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Effect of organic manures, micronutrients and AM on crop growth rate (CGR), relative growth rate (RGR) and yield under residual effect of maize-sunflower cropping system

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ABSTRACT : Field experiments were conducted to find out the influence of organic manures, micronutrients and arbuscular mycorrhiza (AM) on the crop growth rate (CGR), relative growth rate (RGR) and yield of maize-sunflower cropping system at Tamil Nadu Agricultural University, Coimbatore during 2011-12 and 2012-13. The experiment was laid out in Split Plot Design and replicated thrice for maize during winter 2011-12 and 2012-13 and the same experiment after dividing each plot into two was laid out in Split-split Plot Design and replicated thrice for sunflower during summer 2012 and 2013 to find out the crop growth rate (CGR), relative growth rate (RGR) and yield in the residual organic manures as well as micronutrients and arbuscular mycorhiza in the experiment field. During 2011-12, application of poultry manure @ 5 t ha^{-1} recorded higher crop growth rate (CGR) *viz.*, 24.29 to 24.58 g^{-2} day^{-1} (between 30-60 DAS and 60-90 DAS, respectively). Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded larger crop growth rate (CGR) of 22.25 and 23.37 $g^{-2}day^{-1}$ (between 30-60 DAS and 60-90 DAS, respectively). The residual effect of applied poultry manure @ 5 t ha^{-1} to previous maize crop registered highest crop growth rate of sunflower *viz.*, 13.06 to 5.48 g^{-2} day^{-1} (between 30-60 DAS and 60-90 DAS, respectively) regarding the organic manures, higher RGR (0.076 and 0.042 mg g^{-1} day^{-1} between 30-60 and 60-90 DAS, respectively) was recorded under poultry manure 5 t ha^{-1} followed by sericulture waste compost 5 t ha^{-1}, goatmanure 5t ha^{-1} and FYM 12.5 t ha^{-1}. Among the micronutrients and AM treatments, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher RGR of 0.070 and 0.036 mg g^{-1} day^{-1} between 30 - 60 and 60 - 90 DAS, respectively. In 2012, regarding the organic manures, higher RGR (0.058 and 0.029 mg g^{-1} day^{-1} between 30-60 and 60-90 DAS, respectively) was recorded under poultry manure 5 t ha^{-1} to preceding maize followed by sericulture waste 5 t ha^{-1}. In the first crop during 2011-12, among the organic manures, poultry manure 5 t ha^{-1} recorded the highest grain yield of 7230 kg ha^{1}. Micronutrients and AM had a positive influence on grain yield of maize. Among the micronutrients, $ZnSO_4$ 37.5 kg ha^{-1} recorded the highest grain yield (7271 kg ha^{-1}). Higher seed yield of sunflower (2086 kg ha^{-1}) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize followed by sericulture waste 5 t ha^{-1}.

KEY **W**ORDS : Organic manures, Micronutrients, AM , Maize, Sunflower, CGR,RGR, Seed yield

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Maize (*Zea mays* L.) is the third most important cereal next to rice and wheat, at global level as well in India. It is a versatile crop and can be grown under diverse environmental conditions and has multidimensional uses in manufacturing of wide array of products such as starch, plastic, rayon, textile, adhesive, dyes, resins, polish, syrups, ethanol, etc. It has got immense potential and is, therefore, referred to as "miracle crop" and also "queen of cereals". Maize, being a C_4 plant is an efficient converter of carbon and absorbed nutrients into food.

Maize is one of the world's leading crops cultivated over an area of about 175.0 million hectares with a production of about 855.9 million tonnes and productivity of 4.89 tonnes of grain ha^{-1} (USDA, 2013) and per capita total maize grain consumption is 25.2 kg (Ito, 2013). In India, maize is cultivated over an area of 8.71 million hectares with a production of 21.57 million tonnes and the average productivity is 2476 kg ha^{-1}. In Tamil Nadu, maize is cultivated in an area of 0.30 million hectares with a production of 1.57 million tonnes and the productivity is 5173 kg ha^{-1} (Agricoop, 2012).

Sunflower is India's premier oil seed crop that has made a significant role in yellow revolution of the country, to achieve self-sufficiency in vegetable oil. Among the oil seed crops, sunflower appears to be the most promising that not only fits well in the current cropping system but also yields oil of premium quality. Sunflower is often considered as a soil depleting exhaustive crop which puts heavy demand on soil and applied nutrients (Mishra *et al*., 1994). Due to its high uptake of nutrients, sunflower responds very well to applied nutrients.

RESEARCH PROCEDURE

Crop growth rate (CGR) :

Crop growth rate (CGR) is defined as the rate of increase in dry weight per unit land area per unit time. The CGR was computed using the formula suggested by Watson (1958) and expressed in g^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{P(t_2 - t_1)}$$

where,

W_1 and W_2 are the initial and final dry weight of plants, respectively.

t_1 and t_2 are the initial and final day of period of observation, respectively.

P is the plant spacing adopted.

Relative growth rate (RGR) :

Relative growth rate (RGR) is defined as the rate of growth per unit plant weight, which provides more informative comparison of the plants relative performance in a given environment. The RGR during the crop growth was computed using the formula suggested by En Yi (1962) and expressed in mg g^{-1} day^{-1}.

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

where,

W_1 and W_2 are the initial and final dry weight of plants, respectively.

t_1 and t_2 are the initial and final day of period of observation, respectively.

Grain yield :

The cobs from the net plot were harvested separately. The cobs were sun dried, shelled, cleaned and grain yield was recorded for individual treatment at 14 per cent seed moisture and expressed in kg ha^{-1}.

Seed yield :

Seed yield from net plot area was recorded at 14 per cent moisture level and expressed in kg ha^{-1}.

RESEARCH ANALYSIS AND REASONING

The results of the field experiments conducted at Tamil Nadu Agricultural University, Coimbatore during 2011-12 and 2012-13 to investigate the influence of organic manures, micronutrients and mycorrhizal inoculation on the productivity of maize based cropping system under irrigated condition are presented crop growth rate which represents the time trend of growth was recorded at different phenophases of maize. Significant difference in crop growth was observed with organic manures, micronutrients and AM at all the stages of observation both during 2011-12 and 2012-13.

In 2011-12, among the organic manures, higher CGR (24.29 to 24.58 g^{-2} day^{-1} between 30-60 DAS and 60-90 DAS, respectively was recorded under poultry manure 5 t ha^{-1} followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} (Table 1). The least crop growth rate was observed under control at both the

stages.Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher CGR of 22.25 and 23.37 $g^{-2}day^{-1}$ between 30-60 DAS and 60-90 DAS, respectively. The least crop growth rate was observed under control without AM and micronutrients at both the stages.In 2012-13, with respect to organic manures, poultry manure 5 t ha^{-1} recorded higher CGR (23.84 and 25.02 g^{-2} day^{-1} between 30-60 and 60-90 DAS, respectively followed by sericulture waste 5 t ha^{-1} and both were comparable with each other.

The least CGR was observed under control. Considering the micronutrients and AM, $ZnSO_4$ recorded higher CGR of 23.09 and 25.63 g^{-2} day^{-1} between 30 - 60 and 60 - 90 DAS, respectively.

In 2011-12, regarding the organic manures, higher RGR (0.076 and 0.042 mg g^{-1} day^{-1} between 30-60 and

Table1 : Effect of organic manures, micronutrients and AM on crop growth rate of maize (g^{-2} day^{-1})

Treatments	Winter, 2011-12		Winter, 2012-13	
	30-60 DAS	60- 90 DAS	30-60 DAS	60- 90 DAS
Organic manures (M)				
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	18.13	20.73	20.69	22.49
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	22.55	22.08	22.27	24.31
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	24.29	24.58	23.84	25.02
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	19.60	21.13	21.58	23.39
M_5 - RDF alone (Control)	14.19	19.86	17.10	20.00
S.E.±	0.70	0.81	0.84	0.86
C.D. (P=0.05)	1.65	1.91	1.99	2.03
Micronutrients and AM (S)				
S_1 - AM @ 100 kg ha^{-1}	18.97	21.25	21.90	22.804
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	22.25	23.37	23.09	25.63
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	20.91	22.05	21.93	23.10
S_4 - Control	16.88	20.01	17.47	20.60
S.E.±	0.68	0.54	0.69	1.15
C.D. (P=0.05)	1.38	1.11	1.42	2.34
Interaction	NS	NS	NS	NS

NS= Non-significant

Table 2 : Effect of organic manures, micronutrients and AM on relative growth rate of maize ($g\ g^{-1}day^{-1}$)

Treatments	Winter, 2011-12		Winter, 2012-13	
	30-60 DAS	60- 90 DAS	30-60 DAS	60- 90 DAS
Organic manures (M)				
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	0.060	0.029	0.064	0.027
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	0.070	0.038	0.066	0.030
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	0.076	0.042	0.073	0.029
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	0.064	0.032	0.065	0.027
M_5 - RDF alone (Control)	0.055	0.022	0.057	0.022
S.E.±	0.003	0.001	0.003	0.001
C.D. (P=0.05)	0.007	0.003	0.007	0.003
Micronutrients and AM (S)				
S_1 - AM @ 100 kg ha^{-1}	0.064	0.032	0.064	0.027
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	0.070	0.036	0.070	0.029
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	0.065	0.033	0.064	0.027
S_4 - Control	0.061	0.029	0.062	0.023
S.E.±	0.001	0.001	0.003	0.001
C.D. (P=0.05)	0.002	0.003	0.005	0.002
Interaction	NS	NS	NS	NS

NS=Non-significant

60-90 DAS, respectively was recorded under poultry manure 5 t ha^{-1} followed by sericulture waste compost 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} (Table 2). The least RGR was observed under control.

Among the micronutrients and AM treatments, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher RGR of 0.070 and 0.036 mg g^{-1} day^{-1} between 30 - 60 and 60 - 90 DAS, respectively followed by TNAU MN mixture and AM inoculation.

Similar results as evidenced in 2011-12 were also recorded during 2012-13 with regard to organic manures, with poultry manure 5 t ha^{-1} registering higher RGR at all the stages. Among the micronutrients and AM treatments, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher RGR of 0.070 and 0.029 mg g^{-1} day^{-1} between 30 - 60 and 60 - 90 DAS, respectively followed by AM inoculation and TNAU MN mixture.

The maize grain yield was significantly influenced by organic manures, micronutrients and AM during both the years.

In general, all the organic manures tried recorded higher yield than control. In the first crop during 2011-12, among the organic manures, poultry manure 5 t ha^{-1} recorded the highest grain yield of 7230 kg ha^{-1} (Table 3). This was followed by sericulture waste 5 t ha^{-1}, goat manure 5 t $ha^{-1}$and FYM 12.5 t ha^{-1} and they were comparable among themselves. Control recorded the least grain yield. Micronutrients and AM had a positive

Table 3 : Effect of organic manures, micronutrients and AM on grain yield (kg ha^{-1}) of maize (Winter, 2012-13)

Treatments	Grain yield(2012)	Grain yield(2013)
Organic manures (M)		
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	6181	6151
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	6593	6953
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	7230	7635
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	6393	6377
M_5 - RDF alone (Control)	5453	5514
S.E.±	207	219
C.D. (P=0.05)	476	506
Micronutrients and AM (S)		
S_1 - AM @ 100 kg ha^{-1}	6247	6218
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	7271	7524
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	6555	6562
S_4 - Control	5406	5800
S.E.±	125	201
C.D. (P=0.05)	254	411
Interaction	Sig	Sig

Table 4 : Interaction effect of organic manures, micronutrients and AM on grain yield of maize (kg ha^{-1})

Main plot / Sub plot	Winter 2011-12						Winter 2012-13					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	6173	6436	6575	6414	5641	6248	5947	6516	7090	5999	5538	6218
S_2	6785	7523	9104	7261	5681	7271	6784	8501	9310	7382	5645	7524
S_3	6361	6661	7759	6466	5529	6555	6285	6899	7631	6544	5450	6562
S_4	5406	5753	5484	5429	4961	5406	5588	5897	6507	5585	5423	5800
Mean	6181	6593	7230	6392	5453		6151	6953	7635	6377	5514	
	Source	S.E.±	C.D. (P=0.05)				Source	S.E.±	C.D. (P=0.05)			
	M	206	476				M	219	506			
	S	125	254				S	201	411			
	M at S	318	718				M at S	447	1012			
	S at M	279	569				S at M	450	919			

influence on grain yield of maize. Among the micronutrients, $ZnSO_4$ 37.5 kg ha^{-1} recorded the highest grain yield (7271 kg ha^{-1}) followed by TNAU MN mixture and AM. The yield increase under $ZnSO_4$ 37.5 kg ha^{-1} was 34.49 per cent, over control.The interaction between organic manures, micronutrient and AM on maize grain yield was significant (Table 4). The treatment combination poultry manure 5 t ha^{-1} along with $ZnSO_4$ 37.5 kg ha^{-1} (M_3S_2) recorded significantly higher yield (9104 kg ha^{-1}) followed by poultry manure 5 t ha^{-1} along with TNAU MN mixture 30 kg ha^{-1}. Control (100% RDF alone) without AM and micronutrients recorded the least grain yield (4961 kg ha^{-1}).Crop growth rate which represents the time trend of growth was recorded at different phenophases of sunflower. Significant difference in crop growth was observed with organic manures, mycorrhizal inoculation, micronutrients and fertilizer level at all the stages of observation in 2012 and 2013.In 2012, among the organic manures, higher CGR (13.06 to 5.48 g^{-2} day^{-1} between 30-60 DAS and 60-90 DAS, respectively) was recorded under poultry manure 5 t ha^{-1} to preceding maize followed by sericulture waste 5 t ha^{-1} (Table 5). The least crop growth rate was observed under control. Among the micronutrients and AM, $ZnSO_4$ recorded higher CGR of 11.48 and 4.79 g^{-2} day^{-1} between 30-60 DAS and 60-90 DAS, respectively.

In 2013, with respect to organic manures, poultry manure 5 t ha^{-1} to preceding maize recorded higher CGR (14.71 and 6.01 g^{-2} day^{-1} between 30-60 and 60-90 DAS, respectively) followed by sericulture waste 5 t ha^{-1}. The least crop growth rate was recorded under control without micronutrients and AM (M_5S_4). Considering the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher CGR of 13.78 and 5.44 g^{-2} day^{-1} between 30-60 and 60-90 DAS, respectively.With regard to fertilizer levels, 100 per cent RDF to sunflower recorded higher CGR of 11.37 and 4.16 g^{-2} day^{-1} between 30-60 DAS and 60-90 DAS, respectively. The least CGR was recorded under control at all the stages of observation. Relative growth rate which represents the time trend of growth was recorded at different phenophases of sunflower. Significant difference in relative growth rate was observed with organic manures, micronutrients, AM and fertilizer level at all the stages of observation during both

Table 5 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on crop growth rate (CGR) of sunflower (g^{-2} day^{-1})

Treatments	Summer, 2012		Summer, 2013	
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
Organic manures (M)				
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	9.88	3.47	10.61	3.57
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	11.98	4.84	12.82	5.21
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	13.06	5.48	14.71	6.01
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	10.60	3.63	11.85	4.40
M_5 - RDF alone (Control)	7.64	2.37	9.00	2.80
S.E.±	0.53	0.25	0.44	0.26
C.D.(P=0.05)	1.21	0.58	1.02	0.60
Micronutrients and AM (S)				
S_1 - AM @ 100 kg ha^{-1}	9.85	3.92	11.31	4.27
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	11.48	4.79	13.78	5.44
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	10.89	4.07	12.42	4.55
S_4 - Control	8.50	3.05	9.67	3.34
S.E.±	0.16	0.07	0.16	0.08
C.D.(P=0.05)	0.32	0.14	0.33	0.17
Fertilizer levels (F)				
F_0 - Control	9.49	3.76	10.46	4.16
F_1- 100 % RDF	11.37	4.16	13.13	4.64
S.E.±	0.06	0.01	0.09	0.02
C.D. (P=0.05)	0.13	0.03	0.18	0.04
Interaction	NS	NS	NS	NS

NS=Non-significance

2012 and 2013.

In 2012, regarding the organic manures, higher RGR (0.058 and 0.029 mg g^{-1} day^{-1} between 30-60 and 60-90 DAS, respectively) was recorded under poultry manure 5 t ha^{-1} to preceding maize followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} applied to preceding maize (Table 6). The least crop growth rate was observed under control both at 30-60 and 60-90 DAS. Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher RGR of 0.055 and 0.030 mg g^{-1} day^{-1} between 30 - 60 and 60 - 90 DAS, respectively followed by TNAU MN mixture 30 kg $ha^{-1}$and AM. The least RGR was recorded under control. With regard to fertilizer levels, 100 per cent RDF to sunflower recorded higher RGR of 0.051 and 0.022 mg g^{-1} day^{-1} between 30-60 DAS and 60-90 DAS, respectively than control (without fertilizers) to sunflower. Similar results as evidenced in 2012 was also observed during 2013 with regard to organic manures, micronutrients, AM and fertilizer levels. The interaction effect was not significant during both 2012 and 2013.Organic manures, micronutrients, AM and fertilizer levels had a significant influence on the seed yield of hybrid sunflower during 2012 and 2013. During 2012, among the organic manures, higher seed yield of sunflower (2086 kg ha^{-1}) was recorded under poultry manure 5 t ha^{-1} applied to preceding maize followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} (Table 7). The least seed yield of sunflower was recorded under control. Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher seed yield of 2197 kg ha^{-1} followed by TNAU MN mixture 30 kg ha^{-1} and AM applied to preceding maize. The least seed yield was recorded under control. With regard to fertilizer levels, 100 per cent RDF to sunflower recorded higher seed yield (1824 kg ha^{-1}) than unfertilized control.

The interaction between organic manures, micronutrients and AM was significant. The treatment combination of poultry manure 5 t ha^{-1} with $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize recorded higher seed yield of 2859 kg ha^{-1} followed by sericulture waste 5 t ha^{-1} along with $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize (Table 7). The least seed yield (1264 kg ha^{-1}) was recorded under control without organic manures,

Table 6 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on relative growth rate (RGR) of sunflower (g $g^{-1}day^{-1}$)

Treatments	Summer, 2012		Summer, 2013	
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
Organic manures (M)				
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	0.043	0.017	0.044	0.012
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	0.053	0.026	0.058	0.024
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	0.058	0.029	0.066	0.031
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	0.048	0.020	0.050	0.015
M_5 - RDF alone (Control)	0.035	0.007	0.034	0.007
S.E.±	0.002	0.002	0.261	0.002
C.D.(P=0.05)	0.004	0.004	0.602	0.005
Micronutrients and AM (S)				
S_1 - AM @ 100 kg ha^{-1}	0.044	0.017	0.046	0.016
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	0.055	0.030	0.061	0.022
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	0.051	0.019	0.055	0.019
S_4 - Control	0.040	0.014	0.042	0.013
S.E.±	0.001	0.001	0.082	0.001
C.D.(P=0.05)	0.001	0.002	0.167	0.001
Fertilizer levels (F)				
F_0 - Control	0.043	0.018	0.046	0.016
F_1- 100 % RDF	0.051	0.022	0.055	0.019
S.E.±	0.001	0.001	0.02	0.001
C.D.(P=0.05)	0.002	0.002	0.04	0.002
Interaction	NS	NS	NS	NS

NS=Non-significant

micronutrients and AM. The interaction between micronutrient AM and fertilizer levels was also significant. The treatment combination of $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize along with 100 per cent RDF to sunflower (S_2F_1) recorded higher seed yield (2185 kg ha^{-1}) than the other treatment combinations. The seed yield of sunflower recorded during 2013 also indicated similar trend as that of the previous year crop with regard to organic manures, micronutrients, AM and fertilizer levels to sunflower.

Crop production is determined by crop growth rate as a function of light interception by the leaf area of a crop (Whigham, 1983). Shibles and Weber (1966) also stated that as CGR is a linear function of intercepted irradiance, maintaining higher LAI has a positive effect for higher dry matter production due to increased CGR. With respect to micronutrients and AM, higher CGR was recorded under $ZnSO_4$ @ 37.5 kg^{-1} and this was mainly due to significant improvement in the uptake of Zn and the resultant uptake of other nutrients. These results are in conformity with findings of Tabrizi *et al.* (2009) and Tariq *et al.* (2014) who reported similar results of higher CGR due to Zn application in maize hybrids. Among the organic manures, poultry manure registered higher RGR. The increased trend of growth rate might be due to the fact that in the initial stage, applied nutrients might have been entirely used for vegetative growth. This would have led to higher crop growth and hence higher crop growth rate and relative growth rate. Similar results were reported by Banga *et al.* (1994) and Afifi *et al.* (2011) in maize. Among the organic manures, poultry manure recorded the highest grain yield followed by sericulture waste. The yield increase in poultry manure was only due to efficient utilization of nutrients supplied by poultry manure along with inorganic fertilizers to maize as reported by Yilmaz *et al.* (2008). The interaction between poultry manure with RDF and $ZnSO_4$ was significant. The highest grain yield was recorded under the treatment combination of poultry manure with RDF along with $ZnSO_4$ @ 37.5 kg ha^{-1} (M_3S_2) followed by sericulture waste along with RDF and $ZnSO_4$. Positive and significant improvement in CGR and RGR at different stages and higher nutrient uptake due to higher nutrient content and supply of nutrients by poultry manure and zinc by zinc sulphate would have resulted in enhanced yield attributes leading to higher grain yield. The findings of Rafiq *et al.* (2010) who reported that application of zinc increased maize grain yield in combination with higher N dose, supports the present findings.

All the organic manures applied to preceding maize exerted a positive influence on the yield of succeeding sunflower. Among the organic manures, seed and stalk yield of sunflower were higher with application of poultry manure to preceding maize. This positive response recorded could be due to mineralization of nutrients, as a result of which better growth was achieved. Higher vegetative production due to higher interception of light might have improved assimilate production and hence increased the yield as reported by Babaji *et al.* (2011). Similar result of increased crop yields due to residual

Table 7 : Interaction effect of residual organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on seed yield of sunflower (kg ha^{-1})

Main plots / Sub plots	Summer, 2012						Summer, 2013					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	1391	1415	1859	1421	1319	1481	1474	1805	1866	1596	1513	1651
S_2	1604	2848	2859	2424	1248	2197	1978	2381	2931	2288	1562	2228
S_3	1448	1725	1731	1445	1371	1544	1807	1902	2078	1695	1541	1804
S_4	1389	1540	1894	1297	1264	1477	1392	1771	1887	1570	1426	1609
F_0	1372	1799	1986	1575	1206		1603	1897	2124	1728	1425	
F_1	1544	1965	2185	1719	1395		1723	2032	2257	1847	1596	
Mean	1458	1882	2086	1647	1300		1663	1965	2190	1787	1510	
	Source	S.E.±	C.D. (P=0.05)				Source	S.E. ±	C.D. (P=0.05)			
	M	73	169				M	54	125			
	S	43	88				S	30	61			
	F	6	12				F	5	9			
	M at S	101	222				M at S	73	161			
	M at F	61	138				M at F	45	102			

effect of organic manures as reported by Jayanthi *et al.* (1997); Singh *et al.* (1999) and Babaji *et al.* (2011), lend support to the present finding.

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