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RESEARCH PAPER

Evaluation of different sources of organics on fertility status of soil and nutrient uptake of sweet corn [*Zea mays* (L.) *saccharata*]

B.R. WAGHMODE*, S.V. SONAWANE[1] AND D.S. TAJANE[1]
Department of Agronomy, College of Agriculture, University of Agricultural Sciences,
DHARWAD (KARNATAKA) INDIA (Email : waghmodebaburao@gmail.com)

Abstract : A field experiment was carried out during *Kharif* 2009-10 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to find out the influence of organic nutrients on nutrient uptake and fertility status of soil. The experiment has twenty four treatment combinations comprising of organic manures mainly green leaf manure (GLM), enriched compost, FYM and vermicompost and liquid organic manures mainly bio-digester liquid manure, *Panchagavya* and cow-urine. Irrespective of liquid organic manures, the nutrient uptake and fertility status of soil *viz.*, N, P and K content and uptake, available nitrogen, phosphorus and potassium status were significantly higher with 7.5 t FYM + RDF (100:50:25) N, P_2O_5, K_2O kg ha^{-1} + 10 kg $ZnSO_4$ (RPP) and RDF alone as compared to nutrient substitution through organic manures. Similarly, organic carbon and micronutrients (*viz.*, Cu, Zn, Mn and Fe content) were significantly higher with application of organic manurial treatments over RDF and RPP. Among the organic manurial treatment combinations GLM + EC + VC (top dressing at GGS) was significantly superior over basal applied vermicompost.

Key Words : Organic manures, Liquid organic manures, N, P and K content, N, P and K uptake, Available N, P and K status, Micronutrients, Organic carbon, RPP (Recommended package of practice), RDF (Recommended dose of fertilizer)

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INTRODUCTION

Maize (*Zea mays* L.) is the abundantly produced food grain next to rice and wheat. It being C4 plant, has immense production potential, therefore, it is called queen of cereals. Maize is not only used as food, feed and fodder but also used for edible oil, which is well preferred for human diet. Maize has been widely cultivated crop in India in *Kharif* season. Recent studies have shown that new genotypes of maize can be successfully grown and harvested bumper yield during *Rabi* season.

In India, sweet corn is cultivated on very small area by some farmers and private sectors to meet the demands of many industries. The demand for eating roasted cobs in cities and towns is increasing day by day which has resulted into opening of the counters of roasted

*** Author for correspondence (Present Address) :** Department of Agronomy, K.K. Wagh College of Agriculture, NASIK (M.S.) INDIA
[1]K.K. Wagh College of Agriculture, NASIK (M.S.) INDIA

cobs.

Hence, there is a need to develop the organic production technology for sweet corn production. The climatic conditions are very much favourable for production of good quality of sweet corn in Northern transitional zone of Karnataka. Sweet corn is an exhaustive crop and it is harvested at milkey stage and requires fertile soils for optimum production. As the corn is considered as an exhaustive crop, requires more nutrient, organic nutrient management practices play an important role in sustaining productivity of sweet corn. Optimizing the nutrient availability at early stage of crop growth needs priority in sweet corn production.

Hence, the studies were initiated to find out the optimum organic nutrient management practices on nutrient uptake and fertility status of soil.

MATERIAL AND METHODS

A field trail was conducted during *Kharif* 2009 at the Main Agricultural Research Station, Dharwad which comes under Northern Transitional Zone of Karnataka with an average annual rainfall of 750 mm. The soil of the experimental site was medium black soil which was alkaline in reaction (7.7), high in organic carbon (0.75%), low in available N (204.2 %), high in available P_2O_5 (50 kg/ha) and high in available K_2O (321 kg/ha) contents. The trial comprised of 24 treatment combinations having six main plots mainly four organic manurial levels equivalent to recommended chemical fertilizer, one recommended dose of chemical fertilizer (RDF) and a recommended package of practice (RPP) (RDF + FYM) with four sub plots having 3 liquid organic sprays and control were laid out in Split Plot Design with three replications. Based on the nutrient content of organic manures, the quantity of organic manures 1/3 each of green leaf manure (GLM), farm yard manure (FYM), FYM enriched compost (EC), vermicompost in combination were applied equivalent to recommended dose of nitrogen. It was confirmed this quantity of organic manures will meet the requirement of phosphorus and potassium.

All the organic manures were applied 15 days before sowing except the vermicompost equivalent to RDN was applied at grand growth stage (GGS). The Sub plots received two liquid organic sprays at GGS and tasseling as per the treatments. The recommended chemical fertilizer (RDF) treatment received 50 per cent RDN and full phosphorus, potassium and $ZnSO_4$ at sowing and 50 per cent RDN was applied at GGS. Recommended package received RDF with recommended FYM @ 7.5 t ha^{-1} which was applied 15 days before sowing. In organic treatments weeds and pests were managed by cultural and by using bio-pesticides. The sweet corn variety Madhuri was used. The seeds were hand dibbled at 60 × 30 cm spacing at optimum moisture conditions. The crop was raised under rainfed conditions.

Liquid organic manures mainly *Panchagavya*, bio-digester was done by following the standard procedures and *Panchagavya* was sprayed at 3 per cent and bio-digester was sprayed at 10 per cent. The fresh cow urine was collected and sprayed at 10 per cent.

The plant samples of sweet corn utilized for recording dry matter accumulation and distribution at harvest were ground in a willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen, phosphorus and potassium content of leaves and stem (shoot) were estimated by micro Kjeldahl's method, vanado molybdate phosphoric yellow colour method (Jackson, 1973) and potassium was determined by Flame photometer method, respectively (Jackson, 1973) and it was expressed in percentage.

Based on nutrient content of plant part like shoot at harvest in them, the uptake of nitrogen, phosphorus and potassium by sweet corn was worked out using following formula :

$$\text{Nutrient uptake} = \frac{\text{Per cent of nutrient concentration} \times \text{biomass (kg ha}^{-1}\text{)}}{100}$$

The uptake of N, P and K were expressed in kg per ha.

Before the start of experiment, composite soil samples and 0-15 cm depth from the experimental site were collected, processed to pass through 2 mm sieve and preserved for further analysis. Similarly, representative soil samples from each plot were collected after harvest of sweet corn crop. The soil samples were dried in shade, processed to pass through 2 mm sieve and used for further analysis. The soil samples were analysed for organic carbon, available nitrogen, phosphorus and potassium content of the soil.

The organic carbon was determined by Walkley and Black's wet oxidation method by oxidizing organic matter as described by Jackson (1973). It was expressed in per cent. The available nitrogen was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija (1956). It was expressed in kg ha^{-1}. Available phosphorus was determined by Olsen's method using spectrophotometer (660 nm wave length) as outlined by Jackson (1973). It was expressed in kg ha^{-1}. The available potassium was extracted with neutral normal ammonium acetate (1 N NH_4 OAC) and the content of K in the solution was estimated by Flame photometery (Jackson, 1973). It was expressed in kg ha^{-1}.

Ten gram of air dried soil sample was shaken with 20 ml of DTPA extracting solution for two hours. The soil suspension was filtered and the content of zinc, iron, copper and manganese were estimated by using AAS (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Significantly higher nitrogen, phosphorus and potassium content in shoot (2.78, 0.30 and 2.25%, respectively) was recorded with RPP treatment. However, significantly lower nitrogen and phosphorus content in shoot (2.66 and 0.23%) was observed in RDF and potassium (2.12 and 2.12%, respectively) was noticed in (M_3) and (M_4) treatments (Table 1).

All the liquid organic manurial treatments noticed significantly higher nitrogen, phosphorus and potassium content in shoot and were at par with each other. This might be to increased availability of nutrients.

Among the two way interactions, GLM + EC + VC (top dressing at GGS) + *Panchagavya* @ 3 per cent spray recorded significantly higher nitrogen content in shoot (2.99%). While, significantly lower nitrogen content in shoot was recorded in GLM + FYM + VC (basal) equivalent to RDN + control (2.43%) treatment. Phosphorus content in shoot did not differ significantly among all treatment combinations. With the organics in combination with liquid manures increased microbial activity and higher nutrient availability, maximum nutrient content was observed.

The main plot solid organic manurial treatments showed that, significantly higher nitrogen and phosphorus uptake (253.1 and 24.42 kg/ha) was recorded in RPP treatment. Whereas, significantly lower nitrogen and potassium uptake (182.2 and 151.8 kg/ha) was recorded in GLM + FYM + VC (top dressing at GGS) treatment and phosphorus uptake (18.93 kg/ha) was observed in GLM + EC + VC (basal) equivalent to RDN (Table 1). The increased nutrient uptake in treatment receiving vermicompost applied in top dressing at grand growth stage can be well supported by the increased yield levels of sweet corn, over vermicompost applied at basal.

Significantly higher nitrogen and phosphorus uptake (24.53 and 216.5 kg/ha) were recorded in cow urine @ 10 per cent spray treatment. However, significantly lower nitrogen, phosphorus and potassium uptake (204.6, 16.64 and 156.8 kg/ha, respectively) were recorded in control treatment. Due to better nutrition and effective development of root system helped more nutrient uptake.

Treatment combinations such as RPP + bio-digester liquid @ 10 per cent spray (260.2 kg/ha), RPP + *Panchagavya* @ 3 per cent spray (265.5 kg/ha), RPP + cow urine @ 10 per cent spray (263.0 kg/ha) did not differ significantly with each other with respect to nitrogen uptake. While, significantly lower nitrogen uptake (174.0, 177.2 and 176.0 kg/ha) was recorded in M_1S_4, M_2S_2 and M_3S_4 compared to other treatment combinations. Significantly higher phosphorus uptake (28.33 kg/ha) was recorded in GLM + FYM + VC (top dressing at GGS) + cow urine @ 10 per cent spray. However, significantly lower phosphorus uptake (13.95 kg/ha) were recorded in GLM + EC + VC (basal) equivalent to RDN + *Panchagavya* @ 3 per cent spray (Table 1).

Interaction effects, RPP + cow urine @ 10 per cent spray and GLM + EC + VC (top dressing at GGS) + bio-digester liquid @ 10 per cent spray combinations recorded significantly higher potassium uptake (193.8 and (193.0 kg/ha). Significantly lower potassium uptake was recorded in GLM + FYM + VC (top dressing at GGS) + control (142.6 kg/ha) treatment combination. Due to combined application of organic manure and liquid organic manure sources, availability of nutrients was increased which ultimately resulted in higher crop nutrient uptake. Effect of integrated nutrient management on yield, yield attributes and nutrient uptake by sunhemp (*Crotalaria juncea* L.), its residual effect on succeeding rice (*Oryza sativa* L.) crop and residual fertility build up in soil (Tripathi *et al.*, 2009).

Among the manurial treatments, significant differences were not noticed in available nitrogen content in soil except GLM + EC + VC (top dressing at GGS) (167.4 kg/ha) noticed significantly lower available nitrogen content. Significantly higher phosphorus content in soil (20.00 kg/ha) was recorded in RDF treatment. While, significantly lower phosphorus and potassium content in soil (17.83 and 240.8 kg/ha) was recorded in RPP (Table 2). This might to be application of organic manures helped to improving the physical properties of soil hence, increases the availability of nutrients.

The liquid organic manurial treatments did not differ significantly with respect to available nitrogen, phosphorus and potassium content in soil.

The two way interaction effects data indicated that, significantly higher available nitrogen content in soil (259.9 kg/ha) was recorded in RDF + cow urine @ 10 per cent spray, available phosphorus content (21.33 kg/ha) significantly higher was observed with GLM + FYM

Table 1 : Nutrient content in shoot (%) and uptake (kg ha^{-1}) in sweet corn as influenced by different organics and conventional nutrient management practices

Treatments	Nutrient content in shoot (%)			Nutrient uptake (kg ha^{-1})		
	N%	P_2O_5%	K_2O%	N	P_2O_5	K_2O
Main plot (Organic manures)						
M_1- GLM+FYM+VC (Basal) eq. RDN	2.71 b	0.26 b	2.21bc	204.6 c	22.80 c	170.3 b
M_2- GLM+EC+VC (Basal) eq. RDN	2.69 c	0.26 b	2.20 c	203.4 c	18.93 e	162.1 d
M_3- GLM+FYM+VC (Top dressing at GGS)	2.68 c	0.24 bc	2.12 d	182.2 d	19.69 d	151.8 e
M_4- GLM+EC+VC (Top dressing at GGS)	2.77 a	0.28 a	2.12 d	224.1 b	23.80 b	177.4 a
M_5- (100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RDF)	2.66 d	0.23 c	2.25 a	204.7 c	19.48 d	168.5 c
M_6-7.5 t FYM+RDF(100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RPP)	2.78 a	0.30 a	2.24ab	253.1 a	24.42 a	177.1 a
S.E. ±	0.003	0.008	0.005	1.10	0.22	0.59
Sub-plot (Liquid organic manures)						
S_1- Bio-digester liquid spray @ 10% at GGS and tasseling stage	2.77 a	0.27 a	2.21 a	211.8 b	23.73 b	173.2 a
S_2- *Panchagavya* spray @ 3% at GGS and tasseling stage	2.77 a	0.26 a	2.20 a	215.2 a	21.18 c	168.6 b
S_3- Cow urine spray @ 10% at GGS and tasseling stage	2.75 a	0.28 a	2.19 a	216.5 a	24.53 a	172.8 a
S_4- Control	2.58 b	0.24 a	2.13 b	204.6 c	16.64 d	156.8 c
S.E. ±	0.002	0.003	0.003	0.77	0.23	0.38
Interaction (M × S)						
M_1S_1	2.97ab	0.28 a	2.24 b	241.3 b	26.59 ab	179.7 c
M_1S_2	2.84 c-f	0.26 a	2.23 b	214.7 gh	22.32 cd	174.5 d
M_1S_3	2.63 i-k	0.27 a	2.22 b	188.2 k	23.86 c	171.1 ef
M_1S_4	2.43 l	0.23 a	2.16 b	174.0 l	18.43 e-g	155.7 hi
M_2S_1	2.92 a-c	0.25 a	2.23 b	193.8 j	18.59 e-g	162.9 g
M_2S_2	2.72 e-i	0.20 a	2.22 b	177.2 l	13.95 j	152.8 j
M_2S_3	2.62 i-k	0.23 a	2.20 b	229.8 d	28.33 a	174.3 d
M_2S_4	2.50 kl	0.26 a	2.16 b	212.9 gh	14.85 ij	158.2 h
M_3S_1	2.81 c-g	0.23 a	2.14 b	121.1 m	21.99 d	146.6 k
M_3S_2	2.61 i-k	0.30 a	2.14 b	226.5 de	23.67 cd	163.2 g
M_3S_3	2.90 a-d	0.24 a	2.11 b	205.1 i	18.93 ef	154.7 ij
M_3S_4	2.43 l	0.21 a	2.11 b	176.0 l	14.16 ij	142.6 l
M_4S_1	2.53 j-l	0.33 a	2.13 b	244.0 b	27.71 ab	193.0 a
M_4S_2	2.99 a	0.26 a	2.14 b	222.6 ef	22.87 cd	181.8 c
M_4S_3	2.85 b-e	0.32 a	2.12 b	194.4 j	25.94 b	169.8 f
M_4S_4	2.71 f-i	0.23 a	2.10 b	235.5 c	18.67 e-g	164.9 g
M_5S_1	2.66 h-j	0.25 a	2.27 b	210.5 hi	19.88 e	171.4 ef
M_5S_2	2.69 g-i	0.22 a	2.27 b	184.3 k	16.87 gh	164.0 g
M_5S_3	2.67 hi	0.22 a	2.24 b	218.6 fg	23.33 cd	173.0 de
M_5S_4	2.63 i-k	0.21 a	2.24 b	205.5 i	17.86 fg	165.8 g
M_6S_1	2.72 e-i	0.30 a	2.27 b	260.2 a	27.61 ab	185.7 b
M_6S_2	2.80 c-g	0.31 a	2.25 b	265.5 a	27.41 ab	175.5 d
M_6S_3	2.84 c-f	0.30 a	2.50 a	263.0 a	26.81 ab	193.8 a
M_6S_4	2.77 d-h	0.28 a	2.21 b	223.8 ef	15.84 hi	153.3 ij
S.E. ±	0.007	0.008	0.008	1.90	0.57	0.93

Table 2 : Available nitrogen, phosphorus, potassium status (kg ha^{-1}), organic carbon and DTPA extractable micronutrients (Cu, Zn, Mn and Fe) (mg kg^{-1}) status of soil content in soil (%) as influenced by different organics and conventional nutrient management practices

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Organic carbon (%)	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})
Main plot (Organic manures)								
M_1- GLM+FYM+VC (Basal) eq. RDN	195.7 a	18.67 ab	258.3 a	0.70 a	1.32 c	2.35 c	19.59 ab	12.24 c
M_2- GLM+EC+VC (Basal) eq. RDN	204.2 a	18.83 ab	263.4 a	0.69 a	1.54 a	2.48 ab	19.74 a	14.86 a
M_3- GLM+FYM+VC (Top dressing at GGS)	219.2 a	19.17 ab	256.4 a	0.68 a	1.43a-c	2.51 a	19.16 bc	13.69 b
M_4- GLM+EC+VC (Top dressing at GGS)	167.4 b	17.92 b	248.8 ab	0.70 a	1.49 ab	2.35 c	19.23 bc	14.58 a
M_5- (100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RDF)	214.8 a	20.00 a	249.0 ab	0.63 c	1.51 ab	2.40 bc	19.43 a-c	13.71 b
M_6-7.5 t FYM+RDF(100:50:25 N, P_2O_5, K_2O kg ha^{-1}) + 10 kg $ZnSO_4$ (RPP)	225.9 a	17.83 b	240.8 b	0.66 b	1.39 bc	2.50 ab	18.95 c	13.30 b
S.E. ±	12.5	0.64	6.43	0.009	0.05	0.04	0.20	0.35
Sub-plot (Liquid organic manures)								
S_1- Bio-digester liquid spray @ 10% at GGS and tasseling stage	200.5 a	18.50 a	251.4 a	0.69 a	1.52 a	2.47 a	19.27 a	13.79 a
S_2- *Panchagavya* spray @ 3% at GGS and tasseling stage	203.7 a	18.67 a	253.4 a	0.68 a	1.45 ab	2.49 a	19.36 a	13.41 a
S_3- Cow urine spray @ 10% at GGS and tasseling stage	212.5 a	18.17 a	253.1 a	0.69 a	1.39 b	2.40 a	19.36 a	14.20 a
S_4- Control	201.3 a	19.61 a	253.1 a	0.65 b	1.43 ab	2.37 a	19.40 a	13.53 a
S.E. ±	9.61	0.62	5.25	0.007	0.03	0.04	0.14	0.31
Interaction (M × S)								
M_1S_1	170.8 bc	19.00 ab	261.3 ab	0.73 a-c	1.36 c-h	2.55 a-e	19.05 a-f	12.15 e-g
M_1S_2	214.1 a-c	17.00 ab	258.7 ab	0.68 c-g	1.25 gh	2.29 c-e	19.42 a-e	10.75 g
M_1S_3	194.9 a-c	18.33 ab	256.7 ab	0.75 a	1.27 e-h	2.23 e	19.85 a-c	12.27 e-g
M_1S_4	202.9 a-c	20.33 ab	259.3 ab	0.64 gh	1.41 b-h	2.34 c-e	20.03 ab	13.78 a-f
M_2S_1	202.3 a-c	19.00 ab	247.3 ab	0.71 a-e	1.57 a-f	2.48 b-e	19.65 a-e	14.08 a-f
M_2S_2	215.3 a-c	19.33 ab	278.7 a	0.68 b-g	1.79 a	2.62 a-d	20.06 ab	15.57 ab
M_2S_3	195.7 a-c	18.00 ab	268.3 ab	0.70 a-f	1.42 b-h	2.29 c-e	20.03 ab	15.86 a
M_2S_4	203.4 a-c	19.00 ab	256.3 ab	0.68 c-g	1.38 b-h	2.52 a-e	19.24 a-f	13.94 a-f
M_3S_1	235.8 a-c	18.67 ab	259.3 a-b	0.71 a-e	1.69 ab	2.78 ab	19.39 a-e	14.76 a-e
M_3S_2	191.1 a-c	19.33 ab	248.0 ab	0.70 a-f	1.50 a-h	2.65 a-c	18.78 c-f	13.69 a-f
M_3S_3	205.1 a-c	17.33 ab	262.0 ab	0.66 d-g	1.22 h	2.24 de	18.65 d-f	13.58 a-f
M_3S_4	244.5 ab	21.33 a	250.0 ab	0.65 e-h	1.31 e-h	2.37 c-e	19.80 a-e	12.74 d-g
M_4S_1	160.3 c	18.67 ab	258.0 ab	0.69 a-g	1.57 a-f	2.24 de	19.84 a-d	15.40 a-c
M_4S_2	164.7 bc	19.33 ab	248.0 ab	0.74 ab	1.63 a-d	2.38 c-e	18.83 c-f	15.10 a-d
M_4S_3	164.8 bc	15.67 b	239.0 ab	0.72 a-d	1.20 h	2.33 c-e	19.35 a-f	12.81 c-g
M_4S_4	179.9 a-c	18.00 ab	244.0 ab	0.66 e-h	1.55 a-g	2.47 b-e	18.89 b-f	15.04 a-d
M_5S_1	222.2 a-c	18.33 ab	245.7 ab	0.64 gh	1.32 d-h	2.29 c-e	19.07 a-f	11.91 fg
M_5S_2	207.7 a-c	20.00 ab	253.7 ab	0.64 f-h	1.30 e-h	2.55 a-e	19.35 a-f	12.26 e-g
M_5S_3	259.9 a	20.67 ab	252.7 ab	0.66 e-h	1.78 a	2.46 b-e	20.10 a	15.99 a
M_5S_4	169.3 bc	21.00 ab	242.7 ab	0.60 h	1.65 a-c	2.32 c-e	19.20 a-f	14.71 a-e
M_6S_1	211.8 a-c	17.33 ab	249.0 ab	0.64 f-h	1.59 a-e	2.46 b-e	18.64 ef	14.44 a-f
M_6S_2	229.4 a-c	17.00 ab	231.7 b	0.66 d-h	1.25 f-h	2.48 b-e	19.71 a-e	13.07 b-g
M_6S_3	254.6 a	19.00 ab	240.0 ab	0.67 c-g	1.45 b-h	2.86 a	18.19 f	14.68 a-e
M_6S_4	207.9 a-c	18.00 ab	240.0 ab	0.67 c-g	1.27 e-h	2.21 e	19.26 a-f	11.00 g
S.E. ±	23.54	1.53	12.87	0.01	0.09	0.11	0.34	0.76

+ VC (top dressing at GGS) + control combination and potassium content (278.7 kg/ha) significantly higher was noticed in GLM + EC + VC (basal) equivalent to RDN + *Panchagavya* @ 3 per cent spray.

All the organic manurial treatments recorded significantly higher organic carbon and were at par with each other. Whereas, significantly lower organic carbon was noticed in RDF alone (0.63%) over RPP (0.66%) treatment. This might be to application of organic manures helped to addition of organic matter and ultimately increasing the organic carbon content in soil. All the liquid organic manurial treatments, recorded significantly higher organic carbon content over control and they were at par (Table 2).

The interaction effects showed that, significantly higher organic carbon content (0.75%) was noticed with GLM + FYM + VC (basal) equivalent to RDN + cow urine @ 10 per cent spray and GLM + EC + VC (top dressing at GGS) + *Panchagavya* @ 3 per cent spray (0.74%) and were at par with GLM + FYM + VC (basal) equivalent to RDN + cow urine @ 10 per cent spray treatment combination. Significantly lower organic carbon content (0.60%) was noticed in RDF + control treatment combination.

Significantly higher copper, manganese and iron content in soil (1.54, 19.74 and 14.86 mg/kg, respectively) was noticed in treatment receiving GLM + EC + VC (basal) equivalent to RDN. While, GLM + FYM + VC (top dressing at GGS) treatment noticed significantly higher zinc content in soil. However, significantly lower copper, zinc and iron content in soil (1.32, 2.35 and 12.24 mg/kg, respectively) was observed in GLM + FYM + VC (basal) equivalent to RDN and in RPP treatment observed significantly lower manganese content in soil (18.95 mg/kg) (Table 2). This might to be application of organic manures helped to improving the physical properties of soil hence, increases the availability of nutrients.

The liquid organic sources did not notice any significant difference on zinc, manganese and iron content in soil but copper content in soil (1.52 mg/kg) significantly higher was noticed in bio-digester liquid @ 10 per cent spray.

Combined application of GLM + EC + VC (basal) equivalent to RDN + *Panchagavya* @ 3 per cent spray (1.79 mg/kg) treatment recorded significantly higher copper content in soil, RPP + cow urine @ 10 per cent spray noticed significantly higher zinc content in soil (2.86 mg/kg) and RDF (100:50:25 N, P, K kg ha^{-1} + 10 kg $ZnSO_4$) + cow urine @ 10 per cent spray recorded significantly higher manganese and iron content in soil (20.10 and 15.99 mg/kg, respectively).

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