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ASSESSING BORO RICE YIELD VARIANCES ACROSS VARIED SEEDLING AGES TO ADDRESS EARLY FLASH FLOOD VULNERABILITIES IN THE *HAOR* AREA OF BANGLADESH

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Abstract

Haor is one of the most flood-prone areas of Bangladesh and it underlies in water for several months of a year. Boro rice cultivation in this area is challenging due to the flash flood. An experiment was conducted to examine the suitability and productivity of four rice varieties transplanted in different seedling ages. This experiment was carried out at Sunamganj district for two consecutive years of Boro season in 2021-22 and 2022-23. Four Boro rice varieties namely Binadhan-10, Binadhan-17, Binadhan-24, BINA dhan25, and three seedling ages (i.e., 30, 35 and 40 days old seedlings) were used as treatment in the experiment. It was conducted through a split-plot design with three replications placing seedling ages in the main plot and crop varieties in the subplot. Transplanting of 30 days seedlings of Binadhan-24 produced the highest mean grain yield of 7.8 t ha^{-1} and 8.2 t ha^{-1} while 35 days seedlings produced 7.6 t ha^{-1} and 7.7 t ha^{-1} respectively, in two consecutive years, the highest among all varieties. The maturity period among crop varieties varied due to the changes in seedling age as lower seedling age showed an earlier maturity period. So, transplanting of 30-35 days seedlings can be recommended for Binadhan-24 cultivation in the *haor* area.

Keywords: *Haor*, Seeding age, Flash flood, Boro rice

Introduction

The word "*haor*" describes low-lying, flood-prone places that experience multiple months of continuous flooding yearly (Uddin, 2020). Large back swamps or bowl-shaped depressions known as *haors* are often located in the northeastern region of Bangladesh and are created when rivers naturally flood during the monsoon season (Alam *et al.*, 2010). Four hundred twenty three *haors* belong in the *haor* areas of Bangladesh. *Haor* covers 0.86 million hectares, or 43% of the land area in the districts of Sunamganj, Kishoreganj, Netrokona, Habiganj, Moulvibazar, Brahmanbaria and Sylhet. The highest number of *haors* (133) is found in Sunamganj followed by Kishoreganj (122), Netrokona (80) and Habiganj (38) as reported by Alam *et al.* (2010) and Hossain *et al.* (2023).

In Bangladesh, rice is the main cereal crop grown in three distinct seasons, namely Aus, Aman and Boro which covers 77% of the total cultivable area (BBS, 2022). After

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China and India, Bangladesh has been the world's leading producer of rice for the last five years, making it the third-largest producer worldwide (Mamun *et al.,* 2021; FAO, 2022; Remme *et al.,* 2023). Bangladesh produced 38.144 million metric tons of rice in total in 2021-2022, of which 53 percent was Boro rice (BBS, 2022). The northeast region of Bangladesh, especially in the *haor* basin, is the primary rice cultivation zone that produces approximately 18% of the total rice production of the country (BBS, 2021). Almost 85% of the *haor* basin lands are fully dedicated to Boro rice cultivation during the dry period, with the remaining 15% designated for Aman and Rabi crops (Baishakhy *et al.,* 2023; Kamruzzaman *et al.,* 2024). Huda (2004) and Kamruzzaman and Shaw (2018) revealed that Boro-fallow-fallow was the dominant cropping pattern in the *haor* basin of Bangladesh and flash floods severely destroyed standing Boro rice just before harvesting almost every year (Biswas *et al.,* 2008). In the Northeast part of Bangladesh, Boro rice faces multiple challenges e.g., low-temperature stress during the reproductive stages in early sowing while partially safe from flash floods during harvesting; high-temperature stress during reproductive stages and flash floods during the maturity stage are challenges for optimum sowing windows (Rashid and Yasmeen, 2018). Compared to other irrigated areas in Bangladesh, the *haor* areas are inherently riskier. From May to November of each year, the majority of the *haor* area is submerged in water, and from December to April, it is dry (NCVAB, 2018). Unfortunately, in the first week of April, just before the harvest, they face severe flash flooding when the water covers all of the immature or almost matured rice (Biswas *et al.,* 2008). In the northeast, by the last week of April, Boro rice usually achieves maturity. This coincides with the region's regular occurrence of flash floods in mid-April and May (Roy *et al.,* 2017). In April 2017, a sudden flood submerged more than 0.20 million hectares of mature, blooming, or dough-stage Boro rice resulting in a 0.88 million tons loss in production in the *haor* area (Kamruzzaman *et al.,* 2022). About 7,083 hectares of Boro rice went underwater in these regions in March 2022, which caused a loss of around USD 14 million (NIRAPAD, 2022; Hossain *et al.,* 2023). That’s why to escape probable flash floods, seeds of Boro rice need to be transplanted during early November and harvested by the first week of April.

Transplanting time and seedling age are very important aspects in areas like the *haor* because of the possibility of flash floods in April. The primary objective of the study is to investigate the yield potential of different BINA released Boro rice varieties under varying seedling ages on the arrival of the probable flash flood.

Materials and Methods

Experimental Site

The experiment was conducted at Buristhil village of Sadar upazila of Sunamganj district (25^0 3' 2.2" N latitude and 91^0 25' 7.9" E) during the Boro season in the years 2021-22 and 2022-23.

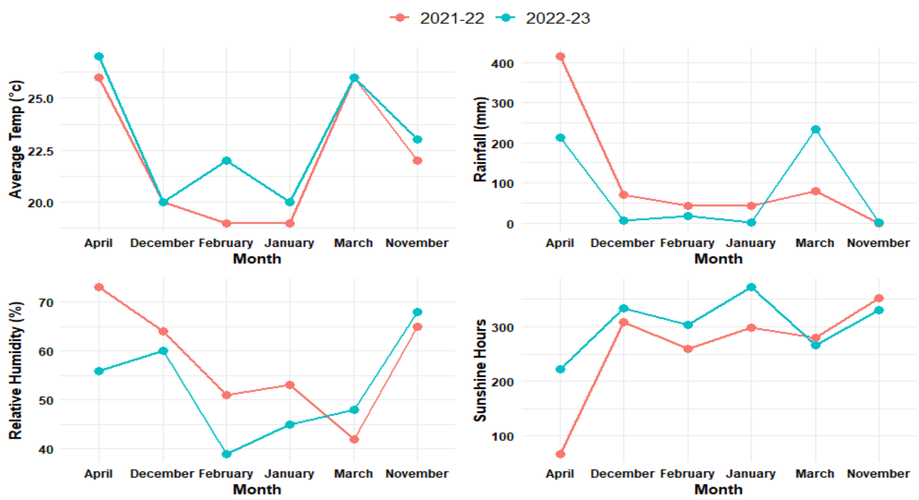

Fig. 1: The climatic parameters of the experimental site during the growing period of Boro rice in 2021-22 and 2022-23

Soils of the area were grey silty clay loams and clay loams in nature on the higher parts that dry out seasonally and grey clays in the wet basins. The soils had a moderate content of organic matter and soil reaction was mainly acidic. The fertility level is medium to high. It lies under Sylhet basin (AEZ-21).

Experimental Design

The experiment was conducted through a split-plot design assigning seedling ages in the main plot and varieties in the subplot with three replications. Total number of unit plots were 12 × 3 = 36. The unit plot size was 4 m × 3 m. The distance maintained between the main plot and the replications were 0.5 m and 1.0 m, respectively.

Experimental Treatments

There were two factors namely seedling ages (A_1 = 30 days, A_2 = 35 days and A_3 = 40 days) and four rice varieties (V_1= Binadhan-10, V_2 = Binadhan-17, V_3 = Binadhan-24 and V_4 = BINA dhan25).

Preparation of seedling nursery bed and Seed sowing

A piece of land was selected and puddled well with country plow followed by leveling with a ladder to raise seedlings. Before sowing, seeds were immersed in water for 24 hours and then taken out and kept in jute sacks in dark conditions for 48 hours. The sprouted seeds were sown in the nursery bed at five days intervals 3 times each in both years according to the treatment of the study. Proper care was taken for raising the healthy seedlings in the nursery bed. Weeds were removed and irrigation was given in the nursery bed as necessary.

Mainland preparation and Transplanting of seedlings

The field was opened with a power tiller and subsequently plowed four times with a country plow followed by laddering. The layout of the field was made after the final land preparation. Weeds and stubbles were removed and fully cleaned from all individual plots. After uniform leveling, the experimental plots were laid out according to the requirement of the treatment. After uprooting healthy and similar-sized seedlings were selected for transplanting. Seedlings were transplanted in the well-prepared puddle field on 07 November both years.

Fertilization and Irrigation

Each plot was fertilized uniformly with a basal dose of triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulphate by 120, 120, 70, and 6.5 kg ha^{-1}, respectively at the time of final land preparation. Urea was applied in three equal splits by 70 kg ha^{-1} at 10, 30, and 45 days after transplanting (BARC, 2018). During booting and flowering stage irrigation was provided to maintain 5-6 cm standing water in each plot. Finally, the field was drained out 7 days before harvesting.

Intercultural Operation

Intercultural operations were done to ensure and maintain the normal growth of the crops as and when needed. After one week of transplanting, dead seedlings were replaced carefully by transplanting fresh seedlings from the same source. The experimental plots were infested with some common weeds which were removed thrice by hand weeding method.

Harvesting and Data Collection

The maturity of Boro rice varieties was determined when some 80% of the seeds attained their characteristic color. Grain and straw yields per plot were recorded after threshing by a pedal thresher and then winnowing and drying were done in the sun properly including the grains and straws of the sample plants. The weight of grains was adjusted to 14% moisture content. The obtained grain and straw yields were then converted to t ha^{-1}. From the 10 randomly harvested hills, data were recorded on plant height, number of total tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, number of grains $panicle^{-1}$, number of sterile spikelets $panicle^{-1}$, 1000-grain weight, grain yield (t ha^{-1}), straw yield (t ha^{-1}), harvest index and maturity duration.

Statistical Analysis

Data recorded for different parameters were tabulated in proper form. The recorded data on various plant characters were statistically analyzed properly. The mean of all treatments was calculated and the Analysis of variance (ANOVA) was done with the help of R Studio 4.2.2 version and the differences among treatment means were compared using the least significant difference test (Gomez and Gomez, 1984).

Results and Discussion

In 2021-22, the highest plant height (139.5 cm) and panicle length (30.9 cm) were obtained when BINA dhan25 were transplanted with 30 days old seedlings but the highest number of filled grains panicle^{-1} (236.0) and Sterile spikelets panicle^{-1} (81.7) was obtained when 35 days and 40 days old seedlings of same variety were transplanted respectively. However, the highest number of total tillers hill^{-1} (14.5) and the number of effective tillers hill^{-1} (13.1) were found in Binadhan-17 when transplanted with 35 days old seedlings. The highest 1000-grain weight (29.1 g) was recorded when Binadhan-24 was transplanted with 30 days old seedlings. But the lowest plant height (94.1 cm), number of total tillers hill^{-1} (10.5), the number of effective tillers hill^{-1} (9.5) and the number of filled grains panicle^{-1} (104.7) were found from Binadhan-24 when 40 days old seedlings were transplanted. Similarly, the lowest panicle length (20.1 cm), the number of Sterile spikelets panicle^{-1} (27.9) and 1000-grain weight (18.2 g) were listed when Binadhan-24 and Binadhan-10 were transplanted with 35 days old seedlings and BINA dhan25 was with 40 days old seedlings, respectively. The findings were supported by Islam *et al.* (2013), Jisan *et al.* (2014) and Hossain *et al.* (2023) who stated that significant variations in 1000–grain weight among the varieties were due to the variation in the genetic makeup of the varieties. The maximum duration (147 days) and the minimum duration (137 days) were recorded in the combination of Binadhan-10 with 40 days old seedlings and Binadhan-17 with 30 days old seedlings transplanted, respectively (Table 1).

In 2022-23, the highest plant height (134.1 cm), panicle length (27.8 cm) and number of filled grains panicle^{-1} (253.3) were obtained when BINA dhan25 were transplanted with 35 days old seedlings. However, the highest number of total tillers hill^{-1} (13.9) and the number of effective tillers hill^{-1} (12.6) were found in Binadhan-17 when transplanted with 35 days old seedlings. Similarly, the highest number of Sterile spikelets panicle^{-1} (59.0) and 1000-grain weight (29.3 g) were recorded when BINA dhan25 and Binadhan-24 were transplanted with 40 and 30 days of seedlings, respectively. But the lowest number of total tillers hill^{-1} (9.9) was recorded when Binadhan-10 were transplanted with 40 days old seedlings and the lowest number of effective tillers hill^{-1} (8.9) was observed in both Binadhan-10 and BINA dhan25 when transplanted with 40 days of seedlings. The lowest panicle length (18.9 cm) and number of filled grains panicle^{-1} (107.7) were listed when Binadhan-24 were transplanted with 40 days old seedlings. Analogously, the lowest plant height (92.7cm), the number of Sterile spikelets panicle^{-1} (18.0) and 1000-grain weight (18.6 g) were recorded in Binadhan-10, Binadhan-24 and BINA dhan25 transplanted with 30, 35 and 40 days old seedlings, respectively. Similar variation in yield attributes was observed among varieties by Mahamud *et al.* (2013), Roy *et al.* (2014) and Akondo *et al.* (2020) due to variation in genetic variability and adaptability in the studied area. The maximum duration (147 days) and the minimum duration (137 days) were recorded when Binadhan-10 and Binadhan-17 when transplanted with 40 days and 30 days old seedlings, respectively (Table 2).

Table 1: Effect of seedling ages, varieties and their interaction in 2021-22

Treatments	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (g.)	Maturity duration (days)
Seedling ages								
30 days (A_1)	109.6a	12.6a	11.4a	25.7a	149.2a	53.6a	23.4ab	139.5c
35 days (A_2)	110.8a	12.6a	11.3a	25.5ab	151.1a	45.5a	23.8a	141.5b
40 days (A_3)	107.7a	11.5b	10.5b	24.8b	149.2a	51.1a	23.1b	143.8a
LSD $_{0.05}$	4.8	0.8	0.8	0.9	13.6	21.1	0.5	6.5
CV (%)	3.9	5.6	6.2	3.1	8.0	37.2	1.9	4.1
Varieties								
Binadhan-10 (V_1)	107.4b	11.5b	10.4b	27.1b	121.2c	31.8c	25.0b	143.7a
Binadhan-17 (V_2)	95.8c	13.1a	11.8a	24.3c	144.1b	44.4b	21.3c	139.3c
Binadhan-24 (V_3)	97.1c	12.2ab	10.9ab	20.4d	112.6c	43.4b	28.7a	143.7a
BINA dhan25 (V_4)	137.3a	11.5b	11.0ab	29.4a	227.2a	70.7a	18.6d	139.7b
LSD $_{0.05}$	3.9	1.2	1.1	1.3	17.2	9.2	1.0	5.7
CV (%)	3.6	9.7	10.2	5.3	11.6	18.6	4.3	4.1
Seedling ages × varieties								
A_1V_1	105.5bc	12.0bcd	11.1bcde	27.1bc	120.2cd	35.7de	24.1c	141f
A_1V_2	94.4d	11.9bcd	10.2de	23.9de	141.3bc	45.3de	21.3d	137j
A_1V_3	99.2cd	13.9ab	12.5ab	20.8f	117.9cd	38.1cd	29.1a	142e
A_1V_4	139.5a	12.8abc	11.6abcd	30.9a	220.8a	78.7ab	19.1e	138i
A_2V_1	108.9b	11.9bcd	10.5cde	27.5bc	126.1bcd	27.9e	26.1b	143d
A_2V_2	98.6d	14.5a	13.1a	25.8cd	151.0b	35.0e	21.4d	139h
A_2V_3	98.3d	12.1bcd	10.9bcde	20.1f	115.0cd	53.9bc	28.9a	144c
A_2V_4	137.8a	12.0bcd	10.7bcde	28.5b	236.0a	51.8cd	18.6e	140g
A_3V_1	107.9b	10.7d	9.7e	26.7bc	117.3cd	31.7e	24.9bc	147a
A_3V_2	94.3d	13.1abc	12.1abc	23.4e	140.0bc	53.0cd	21.3d	142e
A_3V_3	94.1d	10.5d	9.5e	20.2f	104.7d	38.1de	28.3a	145b
A_3V_4	134.5a	11.7cd	10.7bcde	28.8ab	224.9a	81.7a	18.2e	141f
LSD $_{0.05}$	6.8	2.0	1.9	2.3	29.8	16.0	1.7	9.8
CV (%)	3.6	9.7	10.2	5.3	11.6	18.6	4.3	4.0

Table 2: Effect of seedling ages, varieties and their interaction in 2022-23

Treatments	Plant height (cm)	Total tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Sterile spikelets $panicle^{-1}$ (no.)	1000-grain weight (g.)	Maturity duration (days)
Seedling ages								
30 days (A_1)	106.9a	11.8a	10.4a	23.8ab	154.3b	35.6a	23.7a	139.5c
35 days (A_2)	107.9a	12.2a	11.0a	24.3a	169.7a	38.8a	24.1a	141.8b
40 days (A_3)	104.3b	10.4b	9.3b	23.6b	148.5b	37.2a	23.6a	143.8a
LSD $_{0.05}$	1.7	0.5	0.8	0.6	6.0	4.9	1.0	4.6
CV (%)	1.4	3.5	6.9	2.1	3.4	11.6	3.8	2.9
Varieties								
Binadhan-10 (V_1)	105.2b	11.3a	10.2a	26.4a	121.2c	20.6d	25.1b	143.0b
Binadhan-17 (V_2)	94.5c	12.0a	10.9a	22.4b	153.2b	42.6b	22.4c	138.0d
Binadhan-24 (V_3)	95.5c	11.2a	9.9a	19.3c	118.2c	31.4c	28.5a	143.7a
BINA dhan25 (V_4)	130.7a	11.3a	10.0a	27.4a	237.3a	54.1a	19.1d	142.0c
LSD $_{0.05}$	2.4	1.3	1.3	1.3	11.6	6.3	1.2	4.0
CV (%)	2.2	11.1	12.6	5.4	7.4	17.1	5.1	2.9
Seedling ages × varieties								
A_1V_1	105.2cd	12.3ab	11.0ab	26.4a	121.0efg	18.0h	24.9bc	140f
A_1V_2	92.9g	11.3bc	10.3b	21.4bc	133.3de	42.3cd	21.5de	136h
A_1V_3	99.6ef	12.3ab	10.3b	20.0cd	128.1ef	32.1def	29.3a	142e
A_1V_4	129.8b	11.0bc	10.0b	27.4a	234.7ab	50.0abc	18.9f	140f
A_2V_1	108.6c	11.6bc	10.6ab	27.1a	132.0de	23.7fgh	25.5b	143d
A_2V_2	96.4fg	13.9a	12.6a	23.2b	174.7c	45.3bc	23.1cd	138g
A_2V_3	92.7g	10.9bc	9.9b	19.0d	118.7efg	32.7def	27.9a	144c
A_2V_4	134.1a	12.3ab	11.0ab	27.8a	253.3a	53.3ab	19.9ef	142e
A_3V_1	101.9de	9.9c	8.9b	25.8a	110.7fg	20.2gh	24.8bc	146a
A_3V_2	94.3g	10.9bc	9.9b	22.6b	151.7d	40.0cde	22.7d	140f
A_3V_3	92.9g	10.3bc	9.5b	18.9d	107.7g	29.5efg	28.1a	145b
A_3V_4	128.3b	10.5bc	8.9b	27.1a	224.0b	59.0a	18.6f	144c
LSD $_{0.05}$	4.1	2.2	2.2	2.2	20.0	10.9	2.1	6.9
CV (%)	2.2	11.1	12.6	5.4	7.4	17.1	5.1	2.9

In the first year of 2021-22, 35 days seedlings showed a higher mean grain yield (6.7 t ha^{-1}) than 30 days (6.6 t ha^{-1}) and 40 days (5.9 t ha^{-1}) seedlings in BINA dhan25. Similarly, when both Binadhan-10 and Binadhan-17 were transplanted at 35 days old seedling showed a higher mean grain yield (7.2 and 7.4 t ha^{-1}, respectively) than 30 days and 40 days seedlings. However, transplanting of 30 days old seedlings produced a higher mean grain yield (7.8 t ha^{-1}) than 35 days and 40 days old seedlings in Binadhan-24. But the highest grain yield potentiality among all seedlings age was seen when both BINA dhan25 (7.23 t ha^{-1}) and Binadhan-24 (8.15 t ha^{-1}) was transplanted at 30 days old seedlings. However, Binadhan-10 (7.57 t ha^{-1}) and Binadhan-17 (7.75 t ha^{-1}) showed the highest grain yield potentiality when transplanted with 35 days old seedlings (Fig. 2).

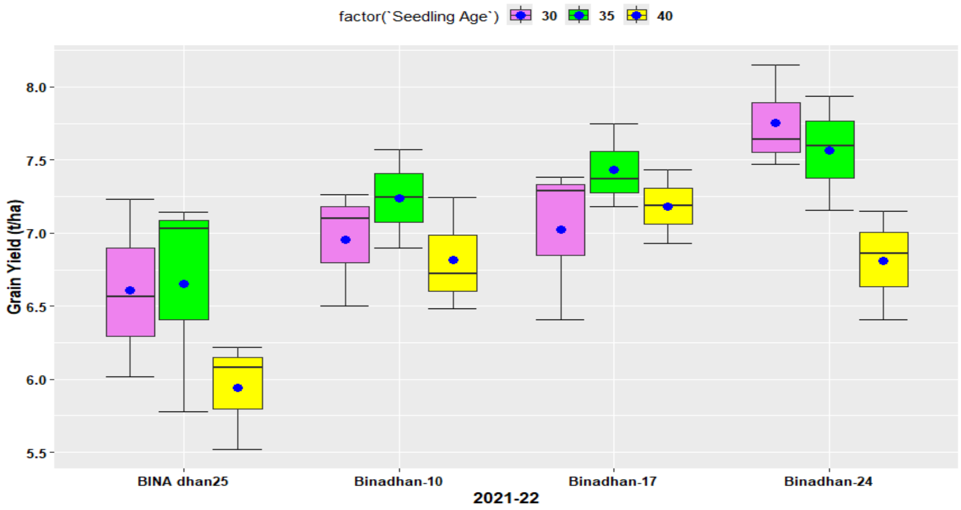

Fig. 2: Boxplot showing the variety and seedling age's impact on grain yield in 2021-22

In the second year of 2022-23, BINA dhan25 when transplanted with 35 days of seedlings showed a higher mean grain yield (6.73 t ha^{-1}) and the highest yield potentiality (7.16 tha^{-1}) than 30 days and 40 days of seedlings. Similarly, when both Binadhan-10 and Binadhan-17 were transplanted at 35 days, showed a higher mean grain yield (7.60 and 7.54 t ha^{-1} respectively) and the highest yield potentiality (7.93 and 7.88 t ha^{-1} respectively) than 30 days and 40 days seedlings. However, transplanting of 30 days of seedlings produced a higher mean grain yield (8.20 t ha^{-1}) and the highest yield potentiality (8.40 tha^{-1}) than 35 days and 40 days of seedlings in Binadhan-24 (Fig. 3).

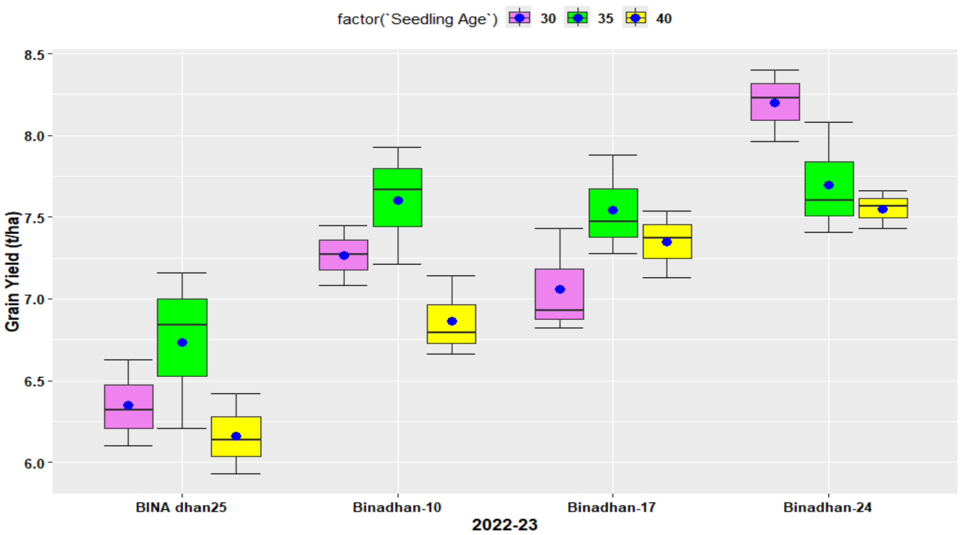

Fig. 3: Boxplot showing the variety and Seedling age's impact on Grain yield in 2022-23

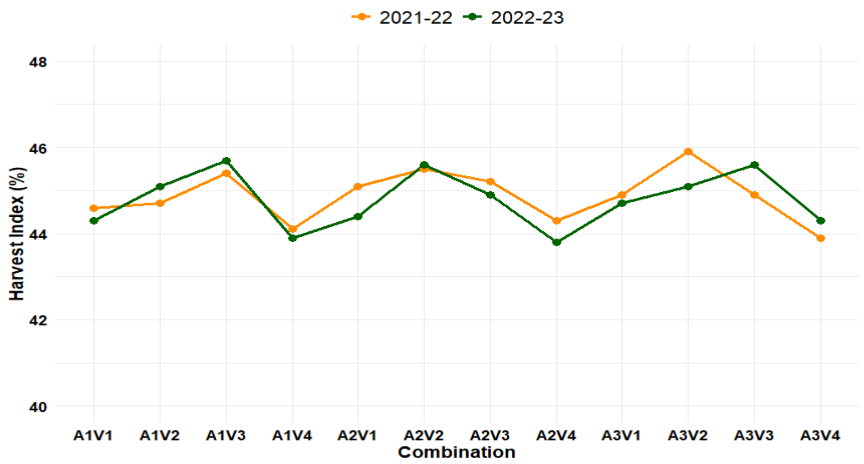

Fig. 4: Harvest Index as influenced by interaction effects of Seedling ages and Varieties in 2021-22 and 2022-23

Transplanting 30 days old seedlings in Binadhan-24 showed the highest mean grain yield. From Tables 1 & 2 we can say that early aged seedlings could enhance for early maturation of rice. This result fully supports the results of Biswas *et al.* (2008), who found that manipulating seedling age might be another technique for shortening life duration and could be shortened by 7-8 days by transplanting seedlings 30 days old instead of 45 days.

Where, Seedling Age = 30 days (A_1), 35 days (A_2), 40 days (A_3) and Varieties = Binadhan-10 (V_1), Binadhan-17 (V_2), Binadhan-24 (V_3), BINA dhan25 (V_4)

The interactions between seedling age and varieties, Binadhan-17 transplanted in 40 days old seedlings exhibited the highest harvest index (45.9%) whereas BINA dhan25 transplanted in 40 days old seedlings exhibited the lowest harvest index (43.9%) in 2021-22. But Binadhan-24 transplanted in 30 days old seedlings exhibited the highest (45.7%) and BINA dhan25 transplanted in 35 days old seedlings exhibited the lowest harvest index (43.8%) in 2022-23 (Fig. 4). Hossain *et al.* (2014) and Islam *et al.* (2014) found that the variation in harvest index was observed due to the variation in grain and straw yields.

Conclusion

Significantly the highest mean grain yield was produced when 35 days old seedlings were transplanted for the varieties of Binadhan-10, Binadhan-17 and BINA dhan25. The highest mean grain yield was found in 30 days of old seedlings only in the case of BINA dhan25. Transplanting of 30 days and 35 days old seedlings of Binadhan-24 produced the highest mean grain yield 7.8 t ha^{-1} and 8.2 tha^{-1} while 35 days seedlings produced 7.6 t ha^{-1} and 7.7 t ha^{-1} respectively, in two consecutive years among all four varieties. So, transplanting of 30-35 days old seedlings could be recommended for Binadhan-24 cultivation in the *haor* area.

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