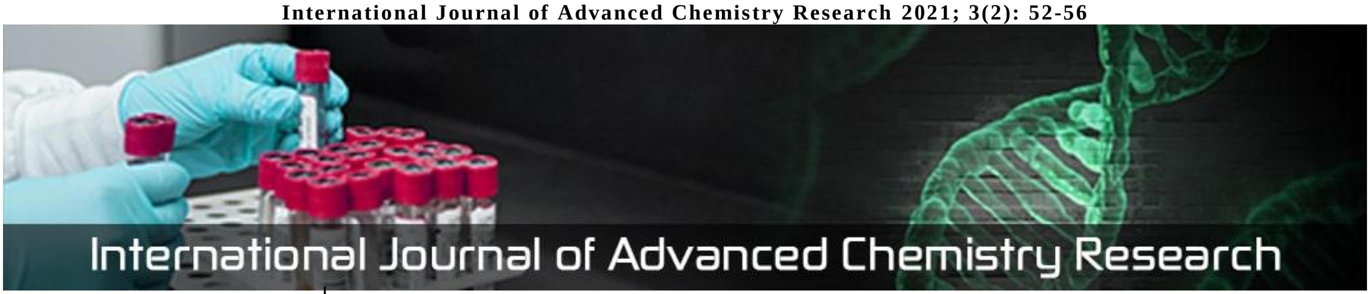

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Effect of FYM, Zn and Fe fertilizer on Physio-chemical properties of soil under Pearlmillet in hyper arid region of Rajasthan

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Abstract
A two years field experiment was conducted at two experimental sites of loamy sand soil. During *Kharif*, 2019 experiment was conducted at Agricultural Research Farm and during *Kharif*, 2020 conducted at Instructional farm, COA, SKRAU, Bikaner. To evaluate the influence of application of FYM, Zn and Fe fertilizer on physio-chemical properties of soil after harvest of pearl millet (RHB-177). Treatments consisted of three levels of FYM (Control, FYM @ 5 t ha^{-1} and 10 t ha^{-1} FYM) and ten methods and levels of Zn and Fe application (Control, soil application of (25 kg ha^{-1} $FeSO_4$, 25 kg ha^{-1} $ZnSO_4$, 25 kg ha^{-1} $ZnSO_4$ + ZSB, 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ + ZSB) and foliar application of (0.5% $FeSO_4$, 1.0% $FeSO_4$, 0.5% $ZnSO_4$, 0.5% $FeSO_4$ + 0.5% $ZnSO_4$, 0.5% $FeSO_4$ + 0.5% $ZnSO_4$) in split plot design with three replications. The results revealed that organic carbon, dehydrogenase activity, bacterial, fungal and actinomycetes count, available nitrogen, phosphorus, potassium and sulphur in soil after harvest of pearl millet was significantly increased, while saturated hydraulic conductivity was significantly decreased with increasing levels of FYM up to @ 10 t ha^{-1} over control and 5 t FYM ha^{-1}. And application of different methods and levels of Zn and Fe manifested significantly positive impact on available sulphur, whereas available phosphorus was significantly decreased as compare to control.

Keywords: FYM, Zn and Fe, pearlmillet, physio-chemical properties of soil

Introduction
Pearl millet (*Pennisetum glaucum* (L.) R. Br. emend Stuntz) is the most widely grown drought tolerant warm season coarse grain cereal and is considered as a Poor man's food crop. Pearl millet is one of the fourth most important crop in India after rice, wheat and sorghum which flourishes well even under adverse conditions of weather, low soil fertility and alkaline soils (Singh *et al.*, 2017; Shekhawat and Kumawat, 2017) [7, 16]. Pearl millet is provided nutritional security as it has higher protein content (12.6%), more balanced amino acid profile, and contribute about one third of iron and zinc requirements (Manga and Kumar, 2011) [10]. In Rajasthan, Pearl millet is mostly cultivated as unirrigated crop, unfertilized or partially fertilized on marginal and submarginal lands having light textured soils, low in nitrogen, phosphorus and organic matter with poor moisture retention capacity, thereby resulting in low and uneconomical harvest. Hence, our research effort should be diverted to remove the constraints that are responsible for its poor yield. Intense temperature and low organic matter content in semi-arid region leads to poor soil fertility and low nitrogen status (Rego *et al.*, 2003) [15]. Application of FYM to crops also avoids its wasteful use for burning purposes. FYM is being used as a major source of organic manure in field crops. Limited availability of this manure is, however, an important constraint in its use as a source of nutrients. FYM is rich in organic matter and is a good source of plant nutrients. Poor nutrient economy of light textured soil necessitates the need for supplementing fertilizers with FYM. Organic manure influence both yield and plant micronutrients need and thus help to sustain crop productivity. Approximately 49 per cent of world & 50 per cent of Indian soils are deficient in Zn (Cakmak *et al.*, 2010; Shekhawat and Kumawat, 2017) [2, 16]. Continuous intensive cropping of high yielding varieties has further aggravated the depletion of soil zinc leading to low zinc concentration in edible grains. The soils of hyper arid region are coarse textured and deficient in N, S, Zn and Fe due to continuous crops removal.

FYM changes the chemical, physical and biological properties of the soil which in terms affect the availability of plant nutrients. Soil application of $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} increase the availability of S, Zn and Fe. Hence, keeping all these facts, the present study was undertaken to assessment of physio-chemical properties of soil through application of FYM, Zn and Fe fertilizer under pearlmillet in hyper arid region of Rajasthan.

Material and Methods

During *kharif*, 2019, the experiment was conducted at experimental farm, Agriculture Research Station, SKRAU, Bikaner, and in *kharif*, 2020, the experiment was conducted at instruction farm, College of Agriculture, SKRAU, Bikaner. These sites were situated at 234 meters above mean sea level on latitude $28^0 10'$ N and $73^0 22'$ E longitude. Bikaner has arid climate with average annual rainfall of about 262 mm. More than 80 per cent of rainfall is received during *kharif* season (July-September) by the South West monsoon. During summer, the maximum temperature may go as high as 48^o C while in the winters it may fall as low as 0^oC. The soil is loamy sand desert soils with low water holding capacity,

slightly alkaline in reaction (pH 8.24), poor in organic carbon (0.13 per cent), low in available nitrogen (104.2 kg ha^{-1}) and medium in available phosphorus (16.68 kg ha^{-1}) and medium in available potassium (178.05 kg ha^{-1}). Similarly, *kharif*, 2020 location analytical results revealed that the soil of the experimental field was sandy in texture and slightly alkaline in reaction (pH 8.29), poor in organic carbon (0.12 per cent), low in available nitrogen (101.36 kg ha^{-1}) and medium in available phosphorus (17.12 kg ha^{-1}) and medium in available potassium (182.32 kg ha^{-1}).

Treatments consisted of three levels of FYM (Control, FYM @ 5 t ha^{-1} and 10 t ha^{-1} FYM) and ten methods and levels of Zn and Fe application (Control, soil application of (25 kg ha^{-1} $FeSO_4$, 25 kg ha^{-1} $ZnSO_4$, 25 kg ha^{-1} $ZnSO_4$ + ZSB, 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ + ZSB) and foliar application of (0.5% $FeSO_4$, 1% $FeSO_4$, 0.5% $ZnSO_4$, 0.5% $FeSO_4$ + 0.5% $ZnSO_4$, 0.5% $FeSO_4$ + 0.5% $ZnSO_4$) in split plot design with three replications were applied to pearl millet crop (RHB-177). FYM was applied at 21 days before sowing @ 5 t ha^{-1} and 10 t ha^{-1} in the field as per treatment. RDF was given through Urea (N), SSP (P) and MOP (K) in each plot. Soil application of Zn and Fe were applied as per treatments through zinc sulphate ($ZnSO_4.7H_2O$) containing 21% Zn and 10% S and iron sulphate ($FeSO_4.7H_2O$) containing 19.6% Fe and 10.5% S at the time of sowing as basal dose and foliar application of zinc (0.5%) and iron sulphate (0.5% and 1%) at 25 and 40 DAS.

Results and Discussions

Soil physical properties

Effect of FYM, Zn and Fe on bulk density, particle density and saturated hydraulic conductivity

Effect of FYM, Zn and Fe application were found non-significant on bulk density and particle density of soil. Saturated hydraulic conductivity of soil significantly decreased due to FYM application. Saturated hydraulic conductivity of soil was varied from 12.16 to 10.96 cm hr^{-1} on the pooled mean basis (Table 1). The lowest hydraulic conductivity was recorded with application of FYM @ 10 t ha^{-1} (10.91, 11.1 and 10.96 cm hr^{-1}), while highest saturated hydraulic conductivity was recorded in controlled plot (12.04, 12.28 and 12.16) during both years and pooled data, respectively. It could be due to granulation effect of farmyard manure which led to increase in soil micro porosity and thus reduction in water movement through soil. These findings are in agreement with earlier findings by Kumawat, 2019 [9]; Kumar, 2021 [8]. And non-significantly influenced due to methods and levels of Zn and Fe application.

Biological properties

Effect of methods & levels of Zn, Fe and FYM on dehydrogenase activity

Different levels of FYM significantly increased dehydrogenase activity (Table 2) in soil after harvest of pearl millet over control. Significantly highest (24.38 µg TPF g^{-1} soil 24 h^{-1}) dehydrogenase activity was recorded with application of FYM @ 10 t ha^{-1} which was significantly higher than FYM @ 5 t ha^{-1}(21.96 µg TPF g^{-1} soil 24 h^{-1}) and control (21.15 µg TPF g^{-1} soil 24 h^{-1}) during both years and pooled data. On the basis of pooled data FYM @ 10 t ha^{-1} increased dehydrogenase activity in the tune of 15.27 per cent over control. The dehydrogenase activity and microbial count did not influence significantly due to methods and levels of Zn and Fe application.

Effect of methods & levels of Zn, Fe and FYM on bacterial counts, fungi counts and actinomycetes counts

The results pertaining to bacterial count in soil presented in (Table 2) after harvest of pearlmillet in both the years and as pooled mean basis indicated that bacterial count was varied from 20.85 to 28.10 × 10^6. Application of different levels of FYM increase bacterial count in soil. Significantly highest bacterial count was recorded with application of FYM @10 t ha^{-1}, while lowest bacterial count was recorded in controlled condition and superior over 5 t ha^{-1} FYM.

And fungi count was varied from 15.62 to 24.60 × 10^4. Application of different levels of FYM increase fungi count in soil. Significantly highest fungi count was recorded with application of FYM @10 t ha^{-1} (24.60 × 10^4), while lowest bacterial fungi count was recorded in controlled condition (15.62 × 10^4) and superior over 5 t ha^{-1} FYM (19.17 × 10^4) in pooled mean basis.

FYM significantly increased actinomycetes count (Table 2) in soil after harvest of pearlmillet over control during both years. Significantly highest (43.69 × 10^5) actinomycetes count was recorded with application of FYM @ 10 t ha^{-1} which was significantly higher than FYM @ 5 t ha^{-1}(40.74 × 10^5) and control (37.90 × 10^5) on the basis of pooled mean. The microbial count did not influence significantly due to methods and levels of Zn and Fe application. The data showed that application of FYM levels significantly increased all biological properties as compared to control. It due to FYM act as source of organic carbon and energy, which stimulate different microbial activities in soil (Bhatt *et al.*, 2016; Rajput *et al.*, 2019; Kumar, 2021) [1, 14, 8]. The increase in microbial count might be due to increasing levels of N, P, K, S, Zn and Fe which might have increased cation exchange capacity, root biomass, root exudates and ultimately provided carbon and energy to the soil microbes resulting into multiplication of microbial count. The similar results were also reported by Parewa *et al.*, 2014 [12], Urmila *et al.*, 2016 [19]; Dudhawal, 2018.

Chemical properties

Effect of FYM, Zn and Fe application on pH and electrical conductivity, organic carbon, available N, P, K and S

pH and electrical conductivity of soil did not influence significantly due to FYM levels and different methods and levels of Zn and Fe application.

Organic carbon of soil increased significantly (Table 3) due to application of different FYM levels during both the years as well as pooled analysis. Significantly the highest organic carbon (1.40 g kg^{-1}) content was observed with application of FYM @ 10 t ha^{-1} as compared to control (1.25 g kg^{-1}) and FYM @ 5 t ha^{-1}(1.29 g kg^{-1}) on pooled mean basis.

Available nitrogen (Table 4) in soil after harvest of pearlmillet during both the years and pooled analysis increased significantly due to application of different FYM levels. It was varied from 101.9 to 110.9 kg ha^{-1}. Significantly the highest available nitrogen (110.9 kg ha^{-1}) was recorded with application of FYM @ 10 t ha^{-1} which was statistically higher than FYM @ 5 t ha^{-1} and control.

Available phosphorous in soil after harvest of pearlmillet during both the years and pooled analysis increased significantly (Table 4) due to application of different FYM levels. It was varied from 15.22 to 17.51 kg ha^{-1}. Significantly the highest available phosphorous (17.50 kg ha^{-1}) was recorded with application of FYM @ 10 t ha^{-1} which was statistically higher than FYM @ 5 t ha^{-1} and control. And application of different methods and levels of Zn and Fe significantly decreased available phosphorous. All treatments of soil application of $ZnSO_4$ had significantly lower (Table 4) available phosphorous than control. On the basis of pooled data soil application of $ZnSO_4$ @ 25 kg ha^{-1} was significantly decrease available phosphorous (15.15 kg ha^{-1}) than control (16.59 kg ha^{-1}).

Available potassium in soil after harvest of pearlmillet during both the years and pooled analysis increased significantly (Table 4) due to application of different FYM levels. It was varied from 175.0 to 188.7 kg ha^{-1}. Significantly the highest available potassium (188.7 kg ha^{-1}) was recorded with application of FYM @ 10 t ha^{-1} which was statistically higher than FYM @ 5 t ha^{-1} (181.9 kg ha^{-1}) and control (175.0 kg ha^{-1}) on pooled data basis.

Progressive increase in levels of FYM up to 10 t ha^{-1} significantly increased available sulphur in soil after harvest of pearlmillet over control (Table 4) during both the individual years and pooled analysis. Application of FYM @ 10 t ha^{-1} significantly influenced (16.28 kg ha^{-1}) available sulphur compared to FYM @ 5 t ha^{-1} (14.98 kg ha^{-1}) and control (13.58 kg ha^{-1}). Sulphur was significantly increased with application of different methods and levels of Zn and Fe over control. All treatments of soil application of $ZnSO_4$ and $FeSO_4$ had significantly higher available sulphur than control during both years of study. On the basis of pooled data soil application of $FeSO_4$ @ 25 kg ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1}+ZSB was significantly increase available sulphur (19.27 kg ha^{-1}) than control (13.44 kg ha^{-1}). And This might be due to adsorption of part of applied sulphur on organic matter and thereby reducing the leaching losses of sulphur.

The use of FYM through proper practice helps in increasing the organic carbon content of soil due to higher biomass and differential rate of oxidation of organic matter by microbes. The similar effects were also observed by (Parewa *et al*, 2014 [12] and Choudhary *et al*., 2019 [3]. Increases in availability of nitrogen, phosphorus, potassium and sulphur in soil under FYM treated plot might be due to FYM attributed to its inherent capacity to add good amount of organic carbon to the soil which hastens the process of mineralization of organically bound nitrogen and phosphorus present in native soil due to masking of adsorption sites by humate ions (Pattanayak *et al*., 2009 and Kaur, 2013; Dudhawal, 2018) [13, 6]. And available phosphorus significantly decreased due to methods and levels of Zn and Fe application. It might be due to the antagonistic effect between Zn on P in soils solution and forming insoluble compounds, $Zn_3(PO4)_2$ resulting in the low amount of P in the available pool. but non-significant difference was found with foliar application of Zn and Fe. Such types of findings were also reported by Keram *et al*., 2012 [7] and Meena *et al*., 2017 [11]. Higher available S in soil is due to greater mineralization of organic S and release of SO_4^{2-} ions on its gradual oxidation. Similar findings were also reported by Tiwari *et al.* (1992) [18]; Jat *et al.* (2012) [5].

Table 1: Effect of FYM levels and methods & levels of Zn and Fe on bulk density (BD), particle density (PD) and saturated hydrolic conductivity (SHC) in soil after harvest of pearlmillet

	Treatments	BD (Mg m^{-3})			PD (Mg m^{-3})			SHC (cm hr^{-1})		
		2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Farm yard manure levels										
	M_0-Control	1.53	1.53	1.53	2.61	2.62	2.62	12.04	12.28	12.16
	M_1-5 t ha^{-1}	1.51	1.51	1.51	2.60	2.61	2.60	11.48	11.69	11.58
	M_2-10 t ha^{-1}	1.50	1.48	1.49	2.59	2.59	2.59	10.91	11.01	10.96
	S.Em±	0.01	0.02	0.01	0.02	0.03	0.02	0.10	0.07	0.06
	CD at 5%	NS	NS	NS	NS	NS	NS	0.40	0.26	0.20
Methods and Levels of Zn & Fe application										
Soil application	F_0-Control	1.52	1.53	1.52	2.61	2.62	2.61	11.63	11.91	11.77
	F_1-25 kg ha^{-1} FS	1.52	1.51	1.51	2.60	2.61	2.60	11.59	11.71	11.65
	F_2-25 kg ha^{-1} ZS	1.50	1.51	1.50	2.61	2.59	2.60	11.61	11.76	11.68
	F_3- 25 kg ha^{-1} ZS + ZSB	1.51	1.49	1.50	2.60	2.61	2.60	11.39	11.61	11.50
	F_4-25 kg ha^{-1} FS + 25 kg ha^{-1} ZS + ZSB	1.49	1.50	1.49	2.59	2.59	2.59	11.19	11.65	11.42
Foliar application	F_5-0.5% FS	1.52	1.49	1.51	2.60	2.62	2.61	11.49	11.60	11.54
	F6-1.0% FS	1.51	1.51	1.51	2.61	2.60	2.61	11.44	11.61	11.52
	F_7-0.5% ZS	1.52	1.50	1.51	2.60	2.61	2.60	11.41	11.54	11.48
	F_8-0.5% FS+0.5% ZS	1.52	1.52	1.52	2.61	2.60	2.61	11.51	11.61	11.56
	F_9-1.0% FS+0.5% ZS	1.51	1.51	1.51	2.59	2.61	2.60	11.49	11.59	11.54
	S.Em±	0.02	0.02	0.01	0.04	0.03	0.03	0.17	0.08	0.09

	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

FS= Ferrous Sulphate, ZS= Zinc Sulphate, ZSB= Zinc Solubilizing Bacteria

Table 2: Effect of FYM levels and methods & levels of Zn and Fe on biological properties of post-harvest soil under pearlmillet

	Treatments	**Dehydrogenase (Ug TPF g^{-1} soil 24 h^{-1})**			**Bacteria Count (10^6)**			**Fungi Count (10^4)**			**Actinomycetes Count (10^5)**		
		2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Farm yard manure levels													
	M_0-Control	21.71	20.59	21.15	21.26	20.45	20.85	16.36	14.89	15.62	38.33	37.47	37.90
	M_1-5 t ha^{-1}	22.01	21.90	21.96	24.83	21.92	23.37	22.05	17.38	19.71	41.68	39.79	40.74
	M_2-10 t ha^{-1}	24.22	24.55	24.38	28.64	27.56	28.10	25.35	23.84	24.60	43.78	43.60	43.69
	S.Em±	0.19	0.17	0.13	0.19	0.23	0.15	0.15	0.15	0.10	0.37	0.17	0.20
	CD at 5%	0.74	0.68	0.42	0.74	0.89	0.48	0.57	0.59	0.34	1.46	0.66	0.66
Methods and Levels of Zn & Fe application													
Soil application	F_0-Control	22.1	22.2	22.2	24.4	23.0	23.7	21.2	18.5	19.8	40.2	40.0	40.1
	F_1-25 kg ha^{-1} FS	22.75	22.63	22.69	24.95	23.44	24.20	21.24	18.60	19.92	41.43	40.50	40.97
	F_2-25 kg ha^{-1} ZS	22.77	22.65	22.71	24.84	23.45	24.15	21.24	18.71	19.97	41.48	40.60	41.04
	F_3- 25 kg ha^{-1} ZS + ZSB	22.80	22.65	22.72	25.03	23.52	24.27	21.28	18.77	20.03	41.56	40.62	41.09
	F_4-25 kg ha^{-1} FS + 25 kg ha^{-1} ZS + ZSB	22.82	22.71	22.76	25.09	23.49	24.29	21.52	19.13	20.32	41.60	40.69	41.15
Foliar application	F_5-0.5% FS	22.42	22.07	22.24	24.93	23.23	24.08	21.19	18.51	19.85	41.01	40.02	40.52
	F6-1.0% FS	22.52	22.21	22.37	25.07	23.38	24.22	21.20	18.72	19.96	41.15	40.10	40.62
	F_7-0.5% ZS	22.61	22.34	22.48	25.01	23.20	24.11	21.21	18.70	19.96	41.43	40.12	40.78
	F_8-0.5% FS+0.5% ZS	22.86	21.94	22.40	24.85	23.36	24.11	21.22	18.85	20.04	41.36	40.04	40.70
	F_9-1.0% FS+0.5% ZS	22.77	22.02	22.40	24.87	23.02	23.95	21.23	18.52	19.88	41.44	40.15	40.80
	S.Em±	0.29	0.30	0.21	0.25	0.34	0.21	0.22	0.29	0.18	0.52	0.59	0.39
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

FS= Ferrous Sulphate, ZS= Zinc Sulphate, ZSB= Zinc Solubilizing Bacteria

Table 3: Effect of FYM levels and methods & levels of Zn and Fe on pH, electric conductivity (EC), organic carbon (OC)in soil in soil after harvest of pearlmillet

	Treatments	**pH**			**EC (dSm^{-1})**			**OC (g kg^{-1})**		
		2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Farm yard manure levels										
	M_0-Control	8.22	8.26	8.24	0.171	0.182	0.176	1.31	1.20	1.25
	M_1-5 t ha^{-1}	8.11	8.20	8.15	0.172	0.183	0.178	1.35	1.22	1.29
	M_2-10 t ha^{-1}	8.09	8.14	8.11	0.174	0.186	0.180	1.45	1.36	1.40
	S.Em±	0.06	0.05	0.04	0.002	0.002	0.001	0.01	0.01	0.01
	CD at 5%	NS	NS	NS	NS	NS	NS	0.06	0.04	0.03
Methods and Levels of Zn & Fe application										
Soil application	F_0-Control	8.20	8.26	8.23	0.171	0.182	0.177	1.36	1.24	1.30
	F_1-25 kg ha^{-1} FS	8.21	8.25	8.23	0.178	0.184	0.181	1.37	1.28	1.33
	F_2-25 kg ha^{-1} ZS	8.16	8.17	8.17	0.172	0.184	0.178	1.38	1.25	1.32
	F_3- 25 kg ha^{-1} ZS + ZSB	8.07	8.08	8.08	0.176	0.186	0.181	1.39	1.28	1.34
	F_4-25 kg ha^{-1} FS + 25 kg ha^{-1} ZS + ZSB	7.98	8.14	8.06	0.176	0.186	0.181	1.39	1.29	1.34
Soil application	F_5-0.5% FS	8.18	8.24	8.21	0.168	0.183	0.175	1.36	1.24	1.30
	F6-1.0% FS	8.15	8.24	8.19	0.170	0.183	0.176	1.36	1.26	1.31
	F_7-0.5% ZS	8.18	8.25	8.22	0.174	0.185	0.179	1.37	1.24	1.31
	F_8-0.5% FS+0.5% ZS	8.15	8.18	8.17	0.172	0.183	0.178	1.36	1.26	1.31
	F_9-1.0% FS+0.5% ZS	8.12	8.17	8.15	0.168	0.179	0.174	1.37	1.25	1.31
	S.Em±	0.09	0.08	0.06	0.003	0.002	0.002	0.02	0.02	0.01
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

FS= Ferrous Sulphate, ZS= Zinc Sulphate, ZSB= Zinc Solubilizing Bacteria

Table 4: Effect of FYM levels and methods & levels of Zn and Fe on available nitrogen, available phosphorous, available potassium and Available sulphur in soil after harvest of pearlmillet

	Treatments	**Avail. Nitrogen (Kg ha^{-1})**			**Avail. phosphorous (Kg ha^{-1})**			**Avail. potassium (Kg ha^{-1})**			**Avail. sulphur (Kg ha^{-1})**		
		2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Farm yard manure levels													
	M_0-Control	102.9	100.9	101.9	15.49	14.95	15.22	173.7	176.3	175.0	14.67	12.49	13.58
	M_1-5 t ha^{-1}	109.7	105.7	107.7	16.75	16.00	16.37	180.7	183.2	181.9	15.59	14.38	14.98
	M_2-10 t ha^{-1}	113.8	107.9	110.9	18.11	16.91	17.51	187.6	189.9	188.7	17.29	15.26	16.28
	S.Em±	0.59	0.68	0.45	0.16	0.16	0.11	1.60	1.61	1.13	0.15	0.14	0.10
	CD at 5%	2.31	2.66	1.46	0.62	0.62	0.36	6.27	6.31	3.69	0.57	0.56	0.33
Methods and Levels of Zn & Fe application													
Soil application	F_0-Control	107.0	103.3	105.2	16.96	16.21	16.59	178.4	181.2	179.8	14.74	12.15	13.44
	F_1-25 kg ha^{-1} FS	109.1	104.9	107.0	17.56	16.59	17.08	179.6	183.6	181.6	15.90	15.10	15.50

	F_2-25 kg ha^{-1} ZS	109.5	105.6	107.5	15.68	14.63	15.15	181.3	185.1	183.2	16.41	15.31	15.86
	F_3- 25 kg ha^{-1} ZS + ZSB	109.9	105.1	107.5	16.07	14.72	15.40	183.2	185.6	184.4	16.90	16.41	16.65
	F_4-25 kg ha^{-1} FS + 25 kg ha^{-1} ZS + ZSB	110.0	105.0	107.5	16.10	15.06	15.58	183.3	185.8	184.6	19.97	18.57	19.27
Foliar application	F_5-0.5% FS	108.8	104.3	106.6	17.26	16.67	16.97	178.4	181.1	179.7	14.88	12.55	13.72
	F6-1.0% FS	107.4	104.6	106.0	16.98	16.65	16.82	179.3	181.6	180.4	14.92	12.72	13.82
	F_7-0.5% ZS	108.6	104.2	106.4	17.29	16.41	16.85	179.8	183.9	181.8	14.89	12.60	13.75
	F_8-0.5% FS+0.5% ZS	108.9	105.6	107.2	16.98	16.26	16.62	180.8	182.1	181.4	15.01	12.66	13.83
	F_9-1.0% FS+0.5% ZS	108.6	105.8	107.2	16.91	16.33	16.62	182.4	181.4	181.9	14.88	12.38	13.63
	S.Em±	1.23	1.22	0.86	0.25	0.26	0.18	2.85	2.85	2.02	0.25	0.21	0.16
	CD at 5%	NS	NS	NS	0.71	0.72	0.50	NS	NS	NS	0.70	0.58	0.45

FS= Ferrous Sulphate, ZS= Zinc Sulphate, ZSB= Zinc Solubilizing Bacteria

Conclusion

Result of the present study shows that significant improvement in organic carbon, available N, P, K and S, biological parameters (Bacterial count, fungal count, actinomycetes and dehydrogenase activity) whereas, saturated hydraulic conductivity significantly decreased with application of FYM @ 10 t ha^{-1}. Available sulphur significantly increased with Zn and Fe application.

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