www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 2829-2835

www.thepharmajournal.com
Received: 17-09-2023
Accepted: 20-10-2023

Nagesha BV
Department of Crop Physiology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Ramesh Thatikunta
College of Agriculture, Warangal, PJTSAU, Hyderabad, Telangana, India

S Narender Reddy
Department of Crop Physiology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

L Krishna
Agricultural Research Institute, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

K Supriya
Department of Statistics and Mathematics, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Corresponding Author:
Nagesha BV
Department of Crop Physiology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Physiological response of rice (*Oryza sativa* L.) genotypes to elevated nitrogen applied under field conditions

Nagesha BV, Ramesh Thatikunta, S Narender Reddy, L Krishna and K Supriya

Abstract
A field experiment was conducted during Rabi, 2019 at College of Agriculture, Rajendranagar, Hyderabad to study the effect of different nitrogen levels and zinc application on growth and development in paddy. The experiment was laid out in split plot design with three varieties as main plots, six nutrient levels as sub plots and replicated thrice. Among the varieties Tella Hamsa had taken less number of days to panicle initiation (64), flowering (83) and maturity (118), Minimum LAI (4.06, 4.43 and 2.44 at vegetative, flowering and grain filling stage respectively) and lower photosynthetic rate (16.7, 19.4 and 12.2 μmol CO_2 m^{-2} s^{-1} at vegetative, flowering and grain filling stage respectively). Telangana Sona had taken more number of days to panicle initiation (67), flowering (87) and maturity (123), maximum LAI, maximum photosynthetic rate, number of panicles m^{-2}, Panicle length, grains $panicle^{-1}$ and higher grain yield. Application of 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray resulted in maximum LAI, maximum photosynthetic rate, panicles m^{-2}, grains $panicle^{-1}$, Panicle length and grain yield.

Keywords: Photosynthetic rate, leaf area index, panicle length, grain yield

Introduction

Rice is a staple and an important food crop around the whole world serving the food requirements of more than half of the world population. In India, rice is grown in an area of 44.5 M ha with a production 115.60 Mt and a productivity of 2800 kg ha^{-1}. Telangana State contributes 2.09 m ha area annually with a production of 6.62 mt, with an average productivity of 3295 kg ha^{-1} during 2018-2019 (CMIE, 2019) [1]. Nitrogen is one of the most important nutritional elements contributing for higher productivity of cereal crops and a major factor that limits agricultural yields. To obtain a better crop yield, one of the major criteria which need to be taken care of is the plant nutrition. Nitrogen on the basis of its function has been categorized as an essential element, which most recurrently limits the crop yield and growth (Fageria *et al*., 2005) [2]. Nitrogen is the indispensable nutrient for rice production and its uptake is affected by rice varieties, fertilizer levels, nitrate, ammonium transporters, soil and environmental conditions etc. Nitrogen absorbed by rice during the vegetative growth stages contributes in growth during reproduction and grain filling through translocation. The application of nitrogen fertilizer either in excess or less than optimum rate affects both yield and quality of rice to remarkable extent, hence proper management of crop nutrition is of immense importance (Manzoor *et al*., 2006) [3].

Managing nitrogen fertilization is a challenging task for farmers in rice fields because of various losses due to de-nitrification, volatilization, leaching in flooded soils resulting in low uptake and nitrogen use efficiency (Peng *et al*., 2006) [4]. Excess application leads to lodging, pest and disease incidence whereas low application results in low growth and yield production. Fertilizers play an important role in maximizing returns and also reduce environmental loss, thus it is important to develop fertilizer responsive varieties. Excess application of nitrogen results in prolonged vegetative growth period, days to heading, plant height and showed variable trend of increment tillers per plant with the application of higher doses of nitrogen.

The higher dose of nitrogen causes excessive vegetative growth that leads to lodging of the crop and a consequent decline in filled grains per panicle (Zhang *et al*., 2014) [5]. Applied nitrogen has been found to have a synergistic effect with zinc in rice. It has been reported that the uptake and concentration of zinc increases substantially with an increase in the rate of nitrogen application (Jiang *et al*., 2008) [6]. Hence the present study was conducted to evaluate the effect of different levels of nitrogen and zinc application on morphological, yield attributes and quality parameters in paddy.

Material and Methods

Field experiment was conducted on sandy clay soil in college farm, College of Agriculture, Rajendranagar, Hyderabad during Rabi, 2019. The experiment was laid out in a split plot design with three replications. The seedlings of different rice varieties G1- Kunaram Sannalu, G2 - Tella Hamsa and G3 - Telangana Sona were selected as main plots. Fertilizers were given as N1 - RDN (120 Kg N ha^{-1}), N2 - 25% less than RDN (90 Kg N ha^{-1}), N3 - 25% higher than RDN (150 Kg N ha^{-1}), N4 - 25% less than RDN + 0.5% $ZnSO_4$ Foliar spray, N5 - 25% higher than RDN + 0.5% $ZnSO_4$ Foliar spray, N6 - Control taken as sub plots.

The varieties were sown separately in raised bed nursery and 25 days old seedlings were transplanted into 15 m^2 (5 m X 3 m) plots by adopting a spacing of 15 cm between rows and 15 cm with in a row. Nitrogen applied as per treatment in form of urea in 3 splits as basal, maximum tillering and flowering stage. Similarly, 0.5% $ZnSO_4$ foliar spray was applied 3 times at tillering, panicle initiation and flowering stage. Phosphorus was applied as single super phosphate at the rate of 60 kg ha^{-1} and Potash as muriate of potash at the rate of 40 kg ha^{-1} as a basal dose at the time of transplanting. Irrigation and weed management was done time to time.

The number days taken to panicle initiation, 50% flowering and maturity from sowing in each variety in each plot were recorded. For analysis of physiological characters, in each plot five plants were tagged and observations were recorded at vegetative, flowering and grain filling stages. Leaf area index at vegetative, flowering and grain filling stages were recorded. Photosynthetic rate measurements were recorded at maximum vegetative, flowering and grain filling stages by using (IRGA- Infra Red Gas Analyser) portable photosynthetic measurement system (PP System,) from leaves. During measurements, Photosynthetically Active Radiation (PAR) was kept at 1200 μmol CO_2 m^{-2} s^{-1}. The CO_2 concentration was kept at 390 ± 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}.

The crop was harvested manually. Before harvesting, the number of productive tillers i.e., number of panicles in m^2 area in net plot was counted and expressed as panicles per m^2. Five panicles were collected in each net plot and the length of the panicle was measured from the point of scar to tip of the panicle and mean length was expressed in cm. Five panicles were selected randomly in each net plot and the number of spikelets of each panicle was counted likewise for all the five panicles and the average number was arrived. From the five panicles selected, the total number of grains $panicle^{-1}$, filled grain percentage, spikelets $panicle^{-1}$ and sterility percentage was calculated. Five hand full of grain samples were collected at random from the net plot yield of each individual treatment. The grains were counted and weighed to arrive at test weight. A Sample of one hundred grams of well dried paddy from each treatment was dehulled in standard Satake dehuller and milling, hulling and head rice recovery percentage was also calculated. The experimental data recorded on different parameters were analyzed statistically by applying the technique of analysis of variance for split-plot design by using windostat software version 9.2.

Results and Discussion

Panicle initiation, 50% Anthesis and Days to maturity

Panicle initiation (PI) is the time when the panicle primordia initiate the production of a panicle in the uppermost node of the culm. Results on days to PI, 50% anthesis and days to maturity as influenced by nitrogen supply in rice genotypes is presented in table 1.

Data revealed that number of days taken ranged from 64 to 67 days for to panicle initiation, 83 to 87 days for 50% anthesis and 118 to 123 days for maturity. Tella Hamsa (G2) was recorded minimum number of days for panicle initiation (64 days), 50% anthesis (83 days) and days to maturity (118 days), while maximum number of days to panicle initiation (67 days), 50% anthesis (87 days) and days to maturity (123 days) was taken by the genotype Telangana Sona (G3).

Panicle initiation, 50% anthesis and days to maturity recorded was significantly different with the fertilizer treatments and ranged from 63-68 days for panicle initiation, 82 to 87 days for 50% anthesis and 117 to 123 days for maturity. Application of fertilizer at 25% higher than RDN (N3) and 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray (N5) were at par and were taken more number of days to panicle initiation (68 days), 50% anthesis (87 days) and days to maturity (123 days). 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 (Venugopal, 2005) [7]. Interaction effect of genotypes and fertilizer levels for days to panicle initiation, 50% anthesis and maturity was found to be non significant.

Leaf Area Index

The ultimate factors which limit the primary process in crop production i.e. crop photosynthesis is the efficiency of light captured and utilization. The leaf area index (LAI) at different stages of crop in response to different fertilizer levels in different genotypes were depicted in table 2.

The leaf area index (LAI) at different stages of crop in response to different fertilizer levels in different genotypes were presented in table 2. LAI recorded was maximum at flowering stages among the genotypes. Mean values ranged from vegetative to grain filling was 4.20 to 2.55. Results revealed among three genotypes Telangana Sona (G3) has recorded maximum LAI at different growth stages (4.41, 4.73 and 2.67 at vegetative, flowering and grain filling stage respectively) whereas lowest LAI found in genotype G2.

LAI was significantly different at the growth stages with application of fertilizer. Mean values of LAI recorded at three growth stages was 4.20 at vegetative, 4.57 at flowering and 2.55 at grain filling stage. At 25% higher than RDN+ 0.5% $ZnSO_4$ foliar spray (N5) application resulted in maximum growth at vegetative stage of the rice crop (4.50), at flowering (4.89) and at grain filling stage (2.77). Enhanced LAI in response to high nitrogen application has been reported by Wang *et al*. (2016) [8].

Interaction of G x N application showed significant variation in the LAI at various crop growth stages. Treatment N5 and G3 recorded maximum LAI at vegetative (4.72), at flowering (5.05) and at grain filling stage (2.85). Such interaction effects are common with application of higher doses of fertilizer application.

Table 1: Days to panicle initiation, 50% anthesis and maturity of rice as influenced by different nitrogen levels and zinc foliar spray

Treatment		Panicle initiation				50% Anthesis				Days to maturity			
		G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
N_1		67	64	68	66	86	83	87	85	122	118	123	121
N_2		66	63	66	65	85	82	86	84	121	117	122	120
N_3		69	66	70	68	88	84	89	87	123	120	125	123
N_4		66	63	66	65	85	82	86	84	121	117	122	120
N_5		69	66	70	68	88	84	89	87	123	120	125	123
N_6		64	61	64	63	83	81	84	83	119	113	120	117
Mean		66	64	67	66	86	83	87	85	122	118	123	121
CD (5%)	Genotype (G)	0.32				0.14				0.48			
	Treatment(N)	0.58				0.47				0.73			
Main plots: Genotypes													
G_1		66				86				122			
G_2		64				83				118			
G_3		67				87				123			
Mean		66				85				121			
SEm±		0.11				0.05				0.17			
CD (5%)		0.32				0.14				0.48			
Subplots: Fertilizer treatments													
N_1		66				85				121			
N_2		65				84				120			
N_3		68				87				123			
N_4		65				84				120			
N_5		68				87				123			
N_6		63				82				117			
Mean		66				85				121			
SEm±		0.20				0.16				0.25			
CD (5%)		0.58				0.47				0.73			
Interaction													
Rice genotypes at same level of fertilizer treatments													
SEm±		0.34				0.28				0.37			
CD (5%)		NS				NS				NS			
Interaction													
Fertilizer treatments at same or different rice genotypes													
SEm±		0.33				0.26				0.37			
CD (5%)		NS				NS				NS			

Photosynthetic rate (μmol 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, and there by increases growth and yield.

Significant differences were observed between the genotypes in photosynthetic rate at various growth stages (Table 3). Photosynthetic rate values ranged from vegetative to grain filling stage 17.5 to 12.2 μmol CO_2 m^{-2} s^{-1}. Maximum photosynthetic rate was recorded in genotype Telangana Sona at different growth stages (18.7, 21.3 and 13.0 μmol CO_2 m^{-2} s^{-1} at vegetative, flowering and grain filling stage respectively).

Photosynthetic rate ranged from vegetative to grain filling stage from 17.5 to 12.2 μmol CO_2 m^{-2} s^{-1}. Data indicate among the fertilizer nutrition levels, highest photosynthetic rate was recorded in treatment 25% higher than RDN + 0.5% $ZnSO_4$ foliar (N5) application at various growth stages (19.7, 22.5 and 13.6 μmol CO_2 m^{-2} s^{-1} at vegetative, flowering and grain filling stage respectively). Hassan *et al.* (2007) [9] suggested low levels of nitrogen can reduce photosynthetic rate as well as leaf chlorophyll content and photosynthetic efficiency. Fallah (2012) [10] studied the physiological characters of rice at various nitrogen treatments and observed net photosynthesis rate increased with increment of nitrogen.

Interaction effect showed significant variation in the photosynthetic rate at various crop growth stages. Treatment N5 and G3 recorded maximum at vegetative (21.3 μmol CO_2 m^{-2} s^{-1}), at flowering (23.1 μmol CO_2 m^{-2} s^{-1}) and grain filling stage (13.8 μmol CO_2 m^{-2} s^{-1}).

Number of panicles m^{-2}

Number of panicles is an important determinant of grain yield and is one of the criteria for assessing the grain yield in cereal crops. Data on number of panicles m^{-2} is presented in table 4.

Significant differences were observed between the genotypes for number of panicles m^{-2}. Data revealed that number of panicles m^{-2} ranged from 329 to 354. Highest number of panicles was recorded by genotype Telangana Sona (G_3) (354).

Table 2: Leaf area index (LAI) in rice as influenced by different nitrogen levels and zinc foliar spray

Treatment	Vegetative stage				Flowering stage				Grain filling stage			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
N_1	4.27	4.20	4.56	4.34	4.67	4.57	4.85	4.70	2.64	2.53	2.73	2.63
N_2	4.16	4.11	4.44	4.24	4.51	4.40	4.72	4.54	2.49	2.53	2.63	2.55
N_3	4.31	4.22	4.64	4.39	4.78	4.63	4.95	4.79	2.70	2.44	2.79	2.64
N_4	4.22	4.19	4.51	4.31	4.61	4.45	4.77	4.61	2.57	2.46	2.67	2.57
N_5	4.44	4.34	4.72	4.50	4.87	4.74	5.05	4.89	2.77	2.68	2.85	2.77
N_6	3.42	3.32	3.61	3.45	3.90	3.78	4.05	3.91	2.17	2.01	2.32	2.17
Mean	4.14	4.06	4.41	4.20	4.56	4.43	4.73	4.57	2.56	2.44	2.67	2.55
CD (5%) Genotype (G)	0.010				0.016				0.181			
CD (5%) Treatment(N)	0.023				0.017				0.022			
Main plots: Genotypes												
G_1	4.14				4.56				2.56			
G_2	4.06				4.43				2.44			
G_3	4.41				4.73				2.67			
Mean	4.20				4.57				2.55			
SEm±	0.003				0.005				0.073			
CD (5%)	0.010				0.016				0.181			
Subplots: Fertilizer treatments												
N_1	4.34				4.70				2.63			
N_2	4.24				4.54				2.55			
N_3	4.39				4.78				2.64			
N_4	4.31				4.61				2.57			
N_5	4.50				4.89				2.77			
N_6	3.45				3.91				2.17			
Mean	4.20				4.57				2.55			
SEm±	0.008				0.006				0.077			
CD (5%)	0.023				0.017				0.022			
Interaction												
Rice genotypes at same level of fertilizer treatments												
SEm±	0.014				0.010				0.013			
CD (5%)	0.041				0.035				NS			
Interaction												
Fertilizer treatments at same or different rice genotypes												
SEm±	0.013				0.011				0.014			
CD (5%)	0.039				0.034				NS			

Table 3: Photosynthetic rate (µmol CO_2 m^{-2} s^{-1}) in rice as influenced by different nitrogen levels and zinc foliar spray

Treatment	Vegetative stage				Flowering stage				Grain filling stage			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
N_1	18.1	17.1	19.2	18.1	21.4	19.6	22.4	21.1	12.7	12.6	13.2	12.8
N_2	17.4	16.4	17.8	17.2	20.5	18.7	21.1	20.1	12.2	11.7	12.6	12.2
N_3	18.6	18.0	20.7	19.1	22.3	20.8	23.0	22.0	13.1	13.0	13.5	13.2
N_4	17.8	16.7	18.5	17.7	20.8	19.6	21.4	20.6	12.5	11.9	12.9	12.5
N_5	19.1	18.6	21.3	19.7	22.8	21.7	23.1	22.5	13.6	13.4	13.8	13.6
N_6	14.2	13.5	14.7	14.1	15.4	16.0	16.8	16.1	11.1	10.3	11.9	11.1
Mean	17.5	16.7	18.7	17.5	20.5	19.4	21.3	20.4	12.5	12.2	13.0	12.6
CD (5%) Genotype (G)	0.20				0.22				0.11			
CD (5%) Treatment(N)	0.28				0.27				0.17			
Main plots: Genotypes												
G_1	17.5				20.5				12.5			
G_2	16.7				19.4				12.2			
G_3	18.7				21.3				13.0			
Mean	17.5				20.4				12.6			
SEm±	0.07				0.07				0.03			
CD (5%)	0.20				0.22				0.11			
Subplots: Fertilizer treatments												
N_1	18.1				21.1				12.8			
N_2	17.2				20.1				12.2			
N_3	19.1				22.0				13.2			
N_4	17.7				20.6				12.5			
N_5	19.7				22.5				13.6			
N_6	14.1				16.1				11.1			
Mean	17.5				20.4				12.6			
SEm±	0.09				0.09				0.06			

CD (5%)	0.28	0.27	0.17
Interaction			
Rice genotypes at same level of fertilizer treatments			
SEm±	0.19	0.19	0.08
CD (5%)	0.52	0.51	0.28
Interaction			
Fertilizer treatments at same or different rice genotypes			
SEm±	0.17	0.17	0.10
CD (5%)	0.54	0.53	0.30

Number of panicles m^{-2} was significantly different with the fertilizer treatments and ranged from 320 to 355. Fertilizer supplied with 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray (G_3) were produced highest panicles m^{-2} (355) whereas lowest number of panicles m^{-2} was produced (320) with application of fertilizer at 25% lower than RDN (N_2). Much of the panicle development is dependent upon the availability of photosynthates when there is competition with strong sinks like tillers, leaf and stem (Reddy 2004) [11]. Mahajan *et al.* (2011) [12] reported that panicle number per unit area and filled grains per panicle are important determinant of sink size. Direct seeded rice crop has better translocation of assimilates to panicle during anthesis and this can result in more number of fertile florets and higher kernel yield (Gosh *et al.*, 2013) [13].

Interaction of genotype and fertilizer application showed significant variation in the productive tillers. Treatment N_5 and G_3 recorded maximum number of panicles (369). Such interaction effects are common with application of higher doses of fertilizer application.

In this study, it was observed that significant interaction effect for panicles was found in genotypes at same level of fertilizer treatments. Genotype Telangana Sona (G_3) has recorded more number of panicles. Fertilizer treatments at same or different genotypes revealed maximum number of panicles with N_5.

Panicle length

Panicle length was found statistically significant among the genotypes (Table 4). Experimental results revealed that panicle length ranged from 21.2 to 24.5 cm. Highest panicle length was recorded by genotype Telangana Sona (G_3) (24.5 cm).

Panicle length was significantly different with the fertilizer treatments and ranged from 21.1 to 23.6 cm. Fertilizer supplied with 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray (N_5) were produced highest panicle length (23.6 cm) whereas lowest panicle length was produced (22.5 cm) with application of fertilizer at 25% lower than RDN (N_2).

Panicle length increased with higher levels of nitrogen. Improved growth parameters and translocation of more assimilates to the panicles might be the reason for the higher panicle length. Pramanik and Bera (2013) [14] observed increase in panicle length with increase in nitrogen levels and longer panicle length was attributed to nitrogen in panicle formation and panicle elongation.

Interaction between G×N was found to be statistically significant for panicle length at same level of fertilizer treatments as compared to fertilizer treatments at same or different rice genotypes. Treatment N_5 and G_3 was found to record highest panicle length (25.7 cm).

In this study, it was observed that significant interaction effect for panicle length was found in genotypes at same level of fertilizer treatments. Genotype Telangana Sona (G_3) has recorded more panicle length. Fertilizer treatments at same or different genotypes revealed maximum panicle length with N5.

Grains panicle^{-1}

Nutrient treatments exerted significant influence on total number of grains panicle^{-1} (Table 4). Grains per panicle varied from 130 to 356 with mean of 211. Experimental results revealed that, grains panicle^{-1} was recorded highest in the Telangana Sona (G_3) (356).

Data on grains per panicle were found statistically significant between the treatments. Mean values ranged from 195 to 217. Results suggest that treatment supplied with 25% higher than RDN + 0.5% $ZnSO_4$ (N_5) had recorded significantly more number of grains per panicle (217).

Table 4: Number of panicle m^{-2}, Panicle length and Grains panicle^{-1} in rice as influenced by different nitrogen levels and zinc foliar spray

Treatment		**Number of panicle m^{-2}**				**Panicle length**				**Grains panicle^{-1}**			
		G1	**G2**	**G3**	**Mean**	**G1**	**G2**	**G3**	**Mean**	**G1**	**G2**	**G3**	Mean
N1		349	332	357	346	22.9	21.5	24.9	23.0	151	134	358	213
N2		344	324	349	339	22.3	20.9	24.4	22.5	151	132	357	211
N3		356	336	365	352	22.8	21.6	25.3	23.2	153	135	361	215
N4		347	328	355	343	22.5	21.2	24.7	22.8	152	133	357	213
N5		358	339	369	355	23.2	22.1	25.7	23.6	154	135	362	217
N6		320	315	326	320	20.9	20.3	22.4	21.1	131	121	340	195
Mean		346	329	354	343	22.4	21.2	24.5	22.7	146	130	356	211
CD (5%)	Genotype (G)	2.11				1.28				1.83			
	Treatment (N)	1.34				0.98				0.71			
Main plots: Genotypes													
G1		346				22.4				146			
G2		329				21.2				130			
G3		354				24.5				356			
Mean		343				22.7				211			
SEm±		0.67				0.04				0.32			
CD (5%)		2.11				0.12				1.83			

Subplots: Fertilizer treatments			
N1	346	23.0	213
N2	339	22.5	211
N3	352	23.2	215
N4	343	22.8	213
N5	355	23.6	217
N6	320	21.1	195
Mean	343	22.7	211
SEm±	0.49	0.05	0.24
CD (5%)	1.34	0.16	0.71
Interaction			
Rice genotypes at same level of fertilizer treatments			
SEm±	1.65	0.11	0.76
CD (5%)	2.92	0.30	1.36
Interaction			
Fertilizer treatments at same or different rice genotypes			
SEm±	1.03	0.09	0.49
CD (5%)	2.50	0.27	1.23

Interaction effect was found to be statistically significant for grains per panicle at same level of fertilizer treatments as compared to fertilizer treatments at same or different rice genotypes. Treatment N_5 and G_3 was found to record highest grains per panicle (362).
In this study, it was observed that significant interaction effect for grains per panicle was found in genotypes at same level of fertilizer treatments. Genotype Telangana Sona (G_3) has recorded more grains per panicle. Fertilizer treatments at same or different genotypes revealed maximum grains per panicle with N_5.

Grain yield (kg ha^{-1})
Data on grain yield (kg ha^{-1}) is presented in table 5. In the present investigation genotype Telangana Sona (G_3) has recorded maximum grain yield of 4959 kg ha^{-1} while lowest grain yield was recorded by Tella Hamsa (G_2).
Data on grain yield indicates that with increase in nitrogen application there was significant increase in grain yield has been observed. Yield ranged from 3178 to 4969 kg ha^{-1} with mean of 4661 kg ha^{-1}. Treatment supplied with 25% higher than RDN + 0.5% $ZnSO_4$ (N_5) recorded highest yield 4969 kg ha^{-1}.
Fertilizer application has significantly affected on grain yield among the treatments studied. Results revealed that values ranged from 3178 to 4969 kg ha^{-1} with mean of 4661 kg ha^{-1} and maximum grain yield (4969 kg ha^{-1}) was observed in 25% higher than RDN + 0.5% $ZnSO_4$ treatment (N_5), while 25% lesser than RDN (N_2) had resulted in lowest grain yield (4873 kg ha^{-1}). Yield is the cumulative effect of all the yield attributing characters. Maximum yield here can be attributed to maximum SCMR values, more photosynthetic rate, maximum number of tillers and panicles^{-1}, more number of grains hill^{-1}, higher filled grain percentage and lower spikelet sterility (Mahajan *et al*., 2011) [12]. The adequate quantity of nitrogen helped rice plants to promote the yield attributing characters *viz.*, number of tillers, number of filled grains, filled grain percentage and test weight which enhanced grain yield (Malla Reddy *et al*., 2012) [15].
Interaction effect between nitrogen levels and rice genotypes was highly significant for grain yield. Among the genotypes Telangana Sona (G_3) and treatment supplied with 25% higher than RDN + 0.5% $ZnSO_4$ (N5) recorded highest grain yield (5345 kg ha^{-1}) same level of fertilizer treatments compared to fertilizer treatments at same or different rice genotypes.

Table 5: Grain yield (kg ha^{-1}) in rice as influenced by different nitrogen levels and zinc foliar spray

Treatment		*Rabi*			
		G1	**G2**	**G3**	**Mean**
N1		5160	4245	5283	4896
N2		5146	4228	5246	4873
N3		5178	4344	5336	4953
N4		5163	4253	5281	4899
N5		5200	4362	5345	4969
N6		3244	3027	3264	3178
Mean		4848	4076	4959	4661
CD (5%)	Genotype (G)	12.55			
	Treatment (N)	6.68			
Main plots: Genotypes					
G1		4848			
G2		4176			
G3		4959			
Mean		4661			
SEm±		4.10			
CD (5%)		12.55			
Subplots: Fertilizer treatments					
N1		4896			
N2		4873			
N3		4953			
N4		4899			
N5		4969			
N6		3178			
Mean		4661			
SEm±		2.99			
CD (5%)		6.68			
Interaction					
Rice genotypes at same level of fertilizer treatments					
SEm±		10.06			
CD (5%)		17.56			
Interaction					
Fertilizer treatments at same or different rice genotypes					
SEm±		6.26			
CD (5%)		17.22			

It was observed that significant interaction effect for grain yield was found in genotypes at same level of fertilizer treatments. Genotype Telangana Sona (G_3) has recorded more grain yield. Fertilizer treatments at same or different genotypes revealed maximum grain yield with N5.

Conclusion
It can be concluded that increased doses of nitrogen and zinc

foliar spray had positive impact on morphological, physiological, and yield and yield attributing parameters. Telangana Sona had recorded high LAI, Photosynthetic rate, Number of panicle m^{-2}, Panicle length, Grains $panicle^{-1}$ and Grain yield. Among the treatments fertilization of application of 25% higher than RDN + 0.5% $ZnSO_4$ recorded high LAI, Photosynthetic rate, Number of panicle m^{-2}, Panicle length, Grains $panicle^{-1}$ and Grain yield.

References

1. CMIE (Centre for Monitoring Indian Economy). Data bases and information products about India's economy; c2019. Apple heritage, Mumbai. Available from: http://www.CMIE.com
2. Fageria NK, Baligar VC. Enhancing nitrogen use efficiency in crop plants. Advances in Agronomy. 2005;88:97-185.
3. Manzoor Z, Awan TH, Safdar ME, Ali RI, Ashraf MM, Ahmad M, *et al*. Effect of nitrogen levels on yield and yield components of basmati. J of Agricultural Research. 2006;44:115-20.
4. Peng SB, Buresh RJ, Huang JL, Yang JC, Zou YB, Zhong XH, *et al*. Strategies for overcoming low agronomic nitrogen use efficiency in irrigated rice systems in China. Field Crops Research. 2006;96:37-47.
5. Zhang WJ, Li GH, Yang YM, Li Q, Zhang J, Liu JY, *et al*. Effects of nitrogen application rate and ratio on lodging resistance of super rice with different genotypes. Journal of Integrative Agriculture. 2014;13(1):63-72.
6. Jiang W, Struik PC, Van Keulen H, Zhao M, Jin LN, Stomph TJ, *et al*. Does increased zinc uptake enhance grain zinc mass concentration in rice? Annals of Applied Biology. 2008;153(1):135-147.
7. Venugopal R. Performance of rice varieties at different nitrogen levels in dry seeded irrigated condition. M.Sc. (Ag.) Thesis. Acharya N G Ranga Agricultural University, Hyderabad, India; c2005.
8. Wang Z, Zhang W, Beebout SS, Zhang H, Liu L, Yang J, *et al*. Grain yield, water and nitrogen use efficiencies of rice as influenced by irrigation regimes and their interaction with nitrogen rates. Field Crops Research. 2016;193:54-69.
9. Hassan MS, Khair A, Haque MM, Hamid A. Photosynthetic characters, SPAD value and nitrogen use efficiency of traditional AUS rice (*Oryza sativa* L.) cultivars. SAARC Journal of Agriculture. 2007;5(2):29-40.
10. Fallah A. Study of silicon and nitrogen effects on some physiological characters of rice. International Journal of Agriculture and Crop Sciences. 2012;4(5):238-241.
11. Reddy SR. Agronomy of Field Crops. Kalyani Publishers. New Delhi; c2004.
12. Mahajan G, Chauhan BS, Gill MS. Optimal nitrogen fertilization timing and rate in dry-seeded rice in northwest India. Agronomy Journal. 2011;103(6):1676-1682.
13. Gosh M, Swain DK, Jha MK, Tewari VK. Precision nitrogen management using chlorophyll meter for improving growth, productivity and nitrogen use efficiency of rice in subtropical climate. Journal of Agricultural Science. 2013;5(2):253-266.
14. Pramanik K, Bera AK. Effect of Seedling Age and Nitrogen Fertilizer on Growth, Chlorophyll Content, Yield and Economics of Hybrid Rice (*Oryza sativa* L.) International Journal of Agronomy and Plant Production. 2013;4:3489-3499.
15. Malla Reddy M, Padmaja B, Veeranna G, Reddy V. Evaluation of popular kharif rice (*Oryza sativa* L.) varieties under aerobic condition and their response to nitrogen dose. Journal of Research, ANGRAU. 2012;40(4):14-19.