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Significant Effect Of Amended Soil On Microbial Flora Of Soil And Plant Growth In Comparison With Natural Low Nutritive Soil

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Abstract;
Soil chemical properties, such as Carbon and Nitrogen levels, are crucial for fulfilling the basic needs of plants. The presence of secondary and tertiary nutrients plays a vital role in constructing soil structure, influencing the survival of normal microbial flora, seeds, and later plant growth. The use of chemical fertilizers addresses nutritional deficiencies, but reports indicate that only 40% is utilized by plants, leading to soil issues like salinity and drought logging. When soil lacks essential nutrients, external amendments are necessary, impacting plant growth and crop yield by enhancing normal microbial flora i.e. Plant growth-promoting rhizobacteria (PGPRs). Recognizing the significance of both chemical nutrients and physical properties for healthy plant growth, a soil amendment called "Fertisol soil" was developed. This involved adding basic and secondary nutrients to the soil. The amended soil underwent analytical characterization and was compared with natural soil through chemical analysis and microbial growth assessments. Comparative studies using the amended soil showed improved plant growth and flowering capacity compared to control plants in terms of height and flowering. This highlights the positive impact of balanced nutrient amendments on soil health and overall plant performance.

Key Words: Amended Soil, Bhalu Soil, PGPR, Plant Nutrients

1. Introduction:

Soil is a complex environment containing interrelated communities of microorganisms mostly determined by physical and chemical parameters of soil. It is stated by Kennedy et al., 1995, that soil's functional integrity is determined by its chemical characteristics and microbial communities. Microbial diversity of soil can determine the soil fertility and productivity in form of crop yield and ecological stability (Nanniperietal., 2003). As barren soil is low in nutritive resource so it doesn't support the growth of many species of microorganisms due to which it's crop yielding ability will also be low in terms of crop production (Tilman,1982).

According to Yachi and Loreau (1999) the microbial diversity of soil enhances the worthiness of ecosystem. Hence it should be understood very well that soil degradation or erosion is directly proportional to deterioration of soil microbial diversity and hence its fertility. Due to this reason, soil chemical analysis is very important if and when cropping is mending to be done on land. If soil is depleted of important nutrients to sustain microbial flora of soil then survival of plant growth promoters (PGPR) will also be affected. To overcome the soil nutrient depletion, chemical fertilizers like DAP or urea fertilizers are mixed with the natural soil in order to fulfill the nutritional depletion of soil and also to improve soil physical and chemical properties.

In viewing the importance of soil macro and micro nutrients to sustain the growth of PGPRs for healthy soil, amended soil has been prepared named "Fertisol soil" which provides all of the essential nutrients needed by plants and encourages the development of the normal microbial flora in the soil.

Initially, commonly available "Bhalu Soil" which is usually used in bedding of agricultural land was analyzed for chemical and microbiological parameters, and the Fertisol Soil was prepared which fulfills all the basic nutrients required by the plant and also supports the growth of normal microbial flora of soil, which is very important for healthy growth and yield of crops. Both Fertisol amended soil and the widely locally available "Bhalu Soil," which is typically used to bed agricultural land, was examined for chemical and microbiological parameters.

Material and Method

2.1 Reagents and Equipments

All chemicals used for the experiments were of AR grade, deionized water was used for the preparation of reagents and samples. The equipments used during the course of this study were Hitachi Z-5000 Atomic Absorption Spectrophotometer equipped with Zeeman background correction, Jenway PFP 7 Flame Photometer, Jenway Ion Meter and Thermo Nicol UV-vis Spectrophotometer. All equipments were used as per manufacturers' instructions and recommendations.

2.2 Collection of "Natural Soil" Samples

Ten samples of locally available ''Bhalu Soil" were randomly collected from different locations of Karachi metropolitan city areas between May-June 2022.

2.3 Preparation of Fortified "Fertisol Soil"

Amended "Fortisol Soil" was prepared by inoculating important macro and micronutrients in certain concentrations. After preparation, chemical analysis of Fertisol amended Soil was carried out. For chemical analysis, soil samples were air dried, grinded and sieved through 20 mesh size. Physical and chemical analysis was carried out using standard methods of soil analysis.

Macronutrients were analyzed in 1:2 soil-water and soil-ammonium acetate extracts using Atomic Absorption Spectrophotometric. Organic matter and Organic Carbon were estimated by dichromate titrimetric methods. Different standard methods were used for the determination of physical properties of soil like pH, Electrical Conductivity, TDS etc.

2.4 Microbial Analysis:

- To check the microbial growth in natural soil and in amended Fertisol soil, soil samples were spiked with soil microbial extract pre-inoculated with nutrient broth and incubated at 37°C for 24 hours. Broth containing 2.3×10^3 Total aerobic plate count (cfu/ml).
- Both samples were incubated at 37°C for one month. Soil samples were microbiologically analyzed for total aerobic load (TAL) after every week for one month.

2.5 Pot Experiment:

- To check the effect of amended Fertisol soil and natural soil on growth of plant, pot experiment was conducted on ornamental plant Champa (Magnolliachampaka).
- Small plants were used initially in which amended Fertisol soil and Bhalu Soil were inoculated.
- Pot experiment was conducted for 03 months, and at the end number and size of leaves, roots size, number of branches and number of flowers on each plant were counted as growth parameters.

3. Results and Discussions:

The data presented in Figure 1 illustrates that the naturally occurring Bhalu soil is severely deficient in both nutrients and a favorable physical structure for healthy plant growth. Despite this, it is commonly used in horticulture to enhance both quality and the structure of soil. It was deficient in basic soil nutrients like nitrogen, phosphate, potassium and presence of organic matter etc, which directly affect the growth and yield of plant.

S. No.	Parameters	Amended Soil	Bhalu Soil	Units
		1:2 Soil Water Extract		
	Macro Nutrients			
1	Nitrogen (N)	4,900 ± 03	ND	mg/Kg
2	Phosphorous as P_2O_5	9,800 ± 02	50 ± 01	mg/Kg
3	Potassium (K)	11 ± 0.56	4 ± 0.21	mg/Kg
	Secondary Nutrients			
4	Calcium (Ca)	1,400 ± 02	48 ± 02	mg/Kg
5	Magnesium (Mg)	300 ± 03	58 ± 02	mg/Kg
6	Sulfur as SO_4	4,900 ± 02	ND*	mg/Kg

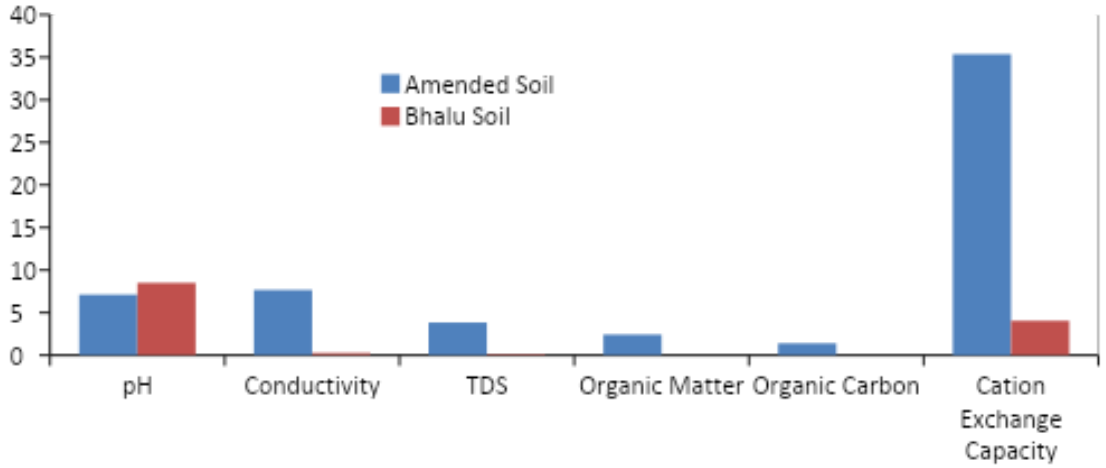
	Micro Nutrients			
7	Chloride (Cl)	2,300 ± 03	1,300 ± 02	mg/Kg
8	Iron (Fe)	30 ± 0.70	2 ± 0.94	mg/Kg
9	Zinc (Zn)	62 ± 01	0.40 ± 0.02	mg/Kg
10	Manganese (Mn)	60 ± 01	5 ± 0.20	mg/Kg
11	Copper (Cu)	6 ± 0.38	0.22 ± 0.01	mg/Kg
12	Boron (B)	72 ± 01	ND*	mg/Kg
	Physical Parameters			
13	pH	7 ± 0.12	8 ± 0.50	
14	Electrical Conductivity (EC)	7 ± 0.67	0.26 ± 0.1	mS/cm
15	Total Dissolved Solids (TDS)	3 ± 0.84	0.13 ± 01	g/L
16	Organic Matter (OM)	2 ± 0.43	ND*	%
17	Organic Carbon (OC)	1 ± 0.40	ND*	%
18	Sand	86 ± 02	95 ± 0.5	%
19	Silt	4 ± 01	2 ± 0.5	%
20	Clay	10 ± 01	2 ± 0.1	%
21	Cation Exchange Capacity (CEC)	35 ± 0.39	4 ± 0.05	meq/100 g

Table #1 Chemical amendments of "Fertisol Soil" and the composition of "Natural Soil".

If soil is lacking in essential basic nutrients, chemical fertilizers such as DAP or nitrogen fertilizers are typically applied in addition to macro and micronutrients to improve the soil's chemical nutritional profile. It was reported in several scientific studies that chemical fertilizers along with organic inputs helps more effectively in improving the microbial flora of plant growth promoters (Gosh et al 2004; Bhatta Charyya et al .,2007; Tewolde et al., 2007) which improves the crop yield as well.

Addition of calculated amount of chemical fertilizers which are mostly acquired by the plants not only improves the soil chemical and microbial profile but also helps in preventing the soil from becoming salt logged due to the deposition of excess amount of chemical fertilizers.

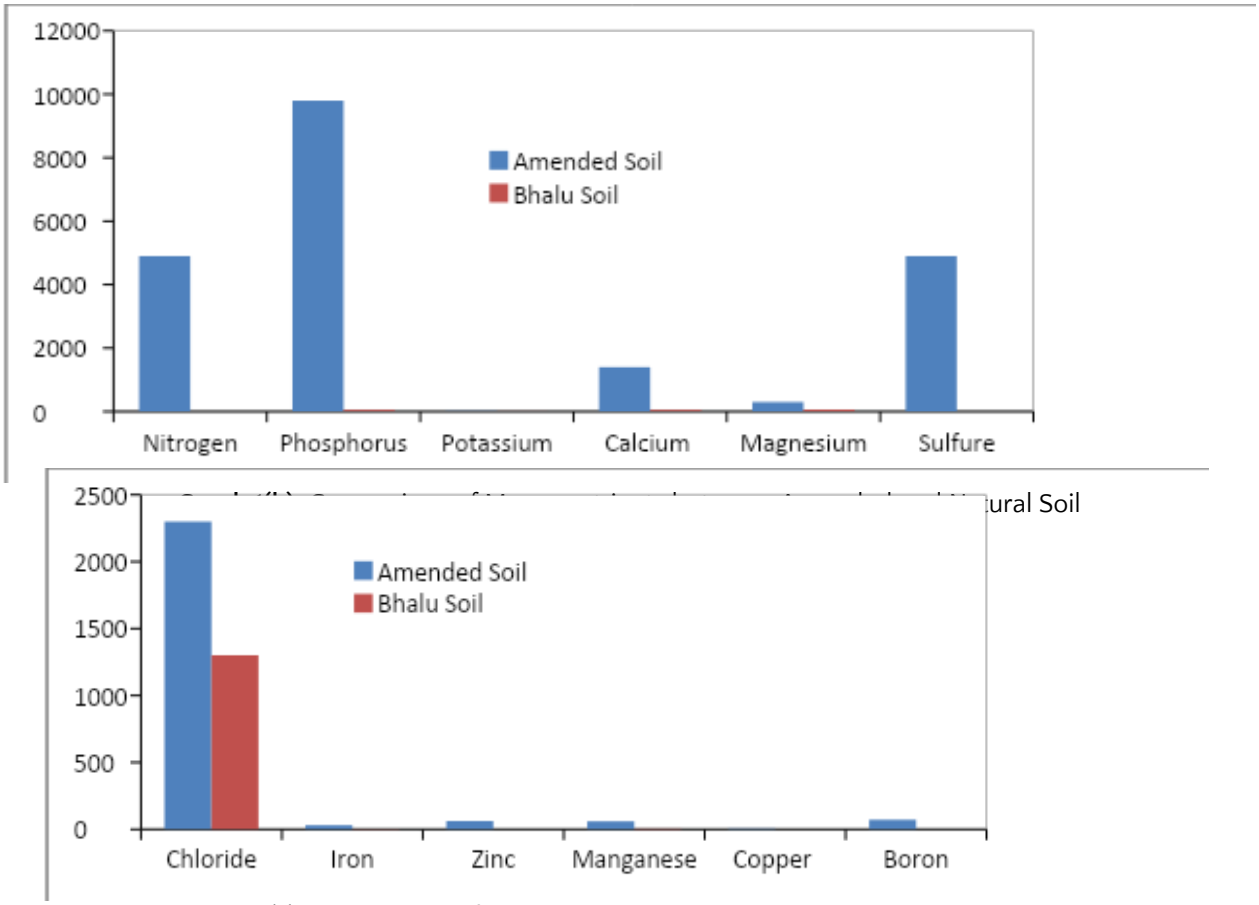
With these issues with the natural soil, the amended "Fertisol soil" was prepared to improve not only the basic and most important plant nutrients but also to improve the physical properties of soil which aids in enhancing the soil's ability to retain water and promote the growth of microorganisms and the better development of plants.



Graph 1(a): Comparison of Physical Parameters between Amended and Natural Soil

The amended soil improves the basic nutritive requirements of Nitrogen (N), Phosphorus in form of P_2O_5 in soil which are very important for the growth of crops like maize as reported by Moss *et al.*, (2001) and Seyfollah *et al.*,

(2013).These essential nutrients are added in amended formulation to fulfill the deficiencies of natural soil as shown in graphs 1.(a), 1.(b), 1.(c)



Graph 1(c): Comparison of Micro nutrients between Amended and Natural Soil

The differentiation between two Magnolia champaca plants grown in Fertisol soil and Bhalu soil highlights the importance of soil fertility. The Fertisol soil, enriched with essential nutrients through amendments, demonstrates higher soil fertility compared to the Bhalu soil, which lacks adequate nutrients. Soil chemical properties, such as Carbon and Nitrogen levels, are crucial for meeting the basic needs of plants. Secondary and tertiary nutrients also contribute to soil structure and influence microbial flora, seed germination, and plant growth. While chemical fertilizers can address soil deficiencies, their effectiveness is limited, with only 40% being utilized by plants, leading to potential soil issues like salinity and drought.

In cases where soil lacks essential nutrients, external amendments are necessary to enhance plant growth and crop yield by promoting normal microbial flora. The development of Fertisol soil, through the addition of basic and secondary nutrients, underscores the significance of balanced nutrient amendments for healthy plant growth. Comparative studies between plants grown in Fertisol soil and natural soil (Bhalu soil) reveal that the former exhibits superior plant growth and flowering capacity in terms of height and flowering (Fig. 1). This outcome underscores the positive impact of balanced nutrient amendments on soil fertility and overall plant performance, emphasizing the importance of soil management practices for sustainable agriculture.

Fig. 1. Comparison of Champa plants grown in **(a).** Fertisol soil and **(b).** Natural Bhalu soil, highlighting the importance of soil amendments.

According to Moss (2001) the addition of nitrogen and phosphorous helps in improving the plant growth especially in calcareous soil with low organic matter content. Soil is mainly comprised of inorganic, organic matter, soil plant growth promoting bacteria or fungus, soil moisture, soil solution and soil air. Roughly soil contains 50-60% minerals, 25-35% water, 15-25% air, and organic matter in low quantities, Chatwal *et al*., (2005).

According to Auton (2013), it is important to emphasize that there are some primary parameters of soil that reflect its use either for germination or development of crop. If fertile soil is required for cropping, pH is the most important parameter to check the quality of the soil because it affects other parameters of soil. Usually neutral pH is very much important for seed germination; however, pH becomes acidic or alkaline in soil due to the utilization of certain chemical fertilizers in high concentrations over the period of time, Suarau (2019).

It was observed that the pH of the naturally occurring "Bhalu Soil" was found to be highly alkaline, at 8.5, but the pH of the prepared Fertisol soil was kept neutral at 7.12.

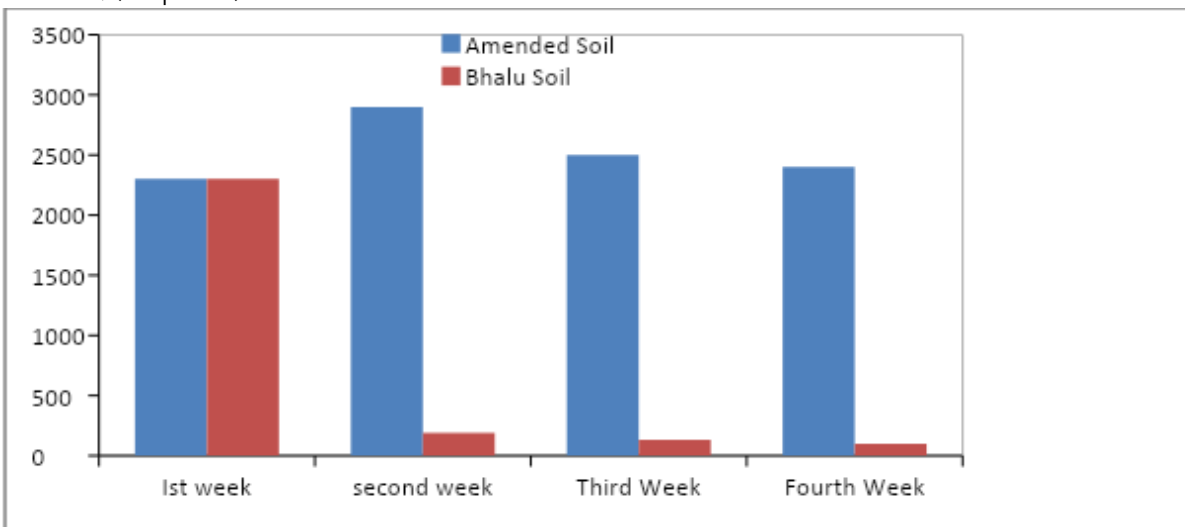
Electrical conductivity (EC) is another important characteristic of soil analysis which measures the concentration of ions in water or soil solution. It rises as the concentration of ions in the soil increases. According to Suarau (2019) EC is most inexpensive method to check the health of soil. Using this significance of soil EC, the analytical data reveals that the EC value of natural Bhalu soil is significantly lower at 0.26 compared to 7.67 (mS/cm) value of Fertisol soil. This indicates that natural soil lacks essential nutrients to support life, either through seed germination or for the normal microbial flora of PGPRs, which affects plant growth directly or indirectly and provides nutrients to plants through their roots.

According to Gul et al. (2011), the physical characteristics of soil, which are crucial for nutrient supply, water retention, and infiltration capability, impact the suitability of soil for crop yield. According to Shemsher (2018) degradation of soil can be measured by measuring the deterioration of physical, chemical and microbial parameters of soil. Usually physical parameter of soil largely depends upon texture, size and mineral composition of soil particles (Fisher and Binklay, (2000), swift et al.,(2004), Gul et al.,(2011). All these parameters play vital role in enhancing crop yield via supplying the essential nutrients and movements of water and air in soil surfaces.

In view of the importance of soil physical and chemical parameters Fertisol Soil was developed with balanced primary and secondary macro and micronutrients as soil "probiotic" to improve the quality of soil and make it suitable for seed germination, plant growth and maintaining normal but important microbial flora collectively known as PGPRs.

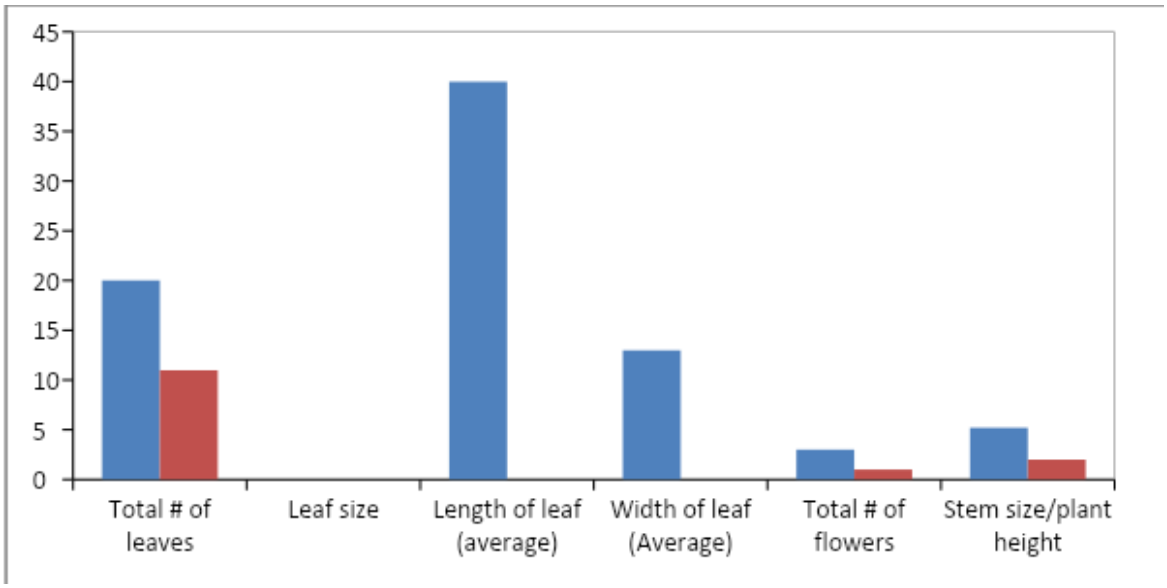
To check the efficiency of natural soil in comparison with supplemented Fortisol soil, growth test of soil bacterial flora was conducted. Soil samples were spiked with solution containing 2.3×103 cfu/ml total aerobic plate count (TAC) and then incubated at 37°C. When the soil samples were analyzed for TAC after every week for one month, it was observed that the amended Fertisol Soil significantly supported the growth of PGPRs as reflected in TAC, but the

natural low nutritive soil fails to supports the bacterial growth and the TAC was decreased significantly with the passage of time, (Graph # 2).



Graph 2: Comparison of Total Aerobic Plate Count of Amended Fertisoil soil and Natural soil

Furthermore, to check the effect of amended Fertisol soil and natural Bhalu soil on plant growth, pot experiments on ornamental plant named Champa (Magnollia champaka) which belongs to family Magnolliaceae were conducted. The results of the field experiment showed (Graph#3) that the plants grown in the Fertisol soil supplemented with nutrients were much healthier than those grown in natural soil. They also had larger leaves and more blossoms than the plants in the natural soil. Plants grown in control pots with natural soil, on the other hand, were substantially smaller and had less healthy leaves. This demonstrates that fundamental nutritional needs, which were lacked in natural soil, are equally crucial for the early support of plant health.



Graph 3: Observed Growth Parameters of Champa (Magnollia champaka) plant in Amended soil and Natural soil

4. Conclusion

Developed amended soil shows encouraging results on the growth of Champa plant, therefore it is established that if physical and chemical properties of soil are balanced the soil may support plant life and promote the formation of microbial flora. Whereas the soil of low nutritive profile could not support the normal PGPRs and hence ultimately nutritional deficiencies effects the growth of plant and yield. Given the significance of nutrients in soil, the amended 'Fertisol' soil is formulated which can fulfill the nutritive requirements of soil by reducing or replacing the use of chemical fertilizers.

Conflict of interest

The authors do not have any conflict of interest.

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