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SEED YIELD AND QUALITY OF WHEAT AS INFLUENCED BY DIFFERENT AGRONOMIC PRACTICES IN SOUTH-CENTRAL COASTAL REGION (AEZ-13) OF BANGLADESH

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Abstract

A field study was carried out at Regional Agricultural Research Station, Rahmatpur, Barishal during Rabi 2019-2020 on wheat seed yield and quality influenced by different management practices. The experiment was comprised of two sowing dates with seven different agronomic management practices. The experiment was laid out in split plot design where sowing dates were assigned in main plot and different agronomic management practices in sub-plot with three replications. The results revealed that, optimum sowing condition (20th November) always maintain superiority over delayed sown condition (20th December) in respect of seed yield and quality. From agronomic management aspects strip tillage + recommended fertilizer doses+ 3 irrigations showed the best permormance in respect of seed yield (3.433 t/ha) and quality. From interaction effects of sowing date × agronomic management practices using strip tillage + recommended fertilizer doses+ 3 irrigations treatment with optimum sowing condition e.g. 20th November sowing condition performed the best in respect of seed yield (4.223 t/ha) and quality. Another two treatments (Strip tillage + recommended fertilizer dose + Boron foliar spray at anthesis (0.2%) + 2 irrigations (CRI, Booting) + Cowdung) and (Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + Boron foliar spray at anthesis (0.2%) + 3 irrigations (CRI, Booting, Grain filling) also produced statistically identical seed yield (4.15 and 4.01 t/ha, respectively). But considering economic point of view, (Recommended fertilizer dose + 0.2% boron foliar spray at anthesis + 3 irrigations) gave the highest BCR (2.46) and economic return. In late seeding condition (20th December) (strip tillage + recommended fertilizer doses+ 3 irrigations) treatment had performed the best in respect of seed yield (2.643 t/ha) and seed quality (germination 67.33%).

Key words: AEZ-13, Agronomic management, Quality, Seed yield, Sowing condition, Wheat.

Introduction

Triticum aestivum L., commonly known as wheat, is the second most produced cereal grain after maize and is significantly cultivated in various regions across the world (Shewry 2009). Due to its chemical composition and extraordinary technological properties, wheat holds significant importance in food processing in many countries (Cacak-Pietrzak 2008, Biel et al. 2020). Carbohydrates, protein, dietary fiber, fat, minerals, B vitamins, and other bioactive substances are the main constituents of wheat grain (Shewry and Hey 2015). It is essential to cultivate wheat in a manner that make sure of achieving optimal grain yield and quality aligns with the demands of food processing (FAO 2018). The yield and quality of wheat grain are regulated by multiple factors, to gathered with the genotype (cultivar), environmental conditions (soil and climate), and agricultural practices (Mäder et al. 2007, Knapowski et al. 2016, Dziki et al. 2017, Zargar et al. 2018). These

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factors also act as a part in determining the economic potentiality of production and the provision of food security (Michalczyk 2012, Fischer et al. 2014, McArthur et al. 2017, Durham et al. 2021). Wheat cultivation takes place worldwide, adapting to diverse environmental conditions. Generally wheat supplies carbohydrate (69.60%) and reasonable amount of protein (12%), fat (1.72%), and also minerals (16.20%) and other necessary nutrients. In south-central coastal region of Bangladesh, cultivation of wheat is usually followed by transplant Aman rice cultivation. Farmers preference of long duration rice varieties, poses a significant delay in wheat cultivation practices. Moreover, severe incidence of wheat blast disease dissuaded farmers to cultivate wheat at large scale. Escaping the blast severity period by optimum sowing is not pragmatic for this region rather; facing the blast favoring criteria with management measures is a prerequisite. The optimum temperature for wheat anthesis and grain filling ranges from 12 to 22°C. Post-anthesis heat stress in wheat induces several physiological effects which eventually result in smaller grain weight due to reduced grain filling period and starch synthesis duration or the combined effect of both. Islam (2009) estimated from 34 meteorological climate sites in Bangladesh, that temperature increases over the past 100 years or all Bangladesh of 0.62°C (maximum) and 1.54°C (minimum) occurred in February. Temperature in Bangladesh increased over the past two decades by 0.035°C/year. If this trend continues, temperatures will have increased 2.13°C more than 1990 levels by 2050. With this scenario, to minimize terminal heat stress during anthesis of wheat, foliar Boron application may be an effective way to minimize sterility and maximize yield. Boron influences cell development and elongation as stated by Bennett, 1993. Deficiency of boron can also cause reduction in crop yield and inferior crop quality. Boron is an essential plant food element, having a specific role in growth and development of plants. Irrigation has a positive correlation with grain yield. Wheat cultivated in irrigated condition has vigorous growth, higher fertilizer use efficiency and greater percentage of pollen fertility. Irrigation frequency and water volume over late sown condition may combat against the terminal heat stress in a significant level. Farmers in south-central coastal region of Bangladesh do not maintain a balanced fertilizer dose in wheat field. Moreover, nitrogenous fertilizers are used abundantly rather than other. Adoption of using organic manure and balanced chemical fertilizers instead of traditional farmers practice system may resulted in better seed quality and yield increment. Sowing wheat by minimum tillage is an efficient tillage system and resource conservation technology (Ali et al. 2016). In the conventional tillage system crop residues and weeds are burned, used as feed or incorporated with soil. But, in conservation tillage more importance is given to conserving the soil properties. Here, the plant cover is used to provide organic matter and higher infiltration of irrigation and rain water (Ortega 1991) into soil. Generally, poor quality seed may affect the succeeding crop yields in 2 ways: first because emergence from the seedbed may be less than expected, and then plant population density may be sub-optimal, and second because the growth rate of those plants that do emerge may be less than those grown from high quality seeds and become a significant factor affecting wheat productivity. Both environmental and agronomical factors highly influence the key physiological processes in seeds under production and finally affect seed yield and quality (Nadew 2018). A better understanding of the effects of both climatic and agronomic variables on quality traits of wheat crop is likely to become a crucial issue (Nadew 2018). Therefore, the study was undertaken based on the following objectives in optimum and late seeding condition for wheat growing areas in south-central coastal region of Bangladesh under climate changed conditions- i) to evaluate the best agronomic management option/s for seed yield of wheat and ii) to find out the best agronomic management option/s for quality wheat seed production.

Materials and Methods

Climate and soil: The geographical location of the experimental site was under the sub-tropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. The topsoil was loamy to loamy clay in nature and the pH ranged from 5.5 to 6.5. The experimental area was flat, having available irrigation and drainage systems and above flood level.

Experimental design and layout

The experiment comprised on- Main Plot: Date of sowing (2): i) 20th November (S_1), and ii) 20th December (S_2), Sub-Plot: Agronomic management practices (7):

Number of Treatments	Treatment symbol	Agronomic management practices
i)	M_1	Strip tillage + Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + Boron foliar spray (0.2%) at anthesis + 3 Irrigations (CRI, Booting, Grain Filling) + Cowdung@5 t/ha
ii)	M_2	Strip tillage + Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + Boron foliar spray at anthesis (0.2%) + 2 Irrigations (CRI, Booting) + Cowdung@5 t/ha
ii)	M_3	Strip tillage + Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + 3 Irrigations (CRI, Booting, Grain filling)
iv)	M_4	Strip tillage + Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + 2 Irrigations (CRI, Booting)
v)	M_5	Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + Boron foliar spray at anthesis (0.2%) + 3 Irrigations (CRI, Booting, Grain filling)
vi)	M_6	Recommended fertilizer dose (NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha) + Boron foliar spray at anthesis (0.2%) + 2 Irrigations (CRI, Booting)
vii)	M_7	Farmer's practice (Conventional tillage, NPK non-judicious dose, only irrigation at CRI stage, no organic matter)

The experiment was laid out in split-plot design where date of sowing as main plot and different management practices in sub plot with three replications during *Rabi* 2017-18. There were 42 plots having unit plot size of 5 m × 4 m. The 14 treatment combinations were randomly assigned in plots of each replication. BARI Gom-26 was used as the variety. Wheat seeds were sown continuously in the 20 cm apart rows to rows and 4-5 cm depth at the rate of 120 Kg/ha. The fertilizers NPKSMgZnB@ 120-30-90-15-6-2.6-1 kg/ha respectively were applied. The entire amount of TSP, MoP and Gypsum, 2/3rd of urea were applied during the final preparation of land. Rest of urea was top dressed after first irrigation, at flowering and at grain filling stage.

Sowing by strip tiller

Minimum tillage seeder can be converted to strip tillage seeder by removing 50 per cent tines from the rotary tillers. The main functional parts of the drill are toolbar frame, seed metering device, seed and fertilizer boxes, and inverted "T" furrow opener. In this system 300 to 400 mm wide planting strip is tilled by the rotary tine to place seeds (Haque et al. 2004). In this sowing system soil strip and seed placement was done simultaneously. The machine was passed along the length of the rectangular field. For proper seed placement the speed of the machine was controlled at an average value of 2.5 km/hr. Wheat seeds were sown by strip tillage seeder adjusted line spacing in 20 cm and retention straw height 30 cm. The depth of planting was measured by a graduated scale and seed depth was maintained at 4-5 cm.

Data collection

Data were collected on (a) plant height in cm (ten randomly selected plant), (b) tiller number/hill (ten randomly selected hill), (c) spike length in cm (ten randomly selected plant), (d) number of spikelet/spike (ten randomly selected plant), (e) number of grain/spike (ten randomly selected plant), (f) 1000 grain weight in gram and (g) seed yield (t/ha) (From whole plot). Data on seed quality were collected on (a) germination percentage (on one hundred seed), (b) seedlings root length (cm) (from ten randomly selected seedlings), (c) seedlings shoot length (cm) (from ten randomly selected seedlings) and (d) seedlings dry weight at 15 DAS (from ten randomly selected seedlings).

Germination (%): A grow out test (GOT) was conducted *in situ* to calculate germination percentage on experimental site. Germination percentage was measured by the following formulae at 15 days after sowing-

$$\text{Germination percentage} = \frac{\text{Seeds germinated}}{\text{Total seeds}} \times 100$$

Seedlings root and shoot length: Seedlings root and shoot length was measured by linear scale at 15 DAS. Ten seedlings were selected randomly from the soil based *in situ* grow out test (GOT), uprooted with necessary precautions and length was measured in centimeter.

Seedling dry weight (g): Seedlings dry weight was measured through oven drying of ten randomly selected seedlings at 120^{o}C for three consecutive days. After drying process weight of ten seedlings were measured in gram.

BCR Calculation: Benefit cost ratio was measured by the following formulae-

$$\text{Benefit cost ratio} = \frac{\text{Gross return/ha}}{\text{Total cost of cultivation /ha}}$$

Statistical analysis

Data on yield and yield contributing characters were collected and compiled. The mean values of all the characters were calculated and analysis of variance was performed by statistical software R and the significance of the difference among the treatment means were estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez 1984).

Results and Discussion

Yield and yield parameters of wheat affected by sowing date: The yield and yield parameters of wheat was affected by variations in sowing dates and presented on Table 1. The data distinctly specifies that the yield and yield-contributing characteristics were significantly influenced by both optimal and late seeding conditions. Remarkably, the maximum yield was observed in the condition of optimal sowing, while late sowing issued to yields. Among the different sowing dates, the highest seed yield of 3.95 t/ha was recorded in those crops which sown on 20 November, whereas the lowest yield of 2.45 t/ha was obtained from the crops, sown on 20 December. Optimal sowing conditions during the winter period demonstrated advantageous as it extended the crop duration and maximized the distribution of growth stages. Accordingly, plants had adequate time to proficiently utilize fertilizers and radiation, resulting in increased yields. Contrarily, late seeding had the opposite effect on yield. In agreement with the result, a research conducted with subsequent repeated trials under almost similar ecological conditions supports the opinion that wheat sown between November, 15 and December, 5 exhibited significantly better plant growth and yield compared to both early sowing (November, 5) and late sowing (December, 15) in the Char land ecosystem of Bangladesh (Kamrozzaman et al. 2016). Another study concluded that using of water soaked seeds and sowing on November, 15 resulted in higher yield and better quality grains for wheat (Shahzad et al. 2007).

Table 1: Yield and yield parameters of wheat affected by sowing dates.

Sowing dates	Plant height (cm)	Tiller no. per hill	Spike length (cm)	Spikelet/spike (No.)	Grain/spike (No.)	1000 grain wt. (g)	Seed Yield (t/ha)
S_1	90.3a	5.89ab	11.61a	17.56a	37.43a	47.74a	3.95a
S_2	76.69b	6.16a	9.37b	14.10b	26.70b	42.84b	2.45b
LSD $_{(0.05)}$	2.93	0.91	0.85	0.87	2.22	1.80	0.14
CV (%)	3.18	13.62	7.37	4.97	6.28	3.61	3.79

**S_1 = 20th November, and S_2 = 20th December.

Effect of different management practices on wheat

Table 2 represents the impact of various management practices on wheat yield and yield contributing characters under both optimum and delayed sown conditions. The results indicate significant variations generated from the different management approaches applied for wheat cultivation. The highest spikelet/spike, grain/spike, and 1000 grain weight were observed in M_3, which yielded 3.43 t/ha showed on Table 2. This results can be assigned to the logical implementation of three scheduled irrigations during critical growth stages, which functionally enhanced the fertilizer use efficiency of the recommended balanced dose with the adoption of strip tillage. Additionally, the retention of residual materials facilitated earlier crop establishment, finally leading to higher seed yield in both optimum and delayed sown conditions. The agronomic management practices performed in treatment M_2 showed statistically similar yield and yield contributing characteristics as applied in M_3. However, in case of strip tillage, the effect of deficit irrigation in M_2 compared to M_3 could be remunerated by the presence of residual soil moisture, which was increased by the addition of organic matter in the form of cow dung. The lowest grain yield was found in M_7 under farmer's practice, with a yield of 2.793 t/ha. Even with the lack of optimal inputs and delayed sowing, the agronomic management practices of conventional tillage, non-judicious NPK use, and irrigation only at the CRI stage still resulted in a decent yield was observed in farmers practice. On the other hand, M_1 treatment, plants did not achieve the maximum seed yield and yield contributing characteristics, leading to a lower seed yield performance of 3.173 t/ha but received high management inputs. The excessive inputs may have forwarded vegetative stage proliferation, thereby attacking the distribution of growth stages. Additionally, the accumulation of dry matter from high inputs may not have been productively conveyed to the reproductive phase, clearly shortening this stage.

Table 2: Yield and yield parameters of wheat affected by different management practices.

Management practices	Plant height (cm)	Tiller no. per hill	Spike length (cm)	Spikelet/spike (no.)	Grain/spike (No.)	1000 grain wt (g)	Seed Yield (t/ha)
M_1	83.47ab	5.733	10.05bc	16.10b	31.75b	48.36a	3.173c
M_2	85.55a	6.000	10.63ab	16.60ab	32.78ab	46.42ab	3.342ab
M_3	86.58a	5.967	11.19a	17.15a	34.90a	48.36a	3.433a
M_4	85.17a	6.667	10.88ab	16.21b	33.30ab	46.53ab	3.248bc
M_5	84.10ab	5.992	10.56ab	15.99bc	32.33b	45.03bc	3.257bc
M_6	81.29bc	6.100	10.61ab	15.14c	31.37b	43.54cd	3.147c
M_7	78.35 c	5.700	9.523c	13.63d	28.01c	41.78d	2.793d
LSD $_{(0.05)}$	3.16	ns	0.92	0.94	2.39	1.95	0.15
CV (%)	3.18	13.62	7.37	4.97	6.28	3.61	3.79

**M_1 = ST + RDF + Boron spray + 3 Irrigations + Cowdung, M_2 = ST + RDF + Boron spray + 2 Irrigations + Cowdung, M_3 = ST + RDF + 3 Irrigations, M_4 = ST + RDF + 2 Irrigations, M_5 = RDF + Boron spray + 3 Irrigations, M_6 = RDF + Boron spray + 2 Irrigations and M_7 = Farmer's practice.

Interaction effects of sowing date and management practices on wheat:

Interaction effects of wheat as affected by sowing date and management practices were represented in Table 3. The results revealed that sowing at 20th November with M_3 treatment exhibited the highest seed yield (4.223 t/ha) and yield contributing characters. In agreement with the result, a research work on wheat concluded that, high 1000-seeds weight was observed for early sown crop of early November. Lighter 1000-seeds weight was recorded for delayed sown crop of early December and at mid-November (Dagash et al. 2014).

Sowing at 20th December along with M_2 treatment also demonstrated the maximum yield which is statistically identical to M_3 and M_5 treatments. It was also found that the minimum tillage is a more appropriate technology than the conventional tillage, on average by 0.12 t/ha (Vrtílek et al. 2019). Sowing at 20th December exhibited comparatively lower yield due to delayed sowing. In late seeding conditions, the highest yield can be observed from M_3 treatment (2.643 t/ha). The lowest grain yield considering early and late seeding can be observed from $S_2 \times M_7$ treatment combination e.g. farmers practice in late seeding (2.243 t/ha). M_1 treatment with high inputs rendered a fair grain yield (3.863 t/ha) in early sown crop. Whereas, in delayed sown condition rendered significantly lower yield in compare to other treatment combinations (2.483 t/ha). In agreement with this, a research suggests that, sowing delayed beyond 15th December showed adverse effects on the growth and yield traits (Kalwar et al. 2018).

Table 3: Yield and yield parameters of wheat affected by different management practices and sowing dates.

Sowing dates × Management practices	Plant height (cm)	Tiller no. per hill	Spike length (cm)	Spikelet /spike (no.)	Grain /spike (no.)	1000 grain wt. (g)	Seed Yield (t/ha)
$S_1 \times M_1$	91.20a	6.267bc	11.08b-d	17.47ab	37.20a	47.42b-d	3.863c
$S_1 \times M_2$	91.37a	6.133bc	11.60 a-c	18.33a	38.47a	48.32bc	4.150ab
$S_1 \times M_3$	92.17a	5.867bc	12.49a	18.77a	40.53a	51.13a	4.223a
$S_1 \times M_4$	91.60a	5.667bc	12.12ab	18.27a	38.73a	48.42ab	4.007bc
$S_1 \times M_5$	91.20a	6.467ab	11.61a-c	18.07ab	37.87a	47.25b-e	4.097ab
$S_1 \times M_6$	89.07ab	5.733bc	11.89ab	16.87b	37.33a	46.73b-e	3.950bc
$S_1 \times M_7$	85.60b	5.067c	10.51c-e	15.13cd	31.87b	44.90d-g	3.343d
$S_2 \times M_1$	75.73de	5.200bc	9.020fg	14.73c-e	26.30c-e	43.32fg	2.483ef
$S_2 \times M_2$	79.73cd	5.867bc	9.667e-g	14.87cd	27.08 c-e	44.52e-g	2.533ef
$S_2 \times M_3$	81.00c	6.067bc	9.887d-f	15.53c	29.27bc	45.58c-f	2.643e
$S_2 \times M_4$	78.73cd	7.667a	9.633e-g	14.15de	27.87cd	44.65e-g	2.490ef
$S_2 \times M_5$	77.00c-e	5.517bc	9.500e-g	13.92de	26.80 c-e	42.81gh	2.417fg
$S_2 \times M_6$	73.52ef	6.467ab	9.333e-g	13.41ef	25.40de	40.35hi	2.343fg
$S_2 \times M_7$	71.10 f	6.333a-c	8.540g	12.12f	24.15e	38.67i	2.243g
LSD $_{(0.05)}$	4.474	1.382	1.303	1.325	3.393	2.755	0.2132
CV (%)	3.18	13.62	7.37	4.97	6.28	3.61	3.79

**S_1 = 20 November and S_2 = 20 December and M_1 = ST + RDF + Boron spray + 3 Irrigations + Cowdung, M_2 = ST + RDF + Boron spray + 2 Irrigations + Cowdung, M_3 = ST + RDF + 3 Irrigations, M_4 = ST + RDF + 2 Irrigations, M_5 = RDF + Boron spray + 3 Irrigations, M_6 = RDF + Boron spray + 2 Irrigations, and M_7 = Farmer's practice.

Qualitative parameters of wheat seed affected by sowing dates

Qualitative parameter of wheat seed was significantly differs by the variation in sowing dates. Optimum sowing is a pre-requisite to quality seed production. Data from Table 4 reveals that seed germination percentage was higher (94.43%) in optimum sowing whereas lower (59.62%) in delayed sowing. Seedlings root and shoot length was comparatively higher in optimum sowing (4.65 and 5.58 cm, respectively) whereas root and shoot length was minimum in delayed sown crop (3.19 and 4.39 cm, respectively). Seedlings dry weight was comparatively higher in optimum sown crop (3.10 g/plant) than delayed sown (1.48 g/plant).

Table 4: Qualitative parameters of wheat seed affected by sowing dates.

Sowing dates	Germination (%)	Root length of seedlings (cm)	Shoot length of seedlings (cm)	Dry wt. of seedling (g)
S_1	94.43a	4.65a	5.58a	3.10a
S_2	59.62b	3.19b	4.39b	1.48b
$LSD_{(0.05)}$	1.93	0.28	0.25	0.31
CV (%)	2.27	6.54	4.57	12.20

**S_1 = 20th November, and S_2 = 20th December.

Qualitative parameters of wheat seed affected by management practices

Significant variations can be observed from the qualitative parameters of wheat seeds due to variation in different management practices. M_3 treatment showed statistically good quality seeds considering the percentages of germination (81.67%), seedlings root and shoot length (4.185 and 5.325 cm, respectively) and seedlings dry weight (2.420 g). M_2 treatment also showed statistically identical germination percentage (80.67%) to M_3 treatment considering all parameters. M_1 and M_5 treatment demonstrated a higher amount of seedlings dry weight (2.508 and 2.4 g, respectively) which was statistically identical to M_3.

Table 5: Qualitative parameters of wheat seed affected by different management practices.

Management practices	Germination (%)	Root length of seedlings (cm)	Shoot length of seedlings (cm)	Dry wt. of seedling (g)
M_1	78.50cd	3.872bc	5.145ab	2.508a
M_2	80.6ab	4.095ab	5.220ab	2.357ab
M_3	81.67a	4.185a	5.325a	2.420a
M_4	78.83bc	3.975abc	5.005bc	2.358ab
M_5	76.67d	3.985abc	4.850cd	2.400a
M_6	72.67e	3.765cd	4.760cd	2.040bc
M_7	70.17f	3.557d	4.605d	1.935c
$LSD_{(0.05)}$	2.083	0.3061	0.2717	0.3328
CV (%)	2.27	6.54	4.57	12.20

**S_1 = 20th November and S_2 = 20th December and M_1 = ST + RDF + Boron spray + 3 irrigations + Cowdung, M_2 = ST + RDF + Boron spray + 2 irrigations + Cowdung, M_3 = ST + RDF + 3 irigations, M_4 = ST + RDF + 2 irrigations, M_5 = RDF + Boron spray + 3 irrigations, M_6 = RDF + Boron spray + 2 irrigations and M_7 = Farmer's practice.

Interaction effects of sowing dates and management practices on qualitative parameters

Considering interaction effects of treatments wheat germination percentage was higher in $S_1 \times M_1$ (95%), $S_1 \times M_2$ (96%), $S_1 \times M_1$ (96%), $S_1 \times M_4$ (95%), $S_1 \times M_5$ (96%) treatment combinations. But, germination percentage was lower in $S_2 \times M_6$ (53.33%) and $S_2 \times M_7$ (49.33%) treatment combinations. In delayed sowing, germination percentage was higher in M_3 treatment (67.33%). Seedlings root length was found higher in $S_2 \times M_2$ treatment combination (4.95 cm) whereas the shortest root length was found (3.150 cm) in $S_2 \times M_7$ treatment combinations. It was observed that, in delayed sown stress condition root system become fibrous and elongated to absorb nutrients and capillary water. The longest shoot length can be observed from $S_1 \times M_2$ and $S_1 \times M_3$ treatment combinations (5.92 and 6.02 cm, respectively). Consequently, the shortest shoot length can be observed from $S_2 \times M_7$ treatment combination. In case of seedlings dry weight, the treatment combinations $S_1 \times M_1$, $S_1 \times M_2$ and $S_1 \times M_3$ had produced the heaviest dry seedlings wt./plant (3.29, 3.41 and 3.33 g. respectively).

Table 6: Qualitative parameters of wheat seeds affected by different management practices with sowing dates.

Sowing dates × Management practices	Germination %	Root length of seeding (cm)	Shoot of seedlings length (cm)	Seedling dry wt. (g)
$S_1 \times M_1$	95.00a	4.095cd	5.810ab	3.290a
$S_1 \times M_2$	96.00a	4.185cd	5.920a	3.410a
$S_1 \times M_3$	96.00a	3.975de	6.020a	3.330a
$S_1 \times M_4$	95.00a	3.985de	5.460bc	3.130ab
$S_1 \times M_5$	96.00a	3.765de	5.400c	3.193ab
$S_1 \times M_6$	92.00b	3.557ef	5.260c	2.730bc
$S_1 \times M_7$	91.00b	4.105cd	5.200c	2.620c
$S_2 \times M_1$	62.00e	4.890ab	4.480d	1.727d
$S_2 \times M_2$	65.33cd	4.950a	4.520d	1.303de
$S_2 \times M_3$	67.33c	4.800ab	4.630d	1.510de
$S_2 \times M_4$	62.67de	4.720ab	4.550d	1.587de
$S_2 \times M_5$	57.33f	4.510bc	4.300de	1.607de
$S_2 \times M_6$	53.33g	4.100cd	4.260de	1.350de
$S_2 \times M_7$	49.33h	3.150f	4.010e	1.250e
$LSD_{(0.05)}$	2.946	0.4329	0.3843	0.4706
CV (%)	2.27	6.54	4.57	12.20

**S_1 = 20th November and S_2 = 20th December and M_1 = ST + RDF + Boron spray + 3 irrigations + Cowdung, M_2 = ST + RDF + Boron spray + 2 irrigations + Cowdung, M_3 = ST + RDF + 3 irrigations, M_4 = ST + RDF + 2 irrigations, M_5 = RDF + Boron spray + 3 irrigations, M_6 = RDF + Boron spray + 2 irrigations and M_7 = Farmer's practice.

Economic analysis

Economic analysis of wheat is represented in Table 7. From Table-7, the highest benefit cost ratio can be observed from $S_1 \times M_5$ (2.46) which are followed by $S_1 \times M_6$ (2.41) and $S_1 \times M_7$ (2.27). Wheat yield from late seeding did not give satisfactory benefit cost ratio than optimum sowing. The lowest benefit cost ratio can be observed from $S_2 \times M_1$ (1.15) *e.g.* high management practice at delayed sowing. The treatment combinations $S_1 \times M_2$ (1.30), $S_2 \times M_2$ (1.19), $S_1 \times M_3$ (1.20) did not give satisfactory benefit cost ratio than other treatment combinations.

Table 7: Economic analysis of wheat (per hectare) as influenced by sowing dates and different management practices.

Sowing dates × Management practices	Total cultivation cost/ha (BDT)	Gross return/ha (BDT)	Net Return/ha (BDT)	BCR
$S_1 \times M_1$	43030	77260	34230	1.80
$S_1 \times M_2$	42630	55170	12540	1.30
$S_1 \times M_3$	33430	65830	32400	1.20
$S_1 \times M_4$	33030	61910	28880	1.87
$S_1 \times M_5$	27930	68810	40880	2.46
$S_1 \times M_6$	27530	66270	38740	2.41
$S_1 \times M_7$	25000	56860	36860	2.27
$S_2 \times M_1$	43030	49660	6630	1.15
$S_2 \times M_2$	42630	50660	8030	1.19
$S_2 \times M_3$	33430	52860	19430	1.58
$S_2 \times M_4$	33030	49800	16770	1.51
$S_2 \times M_5$	27930	48340	20410	1.73
$S_2 \times M_6$	27530	46830	19300	1.70
$S_2 \times M_7$	25000	44860	24860	1.79

**S_1 = 20 November and S_2 = 20 December and M_1- ST + RDF + Boron spray + 3 irrigations + Cowdung, M_2 = ST + RDF + Boron spray + 2 irrigations + Cowdung, M_3 = ST + RDF + 3 irrigations, M_4 = ST + RDF + 2 irrigations, M_5 = RDF + Boron spray + 3 iIrrigations, M_6 = RDF + Boron spray + 2 irrigations and M_7 = Farmer's practice.

Conclusion and Recommendations

From the above discussion, it can be confirmed that- i) optimum sowing condition (20th November) always maintain superiority over late seeding condition (20th December) in respect of seed yield and quality, ii) from agronomic management aspects, (strip tillage + recommended fertilizer doses+ 3 irrigations) performed the best in respect of seed yield and quality in optimum and delayed sown conditions, iii) from interaction effects of sowing date × agronomic management practices (strip tillage + recommended fertilizer doses+ 3 irrigations) treatment with optimum sowing condition e.g. 20th November sowing condition performed the best in respect of seed yield and quality. But considering economic point of view, (recommended fertilizer dose + 0.2% boron foliar spray at anthesis + 3 irrigations) treatment is profitable in optimum sown condition and, iv) in delayed sown condition (20th December) (strip tillage + recommended fertilizer doses+ 3 irrigations) treatment can be recommended to farmers to optimize seed yield and quality. But considering economic point of view, farmers practice (conventional tillage, NPK non-judicious dose, only irrigation at CRI stage, no organic matter) is profitable.

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