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Physiological indices and nutritional quality analysis of rice (*Oryza sativa* L.) genotypes

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Abstract
The experiment was conducted in field and lab with twelve rice genotypes *viz*., NDR-97, NDR-2064, NDR-2065, Bralu, NDR-359, Lalat, MTU-1010, Pusa Basmati, IR-64, Sambha sub-1, Nagina-22 and Kalanamak, were sown in the Nursery bed After 25 days single seedling per hill were planted in a randomized block design (RBD) with three replications of 3m length under normal field condition and a set in earthen pot in net house. All the growth parameters were recorded at various stages of crop growth *i.e.* at Maturity stage. All the physiological traits and biochemical activities were recorded at one stages of crop growth. Physiological traits/growth parameters *viz*. Days to 50% flowering, Plant height (cm), Days to maturity, Number of tillers per plant, Number of grains per panicles, Test weight (1000 grains weight), Grain yield, and biochemical analysis parameters *viz.* Carbohydrate content, Protein content and Starch content.

Keywords: Rice, nutritional quality, protein, carbohydrate, starch

Introduction
Rice is the world's single most important food crops and primary food source for one third of the world population. Within the country rice occupies 1/3 of the total cropped area, contributes about 40 to 43% of total food grain production and continues to play a key role in the national food and livelihood security system. India is the second largest rice producing country in the world after China; as it is grown in almost all the state of India. The total cultivable area of India is 143 million hectare out of which 43.79 million hectare area is utilized for rice cultivation with total production of rice during 2019-20 is estimated at record 117.47 million tones it is higher by 9.67 million tones than the five years average production of 107.80 million tones. Uttar Pradesh has largest area of rice 5.87 million hectare with production of 12.51 million tones. (MoA&FW- 2021)
Therefore global food security is to a large extent dependent upon the performance of rice. However with changing time and situation focus on rice research have diversified. Because of this new aspect of rice are coming to light.
Rice is a dietary staple foods and one of the most important cereal crops, especially for people in Asia, but the consumption outside Asia has increased, recently. It provides the bulk of daily calories for many companion animals and humans. The glycemic index is one of the popular issues in the world, and people are rethinking whether consume rice or not. Some study showed that rice consumption is related to the higher risk of diabetes mellitus (McKeown *et al*., 2002) [1].
Therefore, these toxic elements present in food should be controlled in order to meet the quality of rice. Some countries have set up the maximum limit of these toxic elements in Nutrients and rice consumption The nutrients content of rice were varies depending on the variety of rice soil, and the conditions they growth. Rice contributes to the major dietary energy for body. Pre-germinated brown rice has protein two times more than white rice, *i.e.* 14.6 g/100 g (brown rice) 7.3 g/100 g (white rice). In the other hand, the fat content is so high, namely 24.8 g/100 g for pre-germinated brown rice and 1.5 g/100 g for white rice. The amino acid profile of rice shows that glutamic and aspartic acids are the major amino acids present in rice, while lysine is the limiting amino acid (FAO, 2004) [2].
The harvested unprocessed rice is known as paddy rice and needs to undergo milling for human consumption. As part of the processing, the protective hull is removed, leaving only the actual rice kernel which is called brown rice.

Paddy rice comes in many different colors, including brown, red, purple, and even black. The brown rice is composed of bran layers (6–7% of its total weight), embryo (2–3%), and endosperm (about 90%) (Chen *et al*., 1998) [3].

A new method has been developed to achieve high-lysine content of rice, using over-accumulation of lysine-rich BiP (binding protein) in the endosperm. Several types of rice (commercial samples of brown, parboiled brown, parboiled milled and milled rice) had similar protein and crude fat contents, however, the ash contents among types of rice were slightly different, mainly among milled samples (Heinemann *et al*., 2005) [4].

Materials and methods

The experiment was conducted in field and lab with twelve rice genotypes *viz*., NDR-97, NDR-2064, NDR-2065, Bralu, NDR-359, Lalat, MTU-1010, Pusa Basmati, IR-64, Sambha sub-1, Nagina-22 and Kalanamak, were sown in the Nursery bed After 25 days single seedling per hill were planted in a randomized block design (RBD) with three replications. and a set in earthen pot in net house. The investigation was carried out at Student Instructional Farm and Laboratory in the Department of Plant Molecular Biology and Genetic Engineering, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) India during the *Kharif* season 2019-20 and 2020-21. The geographical situation of Ayodhya district lies between a latitude range from 24º 47" north to 26 º 56" north and longitudes of 81º 12" east and 83º 98" east, an altitude of 113 meters above the mean sea level in the gangtic alluvium soil of Eastern Uttar Pradesh. All the growth parameters were recorded at various stages of crop growth *i.e.* at Maturity stage. All the physiological traits and enzymatic activities were recorded at one stages of crop growth. Physiological traits/growth parameters *viz*. Days to 50% flowering, Plant height (cm), Days to maturity, Number of tillers per plant, Number of tillers per plant, Number of grains per panicles, Test weight (1000 grains weight) and Grain yield, and biochemical analysis parameters *viz.* Carbohydrate content, Protein content and Starch content.

Results and discussion

Days to 50% flowering

The data regarding days to 50% flowering was ranged from 72 days to 110 days which highest was recorded in Kalanamak 110 days followed by Lalat (84.66) and Nagina-22 respectively while minimum number of days taken for achieving 50% flowering was reported in Sambha Sub-1 (69 Days) which was followed by NDR-2065 (72.66) and NDR-97 (72.67days) respectively similar result obtained by the other researcher (Gupta *et al.*, 1999) [5].

Plant height (cm)

The character plant height (cm) was ranged from 92.33 cm to 149 cm highest plant height was reported in Kalanamak (149cm) followed by Nagina-22 (122.66 cm) and Sambha Sub-1 (114.33cm) respectively minimum plant height reported in NDR-359 (92.33cm) which was followed by NDR-97 (100cm) and MTU 1010 (100 cm) respectively. The findings are in agreement with those of other research stated that longer internodes increased plant heights in rice genetic differences between different varieties also caused variation in plant lengths. Similar results were described that plant height depends on genetic character of a plant and environmental conditions (Kanegana MZ and Kargbo AM 2011) [6].

Days to maturity

The data regarding days to maturity was ranged from 98.33 (NDR-97) days to 148.66 days Kalanamak followed by NDR-2065 (132.66 days) and Bralu (131.66) respectively were recorded having maximum days to maturity while minimum number of days taken for achieving maturity was reported in NDR-97 followed by NDR-2065 (117 days) and Nagina-22 (119.66 days) respectively. Maturity expressed in days exhibited greater heritability along with least genetic advance in percent of mean, expressing non-additive gene influence and expression can be partitioned greatly by non-genetic factors (Debi *et al*., 1997) [7].

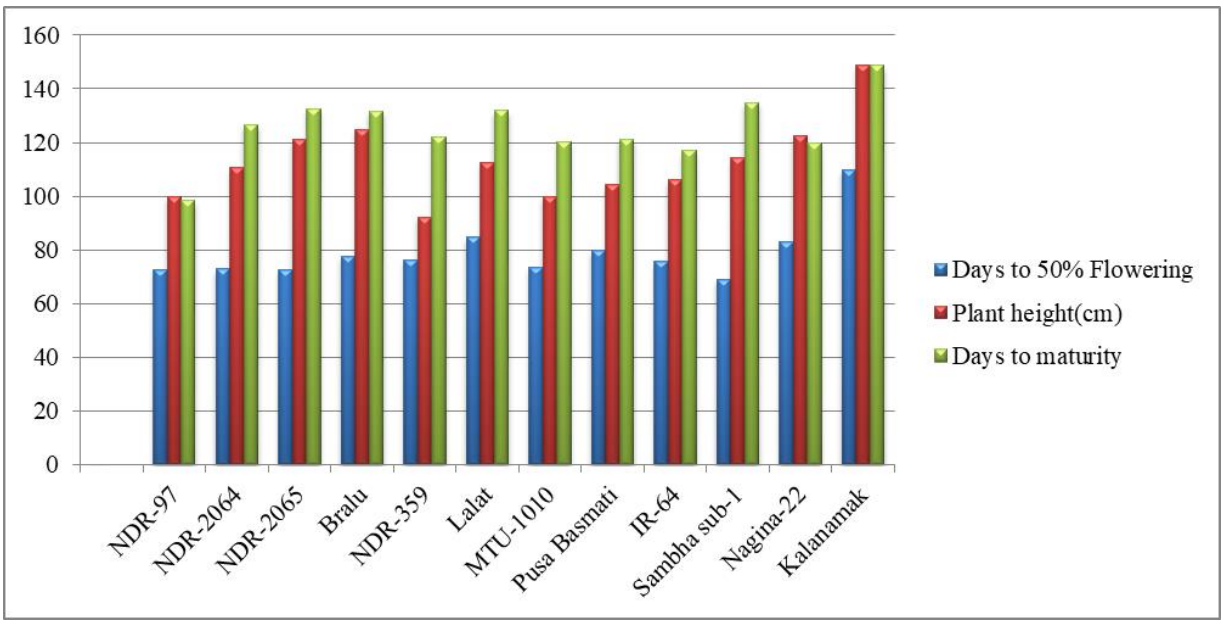

Fig 1: Days to 50% flowering, Plant height (cm) and Days to maturity of twelve rice genotypes

Number of tillers plant^{-1}

The data related to number of tillers per plant varied from 12.33 to 21 highest number of tillers was reported in IR-64 (21) followed by Pusa Basmati (20.66) NDR-2065 (19.66) and NDR-2064 (19.33) respectively while minimum number of tillers plant^{-1}was reported in NDR-359 (12.33), which was followed by Kalanamak (13.66) and MTU-1010 (14.66) respectively. The diversity in the genetic makeup of the variety is the cause of the variability in the number of effective tillers per plant. Ramasamy *et al.*, (1987) [8] reported a similar result, stating that varietal variation affected the quantity of tillers. Rice grain yield is heavily influenced by tillering ability.

Number of panicles plant^{-1}

The data concerning of panicles per plant was ranged from 10.66 to 19.66 maximum number of panicles was reported in IR-64 (19.66) followed by Pusa Basmati (19.33) and NDR-2065 (17.66) respectively. Minimum number of panicles per plant was reported in NDR-359 (10.66), which was followed by Kalanamak (11.66) and MTU-1010 (13.66) respectively. Morphological and yield-associated traits have frequently been used as a criterion to evaluate phenotypic variability and as the basis for the enhancement of rice-yield potential. In rice, the yield is associated with several component traits (Li *et al.*, 2014) [9], including panicle number per unit area, filled grains per panicle, and 1,000-grain weight (Yoshida, Satake & Mackill, 1981) [10].

Number of grains panicles^{-1}

The data in respect to number of grains per panicles was ranged from 135.66 to 196.66 the highest number of grains per panicle were reported in IR-64 (196.66) followed by NDR-2064 (177.33) and NDR-2065 (177) respectively minimum number of panicles per plant was reported in Lalat (135.66) followed by Sumbha Sub-1 (142) and Bralu (145) respectively similar findings were proved by Subramani *et al.*, (2014) [11] recorded highest number of grains per panicle among the other varieties.

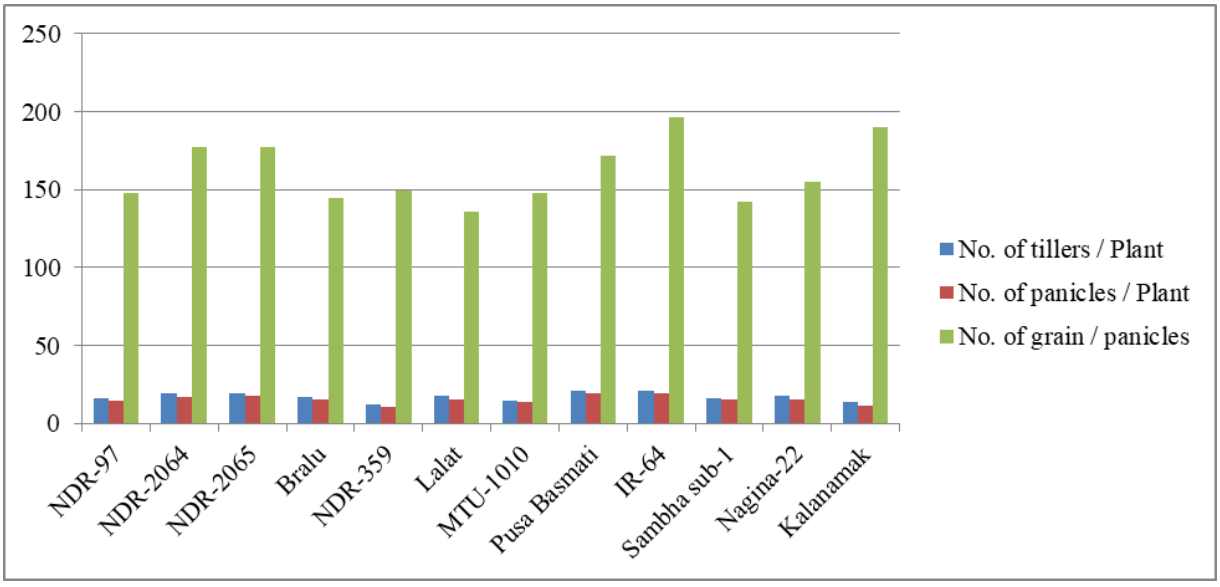

Fig 2: Number of tillers / Plant, Number of panicles per plant and Number of grain per panicles of twelve rice genotypes

Test weight (1000 grains weight)

The data regarding test weight (1000 grains weight) was recorded to be ranged from 18g to 21.66g. Maximum test weight was reported in Bralu (21.66g) followed by Nagina-22 (21.33g) and NDR-2065 (21g) respectively minimum test weight was reported in IR-64 and Pusa Basmati (18g) followed by NDR-97, NDR-2064, Lalat, Sambha Sub-1 and Kalanamak having 19g test weight each respectively. Similar result reported by the Satapathy and Nanda (1997), Xin *et al.* (2000) [12] reported that 1000-grain weight significantly varied with different varieties. The grains of Aghonibora recorded the highest 1000-grain weight (26.01 g) Singh *et al.*, (2013) [13].

Grain yield

Data related to Grain yield / Plant is one of the most important parameter in determining the potential of a variety Grain yield was recorded to be ranged from 38g to 19 g. Maximum grain yield was reported in IR-64 (38g) followed by NDR-2065 (31g) and NDR-2064 (29.33g) respectively while minimum Grain yield was reported in MTU-1010 (19g) and Kalanamak (21g each) followed by Bralu, NDR-2064, Lalat, Sambha Sub-1 having 20.66 g test weight each respectively. Similar results were proved by Subramani *et al.*, (2014) [11].

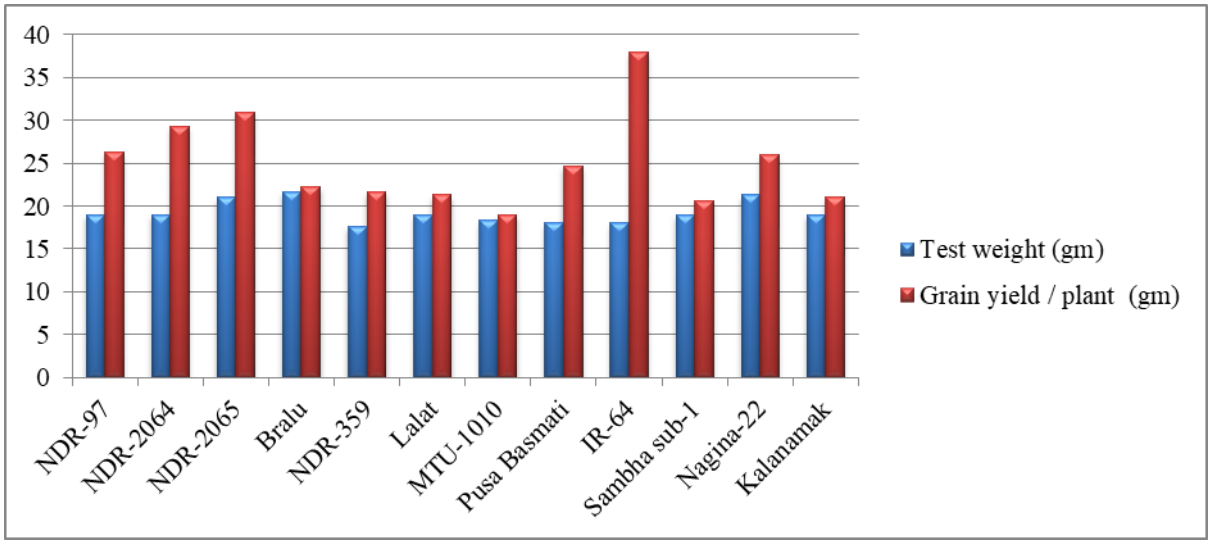

Fig 3: Test weight (gm) and Grain yield per plant (gm) of twelve rice genotypes

Carbohydrate content

Data with respect carbohydrate content was ranged from 49.33% to 80% is presented in to (Table) maximum Carbohydrate content were observed in Kalanamak (80%) followed by NDR-2065 (74.66%) and NDR-2064 (71%) respectively while minimum carbohydrate content was reported in Pusa Basmati (49.33%) followed by MTU-1010 (65%) and Bralu (57.66%) respectively. Significant correlation obtained regarding the carbohydrate content of various rice genotype. Similar results were also obtained by other researchers Asia alone derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7-8% protein, 3% fat, and 3% fibre (Juliano, 1985) [14].

Protein content

Data related to protein content was ranged from 6.66% to 10% highest protein content were reported in Kalanamak (10%) followed by NDR-2065 (8%) and NDR-2064 (7.65%) while minimum protein content was reported in Pusa Basmati (6.66%) followed by Bralu (6.80%) and MTU-1010 (6.85%) respectively. This clearly indicates the existence of wide genetic variability for protein and lysine contents in rice. Similarly, Riza *et al*. (2003) showed 6.3 % - 9.1 % grain proteins levels in 438 rice cultivars. Our results are in conformity with the findings of Chandel *et al*. (2005) [15].

Starch content

Data concerning starch content was ranged from (76.30% To 90.30%) maximum starch content were reported in Pusa Basmati (90.30%) followed by IR-64 (88.30%) and NDR-359 (88.00%) respectively while minimum starch content was reported in Kalanamak (74.90%) followed by Bralu (76.30%) and MTU-1010 (77%) respectively. The starch content of hill rice cultivars ranged from 70.31 to 78.13% and was found to be lower than the glutinous and non-glutinous rice varieties of Assam (Dutta and Baruah, 1978) [16] but higher than those of boro and scented rice varieties (Deka, 2003 and Ahmed, 2003) [17].

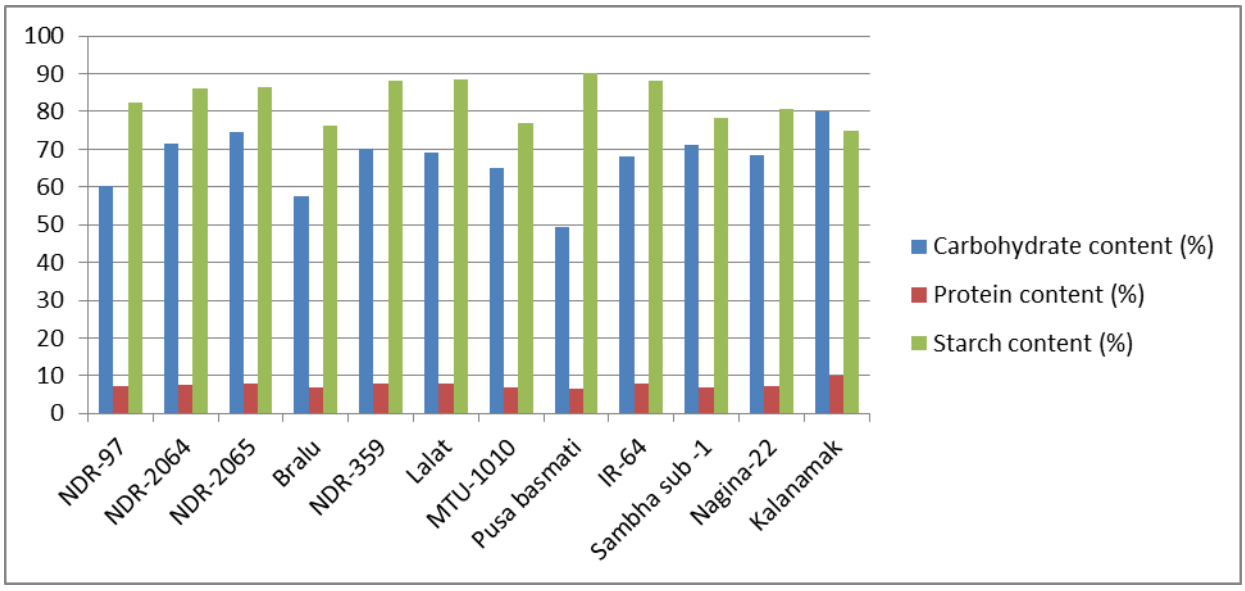

Fig 4: Carbohydrate content, Protein content (%) and Starch content (%) in twelve rice genotypes (%)

Conclusion

The data regarding highest carbohydrate and Protein content was recorded in Kalanamak rice while minimum in Pusa Basmati respectively.

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