INCUBATION STUDIES ON NUTRIENT RELEASE PATTERN OF NPK AND ENZYMATIC ACTIVITIES IN INCEPTISOL OF ANDHRA PRADESH

Abstract:

Incubation experiment was conducted with the initial bulk surface soil sample from experimental field to study the nutrient release pattern of available N, P, K and activity of soil enzymes (urease, alkaline phosphatase and dehydrogenase activity) under NPK alone, IPNS (NPK+FYM), FYM alone and absolute control. As compared to all other treatments, IPNS recorded relatively higher available N, P and K status. In case of NPK alone treatments, the available N content increased up to 90 days of incubation and decreased thereafter. In case of IPNS treatments, the status has shown an increase up to 120 DAI. Both under NPK alone and IPNS, the available P showed an increase up to 90 days after incubation and thereafter declined gradually up to 120 DAI while soil available K showed a gradual increase up to 120 DAI. Irrespective of different stages of incubation, STCR-IPNS treatments recorded comparatively higher enzymatic activity (urease, alkaline phosphatase and dehydrogenase) than STCR-NPK alone. These findings derived from the incubation experiment brought forth the fact that the release pattern of N, P and K and enzymatic activities under NPK alone, IPNS, FYM alone and absolute control paved way for understanding the beneficial effects of IPNS on crop productivity, efficiency and economy in fertiliser application and soil fertility sustenance throughout the period of crop growth.

Key words: Incubation Studies, nutrient release pattern, enzymatic activity.

Introduction:

Knowledge on the mineralization of nutrients in soil under field conditions during cropping season is very much relevant when manure is used as a source of nutrients and predicting their availability. Since mineralization is microbial driven process, it is influenced by several factors including soil physical, chemical and biological properties as well as characteristics of organic manures. In order to meet the nutrient demand of a crop through

application of organic manures *viz.*,FYM or compost, huge quantities are required due to their low nutrient content as compared to chemical fertilisers.

A better understanding of the role of the soil enzymes activity in maintaining the soil health will potentially provide a unique opportunity for an integrated biological assessment of soils due to their crucial role in several soil biological activities, their ease of measurement and their rapid response to changes in soil management. Application of organic manures influenced the enzyme activities greatly by improving the activity of soil micro organisms. A strong positive correlation was observed between enzyme activities and soil properties (Reddy *et al.*1994). Application of inorganic fertilizers improved the soil enzymatic activities and the effect was more pronounced with organic manures in combination with fertilizers.

The objective of the incubation experiment was to study the nutrient release pattern of available N, P and K and soil enzymatic activities *viz.*, urease, alkaline phosphatase and dehydrogenase activity under NPK alone and IPNS (NPK+FYM) treatments. In this regard, an incubation experiment was conducted with the initial bulk surface soil sample of the experimental field.

MATERIALS AND METHODS

Incubation experiment was conducted with initial bulk surface soil samples collected from soils of experimental field on Visakhapatnam soil series (Typic Haplustept) of North Coastal Zone of Andhra Pradesh at the Farm of College of Horticulture, Parvathipuram, Dr. YSR Horticultural University to study the nutrient release pattern of available NPK and soil enzymatic activity (Urease, alkaline phosphatase and dehydrogenase activity) under absolute control, N, P and K alone and IPNS (NPK+FYM) treatments. There were 15 treatments simulating the treatments of test crop experiment with three replications and the design was completely randomized block design. Soil weighing 200 g was mixed thoroughly with calculated quantities of fertiliser N, P_2O_5 and K_2O and FYM and transferred to plastic containers as per specific treatment schedule. Experiment has been maintained at room temperature and at field capacity moisture level for 120 days. Representative soil samples were drawn treatment wise at monthly intervals *i.e.*, 0,30,60,90 and 120 days after incubation coinciding with initial, vegetative, flowering, fruit formation and peak harvest stages of brinjal and processed for further analysis.(Table.1).

Table.1 Treatment details of incubation experiment

Treatment No.	Treatment Details	
	Levels	Doses
T_1	$N_0P_0K_0F_0$	$N_0P_0K_0F_0$
T_2	$N_0P_0K_0F_1$	$N_0P_0K_0F_{12.5}$
T_3	$N_0P_0K_0F_2$	$N_0P_0K_0F_{25}$
T_4	$N_0P_2K_2F_0$	$N_0P_{80}K_{120}F_0$
T_5	$N_0P_2K_2F_2$	$N_0P_{80}K_{120}F_{25}$
T_6	$N_0P_1K_1F_0$	$N_0P_{40}K_{60}F_0$
T_7	$N_1P_1K_1F_2$	$N_{80}P_{40}K_{60}F_{25}$
T_8	$N_1P_2K_2F_0$	$N_{80}P_{80}K_{120}F_0$
T_9	$N_1P_2K_2F_2$	$N_{80}P_{80}K_{120}F_{25}$
T_{10}	$N_2P_2K_2F_0$	$N_{160}P_{80}K_{120}F_0$
T_{11}	$N_2P_2K_2F_2$	$N_{160}P_{80}K_{120}F_{25}$
T_{12}	$N_3P_2K_2F_0$	$N_{240}P_{80}K_{120}F_0$
T_{13}	$N_3P_2K_2F_2$	$N_{240}P_{80}K_{120}F_{25}$
T_{14}	$N_3P_3K_3F_0$	$N_{240}P_{120}K_{180}F_0$
T_{15}	$N_3P_3K_3F_2$	$N_{240}P_{120}K_{180}F_{25}$

Note: N, P and K: Fertiliser N, P_2O_5 and K_2O in kg ha^{-1}; F: FYM in t ha^{-1}

RESULTS AND DISCUSSION

Nutrient release pattern of Available N, P and K (Fig.1)

Available Nitrogen:

Results from the laboratory incubation experiment to study the nutrient release pattern of available N, P and K nutrients clearly showed that for NPK alone treatments, the available N showed an increase up to 90 DAI followed by a gradual decline up to

120 DAI. Whereas in the case of IPNS treatments, the status showed a progressive increase from 30 DAI up to 120 DAI. It has been observed that with addition of fertiliser N there was an associated increase in available N over a period of time. IPNS reported relatively higher available N status at all stages of sampling compared to all other treatments. The mean percentage increase in available N status over the incubation period was 3.0, 7.3, 8.3 and 9.7, respectively due to IPNS treatments over NPK alone, FYM @ 25 and 12.5 t ha^{-1} and absolute control (Table.2). Similarly urease activity also increased with incubation period of 30 days and then declined slowly. However, maximum urease activity was witnessed with IPNS treatment. The greater available nitrogen content of this particular treatment could be attributed to enhanced urease activity which is primarily involved in mineralizing urea into ammonia and carbon dioxide . Another interesting observation is that the treatments receiving both inorganic nitrogen fertilizer and farm yard manure or organic manure recorded substantial activity of urease.

Mineralisation of soil N might have helped to build higher available N due to the favorable conditions in the soil under organic sources (Udaykumar and Santhi,2017). FYM acts as a source of soil nutrients which might have attributed for mineralisation of N in soil in turn which would have increased nitrogen conversion to its usable form due to higher activity of enzymes in soil (Vidyavathi *et al.,* 2012). González-Prieto *et al.*(1995) reported similar results that ammonification prevailed in the first two weeks, and nitrification prevailed from two to six weeks. Basak and Biswas (2014) have also reported an increase in the availability of N status substantially in integrated application of organic manures and inorganic fertiliser application as compared with other treatments as well as an incremental increase up to the last stage of incubation as observed in the present investigation.

Available Phosphorus:

Irrespective of treatments, available P showed an increase up to 90 DAI and thereafter it has declined gradually up to 120 DAI. The study showed a concomitant rise for the amount of available P over a period of time with the inclusion of fertiliser P_2O_5. The results from Dotaniya *et al.* (2014) indicated that there was a major association between applied P and incubation period on the soil's P status. In comparison with all other treatments that have the effect of FYM

on P release to soil, the available P status under IPNS was shown to be relatively higher than available N. The percentage increase in available P status was 3.7, 21.2, 22.9 and 31.9 respectively due to IPNS treatments over NPK alone, FYM @ 25 and 12.5 t ha^{-1} and absolute control (Table.3). Meena *et al.* (2013) also stated that phosphorus availability increased due to FYM application over initial status and absolute control. This might be attributable by decline in P fixation to a relatively better mobilization of native soil P and complexing of Ca^{2+} (Mukesh Kumar *et al.*, 2012) and increase in labile P (Kadu et al., 2012) with addition of organic nutrient sources.

Available Potassium:

Due to the application of organic manures, the available K status showed a gradual increase upto 120 DAI. Irrespective of treatments, relatively higher status was recorded under IPNS as compared to all other treatments. The percentage increase in available K status was 1.6, 4.1, 5.0 and 5.4 respectively due to IPNS treatments over NPK alone, FYM @ 25 and 12.5 t ha^{-1} and absolute control (Table.4). The restoration of available K in soil under integrated use of manures and fertilisers was due to increased ability of organic colloids to hold K ions in the exchange complex (Sheeba and Chellamuthu, 1999). Integrated use of organic and inorganic substances and from FYM significantly improved soil K status with organic nutrient sources over their initial status on Inceptisol (Sharma *et al.*, 2001). Kiraci (2018) documented the K fixation reduction and release of more K as a result of organic matter contact with clay besides the direct K addition of available K pool to the soil. The inclusion of FYM and other organic agents that stimulates microorganisms growth and development is a consequence of this increase in soil fertility. They involved in biological component cycling and mineral compound changes and therefore in increasing the quality of soil nutrients (Vidyavathi *et al.*, 2012).

SOIL ENZYMATIC ACTIVITIES (fig 2)

Alkaline Phosphatase Activity

Phosphatase enzymes act on wide array of hydrolytic esters and phosphoric acid anhydrides. Phosphatases are essential as they release PO_4^{3-} from immobile organic P. Phosphatases hydrolyse organic phosphorus compounds and turn them into various forms of inorganic phosphorus that are assimilated by plants. Similar to other parameters, the alkaline phosphatase activity of all the treatments was greater initially and reduced with the time

of incubation. It could have been due to the activation of phosphatase producing microorganisms to mineralize organic phosphate; further reduction could be related to reduction in organic phosphate source with the time of incubation. The activity after 90 days of incubation of incubation did not change. Among various treatments, the activity was comparatively greater in organic amended treatments. The available phosphorus content of the soil increased with incubation period, could be due to the greater action of alkaline phosphatases during intial phases and thus improved the available phosphorus content.

In this study, higher alkaline phosphatase activity in soil (37.02 µg pNP g^{-1} hr^{-1}) was observed with IPNS - T_{15} (N, P_2O_5 and K_2O @ 240: 120:180 kg ha^{-1} with FYM @ 25 t ha^{-1}) treatments and lower alkaline phosphatase activity (15.15 µg pNP g^{-1} hr^{-1}) was observed with absolute control (T_1). The production of alkaline phosphatase was reduced upto 90 DAI and later slightly increased upto 120 DAI. Regardless of the different incubation durations, treatment with STCR-IPNS was comparatively higher than with STCR-NPK alone in the alkaline phosphatase enzyme activity. In IPNS treatment, the increased percentage alkaline phosphatase enzyme activity was 10.7, 13.4, 23.2 and 27.0, respectively over NPK alone, FYM @ 25 and 12.5 t ha^{-1} and absolute control (Tabel.5).

Higher phosphatase activity in soil under IPNS treatments was due to enhanced carbon content in soil that stimulated microbial multiplication leading to increased decomposition process and Tejada *et al.* (2010) achieved similar results. Increased alkaline phosphatase levels in soils by application of FYM and P fertilisers has been reported (Saha *et al.,* 2008). Bell *et al.* (2006) found increased activity of alkaline phosphatase with a rise in FYM levels. Higher activity of alkaline phosphatases will promote organic phosphorus hydrolysis and increase inorganic phosphorus contents. Increasing phosphatase activity with integrated application of inorganic fertilisers and manures may be due to increasing population of micro-organisms, because of increased availability of substrate through organic manures. Singaram and Kamalakumari (1995) and Reddy and Reddy (2009) have reported similar findings.

Dehydrogenase Activity

This enzyme activity indirectly reveals the heterotrophic microbial activity of the soil. Irrespective of the fertilizer application, the dehydrogenase activity enhanced due to

the application of farm yard manure. Maximum dehydrogenase activity was witnessed after 30 days of incubation. It declined slowly later on with the time of incubation. Higher dehydrogenase activity (5.12µg TPF g^{-1} day^{-1}) was observed in IPNS treatment-T_{15} (N, P_2O_5 and K_2O @240:120:180 kg $ha^{-1}$with FYM @25 t ha^{-1}), Dehydrogenases play an important role in soil organic oxidation by transferring hydrogen from organic substrates to inorganic acceptors (Zhang *et al.*, 2010). and control (T_1) reported lower dehydrogenase activity (0.65 µg TPF g^{-1} day^{-1}) in the present investigation (Tabel.6). The increased activity of dehydrogenase after adding organic manure may be due to an increased microbial population, which is known to stimulate soil dehydrogenase activity (Watts *et al.*, 2010). The increase in soil organic carbon (Aon and Colaneri, 2001) have contributed to dehydrogenase activity as higher levels of organic carbon serve as an energy source that stimulated microbial activity. Meena and Biswas (2014) and Tejada *et al*.(2011) found similar results.

The dehydrogenase activity of STCR-IPNS treatments was comparatively higher than that of STCR-NPK alone. The percentage increase in dehydrogenase activity due to IPNS treatments was 9.0, 37.7, 67.0 and 110.7, respectively over FYM @ 25 and 12.5 t ha^{-1}, NPK alone and absolute control. Dehydrogenase activity closely follows the pattern of organic matter and available soil-built N, P and K (Adak *et al.*, 2014).Sharma and Subehia (2014) reported similar results in long-term studies, where NPK plus FYM reported peak dehydrogenase activity compared to FYM alone.

Urease Activity

This enzyme is involved in mineralizing urea into ammonium and carbon dioxide with the concomitant pH rise of the soil. In the present study, the urease activity decreases steadily from 0 DAI to 120 DAI. In IPNS treatments, T_{15} (N, P_2O_5 and K_2O @ 240:120:180 kg $ha^{-1}$with FYM @25 t ha^{-1}) recorded higher urease activity in soil (270 µg NH_4-N g^{-1} day^{-1}) and absolute control (T_1) reported lower urease activity (95 µg NH_4-N g^{-1} day^{-1}) in Table 7. Urease enzyme activity showed a progressive increase upto 30 DAI which could be attributed to the fact that residue decomposition from organic matter could have had synergistic effect on microbial behavior (Tejada *et al.*, 2011) which was subsequently reduced due to increased nitrogen content

and faster organic manure decomposition and ammonia N release recorded by Saha *et al.* (2008) and Meena *et al.* (2014).

STCR-IPNS treatments demonstrated comparatively higher urease activity than STCR-NPK alone, irrespective of different durations of incubation. The percentage increase in urease enzyme activity was 6.3, 13.2, 15.4 and 16.9, respectively due to IPNS treatments over NPK alone, FYM @ 25 and 12.5 t ha^{-1} and absolute control. Such results were followed by Saha *et al.* (2008) and Wang *et al.* (2010) who found that organic manure had a strong impact on the activity of urease. Urease activity was observed to increase over years, suggesting a longer time supply of the substrate (nitrogen) and confirming supply of nutrients by FYM with N through the slow release (Uz and Tavali, 2014).

CONCLUSIONS:

At all stages, both under NPK alone and IPNS, it has been found that with increase in fertiliser N,P_2O_5 and K_2O levels, there was a proportionate increase in soil available N, P and K status and however, magnitude of increase was relatively higher under IPNS as compared to NPK alone treatments. Irrespective of different stages of incubation, STCR-IPNS treatments recorded comparatively higher enzymatic activity (urease, alkaline phosphatase and dehydrogenase) than STCR-NPK alone. Findings derived from the incubation experiment brought forth the fact that the release pattern of N, P and K and enzymatic activities under NPK alone, IPNS, FYM alone and absolute control paved way for understanding the beneficial effects of IPNS on crop productivity, efficiency and economy in fertiliser application and soil fertility sustenance throughout the period of crop growth.

REFERENCES:

Adak,T., A.Singha, K.Kumar, S. K.Shukla,A.Singh and V.Kumar Singh. 2014. Soil organic carbon, dehydrogenase activity, nutrient availability and leaf nutrient content as affected by organic and inorganic source of nutrient in mango orchard soil. *Journal of Soil Science and Plant Nutrition* 14(2) :394-406.

Aon,M.A.and A.C.Colaneri.2001.II.Temporal and spatial evolution of enzymatic activities and physico-chemical properties in an agricultural soil. *Applied soil ecology* 18(3):255-270.

Basak, B.B.and D.R.Biswas.2014. Carbon and nitrogen mineralization in soil amended with value added manures and fertilizers under varying temperature and soil moisture regimes. *Journal of the Indian Society of Soil Science* 62(1):18-28.

Bell,M.Jourdan, C.A.Robinson and R.C.Schwartz.2006. Changes in soil properties and enzymatic activities following manure applications to a range land."*Range land ecology & management* 59(3):314-320.

González,S.J.,M.Carballas and M.C.Villar.1995.Organic nitrogen mineralization in temperate humid zone soils after two and six week so faerob icincubation. *Biology and fertility of soils* 20 (4):237-242.

Kadu,P.,V.K.Kharche and A.D.Kadlag.2012. Fertiliser and manure prescription equations for different crops grown in various districts of Maharashtra, In: Y. Muralidharudu, A. SubbaRao and K.Sammi Reddy, (Ed.), District wise soil test based fertilizer and manure recommendations for balanced nutrition of crops Indian Institute of Soil Science, Bhopal .p.46-73.

Kiraci,Semih.2018. Effects of sea weed and different farm manures on growth and yield of organic carrots. *Journal of plant nutrition* 41(6):716-721.

Meena,M.D. and D.R.Biswas.2014. Changes in biological properties in soil amended with rock phosphate and waste mica enriched compost using biological amendments and chemical fertilizers under wheat-soybean rotation. *Journal of plant nutrition* 37(12): 2050-2073.

Meena,V.S., B.R.Maurya, R.Verma, R.S.Meena, G.K.Jatav and S.K.Meena.2013. Soil microbial population and selected enzyme activities as influenced by concentrate manure and inorganic fertilizer in alluvium soil of Varanasi *Bioscan* 8(3):931-935.

Mukesh Kumar, N.P.S.Yaduvanshi and Y.V.Singh.2012.Effects of integrated nutrient management on rice yield, nutrient uptake and soil fertility status in reclaimed sodic soils. *Journal of the Indian Society of Soil Science* 60(2):132-137.

Reddy,K.C.K.,M.Velayutham and G.R.M.Sankar.1994. Soil test based fertiliser prescription for specific yield targets of crops. Coordinating Cell, AICRP for investigations on STCR, CRIDA, Hyderabad, AndhraPradesh.

Reddy,R.U.andM.S.Reddy.2009. Phosphatase activity in soil as influenced by Integrated Nutrient Management in tomato-onion cropping system. *Indian Journal of Agricultural Research* 43(4):289-293.

Saha,Krishanu,A.J.Keung,E.F.Irwin,Y.Li,L.Little,D.V.Schaffer and K.E.Healy.2008. Substrate modulus directs neural stem cell behavior. *Biophysical journal* 95(9):4426-4438.

Sharma,M.P.,S.V.Bali and D.K.Gupta. 2001. Soil fertility and productivity of rice-wheat cropping system in an Inceptisol as influenced by integrated nutrient management. *Indian Journal of Agricultural Sciences*71(2):82-86.

Sharma,UpinderandS.K.Subehia.2014. Effect of long-term integrated nutrient management on rice (Oryza sativa L.) wheat (Triticum aestivum L.) productivity and soil properties in North-western Himalaya. *Journal of the Indian Society of Soil science* 62(3):248-254.

Sheeba,S.andS.Chellamuthu.1999. Long-term influence of organic and inorganic fertilization on the macro nutrient status of Inceptisols. *Journal of the Indian Society of Soil Science* 47 (4):803-804.

Singaram,P.and K.Kamalakumari.1995. Long-term effect of FYM and fertilizers on enzyme dynamics of soil. *Journal of the Indian Society of Soil Science* 43(3): 378-381.

Tejada,Manuel,Concepción Benítez, Isidoro Gómez and Juan Parrado.2011.Use of biostimulants on soil restoration: Effects on soil biochemical properties and microbial community. *Applied soil ecology* 49:11-17.

Tejada,Manuel,Isidoro Gómez,Teresa Hernández and Carlos García. 2010. Utilization of vermicomposts in soil restoration:effects on soil biological properties. *Soil Science Society of America Journal* 74(2):525-532.

Udayakumar,S.and R.Santhi.2017. Soil test based integrated plant nutrition system for pearlmillet on an Inceptisol. *Research on Crops* 18(1): 21-28.

Uz,IlkerandI.E.Tavali.2014. Short-term effect of vermicompost application on biological properties of an alkaline soil with high lime content from Mediterranean region of Turkey. *The Scientific World Journal* 2014(1):1-11.

Vidyavathi, G.S., H.B.Dasog, N.S.Babalad, S.K.Hebsur,S.G.Gali,Patil and A.R.Alagawadi.2012. Nutrient status of soil under different nutrient and crop management practices.*Karnataka Journal of Agricultural Sciences* 25(2): (193-198).

Wang, Donghong, QinghuaShi, XiufengWang, MinWei, JinyuHu, JunLiu and Feng juanYang. 2010. Influence of cow manure vermicompost on the growth, metabolite contents,and antioxid ant activities of Chinese cabbage (Brassica campestriss sp.chinensis). *Biology and fertility of soils* 46(7):689-696.

Watts, Dexter B.,H.A.Torbert,Yucheng Feng and S.A.Prior.2010. Soil microbial community dynamics as influenced by composted dairy manure, soil properties, and landscape position. *Soil Science* 175(10):474-486.

Zhang, LI Yang, and Hung.2010.Pedogenic carbonate to mechanical and soil dehydrogenase activity in response to soil organic matter in arteniliaordosica community. *Pedosphere* 20(2):229-235.

Table 2. Effect of NPK alone and IPNS treatments on the release pattern of soil available nitrogen (kg ha^{-1})

Treatment	Treatment Details	Soil available nitrogen (kg ha^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	213	213	219	223	217
T2	$N_0P_0K_0F_{12.5}$	213	214	221	225	228
T3	$N_0P_0K_0F_{25}$	213	215	223	228	232
T4	$N_0P_{80}K_{120}F_0$	213	214	222	231	223
T5	$N_0P_{80}K_{120}F_{25}$	213	217	226	234	241
T6	$N_{80}P_{40}K_{60}F_0$	213	219	228	237	229
T7	$N_{80}P_{40}K_{60}F_{25}$	213	222	232	240	247
T8	$N_{80}P_{80}K_{120}F_0$	213	222	232	242	229
T9	$N_{80}P_{80}K_{120}F_{25}$	213	226	238	247	253
T10	$N_{160}P_{80}K_{120}F_0$	213	229	237	248	235
T11	$N_{160}P_{80}K_{120}F_{25}$	213	233	241	251	260
T12	$N_{240}P_{80}K_{120}F_0$	213	239	246	250	241
T13	$N_{240}P_{80}K_{120}F_{25}$	213	242	248	258	268
T14	$N_{240}P_{120}K_{180}F_0$	213	243	250	260	256
T15	$N_{240}P_{120}K_{180}F_{25}$	213	248	254	265	276
	SEm±		4.02	3.51	2.99	3.15
	SEd±		5.64	4.93	4.20	4.43
	CD (P=0.05)		11.0	10.0	9.0	9.0

Table 3. Effect of NPK alone and IPNS treatments on the release pattern of soil available phosphorus (kg ha^{-1})

Treatment	Treatment Details	Soil available phosphorus (kg ha^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	22.6	23.5	24.3	25.2	23.5
T2	$N_0P_0K_0F_{12.5}$	22.6	23.5	27.0	30.4	24.3
T3	$N_0P_0K_0F_{25}$	22.6	24.3	27.0	29.6	26.1
T4	$N_0P_{80}K_{120}F_0$	22.6	24.3	29.6	34.8	27.0
T5	$N_0P_{80}K_{120}F_{25}$	22.6	26.1	30.4	34.8	29.6
T6	$N_{80}P_{40}K_{60}F_0$	22.6	25.2	30.4	35.7	28.7
T7	$N_{80}P_{40}K_{60}F_{25}$	22.6	27.0	30.4	33.9	30.4
T8	$N_{80}P_{80}K_{120}F_0$	22.6	27.0	32.2	37.4	30.7
T9	$N_{80}P_{80}K_{120}F_{25}$	22.6	27.8	32.2	36.5	32.2
T10	$N_{160}P_{80}K_{120}F_0$	22.6	28.7	33.9	39.1	31.3
T11	$N_{160}P_{80}K_{120}F_{25}$	22.6	29.4	35.5	41.0	33.0
T12	$N_{240}P_{80}K_{120}F_0$	22.6	28.7	34.8	40.9	32.2
T13	$N_{240}P_{80}K_{120}F_{25}$	22.6	30.6	36.5	42.5	34.8
T14	$N_{240}P_{120}K_{180}F_0$	22.6	30.5	35.7	40.9	33.9
T15	$N_{240}P_{120}K_{180}F_{25}$	22.6	32.3	38.4	43.5	38.3
SEm±			0.45	0.51	0.59	0.91
SEd±			0.63	0.71	0.84	1.28
CD (P=0.05)			1.8	2.1	1.8	3.1

Table 4. Effect of NPK alone and IPNS treatments on the release pattern of soil available potassium (kg ha^{-1})

Treatment	Treatment Details	Soil available potassium (kg ha^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	238	239	240	242	245
T2	$N_0P_0K_0F_{12.5}$	238	240	242	244	247
T3	$N_0P_0K_0F_{25}$	238	241	243	246	250
T4	$N_0P_{80}K_{120}F_0$	238	241	243	245	250
T5	$N_0P_{80}K_{120}F_{25}$	238	243	247	250	254
T6	$N_{80}P_{40}K_{60}F_0$	238	244	247	250	253
T7	$N_{80}P_{40}K_{60}F_{25}$	238	246	250	254	257
T8	$N_{80}P_{80}K_{120}F_0$	238	245	251	252	257
T9	$N_{80}P_{80}K_{120}F_{25}$	238	250	254	257	261
T10	$N_{160}P_{80}K_{120}F_0$	238	249	255	257	261
T11	$N_{160}P_{80}K_{120}F_{25}$	238	253	258	261	265
T12	$N_{240}P_{80}K_{120}F_0$	238	252	254	257	264
T13	$N_{240}P_{80}K_{120}F_{25}$	238	257	262	265	268
T14	$N_{240}P_{120}K_{180}F_0$	238	254	259	262	266
T15	$N_{240}P_{120}K_{180}F_{25}$	238	259	266	269	274
	SEm±		1.66	1.76	1.82	1.80
	SEd±		2.34	2.47	2.56	2.52
	CD (P=0.05)		5.1	5.4	6.3	6.2

Table 5. Effect of NPK alone and IPNS treatments on alkaline phosphatase activity inincubated soil

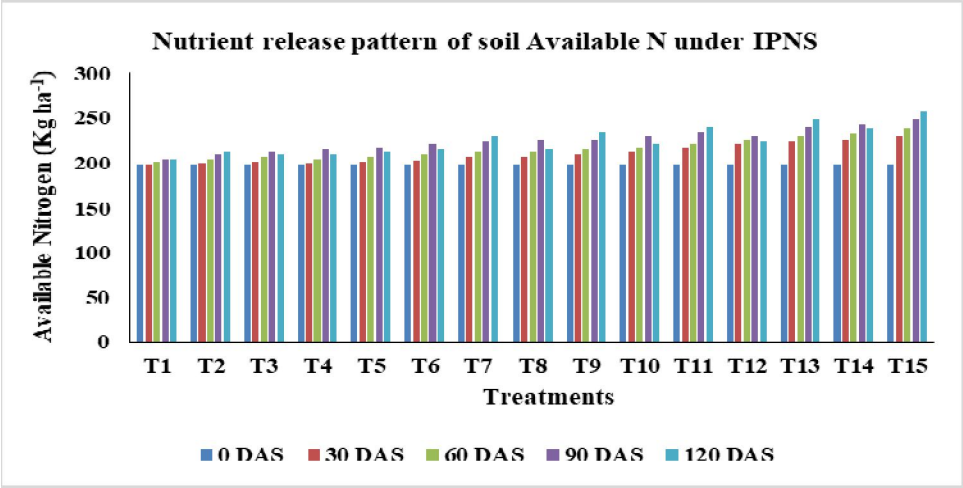
Treatment	Treatment Details	Alkaline phosphatase activity (µg *p*NP g^{-1} hr^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	37.02	19.79	15.58	15.15	15.32
T2	$N_0P_0K_0F_{12.5}$	37.02	20.18	16.80	15.59	16.48
T3	$N_0P_0K_0F_{25}$	37.02	22.77	19.18	17.68	18.57
T4	$N_0P_{80}K_{120}F_0$	37.02	23.57	19.58	18.05	19.04
T5	$N_0P_{80}K_{120}F_{25}$	37.02	25.58	21.14	20.05	21.91
T6	$N_{80}P_{40}K_{60}F_0$	37.02	20.55	16.24	15.54	15.95
T7	$N_{80}P_{40}K_{60}F_{25}$	37.02	25.22	21.28	19.78	20.25
T8	$N_{80}P_{80}K_{120}F_0$	37.02	24.29	20.70	19.38	19.55
T9	$N_{80}P_{80}K_{120}F_{25}$	37.02	25.58	21.08	19.58	20.26
T10	$N_{160}P_{80}K_{120}F_0$	37.02	24.77	20.18	18.88	19.93
T11	$N_{160}P_{80}K_{120}F_{25}$	37.02	26.76	23.97	21.72	25.01
T12	$N_{240}P_{80}K_{120}F_0$	37.02	23.70	20.16	18.28	19.03
T13	$N_{240}P_{80}K_{120}F_{25}$	37.02	27.36	24.75	21.96	25.20
T14	$N_{240}P_{120}K_{180}F_0$	37.02	24.68	20.76	19.58	22.18
T15	$N_{240}P_{120}K_{180}F_{25}$	37.02	28.18	25.71	22.55	26.97
SEm±			0.51	0.59	0.85	0.53
SEd±			0.72	0.83	1.20	0.75
CD (P=0.05)			1.8	1.9	2.5	1.1

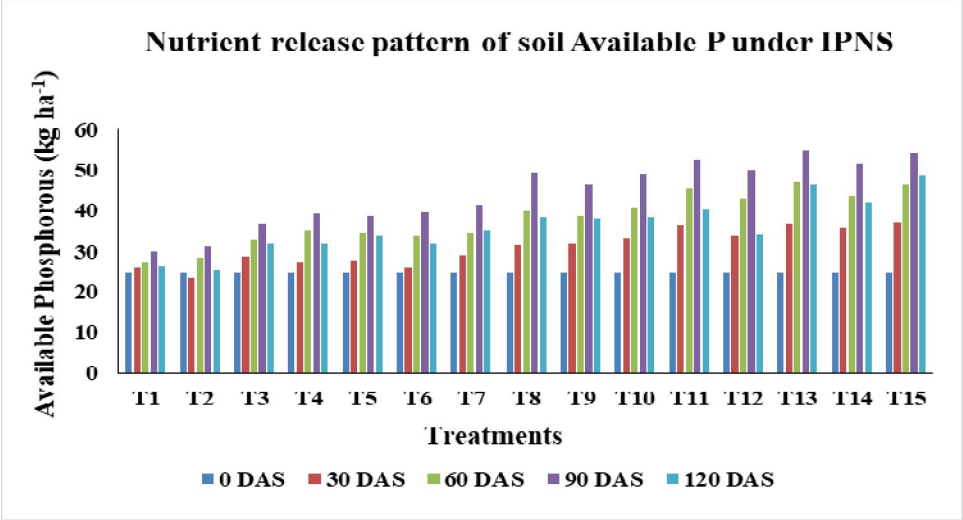
Table 6. Effect of NPK alone and IPNS treatments on dehydrogenase enzyme activity in incubated soil

Treatment	Treatment Details	Dehydrogenase enzyme activity (µg TPF g^{-1} day^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	2.58	1.94	1.46	0.83	0.65
T2	$N_0P_0K_0F_{12.5}$	2.58	3.13	2.65	1.72	1.31
T3	$N_0P_0K_0F_{25}$	2.58	4.13	3.64	2.63	1.41
T4	$N_0P_{80}K_{120}F_0$	2.58	2.14	1.49	0.89	0.66
T5	$N_0P_{80}K_{120}F_{25}$	2.58	4.36	3.39	2.61	1.45
T6	$N_{80}P_{40}K_{60}F_0$	2.58	2.31	1.83	2.65	0.79
T7	$N_{80}P_{40}K_{60}F_{25}$	2.58	4.67	3.61	2.78	1.42
T8	$N_{80}P_{80}K_{120}F_0$	2.58	2.56	2.02	1.36	0.78
T9	$N_{80}P_{80}K_{120}F_{25}$	2.58	4.75	3.78	2.90	1.64
T10	$N_{160}P_{80}K_{120}F_0$	2.58	2.59	2.09	1.45	0.79
T11	$N_{160}P_{80}K_{120}F_{25}$	2.58	4.80	3.84	2.91	1.67
T12	$N_{240}P_{80}K_{120}F_0$	2.58	2.67	2.04	1.47	0.83
T13	$N_{240}P_{80}K_{120}F_{25}$	2.58	4.85	3.88	2.93	1.84
T14	$N_{240}P_{120}K_{180}F_0$	2.58	3.07	2.07	1.50	0.98
T15	$N_{240}P_{120}K_{180}F_{25}$	2.58	5.12	4.03	3.16	2.14
	SEm±		0.14	0.13	0.10	0.09
	SEd±		0.20	0.18	0.14	0.13
	CD (P=0.05)		0.41	0.37	0.25	0.22

Table 7. Effect of NPK alone and IPNS treatments on urease enzyme activity in incubated soil

Treatment	Treatment Details	Urease enzyme activity (µg NH_4-N g^{-1} day^{-1})				
		Days after incubation				
		0	30	60	90	120
T1	$N_0P_0K_0F_0$	193	196	158	126	95
T2	$N_0P_0K_0F_{12.5}$	193	196	161	130	98
T3	$N_0P_0K_0F_{25}$	193	200	165	133	102
T4	$N_0P_{80}K_{120}F_0$	193	200	158	126	95
T5	$N_0P_{80}K_{120}F_{25}$	193	196	165	133	102
T6	$N_{80}P_{40}K_{60}F_0$	193	200	158	126	95
T7	$N_{80}P_{40}K_{60}F_{25}$	193	217	179	147	116
T8	$N_{80}P_{80}K_{120}F_0$	193	196	172	140	109
T9	$N_{80}P_{80}K_{120}F_{25}$	193	238	186	154	123
T10	$N_{160}P_{80}K_{120}F_0$	193	235	182	151	119
T11	$N_{160}P_{80}K_{120}F_{25}$	193	238	193	161	130
T12	$N_{240}P_{80}K_{120}F_0$	193	249	189	158	126
T13	$N_{240}P_{80}K_{120}F_{25}$	193	263	200	168	137
T14	$N_{240}P_{120}K_{180}F_0$	193	256	189	158	126
T15	$N_{240}P_{120}K_{180}F_{25}$	193	270	203	172	140
	SEm±		3.81	3.86	2.75	2.15
	SEd±		5.36	5.42	3.84	3.02
	CD (P=0.05)		9.2	9.3	8.1	7.3





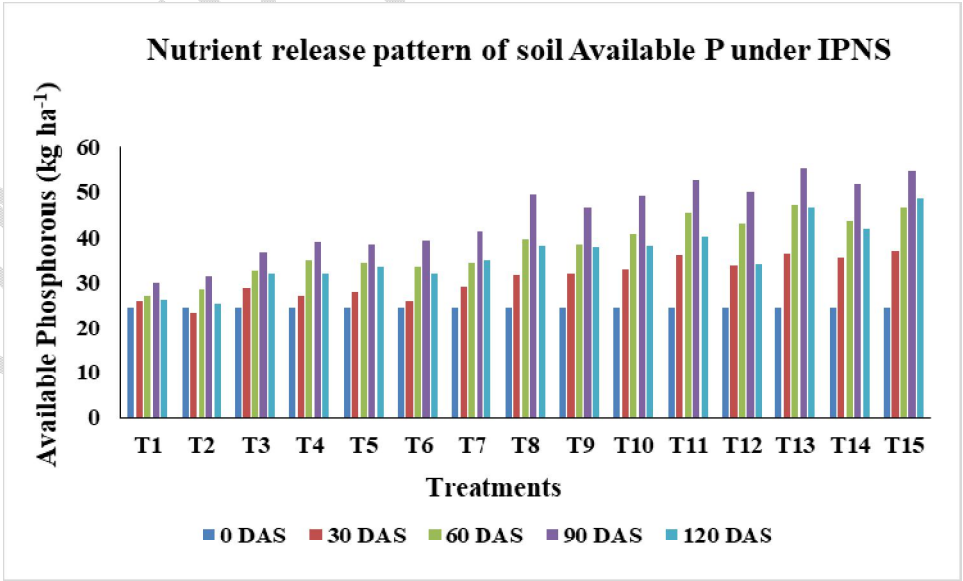
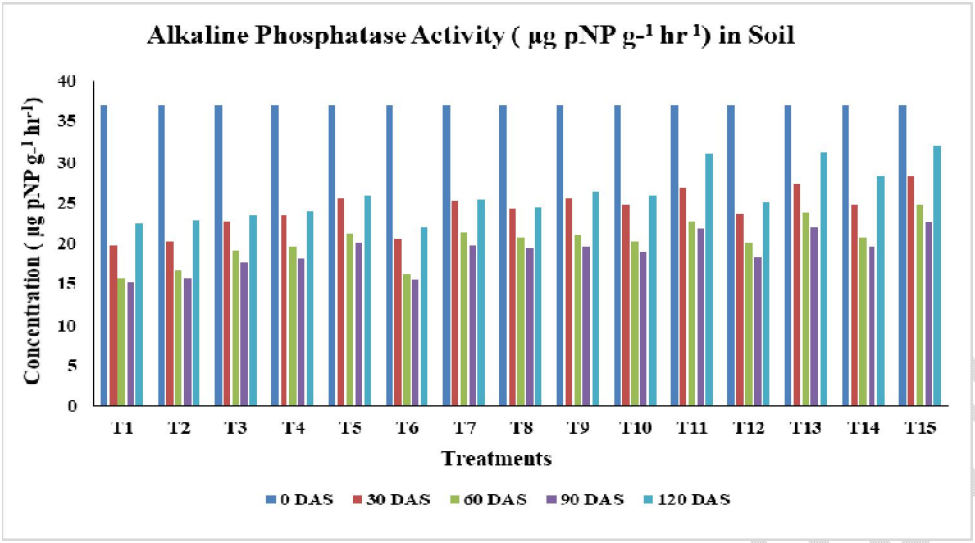
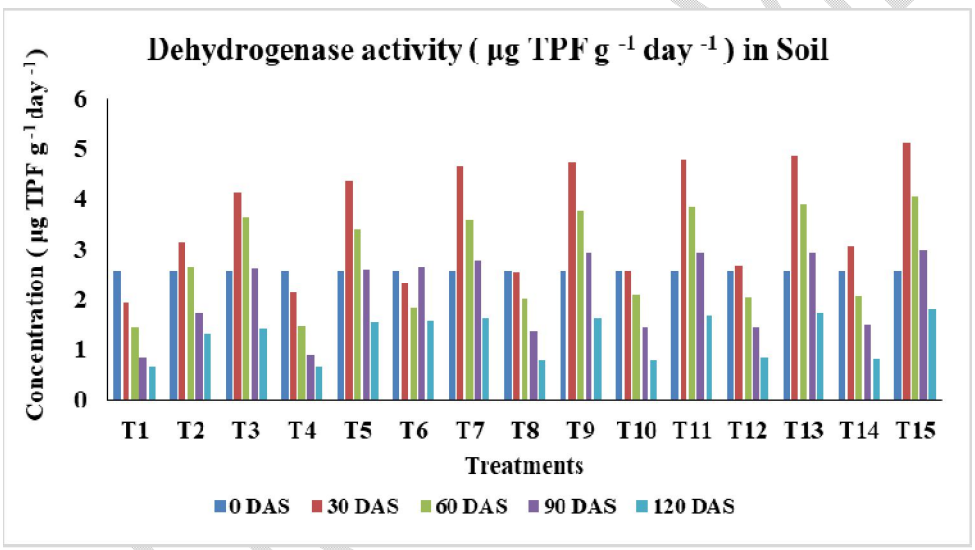


Fig 1. Nutrient release pattern of available NPK under NPK alone and IPNS





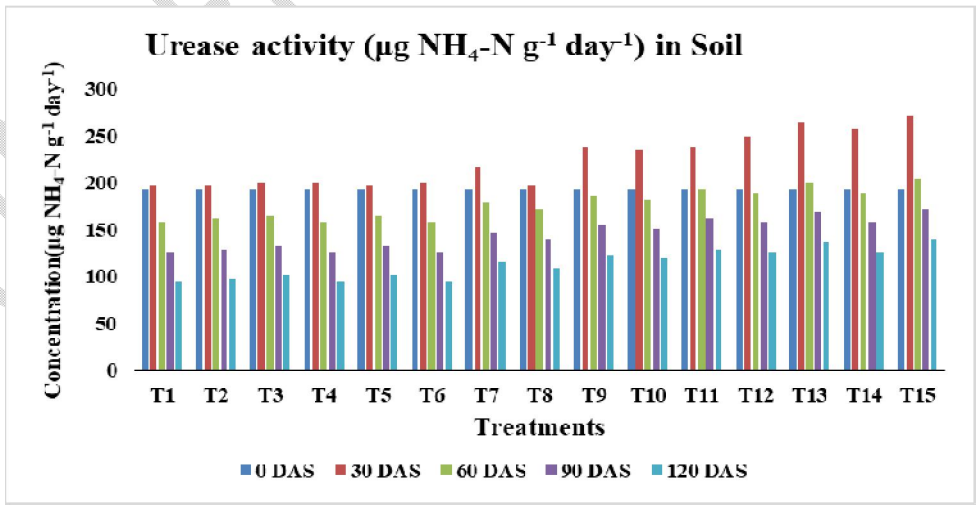


Fig. 2. Enzymatic activities under incubation studies

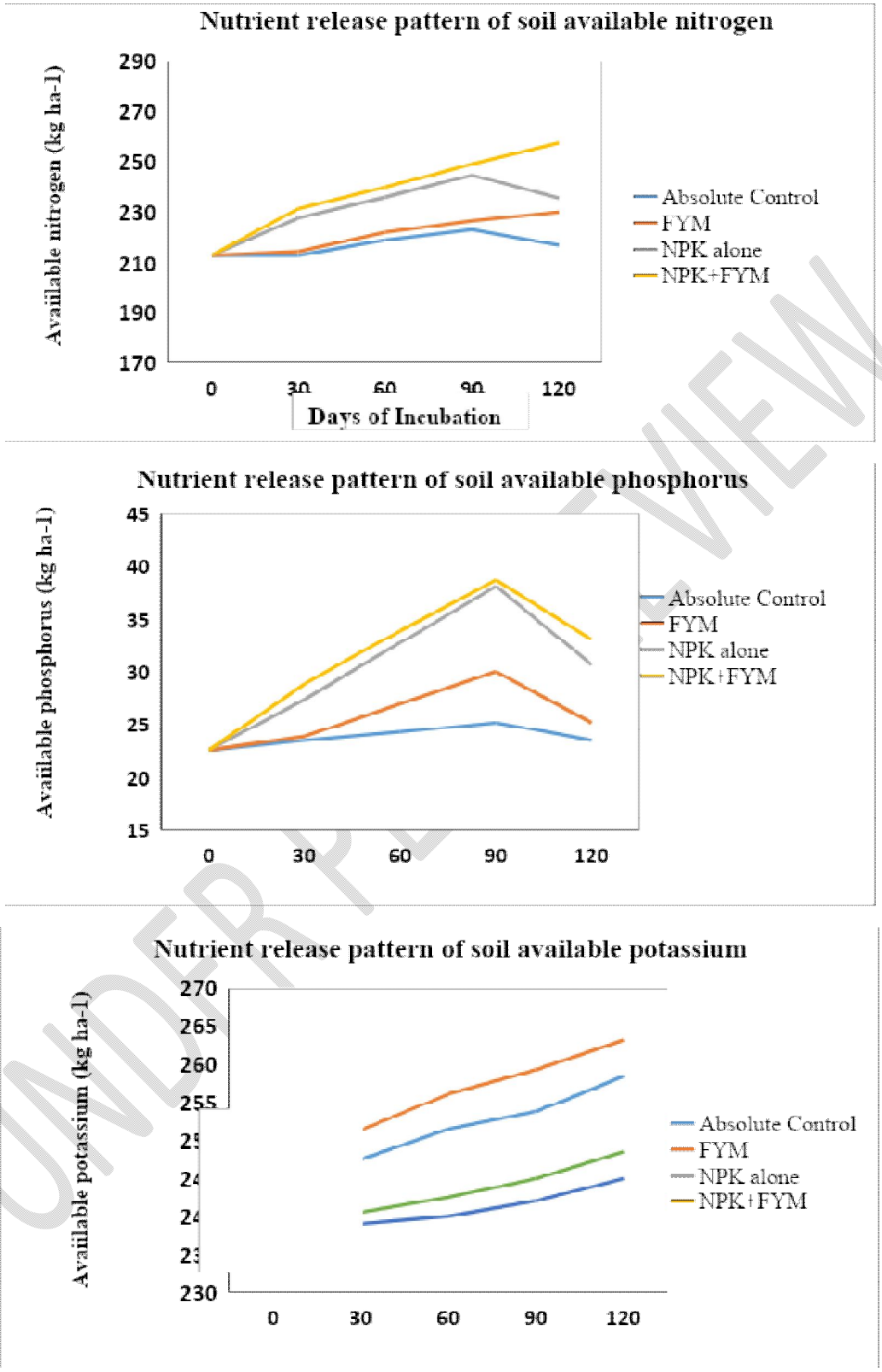


Fig. 3. Nutrient release pattern of available NPK under NPK alone and IPNS

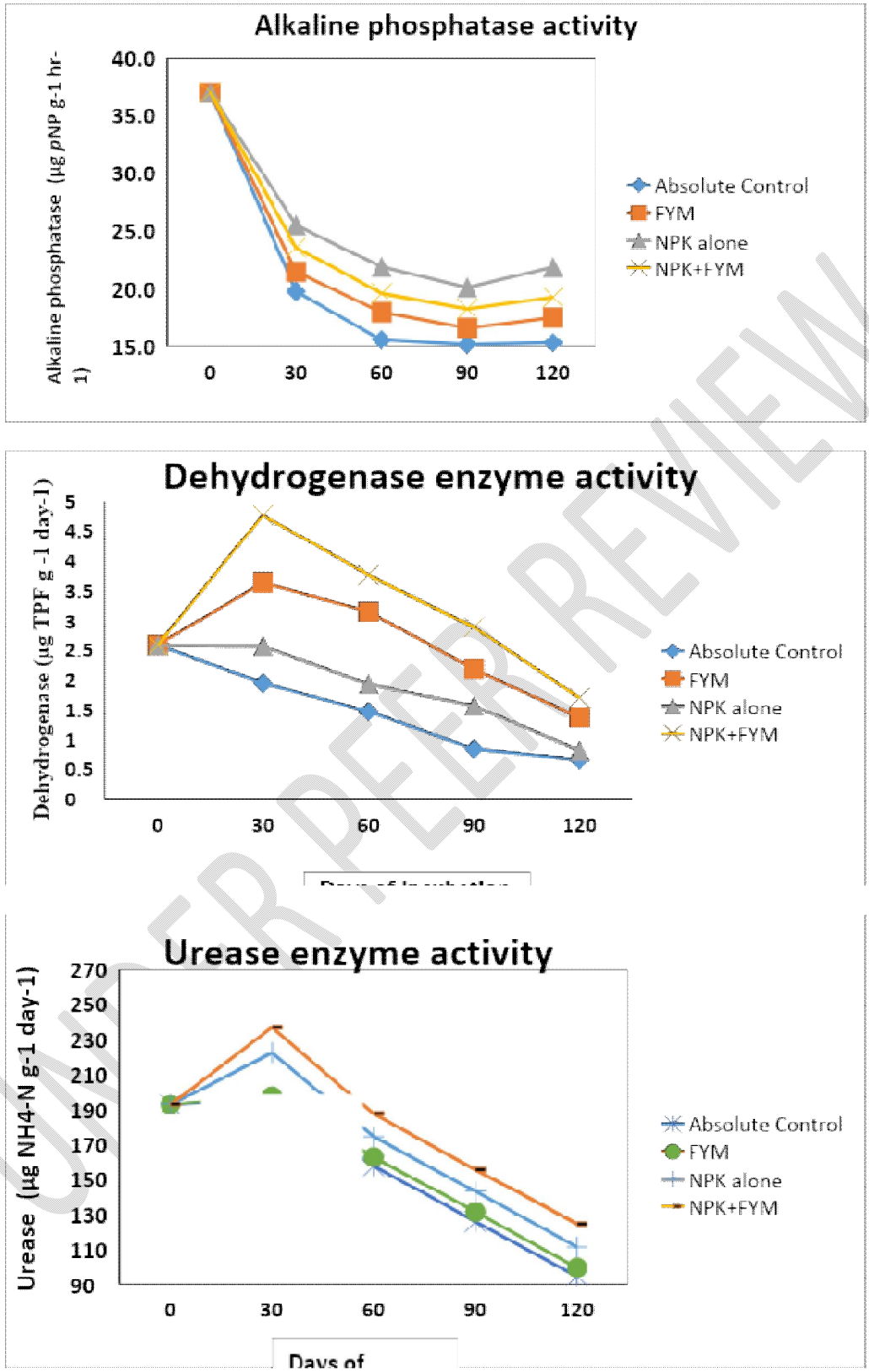


Fig. 4. Enzymatic activities of different treatments under incubation studies