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Optimization of Nitrogen Splitting for Improving the yield and nitrogen use efficiency in rice (*Oryza sativa* L.) under western plain zone of Utter Pradesh

Rohit Kumar, Adesh Singh, Dinesh Kumar Sharma and UP Shahi

Rohit Kumar
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Adesh Singh
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Dinesh Kumar Sharma
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

UP Shahi
Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Abstract

A field experiment was conducted during *kharif* season of 2015 at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut in Western part Uttar Pradesh to evaluated the response of split application time of N on yield (grain, strawl) and for increasing nitrogen use efficiency in Rice (*Oryza sativa* L.), reducing nitrate-N leaching of split through leaf colour chart-based N management in rice. The results indicated that the panicle length (cm), panicle plant^{-1}, grains panicle^{-1}, 1000-grains weight (g), yields (grain, straw and biological) and nitrogen use efficiency viz., partial factor productivity (kg grain yield kg^{-1} nitrogen applied), agronomic (kg grain yield increase kg^{-1} nitrogen applied) and apparent recovery efficiency (%) were significantly superior with the application of 1/4 N as basal+1/4 at tillering+1/4 at panicle initiation and 1/4 at milking stage as compared to rest of the treatments, except 1/2 N as basal, 1/4 at tillering, 1/4 at panicle initiation and 1/4 at milking stage and 1/4 N as basal, rest through leaf colour chart. However, 1/4 N as basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage, treatment gave 60 and 32 kg ha^{-1} higher grain and straw yields as compared to 1/2 N as basal, 1/4 at tillering and 1/4 panicle initiation stage (existing recommendation of N), respectively. Besides, partial factor productivity, agronomic and recovery efficiency in T_3 was improved by 1.43, 2.41 and 3.69%, respectively as compared to 1/2 N as basal, 1/4 at tillering and 1/4 panicle initiation stage, (existing recommended N schedule).

Keywords: rice, nitrogen splitting, nitrogen use efficiency, yield

1. Introduction

Rice (*Oryza sativa* L.) is the most important food crops in the world and forms the staple diet of 2.7 billion people. It is grown in all the continents, except Antarctica and occupying about 150 mha area, producing 573 mt paddy with an average productivity of 3.83 tones ha^{-1}. In India, the area, production and productivity of rice during 2015-16 was 43.42 mha, 105.24 mt and 2.42 t ha^{-1}, respectively. However, Uttar Pradesh is the largest rice growing state after West Bengal but its productivity is low. Rice occupies an area of 5.86 mha, produces 14.41 mt of rice with an average productivity of 2.46 t ha^{-1} in UP FAO [9].

Nitrogen is one of the major plant nutrient required for plant growth for maximizing the yield and encourages above ground vegetative growth of plants. A good supply of nitrogen also stimulates important compounds found in living cell, including amino acid, protein, enzymes, nucleic acid, hormones, vitamin and chlorophyll (Dastan *et al*., 2012, Lin *et al*., 2007 and Yang *et al*., 2010) [6, 13, 25]. Improper nitrogen management results in poor nutrient supply capacity of soil and use efficiency of the applied fertilizer. Suitable nitrogen management is essential for rice as the nitrogen use efficiency is in the range of 40 to 60 % application of nitrogen at right time is perhaps the simplest agronomic solution for improving the use efficiency of nitrogen (Ganga Devi *et al*., 2012 and Datta *et al*., 1979) [10, 7].

The excessive application rates of N and unique condition of the rice can promote N losses through major loss mechanisms, namely ammonia volatilization, nitrification, denitrification, leaching and surface runoff further N losses not only lead to decrease in N fertilizer efficiency but also causes soil, water and atmospheric pollution. Ammonia volatilization is the major process of N losses in irrigated rice, accounting for 0.41-40 percent of applied N as urea in most of the Asian countries (Lin *et al*., 2007 [13].

Correspondence
Rohit Kumar
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

It has been observed that more than 60 % of applied nitrogen is lost due to lack of harmonization between the nitrogen demand and nitrogen supply (Yadav *et al.*, 2004) [23]. However, the judicious use of N fertilizer in rice requires balancing N fertilizer application rates with the needs of plants. Split application is one strategy for the efficient use of N fertilizer throughout the growing season by synchronizing N application with plant demands, denitrification and leaching losses can be reduced and N uptake improved resulting in maximum straw and grain yield and an enhanced harvest index (Lampayan *et al.*, 2010) [12]. Nitrogen application should coincide with crop growth and its requirement. The leaf color chart (LCC) is an easy to use and inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator of the plant N status. The LCC can be used to guide the application of fertilizer N to maintain an optimal leaf N content for achieving high rice yield with effective N management (Sen *et al.*, 2011) [18]. Another method of fertilizer application is foliar application method; foliar application refers to the spraying on leaves of growing plant with suitable fertilizer solution. It is effective to the crop which is growing in water-logging condition. When N fertilizer is available in low amount nitrogen can be supplies to plant through foliar application for economic effectiveness and to reduce the different type of losses viz., denitrification, ammonia volatilization and leaching (Mirza *et al*., 2009 and Saikia *et al*., 2012) [15, 17]. To minimize potential N losses, N fertilizer should be applied according to the time and the needs of the crops. In addition, to solve these problems, farmers could have recourse to variable-rate N fertilization, accounting for the spatial patterns of N fertility, as suggested by precision (LCC) agriculture applications (Nachimuthu *et al*., 2007 and Yoseftabar, 2013) [16, 26]. Thus, the sufficient method of nitrogen application and suitable time of application may play an important role in minimizing the present large gap between potential and achievable yields of rice. Keeping all these facts in view, the present investigation entitled "Efficient management of nitrogen in basmati rice (*Oryza sativa* L.)" was carried out at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut (U.P.) during *kharif*, 2015.The objective of the presentst investigation was to find out the effect of nitrogen management on yield attributes, yield and nitrogen use efficiency in rice.

2. Materials and Methods

2.1. Study site

A field experiment was conducted with rice variety Pusa sughandha-5 (25 days old seedling transplanted at a spacing of (20×15 cm^2) during *kharif* season of 2015 at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (29°40′ N latitude and 77°42′ E longitude and at an altitude of 237 m MSL) in western part Uttar Pradesh. The climate of Meerut is sub-tropical with dry hot summer and cold winter. The average annual rainfall is 1150 mm which is received during the latter part of June to mid-September. The experimental field had an even topography with good drainage system and soil was well drained, sandy loam in texture and slightly alkaline in reaction with medium in organic carbon, available phosphorus and available potassium but low in available nitrogen with an electrical conductivity (1:2, soil: water) of 1.65 dS/m.

2.2. Experimental detail

The experiment was laid out in randomized block design with net plot size 4×2.6 m^2 with three replications. Ten treatments (T_1 -Control, T_2 -1/2 N as basal, 1/4 at tillering and 1/4 panicle initiation stage, T_3 -1/4 N as basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage, T_4-1/2 N as basal, 1% foliar application of nitrogen at tillering and panicle initiation stage, T_5-1/2 N as basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage, T_6-1/2 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage, T_7- 1/4 N as basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage, T_8- 1/4 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage, T_9- 1/2 N as basal, rest through leaf colour chart and T_{10}-1/4 N as basal, rest through leaf colour chart) comprised of splitting of nitrogen as basal, at tillering, panicle iniation and milking stage in different proportions including foliar spray, use of LCC (< 4) and control.

2.3 fertilizers Application

The fertilizer dose, as per the treatments was applied through urea (46% N), single super phosphate (16% P_2O_5), muriate of potash (60% K_2O), and $ZnSO_4$ (21%Zn). In all, entire dose of phosphorus, potassium and Zinc was applied at the time of sowing, while varying dose of N was applied, treatment wise. The LCC developed by the International Rice Research Institute (IRRI 1996) with strips (Fig.1) of six shades of green colour showing increasing intensity of colour with increasing number was used in the study. The leaf colour chart readings were taken at 10 days interval (10, 20, 30, 40, 50, 70, 80 and 90 DAT) starting from 10 DAT till milking stage. Ten disease free hills were selected at random from the sampling area in each plot. From each hill topmost fully expanded leaf was selected and LCC readings were taken by placing the middle part of the leaf on the chart and the leaf colour was observed by keeping the sun light blocked by body as sun light affects leaf colour reading (Fig 2). Whenever the green colour of more than 5 out of 10 leaves were observed equal to or below a set critical limit (4) of LCC, nitrogen was applied @ 20 kg ha^{-1}.The last split application of N was completed by 90 days after transplanting coinciding with the milking stage. The 1% nitrogen (17.44 kg urea/800 liter fresh water) solution for foliar application was prepared by mixing 8 kgN in 800 liter fresh water. At each stage, 800 liter (8kg N ha^{-1}) solution was applied in one hector. This solution was sprayed by a knapshek sprayer using flat fan nozzle till all the leaves got moistened at tillering, booting, panical initiation and milking stage of rice. The plots were sprayed during late afternoon hours when wind speed slowed down to less than 10 km hr^{-1}.

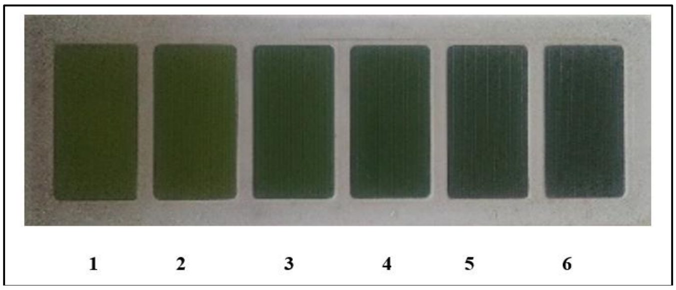

Fig 1: An over view of leaf color leaf chart (< 4 critical value in rice)

Fig 2: Taken the leaf color leaf chart reading at 10 days interval

Table 3: Amount of nitrogen added through treatments.

Symbols	**Treatments**	**Nitrogen (kg ha^{-1})**
T_1	Control	0
T_2	1/2 N as basal, 1/4 at tillering and 1/4 panicle initiation stage	120 (60 kg/ha as B and two equal splits at T and PI)
T_3	1/4 N as basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage	120 (30 kg/ha as B and three equal splites at T, PI and M)
T_4	1/2 N as basal, 1% foliar application of nitrogen at tillering and panicle initiation stage	76 (60 as B and 8 kg/ha two time foliar application at T and PI)
T_5	1/2 N as basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage	84 (60 as B and 8 kg/ha three time foliar application at T, PI and M)
T_6	1/2 N as basal, 1% foliar application of nitrogen at tillering, booting, Panical initiation and milking stage	92 (60 as B and 8 kg/ha foure time foliar application at T, B, PI and M)
T_7	1/4 N as basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage	54 (30 kg/ha as B and 8 kg/ha three time foliar application at T, PI and M)
T_8	1/4 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage	62 (30 kg as B, 8 kg/ha foure time foliar application at T, B, PI and M)
T_9	1/2 N as basal, rest through leaf colour chart	100 (60 kg as B and 20 kg/ha two splits bassed on LCC reading)
T_{10}	1/4 N as basal, rest through leaf colour chart	90 (30 kg as B and 20 kg/ha three splites bassed on LCC reading)

2.3. Method of data collection

At physiological maturity, Shoots bearing panicles m^{-2} at the time of harvesting were recorded by using a quadrate of one square meter in each plot while, another yield attributes viz., panicle length (cm), grain panicle^{-1} and test weight (g) were measured by harvesting from five tagged plants from each plot and grouped into small, medium and large size. From these groups five panicles were selected and length was measured and average was computed as panicle length. The panicles selected for measuring length were used to record the grain panicle^{-1}. The grains are removed by threshing and numbers of filled grains were counted and average number of grains panicle^{-1} was worked out. A handful of seeds were taken without any bias from the total seeds of the plot, after threshing and cleaning. One thousand filled grains from each plot samples were counted, weighed on electronic balance and expressed in grams. After threshing cleaning and drying the grains, the grain yield was recorded in kg plot^{-1}. The crop was harvested when 90% of the seeds become golden yellow in color (physiological maturity).The yield of net plot and then converted to q ha^{-1}. Dry weight of straw collected from net plot was recorded after sun drying for 5-6 days and expressed in q ha^{-1} and after drying weighed the biological yield in kg plot^{-1} than converted in q ha^{1}.

2.3.1. Harvest index

The harvest index of rice was obtained by dividing the economic yield (grain yield) with the biological yield (grains+straw) according to Donald and Hamblin (1976) [8] and represented in percentage as:

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100$$

2.3.2. Nitrogen use efficiency

Total N in the straw and grain samples were used to analyze N use efficiency and its component traits according to an expanded model of Cassman *et al.* (1998) [5].

The following expressions were used for determining NUE as:

Partial factor productivity (kg grain yield kg nitrogen applied^{-1}) was calculated as follows:

$$\text{PFP} = \frac{\text{Y}}{\text{N}}$$

Where,

Y= crop yield (kg ha^{-1})

N= nitrogen applied (kg ha^{-1})

Agronomic efficiency (kg grain yield increase/kg nitrogen applied) was calculated as follows:

$$\text{AE} = \frac{\text{Yn} - \text{Yo}}{\text{N}}$$

Where,

Yn=crop yield (kg ha^{-1}) in fertilized plot

Yo=crop yield (kg ha^{-1}) in control plot

N=nitrogen applied (kg ha^{-1})

Apparent recovery efficiency (%) was calculated as follows:

$$\text{RE} = \frac{\text{Un} - \text{Uo}}{\text{N}}$$

Where,

Un= total nitrogen uptake in (kg ha^{-1}) in fertilized plot

Uo = total nitrogen uptake (kg ha^{-1}) in control plot

N= nitrogen applied (kg ha^{-1})

3. Results and Discussion

3.1. Yield attributes and yield

The significantly highest panicle m^{-2} (326) was found with the application of nitrogen as 1/4 basal, 1/4 at tillering, 1/4 at panicle initiation and 1/4 at milking stage (T_3) followed by T_2 (324 and) and T_{10} (321) while significantly minimum (238) panicle m^{-2} was noted in control, followed by T_7 and T_8 (Table 3.1). The application of nitrogen as 1/2 basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage (T_3) produces the longest panicle (23.5 cm), whereas the shortest panicle (18.6 cm) were noticed under control (T_1). But, the variation between control and all the nitrogen splitting treatments (T_2 to T_{10}) was statistically significant. Significantly highest average number of filled grains panicle^{-1} (184) was observed with nitrogen applied as 1/2 basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage (T_3), which was statistically *on par* with T_2 (1/2 N as basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage) and T_{10} (1/4 N as basal, rest through leaf colour chart), while the minimum number of filled grains panicle^{-1} (152) was recorded under control (T_1). The significantly maximum 1000-grains weight (22.45 g) was recorded when nitrogen was applied as 1/2 basal, 1/4 at tillering, 1/4 panicle initiation and 1/4 milking stage (T_3). The next best treatments in regards to test weight were T_{10}, T_9 and T_6. Although, all the treatments brought significant variation over control. Whereas, minimum 1000-grains weight (17.36 g) was recorded in control plot (T_1). The higher value of grain, straw and biological yield ha^{-1} along with harvest index (Table 3.2) were observed under T_3 (1/4 N as basal, 1/4 at tillering, 1/4 at panicle initiation and 1/4 at milking stage) as compared to recommended split application of nitrogen as 1/2 as basal, 1/4 at tillering and 1/4 panicle initiation (T_2) by the experts, however the difference was not significant for harvest index. The non-significant values of harvest index may probably be due to marginal differences in grain and straw yields and their contrast trends. The increase in grain and straw yields might be due to the role of nitrogen in determining the amount of sunshine absorbed by green leaves of crops, the efficiency of conversion of sunshine to biomass, efficient partitioning of biomass into reproductive parts and also due to significantly higher values of yield attributes *viz*. panicle m^{-2}, panicle length (cm), filled grains panicle^{-1} and test weight (g) in T_3 as compared to rest of the treatments. Further, the yield was also comparable where 1/2 N as basal and rest through LCC or 3-4 foliar spray (T_5, T_6, T_4 and T_{10}).This was probably due to the fact that the split application of nitrogen must helped in continuous and gradual supply of nitrogen to the plant to maintain green ness of leaves for longer period which resulted in increased photosynthetic area, greater dry matter accumulation and also more translocation of photosynthates towards sink and there by improve the yield attributes and yields, in which nitrogen plays a vital role. Similar opinions were also made by (Mannan *et al*., 2012) [14]. Youseftabar *et al.* (2012) [27] reported that split application of nitrogen resulted in utilization of nitrogen more efficiently by the crop which result in optimum utilization of solar energy, higher assimilates production and its conversion to starches resulted higher grains number and weight that ultimately led to more biomass and grain yield production. Satpute *et al*. (2015) [19] also realized the superiority of LCC based nitrogen application over other methods. The higher biological yield in T_3 treatment was mainly due to the combined effects of higher grain and straw yields. Yadvinder *et al.* (2007) [24] suggests that LCC-based N management assures optimal rice yields consistent with efficient N use and enhanced farmers' profits due to saving in the use of N fertilizers. A basal application of N @ 20 kg ha^{-1} though increased the growth parameters, it was not reflected in yields. But when LCC based N was supplied up to panicle initiation stage it enhanced yield with location specific.

3.2. Nitrogen use efficiency

The data (Table 3.3) pertaining to nitrogen use efficiency *viz*., partial factor productivity, agronomic efficiency, recovery efficiency in rice crop. The application of nitrogen as 1/4 basal and 1% foliar application of nitrogen at tillering, panicle initiation and milking stage (T_7) brought significantly maximum value of partial factor productivity (81.48 kg grain yield kg^{-1} nitrogen applied followed by T_8 (1/4 N as basal+1% foliar application at tillering, booting, panicle initiation and milking stage) as compared to rest of the treatments. However, the % increment in T_8 (1/4 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage) over T_2 (1/2 N as basal, 1/4 at tillering and 1/4 at panicle initiation) and T_3 in relation to PEP was to the tune of 88.74 and 86.0%, respectively. While, lowest partial factor productivity of 43.17 kg grain yield 120 kg^{-1} nitrogen applied was noticed in T_2 (1/2 N as basal, 1/4 at tillering and 1/4 at panicle initiation) treatment. The application of nitrogen as 1/4 basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage (T_7) resulted into significantly higher value of agronomic efficiency (31.48 kg grain yield increase/ kg nitrogen applied), which was statistically *on par* with T_8 (1/4 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage) than rest of the treatments. The next in the order were T_4, T_5, and T_{10} treatments. The application of nitrogen 120 kg ha^{-1} in 4 equal splits (T_3) improved the agronomic efficiency by 2.4 % over 1/2 as basal and rest in two equal splits (T_2). Likewise, 30 kg N as basal and rest through LCC (T_{10}) had 13.56 % increase over T_9 (1/2 as basal and rest through LCC). While, the lowest agronomic efficiency (20.67 kg grain yield increase 120 kg nitrogen^{-1}) was recorded with the application of nitrogen 1/2 as basal, 1/4 at tillering and 1/4 panicle initiation (existing recommendation). Apparent recovery efficiency (%) in rice crop varied from 86.17 to 64.40% among various treatments, though split application of nitrogen as 1/4 basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage (T_7) gave significantly higher value of crop recovery efficiency followed by T_8 (1/4 N as basal, 1% foliar application of nitrogen at tillering, booting, panicle initiation and milking stage). However, the per cent increment in T_7 over T_2 and T_3 was 33.80 and 29.03%, respectively. The application of 120 kg N as 1/4 each in 4 equal splits (T_3) improved the apparent recovery efficiency by 3.6 % over 1/2 as basal and rest in 2 equal splits (T_2). Likewise 30kg N as basal, rest through LCC (T_{10}) had 15.62 % increase over T_9 (1/2 as basal and rest through LCC). The application of nitrogen as 1/4 basal, 1% foliar application of nitrogen at tillering, panicle initiation and milking stage (T_7) led to increased partial factor productivity (81.48 kg grain/kg nitrogen applied), agronomic efficiency (31.48 kg grain yield increase/kg nitrogen applied) and apparent recovery efficiency (86.17%) as compared to T_2 and T_3. This was probably due to greater exposure of applied nitrogen at the time of sowing to a range of possible loss processes (immobilization, leaching, denitrification, and clay fixation) at a time when nitrogen uptake rates are relatively low and higher grain yield with lesser N application throusing of LCC and and foliar application of besides saving of 30-40 % kg N/ha. These finding corroborate the findings of Bandyopadhyay, K.K., and Sarkar, M.C. (2005), [2] Tayefe, *et al.* (2011) [20] and Bhuyan *et al.* (2012). [3] The increased nitrogen use efficiency (PFP, AE and RE) in T$_3$ over T$_2$, T$_7$ over T$_6$ and T$_{10}$ over T$_9$ indicated that the increase in nitrogen use efficiency was due to the fact that fertilizer nitrogen recovery by crop greater when nitrogen application is delayed compared with when applied at the time of sowing. Bijay-Singh *et al.* (2012) [4] also reported that the combination of foliar application and LCC bassed N management strategies resulted in optimum rice grain yield and high N use efficiency with less fertilizer N application than the blanket recommendation.

4. Conclusion

it could be infered that yield (grain straw and biological) and nitrogen used efficiency in basmati rice was improved by application of 120 kg ha^{-1} in 4 equal splits (as basal, at tillering, at panicle initiation and at milking stage). Moreover, 90 kg N/ha (1/2 as basal and rest through LCC, < 4) also prove to be better for economic rice production. Thus, study suggests that rice can be successfully grown under semi-arid conditions of Western Uttar Pradesh on 120 kg ha^{-1} in 4 equal splits. Further, one more year research is also needed to validate the recommendations under Western Uttar Pradesh conditions.

Table 1: Effect of various treatments on yield attributes of rice’

	Yield attributes			
Treatment	**Panicles/m^2**	**Panicle length (cm)**	**Filled grains panicle^{-1}**	**Test weight (g)**
T$_1$	238	18.61	152	17.36
T$_2$	324	23.19	182	22.23
T$_3$	326	23.51	184	22.45
T$_4$	313	21.28	172	21.07
T$_5$	315	21.66	173	21.36
T$_6$	317	21.92	175	21.68
T$_7$	309	20.38	170	20.72
T$_8$	310	20.76	170	20.39
T$_9$	319	22.50	177	21.86
T$_{10}$	321	22.73	179	22.05
S Em ±	2	0.28	2	0.27
CD (*p*=0.05)	7	0.84	5	0.83

Table 2: Effect of various treatments on yield (grain, straw and biological in q ha^{-1}) and harvest index (%) of rice

Treatments	**Yields (q ha^{-1})**			**Harvest index (%)**
	Grain	**Straw**	**Biological**	
T$_1$	27.00	43.72	71.33	38.21
T$_2$	51.80	73.04	125.00	41.44
T$_3$	52.40	73.36	125.67	41.70
T$_4$	46.50	69.75	116.33	39.97
T$_5$	47.30	70.00	117.33	40.31
T$_6$	48.00	70.56	118.67	40.45
T$_7$	44.00	67.32	111.33	39.52
T$_8$	44.70	67.94	112.67	39.67
T$_9$	49.70	71.57	121.33	40.96
T$_{10}$	50.20	71.79	122.33	41.04
S Em ±	0.86	0.73	1.27	0.82
CD (P=0.05)	2.60	2.19	3.82	NS

Table 3: Effect of various treatments on nitrogen use efficiency (partial factor productivity, agronomic efficiency and recovery efficiency) in rice

Treatment	**Nitrogen use efficiency**		
	PFP (kg kg^{-1})	**AE (kg kg^{-1})**	**RE (%)**
T$_1$	-	-	-
T$_2$	43.17	20.67	64.40
T$_3$	43.79	21.17	66.78
T$_4$	61.18	25.66	73.25
T$_5$	56.31	24.17	69.11
T$_6$	52.17	22.83	67.05
T$_7$	81.48	31.48	86.17
T$_8$	72.10	28.55	79.95
T$_9$	49.70	22.70	68.24
T$_{10}$	55.78	25.78	78.90
S Em ±	3.19	1.67	2.17
CD (P=0.05)	9.55	5.00	6.52

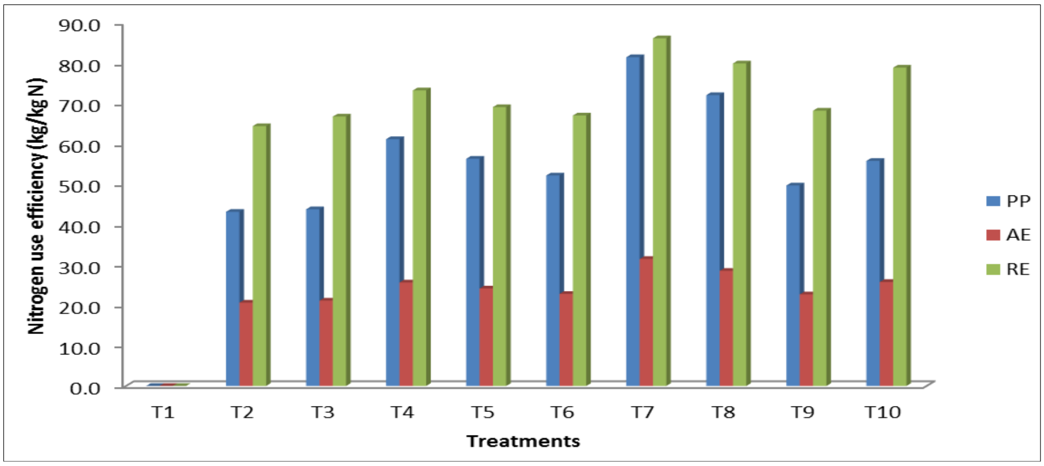

Fig 3: Effect of various treatments on nitrogen use efficiency (partial factor productivity, agronomic, and recovery) in rice

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