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## Effect of irrigation intervals and hybrids on growth, yield and economics of dry (*boro*) rice (*Oryza sativa*) in New Alluvial Zone of West Bengal

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### ABSTRACT

A field experiment was conducted at Jaguli, Nadia, West Bengal, India, during dry (*boro*) season of 2017, to access the performance of 4 rice (*Oryza sativa* L.) hybrids ('6129 Gold', '6444 Gold', 'Tej Gold' and 'DRH 775') under 3 irrigation intervals (1, 3 and 5-day interval) for better yield and profitable production. Irrigation intervals had significant influence on growth attributes, viz., tiller production, leaf area index and dry-matter accumulation at 63 days after transplanting (DAT), crop growth rate at 42–63 DAT, and yield components, viz., panicles/m<sup>2</sup>, filled grains/panicle and test weight, of hybrids at maturity. Rice hybrids grown with irrigation at 1-day interval resulted in the highest grain yield (5.92 t/ha), which was slightly greater (2.07%) over 3-day interval and much higher (18.64%) over 5-day interval. Among the rice hybrids, '6129 Gold' gave the highest grain yield and net income (5.88 t/ha and ₹33,718/ha) followed by 'Tej Gold' (5.57 t/ha and ₹29,088/ha), 'DRH 775' (5.46 t/ha and ₹27,518/ha) and '6,444 Gold' (5.37 t/ha and ₹26,958/ha). Irrigation at 3-day interval in rice hybrids may be adopted in New Alluvial Zone of West Bengal owing to moderate grain yield (5.80 t/ha), higher water-use efficiency (5.02 kg/ha-mm), net income (₹33,518/ha) and benefit: cost ratio (1.70).

**Key words:** Economics, Growth, Hybrid rice, Irrigation interval, Yield

Hybrid rice developed in India has a distinct yield advantage (14–28%) over inbred varieties (Siddiq, 1993) and it is more responsive to fertilizer and can adapt to varying environments. Hybrid rice cultivation is not popular in West Bengal, though sporadic cultivation is found in North Bengal districts and sometimes in South Bengal. Major constraints, related to rapid adoption and large-scale cultivation of hybrid rice in the state, include inconsistent yield advantage across locations, lack of management skills and lower market price.

Rice is generally grown under flooded or submerged conditions, which requires about 1,500–2,000 mm water. The present-day rice cultivation in puddled field usually leads to wastage of water and causes environmental degradation, particularly arsenic contamination in Indo-Gangetic plains of West Bengal. Irrigation plays a vital role in increasing the productivity of rice, though enhancing water-use efficiency. The increase in the cost of irrigation water

associated with decline in return leads to suggest the rice producers to use water more efficiently. In this context, it is essential to find out proper irrigation schedule, especially during dry (*boro*) season, to maintain proper growth and yield of rice along with sustained use of groundwater.

Keeping the above facts in view a field experiment was conducted at the Instructional Farm (22°93' N, 88°53' E, 9.75 m above mean sea-level) of the Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India during *boro* season of 2017. The soil was well-drained gangetic alluvial belonging to the class clay-loam (order Inceptisol), neutral in reaction (pH 7.0), low in organic carbon (0.6%), available nitrogen (209 kg/ha), phosphorus (45 kg/ha) and potassium (147 kg/ha). The experiment was laid out in a split-plot design with 3 replications, which consisted of 3 irrigation intervals (1, 3, 5 days) in main plots and 4 rice hybrids ('6129 Gold', '6444 Gold', 'Tej Gold', 'DRH 775') in subplots. The plots (5 m × 4 m) under each replication were demarcated by raised bunds and buffer channels following the layout and 35-day-old seedlings using single seedling /hill were transplanted at a shallow depth (2-3 cm) with spacing of 20 cm × 15 cm in the study.

A uniform fertilizer dose of 120, 60 and 60 kg/ha N, P

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and K was applied to each experimental units, and hand-weeding twice was done at 3 and 6 weeks after transplanting to remove the weeds from the field. At the time of transplanting, a thin film of water was maintained in the plots along with 2–3 cm water in irrigation channels. During initial 2 weeks after transplanting, 3 cm depth of irrigation water was given at 1-day interval in all the experimental units for recovery of seedlings from transplantation shock as well as to maintain the soft mud condition in puddled field. Thereafter, the irrigations were given to the plots as per treatment schedule, i.e. at 1-, 3- and 5-day intervals up to dough stage. The growth attributes of rice hybrids like plant height, tillers, leaf-area index, root length, dry-matter (DM) production were noted at different stages, while yield components and grain yield were determined at maturity. The irrigation details were considered to calculate total water utilized and field water-use efficiency. The economics of cultivation was worked out based on local rates of inputs, wages and cost of produce. The data obtained in the study were analyzed using ‘Analysis of Variance’ technique (ANOVA) following standard statistical procedures (Gomez and Gomez, 1984).

Although irrigation frequency caused significant variation in plant height of rice hybrids at mid-phase of growth, but it had non-significant effect at maturity (Table 1). Among 4 rice hybrids, ‘DRH 775’ recorded the highest plant height at harvesting (109.6 cm) than the other 3 varieties. The plants raised with irrigation at 1-day interval showed the maximum number of tillers/m<sup>2</sup> (573.0) and leaf-area index (4.65) at 63 DAT compared to 3- and 5-day intervals. The findings could be justified by the fact that moisture stress due to less irrigation frequency (5- and 3-days intervals) had adverse effect on tiller production and leaf area of hybrid rice. However, Hassan *et al.* (2015)

opined that intermittent irrigation at 3-day interval resulted in highest plant height and active tillers/m<sup>2</sup> of 3 local rice varieties compared to continuous submergence, irrigation at 5- and 7-days intervals in Southern Iraq. ‘Tej Gold’ produced the maximum number of tillers/m<sup>2</sup> and LAI at 63 DAT compared to other 3 varieties. The decrease in irrigation interval from 1-day to 5-days resulted in less soil-moisture condition, which led to greater increase in root length at 63 DAT for the purpose of absorption of soil water from deeper layer of soil. Two hybrids (‘6444 Gold’ and ‘6129 Gold’) had similar root length at 63 DAT; however, ‘Tej Gold’ recorded the shortest roots during the cropping period (Table 1).

Irrigation water at 1-day interval resulted in better growth and development of hybrid rice, being quantified in total dry-matter production at 63 DAT, and crop growth rate during 42–63 DAT compared to wider interval (3- and 5-day) of irrigation. Similarly, Nayak *et al.* (2015) reported that dry-matter accumulation in shoot and LAI of aerobic rice at 75 DAS were reduced with the increase in irrigation frequency from 3- to 9-day interval at Chiplima, Odisha. Rice hybrid ‘6129 Gold’ recorded the highest crop-growth rate (CGR) value (13.03 g/m<sup>2</sup>/day) during 42–63 DAT, being significantly greater over other 3 private bred hybrids in the study.

The yield components like panicles/m<sup>2</sup>, filled grains/panicle and 1,000-grain weight decreased gradually with the widening of irrigation interval from 1-day to 5-day during *boro* season (Table 2). Rice hybrids grown with irrigation at 1-day interval recorded the highest grain yield (5.92 t/ha) mainly due to improvement in number of panicles/m<sup>2</sup>, filled grains/panicle and test weight, yield was slightly greater (2.07%) over 3-days interval and much higher (18.64%) over 5-days irrigation interval. Our find-

**Table 1.** Effect of irrigation intervals and hybrids on growth attributes of rice during dry (*boro*) season

| Treatment                    | Plant height (cm) at harvest | Tillers/m <sup>2</sup> at 63 DAT | LAI at 63 DAT | Root length (cm) at 63 DAT | Dry-matter accumulation (g/m <sup>2</sup> ) at 63 DAT | CGR (g/m <sup>2</sup> /day) at 42-63 DAT |
|------------------------------|------------------------------|----------------------------------|---------------|----------------------------|---|--|
| <i>Irrigation interval</i>   |                              |                                  |               |                            |   |  |
| Irrigation at 1-day interval | 109.6                        | 573.0                            | 4.65          | 24.2                       | 685.5   | 11.72                                    |
| Irrigation at 3-day interval | 107.7                        | 529.9                            | 4.52          | 25.6                       | 631.9   | 11.36                                    |
| Irrigation at 5-day interval | 105.8                        | 519.2                            | 3.92          | 27.6                       | 591.2   | 10.45                                    |
| SEm±                         | 1.45                         | 2.54                             | 0.07          | 0.24                       | 0.79  | 0.07                                     |
| CD (P=0.05)                  | NS                           | 10.26                            | 0.27          | 0.98                       | 3.17  | 0.29                                     |
| <i>Variety</i>               |                              |                                  |               |                            |   |  |
| ‘6129 Gold’                  | 107.9                        | 548.3                            | 4.58          | 26.8                       | 691.8   | 13.03                                    |
| ‘6444 Gold’                  | 103.9                        | 527.1                            | 4.05          | 26.4                       | 607.8   | 10.57                                    |
| ‘Tej Gold’                   | 109.3                        | 550.9                            | 4.70          | 24.7                       | 643.2   | 10.85                                    |
| ‘DRH 775’                    | 109.6                        | 536.4                            | 4.10          | 25.3                       | 601.7   | 10.25                                    |
| SEm±                         | 1.35                         | 2.92                             | 0.08          | 0.29                       | 0.93  | 0.10                                     |
| CD (P=0.05)                  | 4.05                         | 8.74                             | 0.23          | 0.86                       | 2.77  | 0.31                                     |

ings support those of Nayak *et al.* (2016), who reported that grain yield of aerobic rice (cv. 'Apo') successively reduced from 3.44 to 2.06 t/ha with the increase in irrigation time interval from 3 days to 9 days during summer season at Chiplima, Odisha. Among 4 rice hybrids, '6129 Gold' yielded highest (5.88 t/ha), being 0.31, 0.42 and 0.51 t/ha greater over 'Tej Gold', 'DRH 775' and '6444 Gold', respectively.

As per variation in irrigation interval, total number of irrigations were recorded as 42, 25 and 19 from 1-, 3-, 5-day intervals, respectively, during the crop-growth period. Considering all the factors (irrigation + effective rainfall + soil profile contribution), rice hybrids with irrigation at 1-day interval utilized about 192.4 cm water, which has gradually decreased to 115.4 cm for 3-day and 89.2 cm for 5-days intervals in the experiment (Table 2). Irrigation interval at 5 days resulted in the highest field water-use efficiency (5.59 kg/ha-mm) of hybrid rice being followed closely by 3-day (5.02 kg/ha-mm), however, the lowest WUE was obtained from 1-day interval (3.08 kg/ha-mm). Similar findings of greater water-use efficiency under irrigation interval of 3 day after disappearance of ponded water (DPW) compared to shorter interval was reported by Luikham *et al.* (2004). Rice hybrids showed variation in field water-use efficiency between 4.05 kg/ha-mm ('6444 Gold') and 4.44 kg/ha-mm ('6129 Gold') in lower Gangetic plains of West Bengal.

Although the common cost of cultivation was same (₹39,902/ha) for all 3 irrigation intervals, but expenditure on irrigation was variable due to differences in number of irrigations. Thus, total cost of cultivation was estimated as ₹52,502, ₹47,402 and ₹45,602/ha for irrigation regimes at 1-, 3- and 5-days intervals respectively (Table 2). Although

the highest gross return was obtained from the crop with irrigation at 1-day interval (₹82,400/ha), but the highest net returns (₹33,518/ha) was recorded with irrigation frequency at 3-days interval. However, Kumar *et al.* (2013) reported that moisture regime at 7 cm irrigation 1-day DPW resulted in the maximum gross income, net return and B:C ratio of rice (cv. 'Sarjoo') compared to 3-days and 5-days DPW during the wet season at Faizabad, Uttar Pradesh. Among the rice hybrids, '6129 Gold' resulted the highest net income (₹33,718/ha), followed by 'Tej Gold' (₹29,088/ha), 'DRH 775' (₹27,518/ha) and '6,444 Gold' (₹26,958/ha), respectively. The maximum benefit: cost ratio (1.70) was obtained with irrigation at 3-days interval, while '6129 Gold' recorded the highest B: C ratio (1.69).

Thus, it could be concluded that even though irrigation at 1-day interval resulted in the highest yield (5.92 t/ha) in the experiment, but irrigation at 3-days interval could be accepted due to moderate grain yield (5.80 t/ha), higher field water-use efficiency (5.02 kg/ha-mm) and net income (₹33,518/ha). Among the 4 rice hybrids, '6129 Gold' could be recommended owing to the maximum yield (6.05 t/ha), higher net return (₹33,518/ha) and benefit: cost ratio (1.70) during dry (*boro*) season in New Alluvial Zone of West Bengal.

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**Table 2.** Effect of irrigation intervals and hybrids on yield attributes, productivity, water utilization and economics of rice during *boroseason*

| Treatment                    | Panicles/<br>m <sup>2</sup> | Filled<br>grains/<br>panicle | 1,000-<br>grain<br>weight<br>(g) | Grain<br>yield<br>(t/ha) | Total<br>water<br>utilized<br>(cm) | Field<br>water-use<br>efficiency<br>(kg/ha-mm) | Cost of<br>cultivation<br>(×10 <sup>3</sup> ₹/ha) | Net<br>income<br>(×10 <sup>3</sup> ₹/ha) | Benefit:<br>cost<br>ratio |
|------------------------------|-----------------------------|------------------------------|----------------------------------|--------------------------|------------------------------------|--|---|--|---------------------------|
| <i>Irrigation interval</i>   |                             |                              |                                  |                          |                                    |  |   |  |                           |
| Irrigation at 1-day interval | 393.4                       | 158.1                        | 23.1                             | 5.92                     | 192.4                              | 3.08   | 52.5  | 29.9                                     | 1.56                      |
| Irrigation at 3-day interval | 374.1                       | 150.4                        | 22.9                             | 5.80                     | 115.4                              | 5.02   | 47.4  | 33.5                                     | 1.70                      |
| Irrigation at 5-day interval | 360.9                       | 149.0                        | 22.4                             | 4.99                     | 89.2                               | 5.59   | 45.6  | 24.6                                     | 1.54                      |
| SEM±                         | 3.96                        | 1.54                         | 0.14                             | 0.03                     |                                    |  |   |  |                           |
| CD (P=0.05)                  | 15.97                       | 6.21                         | 0.55                             | 0.11                     |                                    |  |   |  |                           |
| <i>Variety</i>               |                             |                              |                                  |                          |                                    |  |   |  |                           |
| '6129 Gold'                  | 386.8                       | 154.2                        | 23.2                             | 5.88                     | 132.4                              | 4.44   | 48.5  | 33.7                                     | 1.69                      |
| '6444 Gold'                  | 379.2                       | 147.0                        | 22.6                             | 5.37                     | 132.4                              | 4.05   | 48.5  | 27.0                                     | 1.55                      |
| 'Tej Gold'                   | 376.5                       | 159.2                        | 23.1                             | 5.57                     | 132.4                              | 4.21   | 48.5  | 29.1                                     | 1.59                      |
| 'DRH 775'                    | 361.9                       | 149.7                        | 22.3                             | 5.46                     | 132.4                              | 4.13   | 48.5  | 27.5                                     | 1.57                      |
| SEM±                         | 4.91                        | 1.91                         | 0.17                             | 0.04                     |                                    |  |   |  |                           |
| CD (P=0.05)                  | 14.71                       | 6.21                         | 0.51                             | 0.11                     |                                    |  |   |  |                           |