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# Impact of Fertigation on Soil Microbial Community and Enzyme Activities Cropped with Maize (cultivar. COMH 1) under Precision Farming System

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**Precision farming is an integrated plant nutrient management system attempt to deliver the inputs actual crop needs without disturbing the entire farming area. The fertilizers in liquid state will be delivered through laterals directly to the root zone at high concentrations. Soil microorganisms are potential resources for soil productivity and sustainability, intended to be influenced by various anthropogenic-and farming activities. Hence in present study, we have investigated that the effect of different dose of liquid fertilizers on changes in soil microbial populations and enzyme activities of maize in comparison with conventional practice of fertilization. The results clearly revealed that all the fertilization reduced the microbial population and enzyme activities of maize rhizosphere and among the fertigations, 75 per cent of recommended NPK in the form of liquid fertilizer had a less reduction in the population of *Azospirillum,* P solubilising bacteria and total diazotrophs, soil respiration and enzyme activities. Hence it is evident from the study that the use of more organic manures and microbial inoculants along with inorganic chemicals fertilizers, as integrated approach is needed for precision farming.**

**Key words:** *Azospirillum*; Fertigation; Maize; Precision farming; Soil enzymes

Precision farming or precision agriculture aims at increasing productivity, decreasing production costs and minimizing the environmental impact of farming (Maheswari *et al.*, 2008). It is an integrated crop management system that attempts to match the kind and amount of inputs with the actual crop needs for small area within a farm field (Ahlwaalia *et al.,* 1993). It is based on soil, weather and crop requirement to maximize sustainable productivity, quality and profitability. Agricultural sustainability requires optimal use and management of soil fertility, soil physical properties, both of which relay on soil biological processes (Saxena and Tilak, 1998) which has been achieved through precision farming. Soil microorganisms are responsible for breakdown of organic matter, help releases of nutrients and their availability for other organisms (Jenkinson, 1988). Further microbial activity and biomass dynamics help to regulate long term soil properties such as net fluxes and amount of soil carbon and nutrients (Bauhus and Barthel, 1995), hence it is served as an important reservoir of plant nutrient such as N and P. The soil microbial biomass is often regarded as an early indicator of changes which may occur in the long term with regard to soil fertility and agro ecosystem properties (Powlson *et al.*, 1987). Its size and activity directly related to the amount and quality of carbon and other nutrients available from plant residues, organic amendments and root exudates. Soil enzymes are derived primarily from soil fungi, bacteria, plant roots, microbial cells, plant and animal residues, etc. (Brown, 1973) and play a significant role in mediating biochemical transformations involving organic residue decomposition and nutrient cycling in soil (McLatchey and Reddy, 1998).

Management practices which are associated with intensification of agriculture (Giller *et al.,* 1997) are well known to alter soil microbial biomass and activity and this has been the topic of considerable research effort over the past two decades. Thus microbial biomass responds to alteration in tillage practices (Lynch and Panting, 1980) addition of fertilizers (Fauci and Dick, 1994) and pesticides (Wardle and Parkinson, 1991) and manipulation of organic residues (Franzluebbers *et al.,* 1995) and cover species (Beese *et al.,* 1994).

It has been shown that microbial activity and biomass are higher in fields with organic amendments than field with conventional fertilizers (Gunapala and Scow, 1998). The amount of soil nitrogen in fields under conventional production system has been negatively correlated with soil microbial components, where as soil nitrogen in fields under organic production was positively

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correlated with soil microbial components (Gunapala and Scow, 1998). Inorganic N fertilization can have significant effect on soil microorganisms and enzymes through higher plant yield and thus, crop residues and through its impact on soil pH depending on the amount and type of fertilizers (Tabatabai *et al.,* 1992). Nitrogen fertilizers application may lead to lowering the soil pH (Aref and Wander, 1998). Most N containing inorganic fertilizers, unless specially treated tends to acidify soil. This is mainly due to the fact that most fertilizer supply $NH_4^+$ or result in its production. Upon oxidation $NH_4^+$ can release $H^+$ ions which are potential source of acidification (Magdoff *et al.*, 1997).

Limited field studies have been conducted to determine the impact of soil amendments on microbial communities in actual organic and conventional production systems in the fields (Gunapala and Scow, 1998). As precision farming aims to feed the liquid form of mineral nutrients directly in the rhizosphere region of crop plants, certainly they may cause flux in the native populations of functional microorganisms and enzymes in rhizosphere. With this hypothesis, the present investigation was carried out to study the effect of fertigation on soil microbial community and enzyme activity.

## Materials and Methods

***Field experiment***

A field experiment was conducted to study the impact of liquid fertilizers on soil microbial community and enzyme activity with maize crop (Cultivar COMH 1) under precision farming system at Eastern Block of Tamil Nadu Agricultural University, Coimbatore during *Kharif* season, 2007. The physio chemical and microbiological properties of the experimental field soil were presented as Table 1. The experiments were laid out in a randomized block design with five treatments and three replications with a plot size of 90 sq.m each. The treatments includes $T_1$-Uninoculated and unfertilized control, $T_2$-75% RDF (Recommended dose of fertilizer) of NPK through drip, $T_3$-100% RDF of NPK through drip, $T_4$- 150% RDF of NPK through drip and $T_5$-100% RDF of NPK through conventional method of application. Fertilizers were applied at weekly intervals in the form of urea, multi K and polyfeed as per the schedule recommended for precision farming system through fertigation tank. In the case of conventional method, fertilizers were applied by broadcasting.

***Soil microbial populations***

The rhizosphere soil samples at weekly interval were collected at five different plants of each plot and pooled. The stones and stubbles removed soil samples packed in air tight polybags were stored at 4°C for further analysis. The population of *Azospirillum* was enumerated by MPN count as described by Okon *et al.* (1977). The total diazotrophic bacterial count was done by following the procedure described by Watanabe and Barraquio (1980). The population of P solubilising bacteria was enumerated on hydroxyl apatite medium (Sperber, 1958).

***Soil respiration rate***

The rhizosphere soils collected at vegetative, flowering and harvest stage of the crop were quantified for soil respiration rate by assessing the amount of $CO_2$ evolved by alkali trap method (Pramer & Schmidt, 1956) and expressed as mg of $CO_2$ evolved per g soil per h.

***Soil enzymes***

Acid phosphatase (E.C. 3.1.3.2) and alkaline phosphatase (EC 3.1.3.1) were determined according to Tabatabai (1982) and reported as µg p-nitrophenol per gram dry weight of soil. Dehydrogenase activity (E.C.1.2.1.3) was determined by monitoring the rate of production of triphenylformazon (TPF) using the method of Klein *et al*. (1971) and expressed as µg of TPF per g soil per day. The soil nitrogenase (E.C. 3.2.1.2) was measured by acetylene reduction assay as described by Bergerson (1980) and expressed as µmol of ethylene produced per g soil per h. Soil urease (E.C. 3.5.1.5) was determined according to Tabatabai and Bremner (1972) and reported as µg of $NH_4$ -N released per g soil per day.

## Results and Discussion

The fertigation effects in precision farming of maize on soil microbial and enzyme activities in rhizosphere was investigated in present study and the results clearly revealed that significant difference was noticed between biofertigation and conventional fertilizer application.

**Table 1. Physiochemical properties of experi mental plot soil**

| Properties | Mean ± SE |
|---|---|
| pH | 6.36 ± 0.09 |
| EC (ds/m) | 1.6 ± 0.15 |
| Organic carbon (%) | 0.26 ± 0.01 |
| Available N (kg/ha) | 310 ± 2.88 |
| Available P (kg/ha) | 44 ± 0.57 |
| Available K (kg/ha) | 935.3 ± 1.45 |
| Total bacteria (cfu x $10^5$ / g dry weight of soil)[a] | 19 ± 1.15 |
| Fungi (cfu x $10^3$ / g dry weight of soil)[b] | 4 ± 0.16 |
| Diazotrophs (cfu x $10^4$ / g dry weight of soil)[c] | 46 ± 1.15 |

Values are mean ± SE of three replications

[a]Total bacteria were enumerated by serial dilution plating method on soil extract agar medium (James 1958).

[b]Total culturable fungi were enumerated by serial dilution plating method as described by Parkinson *et al.* (1971).

[c]Total diazotrophs were enumerated by the procedure as described by Rennie (1981).

***Effect of fertigation on rhizosphere microbial population***

In general, application of chemical fertilizers stimulated the growth and multiplication of

**Table 2. Effect of fertigation on soil respiration in maize rhizosphere (COMH 1) under precision farming system**

| Treatment | $CO_2$ evolution (mg $CO_2$/g/h) | | |
|---|---|---|---|
| | Vegetative growth stage | Flowering stage | Harvestingstage |
| $T_1$ Uninoculated and unfertilized control | 216.8 | 210.0 | 202.4 |
| $T_2$ 75% RDF of NPK | 204.0 | 198.0 | 180.4 |
| $T_3$ 100% RDF of NPK | 191.4 | 187.0 | 173.6 |
| $T_4$ 150% RDF of NPK | 156.2 | 147.4 | 112.4 |
| $T_5$ 100% RDFof NPK through conventional method of application | 176.0 | 165.6 | 162.0 |
| CD (P>0.05) | 29.11 | 28.06 | 25.31 |

microorganisms. However, increased dosage inhibits the survival of microbes due to osmotic stress created by fertilizers. Among the three doses of fertilizers, plots supplied with 75% RDF of NPK showed maximum *Azospirillum* (0.478 x $10^5$ MPN / g), *Bacillus* (64 x $10^5$ cfu / g) and diazotrophs (132 x $10^5$ cfu / g) population at 28 Days after sowing (DAS), followed by 100% and 150% RDF of NPK (Fig.1).

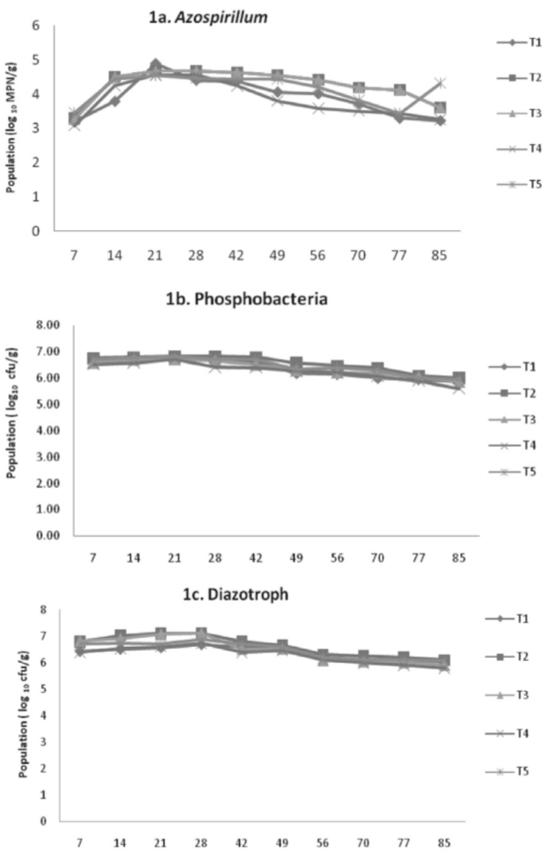


**Fig 1. Effect of fertigation on *Azospirillum*, phosphobacteria and total diazotrophs in the rhizosphere soil of maize (COMH 1) under precision farming system. The treatments ($T_1$ – $T_5$) are described in Materials and methods.**

The results showed that microbial populations were significantly reduced when increasing the dosage of fertilizer. The data from the results suggests that addition of low amount of fertilizer in soil doesn't affect the survival of microorganisms, whereas increased fertilizer dosage leads to accumulation of higher levels of inorganic nutrients in the soil, which inhibits the enzyme activity and survival of microbe's growth. Long term supply of small amount of inorganic amendments in the soil leads to accumulation of more nitrogen nutrients and increases C/N ratio. This leads to slow degradation of organic matter by microorganisms due to decreasing mineralization of organic matter content in soil.

***Effect of fertigation on soil respiration***

Highest $CO_2$ evolution (216. 8 mg $CO_2$ / g / h) was observed in the unfertilized and uninoculated control due to the residual organic matter content of the previous crop, followed by 75% RDF of NPK (204.0 mg $CO_2$ / g / h) and 100 % RDF of NPK (191.4 mg $CO_2$ / g / h) during vegetative growth stage (Table 2). The treatment, 150 % RDF of NPK showed reduction in $CO_2$ evolution (156.6 mg $CO_2$ / g / h) as compared to other treatments due to inhibition of microbial activity, as the result of higher fertilizer dosage. $CO_2$ evolution was maximum during vegetative growth stage (216.8 $CO_2$ / g / h), which was decreased from flowering (210.0 $CO_2$ / g / h) to harvesting stage (202.4 $CO_2$ / g / h), due to reduction of active root growth after flowering stage (Table 2). The results support the findings of Wagner and Wolf (1999), who found that organic matter with high C / N ratio is slowly degraded by soil microorganisms. C/N ratio also affects microbial community structure, both prokaryotic (bacterial) and eukaryotic. Sarathchandra *et al.* (1988) and Perrott *et al.* (1992) conducted research experiments in temperate regions and the results suggested that, following short term removal of fertilizer application from a grazed and limed upland had no effect on abundance or activity of microorgansims. Lack of effect may be due to part of long history of fertilization and accumulation of nutrient reserves in the soil before the experiment. Therefore, it is likely that effect of removing fertilizers application on soil micro organisms will not be evident until accumulated reserves have been used. So, frequent addition of N fertilizers leads to accumulation of substrate in soil. This inhibits enzyme activities of microbes, which in turn decreases microbial populations also.

***Effect of fertigation on soil enzyme activities***

There was significant increase in soil enzyme activities *viz*., urease (78 µg of $NH_4$ / g / day), dehydrogenase (110 µg of TPF /g /day), acid phosphatase (250 µg of p - nitrophenol / g / h) and alkaline phosphatase (810 µg of p - nitrophenol / g / h) and nitrogenase (1912.30 µmol of $C_2H_4$ / g / h) in uninoculated and unfertilized control, followed by 75 % RDF of NPK at 30 DAS (Table 3). Réduction in enzyme activities was observed in 150 % RDF of NPK due to négative impact of fertilizers on survival of microorganisms. This is because of inhibitory effect of fertilizer N on the nitrogenase activity of diazotrophs. The data showed that the soil enzyme activity was more positively influenced by native soil ecosystem than fertilizer application (Table 3). The current results support the finding of Dick (1988), who has reported that long term application of organic manure increased soil enzyme activity and microbial biomass, but $NH_4^+$ - N fertilizer caused a decrease of amidase and urease activity related to N fertilizer cycle. Wang (1982) and Zhou (1983) who has reported different type and amount of fertilizers directly affected soil enzymatic activities and then affected nutrient uptake by plant roots.

**Table 3. Effect of fertigation on soil enzymes activities in maize rhizosphere (COMH 1) under precision farming system**

| | Treatment | Urease (µg of NH4 /g/day) | Dehydrogenase (µg of TPF /g/ day) | Nitrogenase (µmoles of ethylene produced / g of soil / h) | Acid phosphatase (µg of p - nitrophenol/g/h) | Alkaline phosphatase (µg of p nitrophenol/g/h) |
|---|---|---|---|---|---|---|
| $T_1$ | Uninoculated and unfertilized control | 78.6 | 110.0 | 1912.30 | 250 | 810 |
| $T_2$ | 75% RDF of NPK | 65.2 | 86.0 | 1801.60 | 180 | 764 |
| $T_3$ | 100% RDF of NPK | 54.4 | 80.0 | 1100.00 | 160 | 612 |
| $T_4$ | 150% RDF of NPK | 54.0 | 68.0 | 952.70 | 150 | 584 |
| $T_5$ | 100% RDF of NPK through conventional method of application | 55.0 | 82.6 | 1653.55 | 130 | 684 |
| | CD (P> 0.05) | 9.59 | 13.23 | 202.844 | 27.17 | 107.22 |

## Conclusion

The results reveal that the maximum population of diazotrophs, *Azospirillum* and phosphobacteria were recorded in 75% RDF through biofertigation of NPK. Maximum soil enzyme activities *viz*., urease, dehydrogenase, acid and alkaline phosphatase and nitrogenase activities were recorded in the uninoculated and unfertilized control. It is concluded that decreasing the usage of chemical fertilizers and following the organic farming leading to environmental safety and sustainable soil health.

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