Original Research Article

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

Abstract

The study in relation to "Impacts of nutrient management on soil chemical properties and ~~yield of~~ Maize (*Zea mays* L.) yield" was conducted during the year 2021-22 at Vizianagaram district of Andhra Pradesh. ~~An a~~Application of optimal~~um~~ doses of inorganic and organic fertilizers to maize~~, i.e.,~~ at 5 t FYM ha^{-1} yearly ~~every year with~~ containing126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1} ~~the yield of~~ with highest maize ~~was found highest of (~~65.00 q ha^{-1}~~) as~~ compared to the farmers lower yield of ….[?] ~~who are not providing the~~ without the optimum ~~dose of~~ inorganic and organic fertilizers application om ~~to~~ their maize farms. Soils of the study area were acidic to neutral in soil reaction but the use of the FYM resulted to…., non-saline and non-calcareous in nature, low in organic carbon in both surface and sub-surface layers and the soils becomes …..after application of FYM.

Keywords: Inorganic, ~~Organic, fertilizers~~ Fertilizers, FYM, ~~Nutrient, FYM,~~ NPK, nutrient, organic, ~~S~~soil ~~and O~~organic carbon

1. Introduction

Soil is the "soul" of infinite life and it ~~is~~ generally refers to the loose materials composed of weathered rock ~~and other~~ materials including partly decayed and decayed organic matter. It is a reservoir of nutrients and plays a pivotal role in supporting the growth of crops and other vegetation plants, as well as, maintain~~sing~~ the earth~~'s~~ environment clean up. ~~It also acts~~ as major ~~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~~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 ~~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) soils were collected random~~ize~~ly. 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 ~~added~~ for cultivation of maize were also collected from the farmers who we~~a~~re continuously cultivat~~e~~ing maize in kharif were selected for this study. The materials and methods adopted for thi~~s~~e ~~present investigation~~ study we~~a~~re as given ~~presented~~ below:

Comment [DI1]: What is the maize yield on famers farm without the use of optimum fertilizer rate?

Comment [DI2]: What was the soil reaction after use of FYM?

Comment [DI3]: What were the influence of the FYM upon its usage on the soil?

Comment [DI4]: Authority

Comment [DI5]: Authority?

Comment [DI6]: Year of citation?

Comment [DI7]: Authority?

Comment [DI8]: No Authority?

Comment [DI9]: This is not in line with the title of your work

Comment [DI10]: (1)What did you do with soils collected in those location (2) there was no mentioning maize in your methodology

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). The

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

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

While the C=calcium Ccarbonate: 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).

Comment [DI11]: This should be part on introduction

The study revealed that, pH of the 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 with a range of 4,68-7.18 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 of (5 t ha^{-1}) iwas added 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 forin the village at Yadika in sample no. 11 where only inorganic fertilizers were applied.

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

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.

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

Comment [DI12]: Any Authority?

Similar acidic reaction trend was observed in for the red sandy loam soils of Vizianagaram district, Andhra Pradesh, India by Jamuna *et al.* (2008) and by . 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 showed that the EC of the studied soils ranged from 0.06-0.35 and 0.09-0.39 at the surface and sub-surface layers respectively.

Comment [DI13]: This should be in the introduction section

The highest value of EC at surface layer of soil was 0.35 dS m^{-1} was observed in the soils of village Vedulavalasa noticed in sample no. 21 where FYM was not added only inorganic fertilizer is was 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 for the surface soil layer is obtained observed in sample no. 16 of village for Korlam soil 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~~ for the sub-surface soils~~layer~~ was recorded for ~~found in sample no. 20 in village~~ Korlam ~~and~~ while the lowest value (0.09 dS m^{-1}) was ~~in sample no. 16 of village~~ Korlam soils.

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.

Comment [DI14]: Which crop, did you plant any crop? It does not reflect in your materials and methods

Comment [DI15]: How? Why not attribute it to the fact that maize is a high nutrient demanding crop and excess nutrients must have been removed by the cropped maize plants

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

~~Name of v~~Villages or Locations	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~~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 (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).

T~~he data present in t~~able 2 showed~~revealed~~ that ~~the~~ OC of soils of ~~all soils in~~ the studied~~y~~ area ~~were~~ ranged from ~~between~~ 0.81 – 6.07 g kg^{-1} ~~which are~~ and was low to medium in value~~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}) was applied~~added~~ along with 126:58:45 NPK kg ha^{-1} and 17 kg Zn ha^{-1}. This was followed by sample no. 27 with ~~(~~5.85 g kg^{-1}~~)~~. The lowest value (1.54 g kg^{-1}) was obtained ~~observed~~ in sample no. 11 where, FYM wa~~i~~s not applied~~added and~~ but only inorganic fertilizers were used. The organic carbon in the sub-surface layer ~~is~~ was highest in sample no. 6 (4.98 g kg^{-1}) when~~re~~, FYM was applied~~added~~ 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 sample no. 11.

~~Data from the t~~Table 2 indicated~~showed~~ that the soil OC ~~values were found to be~~ decreased~~ing~~ with soil depth. The values were~~organic carbon content was~~ relatively higher for ~~in~~ the top soil ~~surface layers than~~ compared to subsoil ~~subsurface layers in all~~ samples ~~and it decreased with depth~~. This was attributed ~~due~~ to the application ~~addition~~ 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~~horizons~~ compared to the subsurface ~~than that of lower horizons~~ soil which was in trend to the reports by ~~(~~Malavath and Mani, ~~(~~2008).

The ~~W~~warm climatic conditions of the studied~~y area~~ locations would have caused~~s~~ rapid decomposition of soil organic matterials which could have resulteding ~~into~~ the lower soil organic carbon contents recorded. Similar results were reported ~~recorded~~ by Ashokkumar and Jagadish Prasad (2010), while ~~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 the semi-arid condition.

Calcium carbonate (%)

The calcium carbonate denotes the presence of calcareousness in soils. The results of the studied ~~selected~~ areas showed~~revealed~~ that, the calcium carbonate in top soil~~surface~~ and sub-soil~~surface~~ ~~soils~~levels ~~were~~ ranged from~~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~~ (T~~t~~able 2~~)~~. ~~Results~~ showed that 100~~% per cent~~ of the soils contained free calcium ~~carbonate~~ content while less than 1.0~~% per cent~~ indicated~~ing~~ that soils ~~a~~were non-calcareous.

The Ca~~CO3~~ content followed increasing trend with soil depth, which~~. The increase in CaCO3 content down the depth~~ was attributed ~~due~~ to the leaching of nutrients ~~bicarbonate~~ from upper layer during rainy season and the~~ir~~ subsequent precipitation of the Ca as carbonate in the subsoil ~~lower~~ layers. Similar results were reported by Maji *et al.* (2005) as well as~~and~~ Jegan and Subramanian (2006) ~~in~~for soils of Sivagangi block of Tamil Nadu.

Yield of Maize

From ~~the data (~~tTable no. 3~~)~~, it can be interfered that the farmers who are applying inorganic fertilizers along with FYM and Zn for maize would get~~has got~~ better yield compared with~~than~~ the farmers who ~~are~~ applyed~~ing~~ only inorganic fertilizer.

The highest grain yield of maize (65.00 q ha^{-1}) was recorded in ~~sample no. 6 at~~ for Ramalinapuram soils ~~village~~ 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 ~~in sample no. 11 at~~ for ~~village~~ Yadika where FYM wa~~i~~s not applied ~~and~~ but only inorganic fertilizers at ~~were applied @~~ 108:50:30 NPK kg ha^{-1}.

Comment [DI16]: Should be part of introduction

Comment [DI17]: Give location name

Comment [DI18]: Give location name

Comment [DI19]: Give location name

Comment [DI20]: Give name of location

Comment [DI21]: Give name of location

Comment [DI22]: Introduction material

Comment [DI23]: Calccium

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).

Comment [DI24]: Recast the statement for clarity.

Comment [DI25]: This does not relates to the oints being discussed

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

~~Name of v~~Villages of Locations	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.

Comment [DI26]: What are the 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 appliedtreated with nitrogen at@ 150 kg ha^{-1} and zinc at@ 30 kg ha^{-1}.

Table no 3: Technical survey of the farmers

Sample No.	Name of fFarmers' 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
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 revealedFrom the above results, we conclude that the soils were acidic to neutral in reaction, non-saline and non-calcareous in nature and while, the soil organic carbon content was low atin both the surface and sub-surface layers. However, the Aapplication of macro nutrients along with zinc in inorganic forms in combination with organic manuresmaterials significantly increased the grain yield of maize.

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