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Seed priming influences on yield and protein content of wheat sown at different time
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ABSTRACT
The aim of this field experiment conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, was to investigate the impact of different seed priming techniques and sowing dates on the yield and quality of wheat. The study aimed to identify the most effective seed priming technique and optimal sowing date to enhance wheat productivity and minimize yield reduction. The experiment employed a split plot design with two factors: seed priming techniques (no priming, hydropriming with distilled water, osmopriming with PEG, and halopriming with CaCl₂) and sowing dates (November 20, December 05, and December 20). The trial was conducted from November 2019 to April 2020 at the research field. The study consisted of three replications for each treatment combination. Osmopriming exhibited the most favorable results among all priming techniques, showing significantly higher values for effective tillers hill⁻¹ (3.91), number of grains spike⁻¹ (43.82), number of spikelets spike⁻¹ (16.16), grain yield (3.87 tons hectare⁻¹), biological yield (6.02 t ha⁻¹), and harvest index (39.03%). No priming condition resulted in the highest protein content (12.11%), while osmopriming had the lowest protein content (11.77%). The sowing conducted on November 20 yielded the highest number of effective tillers hill⁻¹ (3.57), number of grains spike⁻¹ (42.49), number of spikelets spike⁻¹ (15.75), grain yield (3.71 t ha⁻¹), biological yield (9.70 t ha⁻¹), and lowest protein content (11.74%). Sowing on December 20 resulted in the highest protein content (12.20%). Based on the study’s findings, it can be concluded that the osmopriming technique, combined with sowing on November 20, offers the most promising approach to mitigate the yield reduction of wheat. This combination demonstrated the highest grain yield (4.23 t ha⁻¹) compared to other treatments. Therefore, farmers and agricultural practitioners are recommended to adopt the osmopriming technique with a sowing date of November 20 for optimizing wheat production and enhancing overall crop quality.

INTRODUCTION
More than any other cereal, wheat (Triticum aestivum L.), an important crop of the Poaceae family, provides the majority of the world’s staple foods (Wato et al., 2020). The crop is grown under different climatic conditions in humid to arid, subtropical to temperate zones, and at elevations ranging from a few meters to more than 3600 meters (Hannan et al., 2021;
The position of Bangladesh in a subtropical area of South Asia makes it the best place for the crop. It is Bangladesh’s second-most significant staple crop after rice, which accounts for more than 20% of all dietary calories (Rahman and Hasan, 2009; Afsana et al., 2020). According to projections, global cereal demand would rise by 56% in 2050 compared to the base year of 2000, with wheat accounting for 26% of this rise (Hubert et al., 2010). Wheat output should be expanded to reduce the burden on rice and provide food security. The statistics of (BBS, 2020) state that wheat was cultivated on 816,000 acres in Bangladesh, producing 10,16,000 metric tons annually, or 1220 kg per acre in terms of yield. The production of wheat is constrained by a variety of biotic (diseases, insect pests, and weeds) and abiotic (drought, high temperatures, salinity, flooding, freezing, strong radiation, nutrient shortage, or toxicity) variables (Hannan et al., 2021). Among the abiotic factors, high temperature is the most important environmental factors for limiting the production of wheat in the world (Kumarasawamy and Shetty, 2016). Early wheat planting improves the number of tillers meter−1 square, the number of grains spike−1, and the grain weight of wheat, all of which boost yield (Qasim, 2008). Wheat is frequently sown in November to encourage good crop development and avoid excessive temperatures. When wheat is planted in the field after that, it will be subjected to a wide variety of temperatures that will have an impact on its development, growth, and potential yield. Photosynthesis in wheat is maximum between 22°C to 25°C and decreases sharply above 32°C during anthesis stage (Djanaguiraman et al., 2020).

According to Jafar et al. (2012), seed priming is a controlled hydration and re-drying process that allows pre-germination metabolic activity to start right away. It is a low-risk and efficient approach for increasing growth uniformity and germination rate, which reduces emergence time (Basra et al., 2002). In order to get a good crop stand, especially early emergence, better growth and development on residual soil moisture, and mitigating the negative effects of climatic conditions, seed priming or treating seeds with different salt solutions and growth regulators prior to sowing and sowing of pre-germinated seed is advantageous. It regulates germination metabolism and physio-biochemical characteristics of wheat, resulting in great temperature tolerance (Farooq et al., 2008). Given these facts, the current study was carried out to comprehend the physiological basis of seed priming, the effect of sowing date on yield, the features that contribute to yield, and the protein content of wheat.

**MATERIALS AND METHODS**

**Collection of the germplasms and experimental location**

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period of November 2019 to April 2020 to determine the individual and combined effects of sowing date and seed priming on wheat (BARI Gom33) growth and yield contributing features. The experimental site was located at 24°75’ N latitude and 90° 50’ E longitude, 18 m above sea level, and was part of the Old Brahmaputra Floodplain’s (AEZ-9) non-calcareous dark gray floodplain soil (UNDP and FAO, 1988). The experimental field was a medium high land with silty clay loam soil texture having pH value of 6.5.

**Experimental materials and design**

Wheat variety BARI Gom33 was used as test crop (Table 1). Wheat seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The experiment was set up using a split plot design with three replications, where the main plot was allocated sowing dates (factor A) from (Table 1) and the sub plot was given primed seed (factor B) from the same table. There were 36 plots in total. The plot measured 5m². Continuous rows were used for planting. The space between rows was 20 cm. The experiment’s replication to replication and plot to plot distances were 1 m and 0.75 m, respectively. After land preparation seeds were sown in three different sowing dates. Proper intercultural operations like weeding, thinning, gap filling, irrigation and pest managements were provided as per required.

**Seed priming**

According to the treatment, various priming solutions were created. After that, seeds were left to soak for 12 hours at 252°C room temperature. The ratio of seed weight to solution volume was kept at 1:5 (g L−1). Later, seeds were removed from the primers, lightly washed with blotting paper, and dried by forced air. Dried seeds were put in brown envelopes with tags in sealed polythene bags and stored in a refrigerator at 5±1°C until being placed for germination. While control treatment received no prior seed priming (Mim et al., 2021).

| Table 1. Features of the experimental material and experimental treatments. |
|-------------------------------|-------------------------------|
| **Experimental treatments**   | **Factor B: Priming Techniques (4)** |
| Factor A: Date of sowing (3)  | P0 = No Priming               |
| 20 November (S1)              | Pi = Hydopriming with distilled water |
| 5 December (S2)               | P2 = Halopriming with 1% CaCl2 solution |
| 20 December (S3)              | P3 = Osmopriming with 13.5% PEG solution |
Data collection and analysis

Due to the three separate seeding dates, harvesting took place at three different times when the crop was mature. The plants in a 1.0 m² area were harvested for yield in all cases. The plants in a 1.0 m² area were harvested for yield in all cases. Then sun dry weights of both the grain and straw were recorded for every plot and the weight in g plot⁻¹ was converted to kg ha⁻¹. Data were recorded during the crop cycle of three sowing dates; the dates of emergence, booting, heading and anthesis were recorded using the scale proposed by Zadoks et al. (1974). Data on various morphological traits viz. plant height (cm), number of total tillers hill⁻¹, number of effective tillers hill⁻¹, number of non-effective tillers hill⁻¹ were determined at 20, 40, 60, 80 DAS, respectively. Yield parameter such as spike length (cm), number of spikelets spike⁻¹, number of sterile spikelets spike⁻¹, number of grains spike⁻¹, 1000-grain weight (g), grain yield (t ha⁻¹), straw yield (t ha⁻¹), biological yield (t ha⁻¹), harvest index (t ha⁻¹), protein content (%) were determined following standard lab protocol. At the Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh, protein content was calculated using the Kjeldahl method in accordance with the recommended procedure by Bremner (1982). The recorded data were statistically analyzed using the "Analysis of Variance" technique and the differences among treatment means were adjudged by Duncan’s New Multiple Range Test and Least Significant Difference Test whenever necessary (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of sowing date on yield contributing traits and protein content of wheat

In Table 2, the results of the analysis of variance showed that the sowing date had a statistically significant impact on all of the yield-contributing variables that were examined, in addition to wheat yield and protein content. First sowing date (20 November) produced the longest plant (98.21 cm), the highest number of tillers plant⁻¹ (3.57), effective tillers plant⁻¹ (3.37), the longest spike (13.48 cm), the highest number of spikelets spike⁻¹ (15.75), grains spike⁻¹ (42.49), 1000-grain weight (46.68 g), grain yield (3.8 t ha⁻¹), straw yield (t ha⁻¹), biological yield (t ha⁻¹), harvest index (t ha⁻¹) and the lowest number of non-effective tillers plant⁻¹ (0.15), sterile spikelets spike⁻¹ (1.58) compared to second (05 December) and last (20 December) sowing date (Table 3).

Due to high temperatures negatively affecting wheat’s photosynthesis, the plant height may drop at late sowing. Passioura (1994) and this plant height result were comparable. Hill⁻¹ findings regarding the total number of tillers were consistent with those of Alam et al. (2013). Because plants were subjected to terminal heat stress at the late sowing stage (20 December), the number of effective tillers hill⁻¹ was higher in wheat planted on November 20. The crop sown on November 20 might have enjoyed longer duration for growth as compared to others and produced maximum number of grains spike⁻¹. The results are

Table 2. Analysis of variance (mean square) of the data for yield contributing characters and yield of wheat.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Plant height (cm)</th>
<th>No. of total tillers hill⁻¹</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Biological yield (g)</th>
<th>No. of sterile spikelets spike⁻¹</th>
<th>Spike length (cm)</th>
<th>No. of spikelets spike⁻¹</th>
<th>No. of grains spike⁻¹</th>
<th>1000-grain weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>37.3*</td>
<td>0.56444*</td>
<td>0.001036</td>
<td>0.04103</td>
<td>0.001785</td>
<td>0.0435</td>
<td>0.007778</td>
<td>0.001865</td>
<td>0.00153</td>
<td>0.00778</td>
</tr>
<tr>
<td>Date of sowing</td>
<td>2</td>
<td>37.3*</td>
<td>0.56444*</td>
<td>0.001036</td>
<td>0.04103</td>
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<td>0.001865</td>
<td>0.00153</td>
<td>0.00778</td>
</tr>
<tr>
<td>Error</td>
<td>4</td>
<td>1.576*</td>
<td>0.00444*</td>
<td>0.00133</td>
<td>0.0133</td>
<td>0.00133</td>
<td>0.00133</td>
<td>0.00133</td>
<td>0.00133</td>
<td>0.00133</td>
<td>0.00133</td>
</tr>
<tr>
<td>Seed</td>
<td>3</td>
<td>51.929*</td>
<td>2.41481*</td>
<td>0.000414</td>
<td>0.0414</td>
<td>0.000414</td>
<td>0.00414</td>
<td>0.000414</td>
<td>0.000414</td>
<td>0.000414</td>
<td>0.000414</td>
</tr>
<tr>
<td>A × B</td>
<td>6</td>
<td>1.438*</td>
<td>0.00148*</td>
<td>0.00033</td>
<td>0.0033</td>
<td>0.00033</td>
<td>0.00033</td>
<td>0.00033</td>
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</tr>
<tr>
<td>Error</td>
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<td>0.00148*</td>
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<td>0.0033</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean square</th>
<th>Source of variation</th>
<th>Plant height (cm)</th>
<th>No. of total tillers hill⁻¹</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Biological yield (g)</th>
<th>No. of sterile spikelets spike⁻¹</th>
<th>Spike length (cm)</th>
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<td>0.00033</td>
<td>0.00033</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Effect of date of sowing on the yield contributing characters and protein content of wheat.

<table>
<thead>
<tr>
<th>Date of sowing (month/day)</th>
<th>Plant height (cm)</th>
<th>No. of Effective tillers hill⁻¹</th>
<th>No. of Sterile spikelets hill⁻¹</th>
<th>Spike length (cm)</th>
<th>No. of Grains spike⁻¹</th>
<th>1000 grain weight (g)</th>
<th>Protein content (%)</th>
<th>Protein yield (kg ha⁻¹)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>98.21a</td>
<td>3.37a</td>
<td>0.57b</td>
<td>3.37a</td>
<td>0.13</td>
<td>42.49a</td>
<td>15.75a</td>
<td>9.70a</td>
<td>38.13a</td>
</tr>
<tr>
<td>S2</td>
<td>95.88b</td>
<td>3.37a</td>
<td>0.57b</td>
<td>3.37a</td>
<td>0.13</td>
<td>42.49a</td>
<td>15.75a</td>
<td>9.70a</td>
<td>38.13a</td>
</tr>
<tr>
<td>S3</td>
<td>94.75b</td>
<td>3.37a</td>
<td>0.57b</td>
<td>3.37a</td>
<td>0.13</td>
<td>42.49a</td>
<td>15.75a</td>
<td>9.70a</td>
<td>38.13a</td>
</tr>
<tr>
<td>S4</td>
<td>95.21a</td>
<td>3.37a</td>
<td>0.57b</td>
<td>3.37a</td>
<td>0.13</td>
<td>42.49a</td>
<td>15.75a</td>
<td>9.70a</td>
<td>38.13a</td>
</tr>
</tbody>
</table>

Means with the same letters within the same column do not differ significantly; ** = Significant at 1% level of probability, * = Significant at 5% level of probability; S1 = 20 November, S2 = 05 December, S3 = 20 December.

Effect of seed priming on yield traits and protein content of wheat

On all of the wheat attributes that were investigated, various seed priming procedures had a substantial impact (Table 2). The plant height results corroborated Nayyer et al. (1995) findings. The general theory that plants in their early phases of growth may adapt to their surroundings considerably more easily due to seed priming treatment may be linked to the highest number of effective tillers hill⁻¹. These results supported to those
Table 4. Effect of seed priming on the yield contributing characters and protein content of wheat.

<table>
<thead>
<tr>
<th>Seed priming</th>
<th>Plant height (cm)</th>
<th>No. of Total tillers hill⁻¹</th>
<th>No. of Effective tillers hill⁻¹</th>
<th>No. of Non-effective tillers hill⁻¹</th>
<th>Spike length (cm)</th>
<th>No. of Spikelets spike⁻¹</th>
<th>No. of Sterile spikelets spike⁻¹</th>
<th>No. of Grains spike⁻¹</th>
<th>1000 grain weight (g)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₀</td>
<td>93.90c</td>
<td>2.87d</td>
<td>2.47d</td>
<td>0.40a</td>
<td>11.59d</td>
<td>15.14d</td>
<td>1.73a</td>
<td>40.22d</td>
<td>45.52b</td>
<td>8.17d</td>
<td>35.47c</td>
<td>12.11a</td>
</tr>
<tr>
<td>P₁</td>
<td>94.86c</td>
<td>3.07c</td>
<td>2.76c</td>
<td>0.24b</td>
<td>12.31c</td>
<td>15.59c</td>
<td>1.64b</td>
<td>41.83c</td>
<td>45.76b</td>
<td>9.06c</td>
<td>35.69c</td>
<td>12.05a</td>
</tr>
<tr>
<td>P₂</td>
<td>97.14b</td>
<td>3.44b</td>
<td>3.27b</td>
<td>0.18b</td>
<td>12.98b</td>
<td>15.84b</td>
<td>1.58c</td>
<td>42.77b</td>
<td>46.36a</td>
<td>9.47b</td>
<td>37.45b</td>
<td>11.87ab</td>
</tr>
<tr>
<td>P₃</td>
<td>99.22a</td>
<td>4.04a</td>
<td>3.91a</td>
<td>0.13b</td>
<td>13.81a</td>
<td>16.16a</td>
<td>1.55d</td>
<td>43.82a</td>
<td>46.73a</td>
<td>9.89a</td>
<td>39.03a</td>
<td>11.77b</td>
</tr>
<tr>
<td>S₀</td>
<td>1.19</td>
<td>0.26</td>
<td>0.32</td>
<td>0.06</td>
<td>0.47</td>
<td>0.22</td>
<td>0.04</td>
<td>0.76</td>
<td>0.28</td>
<td>0.37</td>
<td>0.83</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Means with the same letters within the same column do not differ significantly; ** = Significant at 1% level of probability, * = Significant at 5% level of probability.

Table 5. Interaction effect of date of sowing and seed priming on the yield contributing characters and protein content of wheat.

<table>
<thead>
<tr>
<th>Date of sowing; Seed priming</th>
<th>Plant height (cm)</th>
<th>No. of Total tillers hill⁻¹</th>
<th>No. of Effective tillers hill⁻¹</th>
<th>No. of Non-effective tillers hill⁻¹</th>
<th>Spike length (cm)</th>
<th>No. of Spikelets spike⁻¹</th>
<th>No. of Sterile spikelets spike⁻¹</th>
<th>No. of Grains spike⁻¹</th>
<th>1000 grain weight (g)</th>
<th>Biological yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₀; P₀</td>
<td>94.97fg</td>
<td>3.07h</td>
<td>2.80e</td>
<td>0.27cd</td>
<td>12.48de</td>
<td>15.26ef</td>
<td>1.65cd</td>
<td>40.81fg</td>
<td>46.23cd</td>
<td>3.15e</td>
<td>5.52e</td>
<td>8.66e</td>
</tr>
<tr>
<td>S₀; P₁</td>
<td>96.33de</td>
<td>3.27f</td>
<td>2.87e</td>
<td>0.20de</td>
<td>13.23c</td>
<td>15.64df</td>
<td>1.61ef</td>
<td>42.07de</td>
<td>46.47bd</td>
<td>3.47d</td>
<td>6.07bc</td>
<td>9.54d</td>
</tr>
<tr>
<td>S₀; P₂</td>
<td>99.57bc</td>
<td>3.67d</td>
<td>3.53c</td>
<td>0.12e</td>
<td>13.83b</td>
<td>15.84bcd</td>
<td>1.55h</td>
<td>42.85fd</td>
<td>46.87ab</td>
<td>4.00b</td>
<td>6.14ab</td>
<td>10.14b</td>
</tr>
<tr>
<td>S₀; P₃</td>
<td>101.97a</td>
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<td>4.27a</td>
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Means with the same letters within the same column do not differ significantly; ** = Significant at 1% level of probability, * = Significant at 5% level of probability.
reported by Singh and Singh (1991). The findings for number of grains spike⁻¹ confirmed the results of Singh and Singh (1991) that treated seeds gave a greater number of grains spike⁻¹ than untreated seeds. Seed priming of wheat seed prior to planting might have an impact on grain filling stage thus produces higher grain weight. Sarkar (2012) also found that priming had positive effects on yield. This might be due to the effect of seed priming which minimized the stress of temperature in late sown wheat. In contrast, no priming approach produced the maximum levels of ineffective tillers hill⁻¹ (0.40), sterile spikelets spike⁻¹ (1.73), and protein (12.11%) (Table 4). Non-effective tillers might be due to the lowest viability and vigor of seedling in absence of seed priming techniques. High protein content in no priming condition might be due to the highest up taking capability of N through root. But Sallam (1992) reported that water-soaked seeds significantly gave highest protein content as compared to un-soaked and NaHCO₃-soaked seeds.

**Interaction effect of sowing date and seed priming on yield traits and protein content of wheat**

The interaction of the seed priming and sowing dates had a statistically significant impact on the wheat protein content, yield, and all of the yield contributing characteristics (Table 2). The tallest plant (101.97 cm), highest (4.27) number of tillers, highest (4.27) number of effective tillers hill⁻¹, highest spike length (14.39 cm), highest number of spikelets spike⁻¹ (16.26), highest grain number (44.23), highest 1000-grain weight (47.17 g), highest (10.46 t ha⁻¹) biological yield, highest harvest index (40.44%) were found on 20 November from osmopriming technique (Table 5) in contrast with lowest values in no priming technique on 20 December (Table 5). On the other hand, on December 20 in the absence of priming, the highest number of ineffective tillers (0.53), highest number of sterile spikelets spike⁻¹, and highest protein content (12.58%) were discovered (Table 5). Early wheat planting may result in nutritious grains spike⁻¹ that are hefty. These findings concur with Singh and Singh (1991) findings. Higher grain yield in osmopriming technique from 20 November sowing might be due to the inception of higher solar radiation by leaf and higher nutrient uptake by root. Keskitulo et al. (2005) also found the same. Additionally, late sowing of wheat is constantly prone to changeable temperate regimes that extra-accelerate crop development, resulting in crop plants using less solar radiation and producing a lower final yield (Namakka et al., 2008).

**Conflict of interest**

The authors declare that there is no conflict of interests regarding the publication of this paper.

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**REFERENCES**


