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Effect of Different Nitrogen Levels on Morpho Physiological and Yield Parameters in Rice (*Oryza sativa* L.)

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A B S T R A C T

Field experiment was conducted during 2011-12 to study the response of rice varieties on morpho-physiological and yield under two nitrogen levels 120 kg N ha^{-1} [N120], 60 kg N ha^{-1} [N60] as main treatments and twenty six rice genotypes as sub treatments. In the present investigation among the nitrogen treatments application of 120 kg N ha^{-1} recorded significantly higher values for morpho-physiological parameters such as number of tillers hill^{-1}, SCMR values, photosynthetic rate and also resulted in maximum number of panicles hill^{-1}, number of filled grains hill^{-1}, filled grain percentage, 1000 grain weight and grain yield. Spikelet sterility and number of unfilled grains hill^{-1} were minimum in this treatment. Among the genotypes, MTU-1001 recorded the maximum grain yield of 5021 kg ha^{-1} even under application of 60 kg N ha^{-1}. This indicated that maximum yield can be attributed to maximum SCMR values, more photosynthetic rate, more tillers and panicles, more number of grains hill^{-1}, maximum filled grain percentage and minimum spikelet sterility.

Introduction

Rice (*Oryza sativa L.*) is staple food for more than 60% of the global population and forms the cheapest source of food and energy. Nitrogen (N) is the indispensable nutrient to rice production and its uptakes is affected by rice varieties, environment, soil conditions, crop rotations *etc*. Managing nitrogen fertilization in rice fields is a challenging task for farmers because of various kinds of losses due to de -nitrification, deep percolation and run-off in flooded soils resulting in low nitrogen use efficiency. While excessive nitrogen promotes lodging and diseases and results in low nitrogen use efficiency, low application of nitrogen will often reduce rice. Among the various factors contributing for rice production, fertilizers play an important role. Use of adequate nitrogen rate is important not only for obtaining maximum economic returns, but also to reduce environmental pollution. Excessive nitrogen application can result in accumulation of large amounts of post-harvest residual soil nitrogen. Residual soil nitrate (NO^{-3}) may be available for subsequent crops in the next season, but such nitrogen is highly susceptible to leaching during non-crop periods (Sachiko *et al.*, 2009).

Rice varieties may respond differently to nitrogen application. Cultivars selected under high nitrogen fertilizer application may not be suitable for soils with low nitrogen status. Even after the application of high rates of fertilizer nitrogen to rice, expected yield levels might not be obtained. If plant nitrogen status can be increased without lodging or increasing the incidence of disease, a significant increase in yield requires increased sink capacity, maintenance of high leaf nitrogen content and a longer grain filling duration. Rice varieties differ in their ability to extract soil and fertilizer nitrogen and in its distribution to different plant organs. Understanding nitrogen uptake and assimilation is necessary in any attempt to optimize the efficiency of absorbed nitrogen for grain production. Hassan *et al.,* (2007) showed that vigorous biomass accumulation could lead to dilution of plant nitrogen content up to the panicle initiation stage, which could lead to inefficient use of nitrogen for spikelet formation. It is important to increase the efficiency of soil and fertilizer nitrogen by using nutrient efficient varieties. The present investigation was to assess variability in grain yield, and morpho physiological parameters of rice varieties under optimal and suboptimal nitrogen levels.

Materials and Methods

A field experiment was conducted during 2011-12 at Collage Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The experiment was laid out in a split plot design with two nitrogen levels i.e., Optimum of 120 kg N ha^{-1} [N120], Sub optimal of 60 kg N ha^{-1} [N60] as main treatments and twenty six rice genotypes as sub treatments and the experiment was replicated thrice. The rice genotypes were sown separately in raised bed nursery and thirty day old seedlings were transplanted into 6 m^2 (2m X 3m) plots by adopting a spacing of 20 cm between rows and 15 cm between plants with in a row. Nitrogen was applied as per the treatments 60 Kg N ha^{-1} and 120 kg N ha^{-1} in three equal splits in the form of urea. Depending on the nitrogen treatments one third dose of nitrogen was applied as basal dose at the time of planting of the crop. Remaining two equal splits of nitrogen was broadcasted at maximum tillering and panicle initiation stages. Phosphorus was applied at the rate of 60 kg P_2O_5 ha^{-1} in the form of single super phosphate and potassium 40 kg K_2O ha^{-1} in the form of muriate of potash was applied as basal dose at the time of transplanting. Irrigation and weed management was done in time to time. The border rows were harvested first and then, the net plot area was harvested and the produce was threshed by beating on a threshing bench, cleaned and sun dried to 14 percent moisture level. Plants in one m^2 area were tagged separately.

The number of both ear bearing and non ear bearing tillers per hill were counted at the time of harvest and reported as tiller number per hill. At harvest the tillers bearing panicles per hill were counted and expressed as number of effective tillers per hill. Number of days from sowing to the day when primary panicles in 50 percent of the plants in each plot and each replication were in heading was recorded. Number of days required from sowing to the yellowing of the leaves and stem (symptoms of maturity) in each plot and each replication was recorded and reported as days to maturity in different treatments.

For analysis of physiological characters, five plants in each plot were tagged and observations at maximum tillering, flowering and maturity stages were recorded. The SPAD (Soil Plant Analytical Development) chlorophyll meter readings measures the greenness or relative chlorophyll content of leaves. This meter enables to obtain instant readings without destroying the plant tissue. The third leaf from top was used for measuring SCMR, which was taken midway between the leaf base and tip. Mean of five values from five hills was at maximum tillering, flowering and maturity stages were recorded. Photosynthetic rate measurements were recorded at maximum tillering, flowering and maturity stages by using (IRGA- Infra Red Gas Analyser) portable photosynthetic measurement system from leaves that had fully expanded recently. During measurements, the PAR (Photosynthetically Active Radiation) was kept at 1200 µmol m^{-2} s^{-1}. The CO_2 concentration was kept at 387 ± 6 ppm. These measurements were made between 10.00 am to 12.00 noon at all the sampling dates and expressed as µmol CO_2 m^{-2} s^{-1}. Grain from net plot area was thoroughly sun dried, threshed, cleaned and weight of grains was recorded and expressed in yield per hectare. The data were analyzed statistically following the method given by Panse and Sukhatme (1978) and wherever the results were significant, the critical difference (CD) was calculated at 5 per cent level of significance (P=0.05).

Results and Discussion

Morphological characters

Number of tillers hill^{-1}

Number of tillers per unit area is the most important component of yield. More the number of tillers, especially fertile tillers; the more will be the yield. Nitrogen deficiency led to reduction in the number of tillers as well as in the number of productive tillers which in turn had a negative effect on dry matter production and yield (Sandya Rani, 2012).

Data on number of tillers hill^{-1} is presented in table 1. Between the treatments, there was significant increase in number of tillers. With increase in nitrogen application 12.6 to 14.9 with a mean of 13.7 tillers hill^{-1} were recorded. Application of nitrogen at 120 kg N ha^{-1} has resulted in maximum number of tillers hill^{-1}(14.9), while at 60 kg N ha^{-1} minimum tillers hill^{-1} (12.6) were recorded. Among the genotypes the number of tillers ranged from 12.2 to 16.2 with a mean of 13.7 tillers hill^{-1}. MTU-1001 recorded maximum number of 16.2 tillers hill^{-1} followed by MTU-1010 (15.6 tillers hill^{-1}). Minimum number of 12.2 tillers hill^{-1} was recorded in Varalu. The differences among the genotypes for this parameter are statistically significant.

Interaction between nitrogen levels and rice genotypes was found to be significant for number of tillers hill^{-1}. Among the genotypes MTU-1001 recorded maximum number of tillers hill^{-1} both in 120 kg N ha^{-1} (18 tillers hill^{-1}) and 60 kg N ha^{-1} (14.3 tillers hill^{-1}). The minimum number of tillers hill^{-1} were recorded in the genotypes Varalu and JGL-3855 which recorded 13 tillers hill^{-1} at 120 kg N ha^{-1} and Varalu, Chittimutyalu and Divya 11.3 tillers hill^{-1} at 60 kg N ha^{-1}.

Application of optimum nitrogen (120 kg N ha^{-1}) during grand vegetative stage has induced more number of tillers m^{-2} as observed by the Devi and Sumathi (2011). The increase in tillers hill^{-1} was reported with increase in nitrogen levels upto 120 kg N ha^{-1}, 150 kg N ha^{-1} and 175 kg N ha^{-1} (Ramesh *et al.,* 2009).

Time of heading (50% plants with heads)

Data pertaining to time taken for heading as influenced by nitrogen supply in rice genotypes is presented in table 2. The time of heading got delayed with increase in nitrogen levels from 60 to 120 kg N ha^{-1}. The time taken for heading in 120 kg N ha^{-1} is 87 day as against 84 day in 60 kg N ha^{-1}. Abundant supply of nitrogen (150 kg N ha^{-1}) might have delayed the vegetative growth and shifted the balance between vegetative and reproductive growth, leading to delay in days to 50 % heading.

There was significant difference in number of days taken for time of heading in the genotypes studied. Among rice genotypes, Varalu was earliest (67 day) while BPT-5204 was late (95 day) with a genotypic mean of 86 days. Zahid *et al.,* (2009) reported highly significant variation among genotypes for days to 50 percent heading and attributed this to the genetic makeup of exotic lines and genotypic environmental interaction. Days to 50% heading is an important parameter as it is positively and significantly correlated with seed yield per plant in rice crop (Ashrafuzzaman *et al.,* 2009). The interaction between nitrogen levels and genotypes for time of heading was non significant.

Days to maturity

Data on days taken for maturity is presented in table 2 and there was significant increase in the number of days taken for maturity with increase in nitrogen application from 60 kg N ha^{-1} (123 day) to 120 kg N ha^{-1} (128 day). Among the genotypes there was significant difference in number of days taken for maturity which ranged from 97-140 with a genotypic mean of 126 days. BPT-5204 has taken maximum days for maturity (140 days), while it was lower in Varalu (97 days). There was a non significant interaction effect between nitrogen levels and genotypes for days to maturity.

Karim *et al.,* (2007) studied rice genotypes for variability and genetic parameter analysis and reported that such variation for days to maturity was due to genetic constituent rather than environment. Shahidullah *et al.,* (2009) concluded that the wide variation in phenological characters depends on genotypic constituent, micro and macro environments.

Physiological characters

SPAD chlorophyll meter reading (SCMR)

The role of chlorophyll in photosynthesis is well established but the relationship between chlorophyll content and rate of photosynthesis is equivocal. Data on SCMR as influenced by nitrogen application in rice genotypes is presented in table 3. SCMR values increased from maximum tillering stage (37.8) to flowering stage (42.5) and thereafter declined towards maturity (32.5). There was significant increase in SCMR values due to nitrogen application. Among the treatments, application of 120 kg N ha^{-1} has resulted in mean SCMR values of 38.4 at maximum tillering stage which increased to 43.4 at flowering stage and reduced to 33.8 at maturity stage. Plants which were grown in 60 kg N ha^{-1} recorded the minimum SCMR values at all the stages.

The interaction between N levels and genotypes at maximum tillering stage was not significant. SCMR value was maximum in MTU-1001 both at flowering stage (45.1) and at maturity stage (35.4), while minimum values were recorded in Varalu at flowering (40.5) and maturity stages (29.7). It was earlier reported that genotypes maintained high chlorophyll content from panicle initiation stage to grain filling stage, which is more important in determining grain yield (Ranjitha 2011 and Thakur *et al.,* 2011). The interaction between treatments and genotypes was significant at flowering and maturity stages. Among the genotypes MTU-1001 recorded maximum SCMR values at flowering stage in 120 kg N ha^{-1} (47.4) and 60 kg N ha^{-1} (43.2). The minimum SCMR values were observed in Varalu at N 120 (41.2) and at N 60 (39.8) treatments. Similarly at maturity stage the maximum SCMR values were recorded by the genotype MTU-1001 in 120 kg N ha^{-1} (36.1) and 60 kg N ha^{-1} (34.6).

The minimum SCMR values were observed in Varalu at 120 kg N ha^{-1} (30.6) and at 60 kg N ha^{-1} (28.8). The chlorophyll meter quantifies the greenness or relative chlorophyll content of leaves. Critical or threshold SPAD value is important and it indicates the leaf area based critical nitrogen concentration in rice leaves. These results are in agreement with Swain *et al.,* (2006) who found highly significant and positive relation between total chlorophyll content at all the growth stages and grain number m^{-2}, indicating the role of chlorophyll content in sink development and grain filling, leading to higher productivity.

Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})

Nitrogen nutrition influences the content of photosynthetic pigments, synthesis of the enzymes taking part in the carbon reduction, formation of the membrane system of chloroplasts, etc. Thus the increase in growth and yield owing to the application of N-fertilizers may be attributed to the fact that these nutrients being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants.

Data on photosynthetic rate shows that there was an increase in the values from maximum tillering (18.41 μ mol CO_2 m^{-2} s^{-1}) to flowering stage (22.24 μ mol CO_2 m^{-2} s^{-1}) and recorded a decrease thereafter towards maturity stage (13.23 μ mol CO_2 m^{-2} s^{-1}) (Table 4). Significant increase in leaf photosynthetic rate was recorded due to nitrogen application. Nitrogen application at 120 kg N ha^{-1} has resulted in mean leaf photosynthetic rate of 19.47 μ mol CO_2 m^{-2} s^{-1} at maximum tillering stage which increased to 23.43 μ mol CO_2 m^{-2} s^{-1} at flowering stage and decreased to 13.63 μ mol CO_2 m^{-2} s^{-1} by maturity stage. Photosynthetic rate recorded was low at all the stages when nitrogen fertilizers were applied at 60 kg N ha^{-1}. Nitrogen application directly increased the chlorophyll content and leaf surface area which is turn increased photosynthetic process in rice. Similar results were reported by Hassan *et al.,* (2007) who suggested that low levels of nitrogen can reduce photosynthetic rate as well as leaf chlorophyll content and photosynthetic efficiency. Significant differences were observed between the genotypes in photosynthetic rate at maximum tillering and flowering stage, but the differences were non significant at maturity stage. At maximum tillering stage, photosynthetic rate ranged from 16.84 μ mol CO_2 m^{-2} s^{-1} to 19.44 μ mol CO_2 m^{-2} s^{-1}, at flowering stage from 20.49 μ mol CO_2 m^{-2} s^{-1} to 23.14 μ mol CO_2 m^{-2} s^{-1}. The minimum values were recorded in Divya at maximum tillering (16.84) and flowering stages (20.49). While, maximum values were recorded in MTU-1001 at both maximum tillering and flowering stages (19.44 and 23.14 μ mol CO_2 m^{-2} s^{-1} respectively).

Genotypes that maintain higher leaf chlorophyll content during crop growth period may be considered as potential donors for the ability to produce higher photosynthetic rate (Miah *et al.,* 1997). The interaction effects between nitrogen levels and genotypes for photosynthetic rate were non significant at all the crop growth stages.

Yield and yield attributes

The yield ultimately depends on the better expression of yield attributing characters like panicle number $hill^{-1}$, number of filled grains and unfilled grains $panicle^{-1}$, 1000 grain weight and yield.

Panicle number $hill^{-1}$

The data pertaining to panicle number $hill^{-1}$ as influenced by nitrogen in rice genotypes is presented in table 5. The number of panicles hill^{-1} increased significantly with increase in N application from 60 kg N ha^{-1} (11.7) to 120 kg N ha^{-1} (13.5). Increase in panicle number with increase in nitrogen application in rice was earlier reported by Gosh *et al.*, (2013). Among the genotypes, the number of panicle hill^{-1} ranged from 11.5 to 14.5 with a mean of 12.6 panicles hill^{-1} and the difference were statistically significant. The genotype MTU-1001 (14.5) recorded maximum number of panicles hill^{-1} which was on par with MTU-1010 (14.0), BPT-5204 (13.7). While the minimum number of panicles hill^{-1} was recorded in Varalu (11.5).

The interaction between treatments and genotypes was non significant, with respect to this parameter. In rice, number of panicles per unit area is primary yield determining component. For achieving higher yield in rice, the sink size should be increased by increasing panicle size or number or either. The cultivar having large panicles may be the best option but the adequate numbers of panicles need to be maintained properly in terms of sink-source balance (Miah *et al.*, 1997, Kim *et al.*, 1993).

Number of filled grains hill^{-1}

The data on number of filled grains hill^{-1} revealed that there was significant increase in this parameter with increase in nitrogen application which ranged from 1039 (N 60) to 1290 (N120) with a mean of 1165 filled grains hill $^{-1}$ (Table 5). Such increase in filled grains per panicle with increase in N fertilizers up to 200 kg N ha^{-1} was reported by Sharma and Masand (2008). Among the genotype MTU-1001 recorded maximum value of 1507 filled grains hill^{-1} followed by MTU-1010 (1447 filled grains hill^{-1}) while minimum filled grains hill^{-1} of 840 was recorded in genotype Erramallelu. The differences among the genotypes for this parameter are statistically significant.

Interaction between nitrogen levels and rice genotypes was significant for number of filled grains hill^{-1} which ranged from 647 to1586. Among the genotypes MTU-1001 recorded maximum number of filled grains hill^{-1} both in N 120 (1586) and N 60 (1428) treatments. Whereas minimum number of filled grains hill^{-1} were recorded in genotype Erramallelu in 120 kg N ha^{-1} (1032) and 60 kg N ha^{-1} (647). Samonte *et al.*, (1998) found that number of filled grains per panicle had significant positive effect on rice grain yield. Similar results were reported by Sowmya (2008) and Suryaprabha *et al.*, (2011).

Number of unfilled grains hill^{-1}

Data on unfilled grains hill^{-1} as influenced by nitrogen supply in rice genotypes is presented in table 5. Significant differences were noticed between the treatments and increase in nitrogen level reduced the unfilled grains hill^{-1} from 449 to 573. Unfilled grains hill^{-1} was minimum with application of 120 kg N ha^{-1} (449) and maximum number of unfilled grains hill^{-1} was recorded at 60 kg N ha^{-1} (573). Among the rice genotypes there was significant difference in number of unfilled grains hill^{-1} which ranged from 429 to 641 with a mean of 511. Minimum number of unfilled grains hill^{-1} was recorded in MTU-1001 (429) where as maximum number of unfilled grains hill^{-1} was recorded in Kavya (641). Interaction between nitrogen levels and rice genotypes was statistically significant. Number of unfilled grains hill^{-1} which ranged from 374 to 756. Among the interactions minimum number of unfilled grains hill^{-1} were recorded at 120 kg N ha^{-1} (374) in genotype MTU-1001 where as maximum number of unfilled grains hill^{-1} was recorded at 60 kg N ha^{-1} (756) in WGL-32100.

Grain yield (kg ha^{-1})

Nitrogen is the most essential element that determines the yield potential of intensified agricultural system. Additional doses of nitrogen are usually applied to increase grain yield. A perusal of the data on grain yield indicates that with increased nitrogen levels there was significant increase in the grain yield (Table 6). Highest grain yield of 4591 kg ha^{-1} was recorded with 120 Kg N ha^{-1}.While lowest grains yield of 3985 kg ha^{-1} was recorded with 60 Kg N ha^{-1} treatment. There was significant difference in grain yield of various rice genotypes studied. Among the genotypes MTU-1001 has recorded maximum grain yield of 5192 kg ha^{-1}, while the lowest grain yield of 2912 kg $ha^{-1}$was recorded in Varalu

Table.1 The influence of nitrogen on number of tillers $hill^{-1}$ in rice genotypes during kharif-2011

Genotypes		Number of tillers $hill^{-1}$		
		60 kg N ha^{-1}	**120 kg N ha^{-1}**	**Mean**
WGL-14		12.0	14.0	13.0
BPT-5204		14.0	15.0	14.5
WGL-2395		12.7	14.0	13.2
Divya		11.3	14.3	12.8
JGL-11727		11.7	14.0	12.8
Pothana		13.3	14.0	13.7
RNR-C-28		13.3	15.7	14.5
RNR-2354		13.0	15.3	14.2
RNR-2465		11.7	15.3	13.5
JGL-3855		13.7	13.0	13.3
NDLR-7		12.7	15.0	13.8
Surekha		12.3	16.0	14.2
RNR-2458		12.3	13.7	13.0
MTU-1001		14.3	18.0	16.2
Erramallelu		12.0	13.7	12.8
Bhadrakali		14.0	14.3	14.2
JGL-1798		14.0	15.0	14.5
Godavari isukalu		13.3	15.3	14.3
Kavya		11.7	15.0	13.3
MTU-1010		14.0	17.3	15.7
Chittimutyalu		11.3	15.3	13.3
WGL-32100		12.7	16.3	14.5
Varalu		11.3	13.0	12.2
JGL-1470		12.3	15.7	14.0
JGL-3844		11.7	14.0	12.8
JGL-3828		12.0	14.0	13.0
Mean		12.6	14.9	13.7
C.D (5%)	**Treatments (T)**	0.340		
	Genotypes (G)	1.015		
	T X G	1.436		

Table.2 The influence of nitrogen on days to 50% heading and maturity in rice genotypes during kharif-2011

Genotypes		**Days to 50% heading**			**Days to maturity**		
		60 kg N ha^{-1}	**120 kg N ha^{-1}**	**Mean**	**60 kg N ha^{-1}**	**120 kg N ha^{-1}**	**Mean**
WGL-14		88	92	90	126	128	127
BPT-5204		93	96	95	137	142	140
WGL-2395		84	87	85	120	126	123
Divya		82	85	83	122	126	124
JGL-11727		89	92	91	121	128	125
Pothana		81	85	83	120	122	121
RNR-C-28		81	84	83	121	123	122
RNR-2354		83	86	85	126	132	129
RNR-2465		81	85	83	126	130	128
JGL-3855		82	85	84	120	126	123
NDLR-7		88	92	90	126	130	128
Surekha		88	91	90	126	134	130
RNR-2458		84	87	86	124	127	125
MTU-1001		87	90	89	126	132	129
Erramallelu		81	84	82	120	124	122
Bhadrakali		85	88	87	126	132	129
JGL-1798		81	84	83	122	127	125
Godavari isukalu		80	83	82	120	125	123
Kavya		88	92	90	129	133	131
MTU-1010		90	93	92	126	132	129
Chittimutyalu		79	82	81	120	122	121
WGL-32100		88	92	90	128	133	131
Varalu		65	68	67	95	98	97
JGL-1470		83	86	85	123	127	125
JGL-3844		89	91	90	126	133	129
JGL-3828		88	92	90	128	135	132
Mean		84	87	86	123	128	126
C.D (5%)	**Treatments (T)**	1.794			1.624		
	Genotypes (G)	2.097			2.310		
	T X G	NS			NS		

Table.3 The influence of nitrogen on SCMR values in rice genotypes at different stages of crop during kharif-2011

Genotypes		At maximum tillering stage			At flowering stage			At maturity stage		
		60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean
WGL-14		36.5	38.5	37.5	40.5	41.6	41.1	30.1	34.8	32.5
BPT-5204		37.0	39.5	38.2	41.6	43.8	42.7	32.5	35.1	33.8
WGL-2395		37.2	39.2	38.2	41.6	42.2	41.9	32.5	34.3	33.4
Divya		37.7	39.4	38.6	40.4	41.5	41.0	31.3	32.1	31.7
JGL-11727		37.8	39.1	38.4	41.7	46.8	44.3	32.4	33.5	32.9
Pothana		36.9	38.7	37.8	41.0	42.7	41.9	31.3	34.4	32.9
RNR-C-28		37.5	38.6	38.0	41.4	43.7	42.6	31.6	34.4	33.0
RNR-2354		35.9	37.2	36.5	42.5	45.4	44.0	31.9	34.7	33.3
RNR-2465		36.0	38.0	37.0	40.8	41.1	40.9	31.0	31.4	31.2
JGL-3855		38.9	37.5	38.2	42.9	44.8	43.9	32.1	36.1	34.1
NDLR-7		37.2	38.7	37.9	42.9	44.2	43.6	31.1	34.5	32.8
Surekha		38.1	39.1	38.6	42.9	42.7	42.8	29.5	31.9	30.7
RNR-2458		37.0	38.8	37.9	42.4	43.4	42.9	31.6	33.5	32.6
MTU-1001		37.8	40.9	39.3	43.2	47.4	45.1	34.6	36.1	35.4
Erramallelu		36.7	38.0	37.4	40.3	40.9	40.6	29.4	31.3	30.4
Bhadrakali		37.4	38.5	37.9	40.9	42.5	41.7	31.4	33.9	32.6
JGL-1798		36.7	38.4	37.6	41.3	43.1	42.2	32.3	33.8	33.1
Godavari isukalu		38.6	38.8	38.7	41.1	42.8	41.9	30.7	32.8	31.7
Kavya		37.2	38.3	37.8	42.5	44.7	43.6	30.6	34.5	32.6
MTU-1010		37.3	39.5	38.4	42.4	45.1	43.8	32.8	35.8	34.3
Chittimutyalu		37.2	38.8	38.0	41.4	42.9	42.1	29.2	32.8	31.0
WGL-32100		36.1	37.7	36.9	41.2	44.2	42.7	32.4	35.3	33.9
Varalu		35.4	36.3	35.9	39.8	41.2	40.5	28.8	30.6	29.7
JGL-1470		37.3	38.1	37.7	41.6	43.6	42.6	31.1	33.6	32.4
JGL-3844		36.6	37.8	37.2	40.4	42.1	41.3	30.2	32.7	31.5
GL-3828		35.9	36.3	36.1	41.1	43.3	42.2	30.0	33.9	32.0
Mean		37.1	38.4	37.8	41.5	43.4	42.5	31.2	33.8	32.5
C.D (5%)	**Treatments (T)**	1.225			0.671			1.251		
	Genotypes (G)	NS			1.251			0.888		
	T X G	NS			1.825			1.642		

Table.4 The influence of nitrogen on photosynthetic rate (μ mol CO_2 m^{-2} s^{-1}) in rice genotypes at different stages of crop during kharif-2011

Genotypes		At maximum tillering stage			At flowering stage			At maturity stage		
		60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean
WGL-14		18.33	19.09	18.71	21.57	23.10	22.33	12.44	14.46	13.45
BPT-5204		16.58	19.16	17.87	20.65	23.51	22.08	11.94	14.31	13.12
WGL-2395		17.31	19.85	18.58	20.74	23.84	22.29	12.65	13.31	12.98
Divya		16.27	17.40	16.84	19.54	21.43	20.49	12.20	14.20	13.20
JGL-11727		16.80	19.88	18.34	20.94	23.94	22.44	11.27	14.67	12.97
Pothana		16.11	18.76	17.44	20.35	22.86	21.61	12.88	14.23	13.56
RNR-C-28		17.02	17.77	17.39	20.96	21.86	21.41	12.20	12.75	12.48
RNR-2354		18.16	19.00	18.58	21.55	23.09	22.32	14.33	14.03	14.18
RNR-2465		16.35	19.60	17.97	19.86	23.43	21.65	14.82	14.62	14.72
JGL-3855		17.49	20.18	18.83	21.55	24.03	22.79	12.70	14.36	13.53
NDLR-7		17.65	20.03	18.84	21.60	23.73	22.67	14.02	12.52	13.27
Surekha		17.35	18.73	18.04	21.31	22.69	22.00	13.00	13.40	13.20
RNR-2458		16.59	19.68	18.14	20.99	23.66	22.33	12.28	12.60	12.44
MTU-1001		18.39	20.48	19.44	21.84	24.44	23.14	12.23	12.92	12.58
Erramallelu		18.64	19.00	18.82	21.47	22.74	22.11	13.70	13.77	13.73
Bhadrakali		16.08	18.60	17.34	20.12	22.80	21.46	12.93	14.55	13.74
JGL-1798		16.37	19.11	17.74	20.42	23.46	21.94	12.79	13.43	13.11
Godavari isukalu		16.79	20.12	18.45	20.76	24.04	22.40	12.04	12.82	12.43
Kavya		17.61	20.02	18.82	20.69	23.56	22.13	12.70	12.42	12.56
MTU-1010		18.91	19.81	19.36	21.82	24.39	23.11	12.37	13.12	12.74
Chittimutyalu		16.97	20.43	18.70	20.68	23.83	22.26	11.98	13.32	12.65
WGL-32100		18.02	20.51	19.26	21.80	24.15	22.97	13.93	13.79	13.86
Varalu		18.32	19.30	18.81	21.18	23.56	22.37	12.55	13.09	12.82
JGL-1470		17.61	20.07	18.84	21.91	23.54	22.72	14.01	13.50	13.75
JGL-3844		17.51	20.32	18.92	21.60	23.78	22.69	12.65	13.27	12.96
JGL-3828		17.74	19.45	18.59	21.43	23.68	22.55	13.06	14.92	13.99
Mean		17.35	19.47	18.41	21.05	23.43	22.24	12.83	13.63	13.23
C.D (5%)	**Treatments (T)**	0.482			0.056			0.362		
	Genotypes (G)	1.219			1.196			NS		
	T X G	NS			NS			NS		

Table.5 The influence of nitrogen on number of panicles hill^{-1}, filled and unfilled grains hill^{-1} in rice genotypes during kharif 2011

Genotypes		No. of panicles hill^{-1}			No. of filled grains hill^{-1}			No. of unfilled grains hill^{-1}		
		60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean	60 kg N ha^{-1}	120 kg N ha^{-1}	Mean
WGL-14		11.7	13.0	12.3	1221	1386	1304	565	406	485
BPT-5204		13.0	14.3	13.7	1307	1446	1376	528	416	472
WGL-2395		12.0	14.0	13.0	1297	1467	1382	577	424	501
Divya		12.0	14.3	13.2	990	1241	1115	508	417	463
JGL-11727		11.0	13.0	12.0	1024	1282	1153	512	446	479
Pothana		11.7	13.0	12.3	1113	1305	1209	630	468	549
RNR-C-28		12.0	14.0	13.0	1004	1147	1075	611	491	551
RNR-2354		11.7	14.0	12.8	919	1221	1070	555	475	515
RNR-2465		11.0	12.3	11.7	782	1322	1052	536	448	492
JGL-3855		11.7	13.0	12.3	885	1154	1020	488	402	445
NDLR-7		11.0	13.0	12.0	939	1325	1132	549	457	503
Surekha		11.0	13.0	12.0	890	1065	977	543	428	486
RNR-2458		11.0	12.3	11.7	1021	1217	1119	517	417	467
MTU-1001		13.0	16.0	14.5	1428	1586	1507	484	374	429
Erramallelu		12.0	13.3	12.7	647	1032	840	498	404	451
Bhadrakali		12.0	13.0	12.5	1074	1290	1182	646	493	570
JGL-1798		12.3	13.3	12.8	1166	1357	1261	611	447	529
Godavari isukalu		12.0	14.0	13.0	866	1172	1019	679	554	617
Kavya		11.0	13.3	12.2	1105	1314	1210	734	548	641
MTU-1010		13.0	15.0	14.0	1387	1507	1447	509	396	452
Chittimutyalu		11.3	13.3	12.3	917	1275	1096	667	487	577
WGL-32100		11.7	14.0	12.8	1010	1452	1231	756	511	633
Varalu		10.0	13.0	11.5	917	1146	1032	571	465	518
JGL-1470		11.3	14.3	12.8	953	1352	1153	547	445	496
JGL-3844		12.0	13.0	12.5	1082	1226	1154	506	422	464
JGL-3828		11.0	13.0	12.0	1076	1249	1162	581	431	506
Mean		11.7	13.5	12.6	1039	1290	1165	573	449	511
C.D (5%)	**Treatments (T)**	0.457			3.993			15.356		
	Genotypes (G)	1.076			34.760			27.172		
	T X G	NS			48.320			39.849		

Table.6 The influence of nitrogen on grain yield (Kg ha^{-1}) in rice genotypes

Genotypes		Grain yield (Kg ha^{-1})		
		N 60	N 120	Mean
WGL-14		3200	4423	3811
BPT-5204		4810	5036	4923
WGL-2395		4976	5175	5076
DIVYA		4740	4856	4798
JGL-11727		4741	4983	4862
POTHANA		4869	5046	4957
RNR-C-28		4219	4402	4310
RNR-2354		3148	4230	3689
RNR-2465		3072	4072	3572
JGL-3855		3750	4618	4184
NDLR-7		3073	3798	3436
SUREKHA		2636	3458	3047
RNR-2458		3847	4504	4175
MTU-1001		5021	5364	5192
ERRAMALLELU		2923	3641	3282
BHADRAKALI		4821	5001	4911
JGL-1798		4918	5141	5030
GODAVARI ISUKALU		4130	4772	4451
KAVYA		4720	4873	4797
MTU-1010		5015	5338	5176
CHITTIMUTYALU		4144	4816	4480
WGL-32100		3445	4697	4071
VARALU		2549	3275	2912
JGL-1470		3649	4818	4233
JGL-3844		3111	4399	3755
JGL-3828		4094	4634	4364
Mean		3985	4591	4288
C.D (5%)	**Treatments (T)**	73.546		
	Genotypes (G)	108.665		
	T X G	163.049		

The interaction between nitrogen levels and rice genotypes was highly significant for grain yield. Among the treatment combinations, highest grain yield of 5364 kg ha^{-1} was recorded with 120 Kg N ha^{-1} in MTU-1001, whereas lowest grain yields of 2548 kg ha^{-1} was recorded in Varalu with application of 60 Kg N ha^{-1}. The grain yield significantly increased with increasing nitrogen levels up to 120 kg N ha^{-1}. Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre-heading stage and in the grain during the ripening stage of rice (Bahmanyar and Ranjbar, 2007).

In conclusion, in the present study rice varieties responded well to higher levels of nitrogen. Among the nitrogen levels 120 Kg

N ha^{-1} and rice genotypes MTU-1001 has recorded highest grain yield and lowest grain yield was recorded in Varalu with application of 60 Kg N ha^{-1}. The adequate quantity of nitrogen at right time helped rice plants to promote the yield and also accumulation of nitrogen elements in rice productive organs and its distribution is an important process which determines the grain yield.

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