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Impact of Nutrient Management on Soil Chemical Properties and Maize (*Zea mays* L.) Yield

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study in relation to "Impact of nutrient management on soil chemical properties and Maize (*Zea mays* L.) yield" was conducted during the year 2021-22 at Vizianagaram district of Andhra Pradesh. Application of optimal doses of inorganic and organic fertilizers to maize at 5 t FYM ha^{-1} yearly containing 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} with highest maize yield of 65.00 q ha^{-1} as compared to the farmers lower yield of 47 q ha^{-1} without the optimum dose of inorganic and organic fertilizers to maize. Soils of the study area were acidic to neutral in soil reaction, non-saline and non-calcareous in nature, low in organic carbon in both surface and sub-surface layers.

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1. INTRODUCTION

In any agricultural operations, soil is the utmost importance as it is the cradle for all crops and plants. There are non re-renewable resources, formed at the rate of 1 in. every 250-1200 years [1]. To make agriculturally productive, it may takes another 3000-12000 years [2]. Hence, it is important to keep healthy and productive soil to continue our soil to function optimally to increase agriculture production with appropriate soil amendment and crop management practices [3].

Maize is one of the most versatile emerging crops having wider adaptability under agro-climatic conditions. Globally maize is known as the queen of cereals because it has the highest genetic yield potential among the cereals. Maize is the third most important food crop after rice and wheat. Maize in India contributes nearly 9 % in the national food basket.

Raw, yellow, sweet maize kernels are composed of 76% water, 19% carbohydrates, 3% protein and 1% fat. They are a good source of B vitamins, thiamin, niacin, pantothenic acid and folate. In moderate amounts, they supply fibre and essential minerals, magnesium and phosphorous. Maize has optimal amounts of the essential amino acids tryptophan and lysine.

Intensive cultivation, growing of exhaustive crops, use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures resulting to decline in crop response to recommended doses of fertilizers and deterioration of soil physical, chemical and biological properties ultimately responsible for reduction in soil fertility and productivity [4]. Hence, the present study was undertaken to examine the soils of maize growing area of Vizianagaram district in terms of physico-chemical properties and maize yield.

2. MATERIALS AND METHODS

The study in relation to “Impact of nutrient management on soil chemical properties and yield of Maize (*Zea mays* L.)” was conducted during the year 2021-22 at Vizianagaram district of Andhra Pradesh. Six villages were selected and from each village 5 farmers were selected and from each farmer’s field both surface (0-20 cm) and sub-surface (20-40 cm) soils were collected randomly. The information regarding cultivation practices were collected from the state agricultural department, personal survey and discussion with selected farmers of the region. The information regarding inorganic and organic fertilizer being used for cultivation of maize were also collected from the farmers who were continuously cultivating maize in kharif were selected for this study. The materials and methods adopted for this study were given below:

Soil reaction (pH) was determined by using glass electrode pH meter using 1:2.5 soil-water ratio as described by Jackson [5]. Electrical Conductivity (EC) was estimated by using electro conductivity meter according to method described by Jackson [5]. Organic Carbon (OC) was estimated by Walkley and Black chromic acid titration method [6] while calcium carbonate was estimated by rapid titration method as described by Piper [7].

3. RESULTS AND DISCUSSION

3.1 Soil Reaction (pH)

Soil pH or soil reaction is an important estimation for soils which determines the magnitude of the acidity and alkalinity and directly influences the agricultural productivity. The pH value reflects the integrated effect of the acid base reactions taking place in the soil system [8].

The pH of the surface and sub-surface soil of study area varies with a mean of 6.26 and 6.49 respectively. This shows that the soils of the study area with a range of 4.68-7.18 were acidic to neutral in nature. The highest surface pH (7.18) was observed in Ramalingapuram where, FYM of 5 t $ha^{-1}$was applied along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. The lowest surface pH value of 4.68 was recorded for Yadika sample where only inorganic fertilizers were applied.

The highest sub-surface pH (7.46) was obtained for Ramalingapuram soils where, organic fertilizers @ 5 t ha^{-1} and 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} were applied. The lowest sub-surface pH value of 5.09 was obtained.

The acidic reaction of the soils might be due to the acidic nature of the parent materials, topography and also the continuous use of acid producing fertilizers like urea and ammonium sulphate on the soils.

Table 1. Chemical properties of soil (pH and EC)

Villages	Sample No	Nutrients applied		pH		EC (dS m^{-1})	
		Organic (t ha^{-1})	Inorganic N:P:K:Zn (kg ha^{-1})	Surface (0-20 cm)	Sub-surface (20-40 cm)	Surface (0-20 cm)	Sub-surface (20-40 cm)
Viswanadhapuram	1	3.0 (once in 3 years)	126:50:38	6.19	6.27	0.26	0.29
	2	-	138:58:53	5.34	5.69	0.31	0.38
	3	-	110:35:38	5.27	5.74	0.22	0.27
	4	3.0	132:50:38:9.9	6.94	6.98	0.27	0.30
	5	1.0	133:46:45	6.80	7.10	0.29	0.32
Ramalingapuram	6	5.0	126:58:45:17	7.18	7.46	0.23	0.27
	7	-	147:67:47:15	5.82	6.09	0.33	0.39
	8	1.0	115:58:38	6.84	6.91	0.22	0.26
	9	2.0	133:46:45:12	6.99	7.04	0.24	0.28
	10	-	110:46:30:5	5.32	5.57	0.18	0.21
Yadika	11	-	108:50:30	4.68	5.09	0.11	0.13
	12	1.0	115:58:38:5	6.73	6.85	0.14	0.17
	13	3.0	126:58:45:15	6.95	7.10	0.24	0.27
	14	-	110:46:38	5.64	5.69	0.30	0.34
	15	2.5	126:58:45:12	6.94	7.05	0.26	0.29
Korlam	16	-	110:46:38	4.80	5.72	0.06	0.09
	17	5.0 (once in 3years)	120:63:38:12	6.89	6.97	0.24	0.28
	18	1.5	133:46:45:9.9	6.91	6.98	0.26	0.29
	19	1.0	129:55:45:6.6	6.64	6.76	0.25	0.28
	20	-	138:58:53:12	5.62	5.96	0.33	0.39
Mandiravalasa	21	-	147:67:47:17	6.16	6.54	0.35	0.38
	22	1.0	110:46:38	6.63	6.69	0.26	0.29
	23	5.0 (once in 2 years)	126:50:38:13	7.10	7.23	0.28	0.34
	24	-	138:58:53	5.35	5.73	0.31	0.35
	25	-	144:58:23:5	5.57	5.84	0.34	0.38
Vedulavalasa	26	2.5	131:45:45:15	6.83	7.29	0.3	0.38
	27	4.0	129:55:45:17	7.12	7.30	0.24	0.28
	28	2.0	147:67:47:12	6.96	7.15	0.33	0.37
	29	-	115:58:23:8.3	5.89	6.25	0.31	0.36
	30	-	142:69:45:17	5.65	5.84	0.31	0.34

Table 1 revealed that pH of the soils showed increase in soil pH with depth, which could be due to continuous crop uptake of basic cations or through leaching losses of basic cations to depths beyond the reach of crop roots as well as the release of organic acids during decomposition of organic matter.

Similar acidic reaction trend was observed in red sandy loam soils of Vizianagaram district, Andhra Pradesh, India by Jamuna et al. (2008) and by Sathishbabu et al. [9] and Mydhili [10] in the coastal soils of Guntur district.

3.2 Electrical Conductivity (dS m^{-1})

Electrical conductivity (EC) is the measure of the soluble salts present in the soil and is affected by cropping sequence, irrigation, land use and application of fertilizers, manures and compost [11]. Table 1 showed that the EC of the soils ranged from 0.06-0.35 and 0.09-0.39 at the surface and sub-surface layers respectively.

The highest value of EC at surface layer of 0.35 dS m^{-1} was observed in the soils of Vedulavalasa where only inorganic fertilizer was applied @ 147:67:47 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. The lowest EC (0.06 dS m^{-1}) for the surface soil layer was obtained for Korlam soil where 110:46:38 NPK kg ha^{-1} inorganic fertilizer was applied.

After harvest of maize, the highest value of EC (0.39 dS m^{-1}) for the sub-surface soils was recorded for soil of Korlam while the lowest value (0.09 dS m^{-1}) was Korlam soils.

The lower soil EC in maize growing soils was due to free drainage conditions, which favoured the removal of removal bases by percolating and drainage water [12]. Similar findings were made by Jayaramrao [13] in soils of Srikakulam, Andhra Pradesh and Himabindu [14] in soils of north coastal region of Andhra Pradesh.

3.3 Organic Carbon (g kg^{-1})

Organic matter makes the soil a living dynamic system that supports all life in planet. It supplies plant nutrients, improves soil structure, water infiltration, retention, soil micro flora and fauna and enhances the retention and cycling of applied fertilizer [15]. Maintenance and improvement of soil quality in continuous cropping systems is critical to sustaining agricultural productivity and environmental quality for future generations.

Texture and Organic matter are inherent properties of soil and crops, as well as indicators of soil health, which affects the availability of some macro and micronutrients in the soil [16].

Table 2 showed that OC of soils of the studied area ranged from 0.81 – 6.07 g kg^{-1} and was low to medium in value.

The organic carbon in surface layer was highest in Ramalingapuram soils with 6.07 g kg^{-1} where, FYM (5 t ha^{-1}) was applied along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. This was followed with 5.85 g kg^{-1} in the soil of Vedulavalasa. The lowest value (1.54 g kg^{-1}) was obtained in Yadika where, FYM was not applied but only inorganic fertilizers were used. The organic carbon in the sub-surface layer was highest in Ramalingapuram (4.98 g kg^{-1}) when, FYM was applied at 5 t ha^{-1} along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} while the lowest value (0.81 g kg^{-1}) was found in Yadika.

Table 2 showed that the soil OC decrease with soil depth. The values were relatively higher in surface layers than subsurface layers in samples. This was attributed to the application of the farmyard manure and the addition of the cropped plant residues to surface layers which resulted in higher organic carbon content in surface soil compared to the sub surface soil which was in trend to the reports by Malavath and Mani [17].

The warm climatic conditions of the studied location would have caused rapid decomposition of soil organic materials which could have resulted to the lower soil organic carbon contents recorded. Similar results were reported by Ashokkumar and Jagadish Prasad [18] while Niranjan et al. [19] reported low organic carbon content in banana growing soils of Pulivendula and sugarcane growing soils of Ahmednagar respectively due to the semi-arid condition.

3.4 Calcium Carbonate (%)

The calcium carbonate denotes the presence of calcareousness in soils. The results of the studied areas showed that, the calcium carbonate in top soil and sub soil levels ranged from 0.09 - 0.78 and 0.15 – 0.92% with mean value of 0.30 and 0.39% respectively. The extent of spatial distribution of calcium in Table 2 showed that 100% of the soils contained free calcium content while less than 1.0% indicate that soils were non-calcareous.

Table 2. Chemical properties of soil (OC and $CaCO_3$)

Villages	Sample No	Nutrients applied		OC (g kg^{-1})		$CaCO_3$ (%)	
		Organic (t ha^{-1})	Inorganic N:P:K:Zn (kg ha^{-1})	Surface (0-20 cm)	Sub-surface (20-40 cm)	Surface (0-20 cm)	Sub-surface (20-40 cm)
Viswanadhapuram	1	3.0 (once in 3 years)	126:50:38	4.93	2.96	0.23	0.35
	2	-	138:58:53	2.92	1.86	0.09	0.15
	3	-	110:35:38	2.95	2.02	0.11	0.15
	4	3.0	132:50:38:9.9	5.43	4.86	0.50	0.57
	5	1.0	133:46:45	3.39	2.17	0.46	0.52
Ramalingapuram	6	5.0	126:58:45:17	6.07	4.98	0.78	0.92
	7	-	147:67:47:15	3.14	2.92	0.24	0.42
	8	1.0	115:58:38	4.62	2.68	0.13	0.32
	9	2.0	133:46:45:12	5.03	3.85	0.29	0.52
	10	-	110:46:30:5	2.76	1.81	0.16	0.29
Yadika	11	-	108:50:30	1.54	0.81	0.13	0.19
	12	1.0	115:58:38:5	4.10	3.13	0.25	0.42
	13	3.0	126:58:45:15	5.36	3.97	0.75	0.91
	14	-	110:46:38	2.80	2.11	0.15	0.21
	15	2.5	126:58:45:12	5.12	3.38	0.34	0.37
Korlam	16	-	110:46:38	2.59	1.83	0.15	0.22
	17	5.0 (once in 3years)	120:63:38:12	4.28	3.93	0.25	0.29
	18	1.5	133:46:45:9.9	4.92	3.25	0.46	0.52
	19	1.0	129:55:45:6.6	4.54	3.31	0.35	0.43
	20	-	138:58:53:12	3.18	2.66	0.25	0.29
Mandiravalasa	21	-	147:67:47:17	3.86	3.27	0.42	0.48
	22	1.0	110:46:38	4.60	2.89	0.18	0.24
	23	5.0 (once in 2 years)	126:50:38:13	5.32	3.61	0.21	0.27
	24	-	138:58:53	3.14	1.91	0.12	0.18
	25	-	144:58:23:5	3.21	2.36	0.13	0.28
Vedulavalasa	26	2.5	131:45:45:15	5.30	3.32	0.38	0.42
	27	4.0	129:55:45:17	5.85	4.53	0.76	0.84
	28	2.0	147:67:47:12	5.30	3.87	0.40	0.51
	29	-	115:58:23:8.3	3.28	2.86	0.12	0.18
	30	-	142:69:45:17	3.92	2.77	0.20	0.26

The calciuim content followed increasing trend with soil depth which was attributed due to the leaching of nutrients from upper layer during rainy season and the subsequent precipitation of the Ca as carbonate in the subsoil layers. Similar results were reported by Maji et al. [20] as well as Jegan and Subramanian [21] for soils of Sivagangi block of Tamil Nadu.

3.5 Yield of Maize

From Table 3, it can be interfered that the farmers who are applying inorganic fertilizers along with FYM and Zn for maize would get better yield compared with the farmers who applied only inorganic fertilizer.

The highest grain yield of maize (65.00 q ha^{-1}) was recorded for Ramalinapuram soils where, FYM at 5 t ha^{-1} was applied along with 126:58:45 NPK and 17 kg Zn ha^{-1} and the lowest yield (47.00 q ha^{-1}) was recorded for Yadika where FYM was not applied but only inorganic fertilizers at 108:50:30 NPK kg ha^{-1}were applied.

The variation in yield might be due to the differences in amount of fertilizers given to the crop with or without organic fertilizers and Zn in different doses which has an impact on grain yield of maize [22].

Similar results were observed by Raskar et al. [23] and Reddy et al. [24]. A combined application of nitrogen and zinc obtained higher grain yield of maize.

Singh et al. [25] studied the effect of nitrogen and zinc on growth and yield of maize and concluded that higher grain yields (66 q ha^{-1}) were obtained when applied nitrogen at 150 kg ha^{-1} and zinc at 30 kg ha^{-1} [26].

Table 3. Technical survey of the farmers

Sample No.	Farmer's location	Nutrients applied		Yield of Maize (q ha^{-1})
		Organic (t ha^{-1})	Inorganic N:P:K:Zn (kg ha^{-1})	
Viswanadhapuram				
1	Farmer 1	3.0 (once in 3 years)	126:50:38	58.40
2	Farmer 2	-	138:58:53	52.70
3	Farmer 3	-	110:35:38	50.90
4	Farmer 4	3.0	132:50:38:9.9	62.50
5	Farmer 5	1.0	133:46:45	56.40
Ramalingapuram				
6	Farmer 6	5.0	126:58:45:17	65.00
7	Farmer 7	-	147:67:47:15	60.30
8	Farmer 8	1.0	115:58:38	56.84
9	Farmer 9	2.0	133:46:45:12	62.30
10	Farmer 10	-	110:46:30:5	56.60
Yadika				
11	Farmer 11	-	108:50:30	47.00
12	Farmer 12	1.0	115:58:38:5	58.63
13	Farmer 13	3.0	126:58:45:15	63.25
14	Farmer 14	-	110:46:38	51.30
15	Farmer 15	2.5	126:58:45:12	61.80
Korlam				
16	Farmer 16	-	110:46:38	50.60
17	Farmer 17	5.0 (once in 3years)	120:63:38:12	60.20
18	Farmer 18	1.5	133:46:45:9.9	61.90
19	Farmer 19	1.0	129:55:45:6.6	60.80
20	Farmer 20	-	138:58:53:12	57.53
Mandiavalasa				
21	Farmer 21	-	147:67:47:17	60.12
22	Farmer 22	1.0	110:46:38	51.40
23	Farmer 23	5.0 (once in 2 years)	126:50:38:13	63.46
24	Farmer 24	-	138:58:53	53.80
25	Farmer 25	-	144:58:23:5	58.75
Vedulavalasa				
26	Farmer 26	2.5	131:45:45:15	63.19

Sample No.	Farmer's location	Nutrients applied		Yield of Maize (q ha^{-1})
		Organic (t ha^{-1})	Inorganic N:P:K:Zn (kg ha^{-1})	
27	Farmer 27	4.0	129:55:45:17	64.00
28	Farmer 28	2.0	147:67:47:12	60.80
29	Farmer 29	-	115:58:23:8.3	54.70
30	Farmer 30	-	142:69:45:17	58.40

4. CONCLUSION

The study revealed that the soils were acidic to neutral in reaction, non-saline and non-calcareous while, the soil organic carbon content was low at both surface and sub-surface layers. However, the application of macro nutrients along with zinc in inorganic forms in combination with organic manures significantly increased the grain yield of maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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