Plant Archives Volume 20 No. 1, 2020 pp. 2624-2628 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF FORTIFIED ORGANIC MANURE WITH MICRONUTRIENTS AND BIO ACTIVE COMPOUND ON THE NUTRIENT AVAILABILITY AND ZN AND FE BIO FORTIFICATION OF BLACK GRAM IN COASTAL SALINE SOIL

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Abstract

The micro nutrient availability is low in coastal saline soils due to high pH, salinity, poor texture, low organic matter, leaching etc. Crops grown in nutrient deficient soils lacks the nutrient needed to maintain human health. The foundation of human health is the quality of the soil on which it is raised. Hence, to study the effect of fortified organic manure on the nutrient availability and bio fortification of Fe and Zn in black gram under coastal saline condition, one field experiment was conducted in a farmer's field near C. Arulmozhidevan village, Bhuvanagiri taluk during Jan-March, 2018. The initial experimental soil was saline and analysed a pH of 7.92, EC 2.03 dS m^{-1} and represents low NPK and micronutrient status. The following treatments namely, T_1- Control (Recommended NPK), T_2- NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @25 kg ha^{-1}, T_3- NPK + 100 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_4- NPK + 100 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1}, T_5- NPK + 75 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_6- NPK + 75 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1}, T_7- NPK + 50 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_8- NPK + 50 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1} were studied in RBD with three replications. Black gram variety ADT 3 was cultivated. The soil samples at flowering and harvesting stages were collected and analysed for various physico-chemical properties and nutrient availability. Plant sample at flowering and harvest and seed samples at harvest were collected and analysed for major and micro nutrient contents by preparing Di acid extract (H_2SO_4: $HClO_4$, 5:1 ratio). The results of the study indicated the efficient role played by the treatment NPK + 75 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1} in improving the availability of the macro and micro nutrients under saline environment. This treatment also proved efficient in fortifying black gram by registering higher zinc content in seed (44.25ppm) and haulm (51.92 ppm) and Fe content in seed (65.23 ppm) and haulm (141.62 ppm).

Key words: Coastal saline soil, Fortified organic manure, Black gram.

Introduction

India has a total coastline of about 8,129 km and the salt affected soils occupy 9.38 mha, out of which around 5.5. mha are saline soils including 3.1 mha of coastal saline soils Laxminarayana and Archana, (2016). Tamil Nadu occupies 6,80,602 ha of coastal area constituting of 26.8 percent of the total area of the coastal districts. Coastal saline soils are deficient in micronutrients especially Zn and Fe due to high pH and salinity, low organic carbon, CEC etc. Crops grown in nutrient deficient soil have lower nutrient content and the people consuming nutrient deficient crop produce develop hidden deficiency of nutrients especially Zn and Fe. Over 3 billion people in the world suffer from iron deficiency. In particular due to elevated requirements for woman's of reproductive age and young children are at high risk. It is estimated that 50 percent of pregnant and 40 percent of non-pregnant women in developing country are anaemic. Iron deficiencies during childhood and adsolenscene impair physical growth and mental development and learning capacity. Zinc is found in cells throughout the body. It is needed for the body's defensive system to properly work (Cakmak, 2012). It plays a role in cell division, wound healing and the breakdown of carbohydrates. Indians especially suffer from Zn and Fe malnutrition due to the majority of them being vegetarian

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and depending mostly on cereals, which are inherently low in these minerals. “Food and nutrition security” for developing countries is one of the major challenges to mankind (Chrispeels, 2000). Crops can undergo biofortification through the application of Zn and Fe fertilizers in the soil, which are then taken up by the plant. Applied zinc to soil and as a foliar spray to peas before flowering and at early grain-filling stage showed that zinc concentrations increased 3.7 to 5.6 fold and grain zinc accumulation increased to 60 mg Zn kg^{-1} with the foliar Zn applications, alone or in combination with soil Zn applications, suggesting that soil and foliar biofortification could work well for improving zinc bioavailability in field peas (Poblaciones and Rengel, 2016). The fortified organic manure with micro nutrient and bio active compound could play an efficient role in increasing the solubility and availability of micro nutrient thereby increases the uptake and biofortification of the nutrients by crops. Hence, an attempt was made to study the effect of fortified organic manure on the nutrient availability and micronutrient biofortification in black gram.

Materials and Methods

In saline soils of coastal area of Tamil Nadu, to evaluate the effect of fortified organic manure with micronutrients and bio active compounds on the nutrient availability and on the biofortification of micro nutrients in black gram, field experiment was conducted in a farmer’s field at Arunmozhidevan village, Parangipettai Block, Cuddalore district of Tamil-Nadu State, during January-March, 2018. The soil had low alkaline $KMnO_4$-N (120.21 kg ha^{-1}), Olsen-P (7.18 kg ha^{-1}) and medium NH_4OAc-K (286.90 kg ha^{-1}). The following treatments namely, T_1- Control (Recommended NPK), T_2- NPK + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @25 kg ha^{-1}, T_3- NPK + 100 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_4- NPK + 100 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1}, T_5- NPK + 75 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_6- NPK + 75 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1}, T_7- NPK + 50 % Zn and Fe fortified organic manure @ 5 t ha^{-1}, T_8- NPK + 50 % Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1} were studied in RBD with three replications.

The fortified organic manure was prepared by taking required quantities of FYM and adding calculated quantities of micronutrient $ZnSO_4$ @ 25 kg ha^{-1} and $FeSO_4$ @ 25 kg ha^{-1}, as per the treatment schedule. Bio active compounds *viz.*, auxins, amino acids and sea weed extract each @ 1 mg kg^{-1} were added as per the treatments and mixed well. Water was sprinkled to maintain 65 percent water holding capacity. Plastered with mud and incubated for a period of one month, with a stirring on 15^{th} day. After 30 days, the fortified organic manures were used for the field experiment. At flowering and harvesting stages, soil samples were collected from each treatment, air dried, processed, analysed for the properties like pH, EC, organic carbon, available macro nutrients *viz.*, N, P, K and DTPA extractable micronutrient Zn and Fe. Plant sample at flowering and harvest and seed samples at harvest were collected, dried in oven at 65^oC, powdered and digested in Di acid extract (H_2SO_4: $HClO_4$, 5:1 ratio). In the diacid extract, the concentration of N, P, K, Fe and Zn were estimated as per the procedure of Jackson, (1973).

Table 1: Effect of fortified organic manure on the pH, EC and DTPA-Zn and Fe (mg kg^{-1}) of the soil.

Treatment	pH		EC (dS m^{-1})		DTPA-Zn		DTPA-Fe	
	Flow.	Har.	Flow.	Har.	Flow.	Har.	Flow.	Har.
T_1	7.67	7.63	1.70	1.60	0.52	0.49	2.40	2.33
T_2	7.70	7.66	1.72	1.62	0.54	0.51	2.59	2.52
T_3	7.21	7.19	1.26	1.13	0.82	0.76	5.20	5.16
T_4	7.15	7.13	1.23	1.12	0.86	0.80	5.35	5.30
T_5	7.28	7.25	1.21	1.09	0.79	0.71	5.17	5.11
T_6	7.13	7.09	1.19	1.08	0.91	0.87	5.80	5.74
T_7	7.33	7.31	1.34	1.22	0.74	0.69	4.80	4.75
T_8	7.32	7.29	1.32	1.19	0.77	0.71	4.84	4.79
SEd	0.06	0.13	0.05	0.10	0.03	0.01	0.01	0.02
CD (p=0.05)	0.13	0.35	0.12	0.20	0.07	0.02	0.03	0.05

Result and Discussion

pH and EC

The influence of fortified organic manures in decreasing the pH to a range of 7.29 to 7.09 at harvest stage as compared to 7.63 in control was evidenced. Among the treatments, the lowest pH of 7.13 at flowering and 7.09 at harvest stage was recorded by the treatment T_6, NPK+ micronutrients and Bio active compounds fortified FYM @ 5 t ha^{-1}.

The EC reduced to a range of 1.19 to 1.08 dS m^{-1} in the organic manure treatments as compared to control (1.60 dS m^{-1}). The decomposition of organic matter produced various organic acids which might have reduced the pH and EC of the soil. Similar findings were earlier reported by Subramani and Solaimalai, (2000).

Organic carbon

All the organic manure applied treatments *i.e.* T_3-T_8 significantly

Table 2: Effect of Fortified organic manure on the organic carbon, alkaline $KMnO_4$-N, Olsen- P, NH_4OAc-K content of the soil.

Treatment	Organic carbon (%)		Alkaline $KMnO_4$ - N (kg ha^{-1})		Olsen- P (kg ha^{-1})		NH_4OAc-K (kg ha^{-1})	
	Flow.	Har.	Flow.	Har.	Flow.	Har.	Flow.	Har.
T_1	0.44	0.48	120.21	116.32	7.18	7.12	296.9	284.6
T_2	0.45	0.47	123.56	119.20	7.25	7.18	304.6	292.3
T_3	0.54	0.58	144.45	139.20	9.62	10.18	349.9	336.6
T_4	0.56	0.60	153.39	151.21	10.82	10.30	361.4	349.2
T_5	0.52	0.54	142.05	140.2	9.95	9.43	342.5	330.3
T_6	0.58	0.63	158.19	154.20	10.86	10.31	365.9	353.8
T_7	0.48	0.51	132.09	126.05	8.98	8.43	329.9	316.4
T_8	0.50	0.52	135.06	128.02	9.17	8.62	331.8	319.2
SEd	0.01	0.03	3.08	3.43	0.29	0.215	3.40	4.64
CD (p=0.05)	0.02	0.07	6.61	7.36	0.63	0.52	7.30	9.69

increased the organic carbon content of soil. Of all the treatments, a significantly higher organic carbon content was recorded in T_6, NPK+ 75% $ZnSO_4$ + $FeSO_4$ and Bio active compounds fortified FYM @ 5 t ha^{-1} (0.58 percent). The reason for the increase of organic carbon might be due to the application of large quantity of manures which provided sufficient quantity of carbonaceous materials for decomposition by micro-organisms and converting them to mineralized organic colloids, besides adding them to soil reserves. This is in conformity with the findings of Rajashekar Roa, (2000).

Soil available nutrients

The effect due to the application of fortified FYM with micro nutrients and bio active compounds in significantly increasing the availability of N, P and K in soil was well evidenced in the present investigation. Among the treatments T_6, NPK+ 75% $ZnSO_4$ + $FeSO_4$ with FYM and Bio active compounds ranked best by registering the highest alkaline $KMnO_4$-N (154.20 kg ha^{-1}), Olsen-P (10.31 kg ha^{-1}) and NH_4OAc-K (353.8 kg ha^{-1}) at harvest respectively. The fortified organic manures attributed to the faster multiplication of soil microbes, which could convert organically bound N to inorganic form.

This result corroborates the earlier findings of Laxminaraya and Patiram, (2006). Phosphorus availability is low under high pH and saline soil condition. In the present study, the reduction in pH and EC of soil with the organic manure application might have increased the solubility and availability of Olsen-P. Gour, (1994) also reported similar findings. NH_4OAC-K increased due to stimulating effect of the compost and microbial activities. The compost incorporation might have released the organic acids which in turn might have solubilized the potassium from primary minerals of the soil Kumar *et al*., (2004). A significant variation in DTPA-Zn and Fe due to the application of micronutrient and bio active compound fortified organic manure was well evidenced in the present study. The treatments, T_6, NPK+ 75% $ZnSO_4$ + $FeSO_4$ and Bio active compounds fortified FYM recorded the highest DTPA-Zn and Fe content at harvest stages. This treatment recorded a DTPA-Zn content of 0.87 mg kg^{-1} and Fe content of 5.74 mg kg^{-1} at flowering and harvest stages respectively.

Higher levels of Zn in organic manure treated plots could be attributed due to chelating action of organic compounds released during decomposition of organic manures which protected Zn cations from fixation, precipitation, oxidation and leaching (Singh *et al.*, 2003). Devarajan, (1987) also reported significant increase in iron status of soil with iron fortified FYM. This might be due to mineralization of iron from organic matter and release of iron from amino acids during decomposition of organic manure and also due to addition of iron containing fertilizers.

Table 3: Effect of fortified organic manure on the nitrogen, phosphorous and potassium content and uptake by blackgram.

Treatments	Nitrogen				Phosphorous				Potassium			
	Content (%)		Uptake (Kg ha^{-1})		Content (%)		Uptake (Kg ha^{-1})		Content (%)		Uptake (Kg ha^{-1})	
	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed
T_1	1.40	2.08	13.11	9.83	0.10	0.14	0.93	0.66	0.92	0.65	8.62	3.07
T_2	1.49	2.19	15.19	12.09	0.14	0.17	1.42	0.93	0.97	0.68	9.89	3.74
T_3	1.69	2.40	20.7	16.82	0.19	0.20	2.33	1.54	1.16	0.82	14.23	5.64
T_4	1.72	2.49	22.32	18.62	0.23	0.25	2.98	1.87	1.18	0.84	15.31	6.28
T_5	1.62	2.34	19.65	16.02	0.20	0.23	2.42	1.37	1.14	0.78	13.82	5.33
T_6	1.79	2.54	23.52	19.38	0.26	0.29	3.41	2.21	1.21	0.88	15.89	6.71
T_7	1.54	2.27	16.83	13.68	0.16	0.19	1.74	1.19	1.09	0.71	11.91	4.28
T_8	1.56	2.29	17.62	14.38	0.18	0.21	2.03	1.26	1.12	0.73	12.65	4.58
SEd	0.012	0.010	1.60	0.94	0.01	0.009	0.20	0.18	0.009	0.008	0.07	0.08
C.D (p = 0.05)	0.026	0.022	3.43	2.02	0.021	0.020	0.43	0.39	0.019	0.017	0.16	0.17

Table 4: Effect of fortified organic manure on the zinc and iron content and uptake by blackgram.

Treatments	Zinc content (ppm)		Zinc Uptake (g ha^{-1})		Iron content (ppm)		Iron Uptake (g ha^{-1})	
	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed
T_1	1.40	2.08	13.11	9.83	0.10	0.14	0.93	0.66
T_2	1.49	2.19	15.19	12.09	0.14	0.17	1.42	0.93
T_3	1.69	2.40	20.7	16.82	0.19	0.20	2.33	1.54
T_4	1.72	2.49	22.32	18.62	0.23	0.25	2.98	1.87
T_5	1.62	2.34	19.65	16.02	0.20	0.23	2.42	1.37
T_6	1.79	2.54	23.52	19.38	0.26	0.29	3.41	2.2
T_7	1.54	2.27	16.83	13.68	0.16	0.19	1.74	1.19
T_8	1.56	2.29	17.62	14.38	0.18	0.21	2.03	1.26
SEd	0.012	0.010	1.60	0.94	0.01	0.009	0.20	0.18
C.D (p = 0.05)	0.026	0.022	3.43	2.02	0.021	0.020	0.43	0.39

Content and Uptake of macro nutrients

Among the treatments, combined application of NPK + Zn and Fe fortified FYM along with bio active compounds registered the highest macro (NPK) content and uptake at different critical stages of crop growth as compared to control. Among the treatments, T_6, NPK + 75% Zn and Fe fortified FYM along with bio active compounds was associated with higher nutrient content *viz*., higher N (1.79 and 2.54 haulm and seed in percent), P (0.26 and 0.29 in haulm and seed percent) and K (1.21 and 0.88 in haulm and seed percent). The treatment $ZnSO_4$ + $FeSO_4$ @ 25 kg ha^{-1} alone registered the higher level of macro nutrients in seed and haulm as compared to NPK alone. It is very likely that N losses due to leaching or denitrification might have reduced in soil by mixing N-fertilizer with organic compost, resulting in a better utilization of N by the plant (Parvati gadi *et al*., 2017) organics fortified with inorganic P, added to soil are subject to biological mineralization and production of phosphor humus complexes, which readily supply nutrients to plants (Basavaraj and Manjunathaiah, 2003). The added FYM contained (0.52 percent) K nutrient which increased the potassium availability in soil favouring for higher absorption by blackgram. This was in line with the earlier findings of Ahmad *et al*., (2007).

Micronutrient fortification

A profound influence of fortified organic manure in significantly fortifying the content of Zn and Fe in black gram was well evidenced in the present investigation. The content of Zn and Fe in control treatment was 29.85 and 31.50 ppm respectively. With the application of fortified manure the content of Fe increased to a range of 46.68 to 65.23 ppm and Zn increased to a range of 35.60 to 44.25 ppm in seed. Among the fortification treatments, T_6, NPK+ 75% $ZnSO_4$ + $FeSO_4$ and Bio active compounds fortified FYM recorded the highest content of Zn (44.25 ppm) and Fe (65.23ppm).

The increased content of Zn in black gram seed and haulm might be due to the application of $ZnSO_4$ with organic manure formed intermediates metabolites during decomposition of FYM that hold Zn in forms available to plants or release of Zn mobilizing compounds such as phytosiderophores from roots and induction of polypeptides involved in Zn uptake and translocation to shoots (Marschner, 1995; Kanagabushani, 1980). The pH decrease, release of organic acids due to decomposition of FYM, chelating and other compounds resulted in increased root growth that promoted the increased nutrient uptake per unit root volume, (Meena *et al*., 2017). The manure application reflected on DTPA-Fe content could be due to involvement of organic ligands in the transformation reaction of iron. Supplementation of trace elements through sea weed liquid fertilizer could be a result of better utilization of micro nutrient (Fe) especially due to favourable bio stimulation action of sea weed extract for enhancement in assimilation of trace element (Yadav *et al*., 2002).

Conclusion

The results of the study clearly indicated the beneficial influence of fortified organic manures with micronutrients and bioactive compounds application namely, NPK + 75% Zn and Fe + bio active compounds fortified organic manure @ 5 t ha^{-1} in significantly increasing the soil nutrient availability and biofortification of Zn and Fe in black gram grown under Coastal saline soil.

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