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*Research Paper*

# GERMINATION BEHAVIOUR AND CHLOROPHYLL CONTENT OF AROMATIC RICE (*Oryza sativa* L.) GENOTYPES UNDER VARIED NITROGEN CONCENTRATIONS

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**Abstract**

Nitrogen can influence the seed germination parameters and leaf pigment content in aromatic rice. Parameters such as Final germination percentage (FGP), mean daily germination, peak value, germination value, rate of germination and mean germination time were studies in different nitrogen concentration. Final germination percentage was decreased with increasing nitrogen concentrations.Other germination parameters were performed variably under different nitrogen concentration. Similarly seedling parameters *viz.,* root length, shoot length, and root/shoot length ratio expressed higher under treatment compared to control. The shoot length was increased with increasing nitrogen concentration; however the root length was increased up to certain level and then decreased. Among all the genotypes Basmati 370 given maximum response in all germination parameters in contrast Ratnasundari. Among the treatments the maximum FGP was recorded in N-0 and least in N-200. Significant variation was observed in leaf pigment content amongst different varieties and treatments. The mean of Chlorophyll a, Chlorophyll b, Total Chlorophyll and Carotinoids content was higher in N-100 and minimum response was noticed in control. The mean Chl a/ b content was superior in control and least response recorded in N-200. Finally our study concluded that N-100 treatment is the optimal level for seedling parameters and Chl content. While the rate of germination was higher in media lacking nitrate and among the genotypes, Basmati 370 was more tolerant and Ratnasundari was more sensitive to nitrogen stress. This indicates that nitrate could be the most critical factor in delaying germination, though the amount of delay varied between genotypes.

Key words: Germination parameters, Chlorophyll content, Nitrogen stress and Aromatic rice.

## INTRODUCTION

Aromatic rice is one of the major types of rice. It is medium slender grain type rice and known for its nut like aroma and taste. Aroma development is influenced by both genetic factors and the environment. Pleasant aroma is a result of a large number of compounds present in specific proportion. Aromatic rice is considered as the best in quality. So, its lower yield could be accepted for the sake of consumers demand. In India, aromatic rice cultivars are grown in limited regions, usually for personal consumption or holidays. Basmati rice is most popular

Indian variety. The demand of Basmati rice in this country is increasing but grain yield is low. However, the price of fine rice, especially the aromatic is 2-3 times higher than that of coarse rice. Germination is the most energy demanding process in the whole life cycle of a plant. It is the first stage of the plant life and appearance. A radicle is the first easily visible event completely focused by endogenous respiration. The respiration is providing the energy to geminating seed for enhancement of growth. Numbers of physiological activities were take place in seed at different moisture concentrations. But seed priming can increase speed and uniformity of germination (Ghiyasi et al., 2008b). Seed priming treatments can lead to better germination and establishment in many crops such as maize, wheat, rice, canola (Basra et al., 2005; Ghiyasi et al., 2008a,b). The radicle emergence is the last physiological activity in the germination process and its requiring high seed water content. The seed germination performance is very necessary for field crops as the poor germination or irregular and poor seedling growth can lead to great financial losses, by reducing the crop production. The viability, source, age, moisture, temperature, aeration and biotic stress of seed are mainly necessary for the germination process. (Amjad et al., 2001). Nitrogen stress affects the plant growth and developmental process. Rice leaf chlorophyll content is important factors to obtain high yield of rice and it constitutes nearly 70% of the assimilated nitrogen by the plant. Hence fertilization level might be the determining factor for leaf chlorophyll content and in turn plant yield. The seed it's self having the nitrogen nutrition, deposited nitrogen varied among the genotypes and used for germination as well as other process and also survival of cultivar at some extent. The embryo grows at the expense of the food materials which it absorbs from the cotyledons or endosperm when it is present. The objectives of the study was to investigate the response of germination, seedling parameters and Chl content to nitrogen stress compared to control in different rice varieties.

## MATERIALS AND METHOD

The experiment was conducted to study the response of rice (*Oryza sativa* L.) cultivars to germination under different nitrogen concentrations and control with eight aromatic rice genotypes namely Basmati- 370, Ranbhir Basmati, BPT 5204, Dehradun Basmati, Badshahbhog, Krishna joha, Kolajoha -3 and Ratnasundari obtained from Plant breeding, Directorate of Rice Research, Rajendranagar, Hyderabad. Treatment was maintained with Yoshida medium with different $NH_4NO_3$ concentrations in order to attain N-0 (0ppm), N-100 (40ppm), N-150 (60ppm) and N-200 (80ppm) nitrogen concentrations. Control was maintained with distilled water (Without Yoshida medium).

### Germination Test

Seeds of each cultivar with uniform size were surface sterilized with 1% sodium hypochlorite solution for 5 min, followed by repeated wash with deionised water and allowed to germinate on a filter paper in 9 cm petri dishes. Each treatment was maintained in three replications. Thus, the whole experiment comprised to 120 petri dishes. The petri dishes were kept at room temperature in dark for germination. Germination parameters were recorded up to seven days after sowing. Germination percentage was calculated using the formula as per (International Seed Testing Association [ISTA, 1996], similarly, other germination parameters *viz*., Mean daily germination, Peak value [Edwards 1934] and Germination value [Czebator, 1962] were calculated. Vigour index was calculated using the formula given by Abdul Baki and Anderson [1972]. Seedling parameters like shoot and root length were measured using ten seedlings collected at random from each on treatment on $14^{th}$ day. The shoot and root length were measured in centimetres (cm) using a scale and root/shoot length ratio was calculated using the estimates of seedling length.

### Estimation of chlorophyll and Carotinoides:

Leaf photosynthetic pigments were extracted from 21 day old seedlings with mortar and pestle in cold 80% acetone and a pinch of sea sand. The extract was centrifuged at 4°C for 5 min and Chlorophyll and carotenoid content was determined spectrophotometrically by measuring the

absorbance at 663.2 (Chl *a*), 646.8 (Chl *b*) and 470 (Carotinoides) (*Spectrascan UV 2600*, *Toshniwal Instruments* (India) Pvt. Ltd.). The pigment concentration was calculated according to [Lichtenthaler and Wellburn 1983].

## RESULTS

The FGP results were shown in Table-1. The FGP varied significantly among the genotypes and treatment. The experimental mean of FGP was more in N-0 and further, increased concentrations of N were decreased the FGP. Three genotypes v.i.z., Basmati 370, Badshahbhog and BPT 5204 were showed high FGP (98%) in control. The genotypes Basmati 370, Dehradun basmati, Krishna joha and Kola Joha-3 were recorded highest FGP (100%) in N-0 and N-100, whereas in N-150 and N-200 Basmati 370 was showed maximum FGP (99%). The Genotype Basmati 370 had showed maximum FGP in all the treatments including control, while minimum was observed in Ratnasundari. The significant differences in mean daily germination were observed among treatments and genotypes. The experimental mean of highest mean daily germination was recorded by N-150 (13.8) whereas, N-100 was shown lowest (13.4) (Table-1). It was ranged from 14 to 11, 14.3 to 9.7, 14.3 to 10.3, 14.3 to 12.1, and 14.3-11.3 (Control, N-0, N-100, N-150 and N-200) respectively. The genotype Basmati 370 had showed maximum mean daily germination in all the treatments including control, while lowest was observed in Ratnasundari. The study of germination parameters like Peak value indicated significant influence of higher concentrations on the progress of germination in the context of time. Whereas Basmati 370, Dehradun basmati and BPT 5204 under N-150 treatment and Basmati 370 and Kolajoha-3 under N-200 attained peak value within 3 days of sowing. However, as the concentration increased from N-100 to N-200, the respective treatments took 7 days to attain peak values compared to the control (Table-1). Highly significant differences were observed in experimental mean of peak value, N-0 (23.2) was shown maximum peak value and least in N-100 (17.5). The result also clearly indicated increase in concentration of N had not only effects in the reduction in final germination percentage but also prolonged the period for completion of germination process which has finally resulted in lower germination values that are important from field point of view. Irrespective of genotypes and treatments maximum germination value was 412.70 and minimum of 106.95 (Table-2). Highly significant differences were observed among the treatments, varieties and interaction. In control the germination value differed by 2.08 fold among the genotypes and ranged from 154 to 321 with general mean of 243. Where as in N-0, the genotype difference is 3.89 with the general mean of 322 and ranged from 106 to 412. The treatment N-100 was differed by 2.23 fold among the genotypes and ranged from 148 to 333 with general mean of 236.4. In N-150 was differed by 2.23 fold among the genotypes and ranged from 412 to 166 with general mean of 303.4 and N-200 was differed by 2.73 fold among the genotypes and ranged from 412 to 151 with general mean of 310.7. The rate of germination was more in N-200 (42.4) followed by N-100(42.3), N-0 (41.3), N-150 (29.7) and control (12.2). It was differed by 3.45 fold among the treatments ranged from 4.9 to 94. The experimental mean for mean germination time was highly significant among treatments. However, among the treatments, highest mean germination time (3.35) recorded in control followed by N-150 (2.79) and finally low speed of germination was recorded in N-0 (2.68), with N-100 concentration recording a moderate value of 2.74 (Table 2).

### Growth parameters

Along with the germination parameters, seedling parameters like root and shoot length were also influenced by nitrogen supplementation. (Fig.1) The shoot length was increased by increased nitrogen concentration, while root length was increased up to certain level and then decreased. Irrespective of genotypes and treatments maximum shoot length was 16cm and minimum of 2.8cm. The maximum shoot length was observed with mean of irrespective of treatment in Krishnajoha (13.6 cm) followed by Basmathi 370 (12.6), Dehradun Basmti (12.1) Ranbir Basmati (11.7), Ratnasundari (10.3 cm), Badshahbhog (10.2 cm), Kolajoha -3 ( 10.0) and

BPT5204 (8.8 cm). The maximum root length was observed N-100 (6.6 cm) and minimum in control (3.6cm).

**Chlorophyll content**

Result of Table 3 clearly showed that the eight tested cultivars of rice significantly varied for average Chl content. The interaction between treatment and varieties was found to be significant (Fig.2). The mean chlorophyll content in leaves was significantly higher N-100 compared to control and other treatments like N-0, N-150 and N-200. The mean Chl a was more in N-100 (1.15 mg $gFM^{-1}$) and least in N-0 (0.56). Chl a content varied between 0.86 (Kolajoha-3) to 0.42 (Basmathi 370) with a mean of 0.52 [mg $g^{-1}$(FM)] under control , in N-0 varied between 1.48 (Kolajoha-3) to 0.59 (Ratnasundari) with a mean of 1.00 [mg $g^{-1}$(FM)], in N-100 ranged between 1.48 (Kolajoha-3) to 0.59 (Ratnasundari) with a mean of 1.15 [mg $g^{-1}$(FM)], in N-150 ranged between 1.1 (Kolajoha-3) to 0.82 (Ratnasundari) with a mean of 1.03 [mg $g^{-1}$(FM)], in N-200 ranged between 1.26 (Krishna joha) to 0.79 (Ratnasundari) with a mean of 0.99 [mg $g^{-1}$(FM)]. Significant difference was observed in Chl b content between treatment and variety. It was ranged between 0.04 to 0.20, 0.1 to 0.39, 0.17 to 0.48, 0.15 to 0.38 and 0.16 to 0.36 in control, N-0, N-100, N-150 and N-200 respectively. Significant differences were observed in Total chlorophyll (Chl *(a+b)*) content. The ranges varied between (2.34 to 0.97) in N-100 with mean of 1.47, whereas control ranges between (0.50 to 1.03) with a mean of 0.665 [mg $g^{-1}$(FM)]. The Chl *a/b* ratio did not differed significantly in nitrogen stressed plants (Table.4). However, mean Chl *a/b* content was highest in control (4.71) and minimum in N-200 (3.49). The Chl *a/b* ratio varied between 10.6(Krishna joha) and 2.4 (Basmathii-370) with a mean of 4.71 [mg g-1(FM)] under control condition, where as in N-200 ranges varied from 4.56 to 2.4. The significant differences were not observed among the treatments in Car contents. The mean of Car content was more in N-100 (0.33) and minimum value was recorded in control (0.160) (Fig.3).

**DISCUSSION**

Germination is the most energy demanding and respiration intensive process in a plant. Complete Yoshida's media gave the slowest germination rate, followed by double distilled water, while the fastest germination was obtained in media lacking nitrate. This indicates that nitrate could be the most critical factor in delaying germination, though the amount of delay varied between genotypes. This delay was large enough to be captured using un weighed seeds, though use of seeds with uniform weight (health and physiological condition) minimized their intrinsic variation and enhanced the sensitivity of measurement. The effect of nitrogen in delaying germination is not unique to nitrate but also true for ammonium.

The increasing concentration of N has reduced seed germination, which might be due to regulation of endogenous growth factors. The genotype was shown maximum germination percentage could significantly enhance the seed yield [Singh et al., 2008]. Further, it was also found to affect enzyme activity since higher seed vigour is related to higher germination capacity. The inhibitory influence of nitrogen concentration was also reported to be associated with increased membrane permeability with seed vigour loss. Hence, increased nitrogen concentration enhanced the membrane permeability resulting in higher loss of leachates and reduced germination percentage. This study also indicated that the germination test could be successfully applied an indirect measure of nitrogen stress sensitivity in rice crop. The study of germination parameters like peak value and germination value indicated significant influence of higher concentration of nitrogen on the progress of germination in the context of time. The data indicated that the non-treated control attained peak value within 3 days of sowing. However, as the concentration increasing from N-100 to N-200, the respective treatments took 7 days to attain peak values. [Krishnaswamy and Seshu 1990] opined that the rate of germination was positively correlated with Oxygen uptake, Dehydrogenase activity by providing energy to the germinating embryo and interfering with integrity and overall capacity of the metabolic machinery of the young germinating primordial. Rice leaf chlorophyll content is one of the important factors to obtain high yield of rice. The results showed that, rice leaf chlorophyll

content was more in N-100 compared to other treatments like N-150 and N-200 and also control. The effect of fertilization on chlorophyll content showed a trend of bell shaped curve, increasing nitrogen concentration raised the chlorophyll content up to certain level and then decreased. Results were tuned with previous report. Fertilization can affect chlorophyll a and chlorophyll b content, thus affect crop yields through affecting photosynthesis process. In general nitrate reductase activity was more under higher nitrogen level. It is mainly involved in nitrogen assimilation by converting the nitrate to nitrite, can also mediate the Nitric oxide (NO) production from nitrite (9). NO is toxic and unstable free radicle gas its highly polygenic nature its self effect the leaf chlorophyll content. This might be the reason to decrease the chlorophyll content for increasing nitrogen concentration.

## CONCLUSION

Complete Yoshida media with nitrogen at highest concentration (N-200) gave the slowest germination rate, followed by N-150, N-100 and control. Whereas fastest germination was obtained in media lacking nitrate (N-0), so nitrate might be the most critical factor in delaying germination in rice. Basmati 370 was shown maximum and Ratnasundari was shown least in all germination parameters under all treatments along with control. Based on our results finally concluded that Basmati 370 was more tolerant and Ratnasundari was more sensitive to nitrogen stress. Among the all aromatic rice verities Basmati 370 was shown maximum value in all germination parameter, best seedling parameters and Chl. Content so is most suggested to farmers for field trials for sustainable rice production.

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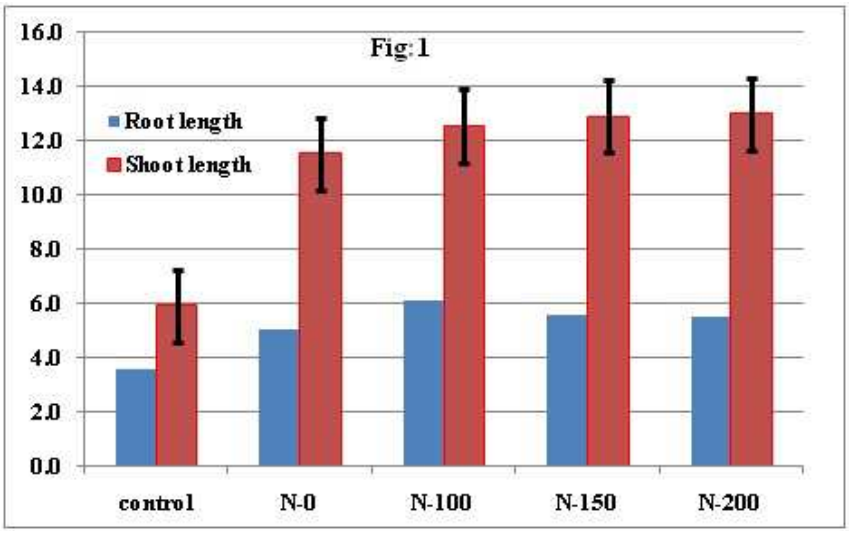


Fig 1: Influence of N levels on Root and Shoot length

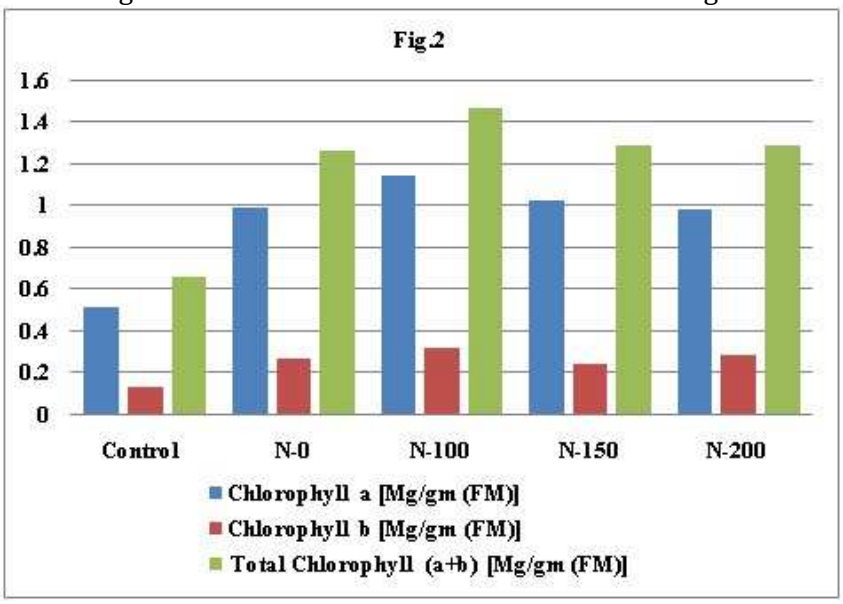


Fig 2: Irrespective of genotypes the effect of different N levels on Chlorophyll content.

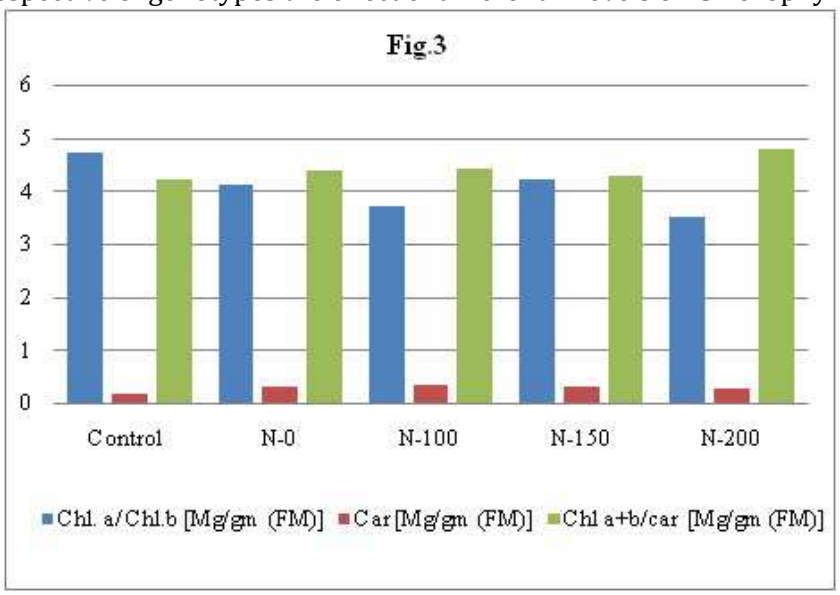


Fig-3: Irrespective of genotypes the effect of different N levels on Chlorophyll and Carotinoides content.

**Table 1:** The tested cultivars of rice significantly varied for averages of Final germination percentage (FGP), Mean daily germination (MDG) and Peak value (PV). Each value represents the mean of three replication. Significantly different at the P<0.05, P<0.01 level according to Fisher's LSD test.

| **Table.1:** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Final Germination Percentage** | | | | | | **Mean daily germination** | | | | | **Peak value** | | | | |
| **Genotypes** | **Control** | **N-0** | **N-100** | **N-150** | **N-200** | **control** | **N-0** | **N-100** | **N-150** | **N-200** | **control** | **N-0** | **N-100** | **N-150** | **N-200** |
| Basmati 370 | 98.0 | 100.0 | 100.0 | 99.0 | 99.3 | 14.0 | 14.3 | 14.3 | 14.1 | 14.2 | 19.60 | 28.89 | 16.19 | 28.60 | 28.71 |
| Ranbir Basmati | 94.0 | 98.0 | 86.0 | 94.0 | 94.0 | 13.4 | 14.0 | 12.3 | 13.4 | 13.4 | 15.18 | 22.87 | 15.24 | 18.80 | 21.93 |
| BPT 5204 | 98.0 | 100.0 | 94.0 | 96.0 | 96.0 | 14.0 | 14.3 | 13.4 | 14.2 | 14.2 | 22.90 | 28.89 | 15.26 | 28.82 | 23.18 |
| Badshahbhog | 98.0 | 98.0 | 98.0 | 96.0 | 96.0 | 14.0 | 14.0 | 14.0 | 13.7 | 13.7 | 15.87 | 28.36 | 19.60 | 19.20 | 22.42 |
| Dehradun Basmati | 96.0 | 100.0 | 100.0 | 96.0 | 95.0 | 13.7 | 14.3 | 14.3 | 14.3 | 13.7 | 19.20 | 23.33 | 16.19 | 28.89 | 22.43 |
| Krishna Joha | 96.0 | 100.0 | 99.0 | 96.0 | 98.0 | 13.7 | 14.3 | 14.1 | 14.3 | 14.0 | 19.20 | 20.00 | 19.80 | 20.00 | 19.60 |
| Kola Joha 3 | 92.0 | 96.0 | 100.0 | 98.0 | 96.0 | 13.1 | 13.7 | 14.3 | 14.3 | 14.3 | 18.40 | 22.42 | 23.33 | 16.19 | 28.89 |
| Ratnasundari | 82.0 | 68.0 | 67.0 | 62.0 | 60.0 | 11.7 | 9.7 | 10.3 | 12.1 | 11.6 | 13.20 | 11.01 | 14.40 | 13.73 | 13.11 |
| Mean | 94.3 | 95.0 | 93.0 | 92.1 | 91.8 | 13.5 | 13.6 | 13.4 | 13.8 | 13.6 | 17.9 | 23.2 | 17.5 | 21.8 | 22.5 |
| Grand Mean | 93.2 | | | | | 13.6 | | | | | 20.60 | | | | |
| | SED | LSD (0.05) | LSD (0.01) | | | SED | LSD (0.05) | LSD (0.01) | | | SED | LSD (0.05) | LSD (0.01) | | |
| Variety (V) | 0.51 | 1.02 | 1.35 | | | 0.07 | 0.15 | 0.19 | | | 1.47 | 2.92 | 3.87 | | |
| Treatment(T) | 0.40 | 0.80 | 1.07 | | | 0.06 | 0.12 | 0.15 | | | 1.16 | 2.31 | 3.06 | | |
| V*T | 1.14 | 2.27 | 3.02 | | | 0.16 | 0.33 | 0.43 | | | 3.28 | 6.52 | 8.65 | | |
| CV% | 1.36 | | | | | 1.37 | | | | | 17.71 | | | | |
| S/NS | S | S | S | | | S | S | S | | | S | S | S | | |

**Table 2:** The tested cultivars of rice significantly varied for averages of Germination value (GV), Rate of germination (GR), Mean of germination time (MGT). Each value represents the mean of three replication. Significantly different at the P<0.05, P<0.01 level according to Fisher's LSD test.

| Table 2: | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Germination value** | | | | | **Rate of germination (%)** | | | | | **Mean germination time** | | | | |
| | **control** | **N-0** | **N-100** | **N-150** | **N-200** | **control** | **N-0** | **N-100** | **N-150** | **N-200** | **control** | **N-0** | **N-100** | **N-150** | **N-200** |
| Basmati 370 | 274.5 | 412.7 | 231.3 | 404.5 | 407.6 | 0.0 | 32.0 | 6.0 | 16.2 | 66.0 | 3.9 | 2.7 | 3.1 | 2.8 | 2.3 |
| Ranbir Basmati | 203.4 | 320.1 | 187.0 | 252.6 | 294.5 | 0.0 | 20.4 | 18.6 | 21.3 | 17.0 | 4.1 | 2.9 | 3.1 | 2.9 | 3.0 |
| BPT 5204 | 321.2 | 412.7 | 205.5 | 410.8 | 329.1 | 12.2 | 94.0 | 80.9 | 60.0 | 76.0 | 2.9 | 2.1 | 2.3 | 2.4 | 2.3 |
| Badshahbhog | 222.1 | 397.6 | 274.5 | 263.3 | 307.7 | 34.7 | 42.9 | 57.1 | 37.5 | 31.3 | 2.8 | 2.6 | 2.6 | 2.7 | 2.8 |
| Dehradun Basmati | 263.3 | 333.3 | 231.3 | 412.7 | 308.2 | 0.0 | 32.0 | 20.0 | 28.0 | 14.6 | 3.5 | 2.8 | 3.1 | 2.7 | 3.0 |
| KrishnaJoha | 263.4 | 285.7 | 280.0 | 285.7 | 274.4 | 0.0 | 38.0 | 45.8 | 14.0 | 28.6 | 3.5 | 2.8 | 2.8 | 3.0 | 3.0 |
| Kola Joha 3 | 241.8 | 307.7 | 333.3 | 231.3 | 412.7 | 45.7 | 57.7 | 82.0 | 56.0 | 80.3 | 2.6 | 2.5 | 2.2 | 2.7 | 2.2 |
| Ratnasundari | 154.0 | 106.9 | 148.1 | 166.4 | 151.8 | 4.9 | 17.6 | 27.8 | 4.5 | 25.0 | 3.5 | 3.1 | 2.8 | 3.1 | 3.2 |
| Mean | 243.0 | 322.1 | 236.4 | 303.4 | 310.7 | 12.2 | 41.8 | 42.3 | 29.7 | 42.4 | 3.4 | 2.7 | 2.7 | 2.8 | 2.7 |
| Grand Mean | 283.12 | | | | | 33.66 | | | | | 2.86 | | | | |
| | SED | LSD (0.05) | LSD (0.01) | | | SED | LSD (0.05) | LSD (0.01) | | | SED | LSD (0.05) | LSD (0.01) | | |
| Variety (V) | 20.88 | 41.56 | 55.15 | | | 0.35 | 0.69 | 0.92 | | | 0.05 | 0.11 | 0.14 | | |
| Treatment(T) | 16.51 | 32.86 | 43.60 | | | 0.27 | 0.55 | 0.72 | | | 0.04 | 0.08 | 0.11 | | |
| V*T | 46.70 | 92.93 | 123.31 | | | 0.77 | 1.54 | 2.05 | | | 0.12 | 0.24 | 0.31 | | |
| CV% | 18.40 | | | | | 2.95 | | | | | 5.14 | | | | |
| S/NS | S | S | S | | | S | S | S | | | S | S | S | | |

**Table: 3**: Variation in leaf pigment content [mg g-1 FM] in rice genotypes. Each value represents the mean of three replications. Each value represents mean of three replications ±SD. Means followed by different letters in the same column are significantly different at the P<0.05 level according to Fisher's LSD test.

**Table: 3**

| | **Chlorophyll a [Mg/gm (FM)]** | | | | | **Chlorophyll b [Mg/gm (FM)]** | | | | | **Total Chlorophyll [Mg/gm (FM)]** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Control** | **N-0** | **N-100** | **N-150** | **N-200** | **Control** | **N-0** | **N-100** | **N-150** | **N-200** | **Control** | **N-0** | **N-100** | **N-150** | **N-200** |
| Basmathi 370 | 0.42 vw | 0.86 p | 1.0 h | 1.1 gh | 0.96 lm | 0.17 mnop | 0.39 bc | 0.33 cdefg | 0.29 defghij | 0.36 cd | 0.59 r | 1.25 ij | 1.42 g | 1.40 g | 1.33 h |
| Ranbir basmathi | 0.44 v | 1.11 gh | 1.45 b | 1.1 gh | 0.89 op | 0.13 opq | 0.33 cdefg | 0.46 ab | 0.32 cdefghi | 0.26 ghij | 0.57 r | 1.44 fg | 1.91 b | 1.43 g | 1.15 lm |
| BPT 5204 | 0.42 vw | 0.89 op | 0.94 mn | 0.91 no | 0.50 u | 0.15 op | 0.25 ghijk | 0.28 efghijk | 0.26 ghijk | 0.16 nop | 0.57 rs | 1.15 lm | 1.21 jkl | 1.17 klm | 0.66 pq |
| Badshahbhog | 0.44 v | 1.00 jk | 0.98 kl | 1.0 jk | 1.14 fg | 0.17 mnop | 0.25 hijkl | 0.26 ghijk | 0.26 ghijk | 0.32 cdefghi | 0.62 qr | 1.25 ij | 1.24 ijk | 1.26 hij | 1.46 fg |
| Dehradun Basmathi | 0.44 v | 1.02 ij | 1.41 c | 1.1 gh | 1.22 e | 0.06 qr | 0.24 jklmn | 0.35 cde | 0.28 defghij | 0.27 fghijk | 0.50 s | 1.26 hij | 1.76 c | 1.40 g | 1.50 ef |
| Krishnajoha | 0.39 w | 1.05 j | 0.77 r | 1.1 f | 1.26 d | 0.04 r | 0.24 ijklm | 0.20 klmno | 0.27 fghijk | 0.34 cdef | 0.43 t | 1.3 hi | 0.97 no | 1.43 fg | 1.60 d |
| Kolajoha-3 | 0.86 p | 1.48 b | 1.85 a | 1.0 ij | 1.2 e | 0.17 lmnop | 0.37 c | 0.48 a | 0.21 jklmno | 0.32 cdefgh | 1.03 n | 1.85 b | 2.34 a | 1.24 ijk | 1.54 de |
| Ranthnasundari | 0.77 r | 0.59 t | 0.73 s | 0.82 q | 0.79 qr | 0.20 klmnop | 0.1 pqr | 0.17 lmnop | 0.15 op | 0.32 cdefghi | 0.97 no | 0.69 p | 0.91 o | 0.976 no | 1.11 m |
| **Mean** | **0.52 d** | **1.0 c** | **1.15 a** | **1.03 b** | **0.99 c** | **0.14 d** | **0.27 bc** | **0.32 a** | **0.25 c** | **0.29 ab** | **0.66 c** | **1.27 b** | **1.47 a** | **1.29 b** | **1.28 b** |
| LSD | Treatment | 0.0126 | | | | Treatment | 0.0272 | | | | Treatment | 0.0244 | | | |
| | variety | 0.016 | | | | variety | 0.0345 | | | | variety | 0.0308 | | | |
| | T X V | 0.0357 | | | | T X V | 0.077 | | | | T X V | 0.069 | | | |
| CV% | | 2.33 | | | | CV% | 18.43 | | | | CV% | 3.53 | | | |

Table: 4: Variation in Chl. a/b ratio and Carotinoides content [mg g-1 FM] in rice genotypes. Each value represents the mean of three replications. Each value represents mean of three replications ±SD. Means followed by different letters in the same column are significantly different at the P<0.05 level according to Fisher's LSD test.

| **Table: 4** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Chl. a/ Chl.b [Mg/gm (FM)]** | | | | | **Car [Mg/gm (FM)]** | | | | | **Chl a+b/car [Mg/gm (FM)]** | | | | |
| | **Control** | **N-0** | **N-100** | **N-150** | **N-200** | **Control** | **N-0** | **N-100** | **N-150** | **N-200** | **Control** | **N-0** | **N-100** | **N-150** | **N-200** |
| Basmathi 370 | 2.4 jk | 2.24 k | 3.28 fghijk | 3.94 efghij | 2.66 ijk | 0.13 o | 0.42 b | 0.29 efghi | 0.29 efgh | 0.25 hijk | 4.68 defg | 2.98 kl | 4.84 cdef | 4.74 defg | 5.21 bcd |
| Ranbir basmathi | 3.26 fghijk | 3.38 efghijk | 3.15 ghijk | 3.52 efghijk | 3.41 efghijk | 0.15 no | 0.30 efgh | 0.41 b | 0.31 def | 0.26 ghij | 3.78 ghijk | 4.9 bcdef | 4.62 defg | 4.63 defg | 4.41 defg |
| BPT 5204 | 2.84 hijk | 4.58 defg | 3.38 efghijk | 3.83 efghijkl | 3.32 fghijk | 0.14 o | 0.23 jklm | 0.26 hij | 0.28 fghi | 0.31 efg | 4.05 fghij | 5.13 bede | 4.75 defg | 4.25 defghij | 2.42 l |
| Badshahbhog | 2.72 hijk | 4.06 defghij | 3.74 efghijk | 3.88 efghij | 3.56 efghijk | 0.11 o | 0.25 hijkl | 0.33 cde | 0.29 efgh | 0.33 cde | 5.80 abc | 4.99 bedef | 3.77 ghijk | 4.27 defghij | 4.39 defgh |
| Dehradun Basmathi | 7.27 b | 4.32 defgh | 3.97 efghij | 4.033 defghij | 4.56 defg | 0.15 o | 0.3 efgh | 0.36 cd | 0.32 def | 0.36 cd | 3.42 hijkl | 4.33 defghij | 4.91 bcdef | 4.36 defghij | 4.15 efghij |
| Krishnajoha | 10.16 a | 4.32 defgh | 3.93 efghij | 4.25 defghi | 3.67 efghijk | 0.13 0 | 0.3 efgh | 0.21 lm | 0.32 def | 0.33 cde | 3.36 ijkl | 4.38 defghi | 4.78 cdefg | 4.49 defg | 4.85 cdef |
| Kolajoha-3 | 4.99 cde | 4.12 defghi | 3.84 efghijk | 4.85 cdef | 3.66 efghijk | 0.25 ijklm | 0.38 bc | 0.49 a | 0.29 efghi | 0.22 jklm | 4.19 defghij | 4.93 bcdef | 4.78 cdefg | 4.22 defghij | 6.83 a |
| Ranthnasundari | 4.01 efghij | 6.46 bc | 4.72 defg | 5.65 cd | 3.12 ghijk | 0.22jklm | 0.21 klm | 0.31 def | 0.29 efghi | 0.2 mn | 4.48 defg | 3.32 jkl | 2.95 kl | 3.38 hijkl | 5.88 ab |
| **Mean** | **4.71 a** | **4.1 ab** | **3.7 bc** | **4.2 ab** | **3.49 c** | **0.1608 c** | **0.2983 b** | **0.3342 a** | **0.3021 b** | **0.2854 b** | **4.22 b** | **4.37 b** | **4.42 ab** | **4.29 b** | **4.77 a** |
| LCD | Treatment | 0.5732 | | | | Treatment | 0.0172 | | | | Treatment | 0.3643 | | | |
| | variety | 0.7251 | | | | variety | 0.0218 | | | | variety | 0.4608 | | | |
| | T X V | 1.6213 | | | | T X V | 0.0487 | | | | T X V | 1.0303 | | | |
| CV% | | 24.44 | | | | CV% | 10.85 | | | | CV% | 14.34 | | | |