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RESPONSE OF RICE GENOTYPES BY DIFFERENT COATED UREA FERTILIZERS

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ABSTRACT

The experiment was conducted during *pishanam* (Sep-Oct)2018 with eleven efficient and responsive (ER) rice cultivated genotypes viz., ASD16, ADT39, ADT45, TPS5, AD09206, CB06803, ACK14001, TM10085, TM12007, PM12009 and EC725224 under four N levels (0, 50, 100 and 150 % recommended N) with modified three N fertilizer (Neem coated urea, Gypsum coated urea and sand incubated urea) using split-split plot design. The genotypic characteristics and different nitrogen levels showed a variation in this growth and utilization of nitrogen. It was described with the support of grain yield and growth parameters such as leaf area index, productive tillers hill^{-1}, number of filled grains panicle^{-1}, panicle length, N uptake and apparent N use efficiency of rice. It also indicated that nitrogen as neem and gypsum coated urea gave a better results compared to sand incubated urea due to slowly release of nitrogen for crop growth period and reduced the losses of nitrogen. It is concluded that 100 % of neem coated and/or 150 % of gypsum coated urea along with recommended $P_2O_5$and K_2O is recommended for N efficient and responsive genotypes particularly TM12077, ADT39 and ACK14001 to enhance rice productivity in Tamirabarani river basin of Tamilnadu.

(Key words : Gypsum CU, NCU, N recovery efficiency, rice, slow release fertilizers)

INTRODUCTION

Rice (*Oryzas ativa* L.) is widely grown in tropical and subtropical regions (Singh *et al*., 2012) and is one of the main staple foods for nearly two-thirds of the population of the world (Roy *et al*., 2012). It has been observed that differences in yield after the application of different fertilizers are related to N losses through volatilization, denitrification and mobilization of N (Carefoot *et al*., 1990). This depends on the degree of contact between fertilizer, root and soil moisture levels. Lower recovery of N has been attributed to the gaseous loss of N and immobilization of N with surface application of nitrogenous fertilizer (Rice and Symth, 1994). Among the methods of N fertilizer application, the split application is a common practice for higher crop yields, nitrogen use efficiency without potential leaching and run-off losses (Randall and Schmitt, 1998). In this situation, the use of slow release fertilizers could decrease nutrient losses by enhancing nutrient use efficiency.

The application of controlled-release or slow-release fertilizers may reduce N losses and toxicity, particularly to young seedlings. It causes specific damage to plants at different sensitive growth stages. They may also reduce lodging and injury from ammonium ions. Thus, controlled release fertilizers, especially those that release nutrients in a sigmoidal pattern, can contribute to improved agronomic safety (Shaviv, 2005). Urea management is critical to minimize potential N loss, especially through ammonia volatilization which has been shown to account for 20 to 80 % of N loss in rice production (Griggs *et al*., 2007; Norman *et al*., 2009). Controlled release fertilizers make it possible to meet the full nutrient requirements of crops and multiple cropping by making a single or split fertilizer application which substantially decreases the risk of environmental pollution (Zhang *et al*., 2001). The present study was carried out to find out the yield and efficiency of different coated slow-release fertilizers such as neem oil coated urea, gypsum coated urea and sand incubated urea.

MATERIALS AND METHODS

The experiment was conducted during *pishanam* 2018 (Sep-Oct) with eleven efficient and responsive (ER) genotypes namely ASD16, ADT39, ADT45, TPS5, AD09206, CB06803, ACK14001, TM10085, TM12007, PM12009 and EC725224 (Chosen from 2017 previous season screening experiment) under four N levels (0, 50, 100 and 150 % recommended N) with modified three N fertilizers (Neem coated urea, Gypsum coated urea and sand incubated urea). The experiment was conducted in Split - Split plot design (rice genotypes as main plot, N levels as sub plot and coated

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urea fertilizers as sub-sub plots) with two replications. The soil of experimental site had the same textural class (sandy clay loam), Ambasamudram series (*AquicHaplustalf*) of shallow soil. The nursery was raised separately for 11 different rice genotypes. The main field was prepared sufficiently earlier before transplanting by puddling initially with cage wheel operation for two times and then levelled uniformly with leveller. The layout was taken up as per the design of the experiment. The entire dose of P_2O_5 (74 kg 0.25 ha^{-}) was applied as a single super phosphate before planting. The potassium was applied as muriate of potash (20 kg 0.25 ha^{-}) in four equal splits before planting, attillering (30 DAT), panicle initiation (60 DAT) and at flowering stage (75DAT).

Preparation of coating fertilizers

The neem oil (3 %) bought was uniformly coated with urea granules (1:5) with the help of a rotating drum. The neem oil coated urea was kept overnight before application. For the Gypsum coated urea, gypsum was thoroughly powdered and mixed with urea using gum acacia as a sticking agent. Gum acacia was added first with urea for coating then gypsum powder was added at a 1:5 ratio uniformly using a rotating drum. The GCU was stored for 24 hours to ensure a strong coating. In sand incubated urea, the sand was mixed with urea in a ratio of 1:1 ratio using kerosene as a sticking agent and stored overnight.

Plant growth characters

The LAI was calculated by dividing the measured leaf area by the ground surface area.Number of filled grains panicle^{-1} was counted of five main panicles in each plot and panicle length (cm) from panicle base up to a piculus of the upper most spikelet of the panicle from five panicles.Straw and grain yield (kg ha^{-1}) were also recorded.The grain yield from each plot was recorded as kg plot^{-1} and converted to kg ha^{-1}. The moisture content of the grains was estimated by oven drying (80^{0}C) and the grain yield was adjusted to 14 per cent moisture content.

Calculation of plant nutrient uptake and use efficiencies

Nitrogen content was estimated by micro-kjeldahl method as per procedure suggested by Piper (1966). Uptake of nitrogen was calculated by multiplying the biomass yield (kg ha^{-1}) with the corresponding nitrogen concentration in the plant parts at every growth stage and the sum of the uptake of straw, grain at harvest was expressed as the total N uptake (kg ha^{-1}).

Apparent N recovery efficiency (ANRE)

Apparent recovery efficiency (RE) is the efficiency with which the crop utilizes the acquired N from the N applied through fertilizer and computed as follows.

$$\text{Apparrent recovery efficiency} = \frac{\text{(Total plant N uptake with N application) - (Total plant Nuptake without N application}}{\text{N application}} \times 100$$

Data analysis

The collected data were subjected to ANOVA using statistical analysis software (Statistix10). The mean separation was done using by the least significant difference test at 5 % probability level and simple correlation was made to determine the association of parameters by using MS office excel (Gomez and Gomez ,1984).

RESULTS AND DISCUSSION

Grain yield

The treatments showed significant differences on yield of rice genotypes by nitrogen application through coating by different materials. The genotype TM12077 recorded highest grain yield which was statistically at par with ADT39 (6280 and 5954 kg ha^{-1}). The lowest grain yield of 4833 kg ha^{-1}was recorded by genotype TPS5. The higher amount of nitrogen application showed better yield in all the genotypes with linear curve. The application rate of 150 % recommended dose of N (N3) significantly recorded the highest grain yield of 6146 kg ha^{-1}which was statistically at par with 6091 kg ha^{-1}that was recorded by the application of 100 % recommended dose of N (N2). Belete *et al*. (2018) reported that application of nitrogen is essential for obtaining optimum yield in wheat varieties. Figure 1 showed the positive relationship between growth parameters and grain yield increased by nitrogen application in optimum quantity with the contribution percentage of 91, 99 and 98 of leaf area index ($R^2 = 0.91$), panicle length ($R^2 = 0.99$), productive tillers ($R^2 = 0.99$) and filled grains panicle^{-1} ($R^2 = 0.98$). Among the three coated N fertilizers, gypsum coated urea (F2) significantly recorded the higher grain yield of 5649 kg ha^{-1} followed by neem coated urea and sand incubated urea.

The interaction between rice genotypes and different N management practices of coated N fertilizer application significantly influenced the grain yield (Table 2). Among the 11 genotypes tested, the 5 of the genotypes such as ADT39, TPS5, TM10085, TM12077 and PM12009 significantly recorded the highest grain yield under neem coated urea, whereas the rice genotypes ASD16, ADT45, CB06803, AD09206, ACK14001 and EC725224 recorded more yield of grain under the application of gypsum coated urea under 150 % recommended dose of nitrogen.All the genotypes are not utilizing the nitrogen released from fertilizer in entire growth period. It showed the varietal potential characters of rice cultivars. The coated urea fertilizers released the nitrogen slowly and minimized the losses of NH_3through volatilization and leaching. Gaju *et al*. (2011) who indicated that grain yield was reduced under low N (LN), with an average reduction of 2.2 t ha^{-1} (29%) in wheat genotypes.The higher level of nitrogen application supplied sufficient nitrogen and maintained its availability throughout rice growth and the plant remained green even at the time of maturity. Hence, the carbohydrates from photosynthesis may be more and efficiently translocated into the grains. Similar results were also reported by Fu-liang *et al*. (2012), who recorded an increase in grain yield of 10.4- 16.5 % with sulfur and polymer-coated urea over traditional urea.Deng *et al*. (2017) concluded that it reduces nutrient loss and improves maize yield.It was further supported by significant and positive relationships between grain yield and leaf area index (R^2 = 0.88) , panicle length (R^2 = 0.49), number of filled grains panicle^{-1}(R^2 = 0.73) and productive tillers panicle^{-1}(R^2 = 0.04) (Fig 1).

N uptake

Straw N uptake

Among the rice genotypes, TM10085 (G8) recorded the highest straw nitrogen uptake of 35.46 kg ha^{-1}which was statistically at par with TM12077 (34.75 kg ha^{-1}) and ACK14001 (33.29 kg ha^{-1}) at the harvest stage. The lowest plant N uptake of 14.79 kg ha^{-1}was recorded by variety ADT45 (G3) in the rice straw at the harvesting stage. Significant differences noticed among the N levels and the application of 150 % recommended dose of N (N3) registered significantly highest straw N uptake of 37.95 kg ha^{-1}at harvest stage of rice. Application of gypsum coated urea (F2) significantly recorded the highest N uptake of 28.52 kg ha^{-1}followed by the application of neem coated urea (27.43 kg ha^{-1}) and sand incubated urea (22.33 kg ha^{-1}) in rice straw (Table 1).

The highest straw nitrogen uptake of 37.03 kg ha^{-1}was registered by the rice genotype ACK14001 under the application of gypsum coated urea which was statistically at par with the same genotype under neem coated urea application and genotype TM10085 with all coated fertilizers and genotype TM12077 under both neem and gypsum coated urea (G6F1, G8F1, G8F2, G8F3, G9F1 and G9F2). Among the 11 genotypes tested, the 5 genotypes (ADT39, TPS5, CB06803, TM12077 and PM12009) significantly recorded the highest straw N uptake, whereas the rice genotypes *viz.*, ASD16, ADT45, ACK14001, AD09206 and EC725224 recorded more straw nitrogen uptake under gypsum coated urea application (Table 2). However, the genotype TM10085 with sand incubated urea registered higher uptake of nitrogen in straw. The lowest straw N uptake of 10.88 kg ha^{-1}was registered by genotype AD07206 under sand incubated urea (G7F3) and it was at par with genotype ADT39 under the same modified N of sand incubated urea (11.27 kg ha^{-1}). Better N uptake from slow release fertilizers has also been proven in previous studies by Kiran *et al*. (2010) and Binti *et al*. (2014), who reported that prolonged availability of N through NCU increased the N content in dry matter due to higher N uptake.Nitrogen content in the straw was significantly affected by the rate of nitrogen application, the highest concentration was observed in 120 kg ha^{-1} (0.513%), while lowest (0.376%) in control. Increasing the nitrogen concentration with N application might be due to the availability of sufficient N for vegetative growth and development with profused root system in wheat. Alemu *et al.* (2016) reported that while increasing the N application increased the N content in wheat straw from 0 to 120 Kg ha^{-1}.

Grain N uptake

Among the rice genotypes, TM10085 (G8) recorded the highest grain nitrogen uptake of 74.38 kg ha^{-1}which was statistically at par with TM12077 (70.54 kg ha^{-1}). The lowest grain N uptake of 50.30 kg ha^{-1}was recorded by genotype AD09206 (G7) at the harvesting stage of rice. Significant differences were noticed among the different N levels. Application of 150 % recommended dose of N (N3) registered higher grain N uptake of 80.02 kg ha^{-1}followed by the application of 100 % recommended dose of N (77.49 kg ha^{-1}) and application of 50 % recommended dose of nitrogen (55.33 kg ha^{-1}) at harvest stage of rice. The control (N0) registered the least N uptake of 36.57 kg ha^{-1}. The coated N fertilizers significantly influenced the nitrogen uptake by grain at different periods of rice growth. The application of gypsum coated urea (F2) significantly recorded higher N uptake of 66.53 kg ha^{-1}followed by the application of neem coated urea (62.45 kg ha^{-1}) and sand incubated urea (58.08 kg ha^{-1}) by the rice grain respectively (Table 1).

The highest grain nitrogen uptake of 78.07 kg ha^{-1}was registered by the rice genotype TM10085 under the application of gypsum coated urea (G8F2) which was statistically at par with TM10085 under gypsum coated urea (G8F2), and genotypes TM12077 and PM12009 under neem coated urea (G9F1 and G10F1). Among the 11 genotypes tested, the 5 genotypes (ADT39, TPS5, CB06803, TM12077 and PM12009) significantly recorded the highest grain N uptake in neem coated urea, whereas the rice genotypes ASD16, ADT45, ACK14001, AD09206 and EC725224 registered more grain nitrogen uptake with gypsum coated urea, while genotype TM10085 alone registered more grain uptake of nitrogen under the sand incubated urea. The lowest grain N uptake of 41.52 kg ha^{-1}was observed in genotype AD09206 under sand incubated urea (G7F3) and was at par with AD09206 under neem coated urea (45.57 kg ha^{-1}).There was a positive interaction between nitrogen applied and uptake could be due to the highest N within the plant which allows it to concentrate nitrogen as their yield increased (Table 2). It has been reported by Motzo*et al*. (2004) that the highest N uptake of wheat resulted from the highest N dose applied. Thind *et al*. (2010) reported the highest biomass yield and uptake from the optimum application 96 kg ha ^{1}of the nitrogen as neem coated urea for wheat crop.

Apparent N recovery efficiency

The main factors such as rice genotypes, N levels, and coated N fertilizers were significantly influenced by the apparent N recovery efficiency and data are presented in Table 3. Among the rice genotypes, TM12077 (G9) recorded the highest apparent N recovery efficiency of 63.28 % which was equally at par with the rice genotypes ACK14001 and ASD16 with an efficiency of 58.56 and 54.83 % respectively. The lowest apparent N recovery efficiency of 40.14 % was recorded by genotype PM12077 and had an equal effect as that of genotypes ADT39 (G2), ADT45 (G3), TPS5 (G4), CB06803 (G5) and AD09206 (G7). As the N level increased, the apparent N recovery efficiency also increased to the level of 100 % recommended dose of nitrogen and thereafter, decreased at 150 % recommended dose of nitrogen. Application of 100 % recommended dose of N significantly registered higher apparent N recovery efficiency of 57.17 % followed by the application of 50 % recommended dose of N with the efficiency of 49.28 % and 150 % recommended dose of nitrogen (40.04 %).Kumare *et al*. (2017) reported that nitrogen use efficiency was increased from lower level (0 kg ha^{-1}) to optimum dose of fertilizer (30 Kg ha^{-1}) application in pigeon pea. The apparent N recovery efficiency was also significantly influenced by coated N fertilizers. The application of gypsum coated urea (F2) significantly recorded higher apparent N use efficiency of 57.03 % followed by the application of neem coated urea (49.63 %) and sand incubated urea (39.83 %) respectively.

The data regarding interaction between genotypes and coated N fertilizer significantly influenced the ANRE are presented in Table 3. The highest percentage of apparent N recovery efficiency of 77.47 was recorded by the rice genotype AD09206 under the application of gypsum coated urea (G7N2) which was at par with genotypes ASD16 and TM12077 under the gypsum coated urea application. Out of the 11 genotypes tested, 6 genotypes (ASD16, ADT45, TPS5, AD09206, TM12077 and EC725224) significantly recorded the highest apparent N recovery efficiency under gypsum coated urea fertilizer, whereas the rice genotypes viz., ADT39, CB08603, ACK14001, TM10085 and PM12009 recorded more ANRE under the application of neem coated urea (F1). Aparna *et al*. (2017) enumerated that neem coated urea reduced leaching and volatilization losses and also inhibit the nitrification process resulting increase in the availability and mobilization of nutrient from source. The sand incubated urea always registered the lowest apparent N recovery efficiency in all the rice genotypes.

A three way interaction (between rice genotypes x levels of nitrogen application x coated N fertilizer) significantly influenced the apparent N recovery efficiency of rice genotypes in Tamirabarani command area (Fig 2). An overall, the ANRE of three-factor interaction ranged from 3.21 to 129.79 %. Among the efficient rice genotypes TM12077 registered higher apparent N recovery efficiency of 129.79 % followed by AD09206 (106.76 %). The genotypes namely ADT39, ADT45, CB06803, ACK14001 and TM10085 registered higher apparent N recovery efficiency by 67.60, 78.55, 63.62, 75.28 and 81.24 % respectively under 100 % recommended dose of nitrogen in the form of neem coated urea (N2F1), whereas the rice genotypes TPS5, AD09206 and TM12077 recorded higher ANRE of 62.62, 106.76 and 129.79 % under the application of 50 % recommended dose of nitrogen in the form of gypsum coated urea (N1F2). The application of 100 % recommended dose of nitrogen as gypsum coated urea registered the highest recovery efficiency of 94.07 and 80.77 % in the genotypes ASD16 and EC725224 respectively. The only genotype PM12009 among the11 rice genotypes registered the highest recovery of 70.37 % under sand incubated urea at 50 % RDN (G10N1F3). Nitrogen application as gypsum coated urea produced significantly higher REN which might be due to the enhanced effectiveness of rice uptake of N from periodical release of N by coated urea fertilizers (Golden *et al*., 2009). The genotypes ADT39 and PM12009 recorded the highest recovery efficiency under neem coated urea because it reduced N losses by the delayed N release which matched the synchronization between crop demand and N supply.Thind *et al*. (2010) reported that the difference in NUE depends upon climate, genotypes, and nitrogen rates and there was decline in apparent nitrogen recovery efficiency beyond 120 kg ha^{-1}in wheat. Kidanu *et al*. (2000) reported that recovery of N efficiency was high at 110 kg ha^{-1} as compared to 60 and 85 kg ha^{-1} in wheat. Value ranging from 30-50% is generally considered as a well-managed system for apparent fertilizer N recovery.

On comparing the efficient and responsive rice genotypes, the genotypes TM12077, ASD16, TM10085 and ACK14001 performed better and registered more grain and straw yields than other genotypes. However, the nitrogen uptake of straw, grain and total yield at harvest were highest in genotypes ASD16, TM12077, TM10085, ACK14001, PM12090 and EC725224. The efficiency indices of ANRE were more under genotypes ASD16, ADT39, ACK14001, TM12077 and EC725224. It is concluded that application of 100 % recommended dose of nitrogen as neem coated urea and / or 150 % recommended dose of N as gypsum coated urea along with recommended $P_2O_5$and K_2O is suitable for N efficient and responsive genotypes particularly TM12077, ADT39 and ACK14001 to enhance the rice productivity in Tamirabarani river basin of Tamilnadu.

Table 1. Main effect of rice genotypes (G), levels of nitrogen (N) and coated N fertilizer (F) on growth and yield attributes of rice

Treatments	Grain yield	Straw N uptake	Grain N uptake
		Main effect – Genotypes (G)	
G_1	5238[d]	28.39[b]	56.44[f]
G_2	5954[ab]	23.55[c]	62.97[de]
G_3	5432[cd]	14.79[e]	57.71[f]
G_4	4833[e]	26.69[cd]	56.51[f]
G_5	5324[d]	22.90[cd]	59.68[f]
G_6	5705[bc]	33.29[a]	69.00[bc]
G_7	5286[d]	20.94[d]	50.30[g]
G_8	5507[cd]	35.46[a]	74.38[a]
G_9	6280[a]	34.75[a]	70.54[ab]
G_{10}	5547[cd]	27.32[b]	66.15[cd]
G_{11}	5423[cd]	22.98[cd]	62.22[de]
Mean	**5503**	**26.10**	**62.35**
SEd	**149.89**	**1.08**	**1.84**
CD (0.05)	**333.97**	**2.42**	**4.11**
		Main effect - Nitrogen level (N)	
N_0	4524[c]	9.31[d]	36.57[d]
N_{50}	5250[b]	20.12[c]	55.33[c]
N_{100}	6091[a]	37.00[b]	77.49[b]
N_{150}	6146[a]	37.95[a]	80.02[a]
Mean	**5503**	**26.10**	**62.35**
SEd	**62.03**	**0.36**	**0.86**
CD (0.05)	**124.61**	**0.72**	**1.71**
		The main effect – Coated N fertilizer	
F_1	5535[b]	27.43[b]	62.45[b]
F_2	5649[a]	28.52[a]	66.53[a]
F_3	5524[c]	22.33[c]	58.08[c]
Mean	**5503**	**26.10**	**62.35**
SEd	**38.97**	**0.25**	**0.49**
CD (0.05)	**80.82**	**0.52**	**1.02**

$\mathbf{G_1}$ – ASD16, $\mathbf{G_2}$ – ADT39, $\mathbf{G_3}$ – ADT45, $\mathbf{G_4}$ – TPS5, $\mathbf{G_5}$ – CB06803, $\mathbf{G_6}$ – ACK14001, $\mathbf{G_7}$ – AD09206, $\mathbf{G_8}$ – TM10085, $\mathbf{G_9}$ – TM12077, $\mathbf{G_{10}}$ – PM12009, $\mathbf{G_{11}}$ – EC725224

$\mathbf{N_0}$ – Control , $\mathbf{N_{50}}$ – 50 % recommended dose of nitrogen, $\mathbf{N_{100}}$ – 100 % recommended dose of nitrogen, $\mathbf{N_{150}}$ – 150 % recommended dose of nitrogen

$\mathbf{F_1}$ – Neem coated urea, $\mathbf{F_2}$ - Gypsum coated urea, $\mathbf{F_3}$ – Sand incubated urea

Table 2. Interaction effect of rice genotypes and coated N fertilizer (G x F) on growth and yield attributes of rice

Treatments	Grain yield	StrawN uptake	GrainN uptake
	Interaction effect – Genotypes x Coated N fertilizer (G x F)		
G_1F_1	$5158^{jklmnopq}$	24.70^{hi}	52.19^{op}
G_1F_2	5364^{jklmn}	32.78^{cde}	62.74^{hijk}
G_1F_3	$5191^{jklmnop}$	26.68^{g}	54.39^{nop}
G_2F_1	6050^{bcd}	30.82^{ef}	68.45^{defg}
G_2F_2	5918^{bcde}	19.67^{lmn}	62.21^{hijkl}
G_2F_3	5892^{bcdef}	20.16^{lmn}	58.26^{klmn}
G_3F_1	5402^{hijklm}	14.02^{o}	56.27^{no}
G_3F_2	5787^{cdefgh}	19.08^{mn}	65.71^{f}
G_3F_3	$5107^{klmnopq}$	11.27^{op}	51.16^{p}
G_4F_1	4913^{opq}	24.86^{hij}	54.74^{nop}
G_4F_2	4801^{pq}	21.45^{klm}	56.52^{no}
G_4F_3	4785^{q}	21.77^{klm}	58.26^{klmn}
G_5F_1	5360^{ijklmn}	24.75^{hij}	59.11^{jklmn}
G_5F_2	5540^{efghij}	23.76^{ijk}	63.12^{hijk}
G_5F_3	5072^{lmnopq}	20.19^{lmn}	56.82^{mno}
G_6F_1	$5723^{cdefghi}$	35.65^{ab}	71.85^{de}
G_6F_2	5886^{bcdef}	37.03^{a}	72.61^{bcd}
G_6F_3	5505^{fghijk}	27.18^{gh}	62.54^{hij}
G_7F_1	5003^{mnopq}	19.32^{lmn}	45.57^{q}
G_7F_2	5859^{cdefg}	32.61^{de}	63.82^{ghij}
G_7F_3	4997^{nopq}	10.88^{p}	41.52^{q}
G_8F_1	5524^{efghij}	34.70^{abcd}	70.08^{bcdef}
G_8F_2	5482^{ghijk}	35.56^{abc}	78.07^{a}
G_8F_3	5514^{fghij}	36.14^{a}	75.00^{ab}
G_9F_1	6480^{a}	36.85^{a}	73.24^{abcd}
G_9F_2	6261^{ab}	35.44^{abc}	69.36^{cdef}
G_9F_3	6100^{ab}	31.95^{de}	69.01^{cdef}
$G_{10}F_1$	5867^{b}	32.98^{bcde}	73.74^{abc}
$G_{10}F_2$	5551^{efghij}	27.50^{h}	67.15^{efgh}
$G_{10}F_3$	5225^{jklmno}	21.48^{klm}	57.57^{lmn}
$G_{11}F_1$	5405^{hijkl}	22.07^{jkl}	61.77^{ijklm}
$G_{11}F_2$	5691^{defghi}	28.88^{fg}	70.48^{bcdef}
$G_{11}F_3$	$5172^{jklmnopq}$	17.99^{n}	54.41^{nop}
Mean	**5503**	**26.10**	**62.35**
SEd	**183.31**	**1.28**	**2.28**
CD (0.05)	**399.08**	**2.81**	**4.95**

Table 3. Apparent N use efficiency of rice in one way, two way and three-way interactions

Treatments		**ANRE (%)**			
Genotypes (G)		**Genotypes x Nitrogen level**		**Genotypes x fertilizer level**	
G_1	54.83^{abc}	G_1N_1	54.74^{def}	G_1F_1	44.82^{ijklmn}
G_2	47.38^{def}	G_1N_2	71.42^{bc}	G_1F_2	71.18^{ab}
G_3	41.95^{ef}	G_1N_3	38.34^{ijk}	G_1F_3	48.50^{ijklm}
G_4	43.48^{ef}	G_2N_1	42.62^{ghijk}	G_2F_1	62.35^{bcdef}
G_5	45.25^{def}	G_2N_2	44.26^{fghij}	G_2F_2	44.62^{jklmn}
G_6	58.56^{ab}	G_2N_3	55.26^{def}	G_2F_3	35.18^{no}
G_7	40.07^{f}	G_3N_1	26.82^{lm}	G_3F_1	41.73^{klmn}
G_8	56.09^{bcde}	G_3N_2	53.37^{defg}	G_3F_2	54.82^{efghi}
G_9	63.28^{a}	G_3N_3	45.67^{fghi}	G_3F_3	29.31^{op}
G_{10}	40.14^{f}	G_4N_1	51.19^{efgh}	G_4F_1	43.92^{jklmn}
G_{11}	52.11^{bcd}	G_4N_2	44.71^{fghij}	G_4F_2	44.08^{jklmn}
Mean	**48.83**	G_4N_3	34.53^{jkl}	G_4F_3	42.44^{jklmn}
SEd	**4.24**	G_5N_1	53.14^{defg}	G_5F_1	47.69^{ijklm}
CD (0.05)	**9.46**	G_5N_2	44.95^{fghij}	G_5F_2	47.57^{ijklm}
Nitrogen Level (N)		G_5N_3	37.65^{ijkl}	G_5F_3	40.48^{lmn}
N_{50}	49.28^{b}	G_6N_1	70.70^{bc}	G_6F_1	64.45^{abcde}
N_{100}	57.17^{a}	G_6N_2	61.28^{cde}	G_6F_2	63.85^{abcde}
N_{150}	40.04^{c}	G_6N_3	43.69^{ghij}	G_6F_3	47.38^{ijklm}
Mean	**48.83**	G_7N_1	55.08^{def}	G_7F_1	26.75^{op}
SEd	**1.04**	G_7N_2	47.43^{fghi}	G_7F_2	73.47^{a}
CD (0.05)	**2.08**	G_7N_3	17.70^{m}	G_7F_3	20.00^{p}
Coated N fertilizer (F)		G_8N_1	31.65^{kl}	G_8F_1	50.80^{ghijk}
F_1	49.63^{b}	G_8N_2	67.48^{bc}	G_8F_2	49.56^{hijklm}
F_2	57.03^{a}	G_8N_3	51.14^{efgh}	G_8F_3	49.91^{hijklm}
F_3	39.83^{c}	G_9N_1	96.02^{a}	G_9F_1	60.53^{cdefg}
Mean	**48.83**	G_9N_2	76.56^{b}	G_9F_2	70.20^{abc}
SEd	**0.66**	G_9N_3	17.25^{m}	G_9F_3	59.11^{defgh}
CD (0.05)	**1.37**	$G_{10}N_1$	19.40^{m}	$G_{10}F_1$	52.60^{fghij}
-	-	$G_{10}N_2$	53.56^{defg}	$G_{10}F_2$	42.09^{klmn}
-	-	$G_{10}N_3$	47.45^{fghi}	$G_{10}F_3$	25.72^{op}
-	-	$G_{11}N_1$	40.69^{hijk}	$G_{11}F_1$	50.32^{hijkl}
-	-	$G_{11}N_2$	63.84^{cd}	$G_{11}F_2$	65.88^{abcd}
-	-	$G_{11}N_3$	51.79^{efg}	$G_{11}F_3$	40.12^{mn}
-	-	**Mean**	**48.83**	**Mean**	**48.83**
-	-	**SEd**	**5.10**	**SEd**	**4.61**
-	-	**CD (0.05)**	**11.00**	**CD (0.05)**	**10.16**

Fig 1. Regression between yields attributes and grain yield by nitrogen application and coated urea application

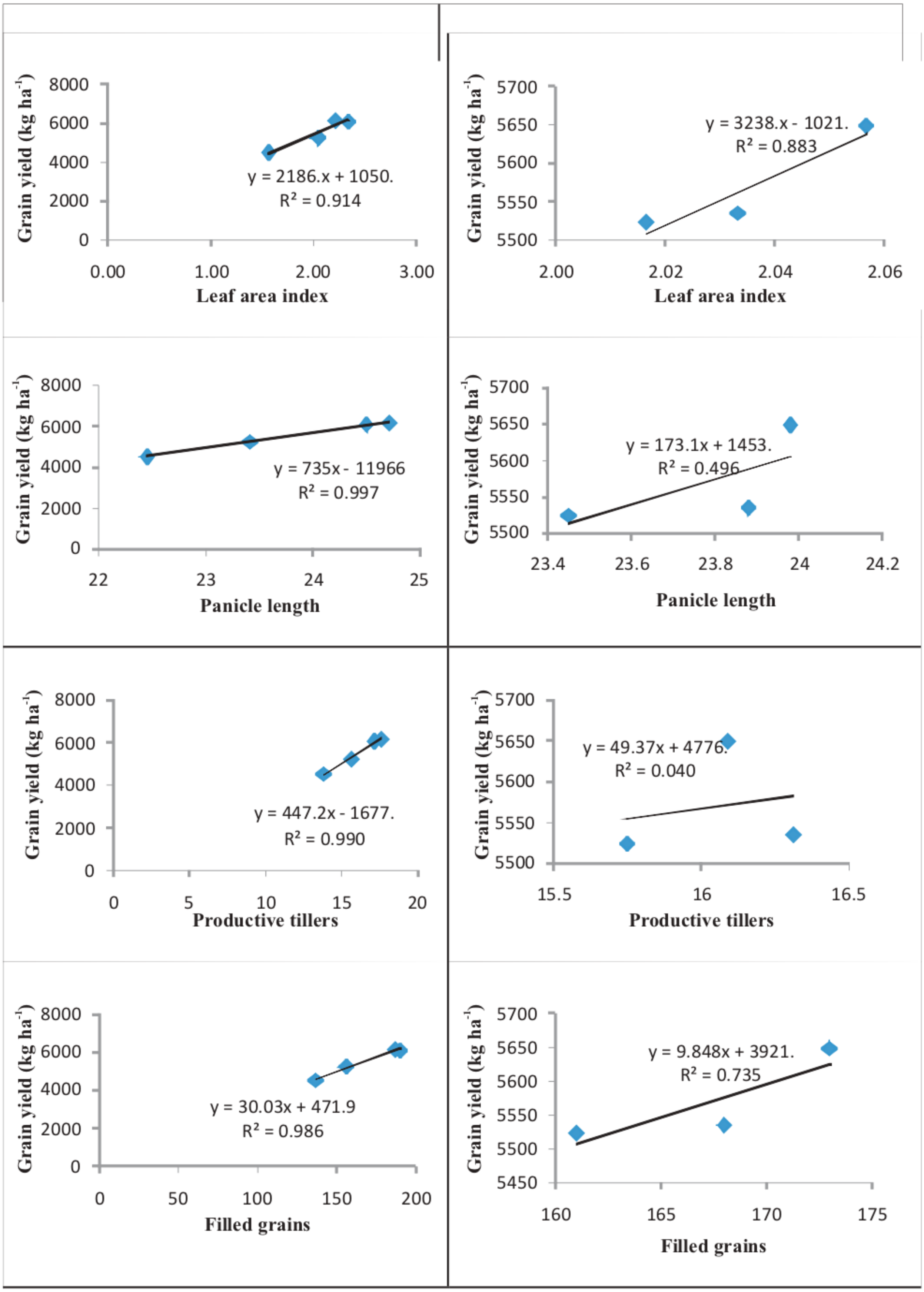
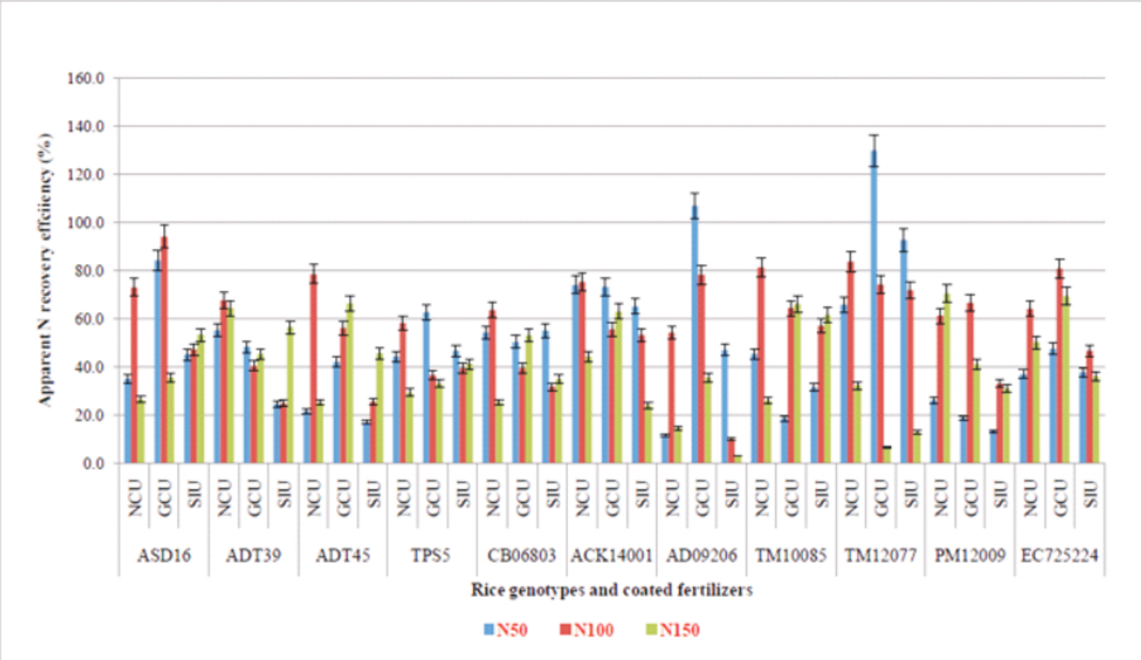


Figure 2. Apparent N recovery efficiency (%) as influenced by the interaction between rice genotypes, N levels and coated N fertilizers



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