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RESEARCH ARTICLE :

Impact on residual effect of different sources of organic manures, micronutrients and Arbuscular Mycorrhiza applied to preceding maize and fertilizer levels to succeeding sunflower on major nutrients uptake, availability and yield of maize-sunflower sequential cropping system

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SUMMARY : Field experiments were conducted to study the influence of organic manures, micronutrients and arbuscular mycorrhiza (AM) on the productivity 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 with three replications for sunflower during summer 2012 and 2013 to estimate the residual effects of organic manures. The popular maize hybrid NK 6240 was taken as test hybrid in maize and Co SFH2 as test hybrid in sunflower. Four sources of organic manures with RDF *viz.*, Farmyard manure 12.5 t ha^{-1}, sericulture waste 5 t ha^{-1}, poultry manure 5 t ha^{-1} and goat manure 5 t ha^{-1} were evaluated in main plot along with one control (RDF only). Arbuscular mycorrhiza 100 kg ha^{-1}, ZnSO4 37.5 kg ha^{-1}, TNAU Micronutrient mixture 30 kg ha^{-1} and a control without micronutrients and AM were studied in the sub plot. Organic manures, micronutrients and AM were applied to first crop of maize only and their residual effect was studied in the succeeding crop of sunflower with and without recommended dose of fertilizer. Observations were recorded on the uptake of Nitrogen (N), Phosphorus (P), Potassium (K), Zinc (Zn) and Iron (Fe) at different growth stages, post harvest soil for available NPK, of different treatments were also worked out for each crop and the system as a whole to justify the significance of treatments. Significantly higher NPK uptake by maize as well as higher soil available NPK was recorded in post harvest soil after maize under application of poultry manure @ 5 t ha^{-1} followed by sericulture waste @ 5 t ha^{-1}. Among the micronutrients and AM treatments, $ZnSO_4$ @ 37.5 kg ha^{-1} recorded the highest NPK uptake and post harvest soil NPK during both the years of study. Among the two fertilizer treatments tried in sunflower, recommended dose of fertilizer application resulted in NPK uptake and post harvest available NPK as compared to no fertilizer treatment in maize-sunflower cropping system revealed that the maximum actual gain in the soil available nitrogen, phosphorus and potassium was recorded under the treatment combination of poultry manure @ 5 t ha^{-1} with RDF and zinc sulphate @ 37.5 kg ha^{-1} to maize and application of RDF to succeeding sunflower.

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BACKGROUND AND OBJECTIVES

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. Besides its use as food, feed and fodder, maize is now gaining increased importance on account of its potential 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 $kgha^{-1}$. 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, 2011 - 12). The use of optimum levels of N, P, K alone failed to maintain yield levels probably due to increasing secondary and micronutrient deficiencies and also unfavourable alterations in the physical and chemical properties of soil. On the other hand, continuous use of organics helps to build up soil humus and beneficial microbes besides, improving the physical properties. With short supply of and escalating price of inorganic fertilizers, there is an increasing awareness in favour of adopting biological pathway for soil fertility management for preventing soil degradation and for sustaining crop production. Micronutrient deficiencies in crop plants are widespread because of increased micronutrient demands due to intensive cropping practices and adaptation of high yielding cultivars which may have higher nutrient demand. Maize is one of the important crops sensitive to Zn deficiency with a high Zn demand that positively responds to Zn fertilization.

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. 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. Nutrients contained in organic manures are released more slowly and stored for a long time in the soil, ensuring a long residual effect (Sharma and Mittra, 2007). Safety of environment as well as public health is also important reasons for advocating increased use of organic sources of nutrients (Hazra, 2007). Hence, an attempt was made to study the influence of different organic sources with recommended dose of inorganic fertilizers in increasing the productivity and the quality of hybrid maize and possible carry-over residual effect on the succeeding sunflower sown immediately after harvest of maize under irrigated garden land conditions.

RESOURCES AND METHODS

Field experiments were conducted during winter and summer seasons of 2011-2012 and 2012-2013 at Eastern block of Tamil Nadu Agricultural University, Coimbatore to investigate the influence of different organic manures with inorganic fertilizers, micronutrients and arbuscular mycorrhiza on the growth and yield of maize and to assess their residual effect on the succeeding sunflower. The details of materials used and methods employed here. The experiments were laid out in split plot design. In the main plot, four organic nutrient treatments with recommended dose of inorganic fertilizers to the maize crop only *viz*., FYM, sericulture waste poultry manure, goat manure, along with a control (RDF only) and in the sub plot, four treatments *viz*., AM, zinc sulphate and TNAU micro nutrient mixture were evaluated along with absolute control. The treatments were replicated thrice. For the second crop individual plots were further divided into two for raising sunflower, one plot without RDF and another plot with 100 % RDF for sunflower.

Analysis of plant samples:

The oven dried plant samples used for dry matter estimation at 45 and 60 DAS were chopped and ground using Willey mill and analysed for available N, P and K.

The methods used for analysis of plant samples for N, P and K are given below.

Nitrogen uptake:

The total N content in the plant was estimated by micro-kjeldahl method as per the procedure given by Humphries (1956). The uptake was calculated by multiplying the nitrogen content of the plant sample with the dry matter production and expressed in kg ha^{-1}.

Phosphorus uptake :

The total P content in the plant sample was estimated by colorimeter method (Jackson, 1973). The uptake was calculated and expressed in kg ha^{-1}.

Potassium uptake:

The total potassium content was estimated by the triple acid digestion method using flame photometer as suggested by Jackson (1973). The uptake was calculated by multiplying the potassium content of the plant sample with the total dry matter and expressed in kg ha^{-1}.

Zinc uptake :

The zinc content in the plant sample was estimated by Atomic Absorption Spectrophotometer in the tri-acid extract as suggested by Lindsay and Norvell (1978). The uptake was calculated and expressed in g ha^{-1}.

Iron uptake :

The iron content in the plant sample was estimated by Atomic Absorption Spectrophotometer in the tri-acid extract as suggested by Lindsay and Norvell (1978). The uptake was calculated and expressed in g ha^{-1}.

Soil analysis :

Mechanical composition of the soil of the experimental field was assessed as per the procedure suggested by Piper (1966) before the start of experiment. Soil pH and EC were estimated by using pH meter and Conductivity Bridge, respectively, in a soil: water suspension of 1: 2.5 ratio (Jackson, 1973). The soil was also analyzed for soil organic carbon (Walkley and Black, 1934). The soil samples collected from 30 cm depth before the conduct of the experiment and after the harvest of the crop were air dried, sieved through 2 mm sieve and used for N, P, and K estimation.

Available soil nitrogen, phosphorus, potassium :

The available soil nitrogen was estimated by the method proposed by Subbiah and Asija (1956) and expressed in kg ha^{-1}.Available soil phosphorus was estimated by the procedure outlined by Olsen *et al*. (1954) and expressed in kg ha^{-1}. Available soil potassium was estimated by the method proposed by Stanford and English (1949) and expressed in kg ha^{-1}.

Grain and stover 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}.and the harvest of cobs, the stover in the net plot area was cut close to the ground level and left in the field for three days for sun drying. After drying, weight of stover from each plot was recorded and expressed in kg ha^{-1}.

Seed and stalk yield :

Seed yield from net plot area was recorded at 14 per cent moisture level and expressed in kg ha^{-1} and the stalk yield from the net plot area was recorded after sun drying to constant weight and expressed in kg ha^{-1}.

Statistical analysis :

The data collected were statistically analyzed as suggested by Gomez and Gomez (1984). Wherever the treatment differences were found significant, critical difference was worked out at five per cent probability level. The interaction effect was discussed wherever it was found significant.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Uptake of N, P, K, Zn and Fe in maize :

In the first crop maize during 2011-12, in respect of organic manures, poultry manure 5 t ha^{-1} recorded higher N uptake (20.64, 112.6 and 189.9 kg ha^{-1} at 30, 60 and

90 DAS, respectively) followed by sericulture waste compost 5 t ha^{-1} and both were comparable with each other. The uptake was however, the least with control. With respect to micronutrients and AM, N uptake was higher under $ZnSO_4$37.5 kg ha^{-1} (17.47, 105.2 and 183.8 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by TNAU MN mixture and AM were comparable among themselves. The least N uptake was recorded under control. During 2012-13, regarding organic manures, poultry manure 5 t ha^{-1} recorded higher N uptake of 21.49, 117.2 and 202.0 kg ha^{-1} respectively at 30, 60 and 90 DAS followed by sericulture waste compost 5 t ha^{-1} and both were comparable with each other. The uptake was however, the least with control. With respect to micronutrients and AM, N up take was higher under $ZnSO_4$37.5 kg ha^{-1} (20.77, 112.4 and 195.2 kg ha^{-1}, at 30,

Table 1 : Effect of organic manures, micronutrients and AM on nitrogen uptake of maize (kg ha^{-1})

Treatments	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	13.14	94.2	171.6	17.86	108.4	193.1
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	17.38	105.8	181.4	20.15	113.2	198.4
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	20.64	112.6	189.9	21.49	117.2	202.0
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	15.34	98.4	175.2	19.00	109.7	195.0
M_5 - RDF alone (Control)	11.21	89.2	167.4	14.30	94.3	178.5
S.E. ±	0.80	4.3	7.6	0.98	6.6	9.6
C.D. (P=0.05)	1.85	9.9	17.5	2.26	15.2	22.1
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	16.12	99.9	173.4	17.57	107.2	192.5
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	17.47	105.2	183.8	20.77	112.4	195.2
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	15.87	102.5	179.3	18.56	108.6	194.8
S_4 - Control	14.63	92.5	172.0	17.35	106.0	191.1
S.E. ±	0.71	3.73	4.8	0.39	5.8	8.4
C.D. (P=0.05)	1.45	7.63	NS	0.79	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

Table 2 : Effect of organic manures, micronutrients and AM on phosphorus uptake of maize (kg ha^{-1})

Treatment	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	12.08	13.15	29.52	12.55	14.50	33.07
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	12.70	13.80	30.59	15.44	16.36	37.90
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	13.23	14.53	31.61	16.50	17.99	39.28
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	12.50	13.50	30.57	14.33	15.24	35.19
M_5 - RDF alone (Control)	9.26	12.20	28.00	10.71	12.92	29.40
S.E. ±	0.62	0.65	1.12	0.88	0.79	1.96
C.D. (P=0.05)	1.43	1.51	2.58	2.02	1.82	4.51
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	11.26	12.86	28.27	13.1	14.72	33.68
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	13.92	15.58	34.88	16.0	17.17	38.97
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	12.49	13.82	30.09	14.4	15.88	36.60
S_4 - Control	10.14	11.49	27.00	12.2	13.83	30.62
S.E. ±	0.54	0.54	0.99	0.72	0.69	0.91
C.D. (P=0.05)	1.10	1.10	2.02	1.47	1.41	1.85
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

60 and 90 DAS, respectively). However, the difference between the treatments did not reach the level of significance at 60 and 90 DAS. The least N uptake was recorded under control.

In the year 2011-12, among the organic manures, poultry manure 5 t ha^{-1} registered higher Phosphorus uptake of (13.23, 14.53 and 31.61 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1} goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} and these treatments were comparable among themselves. The least Phosphorus uptake was recorded under control.

Considering the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded higher Phosphorus uptake (13.92, 15.58 and 34.88 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by TNAU MN mixture and AM. The least uptake of phosphorus was recorded under control. During

Table 3 : Effect of organic manures, micronutrients and AM on potassium uptake of maize (kg ha^{-1})

Treatments	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	13.05	94.56	191.7	15.76	92.57	192.5
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	13.75	96.40	194.2	17.60	102.1	201.9
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	14.63	97.30	198.5	19.80	104.2	206.6
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	13.38	95.61	195.1	16.29	98.30	195.0
M_5 - RDF alone (Control)	11.56	85.45	173.0	12.55	88.69	182.7
S.E. ±	0.65	3.61	6.5	0.99	4.25	8.0
C.D. (P=0.05)	1.49	8.62	15.0	2.28	9.78	18.4
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	12.30	92.90	189.5	15.92	96.29	194.9
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	15.52	97.77	198.8	18.21	100.55	203.4
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	13.60	94.88	190.7	16.75	100.36	197.0
S_4 - Control	11.67	89.91	183.0	14.72	91.47	187.7
S.E. ±	0.32	3.30	5.8	0.46	3.19	7.5
C.D. (P=0.05)	0.65	6.70	11.0	0.94	6.40	15.2
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

Table 4 : Effect of organic manures, micronutrients and AM on zinc (g ha^{-1}) uptake of maize

Treatment	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	96.3	263.8	702.5	93.4	262.7	693.2
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	138.4	300.7	796.2	149.2	314.9	812.1
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	152.7	336.2	842.5	167.3	342.4	856.3
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	115.2	275.6	741.7	121.6	286.3	766.9
M_5 - RDF alone (Control)	65.8	183.4	594.3	73.2	196.8	617.4
S.E. ±	4.6	8.4	16.2	4.8	8.8	16.6
C.D. (P=0.05)	10.6	19.3	37.3	11.0	20.2	38.2
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	95.5	269.2	724.1	98.1	258.2	684.3
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	158.4	341.7	847.8	173.2	351.3	862.4
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	105.8	305.4	749.3	141.4	308.7	786.5
S_4 - Control	35.2	121.3	510.2	78.3	180.2	518.6
S.E. ±	3.8	7.2	14.6	3.9	7.4	16.2
C.D. (P=0.05)	7.7	14.6	29.6	7.9	15.0	32.9
Interaction	NS	NS	NS	NS	NS	NS

NS-Non-significant

2012-13, in the second crop, regarding organic manures, poultry manure 5 t ha^{-1} recorded higher P uptake (16.50, 17.99 and 39.28 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1} and both were comparable with each other. The least uptake was recorded under control.

The potash uptake was significantly influenced by organic manures, micronutrients and mycorrhizal inoculation at all the stages during both 2011-12 and 2012-13. In the year 2011-12, with regard to organic manures, poultry manure 5 t ha^{-1} registered higher K uptake (14.63, 97.30 and 198.5 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1} goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} and were comparable among themselves. The least uptake at all the stages was recorded under control. With respect to

Table 5 : Effect of organic manures, micronutrients and AM on iron (g ha^{-1}) uptake of maize

Treatments	Winter, 2011-12			Winter, 2012-13		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	212.1	356.4	638.3	228.4	367.5	642.5
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	284.7	405.3	694.2	296.8	410.2	708.3
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	295.8	424.1	716.8	305.7	431.5	724.2
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	243.2	378.2	675.6	252.8	384.3	682.6
M_5 - RDF alone (Control)	198.4	284.6	515.4	204.3	290.2	521.4
S.E. ±	5.1	9.4	14.2	5.3	9.6	14.5
C.D. (P=0.05)	12.0	22.1	33.4	12.5	22.6	31.1
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	186.3	372.5	667.8	194.2	395.2	682.1
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	246.2	415.2	721.3	252.8	426.6	728.6
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	198.4	401.4	703.2	216.3	410.2	710.5
S_4 - Control	152.1	281.2	506.3	164.2	285.4	512.3
S.E. ±	4.2	8.2	12.1	4.4	8.3	12.3
C.D. (P=0.05)	8.5	16.6	24.8	8.9	16.8	25.0
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

Table 6 : Effect of organic manures, micronutrients and AM on post harvest soil available nitrogen, phosphorus and potassium (kg ha^{-1}) of maize

Treatments	Winter, 2011-12			Winter, 2012-13		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	233.5	15.68	348.6	244.9	15.37	365.3
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	242.1	18.63	363.5	253.3	18.21	383.1
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	254.9	21.22	389.7	262.4	22.38	405.6
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	236.9	16.42	354.1	217.0	16.68	360.8
M_5 - RDF alone (Control)	214.9	11.78	315.5	216.8	12.50	326.1
S.E. ±	7.0	0.59	13.8	8.3	0.76	13.5
C.D. (P=0.05)	16.2	1.35	31.7	19.2	1.75	31.2
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	257.1	17.73	377.9	272.2	19.22	372.7
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	266.2	18.14	407.1	251.2	20.19	410.6
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	215.8	15.70	338.8	243.6	14.30	358.3
S_4 - Control	206.7	12.99	299.3	188.5	11.99	319.1
S.E. ±	4.7	0.44	13.7	10.4	0.70	17.5
C.D. (P=0.05)	9.6	0.89	27.9	21.3	1.44	35.8
Interaction	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

micronutrients and AM, K uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} (15.52, 97.77 and 198.8 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by TNAU MN and AM. The least K uptake was associated with control. Similar trend of results was evident in the second crop of 2012-13, regarding organic manures, micronutrients and AM. In 2011-12, with regard to organic manures, poultry manure 5 t ha^{-1} registered higher Zn uptake (152.7,

Table 7 : Effect of organic manures, micronutrients and AM on grain yield, stover yield (kg ha^{-1}) of maize (Winter, 2011-12)

Treatments	Grain yield	Stover yield
Organic manures (M)		
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	6181	11939
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	6593	12132
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	7230	12193
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	6393	12032
M_5 - RDF alone (Control)	5453	11412
S.E. ±	207	64
C.D. (P=0.05)	476	147
Micronutrients and AM (S)		
S_1 - AM @ 100 kg ha^{-1}	6247	11695
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	7271	12677
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	6555	12236
S_4 - Control	5406	11158
S.E. ±	125	61
C.D. (P=0.05)	254	125
Interaction	Sig	Sig

Table 8 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on nitrogen uptake of sunflower (kg ha^{1})

Treatments	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	3.65	26.43	56.81	4.34	28.45	69.67
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	4.41	33.87	66.85	5.09	35.95	69.82
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	5.00	39.84	79.43	5.76	45.19	81.76
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	3.93	26.60	59.90	4.57	29.36	69.39
M_5 - RDF alone (Control)	2.97	19.68	39.06	3.47	19.29	45.93
S.E. ±	0.17	2.06	3.18	1.01	2.22	2.73
C.D. (P=0.05)	0.38	4.76	7.33	2.32	5.12	6.29
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	3.93	26.48	59.14	4.68	29.00	62.17
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	4.53	34.99	69.15	5.27	38.95	74.07
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	4.16	30.93	62.43	4.80	34.24	67.26
S_4 - Control	3.20	18.95	45.12	3.75	22.00	51.75
S.E. ±	0.05	0.74	0.96	0.35	0.79	0.94
C.D. (P=0.05)	0.11	1.51	1.96	0.70	1.61	1.92
Fertilizer levels (F)						
F_0 - Control	3.75	24.89	55.74	4.38	28.47	61.63
F_1 - 100 % RDF	4.12	29.28	60.68	4.67	31.63	64.99
S.E. ±	0.01	0.14	0.16	0.09	0.10	0.11
C.D. (P=0.05)	0.03	0.29	0.33	0.18	0.21	0.22
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

336.2 and 842.5 g ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}. The least uptake at all the stages was recorded under control. With respect to micronutrients and AM,K up take was higher under $ZnSO_4$ 37.5 kg ha^{-1} (158.4, 341.7 and 847.8 g ha^{-1} at 30, 60 and 90 DAS, respectively) followed by TNAU MN mixture and AM. The least Zn uptake was associated with control. The iron uptake was significantly influenced by organic manures, micronutrients and mycorrhizal inoculation at 30, 60 and 90 DAS during both 2011-12 and 2012-13. During the year 2011-12, with regard to organic manures, poultry manure 5 t ha^{-1} registered higher Fe uptake (295.8, 424.1 and 716.8 g ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1} and was comparable with poultry manure 5 t ha^{-1}. The least uptake at all the stages was recorded under control. With respect to micronutrients and AM, Fe uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} (246.2, 415.2 and 721.3 g ha^{-1} at 30, 60 and 90 DAS, respectively) followed by TNAU MN and AM. The least Fe uptake was associated with control.

Available of N, P, K, Zn and Fe in maize :

There existed significant differences in the available N status among organic manures, micronutrients and AM. In general, all the organic manures recorded higher soil available N than control. In the first year during 2011-12, poultry manure 5 t ha^{-1} registered significantly higher available nitrogen of 254.9 kg ha^{-1} comparable to sericulture waste 5 t ha^{-1} (242.1) and both were comparable with each other. These treatments were followed by goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}. The least available nitrogen was recorded under control. Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded significantly higher available nitrogen (266.2 kg ha^{-1}) comparable to AM. The least available N status was recorded under control. In the second year experiment during 2012-13, among the organic manures, poultry manure 5 t ha^{-1} registered significantly higher available nitrogen (262.4 kg ha^{-1}) followed by sericulture waste 5 t ha^{-1} and both were comparable with each other. The least available nitrogen was recorded under control. With regard to micronutrients and mycorrhizal treatments,

Table 9 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on phosphorus uptake of sunflower (kg ha^{1})

Treatments	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	0.61	5.87	12.14	0.72	7.35	14.33
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	0.82	5.97	14.48	0.91	7.79	16.16
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	1.01	8.41	16.40	1.18	9.94	18.39
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	0.65	6.23	13.77	0.64	7.98	13.99
M_5 - RDF alone (Control)	0.29	4.47	8.34	0.34	5.45	10.62
S.E. ±	0.06	0.55	0.70	0.12	0.42	0.70
C.D. (P=0.05)	0.13	1.27	1.61	0.27	0.96	1.61
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	0.63	6.83	13.73	0.78	8.29	14.50
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	0.82	6.96	14.48	0.96	9.06	15.96
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	0.68	6.25	12.77	0.85	7.84	13.99
S_4 - Control	0.41	5.72	10.33	0.53	6.62	12.55
S.E. ±	0.02	0.19	0.20	0.07	0.10	0.20
C.D. (P=0.05)	0.04	0.39	0.41	0.13	0.21	0.41
Fertilizer levels (F)						
F_0 - Control	0.57	5.90	11.67	0.59	7.27	13.22
F_1 - 100 % RDF	0.70	6.48	13.98	0.92	8.13	15.78
S.E. ±	0.01	0.04	0.08	0.04	0.03	0.09
C.D. (P=0.05)	0.01	0.09	0.17	0.07	0.07	0.17
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

$ZnSO_4$ 37.5 kg ha^{-1} recorded significantly higher soil available nitrogen (251.2 kg ha^{-1}) comparable to AM and TNAU MN mixture. The least available nitrogen was recorded under control.

The organic manures, micronutrients and AM significantly influenced the available phosphorus status of the soil. In 2011-12, among the organic manures, poultry manure 5 t ha^{-1} registered significantly higher available phosphorus (21.22 kg ha^{-1}) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} . The least available phosphorus was recorded under control. Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded significantly higher available phosphorus (18.14 kg ha^{-1}) followed by AM and TNAU MN mixture. The least available phosphorus was recorded under control. The soil available phosphorus recorded in the second year during 2012-13 also indicated similar trend as that of the previous crop with regard to organic manures, micronutrients and S_1, S_2 on par. In the first year during 2011-12,among the organic manures, poultry manure 5 t ha^{-1} registered significantly higher available potassium (389.7 kg ha^{-1}) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} and were comparable among themselves. The least available potassium was registered under control. Among the micronutrients and AM treatments, AM recorded significantly higher available potassium (407.1 kg ha^{-1}) followed by $ZnSO_4$ 37.5 kg ha^{-1}and TNAU MN mixture. The least available K was recorded under control. The soil available potassium recorded in 2012-13 also indicated similar trend as that of the previous crop with regard to organic manures and micronutrients and AM.

Uptake of N, P, K, Zn and Fe in succeeding Sunflower :

During the year 2012, in respect of organic manures, higher N uptake of sunflower was recorded under poultry manure 5 t ha^{-1} applied to preceding maize (5.00, 39.84 and 79.43 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}at all the stages. The least N uptake was recorded under control. With respect to micronutrients and AM, the N uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize followed

Table 10 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on potassium uptake of sunflower (kg ha^{1})

Treatments	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	7.88	78.04	103.3	7.24	73.89	98.05
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	8.85	90.09	122.7	9.96	94.01	123.88
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	9.74	95.38	131.5	11.35	110.3	144.19
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	7.69	77.22	104.5	8.62	79.64	109.43
M_5 - RDF alone (Control)	5.02	57.39	83.6	6.08	61.46	92.28
S.E. ±	0.43	3.84	4.6	4.3	0.43	4.28
C.D. (P=0.05)	1.00	8.84	10.5	9.9	0.99	9.88
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	6.81	73.88	102.2	7.73	77.01	103.10
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	9.90	96.94	132.1	10.80	105.0	133.47
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	8.58	80.99	114.8	9.26	84.46	120.12
S_4 - Control	6.22	66.68	92.2	6.82	68.91	97.57
S.E. ±	0.16	1.24	1.7	1.6	0.16	1.63
C.D. (P=0.05)	0.33	2.53	3.5	3.3	0.33	3.33
Fertilizer levels (F)						
F_0 - Control	7.20	76.68	106.2	8.23	82.06	111.6
F_1 - 100 % RDF	8.55	82.57	114.4	9.07	85.65	115.5
S.E. ±	0.05	0.20	0.3	0.03	0.3	0.13
C.D. (P=0.05)	0.10	0.40	0.6	0.07	0.7	0.26
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

by TNAU MN mixture and AM. The least N uptake was recorded under control. Among the fertilizer levels, 100% RDF to sunflower recorded higher N uptake (4.12, 29.28 and 60.68 kg ha^{-1} at 30, 60 and 90 DAS, respectively) than no fertilizer control at all the stages of observation. The phosphorus uptake was also significantly influenced by organic manures, micronutrients, AM and fertilizer levels at 30, 60 and 90 DAS during 2012 and 2013.

In the year 2012, among the organic manures, poultry manure 5 t ha^{-1} applied to preceding maize registered higher P uptake (1.01, 8.41 and 16.40 kg ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}at all the stages. The P uptake was however, the least under control. Considering the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher P uptake (0.82, 6.96 and 14.48 kg ha^{-1}) at all the stages followed by AM and TNAU MN mixture. The least uptake of phosphorus was recorded under control. With regard to fertilizer levels, higher P uptake was recorded under 100% RDF to sunflower. In all the stages, the least P uptake was associated with no fertilizer control.The K uptake was significantly influenced by organic manures, micronutrients, AM and fertilizer levels at all the stages of observation. In 2012, with regard to organic manures, poultry manure 5 t ha $^{-1}$ applied to preceding maize recorded higher K uptake (9.74, 95.38 and 131.5 kgha^{-1}at30,60and 90 DAS, respectively) followed by sericulture waste 5 t ha $^{-1}$, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}. The K uptake was however, the least under control.

With respect to micronutrients and AM, the K uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize followed by TNAU MN mixture and AM at all the stages of crop growth. Regarding the fertilizer levels to sunflower, 100 % RDF recorded higher K uptake (8.55, 82.57 and 114.4 kg ha^{-1} at 30, 60 and 90 DAS, respectively). The least uptake of K was associated with no fertilizer control. In the second crop during 2013 also, K uptake indicated similar trend as that of the previous year crop with regard to organic manures, micronutrient, AM and fertilizer levels. The Zinc uptake was significantly influenced by organic manures,

Table 11 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on zinc uptake of sunflower (g ha^{-1})

Treatments	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	11.5	24.3	78.2	13.2	26.5	80.6
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	14.8	32.1	85.4	16.4	34.2	87.2
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	16.4	37.6	88.2	19.2	39.4	91.3
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	12.2	29.4	82.6	14.8	30.1	84.3
M_5 - RDF alone (Control)	9.4	20.5	70.1	11.3	22.3	74.1
S.E. ±	0.50	1.6	3.6	0.6	1.7	3.7
C.D. (P=0.05)	1.20	3.8	8.5	1.4	4.0	8.6
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	14.3	28.5	73.1	15.1	31.3	76.2
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	16.8	39.2	86.6	19.4	41.5	89.3
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	15.1	31.3	80.4	17.2	34.2	81.5
S_4 - Control	12.2	18.2	62.5	13.7	26.1	64.3
S.E. ±	0.2	0.5	1.2	0.2	0.6	1.2
C.D. (P=0.05)	0.4	1.0	2.5	0.4	1.2	2.5
Fertilizer levels (F)						
F_0 - Control	10.3	12.1	62.1	12.1	16.2	64.6
F_1 - 100 % RDF	16.4	19.6	84.3	18.2	38.3	86.2
S.E. ±	0.1	0.1	0.3	0.1	0.2	0.3
C.D. (P=0.05)	0.2	0.2	0.6	0.2	0.3	0.6
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

micronutrients, AM and fertilizer levels at 30, 60 and 90 DAS. In 2012, with regard to organic manures, poultry manure 5 t ha^{-1} applied to preceding maize recorded higher Zn uptake (16.4, 37.6 and 88.2g ha^{-1}at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1} . The Zn uptake was however, the least under control. With respect to micronutrients and AM, Zn uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} applied to preceding maize followed by TNAU MN mixture and AM at all the stages of crop growth. The Zn uptake was however, the least under control. Regarding the fertilizer levels to sunflower, 100 % RDF recorded higher Zn uptake at all the stages of observation than no fertilizer control. The iron uptake was significantly influenced by organic manures, micronutrients, AM and fertilizer levels at all the stages. In 2012, with regard to organic manures, poultry manure 5 t ha^{-1} applied to preceding maize recorded higher Fe uptake (163.2, 221.6 and 444.8 g ha^{-1} at 30, 60 and 90 DAS, respectively) followed by sericulture waste 5 t ha^{-1} and both were comparable. The iron uptake was however, the least under control. With respect to micronutrients and AM, the iron uptake was higher under $ZnSO_4$ 37.5 kg ha^{-1} followed by TNAU MN mixture and AM. Regarding the fertilizer levels to sunflower, 100 % RDF recorded higher iron uptake (164.3, 221.8 and 435.2 g ha^{-1} at 30, 60 and 90 DAS, respectively) The least uptake of iron was associated with no fertilizer control.

Available of N, P, K, Zn and Fe in succeeding sunflower :

The available nitrogen was significantly influenced by organic manures, micronutrients, AM and fertilizer levels during both 2012 and 2013. Among the organic manures, poultry manure 5 t ha^{-1} to preceding maize recorded higher soil available N (161.6 and 173.6 kg ha^{-1} during 2012 and 2013, respectively) followed by sericulture waste compost 5 t ha^{-1}, goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}. The least available N was observed with control. Among the micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher soil available N (151.2 and 177.1 kg ha^{-1} during 2012 and 2013, respectively) followed by TNAU MN mixture and AM. Regarding the fertilizer levels, 100% RDF to

Table 12 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on iron uptake of sunflower (g ha^{-1})

Treatment	Summer, 2012			Summer, 2013		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	132.8	187.3	366.7	136.3	190.4	362.8
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	151.4	208.7	420.2	156.2	212.5	426.3
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	163.2	221.6	444.8	164.4	224.2	441.6
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	136.3	192.4	382.5	141.2	196.3	386.3
M_5 - RDF alone (Control)	84.5	181.3	243.2	87.4	184.2	247.4
S.E. ±	4.8	7.3	10.4	4.9	7.7	10.5
C.D. (P=0.05)	11.3	17.2	24.4	11.5	18.1	24.7
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	139.4	196.2	341.3	141.2	200.3	345.6
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	161.8	224.5	449.6	167.4	229.2	451.2
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	153.2	210.3	398.2	156.3	216.8	401.4
S_4 - Control	80.3	163.2	250.8	84.2	167.4	263.7
S.E. ±	2.2	3.5	5.0	2.3	3.6	5.2
C.D. (P=0.05)	4.5	7.1	10.1	4.6	7.3	10.3
Fertilizer levels (F)						
F_0 - Control	81.2	158.6	263.4	83.6	161.2	268.2
F_1 - 100 % RDF	164.3	221.8	435.2	167.8	227.4	439.4
S.E. ±	1.8	3.8	5.4	1.7	3.9	5.6
C.D. (P=0.05)	3.6	7.6	10.8	3.4	7.8	11.2
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

sunflower registered higher soil available N (137.0 and 153.3 kg ha^{-1} during 2012 and 2013, respectively). The least soil available N was recorded under control during both the years of the study. The interaction between organic manures, micronutrient and AM was significant. The treatment combination of poultry manure 5 t ha^{-1} with $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher soil available N (180.3 kg ha^{-1}) followed by poultry manure 5t ha^{-1} along with TNAU MN mixture 30 kg ha^{-1} to preceding maize. The least soil available N (68.2 kg ha^{-1}) was recorded under control. In general, organic manures, micronutrients, AM and fertilizer levels had significant influence on soil available P. With respect to organic manures, poultry manure 5 t ha^{-1} applied to preceding maize recorded higher available phosphorus followed by sericulture waste 5 t ha^{-1} during both the years. The least available P was recorded under (100% RDF alone) control. Among the micronutrients and AM, application of $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher soil available P (12.52 and 15.19 kg ha^{-1} during 2012 and 2013, respectively) than the other treatments. The fertilizer level of 100% RDF to sunflower resulted in higher soil available P (11.43 and 12.98 kg ha^{-1} during 2012 and 2013, respectively). The least available P was associated with no fertilized control. The interaction between organic manures, micronutrient and AM was significant. The treatment combination of poultry manure 5 t ha^{-1} with $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher soil available P (15.99 kg ha^{-1}) followed by sericulture waste 5 t ha^{-1} along with $ZnSO_4$ 37.5 kg ha^{-1}. The least soil available P (5.64 kg ha^{-1}) was recorded under 100% RDF alone (control). The soil available K status varied with varying organic manures. Higher soil available K was recorded underpoultry manure 5t ha^{-1}followed by sericulture waste 5t ha^{-1} applied to preceding maize. The least available K was observed with control. With regard to micronutrients and AM, $ZnSO_4$ 37.5 kg ha^{-1} recorded significantly higher soil available K (387.9 and 455.9 kg ha^{-1} during 2012 and 2013, respectively) followed by TNAU MN mixture 30 kg ha^{-1}. The least soil available K was recorded under control.

Considering the fertilizer levels, 100 % RDF to preceding maize recorded significantly higher soil

Table 13 : Residual effect of organic manures, micronutrients and AM applied to preceding maize and fertilizer level to sunflower on post harvest soil available nitrogen, phosphorus and potassium (kg ha^{1})

Treatments	Summer, 2012			Summer, 2013		
	Available nitrogen	Available phosphorus	Available potassium	Available nitrogen	Available phosphorus	Available potassium
Organic manures (M)						
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	104.9	8.75	335.3	140.2	10.55	353.0
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	144.9	11.28	385.7	160.1	12.07	416.0
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	161.6	12.93	428.2	173.6	13.87	444.2
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	130.0	9.80	356.3	150.7	10.63	387.3
M_5 - RDF alone (Control)	95.0	7.35	321.6	128.5	9.00	332.6
S.E. ±	5.6	0.44	8.7	3.6	0.38	9.3
C.D. (P=0.05)	13.0	1.02	20.1	8.2	0.87	21.4
Micronutrients and AM (S)						
S_1 - AM @ 100 kg ha^{-1}	136.9	10.97	354.7	135.6	10.21	349.0
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	151.2	12.52	387.9	177.1	15.19	455.9
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	131.4	9.55	373.1	159.1	11.42	394.5
S_4 - Control	89.5	7.05	346.0	130.7	8.07	347.1
S.E. ±	2.7	0.23	1.9	2.1	0.29	5.2
C.D. (P=0.05)	5.6	0.47	3.9	4.3	0.60	10.5
Fertilizer levels (F)						
F_0 - Control	117.6	8.62	354.4	147.9	9.47	377.7
F_1 - 100 % RDF	137.0	11.43	376.5	153.3	12.98	395.5
S.E. ±	0.6	0.10	0.7	0.2	0.12	0.9
C.D. (P=0.05)	1.3	0.20	1.5	0.4	0.25	1.8
Interaction	Sig	Sig	Sig	Sig	Sig	Sig

available K (376.5 and 395.5 kg ha^{-1} during 2012 and 2013, respectively). The least soil K was recorded under control. The interaction between organic manures, micronutrient and AM was significant. The treatment combination of poultry manure 5 t ha^{-1} with $ZnSO_4$ 37.5 kg ha^{-1} to preceding maize recorded higher soil available K (472.1 kg ha^{-1}) followed by poultry manure 5 t ha^{-1} along with TNAU MN mixture 30 kg ha^{-1}. The least soil available K (300.3 kg ha^{-1}) was recorded under 100% RDF (control) to previous maize and no fertilizer to sunflower.

In the first maize crop during 2011-12, among the organic manures, poultry manure 5 t ha^{-1} recorded the highest grain yield of 7230 kg ha^{-1}. 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 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

Table 14 : Effect of organic manures, micronutrients and AM on grain yield, stover yield (kg ha^{-1}) of maize (Winter, 2011-12)

Treatment	Grain yield	Stover yield
Organic manures (M)		
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	6181	11939
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	6593	12132
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	7230	12193
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	6393	12032
M_5 - RDF alone (Control)	5453	11412
S.E. ±	207	64
C.D. (P=0.05)	476	147
Micronutrients and AM (S)		
S_1 - AM @ 100 kg ha^{-1}	6247	11695
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	7271	12677
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	6555	12236
S_4 - Control	5406	11158
S.E. ±	125	61
C.D. (P=0.05)	254	125
Interaction	Sig	Sig

Table 15 : Effect of organic manures, micronutrients and AM on grain yield, stover yield (kg ha^{-1}) of maize (Winter, 2012-13)

Treatments	Grain yield	Stover yield
Organic manures (M)		
M_1 - RDF+ Farmyard manure @12.5 t ha^{-1}	6151	11984
M_2 - RDF+ Sericulture waste @ 5 t ha^{-1}	6953	12208
M_3 - RDF+ Poultry manure @ 5 t ha^{-1}	7635	12300
M_4 - RDF+ Goat manure @ 5 t ha^{-1}	6377	12103
M_5 - RDF alone (Control)	5514	11441
S.E. ±	219	69
C.D. (P=0.05)	506	159
Micronutrients and AM (S)		
S_1 - AM @ 100 kg ha^{-1}	6218	11734
S_2 - $ZnSO_4$ @ 37.5 kg ha^{-1}	7524	12838
S_3 - TNAU MN mixture @ 30 kg ha^{-1}	6562	12268
S_4 - Control	5800	11189
S.E. ±	201	66
C.D. (P=0.05)	411	134
Interaction	Sig	Sig

interaction between organic manures, micronutrient and AM on maize grain yield was significant. 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}). In the second crop during 2012-13 also, similar trend of results as observed in the first crop during 2011-12 was observed. Regarding organic manures, higher yield of 7635 kg ha^{-1} was recorded by 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}. Control recorded the least yield (5514 kg ha^{-1}). In 2011-12, regarding the organic manures, poultry manure 5 t ha^{-1} recorded higher stover yield of 12193 kg ha^{-1} followed by sericulture waste 5 t ha^{-1} and both were comparable. These treatments were followed by goat manure 5 t ha^{-1} and FYM 12.5 t ha^{-1}. The least stover yield was recorded under control. With regard to micronutrients and AM inoculation, $ZnSO_4$ 37.5 kg ha^{-1} recorded significantly higher yield followed by TNAU MN mixture and AM. The least stover yield was recorded under control. The interaction between organic manures, micronutrients and AM inoculation was significant. The treatment combination of poultry manure 5 t ha^{-1} and $ZnSO_4$ 37.5 kg ha^{-1} (M_3S_2) recorded higher stover yield (13026 kg ha^{-1}) followed by sericulture waste compost 5 t ha^{-1} with $ZnSO_4$ 37.5 kg ha^{-1} (M_2S_2) and both were comparable with each other. The least stover yield of 10602 kg ha^{-1} was observed under control without organic manures, micronutrient and AM. 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}. 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% 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. The least seed yield (1264 kg ha^{-1}) was recorded under control without organic manures, 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% RDF to sunflower (S_2F_1) recorded higher seed yield (2185 kg ha^{-1}) than the other treatment combinations.

The rate of uptake is dependent upon crop N demand, phonological stage, soil N availability, transpiration, rooting depth and soil water status. Crop nitrogen demand is estimated depending on the rate of growth and the maximum concentration of nitrogen that different organs can accumulate depends upon their composition (Hebbar *et al.*, 2007). This was due to the fact that poultry manure contains 60 per cent of N in the form of uric acid, which

Table 16 : 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			

changed rapidly to NH_4 form for utilization, by plants which resulted in higher uptake (Amanullah *et al*., 2006). The higher N uptake in the grain, fertilized with poultry manure and inorganic fertilizers reflected the extent and pattern of N release for absorption by the plant from seedling stage to grain filling stage (Norman *et al*., 2003).Application of poultry manure with RDF recorded higher phosphorus uptake at 90 DAS followed by sericulture waste. This might be due to the higher phosphorus available for uptake by plants. Application of organic manure in combination with inorganic fertilizer might have decreased the adsorption capacity and increased the soluble P, P desorption and this lead to higher uptake of P (Sharma and Mitra, 1989). Application of poultry manure with inorganic fertilizers showed higher P uptake among the treatments. This was due to increase in available nutrient status with greater utilization by the crops because of higher DMP and yield. Improved growth and greater accumulation of biomass led to increased uptake (Sharma *et al.* 2008). Regarding organic manures, application of poultry manure with RDF recorded higher K uptake among the treatments. This was due to increase in available nutrient status by poultry manure with greater utilization by the crops because of higher DMP and yield. Improved growth and greater accumulation of biomass led to increased uptake. Accelerated growth in terms of DMP and N content augmented the nutrient uptake of crop (Sharma *et al.* 2008). Similar result has also been reported by Viator *et al.* (2002). Regarding organic manures, poultry manure registered higher Zn uptake at both 45 and 90 DAS followed by sericulture waste and other organic manures. Poultry manure contains all the essential plant nutrients that are required by the crop. These include N, P, K, Zn and Fe and Mo. Application of zinc sulphate @ 37.5 kg ha^{-1} significantly increased the Zn uptake in maize due to the direct supply of Zn. This result is in conformity with the findings of Abbas *et al.* (1995) and Dineshkar and Babulkar (1998) who reported similar results in safflower. Regarding organic manures, poultry manure registered higher Fe uptake at both 45 and 90 DAS followed by sericulture waste. This might be due to higher iron content present in poultry manure and the resultant uptake by maize. The finding of Prasad *et al.* (1984) who reported that addition of poultry manure with N, P, K, Zn and Fe increased the uptake of Fe by wheat is concomitant to the present finding. Application of zinc sulphate @37.5 kg ha^{-1} significantly increased the Fe uptake in maize and this was due to the synergism between Zn and Fe. This result is in line with the findings of Basavaraju *et al.* (1995) who reported that zinc and iron concentration in both grain and stover and their uptake by maize was the highest where $ZnSO_4$ @ 25 kg ha^{-1} was applied. The higher N availability under poultry manure treatments might be due to higher N content and continuous and slow release of nutrients from poultry manure and increased biomass and the resultant accumulated soil organic matter as reported by Amanullah *et al.* (2006) and Prasanthrajan *et al.* (2009). Busari *et al.* (2008) reported that the combined addition of poultry

Table 17 : 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			

manure, chemical fertilizer and lime to the soil was the most efficient in raising the soil total N, available P and exchangeable cation concentrations. Application of poultry manure resulted in higher soil available P at all the growth stages of maize during both the years of study. During 2011-12, it was 9.8 per cent and during 2012-13, 19.5 per cent higher than control. This was due to the fact that during the mineralization of poultry manure, a number of organic acids, especially the hydroxyl ions (product of microbial metabolism) are produced, which released P through chelating or by removal of metal ions from the insoluble metal phosphates (Mohandas and Appavu, 2000). Among the organic manures, all the manurial treatments registered higher available potassium status. The potassium availability was reduced at post harvest analysis while comparing initial level. This is also in confirmation with the study conducted at Coimbatore on nutrient management in cotton based cropping systems, which indicated very high level of K removal from the soil and high negative balances of potassium (Blaise *et al.*, 2004). Similar results were reported by Padole *et al.* (1998) and Malewar *et al.* (2000). Application of RDF alone recorded the least soil available nitrogen, phosphorus and potassium. This might be due to depletion of soil nutrients, due to higher uptake of nutrients N, P and K than the applied level. Similar findings were reported by Ananthi *et al.* (2010) in maize. Different organic manures applied to preceding maize influenced the uptake of major nutrients by succeeding sunflower. In general organic manures increased the availability of nutrients to the crop. Organic manure application also improved the soil environment, which in turn encouraged proliferous root system, resulting in better absorption of water and nutrient and thus resulting in higher biomass yield and nutrient uptake as reported by Singh and Singh (2000).

The findings of Savithri *et al.* (1991) who observed that application of poultry manure at 6.25 t ha{ ¹ to the first crop of sorghum had significant residual effect on the succeeding cowpea crop nutrient uptake due to increased nutrient content of the soil. The enhancement of Zn uptake in seed and stalk of sunflower in the present study depicted the influence of residual effect of zinc on zinc nutrition in sunflower. The formation of hydroxides of zinc or precipitation as zinc carbonate generally occurs in calcareous soils as reported by Rai *et al.* (1982). Organic manures applied to preceding maize recorded higher soil available N, P and K. The increase could be due to contribution of N, P, K by the addition of organic manures and enrichment of available soil pool. The favourable and beneficial effect of organic manures on available nutrient status of soil might also be due to greater availability of nutrients to crop due to solublising effect of different forms of nutrients present in soil and their own contribution (Ghosh *et al.,* 2002).

Among the micronutrients and AM, residual effect of zinc sulphate increased post harvest soil nutrients due to balanced supply of micronutrients to sunflower crop. An increase in availability of zinc in soils with increasing dose of zinc sulphate has been reported by Savithri (1978). Better performance of maize with the application of poultry manure was also due to certain hormonal compounds present in poultry manure. The combined application of poultry manure and inorganic fertilizers produced the synergistic effect on yield and yield attributes. Adeniyan and Ojeniyi (2005) obtained higher maize yield from combined use of NPK fertilizer and poultry manure than from sole inorganic fertilizer applications. The beneficial effect of poultry manure in enhancing the yield of maize in combination with inorganic was also reported earlier by Vasanthi and Kumaraswamy (2000), Agyenium *et al.* (2006) and Ayoola and Makinde (2007). Abdel-Magid *et al.*(1995) reported that grain and straw yield of wheat increased with increased rate of poultry manure in Saudi Arabia and obtained the greatest economic return at 8.25 t ha^{-1}. 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 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. . Saviour and Stalin (2013) have reported that residual effect of zinc improved the pod and haulm yield of blackgram in maize-blackgram cropping system. Sudarsan and Ramasamy (1993) also found that residual effect of zinc sulphate gave good seed and haulm yield in black gram crop in groundnut-blackgram cropping system. Similar results were also reported by Latha *et al*. (2002). Among the two fertilizer levels tried in succeeding sunflower, RDF resulted in significantly higher seed and stover yield. Ananthi (2013) reported higher seed and stalk yield of sunflower in maize-sunflower cropping system. Increasing nitrogen and phosphorus levels enhanced the availability of nutrients to plants throughout the growing period, which resulted in improvement of growth and yield parameters and consequently the yield. Similar results reported by Kumar *et al*. (1998) are concomitant to the present finding. Thus, overall improvement in growth coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structure on the other hand, might have improved the yield (Abayomi *et al*. 2008). These results are in line with the findings of Azarpour *et al.* (2011).

Conclusion :

In maize – sunflower cropping system, application of poultry manure @ 5 t ha^{-1} with RDF along with zinc sulphate @ 37.5 kg ha^{-1} to maize and RDF to succeeding sunflower crop recorded the highest uptake, availability of major and micronutrients and higher grain and seed yield of maize and sunflower.

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REFERENCES

Abayomi, Y.A., Ajibade, T.V., Sammuel, O.F. and Saadudeen, B.F. (2008). Growth and yield responses of cowpea (*Vigna unguiculata* (L.) Walp) genotypes to nitrogen fertilizer (NPK) application in the Southern Guinea Savanna Zone of Nigeria. *Asian J. Plant Sci.,* **7** : 170-176.

Abbas, M., Tomar, S. Surendra and Nigam, K.B. (1995). Effect of phosphorus and sulphur fertilization in safflower (*Carthamus tinctorius* L.). *Indian J. Agron.,* **40**(2): 243-248.

Abdel-Magid, H.M., Al-Abdel, S.I., Rabie, R.K. and Sabrah, R.E.A. 1995. Chicken manure as a bio fertilizer for wheat in the sandy soils of Saudi Arabia. *J. Arid. Environ.,* **29**: 413-420.

Adeniyan, O.N. and Ojeniyi, S.O. (2005). Effect of poultry manure, NPK 15 – 15- 15 fertilizer and combinations of their reduced levels on maize growth and their chemical properties. SSSN 2005. **15**: 34 - 41.

Agyenim, S.B., Zickermann, J. and Kornoohrens, M. (2006). Poultry manure effect on growth and yield of maize. *West Africa J. Appl. Ecol.,* **9** : 1-11.

Amanullah, M.M., Yassin, M.M., Somasundaram, E., Vaiyapuri, K., Sathyamoorthi, K. and Pazhanivelan, S. (2006). N availability in fresh and composted poultry manure. *Res. J. Agric. Biol. Sci.,* **2**(6) : 406-409.

Ananthi, T., M. Mohamed Amanullah and Subramanian, K.S. (2010). Influence of mycorrhizal and synthetic fertilizers on soil nutrient status and uptake in hybrid maize. *Madras Agric. J.,* **97** (10-12) : 374-378.

Ananthi, T. (2013). Influence of intercropping systems, mycorrhizal inoculation and fertilizer levels on the productivity of maize based cropping system. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, T.N. (INDIA).

Ayoola, O.T. and Makinde, E.A. (2007). Complementary organic and inorganic fertilizer application: Influence on growth and yield of cassava/maize/melon Intercrop with a relayed cowpea. *Australian J. Basic Applied Sci.,* **1**(3) : 187-192.

Azarpour, E., Danesh, R.K., Mohammadi, S., Hamid Reza Bozorgi, H.R. and Moraditochaee, M. (2011). Effect of nitrogen fertilizer and foliar spraying of humic acid on yield and yield component of cowpea (*Vigna unguniaulata*). *World Appl. Sci. J.,* **13**(6) : 1445-1449.

Babaji, B.A., Yahaya, R.A. and Mahadi, M.A. (2011). Growth attributes and pod yield of four cowpea (*Vigna unguiculata* (L.) Walp.) Varieties as Influenced by Residual Effect of Different application rates of farmyard manure. *J. Agric. Sci.,* **3**(2) : 165-171.

Basavaraju, P.K., Dasog, G.S., Vijayashekhar, R. and Sarangamath, P.A. (1995). Effect of zinc and iron application on maize yield in an irrigated vertisol. *Karnataka J. Agric. Sci.,* **8**: 34-39.

Blaise, D., Rupa, T.R. and Bonde, A.N. (2004). Effect of organic and modern method of cotton cultivation on soil nutrient status. *Comm. Soil Sci. Plant Annals*, **35**(9and10) : 1247-61.

Busari, M. A., Salako, F.K. and Adetunji, M.T. (2008). Soil chemical properties and maize yield after application of organic and inorganic amendments to an acidic soil in southwestern Nigeria. *Spanish J. Agric. Res.,* **6**(4) : 691-699.

Ghosh, P.K., Manda, K.G., Bandyopadhyay, K.K., Hati, K.M., Subbarao, A. and Tripathi, A.K. (2002). Role of plant nutrient management in oilseed production. *Fertilizer News*, **47**(11): 67-77 and 79-80.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical procedures for agriculture research*, (Second Ed.), John wiley and Sons, Newyork. p.680.

Hazra, C.R. (2007). Organic manures for sustainable agriculture. *J. Agriculture Issues,* **12**(1) : 1-10.

Hebbar, K.B., Rao, M.R.K. and Khadi, B.M. (2007). Synchronized boll development of Bt. cotton hybrids and their physiological consequences. *Curr. Sci.,* **93**(5): 10.

Humphries, E.C. (1956). Mineral components and ash analysis. In: Proc. Modern method of plant analysis, Springer-Verlar, Berlin, 1. pp: 468-502.

Jackson, M.L. (1973). Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi. II[nd] Indian Reprint. pp. 1-498.

Jayanthi, C., Rangasamy, A. and Chinnusamy, C. (1997). Integrated nutrient management in rice based cropping system linked with lowland integrated farming system. *Fertilizer News*, **42**(3) : 25-30.

Kumar, S., Singh, A.K., Vyas, A.K. and Kumar, R. (1998). Response of sunflower (*Helianthus annuus* L.) to varying levels of nitrogen and phosphorus in southern Rajasthan. *Haryana J. Agron.,* **14**(2) : 231-233.

Latha, M.R., Savithri, P., Indirani, R. and Kamaraj, S. (2002). Residual effect of zinc-enriched organic manures on yield and zinc uptake in sunflower under maize sunflower cropping sequence. *Agric. Sci. Digest.,* **22**(2) : 114-116.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.,* **42** : 421-428.

Malewar, G.U., Bodale, S.B., Mali, D.V., Siddiqui, M.B. and Ismail, A. (2000). Influence of flyash with and without FYM and fertilizers on physicochemical properties of sunflower and cotton growing soils. *Ann. Agric. Res.,* **21**(2) : 187-191.

Mishra, O.R., Kandila, S.C. and Sharma, R.A. (1994). Influence of fertility levels, cycocel, rhizobium culture and FYM on growth and yield of soybean. *Crop Res.,* **7**: 156-158.

Mohandas, S. and Appavu, K. (2000). Direct and residual effect of combined application of basic slag with green leaf manure on soil available nutrients and yield of rice. *Madras Agric. J.,* **87**(1/3): 53-56.

Norman, R.J., Junior, W.C.E. and Slaton, N.A. (2003). Soil fertilization and mineral nutrition in U.S. Mechanized rice culture. In: Rice: origin, history, technology and production, Eds. C.W. Smith and R.H. Didday, pp 31-411. Hoboken, Nj: John Wiley and Sons.

Olsen, S.R., Cole, C.V., Watanabe, F.F. and Bean, A.L. (1954). Estimation of available phosphorus of soil extraction with sodium bicarbonate. U.S. Dept. Agric. Circle, 939.

Padole, V.K., Deshmukh, P.W., Nikesar, R.J. and Bansode, N.V. (1998). Effect of organics and inorganics on yield and quality of cotton grown on *Vertisols. PKV Res. J.,* **22**(1): 6-8.

Piper, C.S. (1966). *Soil and plant analysis*. Hans Publishers, Bombay. p. 368.

Prasad, B., Singh, A.P. and Singh, M.K. (1984). Effect of poultry manure as a source of zinc, iron and as a complexing agent on Zn and Fe availability and crop yield in calcareous soil. *Indian Soc. Soil Sci.,* **32**: 519-521.

Prasanthrajan, M., Doraisamy, P. and Balasubramanian, G. (2009). Available nitrogen release pattern in red soil applied with yeast sludge and poultry manure. *J. Ecobiol.,* **25**(3): 297-299.

Rafiq, M.A., Ali, A., Malik, M.A. and Hussain, M. (2010). Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. *Pak. J. Agri. Sci.,* **47**(3):201-208.

Rai, R., Singh, S.N. and Prasad, V. (1982). Effect of pressmud amend pyrite on symbiotic N-fixation, active iron contents of nodules, grain yield and quality of chickpea *(Cicer arietinum* Linn) genotypes in calcareous soil. *J. Plant Nutr.,* **5** : 905-913.

Saviour, N. and Satlin, P. (2013). Influence of zinc and Boron in residual black gram productivity. *Indian J. Sci. Tech.,* **6**(8) : 5105-5108.

Savithri, P. (1978). Studies on the effect of micronutrient fertilization on the availability of nutrients in soil and their uptake in a cropping system. Ph.D., Thesis, Tamil Nadu Agricultural University, Coimbatore, T.N. (INDIA).

Savithri, P., Subbiah, S., Malarvilzhi, P. and Gopalasamy, A. (1991). Effect of coirpith based poultry litter on yield and nutrient uptake by sorghum cowpea cropping system. In: proc. Seminar on utilization of coirpith in agriculture. Nov. 20[th] 1991, Tamil Nadu Agricultural University, Coimbatore.pp.53-55.

Sharma, A.R. and Mitra, B.N. (1989). Direct and residual effect organic materials and phosphorus fertilizer in rice based cropping system. *Indian J. Agron.,* **36**: 299-303.

Sharma, A.R. and Mitra, B.N. (2007). Effect of different rates of application of organic security in harmony with nature. Shirashankar, K. (ed.) held at UAS, Bangalore during 1[st] – 4[th] Dec, pp.97.

Sharma, M., Pandey, C.S. and Mahapatra, B.S. (2008). Effect of biofertilizers on yield and nutrient uptake by rice and wheat in rice–wheat cropping system under organic mode of cultivation. *J. Eco-friendly Agric.,* **3**(1): 19-23.

Singh, G.R., Parihar, S.S. and Chaure, N.K. (1999). Direct and residual effect of organic manures on rice (*Oryza sativa*) – gram (*Cicer arietinum*) cropping sequence. *Indian J. Trop. Agric.,* **17**(1-4) : 195-198.

Singh, J. and Singh, K.P. (2000). Effect of *Azotobacter*, FYM and fertility levels on yield and quality of spring sunflower. *Haryana J. Agron.*, 16(1and2) : 53-56.

Stanford, S. and English, L. (1949). Use of flame photometer in rapid soil test for K and Ca. *Agron. J.,* **41** : 446-447.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci.,* **25**: 259-260.

Sudarsan, S. and Ramasamy, P.P. (1993). *Fertilizer News*. **38**: 51–53.

Vasanthi, D. and Kumaraswamy, K. (2000). Effects of manure-fertilizer schedules on the yield and uptake of nutrients by cereal fodder crops and on soil fertility. *J. Indian Soc. Soil Sci.,* **48**(3) : 510-515.

Viator, R.P., Kovar, J.L. and Hallmark, W.B. (2002). Gypsum and compost effects on sugarcane root growth, yield and plant nutrients. *Agron. J.,* **94** : 1332-1336.

Walkley, A. and Black, C.A. (1934). An examination of wet oxidation methods for determining soil organic matter and proposed modifications of the chromic acid titration. *Soil Sci.,* **37**: 29-38.

WEBLIOGRAPHY

Agricoop (2011-12). *http://agricoop.nic.in/agristatistics.htm.*

USDA (2013). United States Department of Agriculture. Foreign Agricultural Service. *Circular series WAP 13-05. 2013. www.fas.usda.gov/wap/current/*ý

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