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Effect of Zn and Fe enriched FYM on soil properties and yield attributes of cowpea [*Vigna ungiculata* (L.) Wilczek] under sodic water irrigation

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Abstract
A pot experiment was conducted during *kharif* 2018-19 at S.K.N. College of Agriculture, Jobner (Rajasthan) on the "Effect of Zn and Fe enriched FYM on nutrient availability and yield of cowpea *[Vigna ungiculata* (L.) Wilczek] under sodic water irrigation" to evaluate the effect of different sodic water and sources of Zn and Fe on soil properties (pHs, ECe, SAR, OC and DTPA-Zn and Fe content, available N, P_2O_5, K_2O and yield attributes of cowpea on loamy sand soil. The experiment comprising of 15 treatment combinations replicated three times, was laid out in completely randomized block design with three levels of sodic water(2, 4 and 6 mmol L^{-1}) and five levels of sources of Zn and Fe (0, $ZnSO_4.7H_2O$, $FeSO_4.7H_2O$, Zn enriched FYM, Fe enriched FYM) as variables. Results revealed that under 6 mmol L^{-1} RSC of irrigation water, the ECe, organic carbon, DTPA-Zn and Fe, available N, P_2O_5 and K_2O were decreased significantly, while pH and SAR of soil increased significantly. The number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index of cowpea decreased significantly with all levels of sodic water and maximum reduction was recorded with the application of 6 mmol L^{-1} of sodic water. The application of Zn enriched FYM decreased the pH and SAR significantly while Organic carbon, DTPA-Zn and Fe, available N, P_2O_5, K_2O of soil, number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index of cowpea increased significantly.

Keywords: Organic carbon, enriched FYM, sodic water, nodule index

Introduction
The quality of irrigation water plays a vital role in crop production. Generally, irrigation water from all sources contains dissolved salts in very low concentration. The use of sodic water for irrigation adversely affects productivity of soil by influencing the uptake of nutrients and many soil properties (Chauhan *et al.* 1988) [8]. This problem becomes more aggravated when the carbonate and bicarbonate of sodic water occur in association with sodium creating the problem of residual sodium carbonate (RSC). High RSC irrigation water is characterized by low total salt concentration. The relative proportions of calcium and magnesium salts are much smaller as compared to sodium salts. Such waters usually have sodium carbonate as a predominant salt. The prolonged use of such water immobilizes soluble calcium and magnesium in the soil by precipitating them as carbonates consequently the concentration of sodium in the soil solution and exchangeable complex increases which leads to the development of sodic conditions. Chemical degradation by salinization (2.96 Mha) and alkalization (3.78 Mha) is reported to extend to 6.74 Mha of which Rajasthan occupies 0.38 Mha (Mandal *et al*., 2010) [16] and the problem is increasing at an alarming rate in arid and semi-arid region.Cowpea [*Vigna unguiculata* (L.) Wilczek] commonly known in India as *lobia* is one of the important *kharif* pulse crops grown for vegetable, grain, forage and green manuring. This crop has great importance because of availability of short duration, high yielding and quick growing variety. Green tender pods are used as vegetable. The vegetable cowpea pods contain moisture 84.6%, protein 4.3%, carbohydrate 8.0% and fat 0.2%. It is also a rich source of calcium, phosphorus and iron. Being rich in protein and containing many other nutrients, it is known as vegetable meat. The crop gives such a heavy vegetative growth and covers the ground so well that it checks the soil erosion in problem areas and can later be ploughed down for green manure. It is a considerable promising an alternative pulse crop in

dry land farming. Although soil salinity and sodicity are prevalent problems in arid and semiarid regions, it has been found in all the climatic zones.

Zinc deficiency has been reported to be the most widespread micro-nutritional disorder of the food crops in India as well as the world over. The magnitude of zinc deficiency varied widely among soil types and within the various states. Coarse texture, high pH, high calcium carbonate and low organic carbon content in calcareous soils of Bihar, Vertisols and Inceptisols of Andhra Pradesh, Tamil Nadu and Madhya Pradesh and Aridisols of Haryana showed extensive deficiency of zinc resulting low crop yields (Sakal, 2001) [26]. Zinc is a crucial component of package of the practices recommended for sodic soils reclamation. Deficiencies of Fe, Mn and Cu are much less extensive than that to zinc. Continuous use of high sodic water increases the ESP and pH of soil which decreases the availability of Zn (Meena *et al.* 2017) [17]. As the soil pH increase, the ionic form of Zn changed to hydroxide form, which is insoluble and unavailable to plants. Although the high RSC water can be used successfully by applying higher doses of zinc sulphate, Zinc helps in inducing alkalinity tolerance in crop by enhancing its efficiency in utilizing K, Ca and Mg and decreases the adverse effect of sodicity (Raj and Raj 2019) [24]. Zn and Fe application in the enriched form may enhance the fertilizer use efficiency and increase crop yield. However, no systematic study has been conducted on recommendation of zinc and iron enriched FYM in these soils irrigated with high RSC water in the region for cultivation of legume crops. The productivity could be sustained through integrated use of organic and inorganic fertilizers. Use of organic manures for amelioration of zinc and iron deficiency in soils has been emphasized by several workers (Meena *et al.* 2006, Rathod *et al.* 2012) [18, 25]. FYM enriched zinc and iron reacts with native reserves of micro nutrient elements and render them available to plants. Zinc application in the enriched form may enhance the fertilizer use efficiency and increase the rice yield (Veeranagappa *et al.*, 2010) [32]. Substantial build-up of available Zn in soil has been observed with the use of organic manures and residual effect of Zn application. The present study was aimed at assessing the effect of Zn and Fe enriched FYM on soil properties, available nutrients and number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index of cowpea as well as DTPA- extractable Zn and Fe in soil.

Materials and Methods

A pot experiment was conducted in cage house of Department of Plant Physiology and laboratory analysis of plant and soil samples were analyzed in Department of Soil Science and Agricultural Chemistry, S.K.N. College of Agriculture, Jobner (Rajasthan) during the *kharif* season, 2018. The experiment comprising of 15 treatment combinations replicated three times, was laid out in completely randomized block design with three levels of sodic water(2, 4 and 6 mmol L^{-1}) and five levels of sources of Zn and Fe (0, $ZnSO_4.7H_2O$ @ 12.5 mg/kg soil, $FeSO_4.7H_2O$ @ 25 mg/kg soil, Zn enriched FYM 250 mg/kg soil, Fe enriched FYM @ 250 mg/kg soil) as variables.Experimental site is located at 75.28^0 East longitudes and 26.06^0 North latitude at an altitude of 427 metres above mean sea level. This region comes under Agro Climatic Zone III-a (Semi-arid eastern plain). The climate of the region is typically semi-arid characterized by the aridity of atmosphere and salinity of rhizosphere with extremes of temperature both during summer and winter. The average rainfall of this region is about 400 to 500 mm, which is mostly received between July and September (Monsoon season). The loamy sand soil was used for pot experiment. The laboratory analysis of experimental soil evaluated that experimental soil was loamy sand in texture and soil was low in organic carbon (1.8 g/kg), available nitrogen (128.10 kg N/ha), available phosphorus (20.25 kg P_2O_5/ha), DTPA Zn (0.42mg/kg), DTPA Fe (3.4mg/kg) and medium in available potassium (145.80 kg K_2O/ha). The soil was non saline with a reaction 8.2.

Soil analysis: To assess the fertility status of soil, soil samples (0-15 cm depth) from each pot at harvest of crop were analyzed for physico-chemical and biological properties of soil. These were passed through 2.0 mm plastic sieve to avoid contamination. The sample were analyzed for EC, pH, SAR, SOC, available NPK, DTPA extractable Zn and Fe as per methods of subsequent analysis.

Quality of irrigation water: The different sodic water were prepared artificially by dissolving required amount of $NaHCO_3$, NaCl, Na_2SO_4, $CaCl_2$ and $MgCl_2$ in base water (control). The tap water (base water) was used for first irrigation in all pots and later on crop was irrigated 6 times with water of varying RSC levels during experimentation as per treatment. The composition of prepared water is given in table 1.

Zinc and Fe enriched FYM: The locally available organics like farmyard manure (FYM) were used for their enrichment with Zn and Fe. The enrichment process was started 60 days before their use in cowpea. The known quantity of organics was filled in the pre-dug pits of 1.5’ x 1.5’ x 1.5’ size. The FYM were thoroughly mixed with the solutions of $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ equivalent to 25 kg Zn per ha and 50 kg Fe per ha, respectively supplied through 500 kg of FYM. The moisture percentage of FYM after mixing maintained around 70% throughout the course of enrichment process. The cow dung slurry @ 1% was applied as a starter inoculum of microorganisms to boost up the microbiological activities for enhancement of natural process of composting to fix the externally added Zn and Fe through zinc sulphate and iron sulphate, respectively. The pit was covered by polythene sheet for natural chelation during the process of composting. The mixture was turned over weekly and moisture loss was compensated during the process of enrichment. The periodical samples were taken from the pit for determination of water soluble Zn and Fe content, when the value of water soluble Zn and Fe appeared to be more or less constant and the enrichment process was considered as complete. It was found that the process was almost completed within 6 to 7 weeks. After enrichment, the required quantity of zinc and Fe enriched FYM @ 250 mg/kg soil was thoroughly mixed in soil before sowing the crop.

As per the crop production guide, the recommended dose of fertilizers (40:20:20 kg N: P_2O_5: K_2O ha^{-1}) were applied as basal in the form of urea, single super phosphate and murate of potash for all the treatments. The Zinc sulphate ($ZnSO_4$) and ferrous sulphate ($FeSO_4$) as Enriched Farm Yard Manure (EFYM) form applied as per the treatment structures. The loamy sand soil was used for pot experiment.

Yield attributes: The total number of nodules per plant was counted at the pre-flowering stage. Two plants randomly selected from each pot were uprooted carefully. The mean value was recorded as total number of nodules per plant. Numbers of effective nodules were counted from same plants as taken for total number of nodules. Healthy pink coloured nodules were counted and mean value was recorded as effective number of nodules per plant. The numbers of nodules were counted from randomly selected two plants from each pot at the time of flowering stage and nodule index (number of nodules per cm. of taproot) was computed by formula (Sandhu *et al.* 1992) [27].

$$\text{Nodule index} = \frac{\text{No. of nodules per plant}}{\text{Length (cm) of tap root}}$$

Ten pods were randomly selected from each pot from previously selected plants and number of seeds per pod was counted and mean value for number of grains per pod was calculated. 100 seeds were counted from seed sample taken from seed yield of each pot separately and weighed on electronic balance. The weight was recorded as seed index of respective treatment.

Statistical analysis: The statistical analysis of the data on the final value of number of total and effective nodules, nodule index, plant height, number of pods per plant, number of seeds per plant, seed index of cowpea and soil analysis for EC, pH, SAR, organic carbon and DTPA-Zn and Fe were done by statistical method of analysis of variance. To compare the treatment difference, the critical difference (CD) at 5 percent level of significance was calculated as per method described by Panse and Sukhatme (1967) [20] wherever 'F' test was found significant.

Results and Discussion

Effect of sodic water: The pH and SAR of soil increased significantly with the increasing level of sodic water. Application of W_4 and W_6 increase in pH was 7.71 and 17.38; SAR was 9.85 and 21 percent under W_4 and W_6, respectively over W_2 (table 2). Increase in pH and SAR of the soil due to use of different sodic water for irrigation is attributed to an increased sodicity and decreased of Ca in irrigation water because of precipitation of Ca and Mg as carbonates providing more opportunity for Na to be adsorbed on the exchange complex. Yadav *et al.* (2007) [36] and Prasad *et al.* (2010) [23] also reported positive correlation between RSC/SAR of water with pH and ESP of soils. The results are in close conformity with that of Yadav and Tomar (1982) [33].
The ECe of soil (table 2) decreased significantly with increasing level of sodicity of irrigation water over control (W_2). The observed decrease in EC due to application of sodic waters may be attributed to the fact that amount of Ca and Mg in the soil solution decreased owing to its precipitation as carbonates and conversion of soluble Na to adsorbed state have decreased the electrolyte concentration in the soil solution and there by decreased the EC of soil. The low degree of observed salinity at higher RSC level is perhaps due to the precipitation of alkaline earth was also reported by Chauhan *et al.* (1988) [8]. The results are in close agreement with the findings of Yadav and Tomar (1982) [33], who also found a decreased in EC with an increase in level of RSC. The application of different sodic water significantly decreased the soil organic carbon, DTPA-Zn and DTPA-Fe content over W_2 (table 2). The lowest organic carbon content (2.15 g/kg) was recorded under W_6 and highest organic carbon content (2.58 g/kg) under W_2. The data further indicate that 7.75 and 16.67 percent decrease in organic carbon content was observed due to W_4 and W_6, respectively over W_2. The W_4 and W_6 decreased the DTPA-Zn content in soil to the extent of 6.20 and 13.63 percent; DTPA-Fe content 5.90 and 17.23 percent over W_2, respectively. This may be explained on the basis that increasing RSC in irrigation water, the SAR and pH of soil also increased accordingly resulting in to decreased availability of plant nutrients in soil but increase the availability of Na. The higher amount of Na may adversely affect the physio-chemical and biochemical properties. Kumawat and Yadav (2013) [13], Jakhar *et al.* (2013) [10] reported that with increasing levels of RSC in irrigation water, the ECe, OC, DTPA-Zn and DTPA-Fe of soil decreased significantly while, pH and ESP of soil increased significantly.
The available nitrogen, phosphorus and potassium in soil after crop harvest significantly decreased with increasing level of soil sodicity (RSC) over control. This may be explained on the basis that increasing RSC in irrigation water, the SAR and pH of soil also increased accordingly resulting in to decreased availability of plant nutrients in soil but increase the availability of Na. The higher amount of Na may adversely affect the physio-chemical and biochemical properties. Kumawat and Yadav (2013) [13], Jakhar *et al.* (2013) [10] reported that with increasing levels of RSC in irrigation water, the ECe, OC, DTPA-Zn and DTPA-Fe of soil decreased significantly while, pH and ESP of soil increased significantly. Magnitude of decrease of phosphorus was more pronounced in Ca dominated soil than that of Na dominated soil because $CaCO_3$ precipitated the phosphorus as calcium phosphate (Minhas and Gupta, 1992) [19].
Level of sodic water were significantly influence the growth parameters of cowpea (Table 3). Growth parameters of cowpea such as plant height, total and effective nodules, nodule index and seed index were significantly decreased with the increasing levels of RSC. The level of sodic water (W_6) were registered significantly lower plant height (22%), total nodules (19.28%), effective nodules (19.71%), nodule index (15.81%), number of pods per plant (44.67%), number of seeds per pod (28.52%) and seed index (26.35%) as compared to normal level of sodic water (W_2) (table 3 and 4). This might be due to inability of the crop to grow under high SAR is due to the toxicity of Na itself and Ca and K frequently becomes as limiting factor for plant growth (Doodhwal *et al.* 2018). Similar results were also reported by Yadav *et al.* 2019. Restricted supply of Ca was reciprocated by a high Na content and was shown to affect the growth of the roots and shoots. Such a reduction in growth under Ca deficiency caused by Na accumulation was attributed to K leakage (Ben-Hauyyim *et al.* 1987) [7].

Effect of Sources of Zn and Fe: The application of zinc enriched FYM (T_3) decreased the pH significantly over control (T_0), $ZnSO_4.7H_2O$ (T_1), $FeSO_4.7H_20$ (T_2) and Fe enriched FYM (T_4) by 13.90, 12.50, 13.19 and 7.06 percent, respectively and SAR over T_0, T_1, T_2 and T_4 by 13.47, 9.07, 10.83 and 7.15 percent, respectively (table2). This may be explained partially by circumstantial evidence that FYM have a better structure and may contain humic acid, growth hormones and high microbial population resulted into increased CO_2 concentration in soil arising from microbial activity and decomposition of native organic matter. The CO_2 in contact with water forms carbonic acid, which reacts with native $CaCO_3$ of soil to bring Ca in soil solution and Ca promotes the release of Na held on exchange complex which reduces pH and SAR of soil. The SAR of soil decreased with the application of Zn enriched FYM also reported by Kumawat and Yadav (2013) [13]. The ECe of soil (table 2) at harvest was influenced significantly with the application of zinc and Fe enriched FYM. The application of zinc enriched FYM (T_3) increased ECe of soil to the extent of 19.74, 7.14, 10.47 and 4.01 percent over control (T_0), $ZnSO_4$. $7H_2O$ (T_1) $FeSO_4$. $7H_20$ (T_2) and Fe enriched FYM (T_4), respectively. The Zn enriched FYM treated pots showed significant decreases in pH and SAR of soil after harvesting, however, ECe of soil was increased significantly. The significant increase in organic carbon and DTPA-Zn content was observed in soil with application of zinc enriched FYM (table 2). The maximum organic carbon (2.87 g/kg) was observed under T_3 (zinc enriched FYM) and minimum (1.97 g/kg) under control. The application of zinc enriched FYM significantly recorded the higher DTPA-Zn content in soil over other treatment, representing an increase of 31.20, 13.73, 21.44 and 7.98 percent over T_0, T_1, T_2 and T_4, respectively. The formation of stable complexes of Zn with phenolic, hydroxyl, carboxylic and amino group rich in organic manure was reported by Tan *et al*., (1971) [30], Yadav and Jha (1988) [34] and these might sustain zinc in liable pool. This may also be ascribed to its high biodegradability which in turn results higher rate of mineralization of native as well as applied Zn in addition to its own Zn content which caused increased available Zn pool of soil (Singh *et al*., 1979). Argument of similar line was given by Ballakki *et al*., (1997), Vasanthi and Kumarswami (1999) [31] and Parihar (2002) [21].The addition of FYM can decrease this antagonism, to some extent, between these elements may by forming complexes with both (Banik *et al.* 2016) [5]. The magnitude of decrease in seed and straw yield of cowpea with increasing level of sodic water was less evident following application of $ZnSO_4$ and FYM. Thus, it is inferred from the present study that seed yield of cowpea can be compensated to some extent by applying Zn and FYM together under irrigation with high sodic water. (Kumawat and Yadav, 2011) [12] and they also reported that application of Zn and FYM significantly increased the soil DTPA-Zn and OC.The application of Iron enriched FYM (T_4) significantly recorded the higher content of DTPA-Fe content in soil over other treatment, representing an increase of 41.69, 30.99, 20.30 and 12.5 percent over T_0, T_1, T_2 and T_3, respectively (table 2). The overall increase in DTPA-Fe under Zn and Fe treatments was mainly due to their addition to the soil either as inorganic source or through their enrichment with FYM. The narrow change in DTPA-Fe after harvest of cowpea might be due to inter conversion of the different Fe fraction in soil to attain equilibrium in the system besides fixation of Fe in the soil. Similar observations were also made by Bar-Ness *et al.* (1991) [6].

The available nitrogen, phosphorus and potassium content in soil after crop harvest increased significantly with the application of zinc enriched FYM. It is perhaps due to addition of organic matter which helps to stimulate the growth and activity of micro-organism. Since FYM is a good source of organic matter and plant nutrients which in turn improve the physical, chemical and biological properties of soil leading to higher production of biomass might have also increased the carbon content of soil (Vasanthi and Kumarswamy, 1999 [31] and Babulkar *et al.*, 2002) [3]. Parihar (2014) [22] reveled that application of fortified vermicompost significantly increased the organic carbon, available N, and S in soil. Similar finding were also observed by Subramnium and Kumarswamy (1989) [28] and Yaduvanshi (2001) [37], Yadav *et al.* (2011) [35] and Kanwar *et al.* (2014) [11].

The application of zinc enriched FYM (T_3) significantly increased the growth parameters such as plant height, total nodules per plant, effective nodules per plant and nodule index and recorded higher 42.02, 16.75, 27.64 and 7.04% of plant height, 37.68, 15.98, 26.74 and 8.11% of total nodules, 47.96, 21.64, 34.88 and 6.81% of effective nodules and 30.59, 17.21, 25.99 and 9.57% of nodule index over T_0, T_1, T_2 and T_4, respectively (table 3). Yield attributes and yields of cowpea significantly influenced by the application of zinc enriched FYM (T_3). The application of zinc enriched FYM (T_3) significantly increased the pods per plant, seeds per pod and seed index as compared to control and registered a significant increase of 44.93, 16.73, 24.02 and 10.43% of pods per plant, 81.26, 33.91, 54.8 and 12.82% seeds per pod and36.55, 14.62, 23.88 and 6.81% seed index over T_0, T_1, T_2 and T_4, respectively (table 4). The application of Zn enriched FYM had a significant effect on effective and total nodules, nodule index, height of plant, pods per plant, seeds per pod and seed index of cowpea. It is evident from results that application of Zn enriched FYM increased the effective and total nodule, nodule index, plant height, number of pods per plant, seeds per pod and seed index over control. It is established fact that FYM improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Thus, balance nutrients under favourable environmental might have helped in production of new tissues and development of new shoots might have ultimately increased the growth and yield attributes. Similar result was also reported by Tak *et al*., (2014). Another probable reason could be efficient and greater partitioning of metabolites and adequate transformation of nutrients of developing plant structures. As results, almost all the yield attributes of crop resulted into significant improvement due to Zn enriched FYM application. These results corroborate the findings of Lakshmi *et al.* (2017) [14], Mahilane *et al.* (2018) [15] who observed significant improvement in growth and yield attributes.

Interactive effect of different sodic water and sources of Zn and Fe on pods per plant: Interactive effect of sodic water, Zn and Fe enriched FYM on pods per plant was found significant (Table 5 and Fig.1). The data revealed that with every level of RSC in irrigation water, the pods per plant increased significantly with an application of zinc enriched FYM (T_3). The maximum pods per plant (9.15) was obtained with combined application of W_2 (control) and T_3 (Zn enriched FYM) while, minimum (2.79) under W_6 (6 mmol L^{-1}) and T_0 (control). Being at par with W_2T_0 combination, the number of pods per plant was recorded higher with W_6T_3 combination indicating that sodicity tolerance in cowpea can be increased to same extent by applying Zn enriched FYM @ 250 mg/kg soil.

Table 1: Composition of irrigation water

RSC mmol L^{-1}	EC (dSm^{-1})	SAR	Ionic composition (mmol L^{-1})						
			Na^+	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
2.0 Base water	1.31	8.2	10.0	1.5	1.5	1.0	4.0	6.5	1.5
4.0	3.14	16.7	26.4	2.5	2.5	2.0	7.0	11.4	11.0
6.0	3.14	16.7	26.4	2.5	2.5	2.0	9.0	10.5	

Table 2: Effect of different sodic water and sources of Zn and Fe on PH_s, EC_e, SAR, organic carbon, DTPA-Zn and DTPA-Fe content in soil at harvest

Treatments	pH_s	ECe (dSm^{-1})	SAR	Organic carbon (g/kg)	DTPA-Zn (mg/kg)	DTPA-Fe (mg/kg)
Sodic water (RSC-mmol/L)						
W_2	7.65	2.86	17.36	2.58	0.532	4.41
W_4	8.24	2.64	19.07	2.38	0.499	4.15
W_6	8.98	2.43	21.00	2.15	0.431	3.65
S.Em+	0.16	0.05	0.36	0.05	0.009	0.08
CD (P= 0.05)	0.45	0.14	1.05	0.13	0.027	0.23
Sources of Zn and Fe						
T_0 (control)	8.70	2.38	20.26	1.97	0.423	3.43
T_1 ($ZnSO.7H_2O$)	8.56	2.66	19.28	2.31	0.488	3.71
T_2 ($FeSO4.7H_2O$	8.64	2.58	19.76	2.07	0.457	4.04
T_3 (Zn enriched FYM)	7.49	2.85	17.53	2.87	0.555	4.32
T_4 (Fe enriched FYM)	8.08	2.74	18.88	2.63	0.514	4.86
S.Em+	0.20	0.06	0.47	0.06	0.012	0.10
CD (P= 0.05)	0.58	0.18	1.35	0.17	0.035	0.29

Table 3: Effect of different sodic water and sources of Zn and Fe on plant height, number of total and effective nodules at 45 DAS and nodule index of cowpea at harvest

Treatments	Plant height at harvest (cm)	Total nodules at 45 DAS	Effective nodules at 45 DAS	Nodule index
Sodic water (RSC-mmol/L)				
W_2	66.85	26.80	21.90	2.76
W_4	61.28	23.70	19.02	2.53
W_6	52.14	18.63	15.27	2.13
S.Em+	1.15	0.44	0.36	0.05
CD (P= 0.05)	3.32	1.27	1.04	0.14
Sources of Zn and Fe				
T_0 (control)	49.44	19.45	15.16	2.19
T_1 ($ZnSO.7H_2O$)	60.15	23.09	18.44	2.44
T_2 ($FeSO4.7H_2O$	55.02	21.13	16.63	2.27
T_3 (Zn enriched FYM)	70.23	26.78	22.43	2.86
T_4 (Fe enriched FYM)	65.61	24.77	21.00	2.61
S.Em+	1.49	0.57	0.47	0.06
CD (P= 0.05)	4.28	1.64	1.34	0.18

Table 4: Effect of different sodic water and sources of Zn and Fe on number of pods per plant, number of seeds per pod and seed index of cowpea

Treatments	Number of pods per plant	Number of seeds per pod	Seed index (g)
Sodic water (RSC-mmol/L)			
W_2	7.41	6.80	7.06
W_4	6.50	6.13	6.55
W_6	4.10	4.86	5.20
S.Em+	0.12	0.12	0.12
CD (P= 0.05)	0.34	0.34	0.35
Sources of Zn and Fe			
T_0 (control)	4.08	4.27	5.28
T_1 ($ZnSO.7H_2O$)	6.17	5.78	6.29
T_2 ($FeSO4.7H_2O$	5.63	5.00	5.82
T_3 (Zn enriched FYM)	7.41	7.74	7.21
T_4 (Fe enriched FYM)	6.71	6.86	6.75
S.Em+	0.15	0.15	0.16
CD (P= 0.05)	0.44	0.44	0.45

Table 5: Interactive effect of sodic water and sources of Zn and Fe on number of pods per plant

Treatment	T_0	T_1	T_2	T_3	T_4
W_2	5.04	7.62	6.95	9.15	8.28
W_4	4.42	6.68	6.10	8.02	7.27
W_6	2.79	4.21	3.85	5.06	4.58
	S.Em+	0.26			
	CD (P=0.05)	0.76			

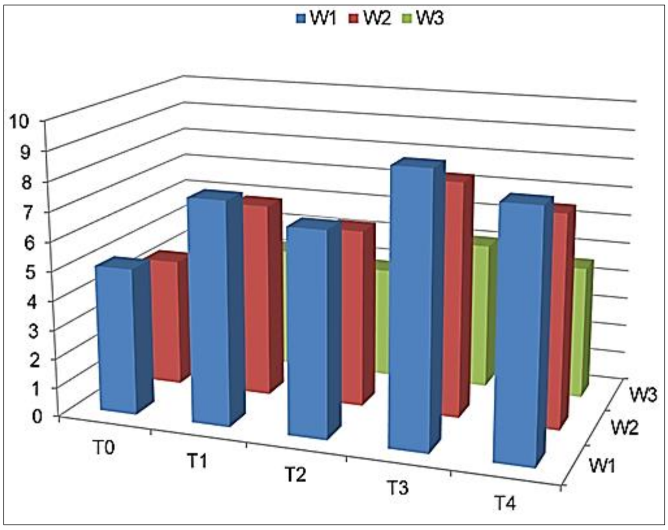

Fig 1: Interactive effect of RSC water and Sources of Zn and Fe on number of pods per plant

Conclusion

Overall results of the study indicated that the micronutrients application in enriched form of FYM was beneficial in increasing crop yields. The beneficial effect of enriched Zn and Fe was clearly noticed over straight Zn and Fe application in cowpea. Also, the micronutrients fertilizer use efficiency was found enhanced as the lower rate i.e. FYM at 500 kg ha^{-1} along with Zn and Fe enriched at 25 kg $ZnSO_4$. $7H_2O$ and 50 kg $FeSO_4$. $7H_2O$ ha^{-1} was sufficient to meet Zn and Fe requirement of cowpea when applied in enriched form. The practice of micronutrient application through enrichment technique improved the available nutrients status of soil and yield of cowpea.

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