

1 **Performance of rice (*Oryza sativa* L.) cultivars under nutrient management practices in eastern**  
2 **plateau and hills zone of India**

3  
4  
5 **Abstract**

6 **Aim: To study the effect of rice cultivars and nutrient management practices on growth**  
7 **parameters, yield attributes, yield, nitrogen uptake and comparative economics.**

8 **Study design: Three varieties and four nutrient management are treated in split plot design with plot**  
9 **size of 4m × 3m. The treatments comprised of three varieties, V<sub>1</sub>: CR Dhan – 206, V<sub>2</sub>: CR Dhan 210**  
10 **and V<sub>3</sub>: CR Dhan 602 were laid out in main plot and four nutrient management comprised of N<sub>1</sub>:**  
11 **100% Recommended dose of nitrogen (RDN) through fertilizer, N<sub>2</sub>: 50% RDN through fertilizer +**  
12 **50% RDN through FYM, N<sub>3</sub>: 50% RDN through fertilizer + 50% RDN through azolla and N<sub>4</sub>: 50%**  
13 **RDN through FYM + 50% RDN through azolla are tested in subplot with replicate thrice.**

14 **Place and duration of study: The field experiment conducted at Chatabar farm, Faculty of agricultural**  
15 **sciences, Siksha 'O' Anusandhan University, Bhubaneswar, Odisha during *kharif* season, 2022.**

16 **Results: The experimental result from this experiment indicated that CR Dhan 206 cultivate with**  
17 **100% RDN through fertilizer produced maximum plant height, number of filled grain per panicle,**  
18 **panicle length, yield (grain and straw), harvest index, nitrogen uptake by grain and straw, net return**  
19 **and return per rupees investment.**

20 **Conclusion: Cultivation of CR Dhan 206 with 100% RDN (80-kg/ha) produced highest grain yield,**  
21 **net return and return per rupees investment.**

22  
23 **Key words: Rice, varieties, RDN, FYM, azolla, yield and economics.**

24 **Introduction**

25 Rice (*Oryzasativa*) is one of the important staple food grain crop in the world. It is a  
26 high calories food which contains about 75% starch, 6-7% protein, 2-2.5% fat, 0.8% cellulose  
27 and 5-9% ash. In Asia, more than two billion people are getting 60-70% of their energy  
28 requirement from rice and its derived products (Tomar *et al.*, 2018). In India, it is cultivated  
29 in an area of 43.66 million hectares with a production of 118.87 million tonnes and  
30 productivity of 2722 kg ha<sup>-1</sup> (AD and FW 2019-20). Increasing population in Asia demanding

31 higher quantity of rice grain in recent days. More yield and profitability motivated the  
32 farmers to switch over to the high yielding varieties cultivation from traditional low yielded  
33 old varieties to feed the increasing population. So, it is needed to boost the rice production  
34 with high yielding varieties because the conventional varieties are still showing low  
35 productivity (Fukushima et al., 2011) and also reclaimed soil (Mehdi et al., 2007). High  
36 yielding varieties uptake more nutrient compared to traditional varieties and deplete soil  
37 fertility (S. Htay Win). The primary concept of integrated nutrient management is to maintain  
38 and adjust long term soil fertility as well as supplying optimum quantity of nutrients to plants  
39 through integration of all possible plant nutrient sources to sustain productivity of crop and  
40 soil. Azolla is a symbiont, anabaena, which have ability to fix atmospheric nitrogen has been  
41 used for a century in the rice ecosystem to increase rice production and maintain soil fertility  
42 (Yao et al., 2018; Bhuvaneswari and Singh, 2015, 15-17). After decomposition, its organic  
43 nitrogen mineralized quickly and released as ammonia form, becomes available as a nitrogen  
44 fixing biofertilizer for the growing rice crop. During the recent times, higher requirement of  
45 rice production as well as maintain soil fertility can be fulfilled by cultivation of recently  
46 developed high yielding rice varieties with integrated approach of nutrient management.  
47 Keeping these views in mind, a field experiment entitled “Performance of rice (*Oryzasativa*  
48 L.) cultivars under nutrient management practices in eastern plateau and hills zone of India”  
49 was conducted to know the ability of rice cultivars and nutrient management on yield  
50 attributes and yield, nitrogen uptake and economics of rice cultivation.

## 51 **Materials and methods**

52 A field experiment was conducted at the Agricultural Research Station, Brinjhagiri,  
53 Chatabar of Faculty of Agricultural Sciences, Siksha O Anusandhan (Deemed to be  
54 University), Bhubaneswar (Odisha) during *kharif* season of 2022. The experimental field  
55 enjoyed medium land situation and contained sandy loam soil with slightly acidic in reaction  
56 (pH = 5.78). The available nitrogen, phosphorous and potassium content of soil before  
57 cultivation was 256 kg/ha, 20.29 kg/ha and 194.16 kg/ha respectively. This region has a hot  
58 and dry tropical climate. During the experimentation, highest maximum temperature was  
59 recorded in the standard week of 31<sup>st</sup> (34.5°C) followed by 36<sup>th</sup> (34.3°C) and lowest  
60 temperature 20.3°C was observed in 44<sup>rd</sup> standard week. A good amount of rainfall (1112mm)  
61 occurred during experimentation (27<sup>th</sup> to 44<sup>th</sup> meteorological week) (Figure 1). Three high  
62 yielding varieties and four nutrient management are treated in split plot design with plot size  
63 of 4m × 3m. The treatments comprised of three varieties, V<sub>1</sub>: CR Dhan – 206, V<sub>2</sub>: CR Dhan

64 210 and V<sub>3</sub>: CR Dhan 602 were laid out in main plot and four nutrient management  
65 comprised of N<sub>1</sub>: 100% Recommended dose of nitrogen (RDN) through fertilizer, N<sub>2</sub>: 50%  
66 RDN through fertilizer + 50% RDN through FYM, N<sub>3</sub>: 50% RDN through fertilizer + 50%  
67 RDN through azolla and N<sub>4</sub>: 50% RDN through FYM + 50% RDN through azolla are tested  
68 in subplot with three replications.

## 69 **Result and discussion:**

### 70 **Growth parameters**

71 At maturity, irrespective of different nutrient management, CR Dhan 210 (V<sub>2</sub>)  
72 produced tallest plant (123.88 cm) whereas, shortest plant observed in CR Dhan 602 (V<sub>3</sub>)  
73 (112.43 cm). Full RDN (100%) through fertilizer (N<sub>1</sub>) attained tallest plant (125.60 cm)  
74 followed by 50% RDN through fertilizer + 50% RDN through azolla (N<sub>3</sub>) (119.83 cm)  
75 whereas, smallest plant recorded at 100 DAT (114.97 cm) on 50% RDN through FYM + 50%  
76 RDN through Azolla (N<sub>4</sub>) at maturity (Table 2). There is no significant difference among the  
77 treatment combination on plant height. Nitrogen application from inorganic source has  
78 increased plant height faster than inorganic and organic combination because of the faster  
79 availability and the same result has found by Malik *et al.*, (2010).

### 80 **Yield parameters**

81 Among three rice varieties, the highest number of effective tillers (panicles) per hill  
82 was obtained from CR Dhan 206 (V<sub>1</sub>) (9.03) and lowest number of effective tillers per hill  
83 was obtained from CR Dhan 602 (V<sub>3</sub>) (8.53). The length of panicle and panicle weight  
84 was found highest in CR Dhan 206 (V<sub>1</sub>) (24.60 cm and 2.37g respectively) and lowest length  
85 of panicle received from CR Dhan 602 (V<sub>3</sub>) (23.20 cm). In case of nutrient management  
86 study, 100% RDN through fertilizer (N<sub>1</sub>) application produced maximum number of effective  
87 tillers per hill (9.17), highest panicle length (24.90 cm) and panicle weight (2.44 g). 50%  
88 RDN through fertilizer + 50% RDN through azolla (N<sub>3</sub>) gave the second highest effective  
89 number of tillers per hill (8.93) and length of panicle (24.60 cm). While the lowest number of  
90 effective tillers/hill and panicle length was found from 50% RDN through FYM + 50% RDN  
91 through azolla (N<sub>4</sub>) i.e. 8.3 and 23.8 cm respectively (Table 2). The maximum number of  
92 effective tillers per hill, length of panicle and panicle weight was obtained from 100% RDN  
93 through fertilizer, due to the availability of nutrient in a simple form that plant can uptake  
94 easily and rapidly and it is similar to the findings of Apon *et al.*, 2018. 50 % RDN through  
95 fertilizer +50 % RDN through azolla gave the statistically at par values of the yield

96 attributing characters. This result also found similar trend by the research of Hussainet *al.*,  
97 2012 and Naing, 2010.

98 Among the three varieties, CR Dhan 206 (V<sub>1</sub>) showed the significantly highest  
99 number of filled grains per panicle (104.33) and the lowest number of filled grains per  
100 panicle obtained from CR Dhan 602 (V<sub>3</sub>) (94.83). While coming to the nutrient management,  
101 100% RDN through fertilizer (N<sub>1</sub>) gave the highest values of number of filled grain per  
102 panicle (109.44) followed by 50% RDN through fertilizer + 50% RDN through azolla (N<sub>3</sub>)  
103 106.56 (Table 2). This might be due to the continuous availability of readily available nutrient  
104 throughout the growing period and biofertilizer (Azolla) supplies timely nutrients to the rice  
105 crop. (Pattanayak et al., 2007)

#### 106 **Yield:**

107 Among the three varieties, CR Dhan 206 (V<sub>1</sub>) produced the highest grain yield (4.22 t  
108 ha<sup>-1</sup>) and lowest grain yield received from CR Dhan 602 (V<sub>3</sub>) (4.07 t ha<sup>-1</sup>). From the nutrient  
109 management practices, 100% RDN through fertilizer (N<sub>1</sub>) gave the highest grain yield (4.79 t  
110 ha<sup>-1</sup>) followed by 50% RDN through fertilizer + 50% RDN through azolla (4.36 t ha<sup>-1</sup>) and  
111 the lowest grain yield is from 50% RDN through FYM + 50% RDN through azolla (N<sub>4</sub>) (3.57  
112 t ha<sup>-1</sup>). There is significant difference of grain yield among the treatment combination (variety  
113 and nutrient management practices) are presented in Table 3 and found the highest yield is  
114 from the treatment V<sub>1</sub>N<sub>1</sub> (4.99 t ha<sup>-1</sup>) and lowest from V<sub>2</sub>N<sub>4</sub> (3.39 t ha<sup>-1</sup>). While coming to  
115 straw yield and harvest index, in terms of varieties CR Dhan 206 (V<sub>1</sub>) is having the highest  
116 values of straw yield (5.73 t ha<sup>-1</sup>). In terms of nutrient management, the straw yield and  
117 harvest index found highest for 100% RDN through fertilizer (N<sub>1</sub>) (6.20 t ha<sup>-1</sup> and 0.44  
118 respectively) followed by 50% RDN through fertilizer + 50% RDN through azolla (N<sub>3</sub>) (5.83  
119 t ha<sup>-1</sup> and 0.43 respectively) but the lowest straw yield and harvest index is obtained from 50%  
120 RDN through FYM + 50% RDN through azolla (N<sub>4</sub>) (4.85 t ha<sup>-1</sup> and 0.42 respectively). This  
121 result was found similar to the findings of Singh *et al.*, 1998.

122

#### 123 **Nutrient uptake by crop**

124 Nitrogen uptake by grain and straw found highest by CR Dhan 602 (V<sub>3</sub>) (50.53 kg ha<sup>-1</sup>  
125 and 44.82 kg ha<sup>-1</sup> respectively) and uptake is lowest by grain and straw observed by CR  
126 Dhan 210 (V<sub>2</sub>) (47.57 kg ha<sup>-1</sup> and 40.78 kg ha<sup>-1</sup> respectively). From nutrient management,  
127 highest uptake of nitrogen by grain and straw obtained by the application of 100% RDN

128 through fertilizer (N<sub>1</sub>) (54.36 kg ha<sup>-1</sup> and 44.37 kg ha<sup>-1</sup>) followed by 50% RDN through  
129 fertilizer + 50% RDN through azolla (N<sub>3</sub>) (50.55 kg ha<sup>-1</sup> and 43.33 kg ha<sup>-1</sup>). The significantly  
130 lowest uptake of nitrogen by grain and straw is obtained by 50% RDN through FYM + 50%  
131 RDN through azolla (N<sub>4</sub>) (45.17 kg ha<sup>-1</sup> and 42.05 kg ha<sup>-1</sup> respectively) (Table 3).

### 132 **Cost of cultivation**

133 The cost of cultivation, gross return, net return and return per rupee invested will vary  
134 according to different varieties and nutrient management practices (Table 4). Cost of  
135 cultivation calculated highest for the treatment V<sub>3</sub>N<sub>2</sub> (Rs/- 71718) followed by V<sub>1</sub>N<sub>2</sub> and  
136 V<sub>2</sub>N<sub>2</sub> (Rs/- 71518 each) and the lowest cost of cultivation is for V<sub>1</sub>N<sub>3</sub> and V<sub>2</sub>N<sub>3</sub> (Rs/- 66518  
137 each). Gross return is highest for V<sub>1</sub>N<sub>1</sub> (Rs/- 108931.7) followed by V<sub>2</sub>N<sub>1</sub> (Rs/- 105438.9)  
138 and lowest for V<sub>2</sub>N<sub>4</sub> (Rs/- 74003.7). Coming to Net return, it is highest for V<sub>1</sub>N<sub>1</sub> (Rs/-  
139 41261.7) followed by V<sub>2</sub>N<sub>1</sub> (Rs/- 38642.1) and lowest for V<sub>2</sub>N<sub>4</sub> (Rs/- 4637.7).

### 140 **Conclusion:**

141 Based on the result from above experiment it can be concluded that growing CR Dhan  
142 206 with 100% RDN through fertilizer produced maximum grain yield (4.99 ton/ha), harvest  
143 index (0.43), net return (Rs 41261/-) and benefit cost ratio (1.60) and can be recommended to  
144 the farmer.

145

### 146 **COMPETING INTERESTS**

147 Authors have declared that they have no known competing financial interests OR non-  
148 financial interests OR personal relationships that could have appeared to influence the work  
149 reported in this paper.

150 **Disclaimer (Artificial intelligence)**

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153 Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during  
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159 all input prompts provided to the generative AI technology

160 Details of the AI usage are given below:

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- 162 2.
- 163 3.

164  
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223 Table 1: Physiochemical properties of soil.

Properties	Value
Soil texture	Sandy loam
pH	5.78
Electrical conductivity (dS m <sup>-1</sup> )	6.7
Organic carbon (%)	0.41
Available nitrogen (kg ha <sup>-1</sup> )	256
Available phosphorus (kg ha <sup>-1</sup> )	20.29
Available potassium (kg ha <sup>-1</sup> )	194.16

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226 Table 2: Effect of varieties and nitrogen management on plant height (cm), no. of panicles/hill, no. of  
 227 grains/panicle, panicle length (cm) and panicle weight (g).

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Treatment	Plant height (cm)	No. of panicles/hill	No. of filled grains/panicle	Panicle length (cm)	Panicle weight (g)
V <sub>1</sub> (CR Dhan 206)	120.50	9.03	104.33	24.6	2.37
V <sub>2</sub> (CR Dhan 210)	123.88	8.77	100.58	24.5	2.21
V <sub>3</sub> (CR Dhan 602)	112.43	8.53	94.83	23.2	1.99
<b>SEm±</b>	<b>1.95</b>	<b>0.19</b>	<b>2.16</b>	<b>0.52</b>	<b>0.09</b>
<b>CD (p = 0.05)</b>	<b>7.67</b>	<b>0.73</b>	<b>8.46</b>	<b>2.06</b>	<b>0.37</b>
N <sub>1</sub> (100% RDN through Fertilizer)	125.60	9.17	109.44	24.9	2.44
N <sub>2</sub> (50% RDN through Fertilizer + 50% RDN through FYM)	115.33	8.62	95.67	24.2	2.06
N <sub>3</sub> (50% RDN through Fertilizer + 50% RDN through Azolla)	119.83	8.93	106.56	24.6	2.40
N <sub>4</sub> (50% RDN through FYM +50% RDN through Azolla)	114.97	8.37	88.00	23.8	1.86
<b>SEm±</b>	<b>1.07</b>	<b>0.23</b>	<b>3.02</b>	<b>0.23</b>	<b>0.08</b>
<b>CD (p = 0.05)</b>	<b>4.19</b>	<b>0.92</b>	<b>11.85</b>	<b>0.92</b>	<b>0.32</b>

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231 Table 3: Effect of varieties and nitrogen management on grain yield(t/ha), straw yield(t/ha), harvest  
 232 index and nitrogen uptake(kg/ha).

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index	Nitrogen uptake (kg/ha)	
				By grain	By straw

V <sub>1</sub> (CR Dhan 206)	4.22	5.73	0.42	48.57	43.36
V <sub>2</sub> (CR Dhan 210)	4.12	5.45	0.43	47.57	40.78
V <sub>3</sub> (CR Dhan 602)	4.07	5.48	0.43	50.53	44.82
<b>SEm±</b>	<b>0.03</b>	<b>0.14</b>	<b>0.01</b>	<b>1.28</b>	<b>3.85</b>
<b>CD (p = 0.05)</b>	<b>0.12</b>	<b>0.53</b>	<b>0.02</b>	<b>5.01</b>	<b>15.12</b>
N <sub>1</sub> (100% RDN through Fertilizer)	4.79	6.20	0.44	54.36	44.37
N <sub>2</sub> (50% RDN through Fertilizer + 50% RDN through FYM)	3.83	5.33	0.42	45.47	42.22
N <sub>3</sub> (50% RDN through Fertilizer + 50% RDN through Azolla)	4.36	5.83	0.43	50.55	43.33
N <sub>4</sub> (50% RDN through FYM +50% RDN through Azolla)	3.57	4.85	0.42	45.17	42.04
<b>SEm±</b>	<b>0.15</b>	<b>0.05</b>	<b>0.00</b>	<b>1.98</b>	<b>1.46</b>
<b>CD (p = 0.05)</b>	<b>0.53</b>	<b>0.19</b>	<b>0.01</b>	<b>7.48</b>	<b>5.74</b>

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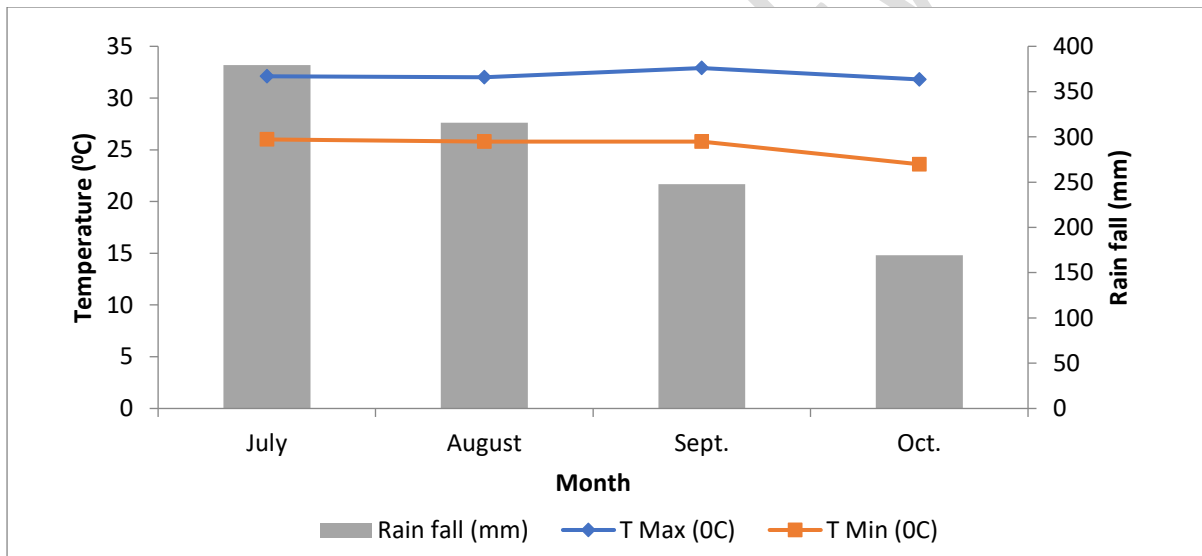
234

235 Table 4: Effect of varieties and nitrogen management on cost of cultivation (Rs/-), gross return (Rs/-),  
 236 net return (Rs/-) and return per rupees investment.

Treatment	Cost of Cultivation (Rs/-)	Gross Return (Rs/-)	Net Return (Rs/-)	Return per rupee investment
V <sub>1</sub> N <sub>1</sub> (CR Dhan 206) (100% RDN through Fertilizer)	67670	108931	41261	1.60
V <sub>1</sub> N <sub>2</sub> (CR Dhan 206) (50% RDN through Fertilizer + 50% RDN through FYM)	71518	84918	13400	1.18
V <sub>1</sub> N <sub>3</sub> (CR Dhan 206) (50% RDN through Fertilizer + 50% RDN through Azolla)	66518	94305	27787	1.41
V <sub>1</sub> N <sub>4</sub> (CR Dhan 206) (50% RDN through FYM + 50% RDN through Azolla)	69366	80334	10968	1.15
V <sub>2</sub> N <sub>1</sub> (CR Dhan 210) (100% RDN through Fertilizer)	67670	106312	38642	1.57
V <sub>2</sub> N <sub>2</sub> (CR Dhan 210) (50% RDN through Fertilizer+ 50% RDN through FYM)	71518	80989	9471	1.13
V <sub>2</sub> N <sub>3</sub> (CR Dhan 210) (50% RDN through Fertilizer + 50% RDN through Azolla)	66518	98016	31498	1.47
V <sub>2</sub> N <sub>4</sub> (CR Dhan 210) (50% RDN through FYM + 50% RDN through Azolla)	69366	74003	4637	1.06
V <sub>3</sub> N <sub>1</sub> (CR Dhan 602) (100% RDN through Fertilizer)	67870	105438	37568	1.55

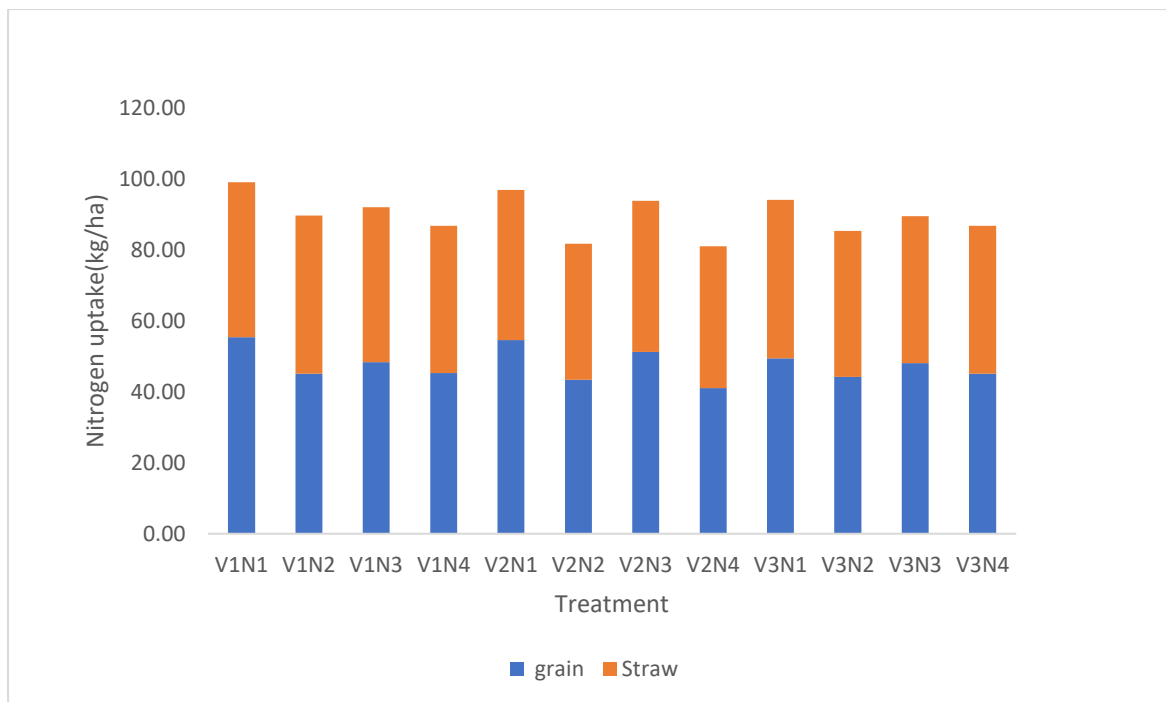
Fertilizer)				
V <sub>3</sub> N <sub>2</sub> (CR Dhan 602) (50% RDN through Fertilizer+ 50% RDN through FYM)	71718	91904	20186	1.28
V <sub>3</sub> N <sub>3</sub> (CR Dhan 602) (50% RDN through Fertilizer + 50% RDN through Azolla)	66718	100199	33481	1.50
V <sub>3</sub> N <sub>4</sub> (CR Dhan 602) (50% RDN through FYM + 50% RDN through Azolla)	69566	86665	17099	1.24
SEm (+)	55.7	69.8	49.9	
CD (p = 0.05)	219	275	192	

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Fig. 1 Temperature and rain fall during the experimental period.



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245 Fig. 2 Effect of variety and nutrient management on nitrogen uptake (kg/ha) by grain and straw of  
 246 *kharif* rice.

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