A Study on the Physical, Chemical, Biological, and Molecular Characteristics of Coastal Saline Soils under a Rice-Based Cropping System

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Abstract:

Carbon (C) dynamics and soil biology are affected by the varying salinity present in coastal agro-ecosystems, which decreases from the coast in landward. The research's goal is to look at coastal saline soils through the lens of a rice-based cropping system from a physical, chemical, biological, and molecular standpoint.

Keywords: *Soil, Coastal saline, Characteristics, Cropping system.*

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Introduction:

In India, 7.3 million hectares (Mha) are covered by soils negatively impacted by salt. This ecosystem's low production may be traced back to the unfavourable agro-climatic conditions that prevail there. Abiotic stressors like as salt, acidity, waterlogging, and a sandy texture are common in coastal soils. Most of the coastal regions, especially in the deltas, have problematic soils such salty, alkaline, acid sulphate, marshy, and waterlogged soils. The low productivity of around 3.1 million acres of farmland is mostly attributable to the high coastal saline.

Salinity in salt-affected soils is caused by three main processes: direct sea water intrusion, indirect sea water intrusion via estuaries, and upward transport of salt from shallow water table. When salt water floods into fields during the monsoons, it retreats over the winter and summer, leaving behind a salt residue that rises and accumulates owing to evaporation and wind. These soils are characterised by the unusual coexistence of salt and acidity.

Crop productivity is severely hampered by the high salinity of these soils. Alterations in soil structure and physical processes, such as the circulation of water and air and the amount of water that may be stored in the soil, are brought on by salinity (Oster and Jaywardane, 1998). The osmotic and matric potential and microbiological activity are also impacted by this (Reitz and Haynes, 2003; Sardinha et al., 2003). This slows down the pace at which organic matter decomposes and releases nutrients, which in turn stunts plant development. Salinity has a negative effect on the structure of the microbial population in soil, as well as on their activities and the activities of their enzymes (Reitz and Haynes, 2003; Vijayakumar et al., 2013). Saline soil resources and their potentials in various Agro-ecological Sub Regions (AESR) of India were disclosed by Velayutham et al., (1999). As the first scientific method for defining coastal soils, it reveals that 10.78 million hectares of India (including the islands) fall within this ecosystem.

Characteristics of coastal saline soils and their formation

The salinity condition of coastal saline soil dramatically changes from ECe 0.5dSm-1 during the monsoon to 50 dSm-1 during the summer/dry month. Most soluble salts are NaCl and Na2SO4, with the quantity of soluble cations going as follows: Na > Mg > Ca > K. The anion concentration is mostly chloride, with little bicarbonate present. Sodicity is uncommon in India's soils, with the exception of few areas in the south and west. A saline soil has a pH below 8.5, an ESP below 15, and a high concentration of salts such sodium chloride and calcium sulphate.

Clay loam, with varying amounts of silt and sand, is typical of coastal saline soils, as noted by Bandyopadhyay et al., (1987). Sodium is the most abundant element in these salts, and its electrical conductivity varies from 0.5 to 9.2 dSm-1. According to Biswas et al. (1990), coastal saline soils often include a very salty shallow subsurface groundwater table, with saline water gradually rising over the summer and contributing to soil salinity via evaporation in the dry season. Deltas, estuaries, and coastal fringes in the humid tropics have a significant challenge in agricultural productivity due to salinity. It poses a significant barrier to the cultivation of rice under irrigation (Ponnamperuma, 1972). Soil salinity changes with the seasons. From January to May, it is at its highest, and then it drops down when the monsoon season begins (Bandyopadhyay and Bandyopadhyay, 1984). Because of the recurring cycles of salt buildup and flooding, rice is mostly grown in these areas. Coastal soils in the Bhavnagar district of Gujarat have been reported to have significant salinity (EC 1.09 to 17.8 dS m -1), however contrary to the findings of the current study, Rajput and Polara (2012) found that the soils in this area had a higher pH (neutral to alkaline, i.e. 7.0 to 8.9). According to Mahajan et al. (2015), the soil accessible nitrogen (N), phosphorus (P), and potassium (K) in Goa's coastal saline soils ranged from low to medium to high. DTPA extractable micronutrients (Fe, Mn, Zn, and Cu) and hot water soluble B was all present in enough amounts in the soils.

Seasonally high salt concentration in the root zone of the soil is the primary barrier to intensifying agricultural output in coastal settings. Towards the end of the dry (winter) season, when the downstream flow of fresh water is at its lowest, the salts reach the land via rivers and channels. The river water becomes more salty at this time. Flooding by salty river water or seepage from the rivers introduces the salts into the soil, and then evaporation concentrates the salts at the soil's surface. Increased salinity in the ground water from the salty river water might render it unusable for irrigation. When it comes to coastal saline oils, the situation is further compounded by the entrance of salty sea water via the soil and the wind.

Methodology

The current investigation included the following three experiments.

Coastal soils properties: Seasonal dynamics

The best regression fits were graphically displayed for relationships between soil microbiological and biochemical parameters and soil salinity (ECe) using linear, power, quadratic, and polynomial functions. Pearson's product moment correlation coefficient was used in Microsoft Excel to find significant associations between variables. We analysed soil parameter data that was duplicated three times using STATISTICA 6.0 (Stat Soft Inc., USA). Two treatment elements that were taken into account were season and soil. There were three tiers of the season factor: monsoon, summer, and winter. Based on its features and past treatment, the soil was classified into nine distinct categories. Analysis of variance (ANOVA) was performed using a split plot design, with season serving as the main plot variable and soil serving as the subplot variable. To determine whether or not there were statistically significant differences between the various treatments, we used the least significant difference (LSD) test at the 5% significance level.

Long-term field experiment on fertilizer application to coastal soil

In order to examine the impact of inorganic fertilisers on soil physico-chemical, microbiological, and biochemical characteristics and the yield ofrice, a long-term field experiment that has been running since 1979 and is overseen by CSSRJ, RRS, Canning Town, West Bengal was chosen for this analysis.

Integrated nutrient management under rice-chilli cropping system

A further ten grammes of soil were collected in a beaker with a volume of fifty millilitres, and this sample was put into a vacuum desiccator along with a vial of ten grammes of soda lime and some moistened tissue paper. Inside the desiccator was a beaker with some boiling chips and 25 mL of ethanol-free chloroform. After waiting for the chloroform to boil for 2 minutes, the desiccator was emptied. After that, we left the desiccator at 25 degrees Celsius for a whole day. After fumigation, the desiccator's beaker holding the chloroform was removed and the chemical was flushed out using six separate 2-minute evacuations spaced by a 3-minute interval. The soil was then extracted with 0.5 (M) K_2SO_4 in a 250 mL conical flask, same as was done with the untreated soil. Carbon was estimated using the extract, using Vance et al.'s (1987) methodology.

Results and Discussion

Coastal soils Properties: Seasonal dynamics

The MBC concentrations and ECe values of the soil samples were shown to be exponentially related (Figure 1). The ECe explained around 53% of the MBC's volatility. This study's findings corroborated those from previous research on naturally occurring saline soil (Mallouhi and

Jacquin, 1985; Ragab, 1993; Garcia et al., 1994) showing a negative correlation between microbial biomass and total soluble salt level.

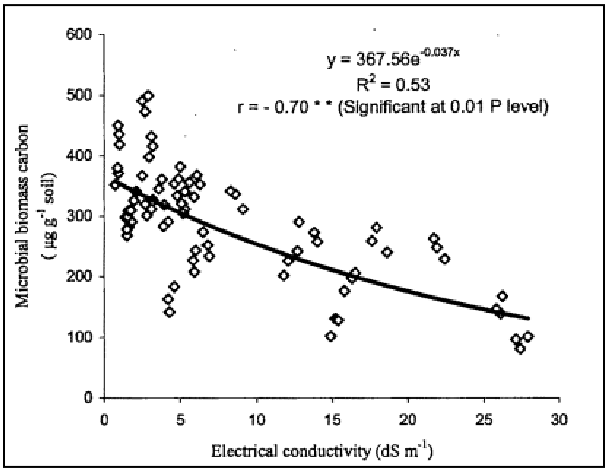

Figure 1: Relationship of salt affected coastal soil between microbial biomass and electrical conductivity

The association between MBC/OC and salinity was exponential (Figure 2), and soils with higher ECe values tended to have lower ratios. The regression equation showed that the variance in ECe accounted for 59% of the total variation in MBC/OC.

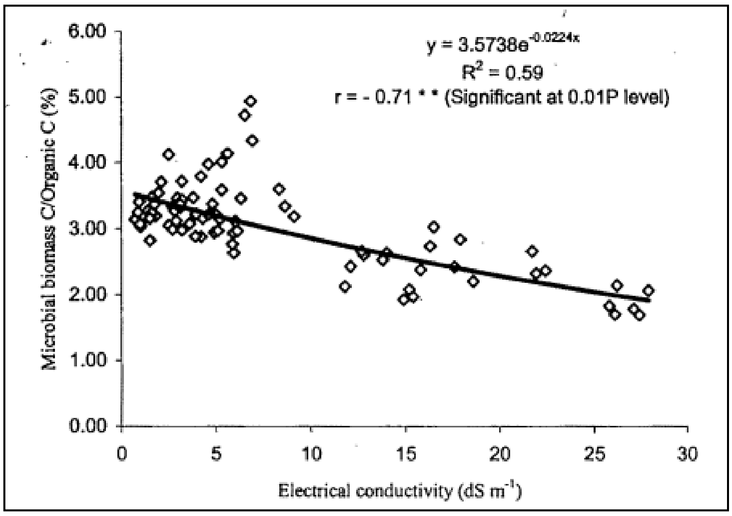

Figure 2: Relationship of salt affected coastal soil between microbial biomass and organic carbon ratio and electrical conductivity

Long-term field experiment on fertilizer application to coastal soil

Figure 3-7 is a graphical representation of the linear regression between soil microbial and biochemical characteristics and rice crop production. The values of the correlation coefficient ("r") between the various enzymes and rice grain yield are as follows: 0.90 for MBC, 0.90 for BSR, 0.88 for FDHA, 0.91 for acid phosphatase, and 0.98 for alkaline phosphatase. According to the corrected R2 value for the regression coefficient, MBC, BSR, FDHA, urease, acid phosphatase, and alkaline phosphatase each explained roughly 81%, 79%, 84%, 97%, and 96% of the variance in grain yield. In addition to rice, pearlmillet and wheat were also shown to have a positive relationship between grain production and MBC in an experiment including the use of both organic and inorganic fertilisers (Goyal et at., 1992).

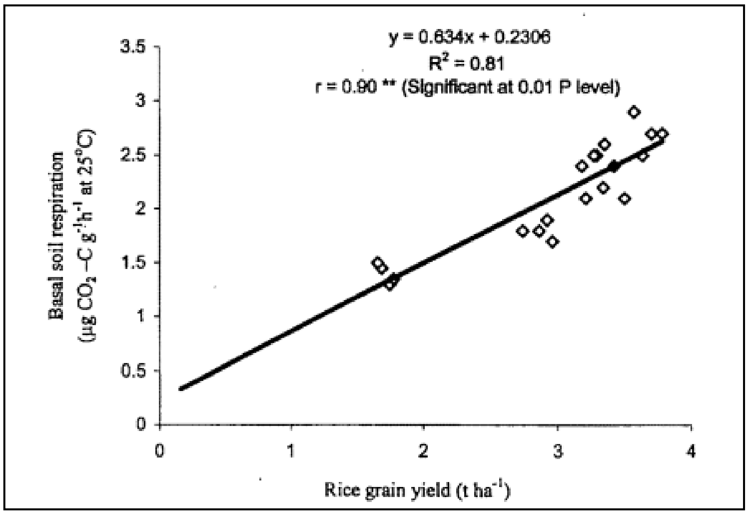

Figure 3: Relationship of rice in long-term fertilizer experiment between basal soil respiration and grain yield

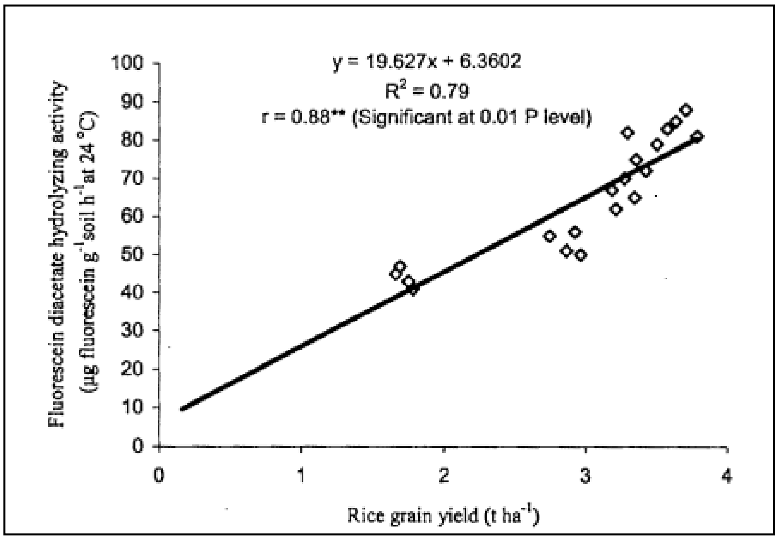

Figure 4: Relationship in long-term fertilizer experiment between fluorescein diacetate hydrolyzing activity and grain yield of rice

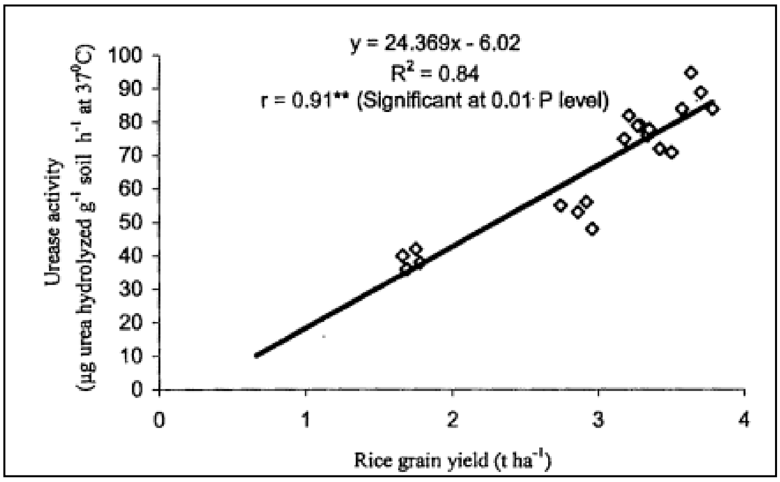

Figure 5: Relationship in long-term fertilizer experiment between urease activity and grain yield of rice

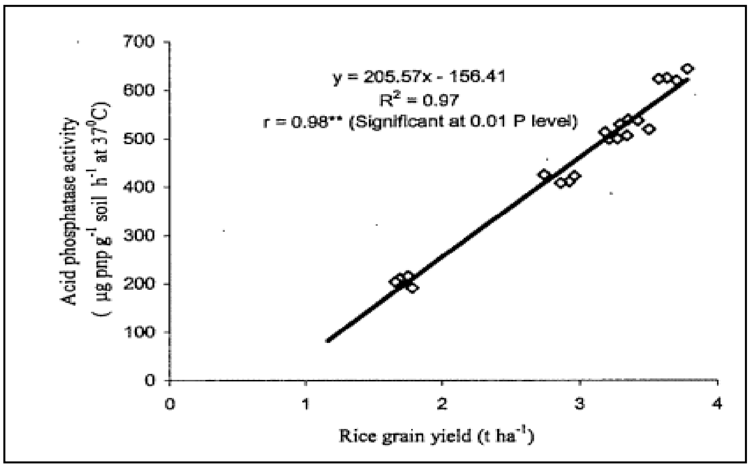

Figure 6: Relationship in long-term fertilizer experiment between acid phosphatase activity and grain yield of rice

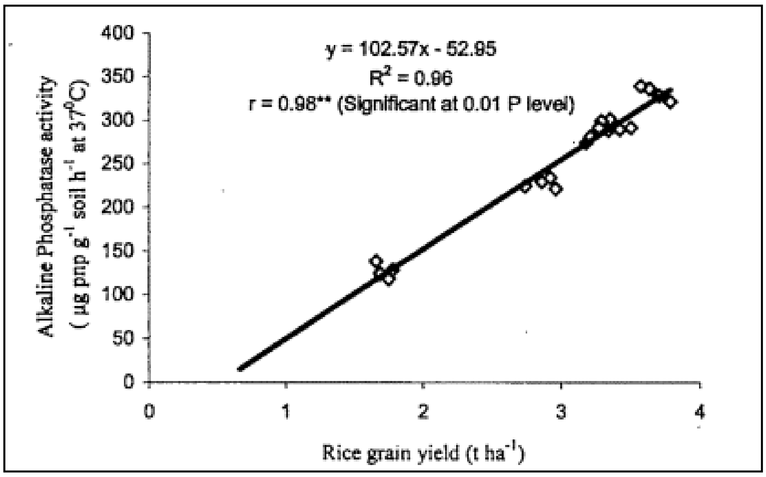

Figure 7: Relationship in long-term fertilizer experiment between alkaline phosphatase activity and grain yield of rice

Graphical representation of the linear regression between soil microbiological and biochemical parameters and green chilli harvest. The values of the correlation coefficient ("r") between rice grain yield and MBC, BSR, FDHA, urease, acid phosphatase, and alkaline phosphatase are 0.89, 0.92, 0.97, 0.94, 95, and 0.86, respectively. According to the modified R2 value from the regression coefficient, MBC, BSR, FDHA, urease, acid phosphatase, and alkaline phosphatase each explain around 79%, 84%, 88%, 90%, and 74% of the variance in grain yield.

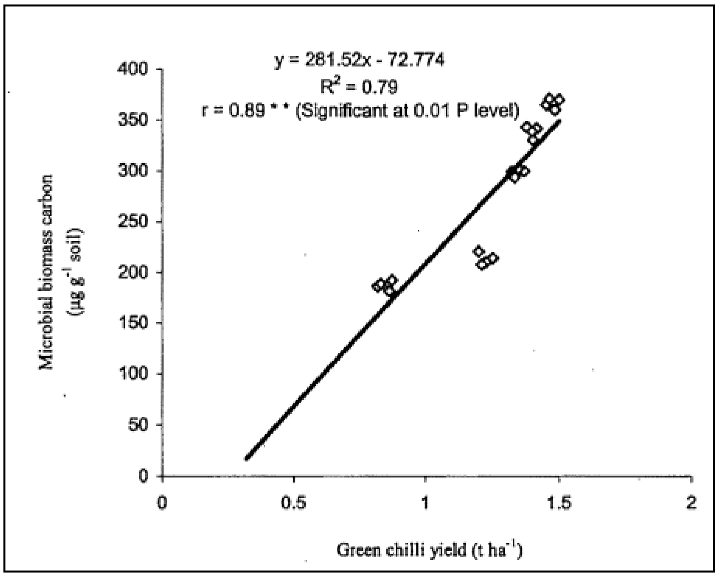

Figure 8: Relationship between nutrient management

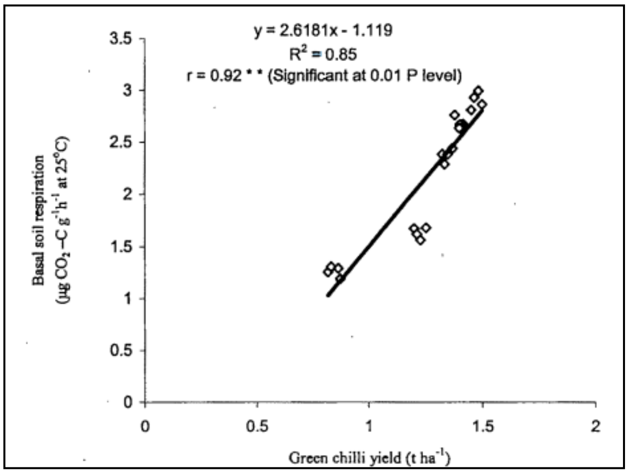

Figure 9: Relationship in integrated nutrient management between basal soil respiration and green chilli yield

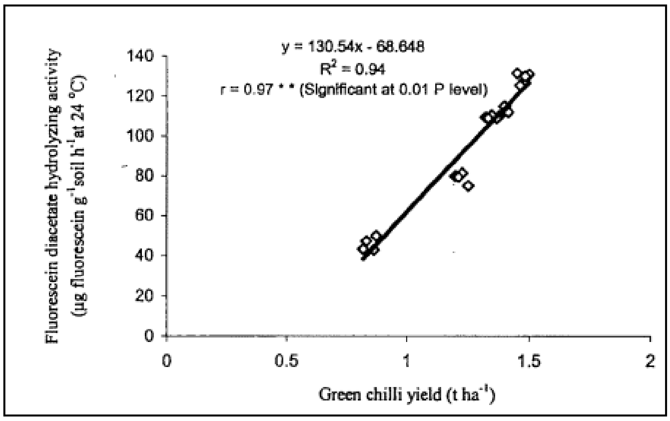

Figure 10: Relationship in integrated nutrient management between fluoresce in diacetate hydrolyzing activity and green chilli yield

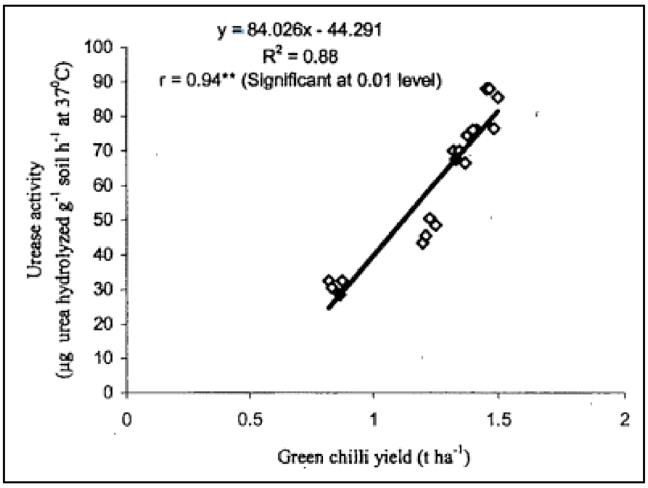

Figure 11: Relationship in integrated nutrient management between urease activity and green chilli yield

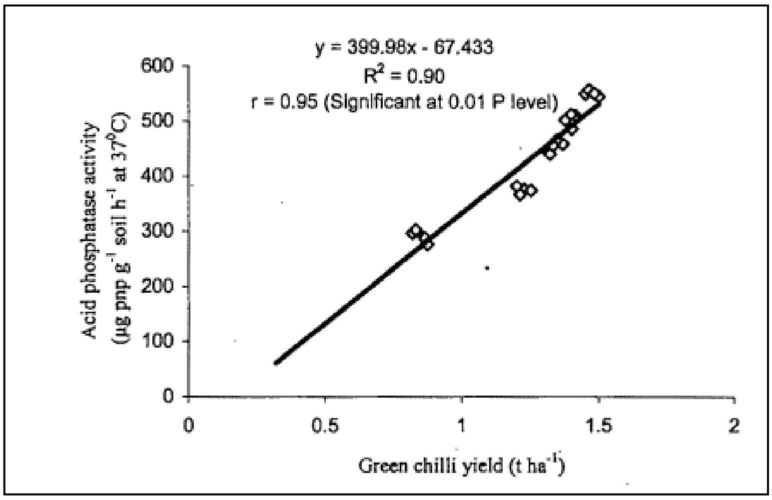

Figure 12: Relationship in integrated nutrient management between acid phosphatase activity and green chilli yield

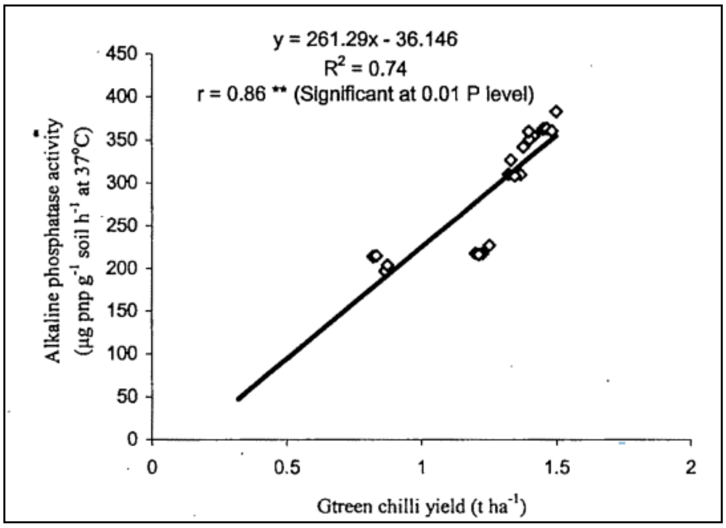

Figure 13: Relationship integrated nutrient management between alkaline phosphatase activity and green chilli yield

Conclusion:

The soil's physicochemical, microbiological, and biochemical qualities, as well as its fertility, were all enhanced by the application of both organic and inorganic sources of nutrients. The agricultural output also increased gradually over time. As a result, using both organic and inorganic nitrogen sources together might be a viable long-term strategy for increasing agricultural productivity in coastal salty soils.

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