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Assessing Soil Chemical and Biological Properties under Major Cropping Systems in SPSR Nellore District, Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A study was carried out during 2023-24 in SPSR Nellore district of Andhra Pradesh, India to know the impact of major cropping systems on soil chemical and biological properties. Totally 100 soil samples were collected randomly from five major cropping systems *viz*., paddy-paddy, fallow-

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paddy, paddy-cotton, paddy-pulses and groundnut-paddy (20 samples from each cropping systems) in SPSR Nellore district and processed, analyzed for available nitrogen, phosphorus, potassium and sulphur and dehydrogenase enzyme. The results revealed that available nitrogen in soils varied from 88 kg ha^{-1} in paddy-cotton cropping system to 289 kg ha^{-1} in paddy-pulses cropping system with a mean value of 130 and 242 kg ha^{-1} respectively. 95% of samples showed deficient in available nitrogen. The available phosphorous in soils varied from 19 kg ha^{-1} in paddy-cotton cropping system to 58 kg ha^{-1} in paddy-pulses cropping system. The mean available phosphorus is 37.03 and 42.8 kg ha^{-1} respectively. The available potassium in soils varied from 177 kg ha^{-1} in paddy-paddy cropping system to 601 kg ha^{-1} in paddy-pulses cropping system. The available potassium of soils of different cropping systems was medium to high in range. The available sulphur of soils varied from 7.56 mg kg^{-1} in paddy-paddy cropping system to 33.73 mg kg^{-1} in paddy-pulses cropping system. The soils had deficient to sufficient in available sulphur in various cropping systems at SPSR Nellore district of Andhra Pradesh. The soils in paddy-pulses cropping system showed the highest dehydrogenase activity (116.47 µg of TPF g^{-1} soil day^{-1}) whereas the lowest dehydrogenase activity (18.08 µg of TPF $g^{-1}day^{-1}$) was observed in paddy-paddy cropping system.

Keywords: Cropping systems; major nutrients; available sulphur; soil dehydrogenase activity and SPSR Nellore district.

1. INTRODUCTION

Soil is a vital natural resource that plays a crucial role in the sustenance of life on Earth. It serves as the foundation for agricultural systems, supporting plant growth by providing essential nutrients, water and a medium for roots to anchor. Healthy soil directly affects the quality and yield of crops. Cropping systems have a significant impact on soil health, influencing its chemical properties. Chemical properties refer to the composition and behaviour of various chemical elements and compounds within the soil. These properties play a crucial role in determining soil fertility, influencing plant growth, and supporting ecosystem functions. the chemical properties of soil are integral to its function as a medium for plant growth and a critical component of broader environmental systems. Cropping systems, including crop diversification, crop rotation and intercropping related agronomic practices used in agriculture impact soil health and quality from various spatial and temporal aspects (Vukicevich et al., 2016). Cropping systems were initially designed to maximize yield from agro-systems, but modern agriculture has become increasingly concerned about the environmental sustainability of cropping systems (Fargione et al., 2018). The goal of soil health maintenance is to ensure long term stable high productivity and environmental sustainability of cropping systems under five essential function evaluation standards, namely nutrient cycling, water relations, biodiversity and habitat, filtering and buffering, and physical stability and support (Hatfield et al*.,* 2017). Proper management and monitoring of these chemical properties such as available nitrogen, phosphorus, potassium, sulphur help maintain soil fertility, prevent degradation, and support sustainable agricultural practices. Dehydrogenase activity in soil is a key indicator of microbial activity and overall soil health. Maintaining or enhancing dehydrogenase activity through practices that support soil microbial health is essential for promoting sustainable agricultural productivity and ecosystem resilience (Joseph et al., 2021). The choice of crops, the diversity of plants, and the management practices all play crucial roles in determining the condition and sustainability of soil. Keeping this view, a study was taken up to know the effect of major cropping systems on soil chemical and biological properties in SPSR Nellore district, Andhra Pradesh, India.

2. MATERIALS AND METHODS

The study area SPSR Nellore district lies in between 14° 4′ 12.9″ and 14^0 57′ 56.8″ North latitudes and $79^0$30′29.6″ and $80^0$4′24.7″ East longitudes and the investigation was carried in the year 2023-24. One hundred soil samples were collected from five major cropping systems. From each cropping system 20 samples (each sample contains one kg of soil) were collected at 0-30 cm depth randomly by digging. The collected soil samples were shade dried, sieved with 2mm sieve and the sieved samples used for analysing chemical and biological properties. All the samples were analyzed for available nitrogen, phosphorus, potassium and sulphur and dehydrogenase enzyme. Available nitrogen in the soil samples was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) and expressed the results in kg ha^{-1}.Available phosphorus in the soil samples were extracted as per procedure described by Olsen et al. (1954) and phosphorus in the extract was determined by using ascorbic acid as reducing agent as described by Watanabe and Olsen (1965) using spectrophotometer (Systronics UV-VIS spectrophotometer 119) at 660 nm wavelength and expressed the results in kg ha^{-1}.Available potassium in the soil samples was extracted with neutral normal ammonium acetate (Jackson, 1973) and determined by using flame photomete (Systronics flame photometer 128) and expressed the results in kg ha^{-1}.Available sulphur was determined by extracting with 0.15 per cent calcium chloride followed by development of turbidity with barium chloride (Hesse, 1971). The turbidity is measured using spectrophotometer (Systronics UV-VIS spectrophotometer 119) at 420 nm wavelength and expressed the results in mg kg^{-1}. Dehydrogenase activity in the soil sample was determined by the procedure described by Casida et al. (1964) and expressed in micro gram of triphenyl formazon (TPF) formed per gram of soil per day (µg of TPF g^{-1} soil day^{-1}). Various soil properties in different cropping systems were statistically analysed by using SPSS 2.0 version.

3. RESULTS AND DISCUSSION

3.1 Available Nitrogen

The data in Table 1 showed that the available nitrogen in soils varied from 88 kg ha^{-1} in paddy-cotton cropping system to 289 kg ha^{-1} in paddy-pulses cropping system. The available nitrogen in soils of paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses, groundnut-paddy cropping systems was ranged from 100-163, 113-176, 88-213, 201-289 and 113-213 kg ha^{-1}, respectively (Fig. 1) with a mean value of 133, 140, 130, 242, and 159 kg ha^{-1} respectively The mean available nitrogen in different cropping systems was in the order of paddy-cotton (130 kg ha^{-1}) followed by paddy-paddy (133 kg ha^{-1}), fallow-paddy (140 kg ha^{-1}), groundnut-paddy (159 kg ha^{-1}) and Paddy-Pulses (242 kg ha^{-1}).The CV was 30.29 per cent for available nitrogen in the soils of different cropping systems. Available nitrogen in soils of different cropping system in SPSR Nellore district was low to medium in range. The maximum value of available nitrogen (289 kg ha^{-1}) was observed in soils of paddy-pulses cropping system. The minimum value (88 kg ha^{-1}) of available nitrogen was observed in paddy-cotton cropping system.

The available nitrogen under paddy-pulses cropping system was higher than that of other cropping systems. Because of their symbiotic relationship with rhizobium bacteria, legumes have the capacity to fix and store more atmospheric nitrogen, increasing the amount of nitrogen that is readily available in the soil of paddy-pulses cropping systems (Rajpoot et al., 2021 and Annesly et al*.,* 2023).

3.2 Available Phosphorus (P_2O_5)

The available phosphorus in soils varied from 19 kg ha^{-1} in paddy-cotton cropping system to 57.5 kg ha^{-1} in paddy-pulses cropping system (Table 1). The range of available phosphorus varied from 20.2-30.1, 22.6-35.6, 19-30, 29.7-57.5 and 29.7-45.3 kg ha^{-1} in soils of paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy cropping systems respectively with a mean value of 25, 29.5, 24.5, 42.8 and 37.03 kg ha^{-1} respectively (Fig. 2). The mean available phosphorus in different cropping systems was in the order of paddy-cotton (24.5 kg ha^{-1}) followed by paddy-paddy (25 kg ha^{-1}), fallow-paddy (29.5 kg ha^{-1}), groundnut-paddy (37.03 kg ha^{-1}), paddy-pulses (42.8 kg ha^{-1}) cropping system. The CV was 26.65 per cent for available phosphorus in the soils of different cropping systems. Available phosphorus in soils of different cropping system in SPSR Nellore district was low to medium in range. The maximum value of available phosphorus (57.5 kg ha^{-1}) was observed in soils of paddy-pulses cropping system. The minimum value of available phosphorus (19 kg ha^{-1}) was observed in paddy-cotton cropping system.

Compared to other cropping systems, the paddy-pulses cropping system has more accessible phosphorus. This might be due to the result of a higher available N in the paddy-pulses cropping system, where a positive interaction between available N and P is caused by BNF. Inclusion of legumes in crop rotation can promote mycorrhizal root colonization. Through root colonization, mycorrhizal connections have the biggest effect on raising P availability in soils. These outcomes agree with the research findings of Smith et al. (2011) and Newton et al. (2011).

3.3 Available Potassium (K_2O)

The data is presented in Table 1 indicated that the available potassium in soils varied from 177 kg ha^{-1} in paddy-paddy cropping system to 601 kg ha^{-1} in paddy-pulses cropping system. The available potassium in soils of paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy cropping systems was ranged from 177-556, 244-401, 235-336, 249-601 and 215-367 kg ha^{-1}, respectively with a mean value of 281, 322, 282, 418 and 308 kg ha^{-1} respectively (Fig. 3). The mean available potassium in different cropping systems were in the order of paddy-paddy (281 kg ha^{-1}) followed by paddy-cotton (282 kg ha^{-1}), groundnut-paddy (308 kg ha^{-1}), fallow-paddy (322 kg ha^{-1}), paddy-pulses (417 kg ha^{-1}) cropping system. The CV was 24.80 per cent for available potassium of different cropping systems.

Available potassium in soils of different cropping system in SPSR Nellore district was medium to high in range. The maximum value of available potassium (601 kg ha^{-1}) was observed in soils of paddy-pulses cropping system. The minimum value of available potassium (177 kg ha^{-1}) was observed in paddy-paddy cropping system. The highest available potassium was observed in soils of paddy-pulses cropping system. This might be attributed to addition of large amount of K through crop residues (Tesfahunegn and Gebru,2020). The potassium requirement for pulse crops is also less. Farmers may not applied the required quantity of K. This might be the reason for lower available N in paddy-paddy cropping system. The results are in agreement with the findings of Malecka et al. (2012) and Jat et al. (2018).

Table 1. Macronutrients status under major cropping systems of SPSR Nellore District, Andhra Pradesh

Cropping Systems		Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail K_2O (kg ha^{-1})	Sulphur (mg kg^{-1})
Paddy-Paddy	Range	100-163	20.2-30.1	177-556	7.56-19.97
	Mean	133	25	281	12.69
Fallow-Paddy	Range	113-176	22.6-35.6	244-401	9.68-19.04
	Mean	140	29.5	322	13.25
Paddy-Cotton	Range	88-213	19-30	235-336	7.71-21.88
	Mean	130	24.5	282	13.41
Paddy-Pulses	Range	201-289	29.7-57.5	249-601	11.74-33.73
	Mean	242	42.8	418	21.94
Groundnut-Paddy	Range	113-213	29.7-45.3	215-367	7.86-25.2
	Mean	159	37.03	308	17.31
Overall range		88-289	19-57.5	177-601	7.56-33.73
Overall mean		161	32	322	16
CV (%)		30.29	26.65	24.80	36.45

Table 2. Dehydrogenase activity under major cropping systems of SPSR Nellore District, Andhra Pradesh

Cropping Systems		Dehydrogenase activity (µg of TPF g^{-1} day^{-1})
Paddy-Paddy	Range	18.08- 43.47
	Mean	31
Fallow-Paddy	Range	26.55- 57.23
	Mean	38.34
Paddy-Cotton	Range	20.20- 45.59
	Mean	31.99
Paddy-Pulses	Range	49.82- 116.47
	Mean	73.8
Groundnut-Paddy	Range	48.76- 94.25
	Mean	70.66
Overall range		18.08-116.47
Overall mean		49
CV (%)		44.45

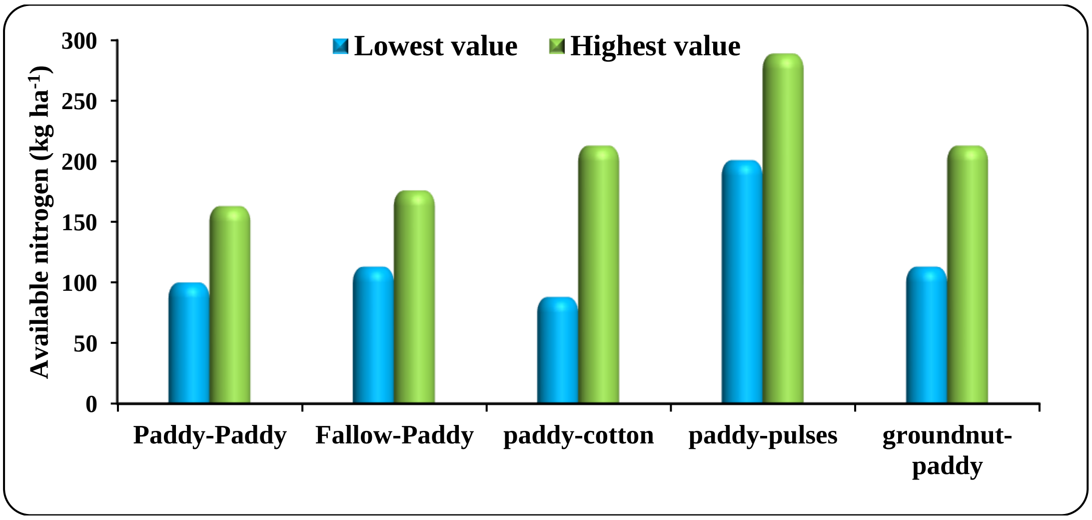

Fig. 1. Range of available nitrogen under major cropping systems

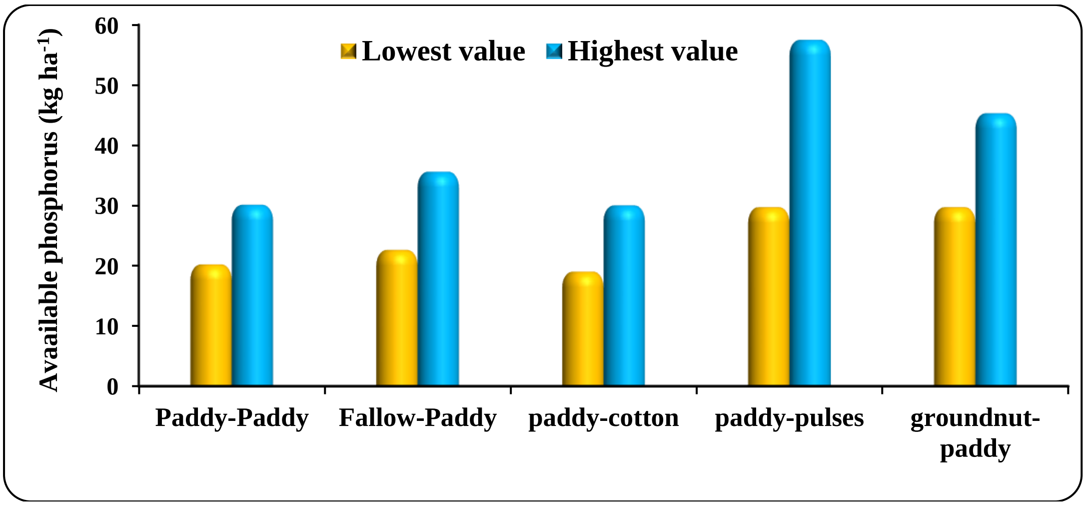

Fig. 2. Range of available phosphorus under major cropping systems

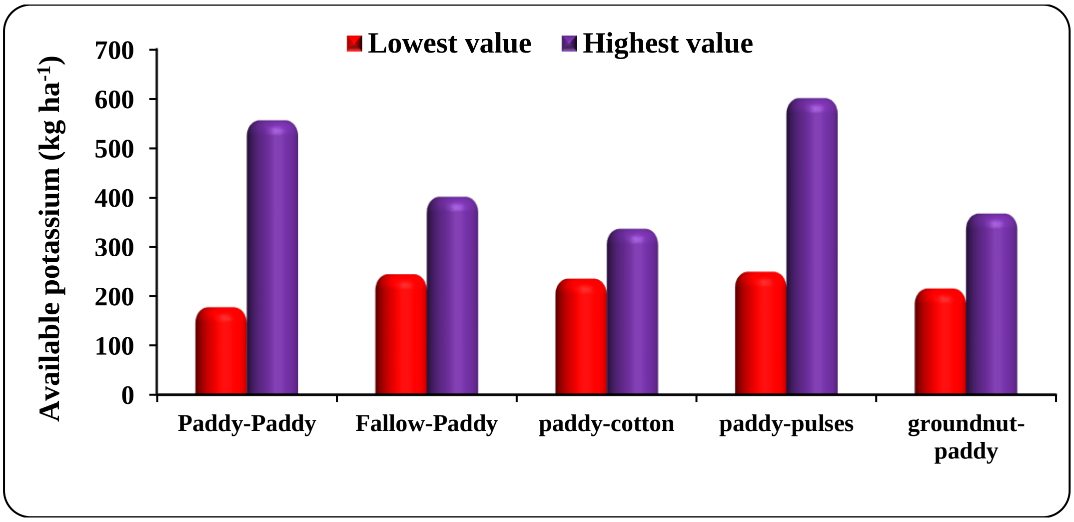

Fig. 3. Range of available potassium under major cropping systems

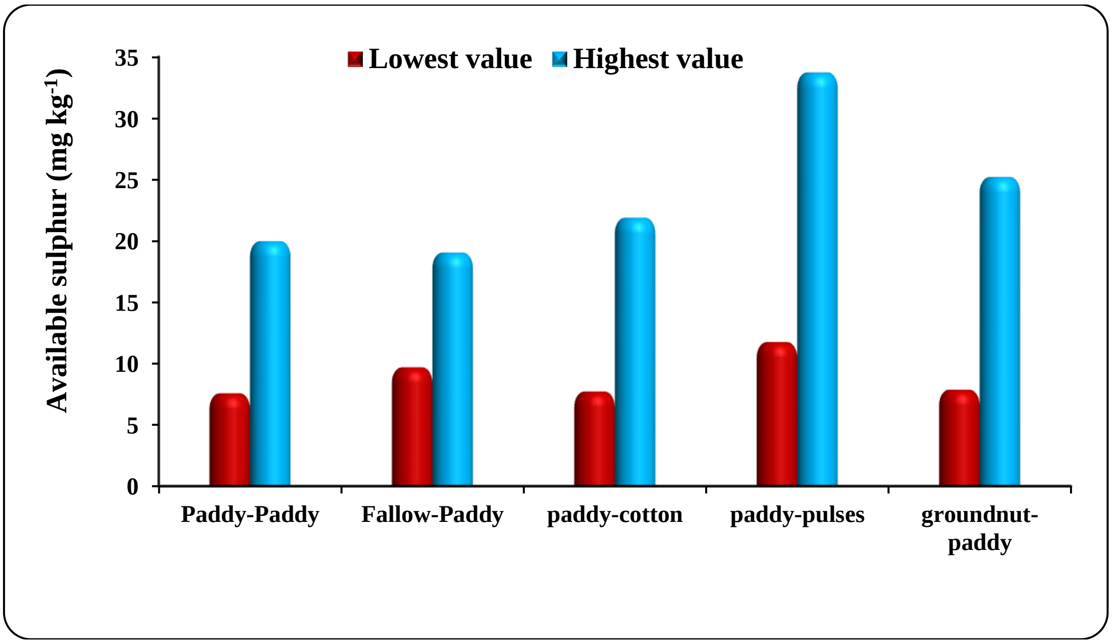

Fig. 4. Range of available Sulphur under major cropping systems

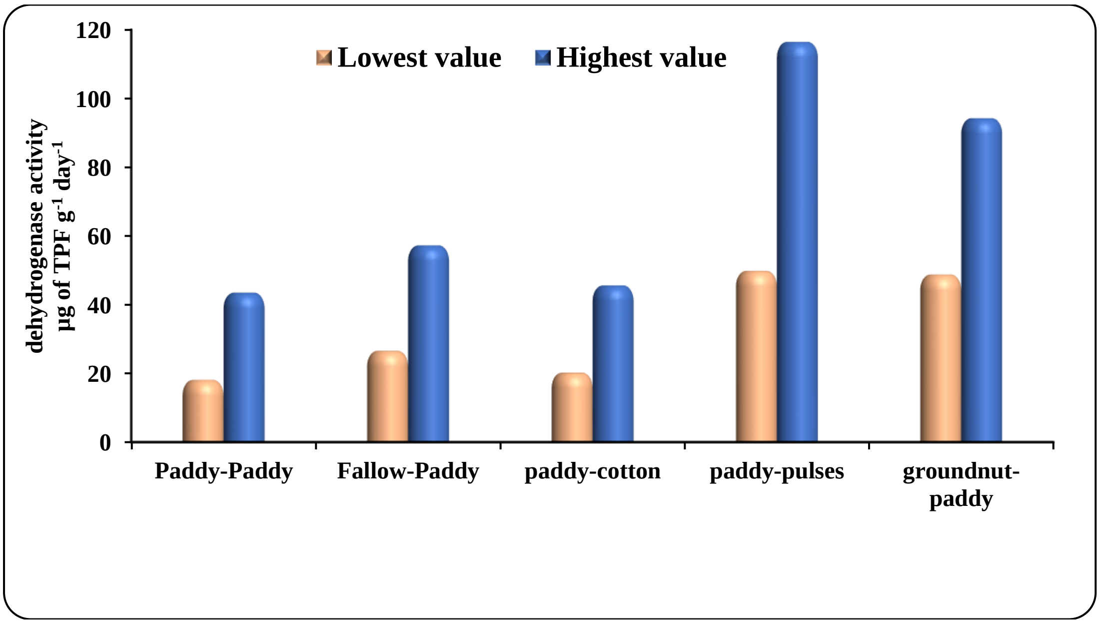

Fig. 5. Range of dehydrogenase activity under major cropping systems

3.4 Available Sulphur

The available sulphur of soils varied from 7.56 mg kg^{-1} in paddy-paddy cropping system to 33.73 mg kg^{-1} in paddy-pulses cropping system. The range of available sulphur varied from 7.56-19.97, 9.68-19.04, 7.71-21.88, 11.74-33.73 and 7.86-25.2 mg kg^{-1}, respectively in soils of paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy cropping systems with a mean value of 12.69, 13.25, 13.41, 21.94 and 17.31 mg kg^{-1}, respectively. The mean available sulphur in different cropping systems were in the order of paddy-paddy (12.69 mg kg^{-1}) followed by fallow-paddy (13.25 mg kg^{-1}), paddy-cotton (13.41mg kg^{-1}), groundnut-paddy (17.31 mg kg^{-1}), paddy-pulses (21.94 mg kg^{-1}). The CV was 36.45 per cent for available sulphur in the soils of different cropping systems. (Table 1 and Fig. 4).

Available sulphur in soils of different cropping system in SPSR Nellore district was deficient to sufficient in range. The maximum value of available sulphur (33.73 mg kg^{-1}) was observed in soils of paddy-pulses cropping system. The minimum value of available sulphur (7.56 mg kg^{-1}) was observed in paddy-paddy cropping system. The higher available sulphur in these soils might be due to the continuous application of fertilizers like single super phosphate which contains sulphur also. These results are in confirmation with findings of Kavitha et al. (2019).

3.5 Dehydrogenase Activity

Data in Table 2 and Fig. 5 showed that a wide variation was noticed from 18.08 µg of TPF $g^{-1}day^{-1}$ in paddy-paddy cropping system to 116.47 µg of TPF $g^{-1}day^{-1}$ in paddy-pulses cropping system. The dehydrogenase activity of soils in paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy cropping systems was ranged from 18.08-43.47, 26.55-57.23, 20.20-45.59, 49.82-116.47 and 48.76-94.25 µg of TPF $g^{-1}day^{-1}$, respectively with a mean value of 31, 38.34, 31.99, 73.8 and 70.66 µg of TPF g^{-1} day^{-1}, respectively. The mean dehydrogenase activity in different cropping systems were in the order of paddy-paddy (31.25 µg of TPF $g^{-1}day^{-1}$) followed by paddy-cotton (31.99 µg of TPF $g^{-1}day^{-1}$), fallow-paddy (38.34 µg of TPF $g^{-1}day^{-1}$), groundnut-paddy (70.66 µg of TPF $g^{-1}day^{-1}$) and paddy-pulses cropping system (73.84 µg of TPF $g^{-1}day^{-1}$). The CV was 44.45 per cent for dehydrogenase activity in soils of different cropping systems.

The higher dehydrogenase activity (116.47 µg of TPF $g^{-1}day^{-1}$) was observed in soils of paddy-pulses cropping system. Higher dehydrogenase activity was discovered in paddy-legume cropping systems, that might be due to addition of more biomass to soil which is converted to organic matter and acted as feed or energy source to microbes led to more microbial proliferation. This indicates more microbial respiration and dehydrogenase activity related to increased microbial biomass and microbial activity, which promotes the degradation of organic materials which is strongly connected with dehydrogenase activity. Dehydrogenase activity is directly correlated with microbial population and also with moisture content in soil. (Zhang et al., 2010). Similar findings were reported by Raviteja et al. (2024). Lesser dehydrogenase activity was observed in paddy-paddy cropping system.

4. CONCLUSION

From this study it was concluded that, the soils in paddy-pulses cropping system were higher available nitrogen (289 kg ha-1). While the lowest was observed in paddy-cotton (88 kg ha-1) cropping system with mean values of 241 and 130 kg ha-1, respectively. The available phosphorus was higher in paddy-pulses cropping system (57.5 kg ha-1) and the lowest was observed in the soils of paddy-cotton cropping system (19 kg ha-1) with mean values of 37.03 and 25.60 kg ha-1 respectively. Available potassium was found to be high in paddy-pulses cropping system (601 kg ha-1) whereas the lowest in paddy-paddy cropping system (177 kg ha-1) with mean values of 417 and 281 kg ha-1, respectively. The highest and the lowest available sulphur was noticed in paddy-pulses (33.73 mg kg-1) and paddy-paddy (7.56 mg kg-1) cropping systems with mean values of 21.94 and 12.69 mg kg-1, respectively. The soils in paddy pulses cropping system showed the highest dehydrogenase activity 118 (116.47 µg of TPF g-1day-1) whereas the lowest dehydrogenase activity (18.08 µg of TPF g-1day-1) was observed in paddy-paddy cropping system. Finally the results indicated that the soils of paddy pulses cropping system was helpful in maintaining sustainable soil health leading to improved crop productivity and profitability (Amsili et al., 2021).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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