Differential growth and yield response of hybrid rice (*Oryza sativa* L.) to seasonal variability

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**ABSTRACT**

The response of hybrid rice to seasonal changes is largely unknown. This study presents the effort to assess the response of tropical hybrid rice to rainy and winter seasons in alluvial soils at Regional Research Sub-Station under Bidhan Chandra Krishi Viswavidyalaya, Chakdah, West Bengal. Five commercial tropical hybrid rice cultivars together with a local HYV were evaluated in randomized complete block design with three replications. The variety NPH-207 (Champion) produced taller plants and recorded significantly higher number of effective tillers than the local HYV (Satabdi) did during both the seasons. The cultivar NPH-8889 (Karishma) recorded the maximum chlorophyll content at all dates of observations and it was statistically at par with NPH-207 (Champion). The values of all measured yield components were higher in the hybrid cultivar NPH-207 (Champion) in comparison with any other tested cultivars. Consequently, NPH-207 (Champion) produced significantly higher grain and straw yield, accounting 67.9 and 50.1% more than those obtained from HYV in rainy season, while 98.2 and 103% more than those obtained from HYV in winter season, respectively. The significant and positive correlations with grain yield were observed between plant height, 1000 grain weight and chlorophyll content at 30 DAT both in rainy and winter season.

**Key words:** Chlorophyll content, Growth, High yielding variety, Hybrid rice, Yield.

**INTRODUCTION**

Rice (*Oryza sativa* L.) is one of the most important cereal crops in our country as well as West Bengal for the dietary energy requirements for almost 60% of the population. The 1st green revolution in the era of 1960s led to an increase in the yield of rice from less than 1.5 t ha⁻¹ to 8-10 t ha⁻¹ (Prasad, 2012) in our country. With growing prosperity and urbanization, the total area under rice cultivation in the country is decreasing at rapid rate; however, the demand for rice in the future is bound to increase with the growing population (Banerjee and Pal, 2011). India’s population is projected to be 1.301 and 1.378 billion by 2020 and 2030 (Goyal and Singh, 2002). In West Bengal, the expected demand for rice by 2020 AD is around 17.6 million tonnes, which is nearly 16 percent more than that of present rice production of 14.9 million tonnes (Mondal *et al*., 2012). However, in order to meet the domestic demand of the increasing population the present-day production of about 100 million tonnes of rice must be increased to 130 million tonnes by 2050 (Jackson, 1967). In West Bengal, the expected demand for rice by 2020 AD is around 17.6 million tonnes, leaving a gap of about 10 M t. The yield of present high yielding cultivars (HYVs) of rice has become plateau, and it is rather difficult to achieve this target with the present day HYVs with best management practices (Banerjee and Pal, 2009).

Among the limited options, hybrid technology is the only proven technology currently available for stepping up rice production significantly. The rice hybrids give 20-30% higher yield on an average over the conventional high yielding varieties (Banerjee and Pal, 2012). Hybrid rice technology has provided farmers with high yields, saved land for agricultural diversification and created rural employment opportunities. Therefore, the introduction and standardization of production technology of hybrids rice considering seasonal variability is not only needed to achieve targeted production level but also to popularize hybrid rice technology amongst the rice growers of West Bengal.

**MATERIALS AND METHODS**

Field experiment was carried out during rainy and winter seasons of 2013-14 at Regional Research Sub-Station (NAZ), Bidhan Chandra Krishi Viswavidyalaya, Chakdah, West Bengal (23°5.3’N latitude, 83°5.3’E longitude and 9.75 m above mean sea level). The climate of the region is humid-tropic with moderately cool winter (Fig. 1). The experimental soil (0-30 cm depth) was sandy clay loam in texture (46.5% sand, 25.0% silt and 28.5% clay), with a pH of 7.1 (Jackson, 1967) and electrical conductivity of soil solution 0.06 dS m⁻¹ (Jackson, 1967). It contained 0.68% organic carbon (Jackson, 1973); and available N, P and K at 126.0 kg N ha⁻¹ (Subbiah and Asija, 1956), 16.0 kg P ha⁻¹ (Olsen *et al*., 1954) and 155.5 kg K ha⁻¹ (Hanway and Heidel, 1952), respectively.

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The experiment was arranged in randomized complete block design replicated thrice, with individual gross plot area of 5 m × 4 m. Five rice hybrids (NPH-567/Winner, NPH-207/Champion, NPH-369/Raja, NPH-8899/Karishma and NPH-924-1) and a local HYV (IET-4786/Satabdi) were tested. Seedlings of 25 and 40 days old were manually transplanted on August 2 and February 1 during rainy and winter seasons, respectively, at a spacing of 20 × 15 cm with one seedling per hill. The fertilizer dose during rainy season was 80 kg ha⁻¹ nitrogen as urea, 40 kg ha⁻¹ phosphorus as single super phosphate and 40 kg ha⁻¹ potassium as muriate of potash, while during winter season the dose was 150 kg, 75 kg and 75 ha⁻¹ respectively (Department of Agriculture, GoWB, 2012). Half dose of urea was applied as basal and the rest amount in two equal splits at 21 and 42 DAT. Entire amounts of SSP were given as basal at the time of final land preparation. MOP was applied in two splits viz. 75% as basal and rest 25% as top dressing (42 DAT). The ponding depth of water in the field was kept at about 2 cm at transplanting and about 5 cm from crop establishment until maturity. Manual weeding was done whenever required. In each plot, third row was marked for destructive sampling as well as for recording different biometric observations. Leaf chlorophyll content was determined calorimetrically as per the DMSO (Dimethyl sulphoxide) method as stated by Shoaf and Lium (1976). Ten panicles were randomly selected from each plot to determine 1000-grain weight and number of grains per panicle and other yield parameters. The middle two rows were marked for the determination of seed yield.

Data on growth and yield of rice hybrids were analyzed using analysis of variance (ANOVA) technique to evaluate the differences among treatments while the means were separated using the critical difference (CD) test at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters: Plant height of all rice varieties was increased with the increasing age of the plant up to 60 DAT (Table 1). Taller plants were produced by all the tested hybrids as compared to HYV (Satabdi) in both the seasons. The variety NPH-207 (Champion) achieved the maximum plant height followed by NPH-924-1. These findings are in agreement with previous reports (Mandal and Mandal, 2015; Biswas et al., 2017). The yield parameters, such as grain yield, harvest index, and biological yield, were also influenced by the planting date and variety. The results showed that the HYV performed better in terms of grain yield and harvest index than the hybrids, indicating the potential of local cultivars in rice cultivation.

Fig 1 [a-b]: Weather parameters during the cropping season.
line with that of Banerjee and Pal (2012). Effective tillers plant$^{-1}$, the most important yields determining trait measured at the time of harvesting recorded significant differences among tested rice cultivars in both the seasons (Table 1). The tested hybrid rice cultivars produced a greater number of effective tillers plant$^{-1}$ during winter season than rainy season. The hybrid cultivar NPH-207 (Champion) recorded significantly higher number of effective tillers, accounting 35.3 and 33.9% more than local HVY (Satabdi) during rainy and winter season, respectively. Other investigators also found that hybrid rice cultivars have higher tillering ability than conventional varieties (Chandrasekhar et al., 2001; Pandey et al., 2001; Maiti et al., 2006), which might have governed by the genotypic makeup of rice hybrids (Swain et al., 2006).

**Chlorophyll content**: Leaf chlorophyll of all tested cultivars was considerably higher in winter season than that in rainy season cultivars. This may be due to higher bright sunshine

**Table 1**: Growth attributes and phenology of rice cultivars.

| Cultivars            | Plant height (cm) | Chlorophyll content (mg g$^{-1}$ of leaf fresh weight) | Effective tillers plant$^{-1}$ at harvest | Days to 50% flowering | Days to 100% flowering | Seed to seed duration (days) |
|----------------------|-------------------|---------------------------------------------------------|------------------------------------------|-----------------------|------------------------|-----------------------------|
|                      | 30 DAT | 60 DAT | At harvest | 30 DAT | 60 DAT | Rainy season | Winter season |
| NPH-567 (Winner)     | 73.3    | 87.0   | 85.6       | 2.95   | 1.98   | 9.0          | 89          | 103          | 145          |
| NPH-207 (Champion)   | 77.9    | 94.9   | 89.3       | 3.11   | 2.03   | 11.5         | 67          | 85           | 135          |
| NPH-924-1            | 66.3    | 86.3   | 84.5       | 2.86   | 1.47   | 9.8          | 69          | 83           | 129          |
| NPH-369 (Raja)       | 69.3    | 87.8   | 84.3       | 2.90   | 1.14   | 10.0         | 73          | 88           | 127          |
| NPH-8889 (Karishma)  | 70.9    | 86.8   | 84.0       | 3.14   | 2.24   | 10.5         | 70          | 77           | 124          |
| Satabdi (Local HYV)  | 60.8    | 75.8   | 76.0       | 2.16   | 0.76   | 8.5          | 80          | 92           | 111          |
| S.Em (±)             | 1.22    | 1.23   | 1.66       | 0.04   | 0.03   | 0.64         | -           | -            | -            |
| CD (P=0.05)          | 3.54    | 3.56   | 4.80       | 0.07   | 0.08   | 1.86         | -           | -            | -            |

**Table 2**: Yield components and yields of rice cultivars.

| Cultivars            | Panicle length (cm) | Panicle weight (g) | Number of filled grains panicle$^{-1}$ | 1000 grain weight (g) | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Harvest index (%) |
|----------------------|---------------------|--------------------|----------------------------------------|------------------------|---------------------------|------------------------|------------------|
|                      | 30 DAT | 60 DAT | Rainy season | Winter season |
| NPH-567 (Winner)     | 22.27  | 2.67   | 147.40       | 247.40  | 21.95 | 6.18 | 6.23 | 49.79 |
| NPH-207 (Champion)   | 24.55  | 2.91   | 143.20       | 149.30  | 21.76 | 5.97 | 5.95 | 50.08 |
| NPH-924-1            | 22.40  | 2.47   | 149.30       | 138.90  | 20.42 | 5.93 | 5.13 | 53.62 |
| Satabdi (Local HYV)  | 22.52  | 1.99   | 118.30       | 113.40  | 20.63 | 5.67 | 5.68 | 49.96 |
| S.Em (±)             | 0.58   | 0.25   | 1.04         | 1.49    | 0.64  | 0.14 | -    | -    |
| CD (P=0.05)          | 1.68   | 0.78   | 2.96         | 1.99    | 0.64  | 0.44 | -    | -    |

DAT, days after transplanting
Table 3: Correlation coefficient (‘r’) of grain yield with different growth attributes and yield components.

| Parameters                                      | Rainy season | Winter season |
|-------------------------------------------------|--------------|---------------|
| Grain yield (t ha\(^{-1}\)) vs                  | 0.883*       | 0.896*        |
| Plant height (cm) at 30 DAT                     | 0.925**      | 0.939**       |
| Plant height (cm) at 60 DAT                     | 0.883*       | 0.910*        |
| Effective tillers plant\(^{-1}\) at harvest     | 0.562        | 0.949**       |
| Panicle length (cm)                             | 0.208        | 0.959**       |
| Panicle weight (g)                              | 0.952**      | 0.518         |
| Number of filled grains panicle\(^{-1}\)       | 0.904*       | 0.672         |
| 1000 grain weight (g)                           | 0.927**      | 0.970**       |
| Chlorophyll content (mg g\(^{-1}\) of leaf fresh weight) at 30 DAT | 0.863* | 0.857*       |
| Chlorophyll content (mg g\(^{-1}\) of leaf fresh weight) at 60 DAT | 0.738 | 0.729 |

*, ** Significant at \(p \leq 0.01\) and \(p \leq 0.05\), respectively

hours during winter than in rainy season which ultimately resulted in higher chlorophyll synthesis. Gitelson \textit{et al.} (2003) also reported similar findings that leaf chlorophyll content positively related to photon flux density and sunshine hour.

In all the varieties, the higher leaf chlorophyll content was recorded at early vegetative stage (30 DAT) than later one (60 DAT), which ultimately showed a declining trend towards maturity in both seasons (Table 1). It was also revealed that among different rice hybrids, NPH-8889 (Karishma) recorded the maximum chlorophyll content at all dates of observations and it was statistically at par with NPH-207 (Champion). The chlorophyll content in NPH-8889 (Karishma) was 45.4 and 194.7% higher than that the HVY (Satabdi) contained at 30 and 60 DAT during rainy season, while during winter season it was 34.2 and 173.7% more than HVY (Satabdi) at 30 and 60 DAT, respectively. It indicated less contribution of leaf area in sink development, which might be compensated by high chlorophyll content in this variety. Ghosh \textit{et al.} (2003) also expressed similar opinion while studying for aromatic rice.

**Phenology:** Different hybrid rice cultivars showed variations in duration (days) to achieve 50% and 100% flowering and seed to seed duration as well (Table 1). All rice hybrids took longer time for maturity than the local check (Satabdi) did. In both the seasons, the cultivar NPH-567 (winner) took the maximum days to achieve 50% and 100% flowering, accounting 89 and 103 in rainy season, while 94 and 111 days in winter seasons, respectively. The same hybrid cultivar matured late and took 145 and 159 days in rainy and winter seasons, respectively.

**Yield attributes and yield:** The tested rainy season cultivars exhibited lower values of most of the yield attributing characters than the winter season cultivars did (Table 2). The values of all recorded yield components were greater in NPH-207 (Champion), accounting 9.01, 46.2, 26.2 and 35.7% more panicle length, panicle weight, number of filled grains panicle\(^{-1}\) and 1000-grain weight than those obtained from HYV in rainy season, while 17.0, 64.9, 18.9 and 21.5% more panicle length, panicle weight, number of filled grains panicle\(^{-1}\) and 1000-grain weight than those obtained from HYV in winter season, respectively.

Irrespective of cultivars tested, both grain and straw yields were higher in winter crops than rainy season crops. The hybrid cultivar NPH-207 (Champion) produced significantly higher grain and straw yield, accounting 67.9 and 50.1% more than those obtained from HYV in rainy season, while 98.2 and 103% more than those obtained from HYV in winter season, respectively (Table 2). There was not much difference in harvest index values for all the varieties due to seasonal variability. These findings corroborate to that of other investigators (Swain \textit{et al.}, 2006; Mondal \textit{et al.}, 2012).

**Correlation study:** Pearson correlation coefficients showed pair-wise associations between the assessed traits of the cultivars (Table 3). Grain yield was significantly correlated with most of the growth attributes and yield components. Among the traits evaluated, significant and positive correlations with grain yield was observed between plant height at 30 DAT \((r = 0.883, 0.896 \text{ at } p \leq 0.01)\), plant height at 60 DAT \((r = 0.925, 0.939 \text{ at } p \leq 0.05)\), panicle length at harvest \((r = 0.883, 0.910 \text{ at } p \leq 0.01)\), 1000 grain weight \((r = 0.927, 0.970 \text{ at } p \leq 0.05)\) and chlorophyll content at 30 DAT \((r = 0.836, 0.857 \text{ at } p \leq 0.01)\) in both rainy and winter seasons.

**CONCLUSION**

Therefore, it can be concluded that the performance of hybrid rice cultivar NPH-207 (Champion) was much better than conventionally grown local HYV (Satabdi) with respect to measured growth attributes, yield components and grain yield in both rainy and winter seasons.
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