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Influence of different rice establishment methods and nutrient levels on soil enzyme activity, nutrient status and grain yield of rice in North Coastal Zone of Andhra Pradesh

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ABSTRACT

To enhance productivity, alleviate environmental and management constraints and enhance farmers' income in the rice, new approaches that are labour-saving, more productive and sustainable need to be developed. Experiment was formulated to know the impact/influence of different rice establishment methods and different levels of nitrogen application on soil and crop productivity of rice. Results revealed that, among different rice establishment systems, machine transplanting recorded significantly higher yields followed by SRI method. Lowest yields were recorded in dry seed broadcasting method. With increasing nitrogen levels, yields were increased in all the systems and further enhancement of rice yields were observed with potassium nitrate foliar spray along with chemical fertilizers. Soil enzyme activity particularly urease and dehydrogenase was significantly high under normal planting and SRI method of planting, respectively and lowest enzyme activities were recorded in broadcasting of dry seed. Soil organic carbon content also followed the same trend as like enzyme activity. With regard to soil nutrient status, significant differences were not observed in phosphorus and potassium, however available nitrogen status was increased with increasing fertilizer levels and among different methods, drum seeding recorded highest status (286 kg ha^{-1}).

Key words: *Rice establishment methods, soil enzyme activity, grain yield, nutrient content*

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population. As global grain demand is projected to double by 2050, the challenge to achieve even higher rice production levels still remains. Transplanting is the most dominant and traditional method of rice establishment system in several parts of India under irrigated low land conditions. Change in rice establishment method from traditional manual transplanting to different rice planting methods i,e direct sowing, mechanical transplanting, seed broadcasting under puddled condition, line sowing, drum seeder along with SRI method of cultivation in the last two decades in response to rising production costs especially for labour and water.Irrigated and rain-fed lowland rice systems account for 92 % of total rice production and nutrients applied as fertilizers account for 20-25 % of total production costs in these rice systems. Fertilizer use is one of the major factors for the continuous increase in rice production; more than 20 % of fertilizer nitrogen (N) produced worldwide is used in the rice fields of Asia. The crop growth, yield and soil properties may be affected differently under different production systems and nutrient management practices. Present study has been taken up to evaluate the effect of different rice establishment systems and nutrient management practices on soil and crop productivity of rice under clay loam soils of North Coastal Zone of Andhra Pradesh.

MATERIALS AND METHODS

Field experiment was conducted at Regional Agricultural Research Station, Anakapalle during *kharif*

2014 and *kharif* 2015 in split plot design with seven planting methods as main plots and 4 nutrient management practices as sub plots. Seven planting methods *viz*., transplanted rice, sprouted seed broad costing under puddled condition, drum seeding, dry seeding by broad casting, dry seeding in lines, mechanical planting and SRI method of planting. Sub plots includes 100 % recommended dose of fertilizers, 100 % recommended dose of fertilizers + foliar spray of potassium nitrate at 10 days after panicle initiation and panicle emergence, 150 % recommended dose of fertilizer nitrogen and 100 % recommended dose of P & K, 150 % recommended dose of fertilizer nitrogen and 100 % recommended dose of P & K + foliar spray of potassium nitrate at 10 days after panicle initiation and panicle emergence. Initial (before sowing of the main crop) and post-harvest soil samples (after harvest of the crop) were dried under shade, pounded and to sieved through a 2 mm sieve. Soil samples for enzyme analysis was collected at peak tillering stage of the crop as the enzyme activity was highest at this stage, hence collected the soil samples in this stage for comparison in between treatments. The samples were analyzed for pH, EC, OC, available N, P, K and micronutrients (Zn, Fe, Cu and Mn) by adopting standard procedures.Available nitrogen was determined by alkaline permanganate method as outlined by Subbiah and Asija (1959). Available phosphorus was determined by Olsens method as outlined by Jackson (1967). Available potassium was determined by neutral normal ammonium acetate solution using flame photometer as outlined by Jackson (1967). Soil pH, Electrical Conductivity and Organic Carbon content in post harvest soils were determined as per standard procedures described by Jackson (1967). Soil micronutrient status was determined by using method described by Lindsay and Norvell(1967). Urease activity was assayed by quantifying the rate of release of NH_4^+ from the hydrolysis of urea as described by Tabatabai and Bremner (1972) but with some modifications as suggested by Sankara Rao (1989). Dehydrogenase activity was assayed by quantifying the mg of TPF (2, 3, 5 - triphenyl formazon) produced by reaction with 2, 3, 5 - TTC and expressed as $mg^{-1}g$ sample d^{-1} as described by Cassida et al. (1964). Analysis of Variance (ANOVA) was performed using standard procedure for split plot design (Chandel, 2002).

RESULTS AND DISCUSSION

Grain and Straw Yields

Data on grain yields and straw yields were presented in Table 1 and Table 2, respectively. Data revealed that, among different rice establishment systems, machine transplanting recorded significantly highest yields (5.15 t ha^{-1}) followed by SRI method (4.75 t ha^{-1}). Data presented in Table 1, revealed that, lowest yields were recorded in dry seed broadcasting method (3.85 tha^{-1}). With increasing nitrogen levels, yields were increased in all the systems and further enhancement of rice yields were observed with potassium nitrate foliar spray along with chemical fertilizers. Highest cane yields of 5.95 t ha^{-1} were recorded with 150 % RDFN + foliar spraying of potassium nitrate in machine transplanting system and lowest grain yields of 4.40 t ha^{-1} were recorded in dry seed broadcasting. Compared to dry seed broadcasting, sprouted seed broadcasting gave an additional yield of 400 to 500 kg ha^{-1} might be due to plant stand compensation. Mean grain yield among different nutrient levels ranged between 4.55 to 5.28 t

Table 1. Effect of different nutrient levels on grain yield (t ha^{-1}) of rice under different rice production systems.

Treatments	100 % RDFN	100 % RDFN+FS	150 % RDFN	150 % RDFN + FS	Mean
Sprouted seed broadcasting	4.38	4.58	4.80	4.98	4.69
Drum seeder	4.65	4.95	5.30	5.55	5.11
SRI method	4.75	5.40	5.38	5.75	5.32
Machine transplanting	5.15	5.50	5.42	5.95	5.51
Dry seed broadcasting	3.85	4.15	4.25	4.40	4.16
Dry seed in lines	4.26	4.40	4.68	4.85	4.55
Normal Transplanting	4.78	5.05	5.10	5.47	5.10
Mean	4.55	4.86	4.99	5.28	4.92
CD (5 %) A	0.3010				
B	0.2786				
A x B	0.4120				
CV (%)	7.50				

Table 2. Effect of different nutrient levels on straw yield (t ha^{-1}) of rice under different rice production systems.

M/S	100 % RDF	100 % RDF+FS	150 % RDF	150 % RDF + FS	Mean
Sprouted seed broadcasting	6.06	6.25	6.49	6.7	6.38
Drum seeder	6.42	6.63	7.18	7.73	6.99
SRI method	6.50	7.27	7.24	7.85	7.22
Machine transplanting	6.80	7.35	7.35	8.08	7.40
Dry seed broadcasting	5.31	5.66	5.76	6.04	5.69
Dry seed in lines	5.72	6.00	6.34	6.74	6.20
Normal transplanting	6.60	6.77	6.87	7.41	6.91
Mean	6.20	6.56	6.75	7.22	6.68
	0.4150				
CD (5 %) A	0.3560				
B	0.4821				
A x B	6.80				
CV (%)	8.10				

ha^{-1} and among different rice production systems it was varied from 4.69 to 5.51 t ha^{-1}. Similar results were report by Mondal et al. (2016). The availability of required quantity of nitrogen for long time was probably responsible for producing more number of effective tillers. Kumari et al. (2000) reported that productive tillers significantly increased with increased levels of N up to 120 kg per ha. Subramaniam et al., 2014 stated that, Grain yield was found significantly higher in SRI method (12 - 23 and 4-35 % in the *kharif* and *rabi* seasons, respectively). He concluded that SRI practices create favorable conditions for beneficial soil microbes to prosper and increase grain yield. Straw yields (Table 2) also followed the same trend as it was high with 150 % RDFN + foliar spraying of potassium nitrate under machine transplanting (8.08 t h^{-1}) and SRI method of cultivation (7.85 t ha^{-1}). This could be due to high availability and utilization of nitrogen by the crop from inorganic source (fertilizer). These findings are in conformity with Singh et al. (2005). Uphoff (2002) reported that rice has the potential to produce more tillers and grain than now observed and that early transplanting and optimal growth condition can fulfill this potential. Subbaiah et al., 2008 found that grain yield recorded under SRI was significantly higher compared to that of normal method of paddy cultivation. Tomar et al (2018) reported that grain yield and straw yield of rice was influenced significantly by crop planting

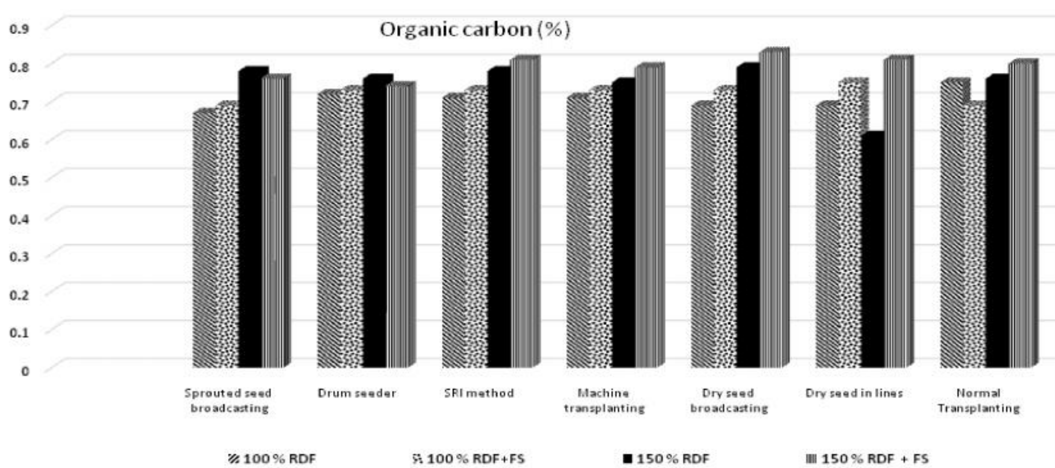


Fig. 1. Effect of different nutrient levels on soil organic carbon and available macronutrient status under different rice establishment systems.

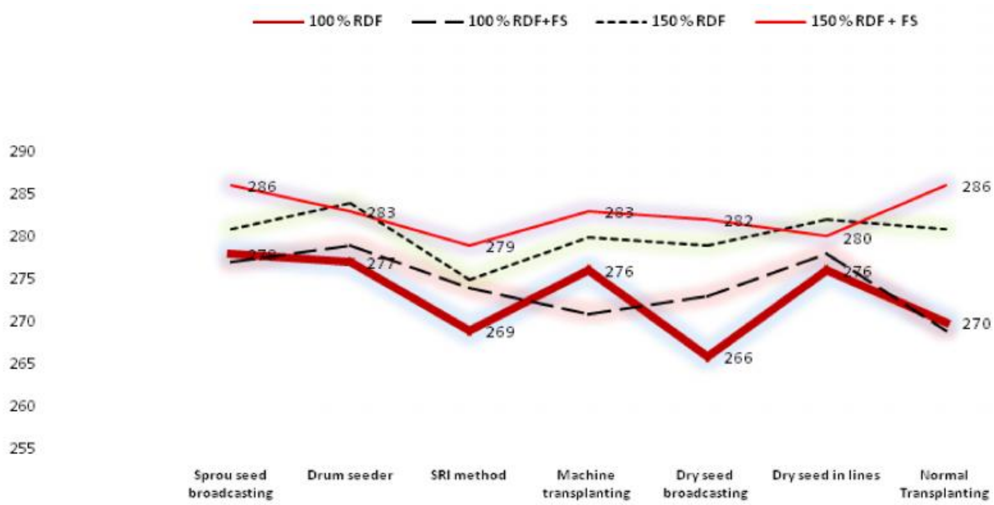


Fig. 2. Effect of different nutrient levels on soil available nitrogen under different rice establishment systems.

methods and they reported, under SRI method significantly higher grain yield was recorded followed by transplanting method and lowest grain yield under direct seeded method. Yield is a function of complex inter relationship of growth in vegetative phase and yield attributes, as well. Higher yield under machine transplanting and SRI method was due to better crop growth and development resulting in to higher value of yield attributes which had direct bearing on the grain yield. Higher number of panicle per unit area, panicle size and filled grains percentage might be responsible for superiority of this treatment over other in respect of grain yield (Krishna et al., 2008).

Soil available macro nutrient status

The data on initial soil analysis revealed that the soils were neutral in soil reaction with non saline conductivity. The organic carbon content was medium in range and the available nitrogen content was low, available phosphorus and potassium was high.

The pH and electrical conductivity of the post harvest soils of rice varied with in a narrow range among different main and sub treatments and the differences were statistically non significant. Significantly highest mean organic carbon content (0.76 %) was recorded in SRI method and Normal transplanting method and lowest organic carbon content of 0.73 % was recorded in dry seed sowing method (Fig. 1). The possible reason might be , when soil is flooded and becomes anaerobic, a fraction of the microbial cells in the soil will lyse and release their contents into the soil solution, creating a flush of nutrients. A similar effect for releasing nitrogen from soil microbes when soil flooding occurs has long been known (Birch, 1958.). Among different nutrient levels, highest content of 0.79 % (Fig. 1) was recorded in the treatment which received 150 % recommended dose of chemical fertilizers + foliar spray of potassium nitrate. It may be attributed to higher contribution of biomass to the soil in the form of crop stubbles and residues. The subsequent decomposition of these materials might have resulted in enhanced organic carbon content of the soil (Datta and Singh, 2010). Further it was also observed that the available nitrogen status in soil increased with the increasing levels of fertilizer nitrogen from 100 % (266 kg ha^{-1}) to 150 % (286 kg ha^{-1}). Regarding available phosphorus status, significance was not observed in between main and sub treatments, however highest available phosphorus status of 82.10 kg ha^{-1} was recorded in 150 % recommended dose of fertilizer nitrogen under drum seeding method and lowest status of 67.50 kg ha^{-1} was recorded in 100 % recommended dose of fertilizers under direct sown in line method of planting (Fig. 4). Increase in available phosphorus status with increasing nitrogen level was observed, might be due to synergistic effect between nitrogen and phosphorus. Available potassium also showed similar trend as like available phosphorus, there is no particular trend among planting

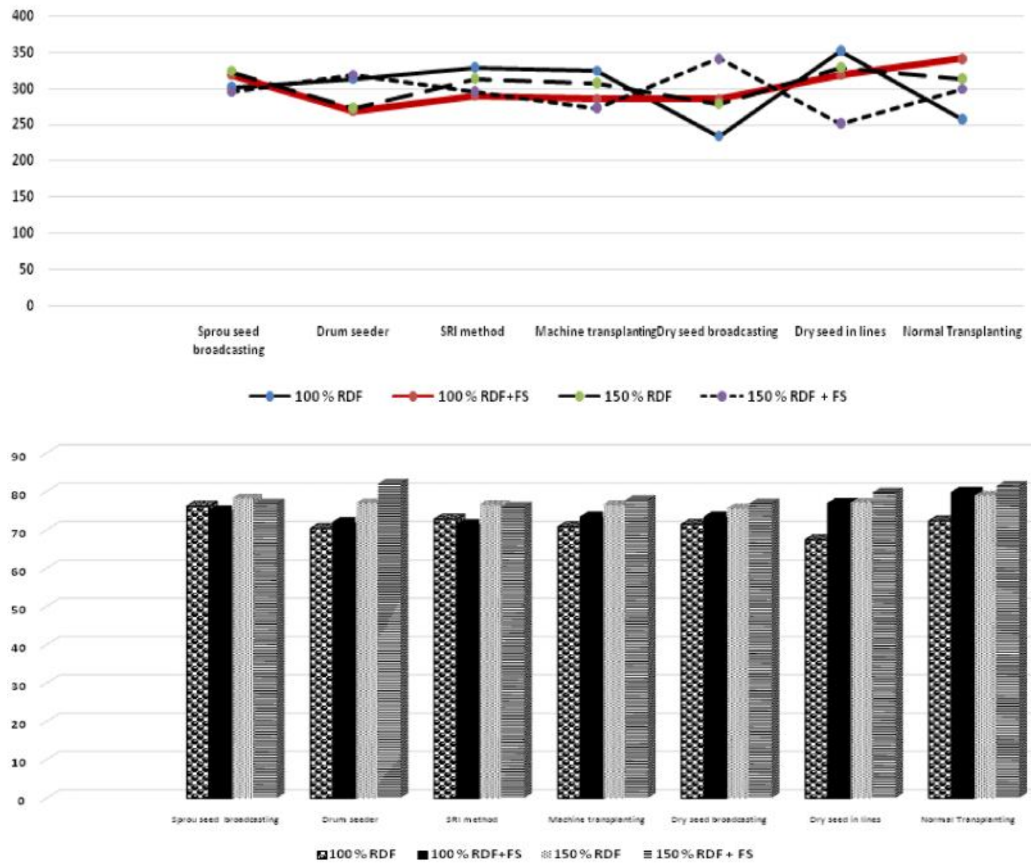


Fig. 3 & **Fig. 4.** Effect of different nutrient levels on soil available potassium and phosphorus under different rice establishment systems.

methods and fertilizer levels. Data presented in Table 3 revealed that highest available potassium status of 353 kg ha^{-1} was recorded in 100 % fertilizer nitrogen under dry seeding in lines and lowest status (253 kg ha^{-1}) recorded under dry seeding in lines with 150 % recommended dose of nitrogen and foliar spray of potassium nitrate.

Soil micronutrient status

Data on soil micronutrient status was presented in Fig. 5. Data revealed that, available zinc status varied from 0.45 to 1.12 ppm in different planting methods, highest content was recorded under drum seeding methods. Among different nutrient levels it was ranged between 0.70 to 0.75 ppm. There is no significant difference among different nutrient levels, however rice establishment methods showed significance with respect to available zinc (Fig. 5). Regarding available iron status, highest status of 15.95 ppm was recorded in machine transplanting method and lowest status (11.01 ppm) was recorded in dry seed broadcasting method. Particular trend was not observed with the in the nutrient levels, however higher mean available status was recorded in 100 % recommended dose with foliar spray (Fig. 5). Available copper content varied from 3.38 (150 % recommended dose of fertilizer nitrogen + 100 % P & K + foliar spray) to 3.63 ppm (150 % recommended dose of fertilizer nitrogen + 100 % P & K) with in the nutrient levels and 3.06 (machine transplanting) to 3.68 ppm (sprouted seed broadcasting) with in the rice establishment methods (Fig. 5). Highest available mean manganese status of 19.77 ppm was recorded with 150 % recommended dose of fertilizer nitrogen + 100 % P & K + foliar spray and lowest status (13.67 ppm) was recorded 100 % recommended dose of fertilizers + foliar spray, among planting methods, highest status of 16.85 ppm was recorded in dry seeding (Fig. 5).

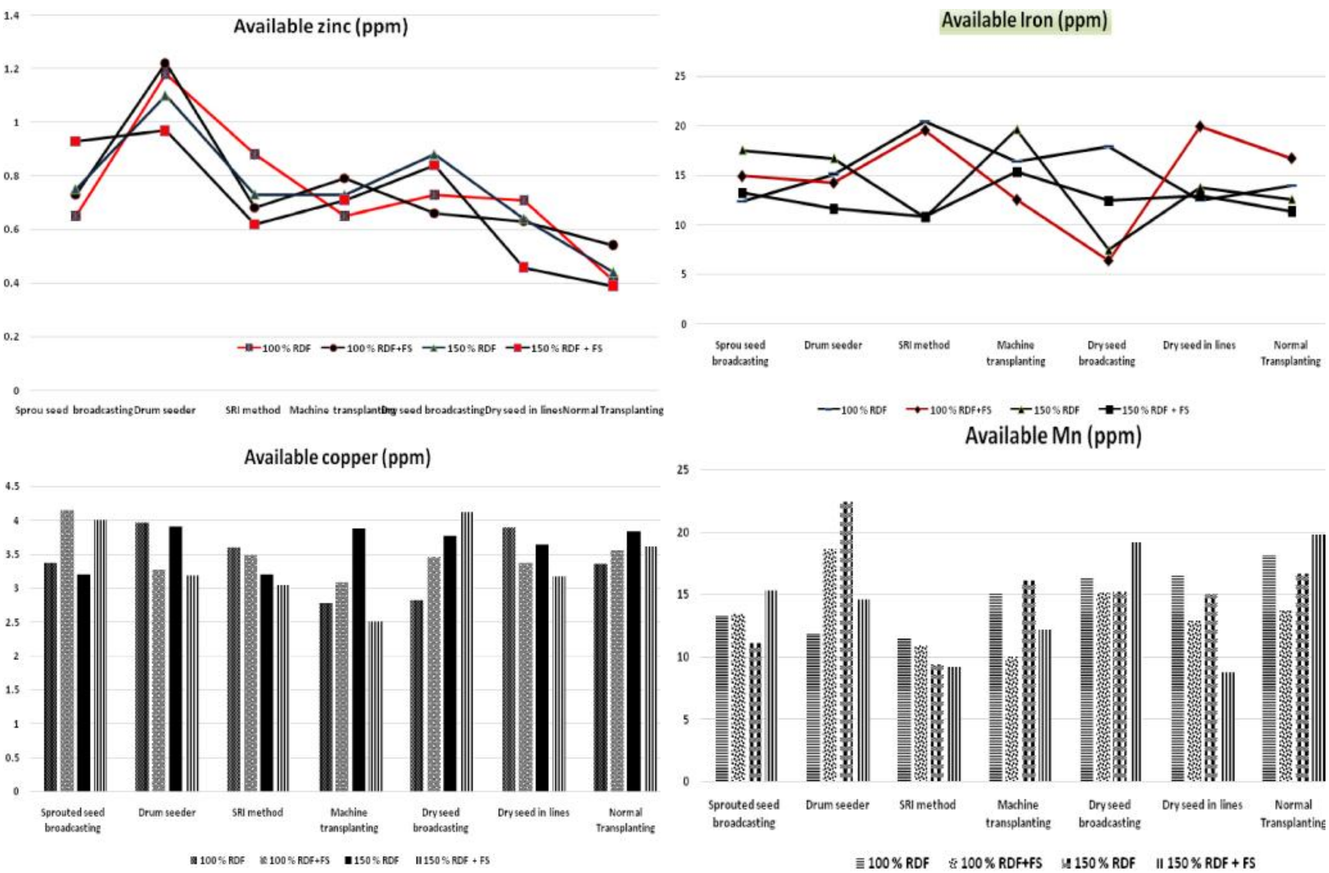
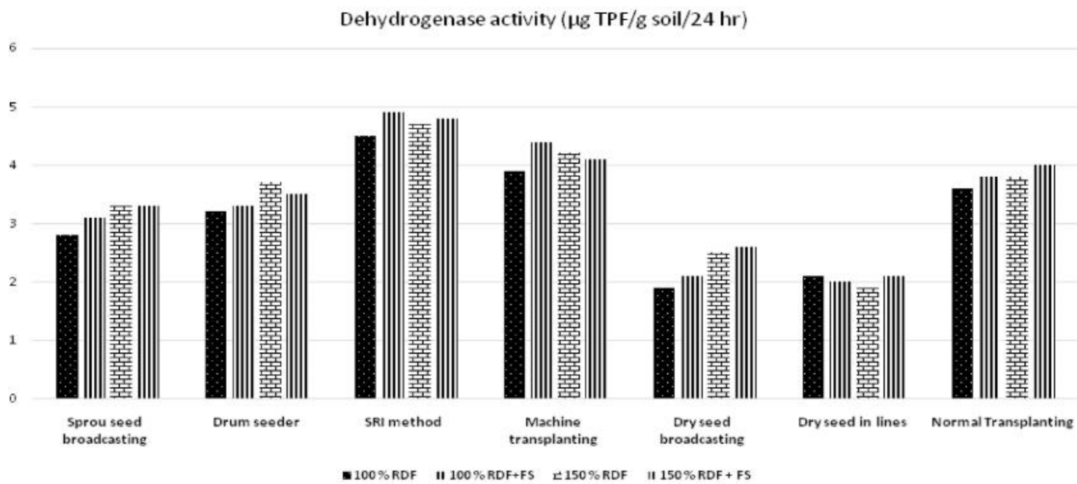


Fig. 5. Effect of different nutrient levels on soil available micronutrient status (ppm) under different rice establishment systems.

Weijabhandara et al., 2011 recorded maximum uptake of zinc than other methods.

Soil enzyme activity

Data presented in Fig. 6 and Fig. 7 revealed that among different rice planting methods, highest dehydrogenase activity was recorded in SRI method of cultivation with 150 % recommended dose of nitrogen + foliar spray of potassium nitrate followed by normal transplanting with 150 % recommended dose of fertilizers + foliar spray of potassium nitrate. Among different nutrient levels the dehydrogenase activity ranged between 3.14 to 3.49 mg TPF produced g^{-1} soil d^{-1} at peak tillering stage and among different planting methods it varied from 2.03 to 4.73 mg TPF produced g^{-1} soil d^{-1}. Highest urease activity of 6.75 mg NH 45 g^{-1} 2 hr^{-1} was observed in normal transplanting method, with in the nutrient levels highest activity was observed with 150 % recommended dose of fertilizers + foliar spray of potassium nitrate (5.90 mg NH 45 g^{-1} 2 hr^{-1}). Lowest enzyme activities were recorded in broadcasting of dry seed with 100 % recommended dose of fertilizers + foliar spray of potassium nitrate. The higher dehydrogenase activity under SRI method of planting could be attributed to luxuriant root proliferation leading to a nutrient rich environment, which was more conducive for proliferation of the microflora for enhanced enzyme synthesis (Ramesh et al., 2006). Further increased availability of nitrogen enhanced the enzyme activity due to increased root biomass. The lower soil enzyme activity under dry seeding, might be due to un favourable soil environment for proliferation of soil microbes and in turn its dehydrogenase activity. Increased availability of nitrogen increases the activities of urease, which indicates that nitrogen act as substrate for urease enzymes.Subramaniam et al., 2014 stated that, organic carbon % and soil enzymes were found be higher in



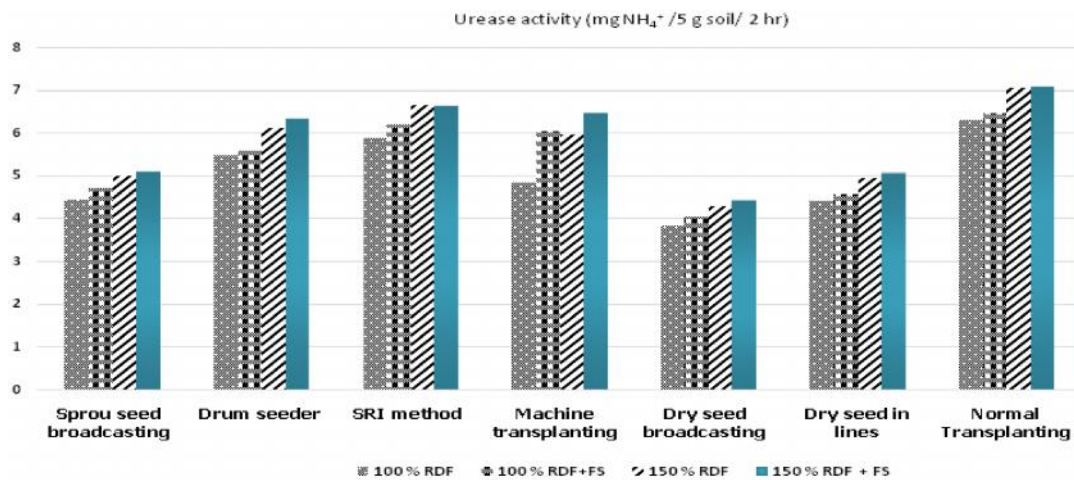


Fig. 6. & **Fig. 7.** Effect of different nutrient levels on soil enzyme activity under different rice establishment systems.

the SRI method and stated that SRI method can create favorable conditions for beneficial soil microbes to prosper.

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