

Original Research Article

<https://doi.org/10.20546/ijcmas.2017.607.285>

Effect of Different levels of Nitrogen on Growth and Yield of Rice (*Oryza sativa* L.) Cultivars under Terai-agro Climatic Situation

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ABSTRACT

An investigation was carried out during *kharif* seasons of 2008 in rice crop with the different levels of nitrogen and various cultivars to find out best rice cultivars and optimum dose of nitrogen under terai region of West Bengal. The experiment was laid out in a factorial Randomized Block Design (RBD) with five cultivars namely, V₁= MTU-7029, V₂= ANNADA, V₃= KHANDAGIRI, V₄= SATABDI and V₅= GS-3 and three levels of nitrogen: 30, 60 and 90 kg /ha. The treatments were replicated thrice. Among the cultivars V₄ (Satabdi) produced tallest plant (24.46, 63.51, 77.50 and 86.49 cm at 20 DAT, 40 DAT, 60 DAT and at harvest respectively) at all the stages of taking observation. Among the cultivars V₁ (MTU-7029) recorded highest number (247.28, 279.84, 212.08 and 205.33 at 20 DAT, 40 DAT, 60 DAT and at harvest respectively). Among the levels of nitrogen N₃ (90 kg N/ha) produced maximum number of tillers (255.20, 280.06, 244.64 and 214.10 at 20 DAT, 40 DAT, 60 DAT and at harvest respectively). Among the cultivars V₁ (MTU-7029) produced longest panicle (22.36) which was statistically at par with Khandagiri (22.13) and Annada (21.88). 1000 grain weight was higher (28.32) in V₁ (MTU-7029) which was statistically at par with V₂ (Annada) and V₃ (Khandagiri). Among the cultivars, maximum grain yield (3.56) was produced by V₁ (MTU-7029) followed by Khandagiri (3.45) Annada (3.38) and GS-3 (3.11). Cultivars MTU-7029 produced higher (4.72) straw yield which was statistically at par with Khandagiri (4.58) and Annada (4.56). Cultivars MTU-7029 registered highest values (42.67) of harvest index which was followed by Khandagiri (42.00) and Annada (41.33).

Keywords

Rice variety,
Nitrogen,
Terai zone.

Article Info

Accepted:

23 June 2017

Available Online:

10 July 2017

Introduction

Rice (*Oryza sativa*), one of the most important food grain crops in the world, forms the staple diet of 2.7 billion people. It occupies 150 million hectare and producing 537 million tones with the average productivity of 3.83 tones/ha. Its cultivation is of immense important to food security of

Asia, where more than 90% of the global rice is produced and consumed. India is the largest rice growing country, while china is the largest producer of rice. In India more than 40% food grains production comes from rice which provides direct employment to about 70% of working rural people in the country. It

forms the basis of many premier industries of India, including the textile, jute, and sugar industries. Agriculture contributes to about 31% GDP and 25% of India's exports comes from agricultural products. Being the staple food for more than 65% of the people, our national food security hangs on the growth and stability of its production. India has the largest acreage under rice about 44.6 million hectares of land under four major ecosystem viz. irrigated, rainfed lowland, rainfed upland and flood prone which occupies 21,14, 6 and 3 million hectare respectively, with a production of about 90 million tones.

Rice (*Oryza sativa* L.) production constitutes the major economic activity and a key source of employment for the rural population of India. India has the largest acreage under rice about 44.6 million hectares of land with a production of about 90 million tones. The total cultivated area under rice in West Bengal was 5856.8 thousand hectare during 2003-2004. In Cooch Behar district total area used for rice cultivation was 276.2 thousand hectare and the production was 515.4 thousand tones having the productivity of 1865 kg per hectare during 2003-2004. Among the crop production tools, proper time, method of sowing and nutrient management is the prerequisites that allow the crop to complete its life phase timely and successfully under specific agro- ecology.

Raza *et al.*, (2003) claimed that number of grains per panicle and panicle length were significantly higher in N applied in two splits i.e. 1/2at tillering and 1/2 at panicle initiation. Biloni and Bocchi (2003) observed that plant height and paddy yield were significantly affected by nitrogen application in splits and N applied at pre-sowing and tillering stage performed better.

The rice crop produced maximum grain yield in response to nitrogen application in three splits. Sahoo *et al.*, (1998) concluded that

number of productive tillers per hill were maximum where nitrogen was applied in three splits

Wang-Dan Ying *et al.*, (2008) reported that rice yield was significantly increased by N. Most of the cultivars reached the highest yields when N was applied at 150-225 kg/ha. As the N rate increased up to 225 kg/ha, 1000-grain weight and seed set rate decreased, whereas the number of grains per panicle and number of effective panicles increased.

Materials and Methods

The field experiment was carried out during *kharif* seasons of 2008 in rice crop with the different levels of nitrogen and various cultivars to find out best rice cultivars and optimum dose of nitrogen under terai region of West Bengal.

Experimental site

The field experiments were carried out at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The farm is situated at 26°19'86"N latitude and 89°023'53" E longitude, et an elevation of 43 meter above mean sea level.

Soil characteristics of the experimental site

The topography of the land where the experimental was under taken was medium high in situation endowed with good drainage facility. The soil of the experimental field was sandy loam in texture with the pH 5.34. Composition soil sample from all the experimental plots were collected and analyzed before sowing of the crop. The Physico-Chemical properties of the experimental soil have found are Organic Carbon (1.02%), Available nitrogen (94.75 kg ha⁻¹), Available phosphorus (16.35 kg ha⁻¹),

Available potassium (76.90 kg ha⁻¹), Total Nitrogen (211.99 kg ha⁻¹), Total phosphorus (56.89 kg ha⁻¹) and Total potassium (189.24 kg ha⁻¹).

Details about experiment

Experimental design

Factorial Randomized Block Design, Total area (m²): 780, Plot size: 4 x 3, Number of replication: 3, Spacing: 20 cm x 15 cm and

Treatment details

Five cultivars namely MTU 7029, ANNADA, KHANDAGIRI, SATABDI and G-S 3 and three levels of nitrogen: 30, 60 and 90 kg /ha.

Test crop and Varieties

Crop: Rice (*Oryza sativa*)

Variety: V₁= MTU 7029, V₂= ANNADA, V₃= KHANDAGIRI, V₄= SATABDI and V₅= G-S 3

Methods of recording biometric observations

Leaving the border rows half of the area in each plot was earmarked for recording biometrical observation including destructive sampling and other half for recording yield components and yield.

Growth parameters

Plant height

Five plants were selected randomly from individual plots and properly tagged. Their height were measured in centimeter from the ground level. Observations were taken at 20 days interval starting from 20 days after transplanting.

Dry matter accumulation (DMA)

For calculation of DMA, destructive plant samples were taken from 50 cm row length of each plot at an interval of 15 days starting from 30 days after transplanting and continue upto 90 days after transplanting. From these sample plants the roots, green leaves and stems were separated and kept in brown paper packet and were allowed to dry in hot air oven at a temperature of 65°C for 24 hours and continued till their constant weight were recorded and from this constant weight total dry matter production per square meter for each treatment was worked out.

Leaf area index (LAI)

Leaf area index (LAI) is the ratio of leaf area to the area of ground cover. For LAI calculation, the destructive plant sample were taken from 50 cm row length of each plot. The green leaf lamina were separated from the destructive sample and 5 leaves were randomly selected. From the central portion of the selected leaves 10 cm size was cut by a sharp blade. The cut portion were kept in a small brown paper packet and allowed to dry in a hot air at a temperature of 70°C till a constant weight were recorded. The cut leaves were then weighted on an electronic balance. On the other hand, the green leaf lamina separated from the destructive sample were separately dried and weighted. There after using area-weight (a/w) relationship of the cut leaf, total leaf area were calculated for each treatment. Then according to the formula given by Watson, 1947 LAI was calculated at 15 days interval starting from 30 days after transplantation.

$$\text{Leaf area index (LAI)} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area from which leaf Sample were collected}}$$

Then the mean LAI (L) was calculated as per the formula given below.

$$\text{Mean LAI (L)} = \frac{L_2 - L_1}{\text{Log}_e L_2 - \text{Log}_e L_1}$$

Where, L_1 and L_2 are the leaf area indices at to successive occasions on time t_1 and t_2 respectively.

Crop growth rate (CGR)

Crop growth rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day ($\text{gm m}^{-2} \text{day}^{-1}$). It is calculated according to the formula given by Watson (1952).

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 were the dry weight of the aerial plant per unit area gained at time t_1 and t_2 respectively.

CGR were calculated at (30-45), (45-60), (60-75) and (75-90) days interval.

Yield attributes

Number of tillers (m^{-2})

Productive and unproductive tillers were counted randomly from each variety at 20 days intervals starting from 20 days after transplanting using 1 m^2 quadrat.

Length of panicle (cm)

Panicles from five hills were selected randomly from each plot prior to harvest and the panicle length was recorded (cm) and the average length was worked out.

Number of grain panicle⁻¹

Ten panicles were randomly selected from each plot. The grains were counted for the crop of rice. Then average number of grains per panicle was worked out.

1000 grain weight (Test weight)

From the fresh product of the each plot, 1000 grains were collected and counted; dried and weights were recorded (g) from each plot separately.

Yield and harvest index

Grain Yield (t ha^{-1})

After harvesting the crop from the net plot, discarding the border rows, those were dried the sun and subsequently threshed. The produce from each in all the cases was sun dried. Clean thoroughly weight (g) and it converted per hectare basis.

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Plot yield (kg)} \times 10000}{\text{Plot size (m}^{-2}\text{)} \times 1000}$$

Straw yield (t ha^{-1})

After threshing grain were separated from harvested material of each plot. Weight of the rest portion of the harvested parts was recorded and converted in per hectare basis.

$$\text{Straw yield (t ha}^{-1}\text{)} = \frac{\text{Straw yield plot (kg)} \times 10000}{\text{Plot size (m}^{-2}\text{)} \times 1000}$$

Harvest Index (HI)

After harvesting and threshing, both grain and straw of individual variety were sun dried. Then the weight of grain and vegetative parts from each variety were recorded in gm m^{-2} and then converted into kg ha^{-1} . Harvest Index

was calculated by using the following formula and expressed in percentage (%).

$$HI (\%) = \frac{\text{Economic yield (Grain)}}{\text{Biological yield (Grain + Straw)}} \times 100$$

Methods of statistical analysis

The data collected from the field and laboratory experiments were subjected to statistical analysis with appropriate design and treatment variation and were tested for significance by F-test (Cochran and Cox, 1955). The standard error of mean and critical difference is indicated in the tables. For determination of critical difference at 5% level of significance Fisher and Yates (1963) table was consulted.

Results and Discussion

Effect of nitrogen levels and cultivars on plant height (cm) of rice

It was revealed from the table 1 that Plant height increased continuously with the advancement of crop growth and varied significantly with different levels of nitrogen and cultivars. Among the cultivars V₄ (Satabdi) produced tallest plant (24.46, 63.51, 77.50 and 86.49 cm at 20 DAT, 40 DAT, 60 DAT and at harvest respectively) at all the stages of taking observation, which was statistically at par with V₃ (Khandagiri) and V₅ (GS-3). Whereas, cultivars V₁ (MTU-7029) recorded the shortest plant (22.27, 58.21, 73.58 and 83.44 cm) at all the stages of crop growth. The probable reason might be due to genetic character of the cultivars.

However, among the levels of nitrogen N₃ (90 kg N/ha) achieved significantly tallest plant (24.47, 62.67, 76.93 and 86.06 cm at 20 DAT, 40 DAT, 60 DAT and at harvest respectively) at all the stages of recording observation which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha). This was probably due to

higher uptake of applied nitrogen and greater availability of soil nutrients. The result may be supported by the findings of Fageria and Wilcox (1977), Thakur and Singh (1987) and Singh *et al.*, (1996).

Effect of nitrogen levels and cultivars on number of tillers/m²

It was clear from the table 2 that number of tillers varied from cultivars to cultivars and with the levels of nitrogen. Among the yield components, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers per unit area. Number of tillers increased continuously and attained a maximum value at 40 days after transplanting, which was considered as active tillering stage. After that, number of tillers decreased towards maturity due to side tiller mortality and initiation of panicle primordia. Among the cultivars V₁ (MTU-7029) recorded highest number (247.28, 279.84, 212.08 and 205.33 at 20 DAT, 40 DAT, 60 DAT and at harvest respectively) of tiller m⁻² which was followed by V₃ (Khandagiri) and V₂ (Annada) in all the sampling dates. Variety V₄ (Satabdi) recorded lowest number of tiller m⁻² in all the dates of taking observation.

Among the levels of nitrogen N₃ (90 kg N/ha) produced maximum number of tillers (255.20, 280.06, 244.64 and 214.10 at 20 DAT, 40 DAT, 60 DAT and at harvest respectively) at all the stages of recording observation which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha).

This was probably due to higher uptake of applied nitrogen and greater availability of soil nutrients. A similar finding was also scrutinized by Rahman *et al.*, (2007), Hossain *et al.*, (2002), and Tunio *et al.*, (2002). Interaction effect of cultivars and nitrogen also depicted similar result.

Effect of nitrogen levels and cultivars on Panicle length (cm)

A perusal of data (Table 3) revealed that length of panicle varied significantly from cultivars to cultivars and also under levels of nitrogen application. Among the cultivars V₁ (MTU-7029) produced longest panicle (22.36) which was statistically at par with Khandagiri (22.13) and Annada (21.88). However, shortest panicle (20.58) was obtained from V₄ (Satabdi). This was might be to genetic character of the variety.

Among the levels of nitrogen, N₃ (90 kg N/ha) produced longest panicle (23.39) which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha). This was probably due to higher uptake of applied nitrogen and greater availability of soil nutrients.

Effect of nitrogen levels and cultivars on percentage of filled grains

Result obtained in the present study revealed that grain filling percentage varied significantly from cultivars to cultivars. Among the cultivars V₁ (MTU-7029)

produced highest (90.05) percentage of fertile grains, which was statistically at par GS-3 (89.18) Khandagiri (88.34) and Annada (87.54). Higher grain filling might be due higher transportation of photosynthates from source to sink. However, cultivars Satabdi produced significantly lowest (84.75) percentage of fertile grains.

Among the levels of nitrogen, N₃ (90 kg N/ha) produced highest (91.82) percentage of fertile grains which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha). This was probably due to higher uptake of applied nitrogen and greater availability of soil nutrients.

Effect of nitrogen levels and cultivars on 1000 grain weight (gm)

Thousand grains weight, an important yield-determining component, is a genetic character and least influenced by environment (Ashraf *et al.*, 1999). Data presented in the table 4 revealed that 1000 grain weight was higher (28.32) in V₁ (MTU-7029) which was statistically at par with V₂ (Annada) and V₃ (Khandagiri).

Table.1 Effect of level of nitrogen and cultivars on plant height of rice

Treatments	Plant height			
	20 DAT	40 DAT	60 DAT	At harvest
V ₁ (MTU-7029)	22.27	58.21	73.58	83.44
V ₂ (Annada)	23.28	60.27	75.06	84.24
V ₃ (Khandagiri)	24.28	62.79	77.09	86.02
V ₄ (Satabdi)	24.46	63.51	77.50	86.49
V ₅ (GS-3)	23.42	60.39	74.81	83.95
S.Em (±)	0.91	1.20	1.25	1.05
CD (P=0.05)	1.72	2.52	2.21	1.82
N ₁ (30 Kg N/ha)	22.66	58.87	73.90	83.00
N ₂ (60 Kg N/ha)	23.49	61.56	75.99	85.42
N ₃ (90 Kg N /ha)	24.47	62.67	76.93	86.06
S.Em (±)	0.55	1.11	0.85	0.84
CD (P=0.05)	0.90	2.01	1.50	1.45

Table.2 Effect of level of nitrogen and cultivars on number of tillers/m²

Treatments	Number of tillers/m ²			
	20 DAT	40 DAT	60 DAT	At harvest
V ₁ (MTU-7029)	247.28	279.84	212.08	205.33
V ₂ (Annada)	222.42	276.10	207.02	190.66
V ₃ (Khandagiri)	232.76	279.40	209.22	202.84
V ₄ (Satabdi)	204.38	264.22	203.84	180.91
V ₅ (GS-3)	216.92	267.96	205.50	185.75
S.Em (±)	3.88	4.54	5.45	3.92
CD (P=0.05)	7.05	8.15	10.06	7.85
N ₁ (30 Kg N/ha)	192.94	264.00	191.18	170.10
N ₂ (60 Kg N/ha)	226.16	276.54	204.60	195.09
N ₃ (90 Kg N /ha)	255.20	280.06	244.64	214.10
S.Em (±)	17.01	5.12	12.99	11.91
CD (P=0.05)	32.88	8.59	26.72	23.25

Table.3 Effect of levels of nitrogen and cultivars on yield attributes and grain yield of rice

Treatments	Yield attributes and grain yield						
	Panicle Length (cm)	Percentage of filled grains	Percentage of unfilled grains	1000 grain weight (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	Harvest Index (%)
V ₁ (MTU-7029)	22.36	90.05	10.80	28.32	3.56	4.72	42.67
V ₂ (Annada)	21.88	87.54	12.52	25.39	3.38	4.56	41.33
V ₃ (Khandagiri)	22.13	88.34	11.65	27.65	3.45	4.58	42.00
V ₄ (Satabdi)	20.58	84.75	15.23	19.36	3.01	4.18	37.67
V ₅ (GS-3)	20.96	89.18	13.27	20.93	3.11	4.30	40.33
S. Em (±)	0.51	1.23	1.34	2.24	0.29	0.14	-
CD (P=0.05)	0.93	2.51	2.86	5.02	0.55	0.25	-
N ₁ (30 Kg N/ha)	19.93	82.04	17.94	28.25	2.87	4.07	36.8
N ₂ (60 Kg N/ha)	21.43	88.05	11.98	29.65	3.19	4.38	40.8
N ₃ (90 Kg N /ha)	23.39	91.82	8.17	30.12	3.85	4.96	44.8
S.Em (±)	1.51	2.46	2.71	0.25	0.23	0.31	-
CD (P=0.05)	2.25	5.03	5.25	0.46	0.49	0.48	-

Table.4 Effect of levels of nitrogen and cultivars on availability of nutrients after harvesting of rice

Cultivars	Available nitrogen (kg ha ⁻¹)			Available phosphorus(kg ha ⁻¹)			Available potassium (kg ha ⁻¹)		
	30 kg N ha ⁻¹	60 kg N ha ⁻¹	90 kg N ha ⁻¹	30 kg N ha ⁻¹	60 kg N ha ⁻¹	90 kg N ha ⁻¹	30 kg N ha ⁻¹	60 kg N ha ⁻¹	90 kg N ha ⁻¹
MTU-7029	137.22	163.36	175.32	19.75	24.56	24.72	69.79	82.30	88.15
Annada	144.10	151.00	188.11	19.86	24.61	32.63	70.22	72.64	101.45
Khandagiri	213.96	213.75	225.77	28.76	29.53	32.54	88.35	99.25	117.26
Shatabdi	200.84	238.88	250.66	30.00	34.42	37.07	90.56	96.18	122.35
GS-3	262.98	275.96	289.27	35.47	36.72	38.99	68.73	97.68	101.56
S.Em (±)	0.51	0.39	0.88	0.23	0.18	0.39	0.27	0.21	0.47
CD (P=0.05)	1.04	0.81	1.80	0.47	0.36	0.81	0.56	0.43	0.96

This might be due to higher conservation of light energy into chemical energy and its subsequent translocation from source to sink. Among the cultivars Satabdi recorded significantly lowest value (19.36) of 1000 grain weight.

This might be due to lower conservation of light energy into chemical energy and its subsequent translocation from source to sink. Similar trends were also registered by Singh *et al.*, (1986), Dhal and Misra (1993) and Tunio *et al.*, (2002).

Among the levels of nitrogen, N₃ (90 kg N/ha) recorded significantly higher (30.12) values of 1000 grain weight which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha). This was probably due to higher uptake of applied nitrogen and greater availability of soil nutrients.

Effect of nitrogen levels and cultivars on straw yield (t/ha)

Table 3 revealed that among the cultivars MTU-7029 produced higher (4.72) straw yield which was statistically at par with Khandagiri (4.58) and Annada (4.56). Cultivar Satabdi produce significantly lower (4.18) straw yield. The probable reason might be due to taller plant and more number of tillers corresponding to MTU-7029. Among the nitrogen levels, 90 kg N/ha produced significantly higher (4.96) straw yield which was followed by 60 kg N/ha (4.38) and 30 kg N/ha (4.07). Gulati *et al.*, (1987), Islam *et al.*, (1997) and Mhaskar *et al.*, (2005) also investigated similar result.

Effect of nitrogen levels and cultivars on Harvest index (%)

It was clearly observed from the table 3 that, harvest index varies with cultivar to cultivar and also with the different levels of nitrogen.

Among the cultivars MTU-7029 registered highest values (42.67) of harvest index which was followed by Khandagiri (42.00) and Annada (41.33). Cultivar Satabdi recorded lowest values (37.67) of harvest index, the reason might be due to lower grain and straw yield. Among the nitrogen levels, 90 kg N/ha registered highest (44.80) value of harvest index which was followed by 60 kg N/ha (40.80) and 30 kg N/ha (36.80).

Effect of nitrogen levels and cultivars on percentage of unfilled grains

Highest percentage of sterile grain (15.23) was found under V₄ (Satabdi) which was statistically at par with V₅ and V₂. Cultivar MTU-7029 achieved significantly lower percentage of sterile grains (10.80). Among the levels of nitrogen, N₃ (90 kg N/ha) produced lowest (8.17) percentage of sterile grains and N₁ (30 kg N/ha) produced highest (17.94) percentage of sterile grains. This was probably due to higher grain filling percentage in MTU-7029. Similar findings has also been reported by Tunio *et al.*, (2002).

Effect of nitrogen levels and cultivars on Grain yield (t/ha)

Grain yield is a function of inter play of various yield components such as number of productive tillers, panicle length, percentage of grain filling and 1000 grain weight (Hassan *et al.*, 2003). Grain yield varied significantly from cultivar to cultivar. Among the cultivars, maximum grain yield (3.56) was produced by V₁ (MTU-7029) followed by Khandagiri (3.45) Annada (3.38) and GS-3 (3.11). Higher values of all growth and yield attributes ultimately produced higher grain yield corresponding to V₁ (MTU-7029). Among the cultivars Satabdi produced significantly lowest grain (3.01) yield. This was probably due to lowest number of panicle meter⁻², filled grains panicle⁻¹ and lower 1000 grain weight.

Among the levels of nitrogen, N₃ (90 kg N/ha) produced significantly higher (3.85) grain yield which was followed by N₂ (60 kg N/ha) and N₁ (30 kg N/ha). The probable reason might be due to vigorous and enhanced plant growth and also due to continuous and synchronize supply of nutrients throughout the growth stages of rice.

Effect of nitrogen levels and cultivars on soil fertility status (kg/ha)

Availability of soil nutrients viz. Nitrogen, Phosphorus and Potassium after harvesting of rice was varied significantly from cultivar to cultivar and also with the nitrogen levels. The highest amount of available N was obtained in the plots where 90 kg N/ha was applied followed by 60 kg N/ha and 30 kg N/ha. On the contrary, highest amount of available N was noticed in the plot where cultivar GS-3 was grown which was followed by Khandagiri, Satabdi, Annada, and MTU-7029. The higher availability of soil nitrogen might be due to less uptake of nitrogen by GS-3. The picture was also same in case of phosphorus and potassium (Table 4).

In the present research, it is clear that higher levels of nitrogen influenced most of the growth and yield parameters, considerably. Among the levels of nitrogen, 90 kg Nitrogen/ha recorded significantly higher grain yield and among the cultivars MTU-7029 performed better in terms of growth, yield attributes and yield. Therefore, cultivars MTU-7029 with 90 kg Nitrogen/ha is recommended for successful rice production under the agro climatic conditions of the terai region of West Bengal.

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How to cite this article:

Biswajit Saha, Parimal Panda, Partha Sarathi Patra, Ranajit Panda, Arindam Kundu, A. K. Singha Roy and Nabakishor Mahato. 2017. Effect of Different levels of Nitrogen on Growth and Yield of Rice (*Oryza sativa* L.) Cultivars under Terai-agro Climatic Situation. *Int.J.Curr.Microbiol.App.Sci*. 6(7): 2408-2418. doi: <https://doi.org/10.20546/ijemas.2017.607.285>