Effect of Micro-Nutrients in Growth and Nutrient Uptake of Maize (Zea Mays L.)[1]

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ABSTRACT

The pot experiment was conducted in Department of Soil Science and Agricultural Chemistry. Annamalai university to evaluate the response of maize (Zea mays L.) with conventional, non – conventional organic source, industrial by-products combined with inorganic fertilizers. The treatments imposed were T_1-Control (100 % RDF), T_2- 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1} , T_3- 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}, T_4 – 100 % RDF + Vermicompost @ 2.5 t ha^{-1}, T_5 – 100 % RDF + Vermicompost @ 5 t ha^{-1} , T_6-100 % RDF + Bagasse Ash @ 5 t ha^{-1} , T_7- 100 % RDF + Bagasse Ash @ 10 t ha^{-1}, T_8- 100 % RDF + Lignite Flyash @ 5 t ha^{-1} ,T_9- 100 % RDF + Lignite Flyash @ 10 t ha^{-1}. There were nine treatments combinations replicated thrice in CRD. The uptake of grain in Fe (5.495 mg pot^{-1}) , Mn (0.592 mg pot^{-1}), Zn (0.746 mg pot^{-1}) and the uptake of grain in Cu (0.118 mg pot^{-1}) recorded higher in the treatment (T_3) which received 100 % RDF with Municipal Solid Waste Compost @ 10 tha^{-1}. Stover uptake in Fe (44.0 mg pot^{-1}), Mn (3.25 mg pot^{-1}) , Zn (0.85 mg pot^{-1}) and Cu (0.72 mg pot^{-1}) was recorded highest due to application of 100 % RDF with Vermicompost @ 5 t ha^{-1} (T_5).

Keywords: *Micronutrients, Maize, Flyash, Municipal waste, Bagasse, Vermicompost.*

INTRODUCTION

Maize (Zea mays L.) is the third most important cereal crops in the world after wheat and rice and known as “King of grain crops”. Maize ranks as the major grain crop worldwide. Maize, which is the only food cereal crop that can be grown in different seasons require moderate climate for growth. In India, maize crop stands up as the third cash crop after wheat and rice. Maize is not only used as human food and animal feed, but is as well commonly used in several other industries as a raw material (Hareesh *et al.* 2016). In India, maize cultivation is taken up in an area of 8.69 million hectares with an annual production of 21.81 million tonnes (Agriculture statistics at a glance 2016). Composting is the controlled biological process to turning organic waste into soil conditioner. In nature, organic matter such as wood, paper, animal waste and plant material are decomposed by bacteria (Shamim Banu and Kanagasabai 2012). Vermicompost maintains a steady mineral balance, improves nutrient availability for rejuvenating the soil, in addition of reduction of pathogenic organisms too (Geeta Utekar and Hanamantrao Deshmukh 2016). The Lignite Flyash of NLC serves as supplementary source of essential plant nutrients and is also effective in the reclamation of waste degraded land and mine spoil (Saranraj 2015). Bagasse ash is a good source of micronutrients like Fe, Mn, Zn and Cu and also high concentration of P and K. (Dotaniya *et al.*, 2016) . At household level and small level composting practices could be effective which needs the people’s awareness. After composting, the final product obtained is called compost, which has very agricultural value. It is used as fertilizer (Health impact of solid waste 2017).

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MATERIALS AND METHODS

Chemical properties of the experimental soil

1	Fe DTPA extractable (mg kg^{-1})	13.2 (high)
2	Mn DTPA extractable (mg kg^{-1})	14.1 (high)
3	Zn DTPA extractable (mg kg^{-1})	0.74 (low)
4	Cu DTPA extractable (mg kg^{-1})	2.8 (high)

Pressmud was used for vermicomposting along with cow dung. Pressmud vermicompost was prepared by pit method (5m× 4m × 0.5m). Pressmud was spread to 30cm height in shade and allowed to decompose. After one month, the temperature subsides, the cow dung slurry (1:10 dung:water) was added and thoroughly turned and mixed. At this stage earth worms were allowed into it (1000 number t^{-1}) and optimum moisture of about 50 percent was maintained. After eight weeks the compost was ready and used in experiment. Big size non-biodegradable wastes like plastics, rubbers metals etc are manually removed at composting yard prior to composting (termed as partially segregated waste compost). Individual households deliver segregated biodegradable wastes separately driving door-to-door collection by municipal organization, which are composted into heaps. The organic material mainly vegetable, fruit and kitchen waste were separated manually and subjected to turned windrows composting process. Aeration typically in the heap was provided by manually turning of waste. A heap of manually separated mixed municipal solid waste of 4' height, 8' breadth was placed on paved ground on composting windrow type and was watered regularly to maintain moisture level between 50-60% and turned manually every 3-5 days for first 6 weeks of composting cycle. From the seventh week, the moisture was allowed to drop when optimum bio solids decomposition was achieved. The process was completed in about 8-9 weeks. After this period the compost was allowed to cure for additional 3 weeks without turning. The finished compost was then screened out and weighed. Bagasse Ash is a type of organic wastes which obtained from sugar industry during the period of sugar production. It is a by-product generated at industrial plants using biomass as energy source. The resulting bagasse ash is an alkaline material namely of nitrogen(N), that containing other elements such as potassium (K) and phosphorus (P), which are required for plants. The bagasse ash in dry form collected from sethiyathoppe co-operative sugar mill, Tamil Nadu used in the experiment. Fly ash is generated by the combustion of lignite in thermal power plant. Lignite apart from clay matter consists of non-combustible inorganic matter, which during combustion produce (Fly ash 80% and bottom ash 20%), which are disposed in wet and dry disposal system. The dry form collected from the electrostatic precipitator and stored in silo (or) storage bunker at the plant itself. The Lignite fly ash (LFA) in dry form collected from Neyveli lignite corporation(NLC), Neyveli, Tamil Nadu was used in the experiment.

Treatment details of the incubation experiment

T_1 - Control -100 % RDF

T_2 - 100 % RDF + Municipal solid waste compost @ 5 t ha^{-1}

T_3 - 100 % RDF + Municipal solid waste compost@ 10 t ha^{-1}

T_4 - 100 % RDF + Vermicompost @ 2.5 t ha^{-1}

T_5 - 100 % RDF + Vermicompost @ 5 t ha^{-1}

T_6 - 100 %RDF + Bagasse Ash @ 5 t ha^{-1}

T_7 - 100 % RDF + Bagasse Ash @ 10 t ha^{-1}

T_8 - 100 % RDF + Lignite Flyash @ 5 t ha^{-1}

T_9 - 100 % RDF + Lignite Flyash @ 10 t ha^{-1}

Micro-nutrients status of the experimental soil

1	Fe DTPA extractable (mg kg^{-1})	13.2 (high)
2	Mn DTPA extractable (mg kg^{-1})	14.1 (high)
3	Zn DTPA extractable (mg kg^{-1})	0.74 (low)
4	Cu DTPA extractable (mg kg^{-1})	2.8 (high)

RESULTS AND DISCUSSION

Micronutrients content in maize grain and stover

Iron content in maize grain

The iron content of maize grain is furnished in **(Table 1)**. The conventional, non – conventional organic sources and industrial by-products showed significant influence in treatments. It was found that highest iron content of 17.9 mg kg^{-1} was recorded with the application of 100 % RDF + Lignite Flyash @ 10 t ha^{-1} (T_9). This was on par with the treatment T_8 registered 17.8 mg kg^{-1}, the treatments T_7 (17.1 mg kg^{-1}) and T_6 (17.0 mg kg^{-1}) stand next in order. This was followed by the treatments T_5 and T_4 registered 16.4 mg kg^{-1} and the treatments T_3 and T_2 registered 16.1 mg kg^{-1}. The lowest iron content of 15.9 mg kg^{-1} was recorded in the control treatment (T_1).

Manganese content in maize grain

The data on manganese content in maize grain under the various treatments are furnished in **(Table 1)**. The conventional, non-conventional organic sources and industrial by-products showed significant influence on Mn content in treatments applied. It was found that highest Mn content of 1.92 mg kg^{-1} was recorded with the application of 100 % RDF + Lignite Flyash @ 10 t ha^{-1} (T_9). This was followed by the treatment T_8 recorded 1.91 mg kg^{-1}. The treatments T_7 , T_6 , T_5 ,T_4, T_3 and T_2 registered 1.8, 1.79, 1.77, 1.76, 1.72 and 1.71 mg kg^{-1} respectively were on par with each other .The treatment T_1 (1.70 mg kg^{-1}) recorded in the control.

Zinc content in maize grain

The data on Zn content in maize grain under the various treatments was furnished in **(Table 1).** The conventional, non- conventional organic sources and industrial by-products did not show significant influence on Zn content in treatments applied. It was found that highest Zinc content of 2.27 mg kg^{-1} was recorded with the application of 100 % RDF + Bagasse Ash @ 10 t ha^{-1} (T_7), The treatments T_6 (2.26 mg kg^{-1}) , T_9 (2.25 mg kg^{-1}), T_8 (2.24 mg kg^{-1}), T_5 (2.23 mg kg^{-1}),T_4 (2.22 mg kg^{-1}) , T_3 (2.21 mg kg^{-1}) and T_2 (2.20 mg kg^{-1}) stand in next in order. The control T_1 recorded the lowest Zn content of 2.19 mg kg^{-1}.

Copper content in maize grain

The data on copper content in maize grain significantly influenced under the various treatments are furnished in **(Table 1)**. The copper content in maize grain ranged from 0.28 to 0.35 mg kg^{-1}. The higher copper content was noticed in treatment (T_3) 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1} recorded 0.37 mg kg^{-1} .This was followed by the treatment T_2 (0.36 mg kg^{-1}) and T_7 (0.35 mg kg^{-1}) were on par with each other. The treatment T_6 (0.34 mg kg^{-1}), T_9 (0.33 mg kg^{-1}) and T_8 (0.32 mg kg^{-1}) stand next in order .The treatment T_5 (0.31 mg kg^{-1}), T_4(0.30 mg kg^{-1}) stand next in order .The lowest value of 0.28 mg kg^{-1} was recorded in control (T_1).

Table 1.Effect of conventional ,non-conventional organic sources and industrial by-products on Fe, Mn ,Zn and Cu contents in grain.

Treatments	Fe	Mn	Zn	Cu
	(mg kg^{-1})			
T_1 - Control 100 % RDF	15.9	1.70	2.19	0.28
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	16.1	1.71	2.20	0.36
T_3 - 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	16.1	1.72	2.21	0.37
T_4 - 100 % RDF + Vermicompost @ 2.5 t ha^{-1}	16.4	1.76	2.22	0.30

T_5 - 100 % RDF + Vermicompost @ 5 t ha^{-1}	16.4	1.77	2.23	0.31
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	17.0	1.79	2.26	0.34
T_7 - 100 % RDF + Bagasse Ash @ 10 t ha^{-1}	17.1	1.80	2.27	0.35
T_8 - 100 % RDF + Lignite Flyash @ 5 t ha^{-1}	17.8	1.91	2.24	0.32
T_9 - 100 % RDF + Lignite Flyash @ 10 t ha^{-1}	17.9	1.92	2.25	0.33
Mean	16.7	1.78	2.23	0.32
S.Ed.	0.28	0.04	0.053	0.009
CD(p = 0.05)	0.60	0.09	**NS**	0.02

Iron uptake in maize grain

The results regarding iron uptake at harvest stage were presented in **(Table 2)**. The maximum iron uptake in grain (5.495 mg pot^{-1}) was significantly higher with the treatment T_5 -100 % RDF + Vermicompost @ 5 t ha^{-1}. This was followed by the treatments T_4, T_3 and T_2 registered 5.381, 5.098 and 5.008 mg pot^{-1} respectively. The treatments T_9, T_8, T_7 and T_6 recorded 3.836, 3.751, 3.523 and 3.478 mg pot^{-1} stand next in order. The lowest iron uptake was 3.207 mg pot^{-1}.

Manganese uptake in maize grain

The data indicating manganese uptake recorded at harvest stage were presented in the **(Table 2).** From the data it was observed that, the concentration and uptake of manganese by maize grain was significantly affected due to the application of conventional, non- conventional organic sources and industrial by-products. The manganese uptake in maize grain (0.592 mg pot^{-1}) was significantly higher with the treatments T_5 -100 % RDF + Vermicompost @ 5 t ha^{-1}.This was followed by the treatments T_4 (0.576 mg pot^{-1}), T_3 (0.544 mg pot^{-1}) and T_2 (0.531 mg pot^{-1}) were on par with each other. The treatments T_9, T_8, T_7 and T_6 registered 0.411, 0.402, 0.370 and 0.366 mg pot^{-1} respectively were on par with each other. The lowest manganese uptake 0.342 mg pot^{-1} was recorded in the treatment (T_1) control.

Zinc uptake in maize grain

The data regarding Zinc uptake by maize grain are presented in **(Table 2)**. The uptake of Zinc in maize grain (0.746 mg pot^{-1}) was significantly higher with the treatment T_5 – 100 % RDF + Vermicompost @ 5 t ha^{-1}. The treatment T_4 (0.727 mg pot^{-1}), T_3 (0.699 mg pot^{-1}) and T_2 (0.683 mg pot^{-1}) were on par with each other .The treatment T_9 (0.481 mg pot^{-1}) , T_8 (0.471 mg pot^{-1}), T_7 (0.467 mg pot^{-1}) and T_6 (0.461 mg pot^{-1}) registered were on par with each other. The lowest value of 0.441 mg pot^{-1} was recorded in the treatment (T_1) control.

Table 2.Effect of conventional ,non-conventional organic sources and industrial by-products on maize grain uptake of Fe, Mn, Zn and Cu.

Treatments	**Fe**	**Mn**	**Zn**	**Cu**
	(mg pot^{-1})			
T_1 - Control 100 % RDF	3.207	0.342	0.441	0.057
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	5.008	0.531	0.683	0.113
T_3 - 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	5.098	0.544	0.699	0.118
T_4 - 100 % RDF + Vermicompost @ 2.5 t ha^{-1}	5.381	0.576	0.727	0.100
T_5 - 100 % RDF + Vermicompost @ 5 t ha^{-1}	5.495	0.592	0.746	0.105
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	3.478	0.366	0.461	0.070
T_7 - 100 % RDF + Bagasse Ash @ 10 t ha^{-1}	3.523	0.370	0.467	0.072
T_8 - 100 % RDF + Lignite Flyash @ 5 t ha^{-1}	3.751	0.402	0.471	0.068
T_9 - 100 % RDF + Lignite Flyash @ 10 t ha^{-1}	3.836	0.411	0.481	0.071
Mean	4.308	0.459	0.575	0.086
S.Ed	0.288	0.034	0.042	0.006
CD (p = 0.05)	0.605	0.072	0.089	0.013

Copper uptake in maize grain

The results regarding copper uptake in maize grain at harvest stage were presented in **(Table 2)**. The total copper uptake significantly influenced by maize grain was maximum in treatment T_3 (0.118 mg pot^{-1}). This was followed by the treatment T_2 (0.113 mg pot^{-1}) and T_5 (0.105 mg pot^{-1}) were on par with each other. This was followed by the treatment T_4 (0.100 mg pot^{-1}), T_7 (0.072 mg pot^{-1}), T_9 (0.071 mg pot^{-1}), T_6(0.070 mg pot^{-1}) and T_8 (0.068 mg pot^{-1}) were on par with each other. The lowest treatment T_1 control recorded 0.057 mg pot^{-1}.

Table 3. Effect of conventional ,non-conventional organic sources and industrial by-products on Fe, Mn, Zn and Cu contents in stover.

Treatments	**Fe**	**Mn**	**Zn**	**Cu**
	(mg kg^{-1})			
T_1 - Control 100 % RDF	139	10.79	2.69	2.39
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	141	10.80	2.70	2.51
T_3 - 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	142	1.0.81	2.71	2.53
T_4 - 100 % RDF + Vermicompost @ 2.5 t ha^{-1}	145	10.82	2.83	2.40
T_5 - 100 % RDF + Vermicompost @ 5 t ha^{-1}	146	10.83	2.84	2.41
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	147	10.89	2.90	2.47
T_7 - 100 % RDF + Bagasse Ash @ 10 t ha^{-1}	149	10.90	2.91	2.48
T_8 - 100 % RDF + Lignite Flyash @ 5 t ha^{-1}	157	10.91	2.86	2.45
T_9 - 100 % RDF + Lignite Flyash @ 10 t ha^{-1}	159	10.92	2.87	2.46
Mean	147.2	10.8	2.81	2.45
S.Ed	3.68	0.26	0.06	0.06
CD (p = 0.05)	7.73	**NS**	0.14	**NS**

Iron content in maize stover

The iron content of stover as significantly influenced by conventional, non- conventional organic sources and industrial by-products treatments is furnished in the **(Table 3).** It was highest in 100 % RDF + Lignite Flyash @ 10 t ha^{-1} (T_9) which recorded 159 mg kg^{-1} which was comparable with T_8 (100 % RDF + Lignite Flyash @ 10 t ha^{-1}) recorded 157 mg kg^{-1}. This was followed by the treatment T_7 registered 149 mg kg^{-1}.The treatments T_6, T_5, T_4, T_3 and T_2 registered 147, 146, 145, 142 and 141 mg kg^{-1} respectively. The control (T_1) treatment registered iron content of 139 mg kg^{-1} .

Manganese content in maize stover

The manganese content of stover as did not significantly influence by conventional, non-conventional organic sources and industrial by-products treatments is furnished in the **(Table 3).** The results presented in table revealed that application of 100 % RDF + Lignite Flyash @ 10 t ha^{-1} (T_9) recorded highest manganese content of 10.92 mg kg^{-1}. The treatments T_8 , T_7 , T_6 ,T_5 ,T_4, T_3 and T_2 registered 10.91, 10.90, 10.89, 10.83, 10.82,10.81 and 10.80 mg kg^{-1} respectively stand next in order. The least manganese content was in T_1 control recorded 10.79 mg kg^{-1}.

Zinc content in maize stover

The data recorded on zinc content was presented in the **(Table 3)**. There was significant increase in Zinc content in the treatment where 100 % RDF + Lignite Flyash @ 10 t ha^{-1} (T_7) recorded 2.91 mg kg^{-1}. The treatments T_6, T_9, T_8, T_5 and T_4 registered 2.90, 2.87, 2.86, 2.84 and 2.83 mg kg^{-1} were found to be on par with each other. This was followed by the treatments T_3 and T_2 registered 2.71 and 2.7 mg kg^{-1}.The least Zinc content was observed in T_1 (control) which recorded 2.69 mg kg^{-1} .

Copper content in maize stover

The data recorded on copper content was presented in the **(Table 3)** . The copper content in maize stover did not significantly influence the treatments. There was a increase in copper content (2.53 mg kg^{-1}) in the treatment (T_3) where 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1} .The treatments T_2 (2.51 mg kg^{-1}), T_7 (2.48 mg kg^{-1}), T_6 (2.47 mg kg^{-1}), T_9 (2.46 mg kg^{-1}), T_8 (2.45 mg kg^{-1}), T_5 (2.41 mg kg^{-1}), T_4 (2.40 mg kg^{-1}) stand next in order.

The minimum value 2.39 mg kg^{-1} is recorded in treatment T_1- control.

Iron uptake in maize stover

The positive significant influence of conventional, non- conventional organic sources and industrial by-products on iron stover uptake was observed in the treatments **(Table 4)**. The highest iron uptake of 44 mg pot^{-1} was recorded with T_5 (100 % RDF + Vermicompost @ 5 t ha^{-1}). This was followed by the treatments T_4(42.8 mg pot^{-1}), T_3 (40.2 mg pot^{-1}) and T_2 (38.9 mg pot^{-1}) were comparable with each other. The treatments T_9 (30 mg pot^{-1}), T_8 (29.1 mg pot^{-1}), T_7 (26.7 mg pot^{-1}) and T_6 (26.1 mg pot^{-1}) were on par with each other. The treatment T_1 recorded lowest uptake of 24.3 mg pot^{-1} in control.

Manganese uptake in maize stover

The data recorded on manganese stover uptake is presented in the **(Table 4)**. There was significant increase in manganese uptake of 3.25 mg pot^{-1} in the treatment T_5 (100 % RDF + Vermicompost @ 5 t ha^{-1}). This was followed by the treatments T_4 (3.18 mg pot^{-1}), T_3(3.04 mg pot^{-1}) and T_2 (2.96 mg pot^{-1}) were comparable with each other. The treatments T_9, T_8, T_7 and T_6 registered 2.05, 2.01, 1.94 and 1.92 mg pot^{-1} stand next in order were on par with each other. The treatment T_1 control registered lowest value of 1.88 mg pot^{-1}.

Table 4. Effect of conventional ,non-conventional organic sources and industrial by-products on maize stover uptake of Fe, Mn, Zn and Cu.

Treatments	Fe	Mn	Zn	Cu
	(mg pot^{-1})			
T_1 - Control 100 % RDF	24.3	1.88	0.47	0.41
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	38.9	2.96	0.74	0.69
T_3 - 100 % RDF + Municipal Solid Waste Compost @ 10 t ha^{-1}	40.2	3.04	0.76	0.71
T_4 - 100 % RDF + Vermicompost @ 2.5 t ha^{-1}	42.8	3.18	0.83	0.70
T_5 - 100 % RDF + Vermicompost @ 5 t ha^{-1}	44.0	3.25	0.85	0.72
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	26.1	1.92	0.51	0.43
T_7 - 100 % RDF + Bagasse Ash @ 10 t ha^{-1}	26.7	1.94	0.52	0.44
T_8 - 100 % RDF + Lignite Flyash @ 5 t ha^{-1}	29.1	2.01	0.53	0.45
T_9 - 100 % RDF + Lignite Flyash @ 10 t ha^{-1}	30.0	2.05	0.54	0.46
Mean	33.5	2.47	0.64	0.56
S.Ed	2.51	0.18	0.04	0.04
CD (p= 0.05)	5.28	0.38	0.10	0.08

Zinc uptake in maize stover

The Zinc uptake by the maize stover increased due to application of various organic sources and industrial by-products are presented in **(Table 4)**. The effect of application of organic sources on Zinc uptake in maize stover were found to be significant. The highest zinc stover uptake of 0.85 mg pot^{-1} was recorded in T_5 treatment (100 % RDF + Vermicompost @ 5 t ha^{-1} . This was followed by the treatments T_4 and T_3 registered 0.83 and 0.76 mg pot^{-1} were comparable with each other. This was followed by the treatments T_2 registered 0.74 mg pot^{-1} .The treatments T_9, T_8, T_7 and T_6 resulted in 0.54, 0.53, 0.52 and 0.51 mg pot^{-1} of Zn uptake in stover were on par with each other. The lowest Zinc stover uptake of 0.47 mg pot^{-1} was recorded in T_1 control treatment.

Copper uptake in maize stover

The copper uptake by the maize stover significantly influenced due to the various organic sources treatments are presented in **(Table 4)**. The highest uptake of copper (0.72 mg pot^{-1}) was recorded in the treatment (T_5) receiving 100 % RDF + Vermicompost @ 5 t ha^{-1}. This was followed by the treatments T_3, T_4 and T_2 registered 0.71, 0.70 and 0.69 mg pot^{-1} were on par with each other. The treatments T_9, T_8, T_7 and T_6 recorded 0.46, 0.45, 0.44 and 0.43 mg pot^{-1} were comparable with each other. The lowest value of 0.41 mg pot^{-1} was recorded in T_1 control.

CONCLUSION

Considering the salient findings in perspective, the study revealed that application of 100 % RDF with Vermicompost @ 5 $t\,ha^{-1}$ (T_5) was found to be best combination for maximizing the growth and nutrient uptake of maize.

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