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Effect of nutrient subsidization on growth performance and soil microbial activity in rice field

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ABSTRACT

The microbial activities of soil in rice agroecosystem are influenced by agro-practices and nutrient regime. The levels of various macronutrients and their ratios determine the plant production. At the same time the soil microbial activities determine the nutrient mobilization and their availability to the rhizosphere. The current work was done at different combinations of nitrogen (N), phosphorus (P), potassium (K) to study the growth and production rate of rice (*Oryza sativa* L.) and the associated changes in soil microbial activity. During 120 days of observation (at 30 days interval), the shoot length showed continuous and significant increase up to 90 days and that of root showed significant increase up to 60 days. The biomass, on the other hand, showed continuous and significant increase with prolongation of cultivation. Each growth parameter showed the highest performance in the plot supplemented with NPK while the lowest was with the plot supplemented with K only. P supplementation was also found to be the most effective in enhancing the growth performance of the crop in the plots. Corresponding values of F_0 and F_M were also observed. As expected the maximum fluorescence yield was recorded in P amended plots, with or without other nutrients. The activities of invertase and amylase were the highest in the plot with manure (3 kg) and the lowest was observed in the unamended plots. No significant difference in the activities of these enzymes was observed among other nutrient amended plots during the period of observation.

1. Introduction

Soil is a fundamental segment of the environment (Kennedy and Smith, 1995) and it is the aftereffect of the mineral, synthetic, physical and biological entity present in the soil (Rolf, 2005). The knowledge of the biological processes that take place within the soil is important for proper soil use and to preserve soil standard (Lavelle et al., 2006). The importance of soil nutrient level in sustaining rice production in tropical paddy fields has been long recognized. The tropical paddy ecosystem has high population of microbes comprising of both cyanobacteria, bacteria and algae, which are responsible for the mobilization of nutrients (Matsuguchi, 1979; Prosser, 2007). Soil microbial activity and nutrient amendments have a direct bearing on the rice plant growth and production potential.

The assurance and preservation of soil biodiversity is critical for a reasonable agro-biological community, particularly under expanding agrarian strengthening (Vandermeer *et al.,* 1998) and has strong financial and environmental ramifications (Gardi *et al.,* 2009). Microbial activity can be influenced by abiotic factors, like moisture, temperature and soil supplements (Singh *et al.,* 2009).

Most of the enzymatic transformations in soil are accomplished by microbial biomass due to which a part of the organic materials is stabilized as humus and the remaining carbon and other nutrients are utilized by microorganisms for their own growth (Anderson and Domsch, 1980). Moreover, there is reduction in microbial biomass and enzyme activities due to excessive cultivation practices (Gupta and Germida, 1988). Nevertheless it is interesting to

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see the relationship between the microbial activity and soil nutrient management and its impact on plant production. This work presents the influence of soil nutrient management on the soil enzyme activity and the dependent changes in the growth and production of rice (*Oryza sativa L*).

2. Materials and methods

2.1. Preparation of experimental plot

The study area is Nimapada block of Puri district in Odisha. It is a coastal area and here rice cultivation is the major agricultural crop. The experimental plot is designed for five different treatments having 15 plots, 1 m^2 of each, and each treatment with three replicates (Table 1).

Table 1

Treatment of different fertilizers in the experimental plots

Treatment	Soil with different fertilizers in the plot
T1	Soil without fertilizer and manure
T2	Manure (3.0 kg) + K (35 g/m^2)
T3	Manure (500g) + K (35 g/m^2) + N (45 g/m^2)
T4	Manure (500g) + K (35 g/m^2) + P (125 g/m^2)
T5	Manure + K (35 g/m^2) + N (45 g/m^2) + P (125 g/m^2)

Note: The quantity of N, P and K given in the table are the weight of urea, super phosphate and Muriate of Potash.

Table 2

The scheme of preparation and amendment of the fields during 120 days of observation

Day	Action
-30	Addition of manure, mechanical dry ploughing
0	Wet ploughing, weeding, irrigation transplantation
30	Full dose of K and P and half dose of N application
60	Half dose N application

Table 3

The physiochemical properties of the field soil before transplantation

Parameter	Value
pH	5.73 ± 0.82
Electrical conductivity (dm/m^2)	0.48 ± 0.03
Mineralization nitrogen (kg/ha)	135.8 ±7.83
Available phosphorus (kg/ha)	18.33 ± 1.42
Available potassium (kg/ha)	118.5 ± 3.85
Organic carbon (g/ha)	4.58 ± 0.21

The plots were prepared through dry ploughing before 30 days of transplantation and through wet ploughing before 7 days of transplantation. The scheme of action and fertilization during 120 days of cultivation has been given in Table 2. Muriate of Potash, urea and super phosphate were used as the source of K, N and P respectively. The physicochemistry of the field soil before manure and fertilizer application was also measured by taking soil sample randomly from five different places in the field (Table 3).

2.2 Analytical parameters

The growth and fluorescence parameters of rice plant and soil enzyme activities were taken as the analytical parameters. The plant performance (shoot length, root length and biomass) were taken at interval of 30 days for a period of 120 days from the day of transplantation. Amount of chlorophyll content was measured spectrophotometrically after extraction with ice cooled absolute methanol following the method of Porra *et al.* (1989). The fluorescence minimum (F_0), maximum (F_M) and yield (F_V/F_M) were determined in the field from the OIP fluorescence transient with the help of a handy PEA (Hansatech, UK) following the method of Chhotaray *et al.* (2014). The activities of carbohydrate enzymes (invertase and amylase) were measured after incubating the soil, in Sorensen's buffer for 24 hours in the respective substrate (1% sucrose for invertase and 1% starch for amylase). The amount of glucose produced was measured using 3,5 – dinitrosalicilic acid (DSA) and the standard was prepared using glucose (Chhotaray *et al.*, 2014).

2.3 Statistical analysis of data

The data were statistically analysed by Excel stat software. The comparisons among the treatments were made through least significant difference test (LSD) and the values of LSD have been given in the text wherever required.

3. Result and discussion

In this study the physiochemical analysis of the soil showed that pH range of the soil condition ranging from 5.73±0.82 (Table 1). The soil pH, organic carbon content and water are the main factors affecting the soil microflora diversity (Zhang *et al.,* 2007). The organic carbon, nitrogen, phosphorus and potassium are important for the development of microflora. Soil enzymes are vital to soil health and fertility management in agroecosystem. These two enzymes amylase and invertase have many significant effects on soil biology, environmental management, growth and nutrient uptake in plant growing in agroecosystem.

The shoot length of the plants constantly increased throughout the observation period but after 90 days the increase was found insignificant irrespective of the treatment (LSD were 4.28 to 6.15 cm; Fig.1A). The root length, on the other hand, showed maximum increase up to 60 days after transplantation and thereafter the increase was insignificant (LSD were 2.19 to 2.73 cm; Fig. 1B). Biomass of the plant increased continuously till 120 days and such increase, when compared among the days of observation, was always significant (Fig. 1C). as expected, the plants in the control plot (without manure and fertilizer) had less number of tillers and lower shoot length as compared to plants in other plots which were supplied with fertilizer and manure. With prolongation of cultivation, the variation in shoot length among the treatments gradually decreased and after 120 days the variation was only 12 % indicating that plant height was not remarkably affected by the cultivation practice. A comparatively higher variation was observed (22%) was observed with respect to root length, when compared to control but among the plots aided with fertilizers, the variation (1%) was insignificant (LSD = 4.88%). This indicated that the addition of fertilizer did not have much effect on the root and shoot length but there is significant impact on the plant biomass. The biomass (Fig 1) shows that there is a gradual increase in the plant growth from 30 days through 120 days of observation.

Significant variations in the activities of amylase and invertase were observed among the treatments which also showed day wise difference (Fig. 2). On each observation day the activity of these enzymes was the highest in in T2 compared to other treatments. The lowest activity was observed in T1 as expected. Irrespective of treatments, there was no significant variation among treatments, except T2, with regard to enzyme activities after 30 days (F = 1.004) but significant variations were recorded thereafter. In each treatment, the activity of invertase and amylase showed insignificant change up to 60 days and significant reduction in the activities were noted thereafter.

From the data presented in Fig. 3 it was found that the chlorophyll content of the plants in the control plot is almost same with the treated plots till 30 days. After 60 days there was a minor change in the chlorophyll content of the control plant whereas significant increase of pigment content was reported in all other treatments. Maximum change was seen in plot treated with manure K and P and manure, K, N, P respectively. After 90 days of observation there was decrease in the chlorophyll content up to 120 days in all treatments but maximum decrease was noticed in T1. This may be due to the rapid utilization of the nutrient and/or the maturation of the crop plant and beginning of senescence of the plants. Nevertheless, the pigment content of T2 remained high, compared to all other treatments throughout observation which could be well corroborated with the soil enzyme activities. Corresponding pattern was also noted for F0, FM and fluorescence yield. While from T2 through T5, the F0 showed insignificant variation with prolongation of cultivation up to 90 days, there was a significant increase in the fluorescence value in T1. This indicated an increased stress on the plant leading to low photosynthetic efficiency. FM did not show significant variation up to 60 days decrease was observed in each treatment thereafter. After 120 days of cultivation the fluorescence and the photosynthetic yield were quite low.

A study on the effect of soil microbes and the enzymes involved on different stage of rice growth showed the increase in microbial biomass and enzyme activities had high rate of release of nutrients for rice crops. Varying soil depth to certain extent also influenced increase in bioactivity (Meena *et al.,* 2014). In another study soil organic carbon, available N, P, K, Zn, Fe and Cu in soil at crop harvest stage significantly increased due to the integrated inoculation of PGPR and Multani mitti based BGA with application of compost and chemical N fertilizer (80 and 120 kg/ha) over N control (Meena *et al.,* 2014). Application of N with inoculation of bacterial and cyanobacterial PGPR along with compost not only improved nutrient availability in soil but also enhanced soil microbial, plant enzymatic activity and crop yield (Meena *et al.,* 2014). An association of zinc solubilizing bacteria with rice plant shows these bacteria facilitate root growth which in terms induces plant growth (Othman *et al.,* 2017). In the present study, the high rate of enzyme activities in T2 may be attributed to the healthy soil microbial population that was supported by the addition of organic manure. It may be noted that the organic manure content of T2 was the highest among treatments. Chhotaray *et al.* (2014) have reported that in organic agroecosystems, a healthy microbial flora and activity is maintained due to high soil organic carbon level. This study showed that wit manure addition, the gain of biomass is not as high as observed with NPK addition, but such practice maintains a healthy microflora, which is necessary to sustain the productivity of the crop field.

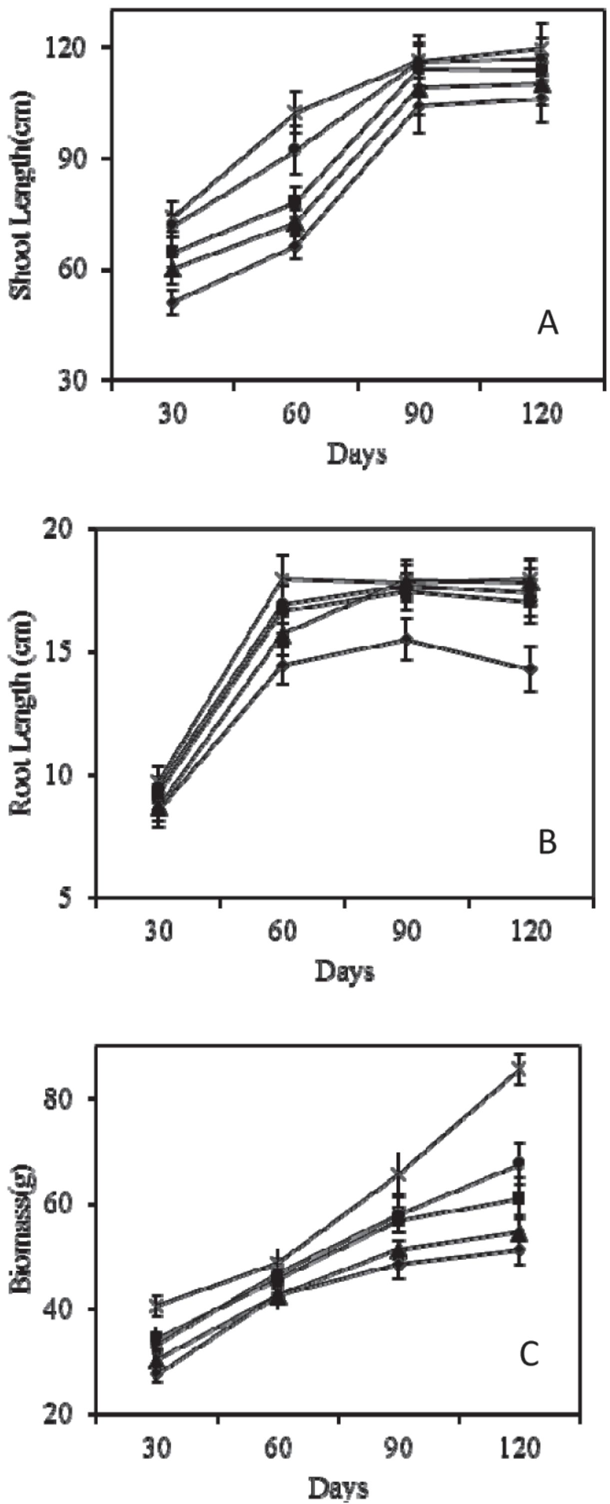

Fig. 1 A,B,C: Control (Diamond), treatment of K (Square), treatment of K&N (triangle), treatment of K&P (circle), treatment of K,P&N (Cross) shows the change of shoot length, root length and biomass of plants at different time period.

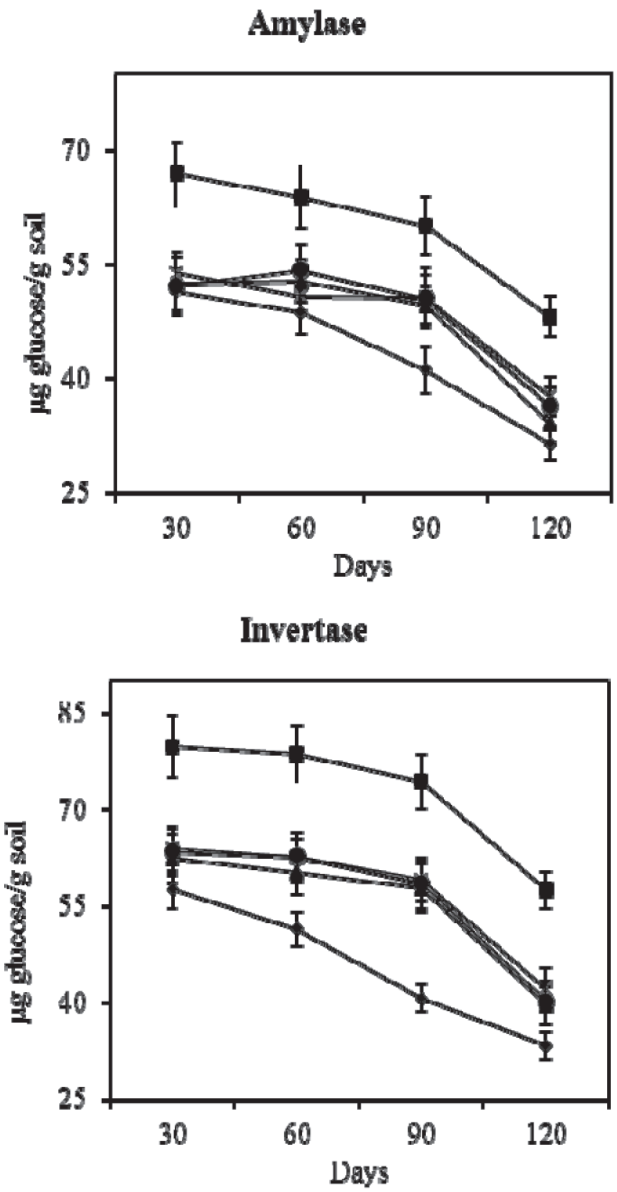

Fig. 2: Control (Diamond), treatment of K (Square), treatment of K&N (triangle), treatment of K&P (circle), treatment of K,P&N (Cross) shows the activities of enzyme amylase and invertase with time period.

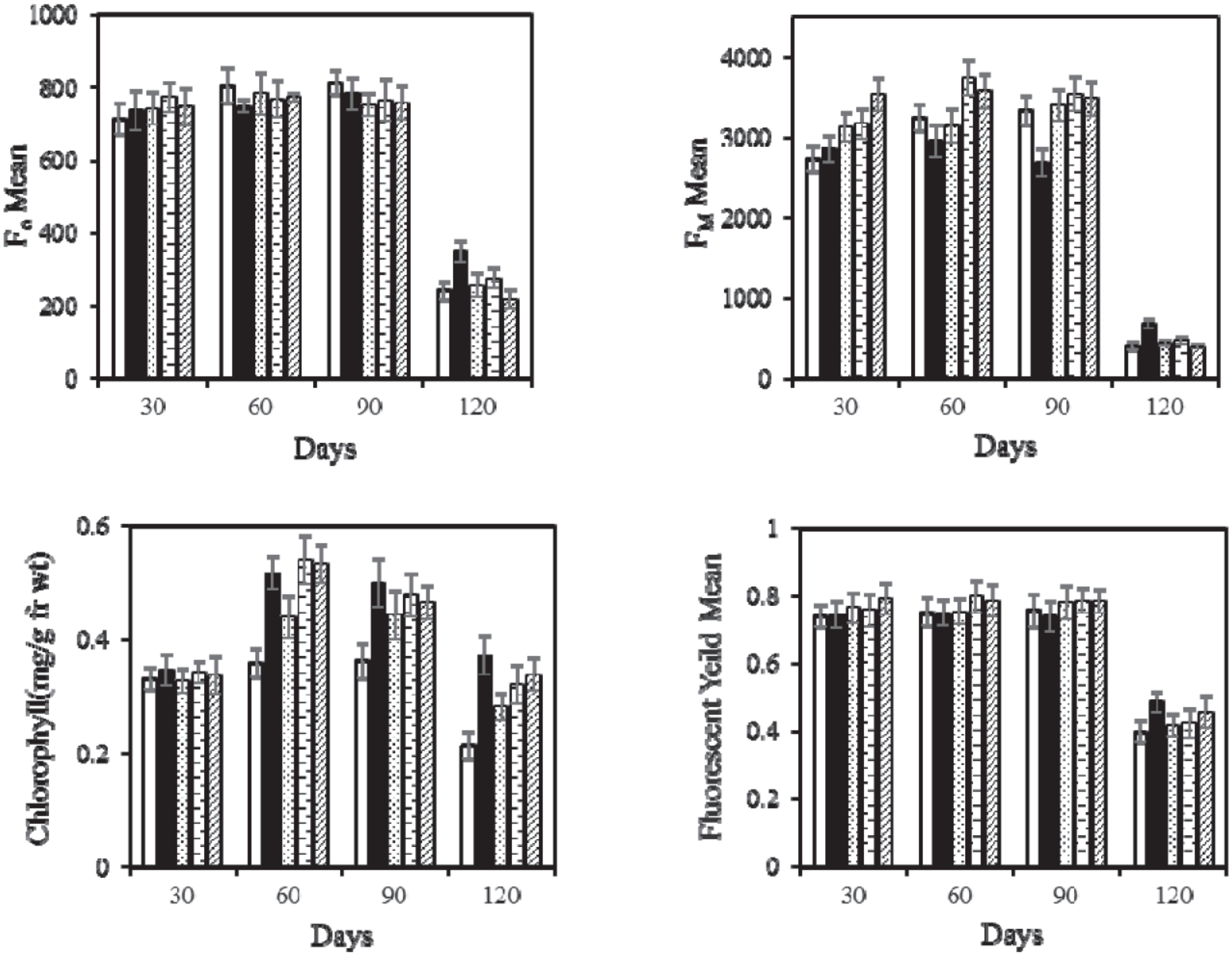

Fig. 3: Control (Empty), treatment of K (Black), treatment of K&N (Dotted), treatment of K&P (Brick), treatment of K,P&N (Oblique) shows the mean value of F_0, F_M, chlorophyll content and Fluorescence yield with different time period.

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