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RESEARCH ARTICLE

CONJUNCTIVE USE OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH AND NUTRIENT UPTAKE IN SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was conducted to study the effect of nutrient management on growth and nutrient uptake in sunflower crop during *rabi,* 2010 at Oilseed Research Station, College of Agriculture, Latur. Twelve treatments were tried in randomized block design with three replications. Growth parameters such as plant height (186.98 cm), number of leaves per plant (35.83), leaf area (4658 cm^2), stem girth (7.89 cm), head diameter (12.76 cm) and dry matter production (76.13 g) were increased significantly due to application of 150 % RDF (T_6) at various critical growth stages of sunflower followed by 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}. Uptake of N, P, K, S, B, Zn and Fe were also recorded maximum *i.e.* 47.36, 31.08, 98.86 30.45 kg ha^{-1}, 0.67,5.81 and 3.47 mg kg^{-1}, respectively with treatment T_6 (150 % RDF) over rest of the treatments.

INTRODUCTION

The productivity and response of sunflower to nutrient management in Alfisols and Vertisols is being assessed under the promising cropping system for sustainable sunflower production. Meeting the higher nutrient need of sunflower through site specific and low cost integrated crop management in major cropping system on term basis. It is the focus for reducing the cost and increasing the profitability besides maintaining soil fertility. Nitrogen is an essential constituent of protein and chlorophyll which is present in plant metabolism such as nucleotides, phosphate alkaloids, enzymes, hormones and vitamins etc. Phosphorus plays important role in growth as well as development and maturity of plants. It helps in flowering and fruiting. Zinc is an essential micronutrient has played an important role in enhancing the crop production. Apart from major plant nutrients, sulphur and boron play important role in the production of phenology of oilseed crops and these crops respond well to applied sulphur and boron. For oilseeds, sulphur and boron are most vital nutrients for the growth and development. Boron plays a vital role in cell wall synthesis, root elongation, glucose metabolism, nucleic acid synthesis, lignifications and tissue differentiation.

MATERIALS AND METHODS

A field experiment was conducted on clayey soil at the Oilseed Research Station, Latur during *rabi* season of 2010. The gross and net plot size were 5.4 X 4.8 m and 4.2 X 4.2 m, respectively. Recommended dose of fertilizer (60:30:30 NPK kg ha^{-1}) was supplied through urea, DAP and SSP. Sunflower variety KBSH-44 was sown at a spacing of 60 X 30 cm , 5 t FYM and 20 kg S ha^{-1} was applied at the time of sowing. Full dose of phosphorus and potassium along with 50 % nitrogen of each treatment was applied as basal dose and remaining 50 % nitrogen dose of each treatment was given 30 days after sowing. Five plants from each net plot were randomly selected and labled for taking biometric observations at different growth stages. *i.e.* 20, 40, 60, 80 DAS and at harvest. On the basis of plant observation, average value was recorded. For nutrient uptake, collected plant and seed samples were oven dried and ground in electrically operated grinder to maximum fineness. The ground plant and seed samples were stored in polythene bags and used for analysis. Total nitrogen in plant was determined by microkjeldhal's methods (Jackson, 1973). Phosphorus content by Vanado-molybdate phosphoric acid yellow colour method and potassium content by Flame photometer (Jackson, 1973), sulphur content was determined on U.V. Spectrophotometer as suggested by Tondon, (1993), boron content was determined by Azomethine- H method as suggested by William's and Steinberg's, 1959. For determination of total content of micronutrients the oven dried seed samples were digested with HNO_3:$HClO_4$ (2:1) di-acid mixture and the extract was analysed for micronutrients Zn and Fe with atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Uptake of nutrients (N, P, K, S, B, Zn and Fe) on dry weight basis of plant was computed by multiplying the respective nutrients concentration to dry matter yield obtained.

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RESULTS AND DISCUSSION

Growth parameters

Growth parameters *viz.* plant height, number of leaves per plant, leaf area, stem girth, head diameter were recorded at 20, 40, 60, 80 DAS and at harvest.

Plant height

Taller plants were observed with treatment T_6 (150% RDF) at all the growth stages except at 20 DAS of sunflower. The treatment T_6 recorded significantly higher plant height at 40 DAS (85.11 cm), 60 DAS (157.05 cm), 80 DAS (184.75 cm) and at harvest (186.98 cm) than the other treatments. However, it was found at par with treatments T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}), T_8 (RDF + FYM 5 t ha^{-1}), T_3 (60 kg N + 30 kg P_2O_5 ha^{-1}) and T_5 (50 % RDF) and significantly superior over rest of the treatments. Whereas, the dwarfer plants were observed at 40 (70.06 cm), 60 (134.54 cm), 80 DAS (134.54 cm) and at harvest (164.54 cm) with control (Table 1). The increase in plant height might be due to greater availability of nutrients from organic and inorganic sources which help in acceleration of various metabolic processes. These results are in agreement with findings of Purohit *et al.* (2006). Ramachandrappa and Nanjappa (2005) observed that application of recommended dose of fertilizer (63:75:63 kg NPK ha^{-1}) registered significantly taller plants as compared to control. This clearly indicates that the need for applying recommended dose of fertilizer to realize better growth. Gunjal *et al.* (2011) observed that application of 50 kg N ha^{-1} + 75 kg P_2O_5 ha^{-1} + 50 kg K_2O ha^{-1} + 5 t FYM ha^{-1} was found at par with 50 kg N ha^{-1} + 75 kg P_2O_5 ha^{-1} + 50 kg K_2O ha^{-1} + 2.5 t FYM ha^{-1} and recorded significantly higher values of plant height as compared with rest of the treatments of different levels of K application alone or in combination with FYM.

Number of leaves per plant

The numbers of leaves per plant of sunflower were significantly influenced due to various treatments at all the growth stages except 80 DAS of crop. Application of 150 % RDF (T_6) recorded significantly higher number of leaves at 20 (12.19 cm), 40 (21.49 cm) 60 DAS (35.83 cm) and at harvest (9.23 cm) in sunflower crop than the other treatments. While, it was at par with treatments T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}), T_8 (RDF + FYM 5 t ha^{-1}), T_3 (60 kg N + 30 kg P_2O_5 ha^{-1}) and T_5 (50 % RDF). Whereas, the less number of leaves were recorded with control (Table 1). The significant improvement in number of leaves per plant with these treatments might be due to increase in availability of nutrients from organic along with inorganic sources resulting into early root ramification and development of extensive root system and thereby increased cell division, cell elongation, expressed in terms of gain in number of leaves. These findings reported by Gudade *et al.* (2010). Byrareddy *et al.* (2008) reported that application of FYM@ 8 t ha^{-1} along with RDF (62.5:75:142.33 NPK kg ha^{-1}) recorded higher number of leaves. Sabale (2003) observed that the application of 90 kg N + 45 kg P_2O_5 recorded significantly more number of leaves (26.50) which was at par with application of 60 kg N + 30 kg P_2O_5 ha^{-1} and significantly superior over rest of the treatments.

Leaf area

Significantly highest leaf area was observed with treatment T_6 (150% RDF) at all the growth stages except at 20 DAS of sunflower (Table 2). The treatment T_6 recorded significantly larger leaf area at 40, 60, 80 DAS and at harvest *i.e.* 2573, 3336, 4658 and 2885 cm^2, respectively than rest of the treatments. However, it was at par with treatments T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}) and T_8 (RDF + FYM 5 t ha^{-1}) and followed by T_3, T_5, T_9 and T_7. While, the smaller leaf area was recorded with treatment T_1 (control). Leaf area index increased significantly with each increment in the dose of phosphorus and sulphur up to 13.1 kg P and 15 kg S ha^{-1}. This was probably due to adequate application of phosphorus and sulphur, which was directly involved in better absorption of applied nutrients and cell multiplication as well as expansion of deep green colour of leaves due to chlorophyll synthesis in comparison with plants deficient in phosphorus and sulphur. These results are in agreement with findings of Kumar and Yadav (2007). Similarly, Ramachandrappa and Nanjappa (2005) reported that the greater availability of nutrients with the application of 200:100:53 NPK kg ha^{-1} along with 10 t FYM ha^{-1} to previous baby corn recorded significantly higher leaf area (3086.2 cm^2) of sunflower as compared to lower levels of residual fertility.

Table 1. Mean plant height and number of leaves per plant of sunflower as influenced by various treatments at different crop growth stages

Treatments	Plant height (cm)					Number of leaves plant^{-1}				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T_1 - Control	12.50	70.06	134.54	134.54	164.54	6.14	14.84	25.05	15.99	7.09
T_2 - 60 kg N ha^{-1}	13.75	73.20	139.26	167.31	168.70	8.17	16.26	26.18	17.03	8.07
T_3 - 60 kg N + 30 kg P_2O_5 ha^{-1}	15.67	80.02	151.91	179.10	180.06	10.53	19.13	32.64	20.03	9.41
T_4 - 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	16.35	83.03	155.15	183.22	184.29	11.20	20.59	34.27	21.76	11.24
T_5 - 50 % RDF	15.51	78.44	149.02	177.42	178.18	10.13	18.29	30.67	19.73	9.23
T_6 - 150 % RDF	17.16	85.11	157.05	184.72	186.98	12.19	21.49	35.83	22.46	12.32
T_7 - RDF + Crop residues	15.09	74.38	143.53	172.06	173.08	9.06	17.95	28.96	18.87	9.17
T_8 - RDF + FYM 5 t ha^{-1}	16.00	82.17	153.53	181.42	182.26	11.04	20.05	34.10	21.56	11.03
T_9 - RDF + S @ 20 kg ha^{-1}	15.38	76.78	146.31	174.73	175.62	3.13	18.11	29.50	19.13	8.27
T_{10} - RDF + B @ 1 kg ha^{-1}	14.16	72.94	138.98	166.79	167.99	7.65	16.00	26.02	17.00	9.10
T_{11} - RDF + $ZnSO_4$ @ 20 kg ha^{-1}	13.32	71.97	136.17	165.18	166.18	7.19	15.85	25.41	16.76	8.01
T_{12} - RDF + S + $ZnSO_4$ @ 20 kg ha^{-1}	14.67	73.99	141.73	169.67	170.58	8.01	17.45	26.83	18.58	8.05
SE ±	1.45	2.38	2.83	2.83	2.92	1.01	0.72	1.89	1.66	0.50
CD @ 5 %	NS	6.97	8.29	8.29	8.54	2.98	2.11	5.53	NS	1.47

Stem girth

Application of 150 % RDF (T_6) significantly increased the stem girth of sunflower at 40 (5.66 cm), 60 (6.82 cm), 80 DAS (7.89 cm) and at harvest except at 20 DAS. It was at par with treatments T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}), T_8 (RDF + FYM 5 t ha^{-1}), T_3 (60 kg N + 30 kg P_2O_5 ha^{-1}), T_5 (50 % RDF), T_9 (RDF + S @ 20 kg ha^{-1}) and T_7 (RDF + Crop residues) which was significantly superior over rest of the treatments. However, decreased stem girth of sunflower was found at control (Table 2). Reddy *et al*. (1996) reported that the growth attributing characters significantly increased with the increasing levels of sulphur. This was expected because the soil of the experimental area was low in available S. Higher stem girth was found under 30 kg ha^{-1} sulphur. Similarly, Kumar and Singh (2005) reported that stem girth of sunflower increased with levels of increasing phosphorus @ 60 kg ha^{-1}. On the other hand, Geetha *et al*. (2010) observed that the application of 20 kg S ha^{-1} through gypsum recorded highest stem girth of sunflower crop.

Table 2. Mean leaf area and stem girth of sunflower as influenced by various treatments at different crop growth stages

Treatments	Leaf area plant^{-1} (cm^2)					Stem girth (cm)				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T_1 - Control	1126	1960	2850	3935	2164	3.90	4.26	5.26	6.21	5.12
T_2 - 60 kg N ha^{-1}	1273	2259	2969	4168	2518	4.20	4.86	6.15	6.93	6.09
T_3 - 60 kg N + 30 kg P_2O_5 ha^{-1}	1394	2380	3068	4390	2638	4.46	5.38	6.47	7.30	6.33
T_4 - 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	1439	2450	3286	4480	2768	4.64	5.46	6.70	7.72	6.42
T_5 - 50 % RDF	1372	2362	3036	4382	2619	4.41	5.37	6.40	7.24	6.30
T_6 - 150 % RDF	1471	2573	3336	4658	2885	4.74	5.66	6.82	7.89	6.72
T_7 - RDF + Crop residues	1316	2335	3022	4220	2588	4.27	5.18	6.29	7.15	6.19
T_8 - RDF + FYM 5 t ha^{-1}	1437	2462	3262	4429	2708	4.55	5.41	6.66	7.57	6.36
T_9 - RDF + S @ 20 kg ha^{-1}	1286	2315	3043	4233	2616	4.37	5.29	6.34	7.21	6.22
T_{10} - RDF + B @ 1 kg ha^{-1}	1265	2255	2917	4075	2481	4.18	4.77	6.12	6.76	6.02
T_{11} - RDF + $ZnSO_4$ @ 20 kg ha^{-1}	1210	2086	2902	4020	2431	4.20	4.61	5.87	6.59	5.75
T_{12} - RDF + S + $ZnSO_4$ @ 20 kg ha^{-1}	1295	2271	3145	4186	2565	4.16	4.99	6.22	7.07	6.16
SE ±	11.53	74.98	91.18	73.16	61.15	0.23	0.26	0.27	0.28	0.64
CD @ 5 %	NS	219.60	267.04	214.27	179.10	NS	0.77	0.79	0.82	NS

Table 3. Mean head diameter, 50 % flowering and dry matter production of sunflower as influenced by various treatments at different crop growth stages

Treatments	Head diameter (cm)			50 % Flowering (days)	Dry matter production at harvest (g)
	60 DAS	80 DAS	At harvest		
T_1 - Control	4.11	7.25	10.05	67	51.59
T_2 - 60 kg N ha^{-1}	5.50	8.58	11.09	63	55.57
T_3 - 60 kg N + 30 kg P_2O_5 ha^{-1}	6.16	9.42	11.93	62	66.18
T_4 - 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	6.49	9.49	12.62	58	72.71
T_5 - 50 % RDF	5.97	9.36	11.86	61	63.78
T_6 - 150 % RDF	6.60	9.58	12.76	56	76.13
T_7 - RDF + Crop residues	5.87	8.87	11.35	61	58.70
T_8 - RDF + FYM 5 t ha^{-1}	6.48	9.46	12.53	59	69.83
T_9 - RDF + S @ 20 kg ha^{-1}	5.94	8.88	11.46	61	60.08
T_{10} - RDF + B @ 1 kg ha^{-1}	5.00	8.01	10.96	61	55.47
T_{11} - RDF + $ZnSO_4$ @ 20 kg ha^{-1}	4.40	7.40	10.68	62	54.52
T_{12} - RDF + S + $ZnSO_4$ @ 20 kg ha^{-1}	5.68	8.64	11.20	63	56.55
SE ±	0.36	0.32	0.86	-	3.12
CD @ 5 %	1.05	0.95	NS	-	9.36

Head diameter

Larger head diameter of sunflower was observed with treatment T_6 (150 % RDF) at 60 (6.60 cm) and 80 DAS (9.58 cm) except at harvest (Table 3). However, it was at par with treatments T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}), T_8 (RDF + FYM 5 t ha^{-1}), T_3 (60 kg N + 30 kg P_2O_5 ha^{-1}), T_5 (50 % RDF), T_9 (RDF + S @ 20 kg ha^{-1}), T_7 (RDF + crop residues) and T_{12} (RDF + S + $ZnSO_4$ @ 20 kg ha^{-1}) but superior over all the treatments. Whereas, the smaller head diameter was recorded with treatment T_1 (control). Better translocation of photosynthates to the reproductive parts was responsible for improvement in head diameter due to split application of N. This result was in conformity with results of Reddy and Giri (1997). The increase in fertility level from recommended dose (100:60:40 kg NPK ha^{-1}) up to 125 and 150 % RDF and likewise addition of FYM @ 10 t ha^{-1} over no application had significant effects on head diameter. Similar findings were recorded by Chitale *et al.* (2004).

50 % Flowering

As regard the different treatments, early flowering (56 days) was recorded with application of 150 % RDF (T_6) as compared to other treatments followed by 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1} (T_4) and RDF + FYM 5 t ha^{-1} (T_8). Whereas, the late flowering (67 days) was recorded with control (Table 3). Ramachandrappa and Nanjappa (2005) revealed that application of 200:100:53 kg NPK ha^{-1} along with 10 t FYM ha^{-1} recorded lesser days (55) to 50 % flowering of sunflower as compared to control. This might be due to need for applying recommended dose of fertilizer to realize better growth of crop.

Dry matter production

The maximum dry matter yield per plant (76.13 g) was significantly produced at harvest stage with treatment T_6 (150 % RDF) of sunflower. It was remained at par with T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O) and T_8 (RDF + FYM 5 t ha^{-1}). Further, the data indicated that lower (51.59 g) dry matter yield per plant was produced significantly with treatment T_1

(control) at harvest of sunflower (Table 3). Ateeque *et al.* (1993) reported that the increasing levels of P, the dry matter yield were increased with every increment of P dose which gave significant increase in dry matter yield of sunflower. The progressive response to added P through dry matter production was associated with the very low P availability in soil. Similarly, Yadav *et al.* (2006) revealed that the successive increase of sulphur doses from 20 to 60 kg S ha^{-1} reflected a significant improvement in dry matter accumulation. Sumathi and Koteshwara Rao (2007) reported that dry matter production was significantly increased when the entire dose of NPK (80:50:30 kg ha^{-1}) was supplied through fertilizers.

Table 4. Effect of nutrient management on N, P, K S, B, Zn and Fe uptake of sunflower

Treatments	Uptake (kg ha^{-1})						
	N	P	K	S	B	Zn	Fe
T_1 - Control	28.11	17.26	42.94	18.03	3.57	0.093	5.41
T_2 - 60 kg N ha^{-1}	31.85	19.51	53.40	20.62	4.38	1.012	6.57
T_3 - 60 kg N + 30 kg P_2O_5 ha^{-1}	39.85	25.33	72.43	25.33	5.95	1.441	8.27
T_4 - 60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	44.43	28.88	98.12	28.47	6.86	1.656	9.61
T_5 - 50 % RDF	43.70	23.91	68.03	24.16	5.63	1.371	7.90
T_6 - 150 % RDF	47.36	31.08	98.86	30.45	7.57	1.780	10.53
T_7 - RDF + Crop residues	34.37	20.96	59.35	22.01	5.02	1.213	7.10
T_8 - RDF + FYM 5 t ha^{-1}	42.36	27.34	82.24	27.62	6.47	1.555	9.07
T_9 - RDF + S @ 20 kg ha^{-1}	35.51	31.99	63.08	22.62	5.20	1.265	7.34
T_{10} - RDF + B @ 1 kg ha^{-1}	31.52	19.35	51.46	20.52	4.22	1.121	6.44
T_{11} - RDF + $ZnSO_4$ @ 20 kg ha^{-1}	30.40	18.62	48.15	19.95	5.99	1.087	5.81
T_{12} - RDF + S + $ZnSO_4$ @ 20 kg ha^{-1}	32.73	20.04	55.29	21.04	4.64	1.159	6.75
SE ±	1.8	1.98	2.9	1.6	0.32	0.06	0.5
CD @ 5 %	5.4	5.79	8.6	4.8	0.94	0.20	1.5

Uptake of N, P, K and S

Uptake of N, P, K and S affected due to various treatments significantly at harvest stage of sunflower. It was observed from the result that uptake of N, P, K and S were recorded maximum *i.e.* 47.36, 31.08, 98.86 and 30.45 kg ha^{-1}, respectively with treatment T_6 (150 % RDF) over rest of the treatments. However, it was at par with treatments T_4, T_5 and T_8 at N uptake, T_4, T_8, T_3 and T_9 at P uptake, T_4 at K uptake and T_4 and T_8 at S uptake. Whereas, the minimum uptake of N, P, K and S were recorded with treatment T_6 (control) in sunflower crop. Syed *et al.* (2006) revealed that application of N significantly increased the N uptake by sunflower plants at flowering and the stalk at harvest from 38.91 to 85.99 and 14.95 to 42.41 kg ha^{-1}, respectively. This increase in N uptake may be attributed to increase in N concentration and dry matter yield. On the other hand, Gudade *et al*. (2009) also found that an appreciable significant increase in total N, P and K was recorded under the higher level if fertilizer is 150 % RDF. The magnitude of increase in mean total uptake of N, P and K were 42.93, 30.74, 21.72 per cent under 150 % RDF and 21.20, 15.11 and 9.23 per cent under 100 % RDF, respectively when compared to 50 % RDF. This may be due to abundant supply of solution particularly NPK, which augmented the growth process directly or indirectly through the balance of phytoharmones and ultimately resulted into higher uptake of nutrients. Similarly, Bahl *et al.* (1997) found that the P uptake at 30 kg N ha^{-1} depressed slightly in the absence of applied P ($N_{30}P_0$) over control but increased significantly with P application up to 60 kg P_2O_5 ha^{-1} increased the total P uptake. Sreemannarayana and Sreenivasa Raju (1994) observed that application of S increased its total uptake by sunflower genotypes significantly at all the growth stages.There was increase in uptake with increase in S level even up to 60 kg S ha^{-1}. The S content in plant decreased with successive growth stages because of dilution effect.

Uptake of B, Zn and Fe

Uptake of B, Zn and Fe were influenced significantly at harvest of sunflower crop. Application of 150 % RDF (T_6) recorded significantly highest B (7.57 kg ha^{-1}), Zn (1.780 kg ha^{-1}) and Fe (10.53 kg ha^{-1}) uptake as compare to other treatments. However, it was at par with treatment T_4 (60 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}) at B and Zn uptake and with treatment T_4 and T_8 (RDF + FYM 5 t ha^{-1}) at Fe uptake of sunflower. While, the lowest uptake of B, Zn and Fe were recorded at control (T_1). Karthikeyan and Shukla (2008) revealed that boron uptake by sunflower straw was increased due to the boron application from 940 µg pot^{-1} in control, 1545 mg pot^{-1} at 3 mg kg^{-1} of boron application. Sharma *et al*. (1990) revealed that zinc application increased the concentration of zinc in root and shoot of crop. Higher concentration of zinc in plant due to sulphur application could be attributed to increased solubility of zinc in soil as a result of lowering of soil pH caused by application of sulphur. Sreemannarayana and Sreenivasa Raju (1995) revealed that the uptake of Fe was more at flowering stage of sunflower, which might be due to dilution effect. At flowering stage, the uptake of this micronutrient was higher in stalks as compared to that flower heads and S applied, which may be attributed to higher yield produced by stalk relative to flower heads.

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