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Rajath E
M. Sc (Agri) Student, Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Raichur, Karnataka, India

Narayana Rao K
Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Raichur, Karnataka, India

Kirana Kumara
M. Sc (Agri) Student, Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Raichur, Karnataka, India

Corresponding Author:
Rajath E
M. Sc (Agri) Student, Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, Raichur, Karnataka, India

Effect of foliar nutrition of micro nutrients mixture on nutrient uptake by sunflower (*Helianthus annuus* L.)

Rajath E, Narayana Rao K and Kirana Kumara

Abstract
The field experiment was conducted at MARS farm Raichur to study the response of sunflower to foliar application of micronutrient mixture. General Grade-I micronutrient mixture recommended by Karnataka State Department of Agriculture consisting Fe: 2.0%, Mn: 1.0%, Zn: 3.0% and B: 0.5% prepared at laboratory was used in the study. Treatments includes RDF, RDF + $ZnSO_4$ @ 10 kg ha^{-1} and combination of these two treatments with foliar application of Grade-I micronutrient mixture @ 2.5, 5.0 and 10 ml L^{-1} of water with a spray volume of 300 litres is used. One absolute control was also included as a treatment to assess the impact of micronutrient mixture foliar application on sunflower nutrient uptake. The foliar application of micronutrient mixture has resulted higher nutrient uptake than the absolute control and treatments without foliar applications. The highest uptake of nutrients was observed in a treatment that received application of RDF (90:90:60 kg ha^{-1} of NPK plus 100 kg ha^{-1} of gypsum) + soil application of $ZnSo_4$ @ 10 kg ha^{-1} with foliar application of micronutrient mixture @ 10 ml L^{-1} of water when compared to the other treatments.

Keywords: Sunflower, uptake, micronutrient mixture

Introduction
Continuous use of high analysis fertilizers under intensified cropping and neglect of organic manures manifested the occurrence of wide spread micronutrients deficiencies; especially of Zn and Fe in many soils of India after 1960. But, later multiple nutrient deficiencies were reported in crops for N, P, K, Fe, Zn, S, B, Mn and Mo within a time frame of 1960 to 2005. According to soil fertility atlas for Karnataka, jointly done by KSDA and ICRISAT, 2011 revealed that 55 per cent, 62 per cent, and 34 per cent of soils of Karnataka are deficient in zinc, boron and iron respectively (Wani *et al*., 2011) [12]. Though these nutrients are required in low quantity, their deficiencies are responsible for low quality and low productivity of sunflower and many crops.

The multi-micronutrients mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth, and are more relevant under site specific nutrient management practices. The low use efficiency of fertilizers, supplying nutrient, in large proportion can be improved by their modifications to lessen the negative aspects as well as trying to combine one or two more nutrients so that with the same application effort, crop benefits with multi-nutrient needs. Therefore, there is a need to promote balanced fertilization for which use of appropriate multi-micronutrient mixture grades would play a big role to improve nutrients use efficiency and enhance crops productivity for food and nutritional security.

Material and methods
The field experiment was conducted at MARS farm Raichur, during *kharif* 2017. Raichur is located in Zone-2 (North Eastern Dry Zone) of Karnataka at latitude, longitude and altitude of 16º 15' N, 77º 20' E and 389 meters above the MSL, respectively.

Experiment was laid out in a Randomized Complete Block Design (RCBD) with nine treatments were replicated thrice, and hybrid used was KBSH-44.

The multi micronutrient mixture (Grade I) was prepared as per Karnataka State Department of Agriculture recommendations consisting of Fe: 2.0%, Mn: 1.0%, Zn: 3.0% and B: 0.5%. This mixture was prepared in the laboratory by using iron sulphate, manganese sulphate, zinc sulphate and boric acid. The prepared mixture was preserved by adding a pinch of citric acid.

Initial soil properties

pH (1:2.5)	Ec (ds m^{-1})	OC (g kg^{-1})	N	P_2O_5	K_2O	Fe	Zn	Mn	Cu	B
			Kg ha^{-1}			mg kg^{-1}				
7.65	0.13	4.6	282.8	31.0	319.2	4.15	0.54	17.20	0.94	0.89

Treatment details

T1: RDF (NPK @ 90:90:60 and Gypsum @100 kg ha-1)
T2: T1 + ZnSO4 @ 10 kg ha-1 soil application
T3: T1 + Foliar spray of Grade-1 micronutrient mixture @ 2.5 ml L-1of water
T4: T1 + Foliar spray of Grade-1 micronutrient mixture @ 5 ml L-1of water
T5: T1 + Foliar spray of Grade-1 micronutrient mixture @ 10 ml L-1of water
T6: T2 + Foliar spray of Grade-1 micronutrient mixture @ 2.5 ml L-1of water
T7: T2 + Foliar spray of Grade-1 micronutrient mixture @ 5 ml L-1of water
T8: T2 + Foliar spray of Grade-1 micronutrient mixture @ 10 ml L-1of water
T9: Absolute control

Note:

1. All the treatments receive FYM @ 8 t ha^{-1} as common basal application except absolute control.
2. KSDA Grade-I Multi micronutrient mixture of Fe- 2.0%, Zn- 3.0%, Mn- 1.0% & B- 0.5%.
3. 75% Nitrogen is applied as basal and remaining 25% at 40 DAS.
4. Micronutrients mixture spray was done at 30, 45 and 60 DAS.

Results and Discussion

Uptake of primary nutrients (NPK)

Application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 5 ml L^{-1} of water @ 30, 45 and 60 DAS has recorded highest uptake of nitrogen at 60 DAS (60.13 kg ha^{-1}), whereas highest nitrogen uptake at 45, 75 DAS and at harvest was recorded with application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS (Table 1and Fig. 1).

Table 1: Effect of foliar nutrition of micronutrient mixture on total nitrogen uptake by sunflower at different intervals (kg ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	39.01	38.91	48.99	81.40
T_2	44.00	51.13	66.23	96.52
T_3	45.25	46.10	57.44	90.32
T_4	45.92	47.99	58.65	93.20
T_5	46.86	48.69	59.63	95.80
T_6	46.06	53.86	69.05	101.14
T_7	47.45	60.13	70.80	104.27
T_8	53.89	55.45	76.33	109.53
T_9	30.56	32.52	36.72	63.33
S.Em. ±	0.99	1.46	0.96	0.94
C.D. @ 5%	2.96	4.38	2.88	2.82

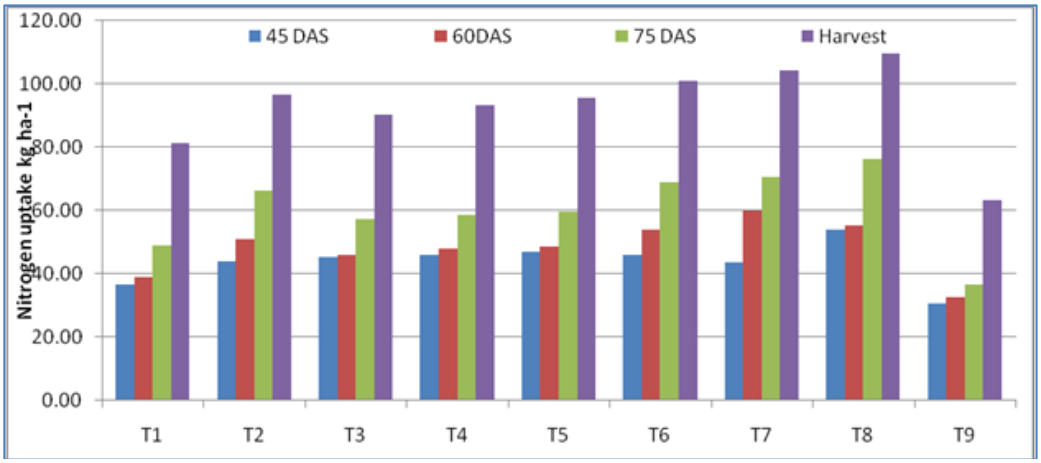

Fig 1: Effect of foliar nutrition on Nitrogen uptake by sunflower (kg ha^{-1})

There was no significant difference was observed with respect to total phosphorous uptake at 45 DAS, but at 60 DAS highest and significant phosphorous uptake (7.69 kg ha^{-1}) was recorded with RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 5 ml L^{-1} of water. At 75 DAS and harvest stages (T_8) has recorded highest phosphorous uptake (17.10 and 21.14 kg ha^{-1}, respectively), (Table 2 and Fig. 2).

Table 2: Effect of foliar nutrition of micronutrient mixture on total phosphorous uptake by sunflower at different intervals (kg ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	2.31	5.16	9.37	15.49
T_2	3.00	6.91	13.66	17.48
T_3	2.78	6.33	14.39	18.07
T_4	2.91	6.70	14.83	18.83
T_5	2.95	6.83	15.50	19.32
T_6	3.17	7.26	14.23	19.47
T_7	3.26	7.69	15.98	20.47
T_8	3.33	7.46	17.10	21.14
T_9	1.96	4.39	7.42	12.37
S.Em. ±	0.04	0.05	0.22	0.20
C.D. @ 5%	NS	0.15	0.67	0.59

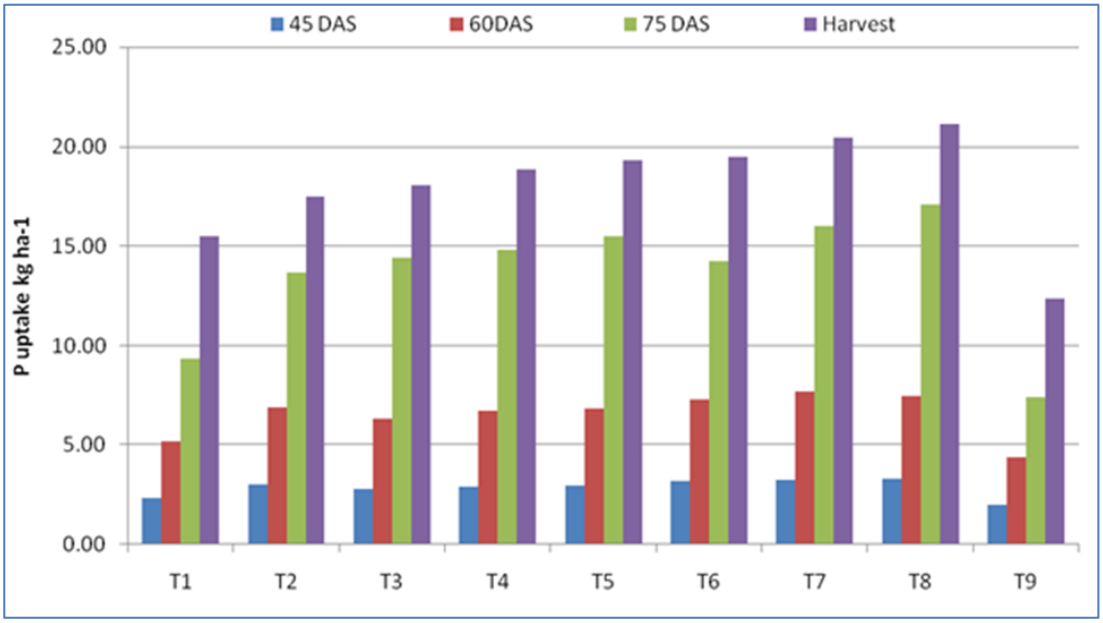

Fig 2: Effect of foliar nutrition on Phosphorous uptake by sunflower (kg ha^{-1})

Highest potassium uptake at 45, 75 and at harvest (52.23, 85.64 and 125.15 kg ha^{-1}, respectively) stages was recorded with the application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS. Whereas, at 60 DAS highest potassium uptake (78.23 kg ha^{-1}) was recorded with T_7 (Table 3 and Fig. 3).

Table 3: Effect of foliar nutrition of micronutrient mixture on total potassium uptake by sunflower at different intervals (kg ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	40.56	60.84	67.30	105.36
T_2	45.31	69.88	77.30	113.55
T_3	44.86	68.29	74.96	111.38
T_4	46.19	70.19	75.51	113.44
T_5	48.40	72.36	76.80	116.47
T_6	48.52	72.85	80.38	118.44
T_7	50.12	78.23	81.91	121.76
T_8	52.23	74.95	85.64	125.15
T_9	36.44	49.32	50.32	82.38
S.Em. ±	0.56	0.62	1.16	0.69
C.D. @ 5%	1.67	1.85	3.49	2.06

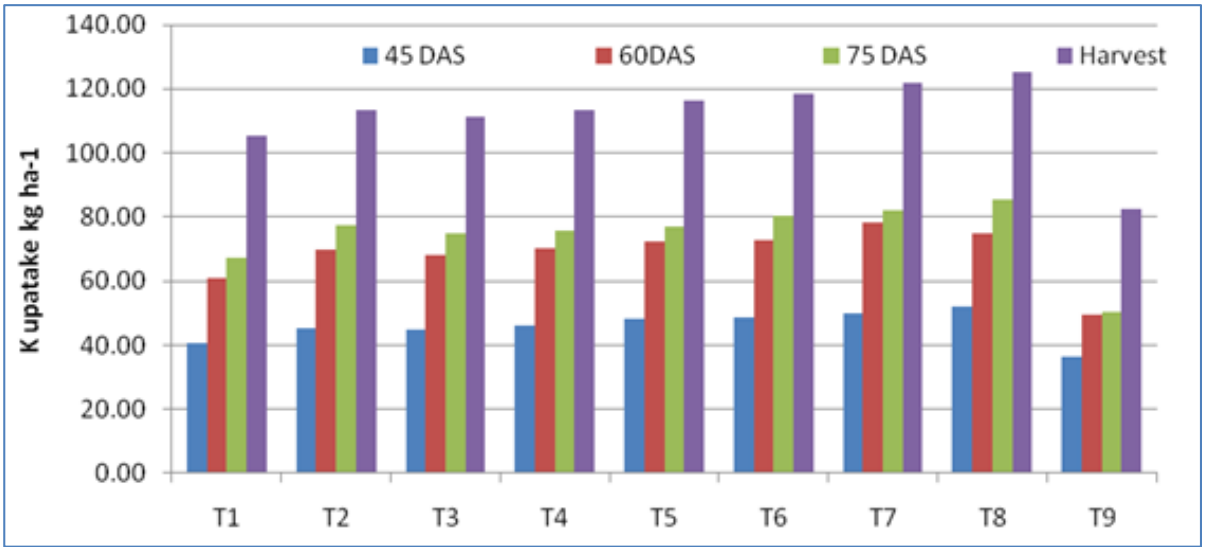

Fig 3: Effect of foliar nutrition on Potassium uptake by sunflower (kg ha^{-1})

Since the uptake is product of dry matter and nutrient concentration, increased uptake may be attributed to higher dry matter production owing dominant role played by Fe, Zn, Mn and B in improving the photosynthetic ability and assimilating capacity of crop by being a component in various enzymatic and other biochemical reactions. The results obtained were in accordance with Aruna *et al.* (2001) [1] and Chowdhary *et al.* (2010) [4] in sunflower.

Uptake of micronutrients (Fe, Zn, Cu, Mn and B)

Application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS has recorded highest uptake of iron at all growth stages (475.10, 685.96, 702.40 and 1377.28 g ha^{-1}, respectively) (Table 4 and Fig. 7). This may be complimented to application of FYM which chelated the iron in soil and made easier availability to plant and also due to absorption of iron from foliar application of micronutrient mixture which contained Fe. Similar results were reported by Hilton and Zubriski (1985) [7], Vinay Kumar (2017) [11] and Babaeian *et al*. (2011) [2].

Highest zinc uptake of 85.35, 186.44, 208.98 and 382.28 g ha^{-1} at 45, 60, 75 and harvest, respectively (Table 5 and Fig. 4) were recorded in T_8 with the application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS. This was due to combined application of Zn through soil and foliage at grand growth stages led to increased availability in soil and increased absorption by above ground parts of sunflower and also due to higher biomass in respective treatment. Results were in conformity with Raghavendra *et al*. (2013) [8], Ravi *et al*. (2008) [9], Ebrahimian and Ahmad Bybordi. (2011) [5].

T_8 (RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS) has recorded the highest uptake of manganese (120.53, 192.41, 200.99 and 273.59 g ha^{-1} at 45, 60, 75 and harvest, respectively) (Table 6 and Fig. 5). This may be attributed to direct absorption from foliage, higher soil contents and higher dry matter accumulation. Results are in conformity with Babaeian *et al*. (2011) [2] and Vinay kumar (2017) [11].

At 45, 60, 75 and harvest highest copper uptake (31.03, 73.20, 76.39 and 152.79 g ha^{-1}, respectively) was recorded with application of treatment T_8 (Table 7 and Fig. 6). This is mainly due to increased biomass which is a result of balanced and sufficient nutrient supply through soil. Guruprasad *et al*. (2009) [6] reported the similar results in groundnut.

Highest uptake of boron at 45, 60, 75 and harvest was recorded with the application of RDF + $ZnSO_4$ @ 10 kg ha^{-1} soil application + foliar spray of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS (14.65, 43.00, 80.49 and 188.14 g ha^{-1}, respectively) (Table 8 and Fig. 8). Since the foliar application of boron has higher efficiency and T_8 was applied with higher concentration of the micronutrients resulted higher boron uptake. Skarpa (2008) [10], Aruna *et al*. (2001) [1] and Bhattacharyya *et al*. (2015) [3] had also found same results.

Table 4: Effect of foliar nutrition of micronutrient mixture on total iron uptake by sunflower at different intervals (g ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	167.20	418.65	433.06	1007.92
T_2	274.07	486.26	503.91	1115.96
T_3	272.91	480.13	493.92	1111.17
T_4	374.26	524.87	527.78	1199.05
T_5	427.58	571.68	565.63	1281.17
T_6	374.08	510.74	527.53	1160.89
T_7	427.52	565.11	578.30	1285.27
T_8	475.10	685.96	702.40	1377.28
T_9	118.39	302.24	439.74	688.48
S.Em. ±	5.37	5.79	24.67	15.42
C.D. @ 5%	16.09	17.37	73.95	46.23

Table 5: Effect of foliar nutrition of micronutrient mixture on total zinc uptake by sunflower at different intervals (g ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	48.93	97.09	107.79	227.83
T_2	67.25	145.13	164.01	310.63
T_3	65.67	137.63	154.29	300.00
T_4	70.88	147.24	160.71	313.48
T_5	75.15	159.17	172.45	347.21
T_6	71.92	154.60	175.09	333.65
T_7	79.19	169.28	189.30	364.64
T_8	85.35	186.44	208.98	382.28
T_9	40.19	80.86	84.18	176.86
S.Em. ±	1.52	5.59	6.73	7.32
C.D. @ 5%	4.56	16.75	20.18	21.95

Table 6: Effect of foliar nutrition of micronutrient mixture on total manganese uptake by sunflower at different intervals (g ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	74.95	121.11	128.01	181.98
T_2	89.34	145.90	154.21	208.99
T_3	88.77	142.30	149.01	204.89
T_4	98.42	163.46	167.56	232.15
T_5	111.27	183.84	185.85	260.38
T_6	99.18	156.44	164.92	224.48
T_7	106.96	164.03	171.22	235.79
T_8	120.53	192.41	200.99	273.59
T_9	48.54	74.31	72.38	106.56
S.Em. ±	0.88	1.94	1.87	2.46
C.D. @ 5%	2.65	5.81	5.61	7.37

Table 7: Effect of foliar nutrition of micronutrient mixture on total copper uptake by sunflower at different intervals (g ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	20.72	47.07	49.67	104.21
T_2	25.58	59.97	63.27	123.14
T_3	24.14	55.20	57.76	120.30
T_4	26.93	62.87	64.36	128.41
T_5	28.55	67.60	68.24	139.93
T_6	27.25	62.98	66.33	130.52
T_7	28.83	67.07	69.96	144.50
T_8	31.03	73.20	76.39	152.79
T_9	18.48	40.15	39.08	76.16
S.Em. ±	1.12	2.58	2.72	3.30
C.D. @ 5%	3.36	7.73	8.17	9.90

Table 8: Effect of foliar nutrition of micronutrient mixture on total boron uptake by sunflower at different intervals (g ha^{-1})

Treatments	45 DAS	60DAS	75 DAS	Harvest
T_1	14.07	39.50	73.55	147.20
T_2	14.21	41.43	77.03	153.40
T_3	14.24	41.74	77.50	162.47
T_4	14.33	41.90	77.77	169.94
T_5	14.48	42.50	79.01	181.71
T_6	14.33	42.06	78.05	169.58
T_7	14.67	43.01	79.85	179.22
T_8	14.65	43.00	80.49	188.14
T_9	13.98	39.13	72.77	141.29
S.Em. ±	0.17	0.16	0.28	2.49
C.D. @ 5%	NS	0.48	0.83	7.48

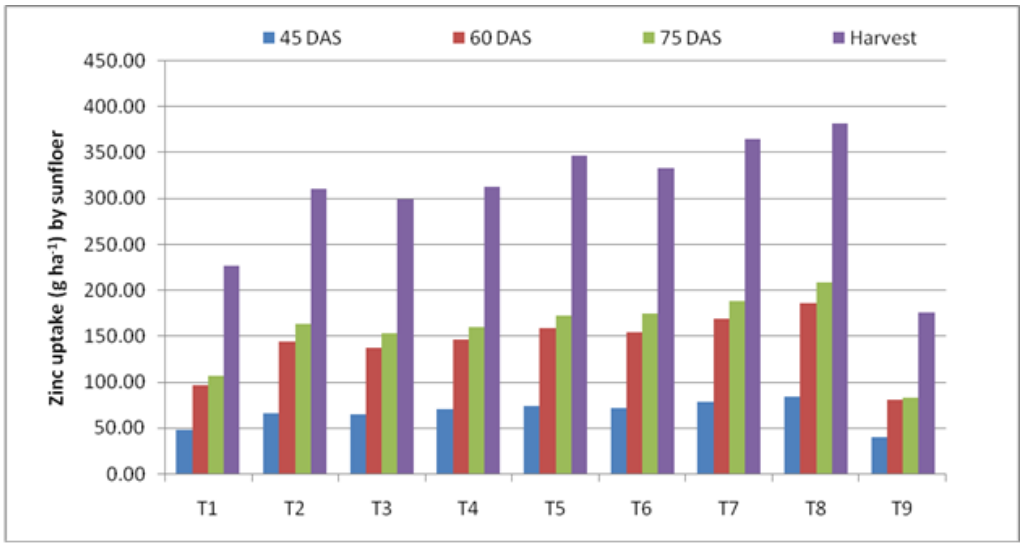

Fig 4: Effect of foliar nutrition on Zinc uptake by sunflower (g ha^{-1})

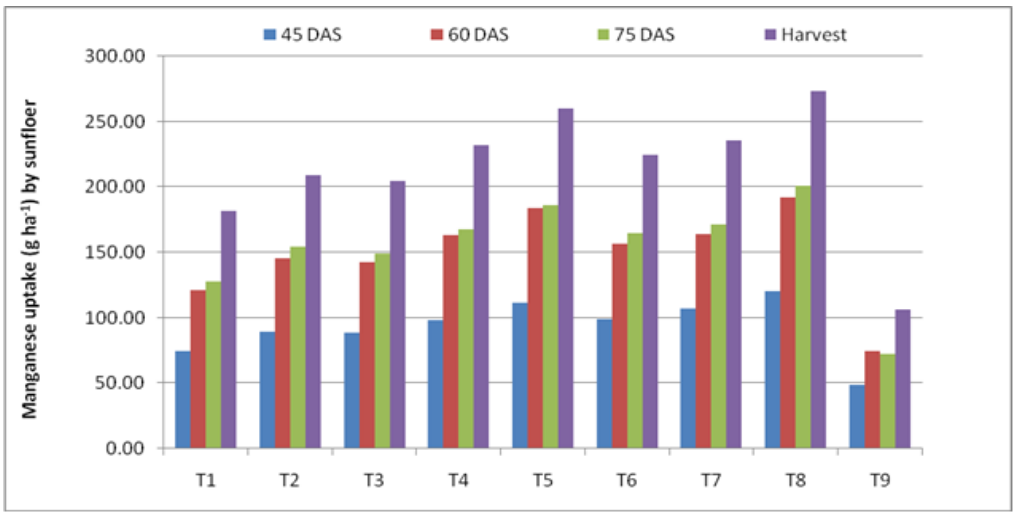

Fig 5: Effect of foliar nutrition on Manganese uptake by sunflower (g ha^{-1})

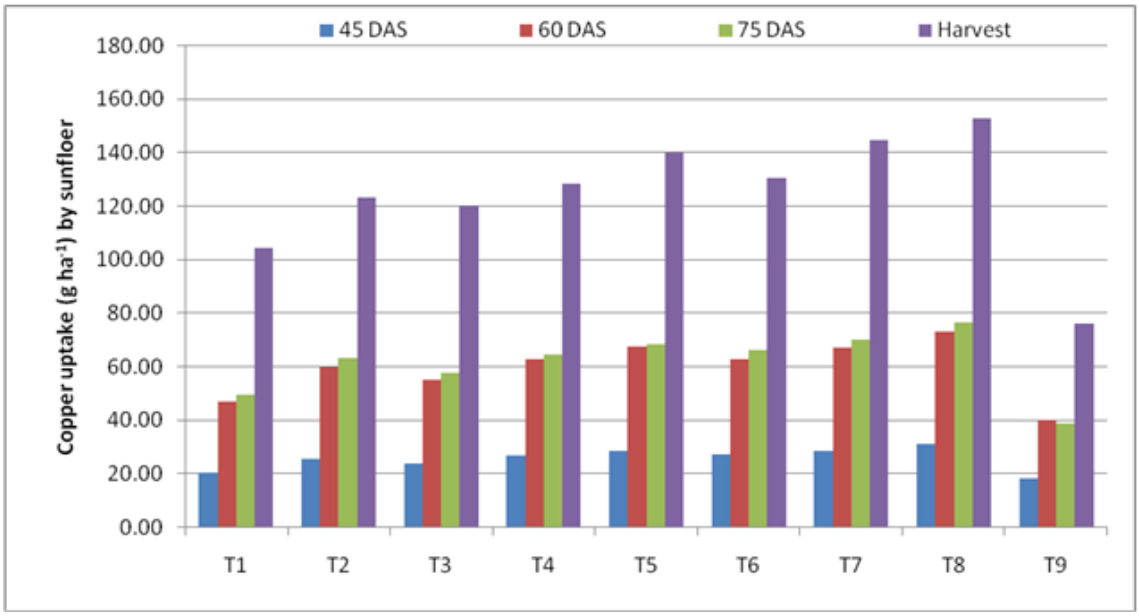

Fig 6: Effect of foliar nutrition on Copper uptake by sunflower (g ha^{-1})

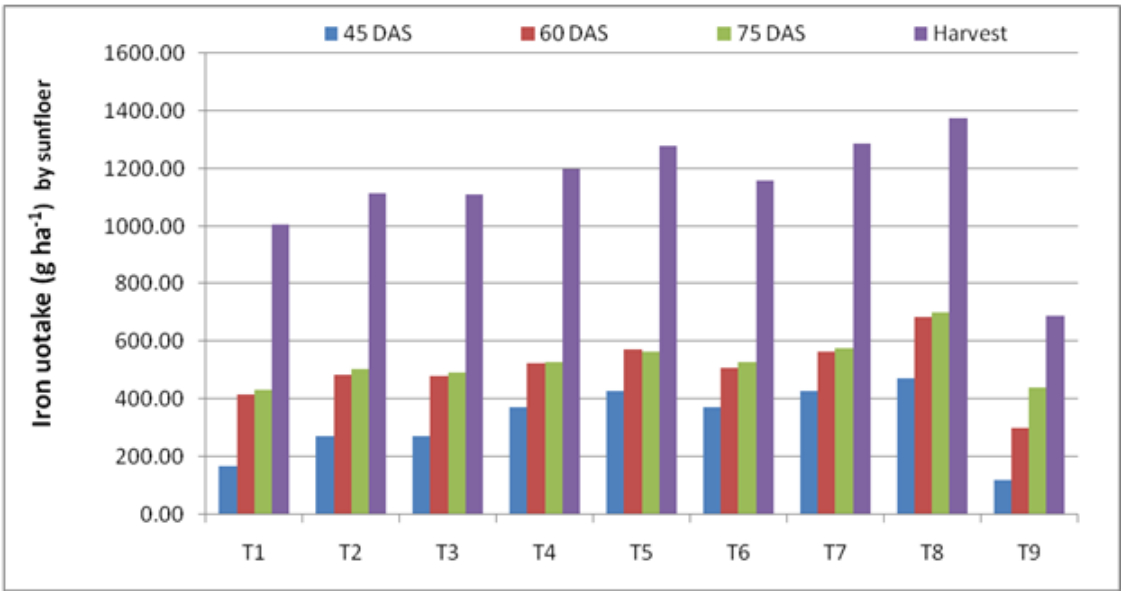

Fig 7: Effect of foliar nutrition on Iron uptake by sunflower (g ha^{-1})

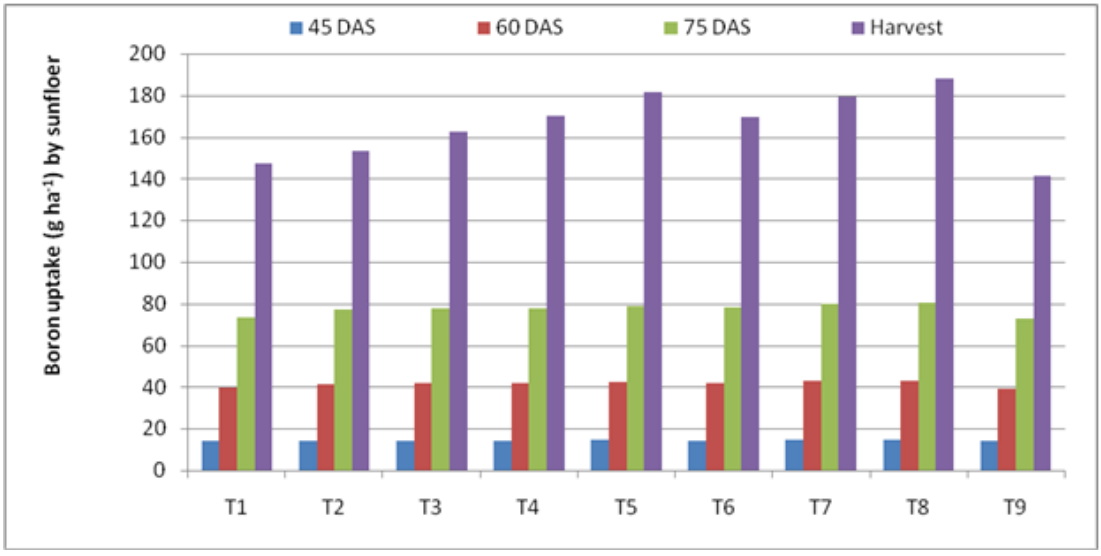

Fig 8: Effect of foliar nutrition on Boron uptake by sunflower (g ha^{-1})

Conclusion

Results of the experiment showed that application of N, P and K @ the rate of 90:90:60 kg ha^{-1}, gypsum @ 100 kg ha^{-1}, soil application of $ZnSO_4$ @ 10 kg ha^{-1} and foliar application of Grade-1 micronutrient mixture @ 10 ml L^{-1} of water @ 30, 45 and 60 DAS has increased uptake of major and micronutrients.

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