Original Research Article

Impact of nutrient management on soil chemical properties and yield of maize (*Zea mays* L.)

Abstract

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. An application of optimum doses of inorganic and organic fertilizers to maize, i.e., 5 t FYM ha^{-1} every year with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} the yield of maize was found highest (65.00 q ha^{-1}) as compared to the farmers who are not providing 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.

Keywords: Inorganic, Organic, fertilizers, Nutrient, FYM, NPK, Soil and Organic carbon

1. Introduction

Soil is the "soul" of infinite life and is generally refer to the loose material composed of weathered rock and other materials including partly decayed organic matter. It is a reservoir of nutrients and plays a pivotal role in supporting the growth of crops and other vegetation maintaining the earth's environment clean. It also acts as a source and sink for atmospheric gases.

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 (USDA Nutrient database). In moderate amounts, they supply fibre and essential minerals, magnesium and phosphorous. Maize has optimal amounts of the essential amino acids tryptophan and lysine which accounts for its lower status as protein source.

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

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) were collected randomizely. The information regarding cultivation practices were collected from state agricultural department, personal survey and discussion with selected farmers of the region. The information regarding inorganic and organic fertilizer added for cultivation of maize were also collected from the farmers who are continuously cultivating maize in kharif were selected for study. The materials and methods adopted for the present investigation are presented below:

Determination of Chemical properties of soil

Soil reaction (pH): It was determined by using glass electrode pH meter using 1:2.5 soil-water ratios as described by Jackson (1973).

Electrical Conductivity (EC): It was estimated by using electro conductivity meter Jackson (1973).

Organic Carbon (OC): Organic carbon was estimated by Walkley and Black chromic acid titration method (1934) and expressed in grams per kg.

Calcium Carbonate: The calcium carbonate was estimated by rapid titration method as described by Piper (1966).

3. Results and discussion

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 (Mokolbate and Haynes, 2002).

The study revealed that, pH of surface and sub-surface soil of study area varies from and with a mean of 6.26 and 6.49 respectively. This shows that the soils of the study area were acidic to neutral in nature. The highest surface pH (7.18) was observed in the village at Ramalingapuram noticed in sample no. 6 where, FYM (5 t ha^{-1}) is added along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. The lowest surface pH value 4.68 was recorded in the village at Yadika in sample no. 11 where only inorganic fertilizers were applied.

The highest sub-surface pH (7.46) was observed in sample no. 6 at Ramalingapuram village where, organic fertilizers @ 5 t ha^{-1} and 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} were added. The lowest sub-surface pH value is observed in sample no. 11 of 5.09.

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

The data presented in the table 1 revealed that pH of the soils showed an increasing trend in the soil with depth. Increasing trend in the soil pH with depth, which could be due to continuous removal of basic cations by crop plants or by leaching of basic cations to deeper layers along with percolating water as well as release of organic acids in surface layers during decomposition of organic matter.

Similar acidic reaction was observed in red sandy loam soils of Vizianagaram district, Andhra Pradesh, India by Jamuna *et al*. (2008). Similar soil reaction with depth was observed by Satish Babu *et al*. (2010) and Mydhili (2006) in the coastal soils of Guntur district.

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 (Singh *et al*. 2016). The data shown in the table 1 revealed that the EC of the studied soils ranged from 0.06-0.35 and 0.09-0.39 at surface and sub-surface layers respectively.

The highest value of EC at surface layer of soil was 0.35 dS m^{-1} observed in the village Vedulavalasa noticed in sample no. 21 where FYM was not added only inorganic fertilizer is applied @ 147:67:47 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. The lowest value of EC (0.06 dS m^{-1}) in surface layer is observed in sample no. 16 of village Korlam where 110:46:38 NPK kg ha^{-1} inorganic fertilizer was applied.

After harvest of crop, the highest value of EC (0.39 dS m^{-1}) at sub-surface layer was found in sample no. 20 in village Korlam and lowest value (0.09 dS m^{-1}) in sample no. 16 of village Korlam.

The lower soil EC in maize growing soils was due to excess leaching of salts and due to free drainage conditions, which favoured the removal of removal bases by percolating and drainage water (Siva Jyothi *et al*. 2017). Similar findings were made by Jayaramarao (2012) in soils of Srikakulam, Andhra Pradesh and Himabindu (2018) in soils of north coastal region of Andhra Pradesh.

Table No. 1. Chemical properties of soil (pH and EC)

Name of village	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	6.98	6.94	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

Organic carbon (g kg^{-1})

Organic matter makes the soil a living dynamic system that support 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 (Johnston, 2007). 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 (Coblinski *et al.* 2021).

The data present in table 2 revealed that the OC of soils of all soils in the study area were ranged between 0.81 – 6.07 g kg^{-1} which are low to medium in range.

The organic carbon in surface layer is highest in sample no. 6 with 6.07 g kg^{-1} where, FYM (5 t ha^{-1}) added along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} followed by sample no. 27 (5.85 g kg^{-1}). The lowest value (1.54 g kg^{-1}) was observed in sample no. 11 where, FYM is not added and only inorganic fertilizers were used. The organic carbon in the sub-surface layer is highest in sample no. 6 (4.98 g kg^{-1}) where, FYM was added @ 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 sample no. 11.

Data from the table 2 showed that OC values were found to be decreasing with soil depth. The organic carbon content was relatively higher in surface layers than subsurface layers in all samples and it decreased with depth. This was attributed due to the addition of farmyard manure and plant residues to surface layers which resulted in higher organic carbon content in surface horizons than that of lower horizons (Malavath and Mani, 2008).

Warm climatic conditions of the study area causes rapid decomposition of organic matter resulting in the low organic carbon content. Similar results were recorded by Ashokkumar and Jagadish Prasad (2010) and Niranjan *et al*. (2011) also reported existence of low organic carbon content in banana growing soils of Pulivendula and sugarcane growing soils of Ahmednagar respectively due to semi-arid condition.

Calcium carbonate (%)

The calcium carbonate denotes the presence of calcareousness in soils. The results of selected area revealed that, the calcium carbonate in surface and sub-surface soils were ranged between 0.09 - 0.78 and 0.15 – 0.92 per cent with the mean value of 0.30 and 0.39 per cent respectively. The extent of spatial distribution of calcium carbonate is shown in table 2. Results showed that 100 per cent of the soils contained free calcium carbonate content less than 1 per cent indicating that soils are non-calcareous.

The CaCO3 content followed increasing trend with soil depth. The increase in CaCO3 content down the depth was attributed due to leaching of bicarbonate from upper layer during rainy season and their subsequent precipitation as carbonate in lower layers. Similar results were reported by Maji *et al.* (2005) and Jegan and Subramanian (2006) in soils of Sivagangi block of Tamil Nadu.

Yield of Maize

From the data (table no. 3) it can be interfered that the farmers who are applying inorganic fertilizers along with FYM and Zn for maize has got better yield than the farmers who are applying only inorganic fertilizer.

The highest grain yield of maize (65.00 q ha^{-1}) was recorded in sample no. 6 at Ramalinapuram village where, FYM 5 t ha^{-1} applied with 126:58:45 NPK and 17 kg Zn ha^{-1} and the lowest (47.00 q ha^{-1}) was recorded in sample no. 11 at village Yadika where FYM is not applied and inorganic fertilizers were applied @ 108:50:30 NPK kg ha^{-1}.

The variation in yield obtained is because of differences in doses of NPK nutrient with or without FYM and Zn in different amount which has an impact on grain yield of maize. In agricultural system, soil and crop management decisions are affecting soil quality, soil nutrient dynamics, and soil chemical properties. These management decisions include crop rotation, residue management and cropping system which influences soil chemical properties and yield (Mikha *et al*. 2005).

Table No. 2 Chemical properties of soil (OC and $CaCO_3$)

Name of village	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

Similar results were observed by Raskar *et al*. (2012) and Reddy *et al*. (2019). A combined application of nitrogen and zinc obtained higher grain yield of maize than compared to other treatments.

Singh *et al*. (2021) 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 treated with nitrogen @ 150 kg ha^{-1} and zinc @ 30 kg ha^{-1}.

Table no 3: Technical survey of the farmers

Sample No.	Name of farmer	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
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

From the above results, we conclude that soils were acidic to neutral in reaction, non-saline and non-calcareous in nature and organic carbon was low in both surface and sub-surface layers. Application of macro nutrients along with zinc in combination with organic materials increased the grain yield of maize.

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