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Both Inorganic and Organic Manures Impact Maize and its Long-Term Consequences on the Physical and Chemical Qualities of the Soil

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Abstract

Organic and artificial fertilizers are essential for soil health and crop yield. The current study looked at how both organic and inorganic manures affected maize over the long term as well as the physio-chemical makeup of the soil. Urea, Di-Ammonium Phosphate (DAP), and Sulphate of Potash (SOP) are employed per inorganic fertilizer sources. Moreover, Sheep Manure (SM), poultry manure (PM), as well as farm manure (FYM) were used as sources of organic fertilizer. The treatments were as follows: U_1: an unfertilized control; 〖U〗 $_2$: NPK at 260-260-240 kg ha-1; U_3: S.M. at 20 t. The findings presented that the application based on inorganic manures greatly improved maize development at harvest, whether used alone or combined with organic manures.On the other hand, the soil's overall biological C, N, P, and K content rose. The link between soil pH, bulk density, and grain yield reduced when organic fertilizer was applied, but the latter two variables also dropped. The product of maize grains and the amounts of accessible N, P, and K in the soil were also positively correlated (R_2= 0.52, 0.91, and 0.55 correspondingly). In conclusion, combining inorganic fertilizers with organic manures at reasonable rates can increase crop productivity over the long term. This work will help create long-term nutrient management techniques to boost crop output while maximizing efficiency.

Keywords: Di-Ammonium Phosphate (DAP), Soil Characteristics, manures (DAP), Poultry Manure (PM).

Full length article **Corresponding Author*, e-mail:pooja.tak@vgu.ac.in

1. Introduction

Since it improves soil fertility and plant quality, applying organic and inorganic fertilizers has long been a beneficial agricultural practice. According to this study, organic and inorganic fertilizers are critical for plant growth. Both fertilizers give plants the nutrients they need for healthy growth. While chemically manufactured inorganic fertilizers were only widely established during the economic revolution, organic fertilizers have been used for millennia. Owing to the usage of artificial nitrogen fertilizers, which consume significantly expanded food production worldwide, about half of the world's population is now nourished. Due to the high price and limited obtainability of inorganic fertilizer, farmers may need to use more of it to promote healthy maize growth [1]. Fertilizers are typically added to the soil to improve or maintain crop yields to fulfill the rising demand for food. Because plants produce more biomass when inorganic fertilizers are applied, the dirt accumulates more Soil Organic Matter (SOM) and is more biologically active. Other sources of organic matter that get recycled into the soil include decomposing roots, trash, and crop residue. A crucial determinant of soil quality and crop output, Soil Organic Carbon (SOC) is increased by SOM addition [2]. For instance, using organic manures and inorganic fertilizers frequently leads to improved nutrient cycling, increased SOM, soil structure, Cation Exchange Capacity (CEC), and raised organic motion. Chemical fertilizers are an essential part of improving agricultural production. Still, a firm reliance on them can result in long-term declines in many soil properties and crop yields, as well as severe issues with the land, like soil degradation. Hence, combining inorganic fertilizers and organic manures uses efficient nutrients that improve chemical fertilizers' effectiveness and decrease nutrient losses [3]. Important soil indicators, including SOM, P.H. value, and seeding food, are impacted by the biological, physical, and chemical processes occurring in the soil, exposing fundamental and dynamic soil characteristics. Organic Matter (O.M.), one of the soil components that can be easily accessed, is crucial because it is a storage place for nutrients and water. Organic sources are the foundation for increasing the quantity of O.M. in the soil. Finding the greatest substantial O.M. on the market is crucial, either as replacements or as a supplement to the appropriate number of inorganic fertilizers. Integrating various nutrients involves mixing all available sources of nutrients and applying them to soils to promote crop growth along with the high yield of high-quality products. Since maize is a heavy feeder, it has a high nutritional need. The control of its nutrient content determines the productivity of maize [4]. One of the areas of fertilizer application research that has had the most activity recently is the mixture based on inorganic and organic manures. Yet conducting total nitrogen and deep SOM research is rare. The study observed that long-term fertilization treatments affected the deep soil organic matter (O.M.) in addition to total nitrogen (N) in winter wheat-summer maize fields using the long-term positioning test platform of the lysimeters [5]. The paper [6] accepted as a potential strategy for attaining sustainable agriculture to Partially Substitute Chemical fertilizers with Organic fertilizers (PSCFOF). The impact of grain production and PSCFOF, Water Use Efficiency (WUE), and financial returning seasonal maize. The paper [7] examined the impacts of various methods for incorporating organic fertilizer on agricultural output, a rotational crop of maize (Zea mays) from fluvo-aquic soils, and wildlife feeding activities on a wheat plant (Triticum aestivum). The effects of long-term dairy manure and organic fertilisers (INF) on soil carbon (C) and nitrogen (N) fractions, enzyme activities, and microbial community structure in various time horizons at planting (P), one month after planting (1MAP), and after harvesting were examined under corn (Zea mays L.) and soybean (Glycine max L.) rotation (H) [8]. The paper [9] used shotgun metagenomics as an impact of applying compost influence of manure and inorganic fertilizer on various microbial species communities in the maize rhizosphere (Zea mays everta). In the paper [10], straws and manure from farms were both evaluated for their effects on soil properties and crop yields. under semi-arid conditions in a crop rotation system. Different chemical, biological, and physical characteristics of the soil were identified during the experiment. The paper [11] used field tests and DeNitrification-DeComposition (DNDC) model simulations to assess the long-term impacts of transitioning from synthetic fertilizers to organic manure on crop production and N2O emission. The paper [12] optimized fertilization in sustaining high crop output and increasing Nitrogen (N) usage efficiency is unknown; however, as are effects throughout time on soil organic matter (C) and inorganic nitrogen dynamics. The paper [13] investigated the impact on calcareous soil's physical, chemical, and microbiological characteristics during long-term LCM fertilization. Long-term applications of fluid calf manure (LCM) can improve soil quality and characteristics while increasing the availability of nutrients and organic carbon.. In a maize-wheat cropping system, we tried to ascertain the effects of various tillage and organic fertilizer regimes on the makeup of the bacterial community and soil carbon fractions, as suggested [14]. The paper [15] combined the impacts of biochar and fertilizer on the deficit irrigation-related factors of maize growth, yield, Crop Water Use Efficiency (CWUE), and Irrigation Water Use Efficiency (IWUE) [10].

2. Materials and methods

2.1 Site details and remedies

The experiment was carried out in Indian Agronomic Research Farm. The experiment was conducted three times (RCBD) using a Randomized Full Block Design. The total plot area was eight by 6.4 meters, with a population density of 65000 plants per hectare, and each plot had six rows with a spacing of 75 and 20 centimeters, respectively.

In contrast to urea, organic fertilizer sources included Di-ammonium Phosphate (DAP), Sulfate Of Potash (SOP), Farm Yard Manure (FYM), Poultry Manure (PM), and Sheep Manure (S.M.). Random models proceeding from sheep manures, FYM, and PM were taken after the substances were ground, sieved, and air-dried to test for dry matter, a total of Organic Carbon (O.C.), Nitrogen (N), Phosphorus (P), Potassium (K), and the C: N ratio. Table 1 lists the organic manures utilized in the experiment according to their content. In this experiment, the following treatments were employed:

U_8 : NPK by 200-70-45 + 8 t ha^{-1} PM 3.3

U_7: NPK appeared in 200-70-45+ 7.5 t ha^{-1}FYM

U_6: NPK on 200-70-45 + 7 tha^{-1} SM

U_5: PM in 18t ha^{-1}

U_4: FYM for 21t ha^{-1}

U_3: S.M. placed on 20t ha^{-1}

U_2 : 500-300-250 kgha^{-1} NPK

U_1: No-fertilization controller

2.2Determine soil properties

The physicochemical properties of the soil in Table 2, soil samples were gathered from various sites around the experimental area. To assess the soil's bulk density, organic carbon content, pH, overall K, N, P contents, and cation exchange capacity, the soil was pulverized, air-dried, and at that time, approved through a 2-mm screen.

Table 1. Composition of the experiment's organic manures

Nutrients source	Total O.C. (%)	C: N	D.M. (%)	Total N (%)	Total P (%)	Total K (%)
PM	18.3	15	66.2	1.35	0.42	0.71
FYM	22.1	21	77.4	1.77	0.64	1.08
SM	18.5	19	74.3	1.55	0.44	0.98

Table 2. Physico-chemical properties of the soil before experiment

Chemical analysis		**Particle size analysis**	
Soli characteristics	Value	Soli characteristics	Value
Saturation percentage	36.9	Silt	21.47
Total organic carbon	0.77	Sand	55.09
C: N	12.8	Clay	26.44
pH	8.8	Textural class	Sandy clay loamy soil
Bulk Density	1.49 g cm^{-3}		
Total nitrogen (N)	0.08%		
Total available potassium (K)	185.2ppm		
Total available phosphorous (P)	15.2 ppm		

Table 3: Impact of organic and inorganic manures on harvest index, LAI, grain weight, and biological and grain yield

Treatments	Leaf Area Index	1000-grain weight (g)	Grain yield (t ha^{-1}	Biological yield ha^{-1}	Harvest index (%)
U_1	3.92 ± 0.08 f				
U_2	6.24 ± 0.011 c	197.4 ± 0.48 d	7.55 ± 0.12 d	12.73 ± 0.03 d	55 ± 0.02 bc
	(33.75)	(15.02)	(85.92)	(62.03)	(15.71)
U_3	6.02 ± 0.04 d	188.7 ± 0.42 e	6.85 ± 0.04 f	11.14 ± 0.02 d	55 ± 0.02 ab
	(27.81)	(10.65)	(70.55)	(42.75)	(19)
	4.77 ± 0.04 e	182.1 ± 0.25 f	6.11 ± 1.13 g	12.94 ± 0.02 e	55 ± 0.01 bc
U_4	5.74 ± 0.22 e	182.0 ± 0.22 f	6.11 ± 0.12 g	11.81 ± 0.02 c	53 ± 0.01 bc
	(20.92)	(6.51)	(51.33)	(39.45)	(9.98)
U_5	5.93 ± 0.01 de	191.4 ± 0.34 e	7.14 ± 0.04 e	11.91 ± 0.04 b	55 ± 0.02 ab
	(25.33)	(12.20)	(75.82)	(52.14)	(15.63)
U_6	5.51 ± 0.14 b	220.7 ± 0.52 b	8.21 ± 0.01 b	13.51 ± 0.81 b	55 ± 0.03 a
	(41.55)	(28.91)	(104.95)	(63.43)	(25.21)
U_7	5.42 ± 0.03 b	$2.14.0 \pm 1.75$ c	8.22 ± 0.03 c	14.11 ± 0.11 ab	55 ± 0.01 ab
	(37.27)	(25.91)	(98.81)	(65.07)	(20.33)
U_8	5.93 ± 0.01 de	191.4 ± 0.34 e	7.14 ± 0.04 e	11.91 ± 0.04 b	55 ± 0.02 ab
	(48.85)	(35.62)	(108.44)	(71.55)	(22.15)
LSD (p<0.05)	0.17	3.09	0.14	0.77	1.91

2.3 Growth and yield

To calculate the Leaf Area Index (LAI), leaf samples were collected 15 days before harvest and quantified using the following formula: LAI = L ×W ×A, where W stands the maximum Leaf, Width, L stays the Leaf Length, and A remains a feature of 1.15 for the maize crop designated in this section. In table 3, only the highest values of LAI are shown. Each plot's grain and biological yields were also noted at crop maturity. The total plant dry biomass to grain yield ratio, expressed as a percentage (%), was ultimately established as the Harvest Index (H.I.).

2.4 Data analysis

The differences between treatments in the dataset were distinguished using the Least Significant Difference (LSD) test at $p < 0.05$ following statistical analysis using the statistics 8.1 programs. Significantly (p<0.05; averages of three replicates plus standard error). Values indicate percentage increases over control in parentheses. NPK at 200-70-45 + 7 t ha^{-1} SM; NPK at 200-70-40 + 9 t

ha^{-1}FYM; NPK at 200-70-45 + 5 t ha^{-1}PM; U_1: Unfertilized control; U_2NPK by 200-70-350 kilogram ha^{-1}; U_3: SM on 20 t ha^{-1}; U_4: FYM appearing in 20t ha^{-1}; U_5: PM on 21 t ha^{-1}. Sheep Manure (S.M.), Farm Yard Manure (FYM), and Poultry Manure (PM).

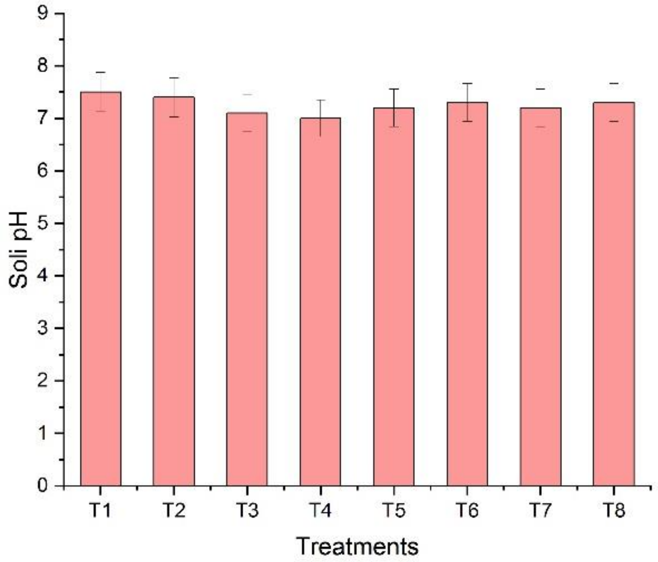
3. Results and Discussions

The growth and yield are substantially impacted by the organic and inorganic nutrition sources characteristics of maize, as shown in Table 3. Maximum Leaf Area Index (LAI), maize production, and biological output were achieved when chemical fertilizer and Poultry Manure (PM) were used. Consequently, T6 has the most significant harvest index values. The lowest values for maize growth and yield characteristics were found in the unfertilized controlled plots. Hence, applying organic and inorganic nutrients together increased maize performance more than using organic or inorganic fertilizers separately. PM, however, continued to be more effective than FYM and S.M. in maize growth and yield. According to the results, she was applying both organic and inorganic fertilizers that substantially impacted the soil's pH, P, total organic C, and total nitrogen.

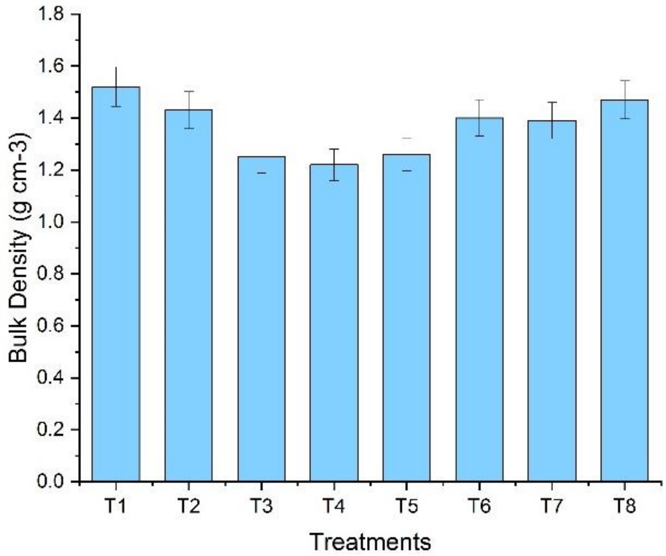
Applying either organic or inorganic manures lowered the pH of the soil. The control area's soil had a pH of 7.5. (a little alkaline), while the lowest value pH of 7.0 was found in treatment areas T_4, T_3, T_5, and T_7 when organic manures were present and had been treated alone, as shown in Figure 1a. Soil pH was decreased by adding organic manures, regardless of their composition. Compared to the control, were significant variations density of bulk in soil between treatments. Following those plots where fertilizers were used, organic and inorganic were all actions treated with organic manures alone, which exhibited a significant fall density of bulk in soil. Control treatments had the highest bulk density, whereas the lowest was observed in T_4, comparable to T_2 and T_5, as shown in Figure 1b. The soil's $C{:}\,N$ ratio was dramatically impacted by applying both organic and inorganic manures, as shown in Figure 1c. The C: N ratio was lower when organic and inorganic manures were used together than when organic manure was applied alone. The C: N ratio trend in organic manures was: S.M.>FYM>PM. The diminished C/N ratio measurements as PM demonstrate her more significance comparing N contents to FYM and S.M.

When organic and inorganic fertilizers were applied, there was a noticeable difference between the treatments in total nitrogen concentrations and soil organic carbon. As shown in Figures 2a and 2b, the total N concentration and overall soil organic carbon have grown due to using organic manure either separately or in combination with fertilizer application. Organic manure-only comparison to treatments T4 and T3, T4 and T5 enhanced soil organic carbon. Although less successful, other treatments also increased soil organic carbon. Furthermore, T3 with sheep manure application recorded a maximum N content of 0.09%, except for T2 and T1, which statistically did not differ from other treatments. Using chemical fertilizers and organic amendments significantly enhanced the soil's P and K conditions. Both T6 and T3 increased soil K levels considerably compared to the control, and T2 was shown to be better regarding soil P contents. As a result, S.M. performed better than FYM and PM when used with chemical fertilizers; however, the effectiveness is dose-dependent. However, as shown in Figures 2c and 2d, all three manures enhanced the soil's nutrient status compared to the control. To support the idea that manures work more effectively with organic manures. The quantity of maize grain produced was highly associated with soil properties that were changed by adding organic and inorganic manures. Grain production and soil total N, P, and K concentrations were shown to be positively correlated (R2 = 0.52, 0.92, and 0.54, respectively), the C: N ratio, Soil Organic Carbon (SOC), and cereal yield were positively correlated but not significantly so. In addition, Figure 3 shows a negative and non-significant association between soil bulk density, pH, and maize grain yield.

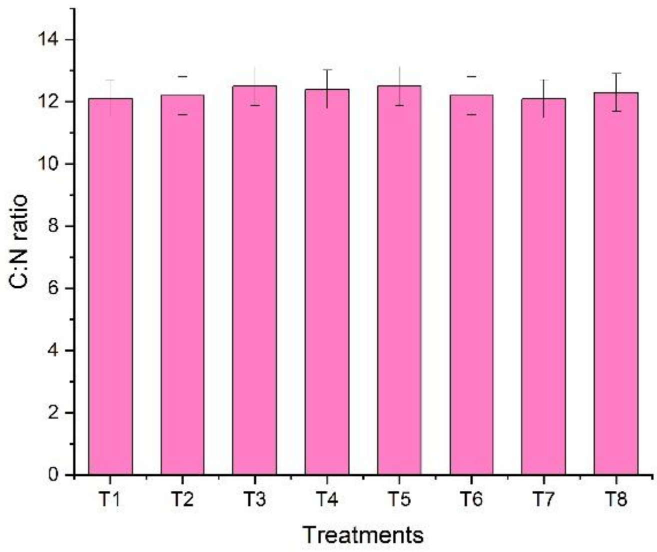
Intense cultivation and heavy reliance on chemical fertilizers undoubtedly enhanced crop yield, but they also significantly degraded the quality of the soil and water and altered agroecosystems. Hence it is possible to increase agricultural output with improved management methods, such as carefully applying fertilizers and certain organic manures while causing little to no environmental harm. Impacts of organic and inorganic manures, individually and together, on soil properties, including maize productivity. They discovered such applying maize growth, yield, and quality were improved by organic and inorganic nutrition sources associated factors, as shown in Table 1. Combining organic manures may have improved the efficiency with which nitrogen was used, recovered micro- and macronutrients, assisted in the solubilization of P and its absorption by plants, and increased K availability, all of which contributed to more excellent maize production and growth. Increased organic matter from using organic manures enhanced soil characteristics and crop performance. Applying organic and inorganic fertilizers is a suitable alternative to improve nutrient recovery for plant growth, including final production; otherwise, increased N and P treatment rates are necessary for growing maize production.



(a)

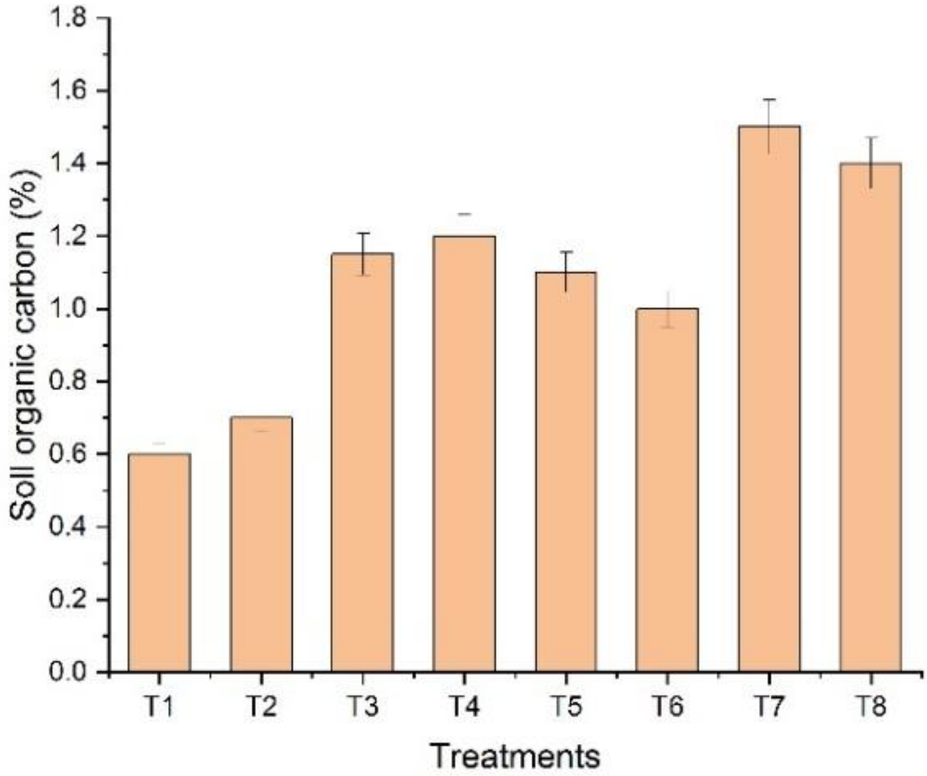


(b)

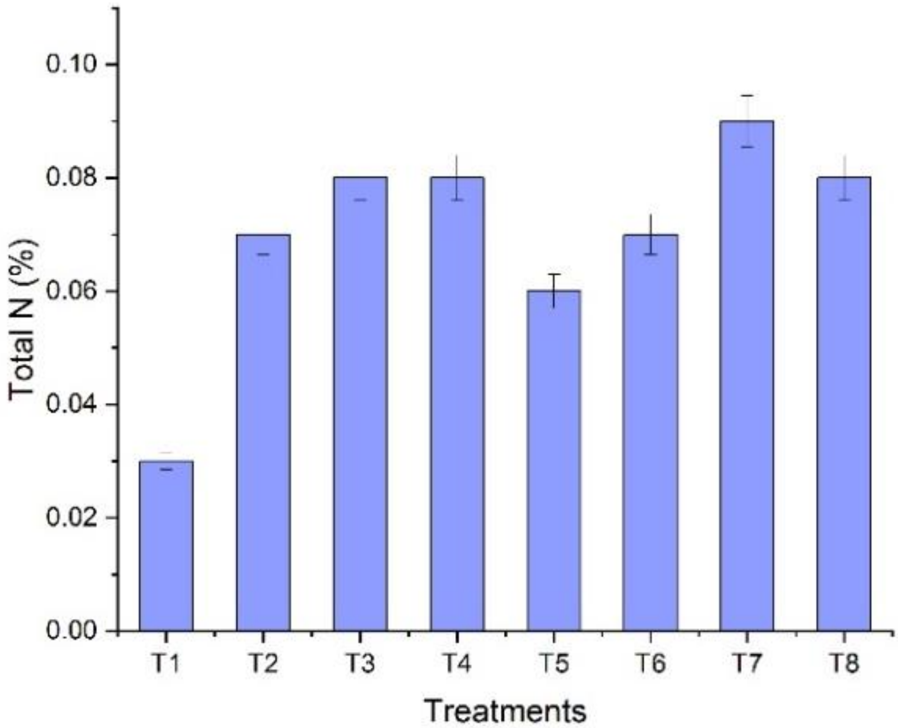


(c)

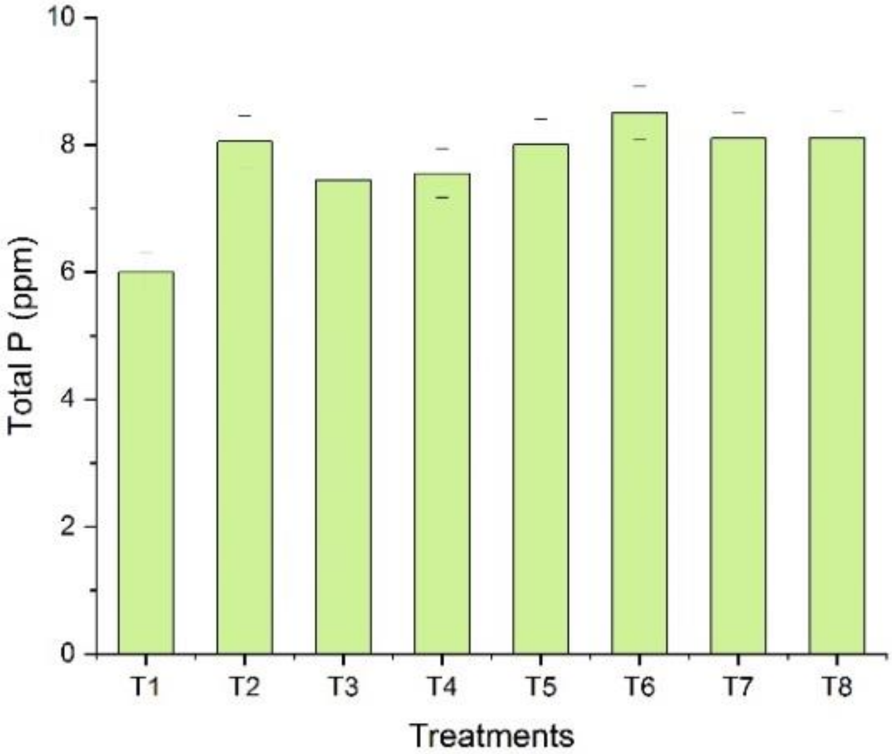
Figure 1. Organic and inorganic manures' residual effects on **(a)** pH of soil, **(b)** Density bulk, **(c)** C:N ratio after harvesting a crop


Soil organic carbon (%)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
T1
T2
T3
T4
T5
T6
T7
T8
Treatments

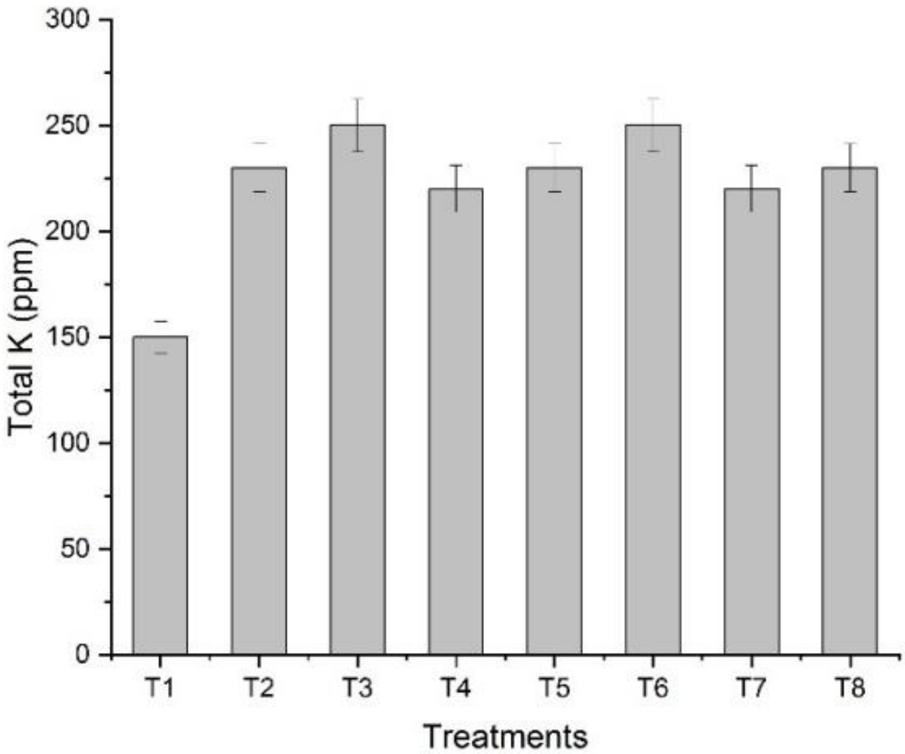
(a)


Total N (%)
0.10
0.08
0.06
0.04
0.02
0.00
T1
T2
T3
T4
T5
T6
T7
T8
Treatments

(b)

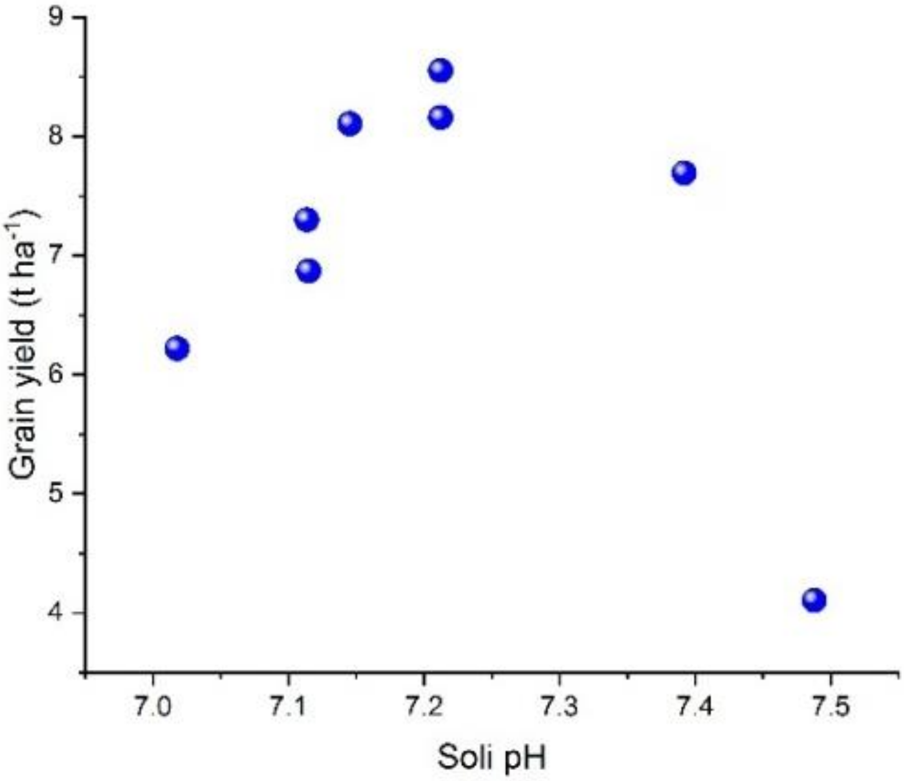


(c)



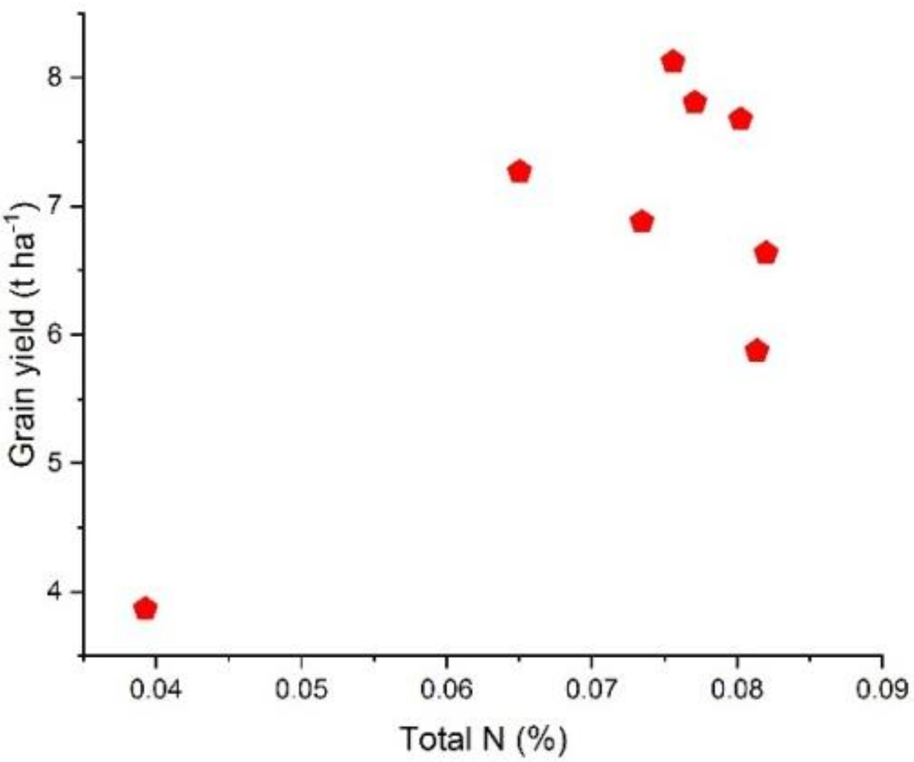
(d)

Figure 2. Organic and inorganic manures' residual effects on **(a)** Organic carbon in soil (%), **(b)** Total N (%), **(c)** Total P (ppm), (d) Post-crop harvest total K (ppm)



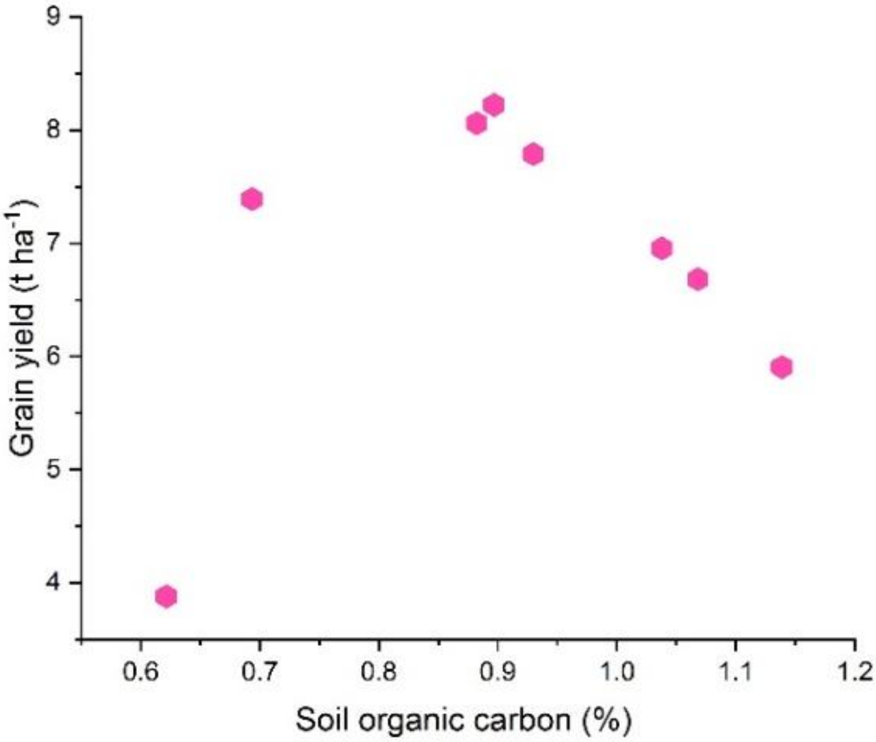
Grain yield (t ha-1)
9
8
7
6
5
4
7.0
7.1
7.2
7.3
7.4
7.5
Soli pH

(a)

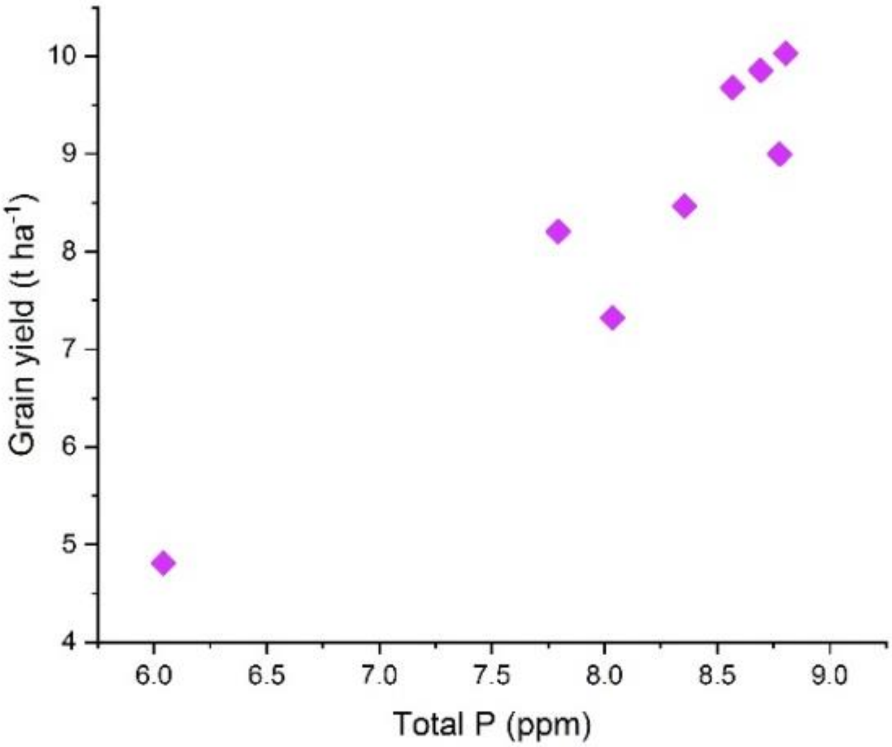


Grain yield (t ha-1)
8
7
6
5
4
0.04
0.05
0.06
0.07
0.08
0.09
Total N (%)

(b)



(c)



(d)

Figure 3. Relationship between soil properties impacted by inorganic and organic fertiliser sources and maize grain yield; *Significant atp<=0.05 ; **Significant at p<=0.01

These findings also demonstrate that inorganic and organic fertilizers boosted maize production by 36%. They observed comparable outcomes with enhanced cotton and maize growth and yield-related characteristics. Improved nutrient release and plant recovery coordination and synergy were achieved by combining organic and inorganic nutrient sources, which enhanced crop growth and production. Also, plants receiving poultry manure used nitrogen more effectively than plants receiving additional organic manure sources, such as ammonium sulphate, pig, sheep, and cow manure. There was no statistically significant difference in rice production across all plots, whether organic, inorganic, or a mix of both manures was used. Also, the use of organic manures and inorganic fertilizers produced changes in the physicochemical characteristics of the soil, as shown in Figures 1a–c and 2a–d. Regardless of their composition, organic manures reduce soil pH. Similar research has shown that adding pH reduces when alkaline soils apply green or farmyard manure. On calcareous soils, minimal pH value FYM is highly beneficial. Reduced bulk density may also result from enhanced soil bio pores, and applications of large organic manures lead to better soil aggregation, aeration, and soil organic carbon content, increasing water-holding capacity and soil porosity.The higher nitrogen availability brought on by adding chemical fertilizer alongside organic manures and their retention in the soil may be the source of decreased C: N ratios in soils treated with a mixture of organic and inorganic manures. According to this argument, organic manure decomposition occurs at lower rates of N loss than C loss. Organic additions greatly improved SOC and, therefore, significantly impacted soil microorganisms, availability, and absorption of nutrients, which can change a $C: N$ proportion. The priming effect is a phenomenon wherein adding a foreign high $C: N$ ratio in biological materials might also result in fast mineralization of the organic materials already present, releasing nitrogen in the current organic matter. Regardless of the manures employed, the surface soil organic carbon increase was likely caused by increasing the surface layer with root exudates, plant and root biomass, and plant residues.

Regarding soil's condition, inorganic and organic fertilizers enhanced plant growth and production while significantly raising a soil's NPK concentrations, confirming increased efficient use of nutrients when organic manures are present. Organic additions combined with a lower dosage of chemical fertilizers may have stimulated nutrient availability and increased microbial activity more than unfertilized control and chemical fertilizer treatment alone, respectively. Applying organic alterations increased soil N, P, and K concentrations when inorganic fertilizers are utilized. Organic manure significantly improves soil quality, enhancing nutrient release and plant availability compared to inorganic fertilizers. The significant relationships between grain productivity and soil NPK status, and soil nutrients directly affect grain yield and its components. These findings represent conclusive evidence that organic manures enhance soil physicochemical characteristics, which may directly or indirectly impact plant development and production parameters.

4. Conclusions

In general, the use of organic fertilizers has a significant impact on the soil's physicochemical characteristics as well as the yield of maize. The fertilizer was effective in terms of the structural parameters of maize as PM, S.M., and FYM after being used in conjunction with chemical fertilizers. The C: N ratio, soil O.C., and overall N, P, and K were augmented by the function of organic fertilizers with chemical fertilizer, while soil pH and bulk density decreased. So, on arable soils with low amounts of organic carbon, organic fertilizers could be mixed with chemical fertilizers to enhance soil characteristics for crop output.

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