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Influence of Nitrogen Levels and Zinc Application on Morphological and Physiological Attributes of Rice Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during Kharif and Rabi, 2018 at the 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, and six nutrient levels as sub plots and replicated thrice. Among the varieties Kunaram Sannalu has recorded lowest Plant height and Telangana Sona has recorded

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highest Plant height (63.3, 98.8 and 103.3 cm at vegetative, flowering and grain filling stages respectively), with maximum stem thickness 5.37, 6.09 and 6.17 mm at vegetative, flowering and grain filling stage respectively), Crop growth rate (13.451 25.77 and 8.86 g m^{-2} day^{-1} at vegetative, flowering and grain filling stage respectively), Total dry matter (2959, 7585 and 8909 kg ha^{-1} at vegetative, flowering and grain filling stages respectively) and had taken more number of days to panicle initiation (67), flowering (86) and maturity (122). Tella Hamsa has recorded less stem thickness, Crop growth rate, total dry matter and has taken less number of days to panicle initiation (64), flowering (83) and maturity (118). Application of 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray resulted in maximum plant height, stem thickness, crop growth rate, and total dry matter.

Keywords: Plant height; stem thickness; crop growth rate; panicle initiation.

1. INTRODUCTION

"Rice is one of the most important cereal crops in the world which feeds half of the world's population providing 35-60% of the total calories" [1]. "During the past few decades, rice production increased mostly due to the adoption of high-yielding varieties, an increase in irrigated areas and the use of chemical fertilizers. However, the rate of increase in rice yield is static and if the rate is not possible to increase, severe food shortage is likely to occur shortly. To push up the yield ceiling, sustainable technologies are essential, which are economically viable and environmentally friendly. Cost minimization by saving resources and the development of low-cost technologies must be considered in rice production. Among the crop management practices, judicious application of nitrogenous fertilizer is paramount for yield enhancement of rice" [1].

"Among the major nutrient elements, nitrogen (N) is the most limiting nutrient for rice crop growth and yield which is required in higher amounts compared to other nutrients" [2]. "N influences rice yield by playing a major role in photosynthesis, biomass accumulation, effective tillering, and spikelet formation" [3]. "Therefore, N fertilization is imperative for modern rice varieties to exploit their full yield potential" [4]. "High-yielding modern rice varieties show a greater response to applied nitrogen, while they differ in N demand depending on their genotype and agronomic traits under different climatic conditions" [5]. "On the other hand, excessive N application can lead to groundwater pollution, increased production cost, reduced yield and environmental pollution" [2].

"Therefore, it is essential to achieve efficient use of nitrogen in chemical fertilizers, through cultivation techniques and fertilizer management with high nitrogen use efficiency and reducing nitrogen inputs from farming to the environment. Evaluating the reaction of rice to diverse doses of nitrogen will aid in the development of high-nitrogen use efficiency varieties, and the screening of appropriate genotypes for all cultivated conditions. Nitrogen use efficiency is complex because rice yield was influenced by inherent factors such as the number of productive culms, grains per panicle and 1000 grain weight, in addition to plant management conditions. However, measuring genotypic differences in dry matter production and nitrogen use efficiency at the vegetative growth stage eliminates those additional variables affecting yield. Understanding the mechanisms regulating the processes of nitrogen uptake, assimilation, utilization efficiency and remobilization is crucial for the improvement of nitrogen use efficiency in crop plants. One important approach is to develop an understanding of the plant response to different nitrogen regimes and study plants that show better growth under nitrogen-limiting conditions. Studies on the impacts of elevated nitrogen on growth dynamics, biomass partitioning, chaffy grain and nitrogen use efficiency are limited" [2].

"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" [6]. "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 increase substantially with an increase in the rate of nitrogen application" [7]. Hence the present study was conducted to evaluate the effect of different levels of nitrogen and zinc application on morphological and physiological parameters in paddy.

2. MATERIALS AND METHODS

A field experiment was conducted on sandy clay soil at the college farm, College of Agriculture, Rajendranagar, Hyderabad during Kharif and Rabi, 2018. The farm is geographically situated at $78^0$23' E longitude and $17^0$19' N latitude and at an altitude of 542.6 m above mean sea level. It falls under Southern Telangana agro climatic zone of Telangana state. The climate of Hyderabad was classified as dry tropical and semi-arid. 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 subplots.

"The varieties were sown separately in a raised bed nursery and 25-day-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 within a row. Nitrogen was applied as per treatment in the form of urea in 3 splits basal, maximum tillering and flowering stage. 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. Similarly, 0.5% $ZnSO_4$ foliar spray was applied 3 times at the 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 from time to time" [8].

For analysis of physiological characters, in each plot, five plants were tagged and observations were recorded at vegetative, flowering and grain-filling stages. Plant height, stem thickness, crop growth rate, and total dry matter at vegetative, flowering and grain-filling stages were recorded. The number of days taken in each genotype in each plot was noted in days to panicle initiation. Number of days taken for 50% of plants to flower in each genotype in each plot was noted in days to 50% flowering. In rice, as physiological maturity approaches the erect flag leaves start desiccating. The number of days taken from sowing to physiological maturity was recorded in each plot and each replication was recorded and reported as days to maturity in different treatments.

The plant height was expressed in centimetres (cm) and measured from the base of the plant to the tip of the terminal leaf or panicle on the main stem. It was measured during the maximum vegetative, flowering and harvest stages. Stem thickness was expressed in centimetres (cm) and measured at the base of the mother stem using digital callipers. It was measured during the maximum vegetative, flowering and maturity stages. The crop growth rate is the rate of dry matter production per unit of land area per unit of time. It was measured during the maximum vegetative, flowering and maturity stages. It was calculated by using this formula, CGR = W_2-W_1/ T_2-T_1 and it is expressed as g m^{-2} day^{-1}. Five plants were cut at ground level from each plot of three replications to determine the dry matter accumulation at vegetative, flowering and harvest stages. The plants were then oven-dried at 60 °C for 3 days until constant weight was attained and expressed in kg ha^{-1}. 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.

Five plants were cut at ground level from each plot of three replications for determining the dry matter accumulation at vegetative, flowering and harvest stage. The plants were then oven dried at 60 °C for 3 days until constant weight was attained and dry matter accumulation was computed based on 5 plants dry matter yield multiplied by total plants per hectare and expressed in kg ha^{-1}. 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.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Significant differences were observed between the genotypes in plant height at different stages of crop growth significantly influenced by nitrogen and zinc foliar spray (Table 1). Plant height recorded was 59.6 to 63.3 cm at vegetative, 91.4 to 98.8 cm at reproductive and 93.9 to 103.3 cm at harvest. Among the three genotypes studied highest plant height was recorded in Telangana Sona (G3). Plant height significantly varied at different growth stages with the application of fertilizer. The mean values of height observed at the three growth stages were 61.7, 95.7 and 99.8 cm. At 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray (N5) application resulted in maximum growth at the vegetative phase of the rice crop (64.8 cm) and at the reproductive phase (98.0 cm) and harvest stage (102.3 cm). Swaroopa and Lakshmi [9] conducted an experiment with four treatments of nitrogen and the results revealed that application of 150% RDN recorded maximum plant height, while shorter plants were observed at 75% RDN. The superior performance of treatments might be due to quick and better utilization of zinc through foliar feeding at different growth stages of rice which in turn increased the nutrient content and total uptake [10].

Significant interaction was observed between genotype and fertilizer for plant height at various crop growth stages. Treatment N5 and G3 recorded maximum growth at vegetative (66.3 cm), flowering (101.5 cm) and harvest stage (105.7 cm). Genotype Telangana Sona (G3) has obtained taller plants at all three stages of crop growth. While Kunaram Sannalu (G2) was recorded lowest height at all stages of crop growth. It can be concluded from the above experimental results that plant height was maximum in Telangana Sona (G3) and treatment 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray (N5) Genotypes were more responsive to fertilizer treatments as indicated by higher plant height.

3.2 Stem Thickness

Pooled data indicate that there was an increase in the stem thickness from the maximum vegetative stage (4.72 mm) to the harvest stage (6.02 mm) (Table 2). At vegetative stage, stem thickness ranged from 4.36 to 5.03 mm, at the flowering stage from 5.60 to 6.09 mm and at harvest stage 5.77 to 6.17 mm. Telangana Sona (G3) was found maximum stem thickness at different crop growth stages (5.03, 6.09 and 6.17 mm at vegetative, flowering and harvest stages respectively).

Stem thickness varied significantly due to the application of different doses of fertilizer treatments and ranged from maximum vegetative stage 4.12 to 4.96 mm, at flowering stage 4.50 to 6.30 mm and at harvest stage 4.64 to 6.42 mm. Application of fertilizer at 25% higher than RDN + 0.5 % $ZnSO_4$ foliar spray recorded maximum thickness at different crop growth stages (4.96, 6.30 and 6.42 mm at vegetative, flowering and harvest stages respectively). Wujun et al. [11] found that stem diameter in rice increased rapidly with increased nitrogen application. The interaction of genotype and fertilizer application showed significant variation in the stem thickness at various crop growth stages. Treatment N5 and G3 recorded maximum growth at vegetative stage (5.22 mm), flowering stage (6.41 mm) and maturity stage (6.46 mm). Such interaction effects are common with application of varied doses of fertilizer application. Genotype Telangana Sona (G3) has recorded significantly higher thickness at all three stages of crop growth. Fertilizer treatments at same or different genotypes revealed maximum thickness with N5 at vegetative, reproductive and maturity stages.

3.3 Crop Growth Rate (CGR)

Pooled results on crop growth rate were significantly affected by genotypes at various nitrogen levels (Table 3). Pooled results on crop growth rate among the genotypes noted a mean to range from vegetative to grain filling was 12.69 to 8.69 g m^{-2} day^{-1}. Among the genotypes, Telangana Sona recorded maximum CGR at different growth stages (13.45, 25.77 and 9.86 g m^{-2} day^{-1} at vegetative, flowering and grain filling respectively). Mean values among the various treatments ranged from vegetative to grain filling was 12.69 to 8.69. Application of 25% higher than RDN + 0.5% $ZnSO_4$ foliar spray was found to be highest CGR at different growth stages (13.87, 26.12 and 9.70 g m^{-2} day^{-1} at vegetative, flowering and grain filling respectively).

The interaction of genotype and fertilizer application showed significant variation in the CGR at various crop growth stages. Treatment N5 and G3 recorded maximum CGR at vegetative (14.86 g m^{-2} day^{-1}), at flowering (28.24 g m^{-2} day^{-1}) and at grain filling stage (11.12 g m^{-2} day^{-1}). Such interaction effects are common with the application of higher doses of fertilizer application. Genotype Telangana Sona (G3) at vegetative, flowering and grain filling recorded the highest CGR, while Tella Hamsa (G1) was observed lowest. Mannan et al. [12] found in rice that the supply of available nitrogen progressively increased the crop growth rate. These findings conformed with the results obtained by Roy et al. [13].

Table 1. Plant height (cm) in rice as influenced by different nitrogen levels and zinc foliar spray during *kharif* and *rabi*, 2018

	Plant height Pooled (Kharif and Rabi)											
	Vegetative stage				Flowering stage				Harvest stage			
Treatment	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
N_1	60.8	62.9	64.0	62.6	91.9	97.0	99.3	96.1	94.7	103.0	104.2	100.6
N_2	58.0	61.6	62.7	60.8	90.0	95.8	97.3	94.4	93.9	101.2	102.5	99.2
N_3	62.6	64.3	65.4	64.1	93.3	98.1	100.6	97.3	95.7	104.0	105.1	101.6
N_4	58.8	62.4	63.8	61.6	91.5	97.1	98.2	95.6	94.4	102.7	103.5	100.2
N_5	63.4	64.8	66.3	64.8	93.8	98.7	101.5	98.0	96.5	104.6	105.7	102.3
N_6	54.2	56.0	57.7	56.0	87.8	94.2	95.8	92.6	88.8	98.0	99.7	95.5
Mean	59.6	62.0	63.3	61.7	91.4	96.8	98.8	95.7	93.9	102.1	103.3	99.8
CD Genotype(G)	0.30				0.91				0.12			
(5%) Treatment(N)	0.34				0.38				0.33			
Main plots : Genotypes												
G_1	59.6				91.4				93.9			
G_2	62.0				96.8				102.1			
G_3	63.3				98.8				103.3			
Mean	61.7				95.7				99.8			
SEm±	0.10				0.30				0.04			
CD (5 %)	0.30				0.91				0.12			
Subplots : Fertilizer treatments												
N_1	62.6				96.1				100.6			
N_2	60.8				94.4				99.2			
N_3	64.1				97.3				101.6			
N_4	61.6				95.6				100.2			
N_5	64.8				98.0				102.2			
N_6	56.0				92.6				95.5			
Mean	61.7				95.7				99.8			
SEm±	0.10				0.13				0.11			
CD (5%)	0.34				0.38				0.33			
Interaction												
Rice genotypes at same level of fertilizer treatments												
SEm±	0.24				0.25				0.11			
CD (5%)	0.58				0.74				0.29			
Interaction												
Fertilizer treatments at same or different rice genotypes												
SEm±	0.19				0.37				0.18			
CD (5%)	0.57				1.11				0.54			

Table 2. Stem thickness (mm) in rice as influenced by different nitrogen levels and zinc foliar spray during *kharif* and *rabi* 2018

		Stem thickness Pooled (Kharif and Rabi)											
Treatment		**Vegetative stage**				**Flowering stage**				**Maturity stage**			
		G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
N_1		4.90	4.43	5.17	4.83	6.26	5.83	6.36	6.15	6.40	6.00	6.46	6.29
N_2		4.77	4.37	5.05	4.73	6.15	5.71	6.28	6.05	6.33	5.86	6.37	6.20
N_3		4.98	4.49	5.24	4.90	6.34	5.91	6.41	6.22	6.48	6.09	6.48	6.35
N_4		4.83	4.40	5.11	4.78	6.20	5.77	6.34	6.10	6.38	5.93	6.42	6.24
N_5		5.02	4.54	5.31	4.96	6.41	6.00	6.48	6.30	6.55	6.17	6.53	6.42
N_6		4.12	3.94	4.31	4.12	4.51	4.35	4.66	4.50	4.59	4.59	4.73	4.64
Mean		4.77	4.36	5.03	4.72	5.98	5.60	6.09	5.89	6.12	5.77	6.17	6.02
CD	Genotype(G)	0.020				0.008				0.009			
(5%)	Treatment(N)	0.015				0.014				0.013			
Main plots : Genotypes													
G_1		4.77				5.98				6.12			
G_2		4.33				5.60				5.77			
G_3		5.03				6.09				6.17			
Mean		4.72				5.89				6.02			
SEm$\pm$		0.007				0.003				0.003			
CD (5 %)		0.020				0.008				0.009			
Subplots : Fertilizer treatments													
N_1		4.83				6.15				6.29			
N_2		4.73				6.05				6.20			
N_3		4.90				6.22				6.35			
N_4		4.78				6.10				6.24			
N_5		4.96				6.30				6.42			
N_6		4.12				4.50				4.64			
Mean		4.72				5.89				6.02			
SEm$\pm$		0.005				0.004				0.004			
CD (5%)		0.015				0.014				0.013			
Interaction													
Rice genotypes at same level of fertilizer treatments													
SEm$\pm$		0.009				0.008				0.007			
CD (5%)		0.026				0.024				0.022			
Interaction													
Fertilizer treatments at same or different rice genotypes													
SEm$\pm$		0.010				0.008				0.007			
CD (5%)		0.028				0.026				0.023			

Table 3. Crop growth rate (g m^{-2} day^{-1}) in rice as influenced by different nitrogen levels and zinc foliar spray during *kharif* and *rabi* 2018

		Crop growth rate Pooled (Kharif and Rabi)											
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		13.35	11.85	14.05	13.35	24.84	22.39	26.60	24.61	9.26	7.76	10.28	9.10
N_2		12.36	11.31	13.23	12.30	23.49	21.13	24.73	23.12	8.22	7.16	9.47	8.28
N_3		14.07	12.25	14.67	13.66	25.93	22.86	27.57	25.45	9.53	7.94	11.00	9.49
N_4		12.67	11.51	13.38	12.52	24.09	21.6	25.32	23.67	8.33	7.40	9.63	8.45
N_5		14.33	12.43	14.86	13.87	26.71	23.42	28.24	26.12	9.60	8.37	11.12	9.70
N_6		10.27	9.80	11.19	10.42	20.79	19.65	22.15	14.86	7.04	6.61	7.67	7.11
Mean		12.84	11.78	13.45	12.69	24.30	21.84	25.77	22.97	8.66	7.54	9.86	8.69
CD	Genotype(G)	0.031				0.145				0.071			
(5%)	Treatment(N)	0.067				0.188				0.092			
Main plots : Genotypes													
G_1		12.84				24.30				8.66			
G_2		11.78				21.84				7.54			
G_3		13.45				25.77				8.86			
Mean		12.69				22.97				8.69			
SEm$\pm$		0.011				0.049				0.024			
CD (5 %)		0.031				0.145				0.071			
Subplots : Fertilizer treatments													
N_1		13.35				24.61				9.10			
N_2		12.30				23.12				8.28			
N_3		13.65				25.45				9.49			
N_4		12.52				23.67				8.45			
N_5		13.87				26.12				9.70			
N_6		10.42				20.86				7.11			
Mean		12.69				23.96				8.69			
SEm$\pm$		0.023				0.065				0.031			
CD (5%)		0.067				0.188				0.092			
Interaction													
Rice genotypes at same level of fertilizer treatments													
SEm$\pm$		0.040				0.113				0.055			
CD (5%)		0.117				0.326				0.159			
Interaction													
Fertilizer treatments at same or different rice genotypes													
SEm$\pm$		0.038				0.114				0.056			
CD (5%)		0.116				0.313				0.143			

Table 4. Total dry matter (Kg ha^{-1}) in rice as influenced by different nitrogen levels and zinc foliar spray *kharif* and *rabi* 2018

Treatment		Total dry matter Pooled (Kharif and Rabi)											
		Vegetative stage				Flowering stage				Harvest stage			
		G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
N_1		2750	2452	2948	2717	7254	6741	7718	7237	8920	8437	9219	8859
N_2		2418	2153	2617	2396	6774	6360	7138	6757	8304	8121	8520	8315
N_3		3081	2833	3379	3098	7568	6972	8050	7530	9153	8770	9419	9114
N_4		2650	2302	2965	2639	7088	6758	7535	7127	8737	8321	8953	8670
N_5		3428	3097	3611	3379	7817	7270	8628	7905	9353	9136	9769	9419
N_6		2054	1921	2236	2070	6144	5929	6443	6172	7156	6640	7572	7123
Mean		2730	2460	2959	2716	7108	6672	7585	7122	8604	8238	8909	8583
CD	Genotype(G)	64.11				74.45				76.10			
(5%)	Treatment(N)	51.75				83.28				86.89			
Main plots : Genotypes													
G_1		2730				7108				8604			
G_2		2460				6672				8238			
G_3		2959				7585				8909			
Mean		2716				7122				8583			
SEm$\pm$		22.05				25.17				26.64			
CD (5 %)		64.11				74.45				76.10			
Subplots : Fertilizer treatments													
N_1		2716				7237				8859			
N_2		2396				6757				8315			
N_3		3098				7530				9114			
N_4		2639				7127				8670			
N_5		3379				7905				9419			
N_6		2070				6172				7123			
Mean		2716				7122				8583			
SEm$\pm$		17.83				28.69				29.94			
CD (5%)		51.75				83.28				86.89			
Interaction													
Rice genotypes at same level of fertilizer treatments													
SEm$\pm$		29.42				39.20				40.71			
CD (5%)		84.58				113.66				114.15			
Interaction													
Fertilizer treatments at same or different rice genotypes													
SEm$\pm$		31.50				41.41				43.71			
CD (5%)		92.50				118.04				119.89			

Table 5. Days to panicle initiation, 50 % anthesis and maturity of rice as influenced by different nitrogen levels and zinc foliar spray during *kharif* and *rabi* 2018

Treatment		Panicle initiation Pooled				50 % Anthesis Pooled				Days to maturity Pooled			
		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	86	85	122	118	123	121
N_2		65	63	66	65	85	82	85	84	121	117	122	119
N_3		69	66	70	68	88	84	89	87	123	119	125	122
N_4		65	63	66	65	85	82	85	84	121	117	122	119
N_5		68	65	70	68	88	84	89	87	123	119	125	122
N_6		64	61	64	63	82	80	84	82	119	113	120	117
Mean		66	64	67	66	85	83	86	85	121	118	122	120
CD	Genotype (G)	0.21				0.28				0.35			
(5%)	Treatment(N)	0.50				0.45				0.45			
Main plots : Genotypes													
G_1		66				85				121			
G_2		64				83				118			
G_3		67				86				122			
Mean		66				85				120			
SEm$\pm$		0.07				0.10				0.14			
CD (5 %)		0.21				0.28				0.35			
Subplots : Fertilizer treatments													
N_1		66				85				121			
N_2		65				84				119			
N_3		68				87				122			
N_4		65				84				119			
N_5		68				87				122			
N_6		63				82				117			
Mean		66				85				120			
SEm$\pm$		0.17				0.15				0.15			
CD (5%)		0.50				0.45				0.45			
Interaction													
Rice genotypes at same level of fertilizer treatments													
SEm$\pm$		0.36				0.27				0.30			
CD (5%)		NS				NS				NS			
Interaction													
Fertilizer treatments at same or different rice genotypes													
SEm$\pm$		0.38				0.27				0.28			
CD (5%)		NS				NS				NS			

3.4 Total Dry Matter

The dry matter accumulation increased progressively in all the genotypes with the advancement of crop age (Table 4). Significant differences were observed between the genotypes in dry matter at all the stages of crop growth. Mean ranged from 2730 to 2959 kg ha-1 at vegetative stage, 7108 to 7585 kg ha-1 at flowering stage and 8604 to 8909 kg ha-1 at harvest stage. Maximum dry matter was observed in Telangana Sona (G3) at different crop growth stages (2959, 7585 and 8909 kg ha-1 at vegetative, flowering and harvest stage respectively).

A significant increase in dry matter was recorded due to nitrogen application and dry matter was significantly different with varied doses of fertilizer treatments. At maximum vegetative stage ranged from 2070 to 3379 kg ha-1, at flowering stage from 6172 to 7905 kg ha-1 and at harvest stage from 7123 to 9419 kg ha-1. Application of fertilizer treatment N5 recorded the highest dry matter at different crop growth stages (3379, 7905 and 9419 kg ha-1 at vegetative, flowering and harvest stages respectively). The increase in plant height and tiller number would have contributed to higher dry matter accumulation which is the outcome of photosynthetic activity of the plant and its capacity to utilize available nutrients. Several research workers also observed a significant increase in dry matter accumulation with foliar application of ZnSO4 [14,15].

Genotype x fertilizer application showed significant interaction for dry matter production. Treatment N5 and G3 recorded the highest in dry matter at 3611 kg ha-1 at vegetative, 8621 kg ha-1 at flowering and 9769 kg ha-1 at the harvest stage. Such interaction effects are common with the application of higher doses of fertilizer application. Genotype Telangana Sona (G3) and N5 have recorded the highest dry matter.

3.5 Days to Panicle Initiation, 50 % Anthesis and Maturity

Pooled data on days to PI, 50% anthesis and maturity as influenced by nitrogen supply in rice genotypes is presented in Table 5. Results from the pooled data revealed that number of days taken ranged from 64 to 67 days for panicle initiation, 83 to 86 days for 50% anthesis and 118 to 122 days for maturity. Tella Hamsa (G2) was taken less number of days for panicle initiation (64 days), 50% anthesis (83 days) and days to maturity (118 days), while more days to panicle initiation (67 days), 50% anthesis (86 days) and days to maturity (122 days) was taken by the genotype Telangana Sona (G3).

Panicle initiation, 50% anthesis and days to maturity recorded were significantly different with the fertilizer treatments and ranged from 63-68 days for panicle initiation, 83 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% ZnSO4 foliar spray (N) were at par and took more days to panicle initiation (68 days), 50% anthesis (87 days) and maturity (123 days). Variation in phenological characters depends on genotypic constituents, micro and macro environments [16]. The interaction effect of genotypes and fertilizer levels for days to PI, 50% anthesis and maturity was found to be non-significant.

4. CONCLUSIONS AND RECOMMENDATIONS

It can be concluded that increased doses of nitrogen and zinc foliar spray had positive impact on morphological and physiological attributing parameters. Telangana Sona had recorded highest plant height, Maximum stem thickness, Crop growth rate, Total dry matter. Among the treatments fertilization of application of 25% higher than RDN + 0.5% $ZnSO_4$ recorded highest plant height, Maximum stem thickness, Crop growth rate and Total dry matter. From these results, it can be suggested that morphological and physiological characters can improved by supplemented with zinc foliar spray along with fertilizer application.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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