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Effect of Organic Manures on the Growth of Wheat (*Triticum aestivum*) and Soil Enzymatic Activity

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Organic agriculture is a holistic production management system which promotes and enhances ecosystem health, including biological cycles and soil biological activity. Application of different organic manures in combination with inorganic fertilizers to wheat crop might give a substitute under pot condition. A pot experiment is conducted during 2012-13with the objective to find out best combination and type of organic and inorganic fertilizer for wheat (*Triticum aestivum*) production. The experiment was laid out with three replication. The treatments were: control (T1, NPK), 100+60+40 NPK Kg/ha+5ton/ha Farmyard manure (T2), 100+60+40 NPK Kg/ha+5 ton/ha Vermicompost (T3), 100+60+40 NPK Kg/ha+5ton/ha Paddy husk (T4), 100+60+40 NPK Kg/ha+2.5 ton/ha Farmyard manure+2.5 ton/ha Vermicompost (T5). After 60days spike length (cm), root length (cm) and number of spikelet's recorded. The soil enzymes dehydrogenase, urease, acid and alkaline phosphatase activity were measured. Enzyme activity in soil is regulated by pH and microbial biomass, which is correlate to soil organic manures content, as well as to soil compaction. The laboratory experiment is conducted in order to monitor the decomposition of vermicompost, paddy husk and farmyard manure when applied in soil under field condition. The rate of decomposition of organic manures was determined in terms of mg of CO_2 evolution per 100g of soil.

Introduction

Worldwide, interest in the use of organic manure is increasing day by day due to depletion in the soil fertility. Continuous use of inorganic fertilizers potential pollutes the environment (Oad *et al.*, 2004). Synthesis of chemical fertilizers consumes a large amount of energy and money. However, the integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interactions leading to increase efficiency and thereby, reduce environmental hazards (Ahmad *et al.*, 1996). The first step should be to increase the organic matter content of the soils through incorporation of as much crop stubble as possible, addition of various kinds of composts, inclusion of rotation crops that contribute organic matter through dropped leaves, and use of legumes as green manures.

Soil is usually degraded due to the constant use and the need to be replenished either by the use of organic matter or fertilizer (Yadav and Arora, 2018). Soil microbes decompose the organic materials to obtain energy for growth and carbon for the synthesis of new cell material. Carbon dioxide, methane, organic acids, alcohol and other oxidised and partially oxidized form of C may be metabolic wastes for one group of microbes, whereas they may serve as energy and C Source for other group. Enzymes are released in the process of decomposition. Possible indicator value of the microbial parameters for environmental stress in general had investigated through microbial possessions including biomass and soil enzyme processes (Bandick *et al.,* 1999). Enzyme activity in soil is regulated by pH and microbial biomass (Dick *et al.,* 1988), which is correlate to soil organic as to soil moisture content (Harrison,1983) as well as to soil compaction (Karaca *et al.,* 2000). Soil enzyme activity is variable in time and limited by available substrate supply (Degens *et al.,* 1988) and may provide useful linkage between microbial community composition and carbon processing (Waldrop *et al.,* 2000). Enzymatic activities as caused by soil microbial activities were sensitive indicators to detect changes occurring in soils (Gonzalez *et al.,* 2007).

Wheat (*Triticum aestivum*) is grown all over the world for its high nutritious value. It is ranked among the top three most produced cereal crops in the world, along with corn and rice (Byerlee *et al.,* 1983). Wheat grain is consumed in several ways in a number of industries and commercial products. Optimal crop growth requires a non-limiting supply of resources such as water and nutrient (Reynolds *et al.,* 1998; Midmore *et al.,* 1984). The application of organic manures like vermicompost, paddy husk and farmyard manure to soil have increased crop yield, improved soil fertility, increased soil organic matter, increased microbial activities and improved soil structure for sustainable agriculture for further years (Blair *et al.,* 2005; Kundu *et al.,* 2006). However the proper combination of both organic and inorganic fertilizers have better effects on crop growth and development and yield component of wheat than alone (Budaruddin *et al.,* 1999; Hossain *et al.,* 2002; Manna *et al.,* 2005).

Hence in light of the significance of the above informatics and possibilities, research project entitled "Effect of organic manures with recommended dose of NPK on the performance of Wheat (*Triticum aestivum*)" was undertaken with the objectives: to understand the effect of organic manures on growth and physiological changes during the growth of wheat (*Triticum aestivum*); and soil bio-chemical properties including soil enzymatic activity, in comparison with chemical fertilizer NPK; and to understand the decomposition rate of organic manures on soil.

Materials and Methods

Study area

The study was conducted in the Shree P. M. Patel Institute of Post Graduate Studies And Research In science, Anand (located at 22° 32' N Latitude 73° 00' E Longitude). The climate condition is hot and dry, pre-monsoon summer months May to June followed by monsoon period June to September. The subsequent short period of October to November received uncertain and infrequent showers followed by fair, dry and mild winter December to February. The mean air temperatures are about 40° C during April-May and minimum, 15-20° C noticed during December-January. Bulk of the rainfall is received during July to September months and the mean annual rainfall. The soil used in this study was collected from farmer's field at Anand, Gujarat, India, during the winter season of 2012-2013.

Pot experiment

To know the response of different organic manures on the wheat (*Triticum aestivum*) and also to monitor effect of manures on soil bio-chemical changes, microbial population and enzymatic activity a pot experiment was conducted. Polythene pots of approximately of 3 Kg capacity were filled with finely powdered and sieved soil. The different organic manure treatments were given along with NPK fertilizer. The treatments imposed were T1: NPK (Control); T2: NPK and vermicompost; T3: NPK and farm yard manure; T4: NPK and paddy husk; T5: NPK and ½ farm yard manure and ½ vermicompost. Each treatment was replicated three times in a completely randomized block design. Pots were arranged on a floor in a wire-netting greenhouse under natural environmental conditions. Water was added to all the pots to bring the soil to 100% saturation and allowed to equilibrate.

Laboratory experiment

In order to monitor the decomposition of Vermicompost, paddy husk and farmyard manure when applied in soil under field capacity moisture condition laboratory incubation experiment was initiated 100g soil treated with Vermicompost, Paddy husk and farmyard manure at 5 ton ha^{-1} were mixed and transferred to 500ml capacity. The glass tube containing 10ml of 0.5N NaOH was hung in each flask and stoppered and made air tight with paraffin wax. The flasks were incubated at $27^{\pm 5}$°c for 60 days. All the flasks were replicated thrice. A control containing only soil and a blank were also maintained. Rate of decomposition was determined in terms of mg of CO_2 evolution per 100 g of soil (Pramer and Schmidt, 1964).

Determination of soil acid and alkaline phosphatase activity

3ml of substrate incubated at 37˚C for 5 minutes. Then 0.5ml of enzyme extract added and mixed well. 0.5ml from this mixture removed immediately and mixed it with 9.5ml 0.085N NaOH. This corresponds to zero time assay (blank). Then remaining solution (Substrate + enzyme) incubated for 15 min at 37˚C. Then 0.5ml sample drawn from this and mixed it with 9.5ml NaOH solution. The absorbance of blank measured at 405nm. 0.2 to 1.0ml (4 to20mM) of aliquot taken for standard, diluted to 10ml with NaOH solution. Acid phosphatase enzyme was extracted in citrate buffer (pH-5.2). Alkaline phosphatase enzyme was extracted in glycine-NaOH buffer(pH-10.4) (Tabatabi M A, Bremmer J M,1969).

Determination of soil Urease activity

Method of Enzyme Extraction

10 g of dry and sieved soil was taken and 1.5 ml of toluene added. Mixed well and incubated for 15 minutes. Then 10 ml of urea solution and 20 ml of citrate buffer added. Mixed thoroughly and incubated for 3 hours at 37 C in an incubator. The solution diluted to 100 ml with water. Filtered through a fluted paper & filtrate used as enzyme source. For each soil sample, blank was prepared, similarly containing water instead of water solution through above steps.

Enzyme assay

For enzyme assay 1ml of filtrate, 9 ml of water, 4 ml phenate solution & 3 ml of sodium hypochlorite solution taken into 50 ml volumetric flask. Mixed well & allowed standing for 20 min until the maximum color was obtained. Diluted to 50 ml with water and mixed well. Reading was taken at 630nm within 60 minute against reagent. The standard curve constructed by pipetting out 0, 1, 2, 4, 6, 8 and 1 ml of diluted standard ammonium sulphate solution into a series of 50 ml volumetric flasks and volume made in each flask to 10 ml with water. Then 4 ml of phenate solution and 3ml of NaOCl solution added and proceed as for sample solution. The absorbance measured against the blank i.e. zero flask & plot a graph optical density v/s concentration.

Determination of soil dehydrogenase Activity

One gram of air dried soil sample taken in air-tight screw capped test tube (15 ml capacity). Then 0.2 ml of 3% TTC (2,3,5-Triphenyltetrazolium chloride) and 0.5ml 15 glucose solution taken in each tube. All tubes incubated at 28±0.5 ^{0}C for 24 h. After incubation, 10 ml of methanol added. The solution was shaken vigorously and allowed to stand for 6 h. The clear pink coloured supernatant withdrawn and reading taken with a spectrophotometer at a wave length of 485nm (blue filter).

Results and Discussion

The effect of different organic manures on wheat along with inorganic fertilizers on growth and development, yield and yield attributes and change in soil characteristics in wheat harvest in pot culture experiments are discussed.

The plant growth parameters

The plant shoot length was maximum in control as compared to other manorial treatments after first harvesting, because at initial stage decomposition of organic manures was slow. After second harvesting higher shoot length was observed in vermicompost, farmyard manure and paddy husk along with NPK as compared to control. After third harvesting higher shoot length was also recorded in all manorial treatments as compared to control. It was because of decomposition of organic manures reached at its peak gave nutrients to plant for better growth. Organic matter from manure, besides supplying multiple nutrients to the soil, affects soil organic matter and tilth in favour of crop emergence and growth (Schoenau *et al.*, 2000; Assefa, 2002; Campbell *et al.*, 1986; Hoyt and Rice, 1977; Stewart, 1982; Unger and Stewart, 1974; Meek *et al.*, 1982; Allison, 1973).The effect of these different organic fertilizers showed significant increase of the biomass of wheat in all the treatments in comparison to controlled one. Plant’s response to vermicompost showed much better result than any other manorial treatments (Gautam Kumar *et al.*, 2010).

The number of grains was found to be higher in vermicompost, farmyard manure and paddy husk given in combination with NPK after second harvesting, because of regular availability of nutrients to plants due to decomposition of vermicompost, farmyard manure and paddy husk in soil.

The maximum grain yield was recorded in paddy husk along with NPK after third harvesting, because of slow release of nutrients due to decomposition of paddy husk attained 36 days after incorporation (fig.). The higher spike length was recorded in vermicompost, farmyard manure and paddy husk along with NPK after second and third harvesting as compared to control, decomposition of organic manures releases N sources had significant effect on spike length. Results showed that either mineral N or organic N both helped the plants to produce well developed spikes (Khan *et al.*, 1996, Singh *et al.*, 2001, Iqbal *et al.*, 2002).

Decomposition rate of Vermicompost, farmyard manure and paddy husk

The study from graph of decomposition of organic manures suggests that the decomposition of vermicompost evolved 114 mg CO_2 attained very early 22 days after incorporation. However, decomposition of farm yard manure and paddy husk evolved 112.4 and 101.3 mg CO_2 attained 28 and 36 days respectively, after incorporation. Interestingly it was observed that only after 22 days the decomposition in the form of CO_2 evolution started to increase to peak in case of vermicompost treated soil. In case of farmyard manure treated soil, decomposition was attained to optimum at 28 days after incorporation. However, in paddy husk treated soil, decomposition was attained to optimum at 36 days after incorporation. This shows that decomposition of paddy husk is slow initially and it takes about 36 days to gets decompose and supply nutrients to treated soils. These results also showed that decomposition of all three organic manures decreases gradually after 61 days after incorporation. This results suggests that vermicompost, paddy husk and farmyard manure if applied, should be incorporated in soil well in advance before sowing to enable the plants get nutrient supply from the since day initial stages (Naher *et al.*, 2004).

Acid phosphatase activity

In first sampling the maximum acid phosphatase activity was recorded as 9.46µg PNP/g in NPK+ ½vermicompost + ½ farmyard manure and minimum activity was observed 8.54 µg PNP/g in soil treated with NPK + vermicompost. In second sampling the maximum acid phosphatase activity was recorded as 10.81 µg PNP/g in NPK+ vermicompost and minimum activity was observed 10.16 µg PNP/g in soil treated with NPK + ½ vermicompost + ½ farmyard manure. In third sampling the maximum acid phosphatase activity was recorded as 7.1 µg PNP/g in NPK+ vermicompost and minimum activity was observed 5.5 µg PNP/g in soil treated with control.

Alkaline phosphatase activity

In first sampling the maximum alkaline phosphatase activity was recorded as 10.63 µg PNP/g in NPK+ paddy husk and minimum activity was observed 9.2 µg PNP/g in soil treated with NPK + vermicompost. In second sampling the maximum alkaline phosphatase activity was recorded as 13.07 µg PNP/g in NPK+ vermicompost and minimum activity was observed 11.56 µg PNP/g in soil treated with control. In third sampling the maximum alkaline phosphatase activity was recorded as7.53 µg PNP/g in NPK+ vermicompost and minimum activity was observed 6.23 µg PNP/g in soil treated with control.

Phosphatases are a broad group of enzymes that are capable of catalysing hydrolysis of esters and anhydrides of phosphoric acid (Schmidt and Lawoski, 1961). Both acid and alkaline phosphatases activity was lower in the first and third harvesting stage while it showed higher during second harvesting stages in all the treatments. The soil phosphatase activity depends on soil pH values.

Urease activity

In first sampling the maximum urease activity was recorded as13.23µg/NH_4 in NPK+ farmyard manure and minimum activity was observed 9.36µg/NH_4 in soil treated with NPK + vermicompost.

Table.1 Physico – chemical properties of the Initial soil

Particular	Values
1. Mechanical analysis	
Bulk density (Mg m^{-3})	1.40
2. Bio-chemical analysis	
Soil pH (1:2)	7.61
Electrical conductivity (dS m^{-1}) (1:2)	1.40
Moisture content (%)	2.73
Organic carbon (%)	0.38
Available phosphate (mg kg^{-1})	11.2
Available potassium (kg K_2O ha^{-1})	low below 112
Ammonical N (mg kg^{-1})	low about-15
Nitrate N (mg kg^{-1})	very-low-04
Total carbon(g kg^{-1})	7
Total nitrogen(g kg^{-1})	0.039
C:N	179.48
Urease (µg NH_3-N $g^{-1}h^{-1}$)	3.83
Acid phosphatase (µg PNP $g^{-1}h^{-1}$)	4.54
Alkaline phosphatase (µg PNP $g^{-1}h^{-1}$)	4.54
Dehydrogenase (µg TPF $g^{-1}h^{-1}$)	5.64

Table.2 Chemical characteristics of organic manures

Parameters	Vermicompost	Farmyard manure	Paddy husk
pH (1:5)	**6.69**	**7.04**	**6.89**
Electrical conductivity (1:5) (dS m^{-1})	**2.5**	**0.7**	**1.8**
Total phosphate (mg kg^{-1})	**284**	**224**	**384**
Total potassium (mg kg^{-1})	**392**	**315**	**345**
Total N (g kg^{-1})	**14.7**	**10.4**	**6.93**
Total C (g kg^{-1})	**270**	**230**	**357**
C:N	**18.3:1**	**22.1:1**	**51.5:1**
Moisture content (%)	**56.60**	**23.40**	**7.29**

Table.3 Chemical parameters of irrigation water

Parameter	Value
pH	**8.26**
EC (dS/m)	**0.70**
Na	**58.75**
K	**0.08**
Ca	**Traces**
Mg (meq/l)	**7.0**
Cl (meq/l)	**30.0**
HCO_3 (meq/l)	**15**
CO_3 (meq/l)	**10**

Fig.1 Decomposition rate of Vermicompost, farmyard manure and paddy husk

Fig.2 Decomposition of organic manures in soil

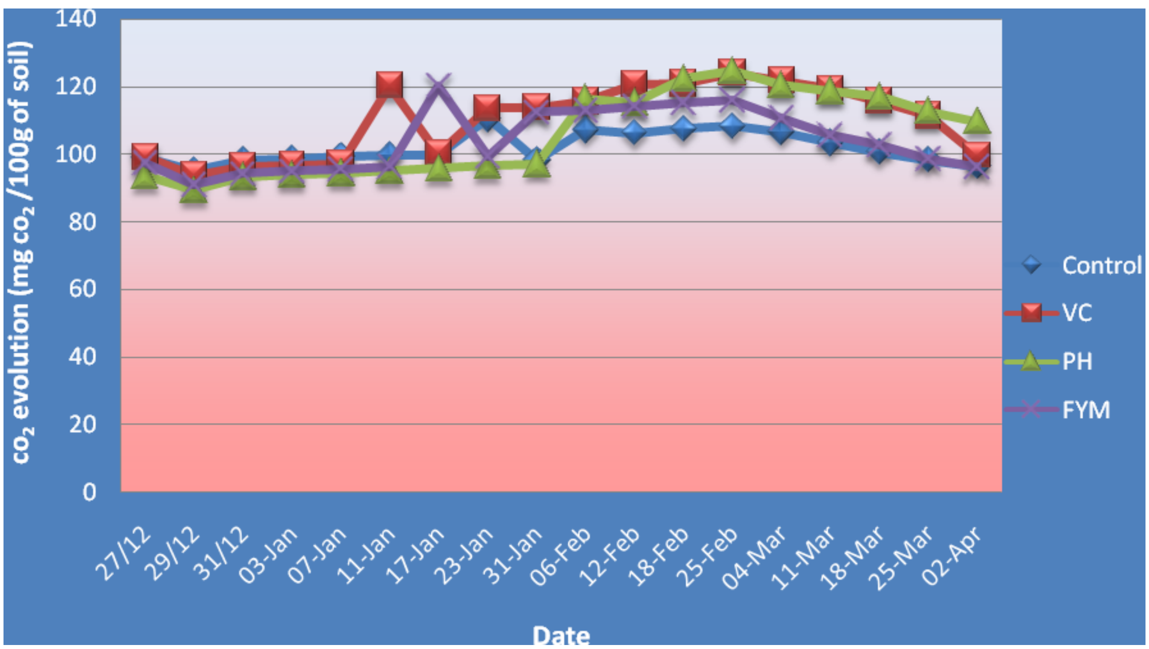


Fig.3 Effect of organic manures on soil acid phosphatase activity

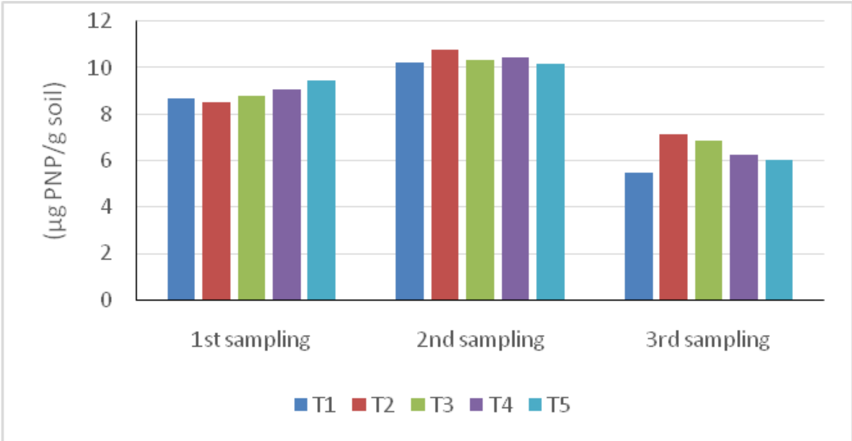


Fig.4 Effect of organic manures on soil alkaline phosphatase activity

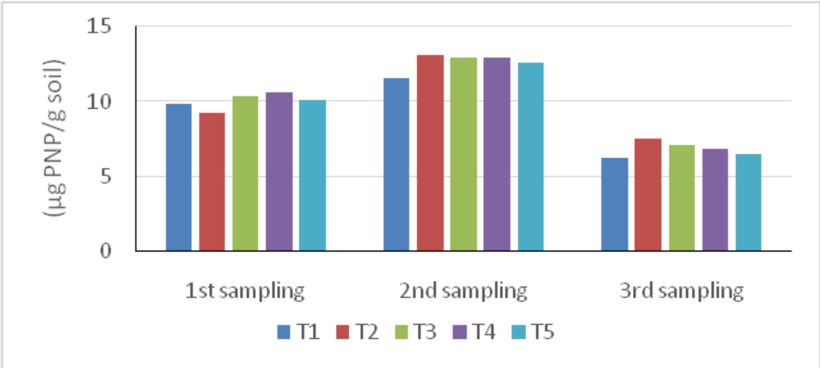


Fig.5 Effect of organic manures on soil urease activity

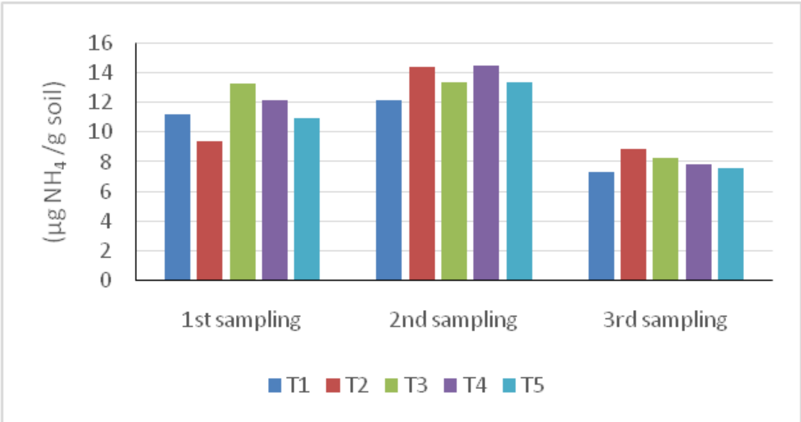
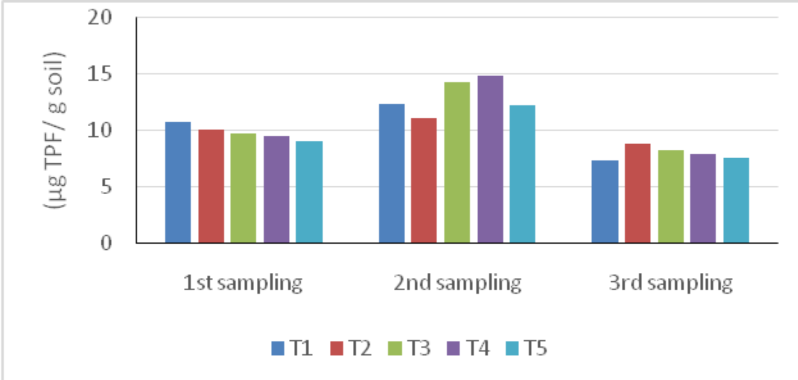


Fig.6 Effect of organic manures on soil dehydrogenase activity



In second sampling the maximum urease activity was recorded as14.49 µg/NH_4 in NPK+ paddy husk and minimum activity was observed 12.17µg/NH_4 in soil treated with control. In third sampling the maximum urease activity was recorded as 8.83 µg/NH_4 in NPK+ vermicompost and minimum activity was observed 7.3 µg/NH_4 in soil treated with control.

Urea hydrolysis did not occur in all the amended soils at the initial days. The perusal data of this investigation reveals that after first, second and third harvesting urease activity increases in manurial treatments as compared to control that might be due to all manurial treatments applied with NPK which rapidly release NH_3 and CO_2. In all manurial treatment urease activity shows increase activity as days passes. The maximum urease activity was measured after second harvesting, because decomposition of vermicompost, farmyard manure and paddy husk attained 22, 28 and 36 days after incorporation which releases nutrient.

Dehydrogenase activity

In first sampling the maximum dehydrogenase activity was recorded as 10.7µgTPF/g in control and minimum activity was observed 9 µgTPF/g in soil treated with NPK + ½ vermicompost + ½ farmyard manure. In second sampling the maximum dehydrogenase activity was recorded as 14.86µgTPF/g in NPK+ paddyhusk and minimum activity was observed 11.05 µgTPF/g in soil treated with NPK + vermicompost. In third sampling the maximum dehydrogenase activity was recorded as 8.8 µgTPF/g in NPK + vermicompost and minimum activity was observed 7.3 µgTPF/g in soil treated with control.

Dehydrogenase enzyme is known to oxidise soil organic matter by transferring protons and electrons from substrate to acceptor. These processes are part of respiration pathways of soil micro-organisms and are closely related to the type of soil and soil air-water conditions (Doelman and Haanstra, 1979; Kandeler *et al.*, 1996; Glinski and Stepniewski, 1985). After second harvesting dehydrogenase activity increases as compared to first and third harvesting in all manurial treatments.

The salient findings of the present study are:

Application of organic manures/amendments in combination with NPK resulted in better growth and biomass of Wheat.

Application of organic soil amendments increases soil total nitrogen and total carbon content as compared to control. Organic manures/ amendment treatment also resulted in soil physical condition that favours better root growth and overall crop production. The results from the decomposition of organic manures/amendments suggest that the enzymes like urease, acid and alkaline phosphatase and dehydrogenase in soil increases.

The results from decomposition rate of biological sludge and vermi compost suggest that if applied, should be incorporated in soil well in advance before sowing to enable the plants get nutrient supply from the since day initial stages.

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