YIELD AND YIELD ATTRIBUTES ARE INFLUENCED BY THE DIFFERENT NITROGEN LEVELS IN RICE GENOTYPES

Abstract

The experiment was conducted during 2017, *pishanam* season at Rice Research Station, Ambasamudram with the objective to screen the efficient and responsive rice genotypes based on nitrogen use efficiency and yield and yield attributes of different genotypes by N levels under 32 rice genotypes as main plot treatments and four nitrogen levels N_0 (control), N_1 (50% recommended dose of N ha^{-1}), N_2 (100% recommended dose of N ha^{-1}) and N_3 (150% recommended dose of N ha^{-1}) as subplot treatments. The experimental results showed that, the highest grain and straw yields were recorded at N_3 (180 kg ha^{-1}) by the most of the rice genotypes, except the AS 12051, ACK 14004, CB08702, CB 13539 and PM 12009 which were not responded genotypes for higher dose of (180 kg ha^{-1}) nitrogen. In the genotypes ASD 16, ADT 43, ADT 45, CO 51, MDU 5, CB 14508, CB 14533, TR 0927, TR 13069 and TM 12061 the AE was increasing with increasing level of nitrogen, other genotypes showed decreasing sequence with increasing level of nitrogen levels. The genotypes viz., ASD16, ADT39, ADT45, TPS 5, AD09206, CB06803, ACK14001, TM10085, TM12007, PM12009 and EC725224 are under Efficient and responsive (ER) category which gives average yield at low level and high N use efficiency. The plant height, Productive tillers, total grains, harvest index, panicle length and 1000 grain weights given veried results among the genotypes due to genetic characters. Among the N levels the plant height, panicle length, productive tillers per hill and total grains showed highest in 180 kg N ha-1. 1000 grain weight and N harvest index were decreased with increasing level of N application.

Keywords: Nitrogen, Rice genotypes, N harvest index, Yield attributes, N use efficiency

Introduction

Rice (*oryza sativa* L.) belongs to family "Graminae" and genus "*Oryza*". Rice is one of the most vital crops among the cereals; it serves as the staple food for world's half population for over 2.7 billion people (FAO, 2014). It is required that by 2025, the world will need about 800 million tonnes of rice to accomplish for the growing population, whereas India demand to produce 120 million tonnes by 2030 to feed its one and half billion plus population by then. Therefore, it is requisite to overcome food scarcity throughout the globe by sustainable production of rice. In India, area under rice is 44.6 m ha with total output of 80 million tonnes (paddy) with an average productivity of 1855 kg ha^{-1}. India is not only a leading consumer of rice but also its second largest producer in the world (106.5 million tonnes), lagging behind only china (144 million tonnes). The constraints in rice production vary from state to state and area to area. Imbalanced nutrient is one among the problem for low rice production.

Nitrogen is the most limiting macronutrient in rice production given the importance of nitrogen fertilization on the yield on grain from rice plant, it is necessary to know what the optimum rate for each variety/genotypes as well as its influence on components of yield and yield parameters to obtain better knowledge to productive response (Noor, 2017). Since fertilization is considered to be quite expensive it becomes highly essential to apply doses that would prove not only appropriate but economical as well. The rice crops are inefficient at nitrogen uptake from soil, with as much as 50-75% of applied N being left unused by the plants (Hodge *et al*., 2000). Therefore, excessive use of nitrogen fertilizer leads to the negative impact on the soil and environment through residual effect. Hence, next to fertilization of soil, selection of N use efficient crops is an important target to produce higher yields with low nitrogen rates. El-Batal *et al*. (2004) recorded that nitrogen application increase from 120 to 190 kg N ha^{-1} improved plant height, panicle length, number of filled grains/panicle and grain yields significantly. Similarly, Yoseftabar (2013) found significant increase in plant growth parameters, yield traits and grain yield at the rate of 100, 200 and 300 kg N ha^{-1}. This study was conducted with the objectives to evaluate different nitrogen levels on yield and yield attributes of rice genotypes in southern district of tamilnadu.

Materials and Methods

Soil characteristics

Soil samples for the experiment were obtained at a depth of 0-15cm from rice research station, Ambasamudram, Tirunelveli. The collected sample was air-dried, crushed thoroughly, sieved through a 2 mm sieve and physical and chemical characterization obtained through laboratory analysis (Table 1). The soil was sandy loam in texture, acidity in reaction, low in organic carbon, available nitrogen, phosphorus and potassium.

Field experiment design

Field experiment was conducted at B1 field at experimental farm of rice research station, Ambasamudram during 2017 rice growing season of pishanam. The 32 rice genotypes/varieties namely ASD16, ADT 39, ADT 43, ADT 45, MDU 5, CO51, TPS 5, Anna 4, AS 12051, AS12104, AD 09206, AD 10034, ACK 14001, ACK 14004, CB 08702, CB 13539, CB 14508, CB 06803, CB 14533, TR0927, TR0351, TR13069, TR13083, TM1307, TM07335, TM 09135, TM 10085, TM 12059, TM12077, PM12009 and EC 725224 were evaluated in this experiment. Nitrogen fertilizer was applied at different 4 levels (0, 50, 100 and 150% of recommended doses) as urea form. It was applied as four equal splits as split method as follows i.e., basal- the first dose of nitrogen after transplanting, the second dose was applied after 30 days of transplanting, the third dose was applied after 60 days of transplanting and the last dose was applied after 75 days of transplanting. The experiment was designed as split plot randomized design with two replications. In that, the 32 genotypes/ varieties were subjected in main plots and subplots were subjected to the different nitrogen levels. The germination percentage of all the genotype seeds was 90%. The seeds were sown by line sowing method in nursery bed on 3rd October in 2017. Seedlings of 14 days old age (single seedlings per hill) was transplanted at 25 cm x 25 cm distance between hills and rows by following system of rice Intensification (SRI). Phosphorus fertilizer at the rate of 57 kg P_2O_5 / 0.24 ha was applied basally before last puddling. Intercultural operations such as irrigation and drainage, weeding and pest control were done as and when required. Plots were drained with water before 10 days of harvesting for ease of handling crop harvest. Plant height at maturity was measured from randomly selected 5 hills per plot from the soil surface to the tip of the tallest panicle of each hill. Number of filled and unfilled grains per panicle was counted of five main panicles in each plot. Panicle length (cm) from panicle base up to a piculus of the upper most spikelet of the panicle from five panicles, 1000 grain weight (g), straw and grain yield kg ha^{-1} were estimated according to IRRI (1996). Nitrogen use efficiency was calculated according to fageria *et al*. (1997). Nitrogen harvest index is defined as the ratio between nitrogen (N) uptake in grain and N uptake in grain plus straw or shoot. Nitrogen harvest index = Nitrogen uptake in grain / Nitrogen uptake in grain and shoot.

Statistical analysis

All data recorded were statistically analysed by following the procedure described by Gomez and Gomez (1984) using the AGRESS computer software at P > 0.05.

Results

Effect of rice genotypes

Our experiment revealed that plant height of genotypes showed significantly different (table 1). The total mean of plant height was 105.6 cm and ranged from 98.1 to 129.0 cm. The highest plant height was found in the genotypes CB06803 (V_{15}) of 129 cm which was statistically on par with CBN08702 (V_{16}) of 127.6 cm whereas; genotypes V_{10} (AS12104) entered the shortest plant (94.3 cm). The probable reason might be due to genetic characters of the cultivars. Kumar *et al.* (2003) also observed the variable plant heights among the genotypes. The number of productive tillers of the rice genotypes ranged between 11.3 to 21.5 tillers per hill. The total mean productive tiller was 15.6 and the highest number recorded in TR13083 with 21.5 numbers. The lowest number of productive tillers was observed in CB14533 (11.3 per hill). Thenmozhi and rajasekaran (2014) who stated the number of productive tillers differed due to varietal variation. The result is supported by Hussain *et al*. (2008) who stated that effective tillers / hill varied with their genotype.

The NHI is an important index to measure retranslocation efficiency of absorbed N from vegetative plant parts to grain. It ranged from 0.47 to 0.79 among the genotypes. The maximum NHI was recorded in MDU5 (0.79) and lowest was obtained from CB14508 (0.47). This index is very useful in measuring N partitioning in crop plants, which provides an indication of how efficiently the plant utilized acquired N for grain production (Fageria and Baligar, 2003a). Thus, the variations in NHI are characteristic of genotypes and this trait may be useful in selecting crop genotypes for higher grain yield (Fageria and Baligar, 2005).

The length of panicle was significantly affected by rice cultures. The longest panicle (28.5) was found in the genotype TR13083 which was statistically on par with ASD16. The shortest panicle length (20.2 cm) was recorded from the genotypes CB14533. The variation as assessed might be mainly due to the genetic background of the genotypes. The data showed that number of total grains per panicle was highly significantly ($p<0.05$) affected by the main effect of genotypes. The highest number of total grains was recorded in the rice genotype ASD16 with 292 numbers per panicle which was statistically on par with TR12083 genotype with 284 grains per panicle. The lowest number of grains per panicle was recorded in CB 14533 with 87 grains per panicle. It might be due to their differences in genetic constituents. The less significant difference was found in 1000 grain weight among the genotypes due to genetic variability (Mannan *et al*., 2010). Maximum 1000 grain weight was observed in CB08702 (28.39) followed by EC725224 (27.4 g).

Effect of nitrogen

Plant height was increased with the increasing rates of nitrogen up to 180 kg N ha^{-1} and was found significantly higher from the other levels of nitrogen (Table 2). The shortest plant height (102.3 cm) was found in control plot (without N). Nitrogen included maximum vegetative growth with higher rates of N. The increase in plant height was due to the various physiological processes including cell division and cell elongation of the plant. Similar result was found by mallareddy and padmaja, 2013 who found the tallest plant height from 180 kg ha^{-1} and the shortest was obtained from control.

Nitrogen harvest index (NHI) is defined as the ratio between nitrogen (N) uptake in grain and N uptake in grain plus straw or shoot. Nitrogen harvest index ranged from 0.63 to 0.71 by the application of nitrogen. The maximum value of NHI was recorded in the application at 50% RD of nitrogen. NHI decreased with increasing nitrogen application. The Number of productive tillers hill $^{-1}$ followed a pattern similar to that of plant height. Nitrogen dose of 180 kg N ha^{-1} produced the highest number of tillers which was statistically on par with 120 kg N ha^{-1} respectively. The lowest number of productive tillers found from control plot. The tiller numbers was increased proportionally with the increase of nitrogen levels and also found by Haque *et al*., (2004). Panicle length and total grains was higher in the N dose of 180 Kg N ha^{-1}. Dahi and Singh (2018) also stated that among the nitrogen levels, application of 180 kg N ha^{-1} recorded significantly higher panicle length, grains panicle^{-1} , number of panicles m^{2} which is at par with application of 150 kg N ha^{-1} . Increased yield attributes with higher nitrogen application might be due to better growth characters which ultimately resulted in higher production and translocation of photosynthates towards panicle.

In thousand grain weight the varieties ASD16, ADT39, ADT43, TPS5, Anna4, ACK14004, AS12051,AS12104,TR13069,TM13007, TM12059,PM12009 and EC725224 increased with increased nitrogen application, rest of the genotypes showed decreasing effect when nitrogen increases at 120 and 180 kg N ha^{-1}. Bhuiya *et al*. (1998) also found that application of nitrogen 0-60 kg N ha^{-1} increased the thousand grain weight linearly. However the individual grain weight is usually a stable varietal character and the management practice gas less effect on its variation (yoshida,1981).

Combined effect of genotypes and Nitrogen levels

There is a non significant result in plant height, thousand grain weight and productive tillers. There is a significant result in grain and straw yields, total grains per panicle and panicle length. In V_1N_3 (ASD16 along with 180 kg N ha^{-1}) showed highest yield, panicle length and total grains per panicle. In plant height, $V_{15}N_3$ (CB06803 with 180 Kg N ha^{-1}) and in thousand grain weight $V_{16}N_1$ (CB08702 with 60 kg N ha^{-1}) showed highest weight.

Grain and straw yield

Grain yield of rice genotypes mainly depends on the number of effective tillers per hill, panicle length, total grains $panicle^{-1}$ and thousand grain weight. Grain and straw yields increased in a linear model with the addition of nitrogen at different levels from 60 to 180 kg ha^{-1} (Table 1). Grain yield varied from 1543 kg ha^{-1} at control (CB14533) to 8150 kg ha^{-1} at 150% N (ASD 16) with an average value of 5155 kg ha^{-1}. Among four N levels of 0, 60, 120 and 180 kg ha^{-1}, the highest grain and straw yields were recorded at N_3 (180 kg ha^{-1}) by the most of the rice cultures, except the AS 12051, ACK 14004, CB08702, CB 13539 and PM 12009 which were not responded genotypes for higher dose of (180 kg ha^{-1}) nitrogen. Among the released varieties, ASD 16 recorded highest mean yield of 6698 kg ha^{-1} followed by MDU5 (6014 kg ha^{-1}), ADT 45 (5875 kg ha^{-1}) recorded and were responded to higher dose of N applied. In cultivars, the highest mean yield was observed in ASD 16 (6698 kg ha^{-1}) , TR 13083 (6695 kg ha^{-1}) followed by TM 12077 (6162 kg ha^{-1}). The percent increase of grain yield was maximum (57.55%) in CB 14533 though it gives lowest yield among all the genotypes. The straw yield varied from 3011 kg ha^{-1} (CB14533) to 10292 kg ha^{-1} (ASD16) with an average of 7505 kg ha^{-1}. As that of grain yield, the same trend was followed on straw yield also. The overall highest mean yield was recorded by TR13083 (9388 kg ha^{-1}) which was on par with ASD 16 (8884 kg ha^{-1}). The lowest yield of 4798 kg ha^{-1} was recorded in the cultivar CB 14533 but the percentage increase in both grain and straw yields by computed to control by highest level of N was more in this cultivar CB14533 which indicate the response level was high in cultivar.

Nitrogen use efficiency

NUE is a product of nutrient recovery from mineral or organic fertilizer and the efficiency (ARE) with which the plant uses each additional unit of nutrient (PE). It depends on cultural practices that influence recovery and physiological efficiency. NUE was significantly affected by nitrogen application and increased with N levels and also decrease with increasing N levels in different rice genotypes (table 2). Among the genotypes, TM 12077 had the highest nitrogen use efficiency of 22.73 kg kg N^{-1} followed by TM 10085 (20.51 kg kg N^{-1}). Across the N levels, the agronomic efficiency decrease with increasing N levels of nitrogen from 13.41 kg kg N^{-1} at 50% RD of N to 10.90 kg kg N^{-1} at 150% RD of N. In the interaction of Genotype and N levels, the highest NUE was recorded in PM12009 at the rate of 50% RD of N (60 kg ha^{-1}). The lowest NUE was recorded in genotypes, N levels and interaction, Anna 4 recorded the lowest AE. In the genotypes ASD 16, ADT 43, ADT 45, CO 51, MDU 5, CB 14508, CB 14533, TR 0927, TR 13069 and TM 12061 the NUE was increasing with increasing level of nitrogen, other genotypes showed decreasing sequence with increasing level of nitrogen levels. Such variations may be occurred because of genetic factors, biochemical and physiological processes such as translocation, assimilation and N remobilization (Isfan 1993; Fageria and Baligar 2003).

Overall, the results of this experiment identified that the application of higher doses of nitrogen increased the grain yield up to 150% recommended doses of nitrogen ha^{-1}, but in some of the genotypes viz., AS12051, ACK14004, CB08702 and PM12009 were not given any response to higher doses of N application (150% RD of N ha^{-1}). The NUE parameters varied significantly among rice genotypes. The choosing of rice genotypes and optimum N application rate for different rice genotypes is not only for producing higher yield, but also for improving soil fertility and economic net return for farmers.

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Table 1: Differences in yield parameters of 32 rice genotypes

	Plant height (cm)	No. of total grains hill^{-1}	N Harvest Index	No. of productive tillers hill^{-1}	Panicle length (cm)	1000 grain weight (g)
Genotype V_{1}	108.2	292	0.70	19.8	27.8	27.4
V_{2}	96.3	186	0.73	15.5	23.7	19.5
V_{3}	106.9	177	0.70	15.5	23.5	19.2
V_{4}	104.7	219	0.75	16.5	24.9	24.1
V_{5}	103.5	193	0.67	15.5	23.8	19.6
V_{6}	98.4	167	0.55	14.8	23.1	18.6
V_{7}	102.0	258	0.79	17.8	26.4	25.9
V_{8}	106.6	201	0.61	16.3	24.1	21.1
V_{9}	100.0	142	0.72	13.8	21.7	17.1
V_{10}	94.3	213	0.72	16.5	24.8	23.5
V_{11}	102.1	146	0.57	14.3	22.4	17.3
V_{12}	101.8	174	0.70	15.5	23.4	19.0
V_{13}	110.6	264	0.68	18.3	26.2	26.0
V_{14}	98.1	199	0.63	15.8	23.9	19.9
V_{15}	129.0	170	0.67	15.3	23.2	18.9
V_{16}	127.6	159	0.74	14.5	22.8	18.1
V_{17}	106.2	118	0.47	12.3	20.5	15.8
V_{18}	104.7	208	0.63	16.5	24.5	22.9
V_{19}	94.9	87	0.51	11.3	20.2	15.1
V_{20}	95.3	121	0.51	12.8	21.2	16.4
V_{21}	115.8	240	0.69	17.3	25.3	24.9
V_{22}	105.8	152	0.62	14.3	22.8	17.5
V_{23}	103.7	284	0.69	21.5	28.5	19.4
V_{24}	101.9	246	0.66	17.3	25.5	25.7
V_{25}	98.2	224	0.69	16.8	25.1	24.4
V_{26}	115.4	147	0.69	14.3	22.8	17.4
V_{27}	102.7	205	0.68	16.3	24.3	21.6

V_{28}	108.3	154	0.74	14.3	22.8	17.9
V_{29}	107.3	132	0.59	13.3	21.4	16.7
V_{30}	109.0	273	0.62	18.5	26.8	26.6
V_{31}	112.6	162	0.61	14.5	23.0	18.2
V_{32}	106.7	136	0.58	13.5	21.8	16.9
CD (P =0.05)	2.82	11.75	0.03	1.74	0.65	0.05

Table 2: Effect of nitrogen on different yield parameters of 32 rice genotypes

	Plant height (cm)	No. of total grains hill^{-1}	N Harvest index	No. of productive tillers hill^{-1}	Panicle length (cm)	1000 grain weight (g)
N levels N_0	102.3	171	0.70	14.2	22.9	19.7
N_1	104.9	188	0.65	15.2	23.7	20.3
N_2	106.6	196	0.64	16.2	24.2	20.6
N_3	108.5	201	0.63	16.8	24.4	20.9
CD (P =0.05)	1.11	3.47	0.009	0.61	0.21	0.02

Fig 1: Effect of different N application on grain yield of 32 rice genotypes

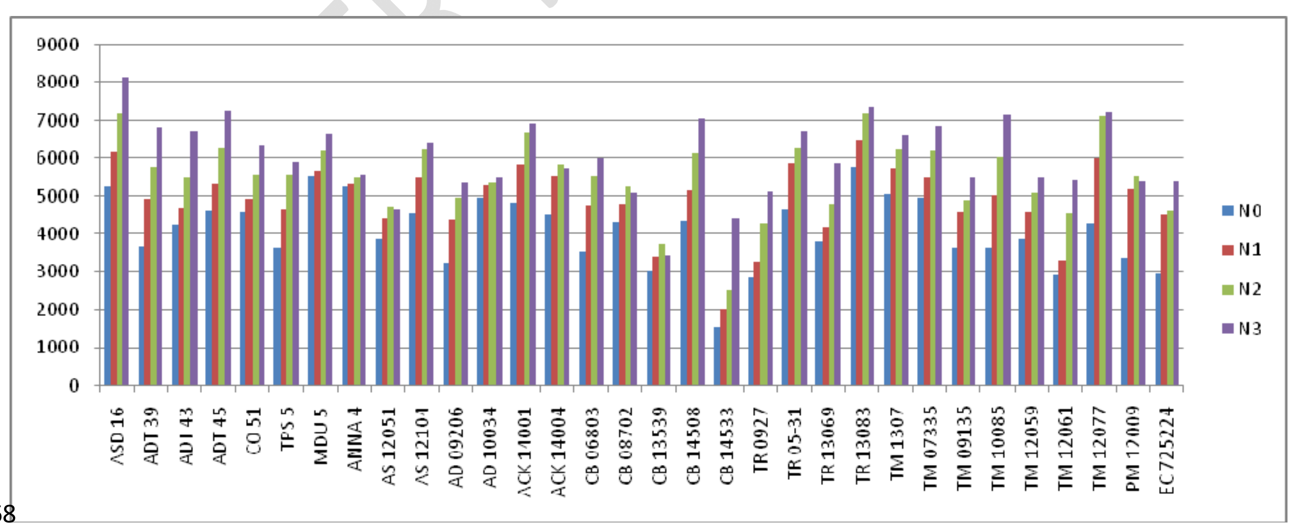
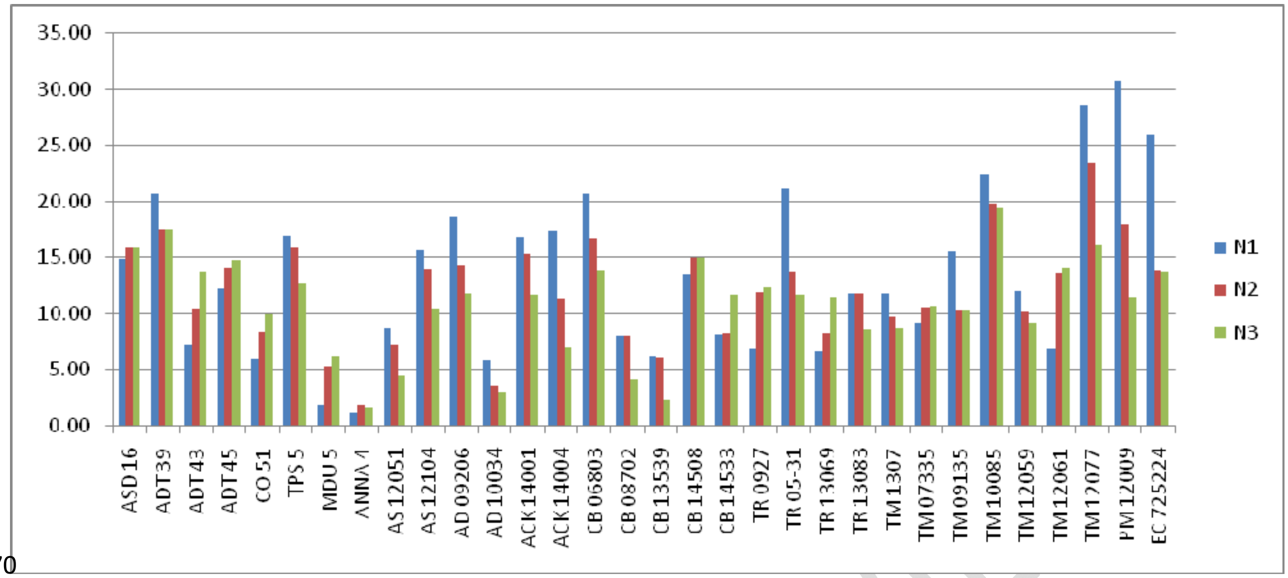


Fig 2: Effect of different N application on NUE of 32 rice genotypes



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TPS 5
MDU 5
ASD 12051
AS 12104
AD 09206
AD 10034
ACK 14001
ACK 14004
CB 06803
CB 08702
CB 13539
CB 14508
CB 14533
TR 0927
TR 05-31
TR 13069
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PM12009
EC 725224