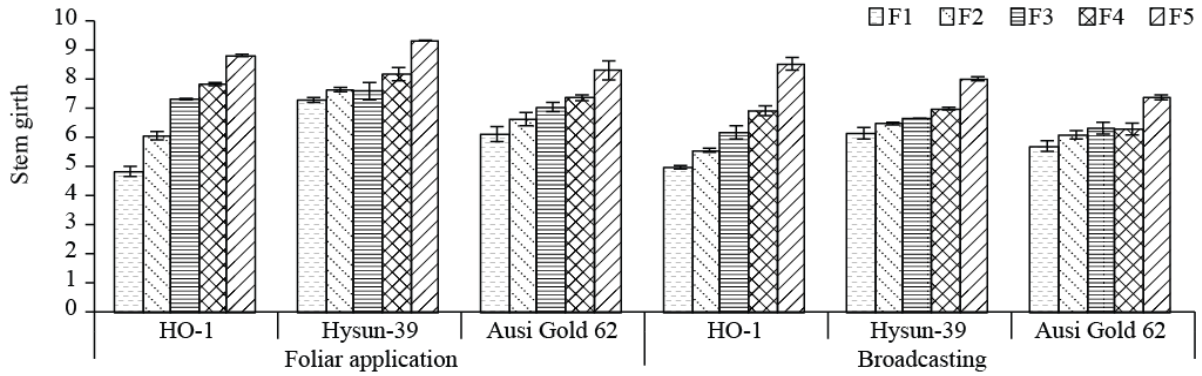

Fig. 1c. Interaction between methods of application and fertility levels of various sunflower cultivars for stem girth.

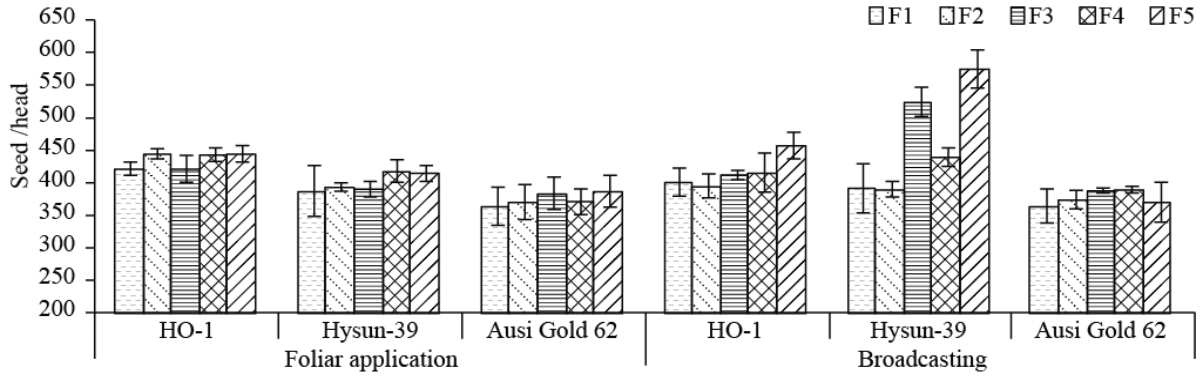

Fig. 1d. Interaction between methods of application and fertility levels of various sunflower cultivars for seeds head^{-1}.

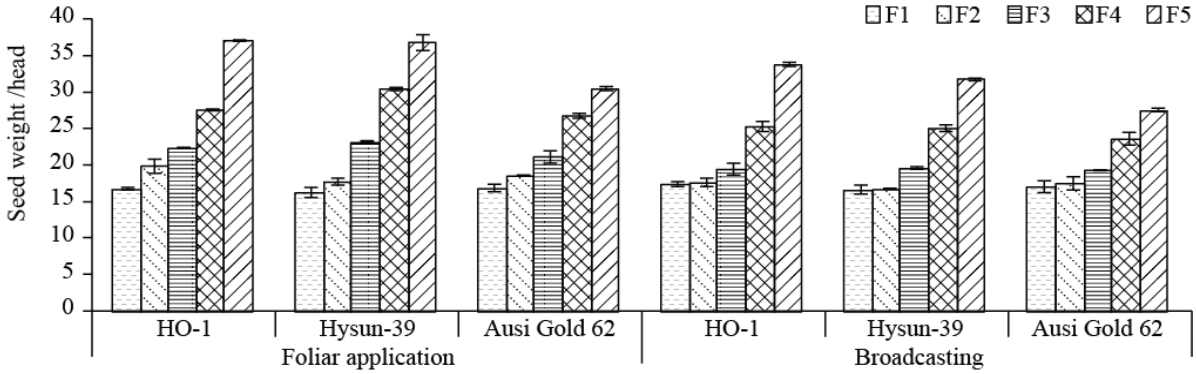

Fig. 1e. Interaction between methods of application and fertility levels of various sunflower cultivars for seed weight head^{-1}.

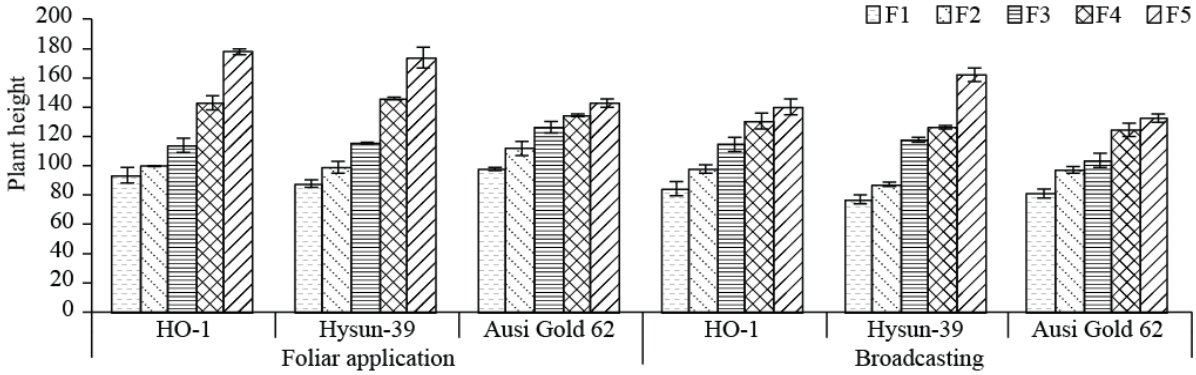

Fig. 1f. Interaction between methods of application and fertility levels of various sunflower cultivars for plant height.

Micronutrients levels and methods of application and cultivars: The interaction among micronutrient levels x application methods x cultivars showed significant response to all agronomic traits except germination (Fig. 1a-f). Plant height was ranged from 173.6 cm to 76.97 cm and the maximum plant height was attained by HO-1 when the highest levels of micronutrients was applied as foliar spray however, it was at par with the hybrid Hysun-39 for the same plots. The same cultivar Hysun-39 ranked 2nd when received the same fertility applied as placement. Flowering was delayed by Ausigold-62 for higher fertility levels applied both as foliar and Placement whereas plants of HO-1 and Hysun-39 produced flower earlier with inconsistent response of fertility applied by both methods of application. Maturity was delayed in Ausi gold-62 under 2nd highest levels of micronutrients applied as foliar however it was at par with all cultivars at all levels of fertility applied as foliar and soil applied except the lower levels of fertility applied as placement for Hysun-39 and Ausigold-62. Sunflower stem girth ranged between 4.8 to 9.3 cm and the highest stem girth was recorded by Hysun-39 when micronutrients was applied as foliar spray at the highest levels followed by the same fertility and applied methods for HO-1. Head diameter was also higher for the higher fertility applied as foliar for HO-1 followed by the same combination for the sunflower hybrid Hysun-39 whereas it was decreased for all other treatment combinations for all cultivars. Seeds head^{-1} was higher when the micronutrients was applied as placement at the highest level for Hysun-39. Seed weight head^{-1} was higher for higher level of fertility applied as foliar for both HO-1 and Hysun-39.

Discussion

All agronomic traits were considerably varied among sunflower hybrids except seed yield. The differences in these traits might be due to the variability in genetic makeup of tested cultivars. These results are in accordance with the findings of Espinosa *et al*. (1992) and Bakht *et al*. (2006), who also observed substantial differences for most of the agronomic traits among sunflower hybrids due to its genetic variability. Higher plant height, seed weight head^{-1}, number of seeds head^{-1} and early flowering and maturity was recorded in sunflower hybrids HO-1 and Hysun-39. Significant differences among sunflower hybrids for seed weight were also reported by Bakht *et al*. (2006). The cultivar HO-1 was superior in germination and head diameter whereas the stem girth was higher in case of Hysun-39. The results are in line with the findings of Sarwar *et al*. (2013) who also reported that Hysun-33 showed greater plant height and seeds head^{-1} than remaining hybrids. Likewise, the results are in agreement with Khan (2003) who found significant differences among the hybrids for head diameter. The variation in days to flowering and maturity by the sunflower hybrids might be ascribed to genetic difference among the respective hybrids and the same was reported with Iqbal (2008) where substantial differences were observed for days to flowering and maturity among hybrids. These results are in line with the Reddy *et al.* (2002) also demonstrated an increase in plant height and stem diameter and days to maturity that of sunflower hybrid 'KBSH-44' than the hybrid KBSH-1. Similarly several researchers (Reddy *et al.,* 2002; Saleem & Malik, 2004) reported disparity in agronomic and

productive potential for various sunflower hybrids. The seed yield of all cultivars remained statistically similar with each other. However, Zheljazkov *et al*. (2010) reported significant differences among different sunflower hybrids for seed yield and oil content.

Foliar application of micronutrients is important when the roots cannot provide necessary nutrients (Kinaci & Gulmezoglu, 2007) and hence the application on the foliage can help in the rapid absorption of the required nutrients by the crop for higher production. The effect of fertilizer application methods was significant on all agronomic parameters except germination, flowering and seed yield. The probable reason for improved agronomic traits of sunflower with foliar application of micronutrients might be ascribed to the direct and rapid absorption of these micro nutrients on the foliage of the crop. The same was reported by many other scientists in several crops including sunflower crop (Singh, 2000; Khurana & Chatterjee, 2001). Similar results were also obtained by Tariq *et al*. (2010) who found that foliar application of B had better response than placement. The increase with soil application of micronutrients might be due to the increase in the concentration of available Zn, B and Fe in soil. Contrary to our findings, Banks (2004) found that number of seed head^{-1} was enhanced by foliar application of Zn. Likewise, Babaeian *et al*. (2011) reported that foliar application of Fe and Zn had improved 1000-seed weight, plant height, biological yield, grain yield, harvest index and oil content of sunflower. Movahhedy-Dehnavy *et al*. (2009) also found that application of Zn significantly enhanced seed yield. Likewise, Vyakaranahal *et al.* (2001) reported that B application as foliar spray at 0.1% enhanced seed yield by 49.0 and 43.1% in spring and fall sunflower crops, respectively.

The use of micronutrients has a profound effect on the growth and development of plants as they are essential for plant growth since they increase the absorption and uptake of NPK and also trigger the defense mechanism of plants and ultimately enhance plant growth (Anuprita *et al*., 2005). The improvement in sunflower yield components in various micronutrients applied plots may be due to the increase amount of assimilates translocation, activation of photosynthetic enzymes, chlorophyll formation and improvement of plant growth (Movahhedy-Dehnavy *et al*., 2009). Micronutrient enhance oil content as they are responsible for supplying plant need (Ravi *et al*., 2008). Heitholt *et al.* (2002); Adediran *et al.* (2004) and Taiwo *et al. (*2001) demonstrated an increase in seed yield with the application of micronutrients. Application of both Zn and B increased yield as compared to control (Gitte *et al*. (2005). Likewise, Soylu *et al*. (2005) and Heitholt *et al*. (2002) reported an increase in 1000-grain weight and number of grains head^{-1} with the application of Zn and Fe. The application of micronutrients had positive effect on the yield and other quantitative traits of crops as reported by many scientists (Tavassoli *et al*., 2010; Paygozar *et al*., 2009). Mirzapour *et al.* (2006) showed that the application of Zn had considerable influence on seed index of sunflower. Our results are in line with Trehan & Sharma (2000) who investigated that 5 kg Zn ha^{-1} had enhanced seed yield of sunflower.

The differential response regarding stem girth, head diameter, seed weight head^{-1} and seed index among sunflower cultivars might be due the efficient utilization of the micronutrients applied as foliar compared to the broad cast methods. However, more number of seeds head^{-1} was produced by Hysun-39 for micronutrients application as placement compared to foliar spray. Differences in cultivars may be attributed to the genetic potential. Application of micronutrients as foliar spray might have enhanced the availability of macro and micronutrients as well as the activated defense mechanism thus increased the vegetative growth (Anuprita *et al*., 2005). The present results are in accordance with Babaeian *et al*. (2011) who also reported that foliar application of Zn and Fe substantially improved plant height, 1000-seed weight, biological and grain yield and oil content. Thus the optimum application of micro-nutrients with efficient methods is important for improving agronomic traits of sunflower.

Conclusion

It is concluded from the two years studies that the micronutrients foliar application considerably improved most of the agronomic traits of sunflower. Sunflower cultivars HO-1, Hysun-39 and Ausi gold-62 produced higher yield when ZnBFe fertilizer was applied as foliar spray at the rate of 8+0.75+0.30 ZnBFe kg ha^{-1}, respectively.

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