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Assessment of Different Organic Manures on the Performance of Amaranthus (*Amaranthus cruentus*) and Enzymatic Activity and Soil Physical Properties under Saline Water Irrigation

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A B S T R A C T

Salinity is one of the most widespread soil degradation processes on the Earth. Excess soil salinity causes poor and spotty stands of crops, uneven and stunted growth and poor yields, the extent depending on the degree of salinity. Organic manures provides nutrient in stress condition. Application of different organic manures in combination with inorganic fertilizers to Amaranthus might give a substitute under pot condition. A pot experiment is conducted during 2010-12 with the objective to find out best combination and type of organic and inorganic fertilizer for Amaranthus (*Amaranthus cruentus*) production. The experiment was laid out with three replication. The treatments were: control (T_1), 100+60+40 NPK Kg/ha+5ton/ha Vermicompost (T_2), 100+60+40 NPK Kg/ha+5 ton/ha Farmyard manure (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). The aim of this work therefore was to investigate the effects of vermicompost, farmyard manure, paddy husk and NPK fertilizer on soil chemical properties and amaranthus yield in stress condition. The activity of dehydrogenase, urease and phosphatase(i.e. acid and alkali phosphatase) was measured after 7, 14, 21, 28, 35 days after sowing.

Introduction

Agriculture is an integral part of our environment because it is practiced on about 30 percent of the earth's land. Agro ecosystem is a much more open system with a greater number and a larger volume of inputs and outputs than that of unmodified ecosystems. The agro ecosystem is frequently subsidized by the addition of direct or indirect energy which is often seen as necessary for cultivation and increased yields. This more highly concentrated energy flow in the agro ecosystem is accompanied by a disruption of the natural nutrient cycle. The mineral and organic matter of the soil is part of the environment of most terrestrial ecosystems including the agro ecosystem. Soil consists of mineral material, the roots of plants, microbial and animal biomass, organic matter in

various states of decay, as well as water and gaseous atmosphere. Sustainability of agriculture has become a major global concern since the 1980s.

Salinization has been identified as one of the most stressing environmental replacement of ions responsible for the salinity either chemically or by adding organic manure is found to be a viable strategy in ameliorating of salt-affected soils (Jayanta Sinha *et al.*, 2010). The toxic compounds of acidic soil have ability to adsorb the major elements onto their surface such that most of nutrients are fixed instead of being made available for crop use. In these conditions soil suffered from multi-nutrient deficiencies, application of mineral fertilizers has become mandatory to increase crop yields. However, mineral fertilizers are commonly scarce, costly, having imbalanced nutrition and their use could exacerbate the problem of soil acidity. Chemical fertilizer, herbicide and pesticide used in agriculture for increasing yield and controlling weeds and pests can contaminate the water, air and food, decrease soil fertility, inhibit growth of soil microorganisms and hazard human health (Prasad and Sinha, 2008; Law-Ogbomo and Ajayi, 2009; Abdullah Adil Ansari and Kumar Sukhraj, 2010). In addition, chemicals may destroy many species of plants, insects, fishes and soil microorganisms (Eifediyi *et al.,* 2010). Therefore, utilization of organic manures in agriculture is recommended for retaining productivity of problem soils, reducing the usages of chemical fertilizer, improving economy in agriculture and minimizing environmental problems (Zahir Shah and Mian Ishaq Ahmad, 2006; Taura and Fatima, 2008).

Use of saline water with organic manure increased the crop yield. Organic manure improved the soil physical properties, improves soil structure, buffer the soil, improves soil aggregate stability. Increase the soil microorganisms, and enhance water-retention capacity and applied manures raise the soil pH of acidic soil. Organic matter is involved in the enhancement of soil quality since it acts on soil structure, nutrient storage and biological activity. Soil microorganisms are significant determinants of organic matter decomposition, soil nutrient status, crop health, and overall crop productivity. Nutrient cycling in soil involves chemical, biochemical and physico-chemical reactions, with the biochemical reactions being catalysed by soil enzymes primarily associated with viable cells of microbial origin (Klein *et al.,* 1971). Therefore, any factor that affects soil microbial population will necessarily alter soil enzyme activity. Many enzymes involved in the cycling of the principal nutrients are sensitive indicators of management induced changes in soil properties due to their strong relationship with soil organic matter content and quality (Joachim, *et al.*, 2008). Declining soil organic carbon content, and resultant declines in soil fertility, are problems for many of the world's agricultural production systems (Oldeman, 1990).

Hence in light of the significance of the above informatics and possibilities, research project entitled "Assessment of different organic manures on the performance of Amaranthus (*Amaranthus cruentus*) and enzymatic activity and soil physical properties under saline water irrigation" was undertaken with the following objectives: to understand the effect of organic manures on soil chemical and physical properties, in comparison with chemical fertilizer NPK; to study the impact of organic manures on growth and physiological changes during the growth of amaranthus; to study the effect of organic manures on soil enzymatic activity

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 2011-2012.

Pot experiment

To know the response of different organic manures on the Amaranthus (*Amaranthus cruentus*) and also to monitor effect of manures on soil bio-chemical changes 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.

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 1.0 ml (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).

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 ˚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 results pertaining to the present investigation showed the decrease in the growth of amaranthus at first, second and third harvesting stage under different organic manure treatments as compared to control, because of nutrient unavailability in the soil. The decomposition of organic manure takes place after thirty days of application. During the fourth and fifth harvesting stage, it was observed that the growth of amaranthus was higher in all treatments where NPK was coupled with organic amendments, as compared to control, because of decomposition of the organic materials results in release of nutrients that are available in the soil.

The plant growth parameters

In first harvesting maximum wet weight was found in the soil treated with NPK+farmyard manure, because of N availability in the soil. The increase in fresh weight of crop was found at third harvesting stage in the pots that received treatment of NPK+vermicompost. This might be due to slow and steady release of nutrients supply especially N and P in the soil. In the fourth and fifth harvesting stage, increase in fresh weight and dry weight of Amaranthus was found in all organic manures treatments as compared to control. That might be due to application of organic material which tends to decompose and slow release of relatively large amounts of nitrogen into the soil which in turn enhanced plant foliage/biomass. As a result, the plants produced by inorganic fertilizers showed relatively lower yield compared to organic materials (Shashidhar *et al.*, 2009). In the present study, increase in growth parameters viz. dry and wet weight of amaranthus were influenced by the application of organic soil amendments in combination with NPK. Similarly, there are reports that, application of different kinds of combination of organic manures+ inorganic fertilizers recorded significant higher number of leaves, shoot length and root length as compared to control (Shashidhar *et al.,* 2009). The casts of earthworm through vermicompost is one of the most useful and active agent in introducing suitable chemical, physical and microbiological changes in the soil and thereby, directly increasing fertility and crop productivity power in the soil (Kipkosgei, *et al*., 2003).

Physical and chemical properties of soil

Soil Bulk density

Data related to soil bulk density as mentioned in graph depicted the applications of organic manures have significantly affected the bulk density of soil. In the first, second and third harvesting bulk density was higher in all organic manure treatment, but it decreases after fourth and fifth harvesting as compared to control (Surindra Suthar, 2009). The decrease in bulk density after fourth and fifth harvesting might be due to the more aggregation of soil particles that resulted because of decomposed material and this aggregation improves porosity of the soil (Akparobi, 2009).

Soil Electrical conductivity

Electrical conductivity of soil in all treatments of the first and second harvesting lower as compared to third and fourth harvesting stage might be because of decomposition of organic manures takes place after twenty days of treatment and in turn release of organic acids. Then again it showed decrease in electrical conductivity in the fifth harvesting, because after thirty days again decomposition decreases due to low microbial activity in lack of substrate.

Table.1 Physico-chemical properties of the Initial soil

Particular	*Values*
1. Mechanical analysis	
Soil texture	loamy
Bulk density (Mg m^{-3})	1.26
2. Bio-chemical analysis	
Soil pH (1:2)	7.37
Electrical conductivity (dS m^{-1}) (1:2)	0.47
Moisture content (%)	0.73
Organic carbon (%)	0.50
Available Nitrogen (kg ha^{-1})	78
Available phosphate(mg kg^{-1})	3.6
Available potassium (kg K_2O ha^{-1})	392
Ammonical N (mg kg^{-1})	1.5
Nitrate N (mg kg^{-1})	5.0
Total carbon(g kg^{-1})	17.4
Total nitrogen(g kg^{-1})	0.66
C:N	10.5:1
Urease (µg NH_3-N $g^{-1}h^{-1}$)	11.74
Acid phosphatase (µg PNP $g^{-1}h^{-1}$)	9.36
Alkaline phosphatase (µg PNP $g^{-1}h^{-1}$)	18.24
Dehydrogenase (µg TPF $g^{-1}h^{-1}$)	13.87

Table.2 Chemical characteristics of organic manures

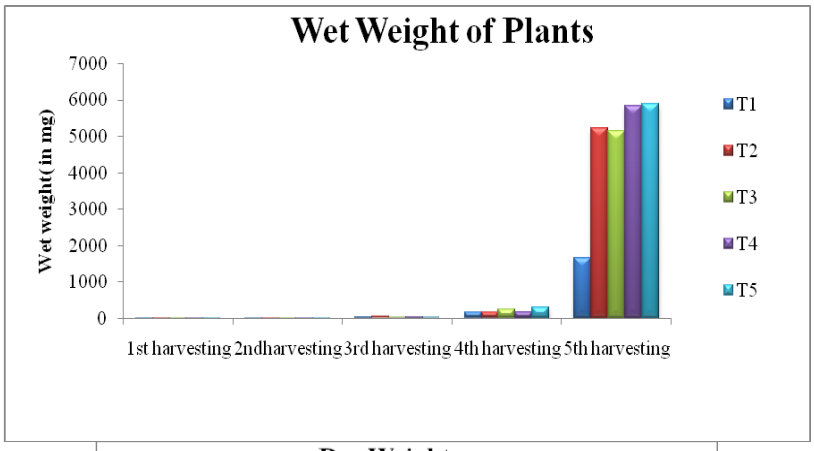
Parameters	Vermi compost	Farmyard manure	Paddy husk
pH (1:5)	6.69	7.04	6.89
Electrical conductivity (1:5)	2.5	0.7	1.8
Total phosphate (mg kg^{-1})	284	224	384
Total potassium (mg kg^{-1})	392	315	345
Total N (g kg^{-1})	14.7	10.4	6.93
Total C (g kg^{-1})	270	230	357
C:N	18.3:1	22.1:1	51.5:1
Moisture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

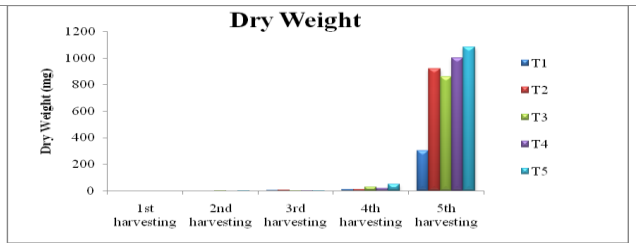
Table.3 Chemical parameters of irrigation water

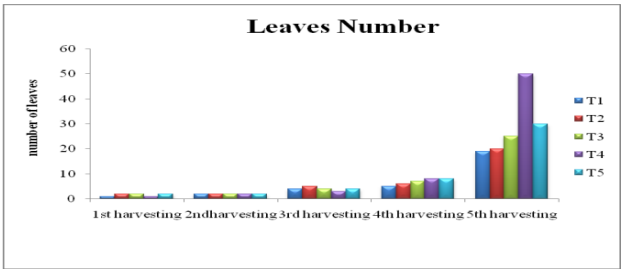
Parameter	Value
pH	8.26
EC (dS/m)	2.70
Na	58.75
K	0.08
Ca	Traces
Mg (meq/l)	7.0
Cl (meq/l)	30.0
HCO_3 (meq/l)	15

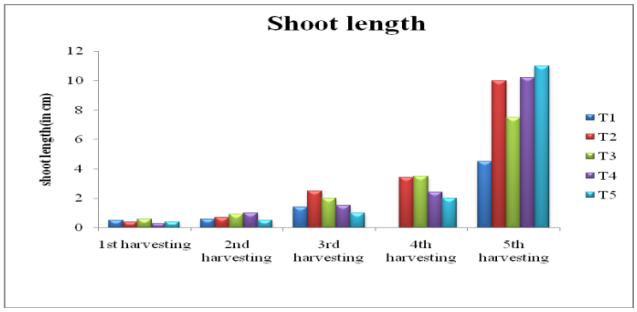
CO_3 (meq/l)	10

Fig.1 The plant growth parameters


Wet Weight of Plants
Wet weight(in mg)
7000
6000
5000
4000
3000
2000
1000
0
1st harvesting
2ndharvesting
3rd harvesting
4th harvesting
5th harvesting
T1
T2
T3
T4
T5


Dry Weight
Dry Weight (mg)
1200
1000
800
600
400
200
0
1st harvesting
2nd harvesting
3rd harvesting
4th harvesting
5th harvesting
T1
T2
T3
T4
T5


Leaves Number
number of leaves
60
50
40
30
20
10
0
1st harvesting
2ndharvesting
3rd harvesting
4th harvesting
5th harvesting
T1
T2
T3
T4
T5


Shoot length
shoot length(in cm)
12
10
8
6
4
2
0
1st harvesting
2nd harvesting
3rd harvesting
4th harvesting
5th harvesting
T1
T2
T3
T4
T5

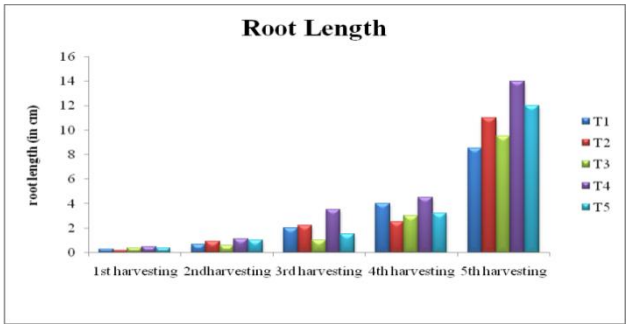

Root Length
root length (in cm)
16
14
12
10
8
6
4
2
0
1st harvesting
2ndharvesting
3rd harvesting
4th harvesting
5th harvesting
T1
T2
T3
T4
T5

Fig.2 Bulk density

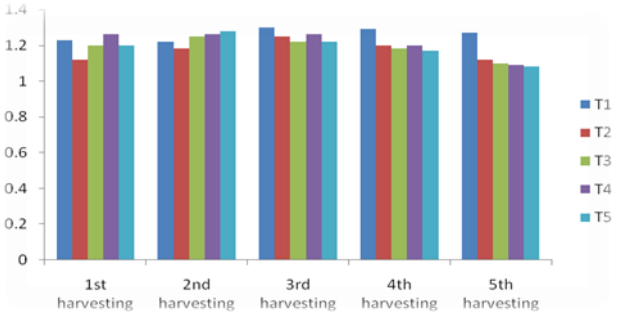


Fig.3 Soil Electrical conductivity

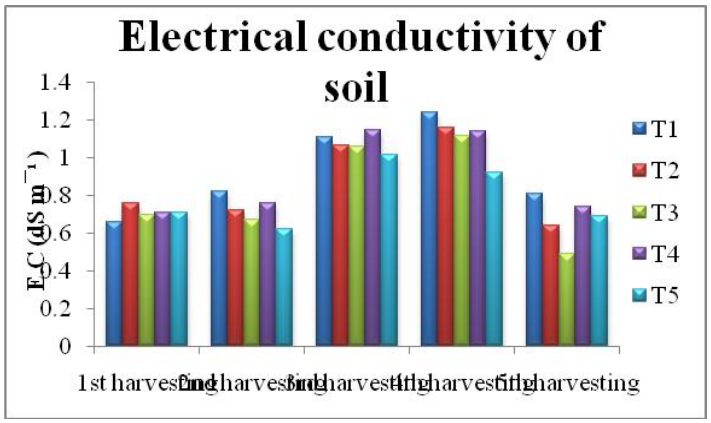


Fig.4 Soil pH

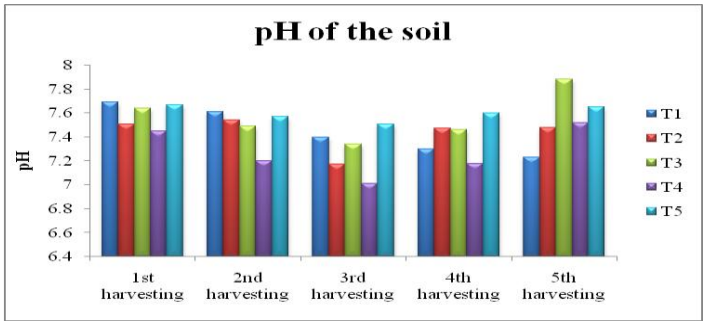
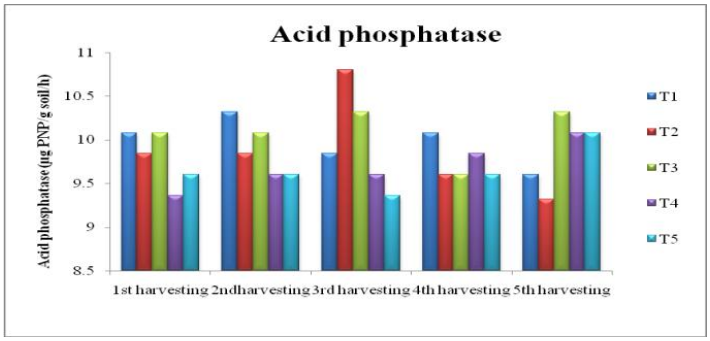


Fig.5 Acid and Alkaline phosphatase activity



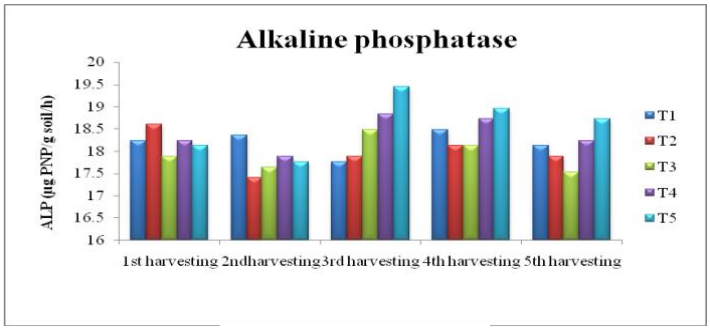


Fig.6 Urease activity

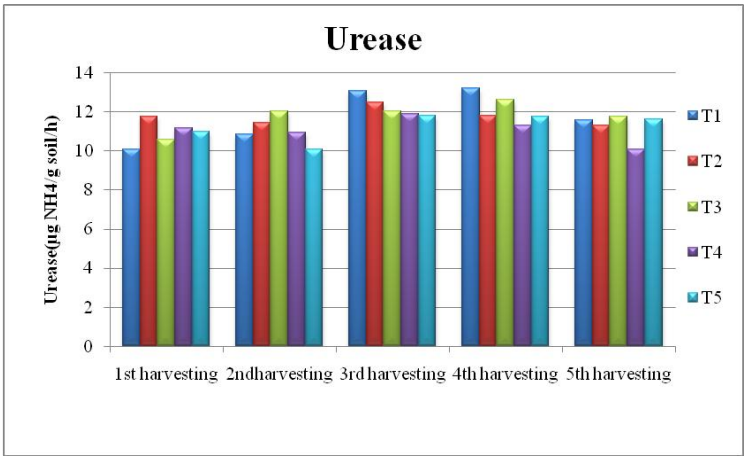
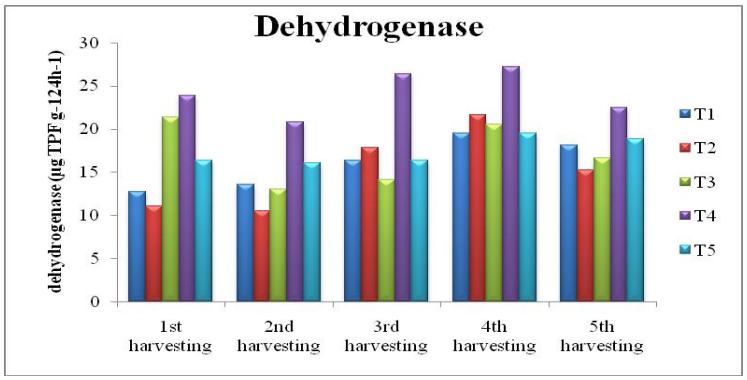


Fig.7 Dehydrogenase activity



Soil pH

The data shows that soil pH in all treatments in the second and third harvesting decreases as compared to first harvesting. Then it increases in the fourth and fifth harvesting in all treatments as compared to second and third harvesting.

These could be due to initial decomposition of organic manures was slow, it increases with the period. So in the fourth and fifth harvesting because of decomposition of organic manures occur that results in release of organic acids and nutrients to soil which decreases soil alkalinity.

The maximum pH value found in the soil treated with NPK+farmyard manure in the fifth harvesting. It shows increase pH values in all organic manures treatments as compared to control.

Acid and Alkaline phosphatase activity

Phosphatases are a broad group of enzymes that are capable of catalysing hydrolysis of esters and anhydrides of phosphoric acid. Both acid and alkaline phosphatases activity was lower in the first and second harvesting stage while it showed higher during third and fourth harvesting stages in all the treatments. In the fifth harvesting maximum phosphatase activity found to be high in the soil treated with NPK+ farmyard manure. The soil phosphatase activity depends on soil pH values.

Urease activity

Application of crop residues and organic manures significantly increased the rate of urea hydrolysis in the amended soils. Urea hydrolysis did not occur in all the amended soils at the initial days. The perusal data of this investigation reveals that after first and second 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.

Dehydrogenase activity

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 (Buntingd, 1965; Ayers and Westcot, 1985; Bibhuti, *et al.*, 2011). After second, third and fourth harvesting dehydrogenase activity increases as compared to first harvesting in all manurial treatments. The dehydrogenase activity found to be maximum in the soil treated with NPK+paddy husk treatment followed by NPK+farmyard manure.

The present study was undertaken to understand the effect of use of organic soil amendments coupled with NPK on growth and performance of Amaranthus as well as to monitor the impact produced on soil bio-chemical properties.

The salient findings of the present study are:

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

Application of organic manures improves soil physical properties like soil bulk density which is directly related to porosity, water holding capacity, infiltration rate, aeration and soil structure.

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.

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