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Effect of varying fertilizer doses and soil test crop response based integrated plant nutrient system on enzyme activity in Bahour soil series of Puducherry

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Abstract
An incubation experiment was conducted during *Kharif*, 2018 on bahour soil series of puducherry to study the influence of various fertilizer doses and Soil Test Crop Response (STCR) based Integrated Plant Nutrient System (IPNS) on soil enzymatic activity. The incubation experiment was carried out with ten treatments and three replications. The soil samples were drawn at 0^{th}, 40^{th} and 80^{th} day of incubation and subjected for urease, phosphatase and dehydrogenase enzyme analysis. The results revealed that the application of STCR + IPNS – 180 q ha^{-1} treatment has improved the activities of Urease (12.08 µg NH_4-N $g^{-1}h^{-1}$), Phosphatase (13.65µg PNP $g^{-1}h^{-1}$) and dehydrogenase (2.48µg TPF $g^{-1}day^{-1}$). All the three enzymes activities were increased from the Initial day of incubation to 40^{th} day and later showed decrease at final days.

Keywords: Fertilizer doses, STCR-IPNS, enzyme, improved, decrease

1. Introduction
Soil is a fundamental resource in the agricultural production system and monitoring its fertility is an important objective in the sustainable development of agro-ecosystems. Soil enzymes are often used as index of soil fertility since they are very sensitive and respond to changes in soil management more quickly than other soil variables. Soil enzymes are involved in the biogeochemical cycles (nutrient cycles) and are known as the determinant of the soil microbial activity. Microorganisms improve soil health by ameliorating the soil enzyme activity (Gong *et al*., 2007) [9] Soil enzymes increase the reaction rate at which plant residues decompose and release plant available nutrients. It is thought that 40 to 60% of enzyme activity can come from stabilized enzymes, so activity does not necessarily correlate highly with microbial biomass or respiration. They are important in catalyzing several important reactions necessary for the life processes of micro-organisms in soils, stabilization of soil structure (Rao *et al*.,2017) [15], and the decomposition of organic wastes, organic matter formation and nutrient cycling (Dick *et al*., 1994) [6]. Soil enzymes play crucial role in fertility of soil.Among soil enzymes, urease performs the most important role in hydrolyzing the urea that has been leached down. Urea hydrolysis is a complicated process influenced by multiple factors. Two steps are the most important when urea undergoes transformation: the first step is the urea transformation into carbonate and ammonia in the presence of urease enzyme; in the second step, ammonia is converted to nitrite and then to nitrate ions which are readily available for the direct use of plant (Maithani *et al*., 2017) [14]. Phosphatase enzyme plays an important role in phosphate solubilization and release of inorganic phosphate and provides phosphorus nutrition to the plants (Beheraa *et al*. 2017) [1]. Dehydrogenase is an enzyme that oxidizes soil organic matter by transferring protons and electrons from substrates to acceptors (Das and Varma, 2011) [5]. This enzyme is considered to exist as an integral part of intact cells but does not accumulate extra-cellular in the soil.
The excessive use of chemical fertilizer without soil testing results in soil degradation, nutrients losses and low utilization rates of fertilizers and causes adverse impacts on the soil's ecological functions and biochemical characteristics. Moreover, excessive chemical fertilizers decrease soil enzymatic activities and the concentration of soil microbial biomass carbon (Saha *et al*., 2008) [16]. However, reducing chemical fertilizer applications and reasonably combining its use with organic fertilizers would be environmental friendly and preserve soil ecological functions, which are considered to be important factors in creating intensive and sustainable agriculture.

Integrated fertilization with both chemical fertilizers and organic manure is the main strategy for nutrient cycling in agro ecosystems and for developing sustainable agriculture. The application of organic manure and organic-inorganic fertilizers can maintain and improve soil fertility, significantly increasing soil organic matter (SOM) and the available nutrient concentration in different crop systems. Soil enzymes mediate microbial nutrient acquisition from organic matter and are typically more sensitive to changes in soil management practices and environmental conditions than Soil organic matter (Dinesh *et al*., 2012) [7]. These activities are commonly used as indicators of microbial nutrient demand and soil quality changes.

Based on the aforementioned discussion, the current study was conducted to investigate the enzyme activity based on applications of organic and inorganic fertilizers under controlled conditions.

2. Materials and Methods

An incubation experiment was conducted during 2018 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, PAJANCOA & RI, Karaikal. The incubation experiment was carried out with 10 treatments and 3 replications. The treatments are farmer's practice, FYM alone @ 12.5 t ha^{-1}, blanket recommendation, STCR-NPK alone @ 160, 170 and 180 q ha^{-1} yield target and STCR-IPNS @ 160, 170 and 180 q ha^{-1} yield target and control. The study was taken up on a Bahour soil series, taxonomically *Typic Ustropept*. The pH of the soil was almost neutral (6.96) and the EC suggested that the soil was non-saline (1.17 dSm^{-1}). The soil was low in available nitrogen (212 kg ha^{-1}) and organic carbon (4.20 g kg^{-1}) and medium in available phosphorous (20.60 kg ha^{-1}) and available potassium (196 kg ha^{-1})

An unfertilized surface soil was collected from Karikalampakkam farmer's field. The soil was air dried and sieved to < 2 mm. The fertilizer sources such as Urea, single super phosphate and muriate of potash was added in 500 ml plastic cups containing 200 g soil and thoroughly mixed as per the treatments. After thorough mixing, distilled water was added to bring the gravimetric water content of soil to field capacity. The soil samples with different treatments in triplicate were maintained separately. The moisture content was maintained throughout the experimental period by correcting the water loss periodically. Soil samples of each treatment plastic cups were drawn at 0, 40 and 80 days of incubation and were immediately stored in polythene bags. The soils were preserved and stored at 5°C in a refrigerator until analysis. These samples were utilized for the assay of soil enzyme activity activity *viz*.,urease (Tabatabai and Bremner (1972) [18], phosphatase (Tabatabai and Bremner (1969) [17] and dehydrogenase (Casida *et al*., 1964) [4]. The recorded data were subjected to statistical scrutiny following the procedure outlined by Gomez and Gomez (1976) [8].

3. Results and Discussion

3.1 Urease activity

Soil urease plays a major role in catalysis of the hydrolysis of urea to ammonical form, which will be subsequently oxidized by nitrifiers to nitrate form, which increases the utilization rate of nitrogen fertilizer. The activity of urease was found to be highest in STCR + IPNS – 180 q ha^{-1} (12.08 µg NH_4- N $g^{-1}h^{-1}$) which was comparable with other STCR+IPNS treatments and blanket recommendation treatments. The activity of urease did not have any marked variation in STCR alone treatments Table 1.

At 0th DAI the highest urease activity was observed in the treatment receiving STCR-NPK alone-160 q ha^{-1}(11.66 µg NH_4- N $g^{-1}h^{-1}$) and the lowest urease activity was observed in control (10.00 µg NH_4- N $g^{-1}h^{-1}$).The maximum urease activity was recorded at 40th day of incubation which was significantly different from all the other days. The treatment receiving STCR + IPNS – 180 q ha^{-1} (15.12 µg NH_4- N $g^{-1}h^{-1}$) was found to be highest. At 80th DAI there was a decrease in urease activity among all the treatments and the highest value was seen in STCR + IPNS – 180 q ha^{-1} (10.12 µg NH_4- N $g^{-1}h^{-1}$). The lowest was recorded in control (7.16 µg NH_4- N $g^{-1}h^{-1}$). Throughout the incubation period the urease activity follows an increasing trend at 40th day of incubation and decreasing trend at 80th day of incubation. The interaction effect between treatments and days was significant and revealed that the maximum activity of urease was found in STCR+IPNS treatments at 40th day of incubation.

Addition of organic manures showed significant increase in urease activity upto 40DAI. The STCR+IPNS treatments released high urease enzyme during incubation. The increase in urease activity with N levels could be due to higher availability of substrate N (urea). Krishnamurthy *et al*. (2011) [12] reported that the addition of organic manure increased the urease activity over mineral N and control to a significant extent.

Table 1: Effect of different fertilizer doses of NPK and STCR - IPNS on activity of Urease (µg NH_4- N $g^{-1}h^{-1}$)

Treatments	0th day	40th day	80th day	Treatment Mean
T_1-Control	10.00	10.62	7.16	9.26
T_2- FYM (12.5 t ha^{-1}) alone	10.32	12.82	9.88	11.00
T_3-Farmer's Practice	11.12	12.66	9.00	10.92
T_4-Blanket Recommendation	10.50	13.22	10.28	11.33
T_5-STCR-NPK alone-160 q ha^{-1}	11.66	11.00	8.12	10.26
T_6-STCR-NPK alone-170 q ha^{-1}	11.00	11.22	8.76	10.32
T_7-STCR-NPK alone-180 q ha^{-1}	10.66	11.98	9.06	10.56
T_8-STCR+IPNS-160 q ha^{-1}	11.12	13.68	9.48	11.42
T_9-STCR+IPNS-170 q ha^{-1}	10.50	14.72	9.98	11.73
T_{10}-STCR+IPNS-180 q ha^{-1}	11.00	15.12	10.12	12.08
Days Mean	**10.78**	**12.70**	**9.18**	

	T	D	T X D
S.Ed	0.50	0.27	0.86
C.D(0.05)	1.00	0.55	1.74

3.2 Phosphatase activity

Phosphatases are broad groups of enzymes that are capable of catalyzing hydrolysis of esters and anhydrides of phosphoric acid. The effect of different sources of organic and inorganic manure on phosphatase activity at different days of incubation is presented in Table 2.

At 0th DAI the highest phosphatase activity was observed in the treatment receiving STCR-NPK alone-180 q ha^{-1}(13.90µg PNP $g^{-1}h^{-1}$) and the lowest was observed in FYM (12.5 t ha^{-1}) alone (12.22µg PNP $g^{-1}h^{-1}$). At 40th day of incubation there was a maximum increase in phosphatase activity and the treatment receiving Blanket Recommendation (16.00µg PNP $g^{-1}h^{-1}$) recorded the highest. There was a gradual decrease seen in phosphatase activity at 80th DAI and the treatment receiving Blanket Recommendation (13.16µg PNP $g^{-1}h^{-1}$) recorded the highest. The lowest was recorded in control (9.20µg PNP $g^{-1}h^{-1}$)

The lowest activity of phosphatase was recorded in control (11.78µg PNP $g^{-1}h^{-1}$). The results indicated that as the incubation period progresses, the phosphatase activity follows an increasing trend at 40th day of incubation and decreasing trend at 80th day of incubation for all the treatments. The increasing trend is not well pronounced in case of FYM (12.5 t ha^{-1}) alone, STCR alone and STCR+IPNS treatments. The interaction effect revealed that the maximum activity of phosphatase was found in blanket recommendation treatment at 40th day of incubation.

STCR-IPNS treatments had higher phosphatase activity than those under STCR-NPK alone which might be due to application of organic manures. The organic manure stimulated microorganism activities, increased the activity of enzymes (Saha *et al*., 2008) [16]. As organic P forms must be mineralized via phosphatases into inorganic P prior to plant uptake, soil biological activity and enzyme production related to organic P hydrolysis will affect P cycling (Magid *et al*., 1996) [13]. Manure can stimulate phosphatase activity by providing soil microorganisms with sources of C, N, and P (Heidi *et al*., 2011) [11]. Phosphatases can also affect environmental quality following mismanagement of manure, as P in surface runoff is related to organic P content and phosphatase activity (Yu *et al*., 2006) [19]. Changes in phosphatase activity in the soil depended on whether the organic matter added was fresh or stabilized. At the end of incubation period, the soil amended with fresh products showed lower activity than initial values which could be attributed to a decrease in biodegradable compounds brought about by microbial activity.

Table 2: Effect of different fertilizer doses of NPK and STCR - IPNS on activity of Phosphatase (µg PNP $g^{-1}h^{-1}$)

Treatments	0th day	40th day	80th day	Treatment Mean
T_1-Control	12.98	13.16	9.2	11.78
T_2- FYM (12.5 t ha^{-1}) alone	12.22	14.42	11.96	12.86
T_3-Farmer's Practice	13.66	15.49	12.12	13.75
T_4-Blanket Recommendation	13.77	16.00	13.16	14.31
T_5-STCR-NPK alone-160 q ha^{-1}	13.16	14.00	10.52	12.56
T_6-STCR-NPK alone-170 q ha^{-1}	13.34	14.86	10.96	13.05
T_7-STCR-NPK alone-180 q ha^{-1}	13.90	15.00	11.52	13.47
T_8-STCR+IPNS-160 q ha^{-1}	13.64	14.06	11.40	13.03
T_9-STCR+IPNS-170 q ha^{-1}	13.49	14.68	11.82	13.33
T_{10}-STCR+IPNS-180 q ha^{-1}	13.85	15.12	12.00	13.65
Days Mean	**13.40**	**14.67**	**11.46**	

	T	D	T X D
S.Ed	0.31	0.17	0.55
C.D(0.05)	0.63	0.34	1.10

3.3 Dehydrogenase activity

Dehydrogenase is considered as an indicator of overall microbial activity because it has intracellular activity in all living microbial cells and it is linked with microbial respiratory process. The dehydrogenase activity is commonly used as an indicator of biological activity in soils (Burns. 1978) [3]. Dehydrogenase enzyme is known to oxidize soil organic matter by transferring protons and electrons from substrates to acceptors. These processes are part of respiration pathways of soil microorganisms and closely related to the type of soil. The data on effect of different sources of organic and inorganic manures on activity of dehydrogenase (µg TPF g^{-1} day^{-1}) is presented in Table 3.

At 0th DAI the highest dehydrogenase activity was observed in the treatment receiving STCR + IPNS – 180 q ha^{-1}(2.23µg TPF g^{-1} day^{-1}) followed by FYM (12.5 t ha^{-1}) alone (2.12µg TPF g^{-1} day^{-1}) and STCR + IPNS – 170 q ha^{-1}(2.06 µg TPF g^{-1} day^{-1}). At 40th day of incubation there was a maximum increase in dehydrogenase activity and the treatment receiving STCR + IPNS – 180 q ha^{-1}(3.48µg TPF g^{-1} day^{-1}) recorded the highest activity. There was a gradual decrease seen in dehydrogenase activity at 80th DAI and the treatment receiving STCR + IPNS – 180 q ha^{-1}(1.74µg TPF g^{-1} day^{-1}) recorded the highest and the lowest was recorded in control (1.20µg TPF g^{-1} day^{-1})

The treatment STCR + IPNS – 180 q ha^{-1} has recorded maximum dehydrogenase activity (2.48µg TPF g^{-1} day^{-1}) followed by FYM (12.5 t ha^{-1}) alone and STCR + IPNS – 170 q ha^{-1} which were comparable with each other. The lowest dehydrogenase activity was observed in control (1.31µg TPF g^{-1} day^{-1}).

Over the advancement of incubation period the dehydrogenase activity follows an increasing trend at 40th day of incubation and decreasing trend at 80th day of incubation. The days of incubation were significantly different from each other and maximum dehydrogenase activity was observed at 40th day of incubation. The interaction effect was significant and revealed that maximum dehydrogenase activity was found for STCR + IPNS – 170 and 180 q ha^{-1} at 40th day of incubation followed by FYM (12.5 t ha^{-1}) alone and STCR-NPK- 180 q ha^{-1} treatments.

The results further clearly revealed that with increase in yield targets, there was a concomitant increase in dehydrogenase activity which is due to the increased doses of the fertilizer application. Increased nutrient availability in organic-manure treatment could also be due to increased dehydrogenase and phosphatase activity (Gunapala *et al*., 1998) [10]. The enhanced level of soil enzyme activity due to addition of organic manures promotes the recycling of nutrients in the soil ecosystem stimulates dehydrogenase activity because the added material on decomposition may provide intra and extracellular enzymes and may also stimulate microbial activity in the soil (Bhattacharyya *et al*., 2005) [2].

Table 3: Effect of different fertilizer doses of NPK and STCR - IPNS on activity of Dehydrogenase (µg TPF g^{-1} day^{-1})

Treatments	0th day	40th day	80th day	Treatment Mean
T_1-Control	1.31	1.78	1.20	1.43
T_2- FYM (12.5 t ha^{-1}) alone	2.12	3.12	1.74	2.32
T_3-Farmer's Practice	1.56	2.31	1.46	1.77
T_4-Blanket Recommendation	1.96	2.94	1.62	2.17
T_5-STCR-NPK alone-160 q ha^{-1}	1.41	2.26	1.19	1.62
T_6-STCR-NPK alone-170 q ha^{-1}	1.52	2.56	1.27	1.78
T_7-STCR-NPK alone-180 q ha^{-1}	1.60	2..98	1.32	1.96
T_8-STCR+IPNS-160 q ha^{-1}	1.77	2.76	1.42	1.98
T_9-STCR+IPNS-170 q ha^{-1}	2.06	3.24	1.60	2.30
T_{10}-STCR+IPNS-180 q ha^{-1}	2.23	3.48	1.74	2.48
Days Mean	**1.75**	**2.74**	**1.45**	

	T	D	T X D
S.Ed	0.05	0.02	0.08
C.D(0.05)	0.10	0.05	0.17

4. Conclusion

From the foregoing discussion it was concluded that the enzyme activity from

STCR-IPNS treatment was higher as compared to STCR-NPK alone, blanket recommendation and farmer's practice.

The balanced nutrient application through STCR along with IPNS increased the enzyme activity and enhanced the nutrient release in the soil thereby it will improve the productivity.When fertilizers are applied based on the STCR equations there is neither excess nor deficient levels of fertilizer doses. Major finding ofthe experiment is time of nutrients release and quantity from different treatments; it will avoid the mismatch between crop nutrient demand and nutrient supply from organic sources.

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