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**Sagun Hembram**
Department of Agronomy, Palli Siksha Bhavana (Institution of Agriculture), Visva-Bharati, Sriniketan, West Bengal, India

**SK Maity**
Associate Professor, Department of Agronomy, Palli Siksha Bhavana (Institution of Agriculture), Visva-Bharati, Sriniketan, West Bengal, India

**Corresponding Author:**
**Sagun Hembram**
Department of Agronomy, Palli Siksha Bhavana (Institution of Agriculture), Visva-Bharati, Sriniketan, West Bengal, India

# Growth and productivity of different rice cultivars under dry direct seeding in red and laterite soil of West Bengal

**Sagun Hembram and SK Maity**

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**Abstract**
A field experiment was conducted during the *kharif* season of 2019-20 at the Agricultural Farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal, to evaluate different rice cultivars under dry direct seeding conditions. The rice cultivars included 11 varieties namely MTU 7029, Pratiksha, MTU 1010, Shatabdi, Khitish, IR 36, IR 64, GB1, Sahabhagi, Annada and Parijat and two hybrids such as 6444 Gold and AZ 6453. The experiment was laid out in a Randomized Block Design, replicated thrice. The soil of the experimental field was sandy loam in texture, acidic in reaction (pH 6.15), low in available nitrogen (265 kg N $ha^{-1}$), medium in available phosphorus (19 kg $P_2O_5$ $ha^{-1}$), medium in available potassium content (140 kg $K_2O$ $ha^{-1}$) and low in organic carbon (0.38%) content. In terms of the growth parameters, like plant height, tillers per $m^{-2}$, dry matter accumulation and leaf area index, rice hybrids 6444 Gold and AZ 6453 showed better performance but some HYVs like Pratiksha and MTU 7029 recorded closer values. However, it was rice hybrid 6444 Gold that recorded the highest grain yield (4.31 t $ha^{-1}$) being on a par with the grain yield (4.19 t $ha^{-1}$) of other rice hybrids tested (AZ 6453) and significantly higher than all the HYVs evaluated in the experiment. Medium duration variety GB1 recorded the highest grain yield (3.34 t $ha^{-1}$) among all the HYVs tested which was closely followed by the grain yield of Pratiksha (3.27 t $ha^{-1}$) which was a long duration variety. Among other HYVs evaluated, Annada performed better, among short-duration cultivars with the grain yield of 2.59 t $ha^{-1}$.

**Keywords:** DSR, HYVs, Hybrids, Grain yield

## Introduction
The rice culture system in the country mainly depends on the onset and distribution of monsoon rain. Erratic distribution of rainfall and lack of irrigation during these periods compel the farmers to choose alternative for transplanting. Transplanted puddled rice, the conventional way of rice cultivation has lot of challenges particularly with respect to water use efficiency, time consuming, more labour use etc (Saha *et al.*, 2020) [7]. These factors demand a major shift from puddled transplanting to direct seeding of rice (Kaur and Singh, 2017) [3]. Direct seeded rice (DSR), probably the oldest method of crop establishment throughout Asia, is gaining popularity because of its low input demands. It offers certain advantages *viz*., it gives similar yields, saving water, labour and production costs, slow the loss of organic matter, reduces the soil erosion, less drudgery, early crop maturity, low production cost, better soil physical condition, highest net economic return and reduction of methane emissions. Direct seeded rice requires shorter crop duration, requires less water and had high water efficiency than transplanting rice. Direct seeding gave grain yields superior to those of transplanted rice using short-duration IR58, PR-115, Shusk Samrat, Pusa-33, PR-120, Sahabhagidhan but equal or lower grain-yield using the medium- and long-duration varieties (Samant *et al*., 2015 and Kumar *et al*., 2018) [28, 4]. Among the varieties, significantly higher grain and straw yield was recorded with GGV-05-01, SIRI-1253 and BPT-5204 as compared to KRH-4 hybrid reported by Anand *et al.* (2018) [1]. As all rice cultivars do not perform favourably under direct seeding, there is a need for the evaluation of rice cultivars under dry seeding conditions to establish the better ones.

## 2. Material and Methods

### 2.1 Description of Experimental site

The field experiment was conducted during *kharif* season in 2019-20 at Agricultural farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal, India. The soil of the experimental site belonged to red and laterite soil group and was sandy loam in texture with acidic in reaction with pH of 6.15, low in available nitrogen (265 kg N $ha^{-1}$), medium in available phosphorus (19 kg $P_2O_5$ $ha^{-1}$), medium in available potassium content (140 kg $K_2O$ $ha^{-1}$) and low in organic carbon (0.38%) content. During cropping season, the amount of rain fall received from middle of June and continues up to October was 116.9 mm spanned over 77 rainy days.

### 2.2 Rice cultivars evaluated

The experiment was laid out in randomized complete block design with three replications allocating different HYV and hybrid rice varieties based on small, medium and long duration (Table 1). All 13 varieties of rice were directly sown at the spacing of 20 cm line to line and depth of sowing was 2-3 cm. The well decomposed farm yard manure @ 5 ton $ha^{-1}$ was applied before final land preparation. The recommended fertilizer was applied by broadcasting @ 80:40:40 kg N-$P_2O_5$-$K_2O$ $ha^{-1}$ for variety having 140-160 days of duration (MTU 7029 and Pratiksha) and @ 60:30:30 kg N-$P_2O_5$-$K_2O$ $ha^{-1}$ for variety having 115-125 days of duration (MTU 1010, Shatabdi (IET 4786), Khitish (IET 4094), IR 36, IR 64, Gotra Bidhan 1 (GB1), Sahabhagi, Annada, Parijat) and @ 120:60:60 kg N-$P_2O_5$-$K_2O$ $ha^{-1}$ for hybrid duration of 110-130 days (6444 Gold and AZ 6453). At basal, one-fourth of N, total $P_2O_5$ and 50% $K_2O$ were applied. Half N was applied at active tillering stage and final one-fourth part of N and half $K_2O$ were applied at panicle initiation stage. Growth parameters like plant height, number of tillers $m^{-2}$ at milk stage of grain filling while dry matter production was recorded at harvesting time. Observation on yield attributes such as number of effective tillers $m^{-2}$, panicle length, panicle weight, number of spikelets per panicle, number of filled grains and 1000 grain weight were recorded. Crop was harvested at full maturity stage. Both grain and straw yield were recorded after harvesting and threshing followed by proper cleaning and drying of grain and straw.

### 2.3 Statistical analysis

Finally collected data were statistically analysed for ANOVA and the treatment means were compared by following DMRT as outlined in Gomez and Gomez (1984).

**Table 1:** Details of rice cultivars evaluated

| Sl No. | Name of the rice culture | HYV or Hybrid | Duration (days) | Other characteristics |
|---|---|---|---|---|
| 1 | MTU 7029 | HYV | 150-155 | Short bold grain, tolerant to Brown plant hopper (BPH) and Blast |
| 2 | Pratiksha | HYV | 142-144 | Medium slender grain |
| 3 | MTU 1010 | HYV | 115-120 | Medium slender grain, tolerant to leaf blast, susceptible to BPH |
| 4 | Shatabdi | HYV | 112-115 | Fine long slender grain, suitable for upland and medium upland |
| 5 | Khitish | HYV | 115-120 | Long slender grain, good tiller habit and suitable for upland |
| 6 | IR 36 | HYV | 112-115 | Slender grain, semi-dwarf |
| 7 | IR 64 | HYV | 120-125 | Long grain, resistant to green leafhopper, grassy stunt |
| 8 | GB 1 | HYV | 115-125 | Medium bold grain, suitable for kharif paddy followed by potato |
| 9 | Sahabhagi | HYV | 105-110 | Drought tolerant, early maturity variety, |
| 10 | Annada | HYV | 110-120 | Short bold grain, drought tolerant variety |
| 11 | Parijat | HYV | 95-115 | Medium long slender grain, suitable for pre kharif cultivation |
| 12 | 6444 Gold | Hybrid | 125-130 | Resistant to leaf blight, low water requirement |
| 13 | AZ 6453 | Hybrid | 110-115 | Tolerant to BPH |

## Results and Discussion

The growth attributes of direct seeded rice, like plant counts, plant height, number of tillers $m^{-2}$, and dry matter accumulation, recorded at various stages of growth of different cultivars, were presented in Table 2.

### 3.1 Growth parameters

#### 3.1.1 Plant height

There were significant differences in the plant height of the rice varieties/hybrids tested. The hybrid AZ 6453 registered the maximum plant height (106.7 cm), which was at par with the plant height of other hybrid 6444 Gold (101.1 cm) Gevrek *et al.* (2008) [2], and rice varieties like Sahabhagi (106.3 cm), GB 1 (106.3 cm), Khitish (101.3 cm), Pratiksha (102.0 cm) and Shatabdi (99.8 cm). The varieties like MTU 7029, IR 36 and Annada recorded plant height less than 90 cm, whereas plant heights of MTU 1010, IR 64 and Parijat were in the range of above 90 cm and below 1m.

**Table 2:** Growth parameters of different rice varieties and hybrids under dry direct seeding

| Rice varieties/hybrids | Plant height (cm) | Tiller production (number $m^{-2}$) | Dry matter production (g $m^{-2}$) |
|---|---|---|---|
| MTU 7029 | 87.5 $^{ef}$ | 643 $^{ab}$ | 1167 $^{ab}$ |
| Pratiksha | 102.0 $^{ab}$ | 552 $^{bcd}$ | 1097 $^{abc}$ |
| MTU 1010 | 93.7 $^{de}$ | 551 $^{bcd}$ | 829 $^{def}$ |
| Shatabdi | 99.8 $^{abcd}$ | 533 $^{bcd}$ | 724 $^{f}$ |
| Khitish | 101.3 $^{abc}$ | 524 $^{bcd}$ | 1059 $^{bcd}$ |
| IR 36 | 87.7 $^{ef}$ | 682 $^{a}$ | 1020 $^{bcde}$ |
| IR 64 | 97.9 $^{bcd}$ | 624 $^{ab}$ | 1103 $^{abc}$ |
| GB 1 | 106.3 $^{a}$ | 496 $^{cd}$ | 1023 $^{bcde}$ |
| Sahabhagi | 106.3 $^{a}$ | 442 $^{d}$ | 877 $^{cdef}$ |
| Annada | 81.3 $^{f}$ | 501 $^{cd}$ | 798 $^{ef}$ |
| Parijat | 94.2 $^{cde}$ | 591 $^{abc}$ | 711 $^{f}$ |
| 6444 Gold | 101.1 $^{abc}$ | 611 $^{abc}$ | 1185 $^{ab}$ |
| AZ 6453 | 106.7 $^{a}$ | 557 $^{bcd}$ | 1338 $^{a}$ |
| SEm (±) | 2.3 | 36 | 77 |
| CV % | 4.1 | 11.0 | 13.3 |

### 3.1.2 Tiller production

Number of tillers is one of the most important growth parameters, which influence the grain yield directly. There were significant differences in the tiller production among the rice varieties and hybrids under dry direct seeding. The variety IR 36 recorded the highest tiller number (682 $m^{-2}$), which was at par with MTU 7029 (643 $m^{-2}$), IR 64 (624 $m^{-2}$) and hybrid 6444 Gold (611 $m^{-2}$), indicating their superiority in tillering ability. Moderate tiller production was observed in Parijat (591 $m^{-2}$), AZ 6453 (557 $m^{-2}$), Pratiksha (552 $m^{-2}$), MTU 1010 (551 $m^{-2}$), Shatabdi (533 $m^{-2}$), and Khitish (524 $m^{-2}$), these results are in closely conformity with the findings of several workers (Longshithung *et al*., 2005 and Sabir *et al*., 2007) [5, 6]. Comparatively lower tiller numbers were recorded in varieties like Annada (501 $m^{-2}$) and GB 1 (496 $m^{-2}$), whereas Sahabhagi (442 $m^{-2}$) produced the minimum number of tillers per square meter. Overall, the results indicated that modern varieties and hybrids generally performed better in tillering than traditional cultivars, though a few varieties like Sahabhagi showed limited tillering ability under dry direct seeding.

### 3.1.3 Dry matter production

In terms of dry matter production also there were significant differences among the rice varieties and hybrids tested under dry direct seeding. The hybrid AZ 6453 recorded the maximum dry matter production (1338 g $m^{-2}$), which was significantly superior over all other varieties and hybrids, followed by 6444 Gold (1185 g $m^{-2}$) and MTU 7029 (1167 g $m^{-2}$). These were statistically at par with IR 64 (1103 g $m^{-2}$), Pratiksha (1097 g $m^{-2}$), and Khitish (1059 g $m^{-2}$), indicating better biomass accumulation. Moderate dry matter accumulation was observed in varieties like GB 1 (1023 g $m^{-2}$), IR 36 (1020 g $m^{-2}$), and Sahabhagi (877 g $m^{-2}$). Comparatively lower dry matter production was registered in varieties such as MTU 1010 (829 g $m^{-2}$), Annada (798 g $m^{-2}$), Shatabdi (724 g $m^{-2}$), and Parijat (711 g $m^{-2}$), suggesting relatively poor growth performance. Overall, hybrids and improved varieties exhibited higher dry matter accumulation compared to traditional cultivars, reflecting their better growth efficiency under dry direct seeding conditions. Higher plant height, irrespective of source, accumulation of higher amount of dry matter almost in all cultivar, supporting the well establishment fact nitrogen sufficiency resulted into vigorous growth of the foliage (Singh *et al.*, 2007) [9].

**Table 3:** Yield attributing parameters of different rice varieties and hybrids under dry direct seeding

| Rice varieties/ hybrids | No. of effective tillers $m^{-2}$ | Panicle length (cm) | Panicle weight (g) | No. of spikelets/panicle | No. of filled grain | 1000 grain weight (g) |
|---|---|---|---|---|---|---|
| MTU 7029 | 497 $^{a}$ | 18.9 $^{e}$ | 13.2 $^{bcd}$ | 118 $^{cd}$ | 53 $^{ef}$ | 15.9 $^{de}$ |
| Pratiksha | 416 $^{bcd}$ | 22.8 $^{abc}$ | 27.1 $^{ab}$ | 146 $^{bc}$ | 112 $^{a}$ | 20.6 $^{ab}$ |
| MTU 1010 | 451 $^{abc}$ | 21.3 $^{abc}$ | 12.5 $^{abcd}$ | 73 $^{e}$ | 50 $^{f}$ | 20.7 $^{ab}$ |
| Shatabdi | 456 $^{abc}$ | 22.7 $^{abc}$ | 15.8 $^{bcd}$ | 158 $^{b}$ | 78 $^{cd}$ | 13.7 $^{e}$ |
| Khitish | 422 $^{bc}$ | 22.0 $^{abc}$ | 11.5 $^{cd}$ | 83 $^{e}$ | 48 $^{f}$ | 18.3 $^{bcd}$ |
| IR 36 | 464 $^{abc}$ | 20.9 $^{cd}$ | 15.0 $^{bcd}$ | 85 $^{e}$ | 58 $^{def}$ | 19.7 $^{abc}$ |
| IR 64 | 448 $^{abc}$ | 21.9 $^{abc}$ | 13.8 $^{bcd}$ | 94 $^{de}$ | 57 $^{def}$ | 21.8 $^{a}$ |
| GB 1 | 354 $^{de}$ | 22.2 $^{abc}$ | 26.5 $^{a}$ | 192 $^{a}$ | 123 $^{a}$ | 17.4 $^{cd}$ |
| Sahabhagi | 346 $^{e}$ | 23.9 $^{a}$ | 20.7 $^{ab}$ | 121 $^{cd}$ | 75 $^{cde}$ | 20.0 $^{abc}$ |
| Annada | 421 $^{bc}$ | 20.0 $^{de}$ | 16.1 $^{bcd}$ | 81 $^{e}$ | 64 $^{cdef}$ | 22.0 $^{a}$ |
| Parijat | 471 $^{ab}$ | 20.8 $^{cd}$ | 10.2 $^{d}$ | 75 $^{e}$ | 46 $^{f}$ | 16.4 $^{de}$ |
| 6444 Gold | 424 $^{bc}$ | 23.2 $^{ab}$ | 20.4 $^{ab}$ | 125 $^{c}$ | 85 $^{bc}$ | 20.6 $^{ab}$ |
| AZ 6453 | 400 $^{cde}$ | 21.6 $^{bcd}$ | 20.1 $^{abc}$ | 167 $^{ab}$ | 101 $^{ab}$ | 17.3 $^{cd}$ |
| SEm (±) | 20 | 0.6 | 1.6 | 10 | 7 | 0.9 |
| CV% | 8.1 | 4.7 | 16.0 | 14.2 | 17.1 | 8.6 |

## 3.2 Yield attributes

### 3.2.1 Number of effective tillers $m^{-2}$

Significant variation in the number of effective tillers was observed among the rice varieties and hybrids under dry direct seeding. The maximum number of effective tillers (497 $m^{-2}$) was produced by MTU 7029, which was statistically at par with Parijat (471 $m^{-2}$), Shatabdi (456 $m^{-2}$), IR36 (464 $m^{-2}$), MTU 1010 (451 $m^{-2}$), and IR64 (448 $m^{-2}$). Moderate tiller numbers were noted in Annada (421 $m^{-2}$), Khitish (422 $m^{-2}$), and 6444 Gold (424 $m^{-2}$). On the other hand, the lowest number of effective tillers was recorded in Sahabhagi (346 $m^{-2}$) and GB1 (354 $m^{-2}$). In comparison, hybrid AZ 6453 (400 $m^{-2}$) also showed a comparatively fewer number of tillers than most other entries.

### 3.2.2 Panicle length

There were significant differences in panicle length among the rice varieties and hybrids. The longest panicle was recorded in Sahabhagi (23.9 cm), which was statistically par with the panicle length of hybrid 6444 Gold (23.2 cm) and rice varieties like Pratiksha (22.8 cm), Shatabdi (22.7 cm), GB1 (22.2 cm), and Khitish (22.0 cm). The hybrids AZ 6453 (21.6 cm) and rice varieties IR 64 (21.9 cm) and MTU 1010 (21.3 cm) also registered higher panicle length compared to others. In contrast, shorter panicles were observed in rice varieties MTU 7029 (18.9 cm) and Annada (20.0 cm), which were significantly lower than most of the other tested varieties.

### 3.2.3 Panicle weight

Panicle weight also varied significantly across the tested varieties and hybrids. The highest panicle weight was observed in rice variety GB1 (26.5 g), which was at par with the rice varieties Pratiksha (27.1 g) and Sahabhagi (20.7 g) and hybrids 6444 Gold (20.4 g) and AZ6453 (20.1 g). Medium panicle weight was recorded in rice varieties like Annada (16.1 g), Shatabdi (15.8 g), IR 36 (15.0 g), and IR 64 (13.8 g). On the other hand, lighter panicles were found in rice varieties like MTU 1010 (12.5 g), MTU 7029 (13.2 g), Khitish (11.5 g), and Parijat (10.2 g) than other varieties.

### 3.2.4 Number of spikelets $panicle^{-1}$

The number of spikelets per panicle differed widely among the varieties and hybrids. GB1 produced the highest spikelet count (192), which was at par with the rice hybrid AZ 6453 (167) and

rice variety Shatabdi (158). Varieties Pratiksha (146) and Sahabhagi (121) and hybrid 6444 Gold (125) also recorded higher spikelet numbers. Moderate values were recorded in rice varieties like MTU 7029 (118) and IR 64 (94). In contrast, the lowest spikelet counts were observed in MTU 1010 (73), Parijat (75), Annada (81), IR 36 (85), and Khitish (83), which indicated relatively poor spikelet-bearing ability.

### 3.2.5 Number of filled grains panicle$^{-1}$

Significance differences were observed in the number of filled grains per panicle. Rice variety GB1 recorded the highest number of filled grains (123), which was statistically similar to variety Pratiksha (112) and hybrid AZ 6453 (101). These were followed by hybrid 6444 Gold (85) and variety Shatabdi (78), which had moderately higher filled grain numbers. Rice varieties Sahabhagi (75), Annada (64), and IR 36 (58) produced comparatively fewer filled grains, while varieties like IR64 (57), Khitish (48), MTU 1010 (50), and Parijat (46) registered the lowest values among the other tested varieties.

### 3.2.6 1000-grain weight

The 1000-grain weight also differed significantly across rice varieties and hybrids. The highest test weight was recorded in Annada (22.0 g) and IR64 (21.8 g), which were statistically similar to the rice varieties like MTU 1010 (20.7 g), Pratiksha (20.6 g), Sahabhagi (20.0 g) and hybrid 6444 Gold (20.6 g). Moderate grain weight was recorded in varieties like IR36 (19.7 g) and Khitish (18.3 g), followed by GB1 (17.4 g) and hybrid AZ 6453 (17.3 g). Comparatively lower test weights were observed in MTU 7029 (15.9 g) and Parijat (16.4 g), while Shatabdi recorded the lowest grain weight (13.7 g).

**Table 4:** Yield and harvest index of different rice varieties and hybrids under direct seeding

| Rice varieties/ hybrids | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Harvest index |
|---|---|---|---|---|
| MTU 7029 | 1.38 $^{d}$ | 6.69 $^{ab}$ | 8.47 $^{c}$ | 0.16 $^{e}$ |
| Pratiksha | 3.27 $^{b}$ | 6.37 $^{b}$ | 9.88 $^{b}$ | 0.33 $^{bc}$ |
| MTU 1010 | 1.97 $^{c}$ | 3.84 $^{de}$ | 5.99 $^{fg}$ | 0.33 $^{bc}$ |
| Shatabdi | 2.00 $^{c}$ | 4.14 $^{d}$ | 6.39 $^{efg}$ | 0.31 $^{c}$ |
| Khitish | 2.00 $^{c}$ | 5.23 $^{c}$ | 7.47 $^{cde}$ | 0.27 $^{d}$ |
| IR 36 | 2.56 $^{c}$ | 4.17 $^{d}$ | 6.98 $^{defg}$ | 0.37 $^{bc}$ |
| IR 64 | 2.42 $^{c}$ | 4.64 $^{cd}$ | 7.27 $^{cdef}$ | 0.34 $^{bc}$ |
| GB 1 | 3.34 $^{b}$ | 4.21 $^{d}$ | 7.84 $^{cd}$ | 0.43 $^{a}$ |
| Sahabhagi | 2.53 $^{c}$ | 4.01 $^{d}$ | 6.77 $^{defg}$ | 0.37 $^{b}$ |
| Annada | 2.59 $^{c}$ | 3.20 $^{e}$ | 5.91 $^{g}$ | 0.44 $^{a}$ |
| Parijat | 2.00 c | 3.89 $^{de}$ | 6.05 $^{fg}$ | 0.33 $^{bc}$ |
| 6444 Gold | 4.31 $^{a}$ | 7.22 $^{a}$ | 11.84 $^{a}$ | 0.36 $^{bc}$ |
| AZ 6453 | 4.19 $^{a}$ | 7.11 $^{ab}$ | 11.72 $^{a}$ | 0.36 $^{bc}$ |
| SEm (±) | 0.19 | 0.25 | 0.40 | 0.02 |
| CV% | 12.3 | 8.8 | 8.7 | 8.1 |

## 3.3 Yield and harvest index

### 3.3.1 Grain yield

Significant variation in grain yield was observed among the rice varieties and hybrids tested under dry direct seeding. The highest grain yield was recorded in hybrid 6444 Gold (4.31 t ha$^{-1}$), which was statistically at par with hybrid AZ 6453 (4.19 t ha$^{-1}$). Both of these hybrids outperformed all other varieties. Among the varieties, GB1 (3.34 t ha$^{-1}$) and Pratiksha (3.27 t ha$^{-1}$) also registered higher yields, significantly superior to the rest. Moderate grain yields were obtained from IR36 (2.56 t ha$^{-1}$), Annada (2.59 t ha$^{-1}$), and Sahabhagi (2.53 t ha$^{-1}$), while MTU 1010 (1.97 t ha$^{-1}$), Shatabdi (2.00 t ha$^{-1}$), Khitish (2.00 t ha$^{-1}$), and Parijat (2.00 t ha$^{-1}$) showed relatively lower yields. The lowest yield was recorded in MTU 7029 (1.38 t ha$^{-1}$).

### 3.3.2 Straw yield

Straw yield also showed significant differences across the rice varieties and hybrid. The maximum straw yield was produced by hybrid 6444 Gold (7.22 t ha$^{-1}$), closely followed by hybrid AZ 6453 (7.11 t ha$^{-1}$) and variety MTU 7029 (6.69 t ha$^{-1}$). Pratiksha (6.37 t ha$^{-1}$) also recorded higher straw yield compared to most varieties. Moderate straw yields were recorded for varieties like Khitish (5.23 t ha$^{-1}$) and IR 64 (4.64 t ha$^{-1}$), while comparatively lower values were recorded in rice varieties like IR 36 (4.17 t ha$^{-1}$), Shatabdi (4.14 t ha$^{-1}$), GB1 (4.21 t ha$^{-1}$), and Sahabhagi (4.01 t ha$^{-1}$). The lowest straw yield was found in Annada (3.20 t ha$^{-1}$), followed by Parijat (3.89 t ha$^{-1}$) and MTU 1010 (3.84 t ha$^{-1}$).

### 3.3.3 Biological yield

Among all the varieties or treatments hybrid 6444 Gold and AZ 6453 gives maximum biological yield about 11.84 t ha$^{-1}$ and 11.72 t ha$^{-1}$ respectively. Pratiksha (9.88 t ha$^{-1}$) also recorded higher biological yield compared to other varieties. Moderate values were observed in MTU 7029 (8.47 t ha$^{-1}$), GB1 (7.84 t ha$^{-1}$), and Khitish (7.47 t ha$^{-1}$). On the other hand, comparatively lower biological yields were registered in varieties like IR 64 (7.27 t ha$^{-1}$), IR36 (6.98 t ha$^{-1}$), Sahabhagi (6.77 t ha$^{-1}$), and Shatabdi (6.39 t ha$^{-1}$). The lowest biological yields were recorded in MTU 1010 (5.99 t ha$^{-1}$), Parijat (6.05 t ha$^{-1}$), and Annada (5.91 t ha$^{-1}$)

### 3.3.4 Harvest index

The harvest index also showed noticeable variation among the tested varieties and hybrids. The highest harvest index was recorded in Annada (0.44) and GB1 (0.43), indicating their greater efficiency in partitioning assimilates towards grain production. Moderate harvest index values were observed in rice varieties like IR36 (0.37), Sahabhagi (0.37), IR64 (0.34), Parijat (0.33), MTU1010 (0.33), and Pratiksha (0.33). The hybrids 6444 Gold (0.36) and AZ6453 (0.36) also maintained balanced harvest index values. Lower harvest index values were recorded in Shatabdi (0.31) and Khitish (0.27), while MTU7029 (0.16) exhibited the lowest harvest index among all rice varieties and hybrids, reflecting poor efficiency in converting total biomass into grain yield.

## 3.4 Economic parameters

Data of economic analysis *viz*., cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR), return per rupee are given in Table 5.

**Table 5:** Economics of different rice varieties and hybrids under dry direct seeding

| Rice varieties/ hybrids | Cost of cultivation (Rs) | GMR (Rs ha$^{-1}$) | NMR (Rs ha$^{-1}$) | Return per rupee |
|---|---|---|---|---|
| MTU 7029 | 30965.16 | 25108 $^{f}$ | -5858 $^{f}$ | 0.81 $^{f}$ |
| Pratiksha | 30965.16 | 59423 $^{b}$ | 28458 $^{b}$ | 1.92 $^{b}$ |
| MTU 1010 | 30570.53 | 35840 $^{de}$ | 5270 $^{de}$ | 1.17 $^{e}$ |
| Shatabdi | 30570.53 | 36688 $^{de}$ | 6117 $^{de}$ | 1.20 $^{e}$ |
| Khitish | 30570.53 | 36639 $^{de}$ | 6068 $^{de}$ | 1.20 $^{e}$ |
| IR 36 | 30570.53 | 46549 $^{c}$ | 15978 $^{c}$ | 1.52 $^{c}$ |
| IR 64 | 30570.53 | 43838 $^{cd}$ | 13268 $^{cd}$ | 1.43 $^{d}$ |
| GB 1 | 30570.53 | 60597 $^{b}$ | 30026 $^{b}$ | 1.98 $^{b}$ |
| Sahabhagi | 30570.53 | 45835 $^{c}$ | 15264 $^{c}$ | 1.50 $^{cd}$ |
| Annada | 30570.53 | 47033 $^{c}$ | 16462 $^{c}$ | 1.54 $^{c}$ |
| Parijat | 30570.53 | 36373 $^{de}$ | 5802 $^{de}$ | 1.19 $^{e}$ |
| 6444 Gold | 35389.06 | 78299 $^{a}$ | 42910 $^{a}$ | 2.21 $^{a}$ |
| AZ 6453 | 35389.06 | 76862 $^{a}$ | 41473 $^{a}$ | 2.17 $^{a}$ |
| SEm (±) | - | 3433 | 3433 | 0.11 |
| CV% | - | 12.3 | 34.9 | 12.6 |

### 3.4.1 Cost of cultivation
The cost needed for cultivation of rice crop is different for different cultivars due to variation in cost of seeds (HYV& hybrids) and dose of fertilizers. Rice crop required an investment of Rs. 30965.2 for 140-160 duration, Rs. 30570.5 for 115-125 days of duration and Rs. 35389.1 for 110-130 days of duration expenses in different operation and input.

### 3.4.2 Gross monetary returns (GMR)
There were significant differences in gross monetary return among the rice varieties and hybrids tested under dry direct seeding. The hybrid 6444 Gold recorded the highest GMR (₹78,299 ha$^{-1}$), closely followed by AZ6453 (₹76,862 ha$^{-1}$). Among the varieties, GB1 (₹60,597 ha$^{-1}$) and Pratiksha (₹59,423 ha$^{-1}$) also registered comparatively higher returns. Moderate GMR values were observed in varieties like Annada (₹47,033 ha$^{-1}$), IR36 (₹46,549 ha$^{-1}$), Sahabhagi (₹45,835 ha$^{-1}$), and IR64 (₹43,838 ha$^{-1}$). On the other hand, lower GMR was observed in Khitish (₹36,639 ha$^{-1}$), Shatabdi (₹36,688 ha$^{-1}$), and Parijat (₹36,373 ha$^{-1}$). The lowest GMR was obtained from MTU 7029 (₹25,108 ha$^{-1}$).

### 3.4.3 Net monetary returns (NMR)
The net monetary return also showed wide variation across the rice varieties and hybrids. The maximum NMR was recorded in 6444 Gold (₹42,910 ha$^{-1}$), which was at par with the hybrid AZ 6453 (₹41,473 ha$^{-1}$) and variety GB1 (₹30,026 ha$^{-1}$). Among the high-yielding varieties, Pratiksha (₹28,458 ha$^{-1}$) also performed well in terms of profitability. Moderate NMR values were obtained from the varieties like Annada (₹16,462 ha$^{-1}$), IR 36 (₹15,978 ha$^{-1}$), Sahabhagi (₹15,264 ha$^{-1}$), and IR64 (₹13,268 ha$^{-1}$). Comparatively lower NMR was observed in Shatabdi (₹6,117 ha$^{-1}$), Khitish (₹6,068 ha$^{-1}$), and Parijat (₹5,802 ha$^{-1}$). MTU 1010 also recorded low NMR (₹5,270 ha$^{-1}$), while MTU 7029 incurred a negative return of -₹5,858 ha$^{-1}$.

### 3.4.4 Return per rupees
Return per rupee invested differed significantly among the tested rice varieties and hybrids. The highest return per rupee was recorded in hybrid 6444 Gold (2.21), which was statistically at par with hybrid AZ6453 (2.17) and variety GB1 (1.98). Pratiksha (1.92) also registered a high benefit-cost ratio. Moderate returns were achieved by Annada (1.54), IR36 (1.52), Sahabhagi (1.50), and IR64 (1.43). Comparatively lower values were obtained in Shatabdi (1.20), Khitish (1.20), Parijat (1.19), and MTU1010 (1.17). The least return per rupee was recorded in MTU7029 (0.81), which was indicate economic unprofitability of the variety under dry direct seeded conditions.

## 4. Conclusion
The evaluation of different rice varieties and hybrids under dry direct seeded conditions revealed considerable variability in growth, yield attributes, productivity, and economic performance. The growth and productivity of different rice cultivars varied significantly. The hybrid 6444 Gold (4.31 t ha$^{-1}$) recorded the highest growth and productivity among all the cultivars tested under direct seeding. Among HYVs MTU 7029 recorded minimum productivity (1.38 t ha$^{-1}$). Among the hybrid 6444 Gold recorded higher grain yield (4.31 t ha$^{-1}$) being at par with AZ 6453 (4.19 t ha$^{-1}$). And among the HYVs under long duration Pratiksha (3.27 t ha$^{-1}$) recorded highest grain yield and among medium duration cultivars, GB1 (3.34 t ha$^{-1}$) recorded higher grain yield, followed by Annada (2.59 t ha$^{-1}$). Considering economics of crop production, the highest gross monetary return (GMR), net monetary return (NMR) and return per rupee investment was recorded by hybrid 6444 Gold (78299 Rs ha$^{-1}$), (42910 Rs ha$^{-1}$) and (2.21 Rs ha$^{-1}$) respectively. The HYV GB1 and Pratiksha was found to be at par with the hybrids in terms of net return and return per Rupee invested. Overall, the study emphasizes that hybrids like 6444 Gold and AZ6453, followed by varieties such as GB1 and Pratiksha, are promising options for enhancing the productivity and profitability of rice under dry direct seeded conditions in red and lateritic soils of West Bengal.

## 5. References

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