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Influence of nutrient management practices on microbial activity, fertility and yield of paddy

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Abstract
A field study was conducted during *kharif* 2019-20 to understand the effect of different paddy growing practices on microbial activity, fertility and yield of paddy. The soil samples were collected from certified organic farmer's lowland, conventional lowland and upland, INM lowland and upland fields in Kamthi and Mouda tehsil of Nagpur district to assess the soil properties like chemical, biological properties and yield under paddy cultivation on farmers field. The results showed that the highest N, P content recorded in organic lowland practice whereas, available K was higher in INM lowland. The DTPA extractable Fe, Zn, Cu and Mn status were highest observed in organic lowland and lowest occurred in conventional practices. SMBC and DHA highly occurred in organic lowland and INM upland practice and yield is also higher in INM lowland farmers field followed by organic lowland practice.

Keywords: Paddy, available N,P,K, available micronutrient, INM, organic, and fertility status

Introduction
Rice (*Oryza sativa* L.) is the staple food crop in the diet of about one-half of the world's population. It is grown mainly under two ecosystem, known as upland and lowland. Upland rice, also known as aerobic rice, is generally grown on undulated and unbounded fields and totally depends on rainfall for water requirements.

Paddy is the main crop of eastern Vidarbha zone and taken over in large area by most of the farmers. The total area under paddy in Vidarbha is 7.319 lakh ha with a production 8.31 lakh tonnes, average productivity 1.14 tonnes per hectare (Thaware *et al.*, 2014) [21]. The low productivity of paddy soil is attributed to poor soil fertility with low SOC content. Use of imbalance chemical fertilizers without proper organic amendment could have reduced the fertility status of soils that necessitates the use of INM in paddy soils (Nath *et al.*, 2015) [14].

An estimated 24% of the increase in Asian rice production from 1965 to 1980 was attributed to use of fertilizer, mainly. Despite the past gains in rice production through chemical fertilizer, recent observations of stagnant or declining yields under continuous rice growing with high levels of N fertilizer have raised concerns about the long-term sustainability impacts of monoculture rice receiving high inputs of N fertilizers. In recent years, there has been serious concern about long-term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution. Organic manures can be a good alternative to chemical fertilizers in rice cultivation. Soil organic matter is considered to be the key attribute of soil quality (Banik *et al.*, 2006) [4].

Soils are highly variable partially due to the combined effects of physical, chemical and biological processes that operate with different intensities and scales. The spatial variability of soil properties is influenced by both intrinsic (soil formation factors, such as soil parent materials) and extrinsic (agricultural management practices, such as fertilization and irrigation) factors. Uniform management of fields often results in over-application of inputs in areas with high nutrient levels and under-application in areas with low nutrient levels. Site-specific management of nutrient, generally via variable rate fertilizer application, has been acknowledged as one means for addressing this problem (Davatgar *et al.*, 2012) [7].

Materials and Methods
Survey of soil and sampling area
Six farmers from each paddy growing practices were selected from Kamthi and Mouda tehsil of Nagpur. The input and management differences was recorded from the farmers, In order to study the properties, soil samples were taken from 0-20 cm depth, from the farmers field under various paddy growing practices at maturity stage of paddy crop, Soil samples from six farmers field under each paddy growing practices were collected and was analyzed for various soil properties.

Details and methods of soil analysis

Soil reaction (pH)

The pH of soil was determined by using glass electrode pH meter (Jackson, 1973) [9]. Ratio of soil and water is 1:2.5 standardize the glass electrode using both the standard buffer solution, pH 4 and pH 9.2, measure the pH of the sample suspension, stirring the suspension well just before introducing electrodes. Rinsing electrode with distilled water carried out after each determination.

Electrical conductivity (dSm^{-1})

The EC (dSm^{-1}) of soil was determining by using conductivity meter (Jackson, 1973) [9]. The clear extract after pH determination was used for electrical conductivity. Soil water suspension is kept as such for 3-4 hours to settle down the silt and clay particles.

The clear liquid is used for measuring electrical conductivity. The measurement of EC is to be adjusted for known temperature 25 ^{0}C.

Available nitrogen (kg ha^{-1})

Available nitrogen in soil was estimated using alkaline permanganate method (Subbiah and Asija, 1956) [21] 0.32% $KMnO_4$ and 2.5% NaoH solutions were used for distillation.

Available phosphorus (kg ha^{-1})

Available phosphorus in soil was determined by Olsen's method using spectrophotometer (Olsen and Sommer, 1982) [15] Olsen reagent 0.5M $NaHCO_3$ solution of pH 8.5 was used for extraction.

Available potassium (kg ha^{-1})

Available potassium in soil was extracted by 1N ammonium acetate solution (pH 7.0) and it determined by using flame photometer (Jackson, 1973) [9].

Available micronutrients (mg kg^{-1})

DTPA (Diethylene triaminepenta acetic acid) (0.005 M) extractable (1:2, soil: DTPA), Fe, Mn, Zn and Cu were determined as per the procedure outlined by Lindsay and Norvell (1978) [11] using Atomic Absorption Spectrophotometer (AAS).

Microbial Biomass Carbon (MBC), mg kg^{-1}

It was determined by Chloroform Fumigation Extraction Method given by Vance *et al*., (1987) [23].

Dehydrogenase Activity (DHA), µTpfg^{-1}d^{-1}

It was estimated by Reduction of 2, 3, 5 triphenyl tetrazodium chloride to triphenyl formazan (TPF) as per the given by method Casida *et al*., (1964) [6]. In the process (TTC) gets reduced to a pink coloured compound TPF which can be quantitatively extracted by methanol and measured.

Yield studies

Paddy yield (t ha^{-1}) were collected from the farmers of organic lowland, conventional lowland, INM lowland, conventional upland, INM upland practices of paddy crop of all the selected locations i.e, Mouda and Kamptee tehsil villages of Nagpur district.

Results and discussion

Inputs used by the farmers and different paddy growing practices

In various paddy growing practices the supply of nutrients through the inputs varied much. In conventional lowland practice manure used was rare and low use at about 2-4 t ha^{-1}. Low dose of NPK was used.

Residue in the form of root stubbles was used. Farmers did not use any type of bio fertilizer. (Table 1)

Table 1: Inputs used by the farmers and different paddy growing practice

Practices/ Input Used	Conventional practice of growing low land Paddy	Organic farming of growing low land paddy	INM practice of growing Lowland paddy	Conventional Upland Paddy	INM practice of Upland paddy
Manure	Rare and low use (2-3 t ha^{-1})	Regular and high use (10 t ha^{-1})	Regular (5 t ha^{-1})	Rare and low use (2-3 t ha^{-1})	Regular (5 t ha^{--1})
Sowing	Transplanting	Transplanting	Transplanting	Drilling	Drilling
Fertilizer (Soil application)	Low dose 60:30:20 NPK	No dose	Optimum 100:50:50 NPK	Low dose 40:20:20 NPK	Optimum 60:30:30 NPK
Fertilizer Spray	No Spray	Manurial liquid (500L^{-1}ha)	Spraying of 2% Urea solution	No Spray	Spraying of 2% Urea solution
Residue addition	Low residue in the form of root stubles	Straw 5 t ha^{-1}	Straw 2-3 t ha^{-1}	Low residue in the form of root stubbles	Low residue in the form of root stubbles
Biofertilizer used	No Use	Biola (Azola)	Blue green algae	No Use	Azotobactor

Soil pH (Soil reaction)

The data of soil pH, electrical conductivity (EC) and available N, P and K is presented in table 2. Soil pH is an important intrinsic property of soil which usually does not change easily. Result found that soil pH was slightly influenced by the continuous incorporation of various inputs of organic (solid/liquid) for rice crop. pH of the soil ranges between 7.47 to 7.77 under various paddy growing practices. The lowest pH observed in conventional lowland. All the soils were neutral to slightly alkaline in reaction. (Patil *et al.*, 2003) [16] under flooded method of cultivation the pH of soils is generally stabilized.

Electrical Conductivity of soil (dS m^{-1})

The electrical conductivity of soils in all paddy growing practices were under the safe limit (‹1.0 d S m^{-1}). Highest EC (0.37 d Sm^{-1}) was recorded in the organic lowland practice. This could be attributed to the addition of organic manures supplied soil with soluble compounds, the lowest EC (0.16 d S m^{-1}) was recorded in the INM upland.

The EC is also an important property of soil related to concentration of salt. In all locations, there was no much variation in EC of soil.EC content was slightly high in lowland practices than the upland practices.

Table 2: Soil properties, nutrient status in various paddy growing practices

Paddy Growing Practice	pH	EC	Available		
			N	P	K
	1:2.5	d S m^{-1}	kg ha^{-1}		
Conventional Lowland	7.47	0.32	162.01	25.32	312.39
Organic Lowland	7.62	0.37	207.54	37.41	376.55
INM Lowland	7.77	0.31	173.38	30.49	383.66
Conventional Upland	7.50	0.25	174.73	21.15	344.79
INM Upland	7.64	0.16	186.11	26.74	370.08
SE (m)$^{+-}$	0.13	0.04	8.98	4.23	41.7
CD at 5%	NS	NS	26.50	12.65	NS

Available N, P and K (kg ha^{-1})

The observed value of available N content of soil comes under the categories of medium in range. The available N significantly and varied from 162.01 to 207.54 kg ha^{-1}, the highest available N content was recorded in organic lowland practice whereas lowest available N observed in conventional lowland.

The available P and K at maturity stage of paddy were not significant under various paddy growing practices. The available Pranges from 21.15 to 3741 kg ha^{-1} and available K is varied from 312.39 to 383.66 kg ha^{-1}, slightly more P content was recorded in organic lowland practice whereas, available K was higher in INM lowland.

This may be attributed to slow release of nutrients through the organic sources. Vidyavathi *et al.*, (2012) [24] reported that the integrated nutrient management practice recorded significantly higher available P_2O_5 and K_2O when compared to chemical nutrient management practice. Available N, P_2O_5 and K_2O status of soil significantly increased over their initial level with organic sources (Sharma *et al*., 2001). These results are in line with those reported by Ponnamperuma (1972) [17] and Narteh and Sahrawat, (1999) [13].

Table 3: Available micro-nutrient status at maturity stage of Paddy in various growing practices

Paddy Growing Practice	Available (mg kg-1)				MBC	DHA
	Fe	Mn	Cu	Zn	mg kg^{-1}	μ TPFg^{-1}d^{-1}
Conventional Lowland	7.40	4.79	0.56	0.71	191.13	35.76
Organic Lowland	8.02	4.69	0.64	1.22	251.25	44.87
INM Lowland	7.44	4.84	0.60	1.03	236.35	37.30
Conventional Upland	4.50	4.32	0.60	0.59	171.19	30.24
INM Upland	5.20	4.27	0.61	0.72	241.18	39.98
SE (m)$^{+-}$	0.81	0.71	0.05	0.16	17.67	1.72
CD at 5%	2.39	NS	NS	0.46	52.12	5.08

Available Micronutrients status of soils as influenced by various paddy growing practices

The available DTPA-extractable micro nutrients were significantly higher under flooded method as compared to aerobic method of cultivation. The DTPA- Fe content varied from 2.78 to 3.65 ppm, DTPA-Cu content varied from 0.41 to 0.62ppm, DTPA- Zn varied from 0.37 to 0.50ppm and DTPA-Mn varied from 1.50 to 1.90 ppm. Application of 100% RDF along with the different organic sources significantly increased the status of micro nutrients content in soil compared to 100% RDF. Sharma *et al.*, (2000) Also, observed the significant enhancement in DTPA-extractable micronutrients due to incorporation of crop residues and FYM compared to chemical fertilizers application. Bellakki and Badanur (1997) [5] reported the increase in micronutrients in soils with addition of organics to the enhanced microbial activity and consequent release of complex organic substances (chelating agents) which helped in preventing the loss besides addition of these nutrients to the available pool on decomposition of organics. However lower micro nutrients was recorded in burning of rice straw compared to other organic sources this may be attributed to loss nutrients during burning

The micro nutrients content under flooded method with different organic sources was significantly higher compared to aerobic method of cultivation for all the organic sources except Zn this may be attributed to loss of Zn under flooded method more compared to aerobic. These results are in line with those reported by Ponnamperuma (1972) [17], Sahrawat (1998) [19]; Narteh and Sahrawat (1999) [13].

The data in respect of DTPA extractable micro-nutrients (Zn, Fe, Mn and Cu) in soil after maturity of rice crop is depicted in table 6. The results revealed that the status of DTPA extractable Zn and Fe ranged between 0.71 to 1.22 and 4.50 to 8.02 mg kg^{-1}, respectively when the field treated with the application of organic sources and chemical fertilizer alone among the different locations. The Zn status of these locations comes under low to high in range. The available zinc and Iron in soil is extracted with DTPA. The high amount of zinc is 1.22 mg kg^{-1}present in organic lowland practice and low amount of zinc is 0.71 mg kg^{-1} present in conventional lowland.

Microbial biomass carbon, (mg kg^{-1})

The soil microbial biomass carbon occurred in different paddy growing practices it ranges in between 171.19 to 251.85 mg kg^{-1} The minimum amount of microbial biomass carbon observed in conventional upland practice 171.19 and maximum amount of microbial biomass carbon observed in organic lowland practice 251.85. The MBC was significantly higher in organic lowland practice followed by INM lowland and upland practice.

Microbial biomass C (MBC) is recognized as a sensitive indicator of cultivation-induced changes in both SOC and biological properties of soil (Anderson and Domesch, 1989; Powlson *et al.*, 1987; Karlen *et al.*, 1997) [2, 18, 10]. Microbial biomass, small but labile component of soil organic matter pool that can be used as an early indicator of changes occurring in soil due to management practices. Microbial biomass responds quickly to changes in soil management and is used as an indicator of soil quality. Microbial biomass is not only used as an indicator of soil quality, it is the main agent that also controls the cycling of important nutrient elements such as C, N, P, S and other nutrients in terrestrial ecosystems.

The soil microbial biomass serves as a sink (immobilization) and a source (mineralization) of important nutrient elements, controlling the supply of nutrients to crops through mineralization and immobilization processes (Abbasi *et al.*, 2001; Fosu *et al*., 2007) [1, 8] depending on moisture, temperature and other environmental influences (Lodhi *et al.*, 2009) [12]. Yang *et al*. (2005) [25] reported that integrated nutrient management practices maintained highest MBC and MBN in soil compared to chemical fertilizer alone. Anil Kumar Singh (2010) [3] observed that organic carbon and microbial biomass carbon increased in the treatments that received organic manures (particularly FYM), green manure and bio fertilizers in conjunction with inorganic fertilizers.

Dehydrogenase Activity (μgTPF/g/d)

The dehydrogenase activity observed in different paddy growing practices ranges in between 30.24 to 44.87 μg

TPF/g/d the lowest amount of dehydrogenase activity occurred in conventional upland practice 30.24 and highest amount of dehydrogenase activity occurred in organic lowland practice 44.87

DHA is considered as indicator of overall microbial activity in soils as this enzyme is known as oxidize soil organic matter because it occurs intracellular in all living microbial cells and it is linked with microbial respiratory process. It is commonly used as an indicator of biological activity in soils (Sharma and subehia, 2014) [20]. The activities of dehydrogenase enzyme in a soil system are very important as it may give indications of the potential of the soil to support bio-chemical processes which are essential for maintaining soil fertility. It produced by intact cell, promotes mineralization of organic matter which is an important index to evaluate anaerobic decomposition of soil organic matter.

Yield of Rice (qha^{-1})

The yield data depicted in table 6 was collected from the farmers. The yield of paddy was recorded between 32.34 to 48.10 t ha^{-1} in location of villages of Kamthi and Mauda under various paddy growing practices. Higher grain yield of paddy observed in lowland than upland cultivation practices. Grain yield (48.10 q ha^{-1}) was highest in INM lowland farmer's field which was followed by organic lowland practice.

Relationship between microbial activity, fertility and yield. Significant positive correlation was observed between SMBC and DHA (R^2 = 0.759) indicating higher microbial activity with increase in soil biomass carbon. DHa was positively correlated with available N, Fe and Zn indicated its role in nutrient availability. The yield pf paddy increased with increase in microbial activity.

Table 4: Yield of paddy crop under various paddy growing practices

Paddy Growing Practice	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Mean
Conventional Lowland	35.78	39.54	37.44	35.98	34.43	38.89	37.01
Organic Lowland	37.65	36.44	38.87	41.36	38.54	36.68	38.25
INM Lowland	44.54	43.35	44.64	45.12	46.43	48.10	45.36
Conventional Upland	32.34	35.45	34.45	32.87	33.94	37.14	34.36
INM Upland	35.43	38.45	33.56	35.48	34.43	36.98	35.72
					SE (m)$^{+-}$ CD at 5%		0.78 2.30

Conclusion

From the result obtained in the present investigation, it can be concluded that, the soils are alkaline in reaction, the nitrogen content present low to medium range. The nitrogen is higher in organic lowland practice. The value of available P content of soil comes under highest range in organic lowland practice and lowest range in INM upland practice. Available K was higher in INM lowland and lowest in conventional lowland. The DTPA extractable Fe, Cu and Zn were highest in organic lowland cultivation and the DTPA extractable Mn highest in INM lowland practice. The maximum amount of microbial biomass carbon and dehydrogenase activity was observed in organic lowland practice. Soil microbial activity and fertility status were maintained in organic lowland followed by INM lowland practices and therefore higher productivity of paddy.

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