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Title: Agronomic Performance of Water Melon Varieties for Off-season Cultivation in a Coastal Soil of Southwestern Bangladesh

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ABSTRACT

The watermelon {*Citrullus lanatus* L. (Thunb.) Matsum. & Nakai} - an annual and monoecious fruit - belongs to the family Cucurbitaceae. It is usually grown in Bangladesh during the month from February to April. However, there is opportunity of year-round cultivation, and off-season watermelon cultivation is more profitable than usual farming. The study was conducted the field of Salinity Management Research Center (SMRC), SRDI, Batiaghata under Khulna district from June to September 2025 to evaluate the off-season agronomic performance of fifteen watermelon varieties. The experiment followed a Randomized Complete Block Design (RCBD) with three replications. Data were collected on various physical and qualitative characters of watermelon fruits and were analyzed statistically. Varieties Ashtha, Shahi and Japanese Dragon produced fruits with greater lengths (cm) and individual fruit weight (kg). Fruit diameter (cm) was also greater in Ashtha and Shahi. The peak total soluble solid was noticed in Ashtha followed by BARI Tarmuj-2 and BARI Tarmuj-1. Sweetness was found the greatest in Ashtha, Japanese Dragon and BARI Tarmuj-1. Additionally, Ashtha, Japanese Dragon, Pakija, Yellow Sweet and BARI Tarmuj-1 offered the enjoyable taste. Therefore, watermelon varieties Ashtha, Shahi and Japanese Dragon are recommended for cultivation during the off season in the south-western coastal region of Bangladesh.

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INTRODUCTION

Watermelon {*Citrullus lanatus* L. (Thunb.) Matsum. & Nakai} is a monoecious fruit belongs to the Cucurbitaceae family. It is a creeping plant with a giant edible fruit called 'pepo' that has a thick exocarp with a fleshy center (mesocarp and endocarp)

(Remme et al., 2023). It is a widely held and delicious horticultural product all over the world (Rabbany et al., 2013). It is famous for its thirst-quenching feature, sweet and juicy fruit (Mangila et al., 2007) or as an ingredient in mixed drinks (Joy et al., 2020) which is also widely grown in coastal areas of Bangladesh including Khulna (Haq and Ahmed, 2023). The fruit covers a range of vitamins, as well as potassium, magnesium, and other minerals. Watermelon juice contains 30-46.2 kcal, 7.6-11.6 g carbohydrate, and 0.6-0.9 g protein per 100 g, 569-864.88 IU vitamin A, 8.1-12.31 mg vitamin C, 3.38-11.34 mg lycopene, 7 mg calcium, 0.24 mg iron, 112 mg potassium, 11 mg phosphorus, 0.0-0.001 mg sodium, 5.2-5.4% ash, 93.12-95.2% moisture (Maoto et al., 2019). It has also a highly efficient flavonoids and antioxidants that offer protection against cardio-vascular diseases and cancers (Perkins-Veazie et al., 2007).

Bangladesh produces a wide range of watermelon cultivars, including those with a simple, pale green rind, a blackish green rind, diffused black, a green stripe on three light green or blackish green background rinds, a yellow rind with red inside flesh, etc. In Bangladesh, watermelon is usually cultivated in the late *Rabi* season (December-January), after harvesting the *Aman* rice. Just a decade ago, watermelon cultivation was virtually non-existent in Bangladesh as well as in Khulna. Today, it has emerged as one of the most lucrative options for farmers, particularly in coastal areas. Encouraged by earlier successful harvests, more farmers are shifting from traditional crops like paddy (rice) and sesame to watermelon farming (Roy, 2021).

Bangladesh is one of the nations, most vulnerable to the consequences of climate change. Agricultural adaptation is becoming a greater threat here. Hence, diversity is one of the best approaches to boost agricultural productivity. Watermelon farming in the off-season will help in the diversification and give the consumer additional options. It will also provide ways of alleviating malnutrition and fighting climate change. Saline-prone areas that were previously left fallow after the *Aman* rice season are now flourishing with striped watermelon vines, bringing prosperity to thousands of farming households. Once dominated by shrimp farming, these coastal lands are now being used to cultivate watermelon - a fast-growing, profitable crop that is reshaping the region's agricultural landscape (BSS, 2025). Experts believe that off-season watermelon cultivation has unlocked a new era of agricultural diversification and rural economic growth in coastal Bangladesh. With better market linkages and export strategies, the fruit holds strong potential for the international market as well. As of now, around 50% of the off-season watermelon crop has been harvested in the Khulna agricultural zone (BSS, 2025). Since there is a few varieties of watermelon released in Bangladesh, there are several exotics varieties having good quality traits are needed to be introduced in Khulna areas to select suitable watermelon varieties for off-season. Moreover, there is limited information on off-season watermelon cultivation in Bangladesh. In light of these facts, this study was directed to assess the agronomic performance of fifteen different watermelon varieties during the off-season. This will help to introduce of new crop in the existing cropping pattern of this area and might change the socio-economic conditions of the farmers. The specific objective of the study was to assess the varietal performance of watermelon for off-season cultivation in the coastal saline soil of southwestern Bangladesh.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the field of Salinity Management and Research Center (SMRC), SRDI, Batiaghata under Khulna district from June to September 2025. The experimental site falls in the Agroecological Zone 13 (the Ganges Tidal Floodplain). The climatic condition of this area is typically tropical with a mild winter from October to

March, a hot and humid summer in March to June, and a humid, warm rainy monsoon from June to October.

Plant materials

Fifteen varieties of watermelon were used in the study. The varieties were- Five Star Dragon, Kanya, Ullash, Asian-2, Astha, Big Family, Legend-2, Shahi, Super Dragon, Black Baby, Japanese Dragon, BARI Tarmuj-2, Pakija, Yellow Sweet and BARI Tarmuj-1. The seeds of the varieties were collected from the seed dealers of Chuknagor Bazar of Dumuria upazila, Khulna, Bangladesh.

Experimental design

The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications.

Field and pit preparation

The experimental plot for off-season watermelon cultivation was selected nearby a narrow water body locally known as *Khal*. The field was thoroughly ploughed and cross-plowed using a power tiller two weeks prior to transplanting the watermelon seedlings. The stables and weeds from the field were removed completely. Necessary fertilizers were applied, and properly mixed with the soil during final land preparation. Hand-dug planting pits 1.0 m apart and the height of each pit was 30 cm.

Fertilizer application

As a source of organic matter, decomposed cow dung was applied @ 20 t ha^{-1}. In addition, chemical fertilizers like 280 kg urea ha^{-1}, 300 kg TSP ha^{-1}, 320 kg MoP ha^{-1} and 8 kg $ZnSO_4$ ha^{-1} (Roy and Rahman, 2023) were also added to the soil. Cow dung and TSP were applied during final land preparation as a basal dose. All other chemical fertilizers were applied locally in the pits. Urea and MoP were applied in four splits, after 10 to 15 days of transplanting 26 g urea and 20 g MoP were applied pit^{-1}. During flowering 15.6 g urea and 20 g MoP pit^{-1}were top dressed. The third instalment was given at fruit initiation time (urea 15.6 g pit^{-1} and MoP 20 g pit^{-1}). After 15-20 days of initiation of fruits the final fraction was applied (urea 15.6 g pit^{-1} and MoP 20 g pit^{-1}). Zn was applied @ 2.08 g pit^{-1} during fruit initiation time (Awal, 2015).

Growing of seedlings and transplanting

Seedlings were raised in a plastic bag (11 cm x 11 cm x 17 cm) using a 1:1 mixture of top soil and decomposed cow dung. Four hundred fifty seedlings in total were raised. One-month-old seedlings (4-5 leaf stage) were transplanted to the main field.

Pruning and hanging

Pruning was done at the 8-10 leaf stage, leaving at least 5 knots. Well ahead, keeping 4-5 branches along with the main branch, the rest of the branches were cut off. Watermelon plants were hung in nets from bamboo frames to prevent rotting on the wet ground.

Pest management

Thrips infestation was noticed at the flowering stage and the plants were subsequently sprayed with Tido (Imidacloprid) at 10 ml per 10 liters of water. Another spray with the same preparation was applied after ten days of the first spray.

Harvesting of fruits

Watermelons were harvested at their full maturity stage when the fruits gained deep color and a deep hollow sound after thumbing the rind with the hand. Harvesting was started 70 days after transplanting, and the last harvest was done 90 days after transplanting.

Data collection

Physical and chemical attributes

Number of fruits plant-1, individual fruit weight, and fruit yield plant-1, fruit length, fruit diameter and rind length were collected weekly intervals. The first harvesting was performed on 20 September, 2025 and the final harvesting was done on 19 October, 2025. The average of each trait was calculated for each variety separately. The total soluble solid (TSS) was estimated in the Agronomy Laboratory of Agrotechnology

Discipline, Khulna University by refractometer.

Organoleptic evaluation

A 5-point organoleptic evaluation parameters for the acceptance of watermelon fleshes after harvest were conducted with 15 panels from the Agronomy Laboratory of Agrotechnology Discipline, Khulna University. Of the panelists, 9 were male and 6 were female, with an age range of 21-23 years. The flesh quality was then evaluated based by the sensory characteristics of juiciness, sweetness, firmness and taste by the evaluation scale of 1: very bad, 2: bad, 3: neither good nor bad, 4: good, and 5: excellent (Salin et al., 2022).

Statistical analyses

The collected data were analyzed using Statistical Tool for Agricultural Research (STAR) following one-way analysis of variance (ANOVA) technique (R Core team, 2018). Variety means were separated by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at 5% level of significance. Association between fruit weight and fruit length as well as between fruit weight and fruit diameter were inquired using correlation analysis. Microsoft Excel Office 2010 software was used to prepare graphs.

RESULTS AND DISCUSSION

Number of Fruits Plant^{-1}

The number of fruits plant^{-1} varied significantly ($p < 0.001$) from 1.33 to 3.33 (Fig. 1) among fifteen watermelon varieties during off-season. The highest number of fruits per plant (3.33) was recorded from varieties Ashtha, Ullash and Super Dragon which was statistically different from fruits plant^{-1} of other twelve varieties. On the other hand, the least number of fruits plant^{-1} (1.33) was obtained from Yellow Sweet which was statistically similar to Asian-2 (1.67), Big Family (1.67) and BARI Tarmuj-2 (1.67). The remaining eight varieties produced the intermediate number of fruits plant^{-1} (2.00-2.33). Bernard et al. (2009) reported one to five fruits plant^{-1} in watermelon varieties that is different from our study. Haq and Ahmed (2022) also described significant variation in fruits plant^{-1} among different watermelon varieties from Bangladesh, showing a range of 2.92-6.08 fruits plant^{-1}. The discrepancy in fruit production in the present study might be due to heredity as well as variability in environmental and soil conditions (Maynard, 2007).

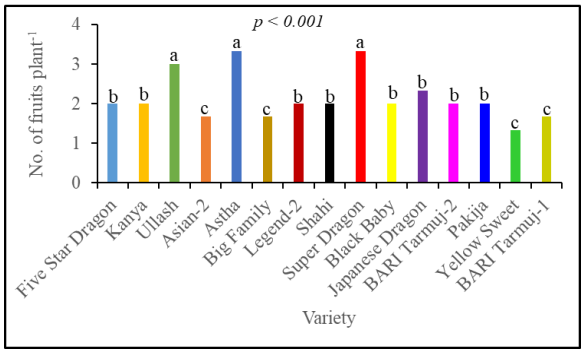

Figure 1. Number of fruits plant-1among fifteen watermelon varieties during off-season.

Fruit Length (cm)

Watermelon varieties showed significant variation ($p < 0.01$) in fruit length (Table 1 and Table 2). The recorded fruit length varied remarkably from 16.00 cm to 32.87 cm across varieties. The highest fruit length (32.87 cm) was found in the variety Ashtha which was statistically at par with Shahi (30.43 cm), Black Baby (27.33 cm) and Japanese Dragon (32.67 cm). The shortest fruits were found in BARI Tarmuj-1 (16.00 cm), which was statistically similar to Yellow Sweet (21.00 cm). The results of our study is supported by the outcomes of Remme et al. (2024) who found varietal differences in watermelon fruit lengths in their study. Haq and Ahmed (2022) also reported significant variation in fruit length among different watermelon accessions from Bangladesh. Fruit size enlargement is a result of cell expansion. Fruit size may be increased using varieties with many branches and many male and female flowers (Wien, 1997). The size of fruits is affected by genetics, environment, and the conditions during the development of the pistillate flower and fruit (Maynard, 2007).

Table 1. Mean square values for fruit length (cm) of watermelon varieties

Source of variation (SV)	Degrees of freedom (df)	Mean Square (MS)
Replication	2	5.1629
Variety	14	57.5356***
Error	28	4.1672
Total	44	-
CV (%)	-	7.97

CV: Coefficient of variation, ***: Significant at 0.1% level of probability

Fruit Diameter (cm)

The results of the current study presented significant variation ($p < 0.01$) in fruit diameter due to the influence of different watermelon varieties (Table 2). Fruit diameter varied widely among different watermelon varieties mainlining an array between 39.00 cm and 60.50 cm. The maximum fruit diameter was witnessed in Ashtha (60.50 cm) whereas the minimum fruit diameter was recorded in BARI Tarmuj-1 (39.00 cm). The diameter of BARI Tarmuj-1 fruits were statistically similar to Yellow Sweet (45.33 cm) and Kanya (45.27 cm). Our results are well supported by the findings of Remme et al. (2024) and Haq and Ahmed (2022) who reported varietal differences in watermelon fruit diameter in their study during off-season.

Table 2. Variation in physical parameters of fruits among fifteen watermelon varieties

Variety	Fruit Length (cm)	Fruit Diameter (cm)	Individual Fruit Weight (kg)	Fruit Weight Plant^{-1} (kg)
Five Star Dragon	26.67^{bcde}	51.67^{abcd}	2.37^{abcd}	4.73^{d}
Kanya	23.17^{de}	45.27^{cd}	1.80^{cd}	3.66^{e}
Ullash	27.50^{abcd}	53.50^{abc}	2.82^{abc}	8.35^{b}
Asian-2	25.00^{cde}	51.33^{abcd}	1.99^{abcd}	3.35^{e}
Astha	32.87^{a}	60.50^{a}	3.94^{a}	11.65^{a}
Big Family	24.00^{de}	46.00^{bcd}	1.76^{bcd}	2.93^{e}
Legend-2	25.87^{cde}	52.67^{abc}	2.16^{abc}	4.34^{d}
Shahi	30.43^{abc}	59.00^{ab}	3.58^{ab}	6.87^{c}
Super Dragon	25.33^{cde}	48.67^{abcd}	2.03^{abcd}	6.77^{c}
Black Baby	27.33^{abcd}	57.33^{abc}	2.44^{abc}	4.93^{d}
Japanese Dragon	32.67^{ab}	58.33^{abc}	3.75^{ab}	7.43^{b}
BARI Tarmuj-2	23.67^{de}	51.00^{abcd}	1.85^{abcd}	3.73^{e}
Pakija	22.67^{de}	46.67^{bcd}	1.34^{bcd}	2.70^{e}
Yellow Sweet	21.00^{ef}	45.33^{cd}	1.24^{cd}	1.79^{f}
BARI Tarmuj-1	16.00^{f}	39.00^{d}	0.78^{d}	1.49^{f}
p value	0.00	0.00	0.00	0.00
CV (%)	7.97	8.48	7.92	13.15

Mean values within the column with similar letter (s) are not significantly ($p<0.05$) different; CV = Coefficient of variation; Data are means of three replications.

Individual Fruit Weight (kg)

Different watermelon varieties exerted noteworthy influence ($p < 0.001$) on weight of fruits (Table 2). A wide range of weight, 0.78 to 3.94 kg was detected in watermelon varieties in the present study. The highest fruit weight was observed in Ashtha (3.94 kg), followed by Japanese Dragon (3.75 kg), and Shahi (3.58 kg). This result is harmonious with Enujeke (2014). Higher stomatal conductance, partitioning of photosynthetic materials towards economic yield, greater genetic structure, and greater potential to transport photosynthetic material within plants can all result in higher fruit weight (Enujeke, 2014). Bernard et al. (2009) found 2-3 kg weight per fruit in his experiment. Remme et al. (2024) and Haq and Ahmed (2022) also demonstrated varietal differences in watermelon fruit weight in their study during off-season. We detected a strong and positive association

between individual fruit weight (kg) and fruit length (cm) as well as between individual fruit weight and fruit diameter (cm) (Table 3). The values of correlation coefficient computed were 0.972 and 0.928, respectively suggesting the dependency of fruit weight on fruit length and fruit diameter. Sari et al. (2017) reported that there is a significant correlation between fruit length, fruit width, and fruit weight.

Fruit Yield Plant^{-1} (kg)

Fruit yield per plant different significantly from 1.49 kg to 11.65 kg ($p < 0.001$) among fifteen genotypes of watermelon in off-season (Table 2) in the current research. The supreme fruit yield plant^{-1} (11.65 kg) was noted in Ashtha followed by Ullash (8.35 kg) and Japanese Dragon (7.43 kg). Moreover, per plant fruit yield of Astha is extraordinarily different from fruit yield plant^{-1} of other fourteen varieties. The minimum fruit yield plant^{-1} (1.49 kg) was obtained in BARI Tarmuj-1 which was statistically at par with Yellow Sweet (1.79 kg). Haq and Ahmed (2022) demonstrated that fruit yield plant^{-1} varied significantly from 6.90 kg to 17.73 kg in four watermelon accessions during off-season. However, according to Remme et al. (2024) fruit yield plot^{-1} ranged between 5.56 kg and 9.27 kg as observed in three watermelon varieties in off-season.

Table. 3. Correlation of fruit weight (kg) with fruit length (cm) and fruit diameter (cm) among watermelon varieties

	Fruit Length (cm)	Fruit Diameter (cm)
Fruit Weight (kg)	0.972***	0.928***

Rind Length (cm)

Watermelon rind (*Citrullus lanatus*) constitutes up to 40% of the fruit, to reduce waste and create functional food ingredients. Studies highlight high concentrations of citrulline, potassium, fiber (approx. 55%), antioxidants (phenols/flavonoids), and antimicrobial properties in rinds. In our study, significant variation rind length was found in fifteen watermelon varieties (Fig. 2). However, rind length varied between 0.59 cm and 2.05 cm (Fig. 2). BARI Tarmuj-2 displayed the highest rind length (2.05 cm) which was significantly different from other varieties. On the other hand, Kanya exhibited the minimum rind length of 0.59 cm which is statistically similar to Yellow Sweet (0.60 cm). Bazié et al. (2022) concluded that rind thickness varied between 0.92 cm and 1.30 cm in five watermelon varieties. Ripened watermelon has firm, symmetrical, fresh, and attractive waxy surface peel features (Kyriacou et al., 2018). Angeline and Krishnakumari (2015) suggested that an average watermelon contains about 30% peel (also known as rind), 68% flesh and 2% seed.

Total Soluble Solid (TSS)

The TSS value represents the sugar and soluble mineral content of fruit. According to the TSS study, there was statistically significant variation ($p < 0.01$) among different watermelon varieties (Table 4 and Table 5). The highest total soluble solid was obtained from Ashtha (12.16). The TSS value of Astha was followed by BARI Tarmuj-2 (11.32), and BARI Tarmuj-1 (11.16) (Table 5). The lowest total soluble solid was determined in the variety Asian-2 which was significantly different from other varieties. The differences in TSS might happen due to the genetic constitution, ripening stages of watermelon, soil variability in the growing sites (Ammawath et al., 2009, Amin et al., 2014). Miguel et al. (2008) showed that the soluble solid content of fruit was mostly influenced by the storage period and to a lesser extent by cultivar.

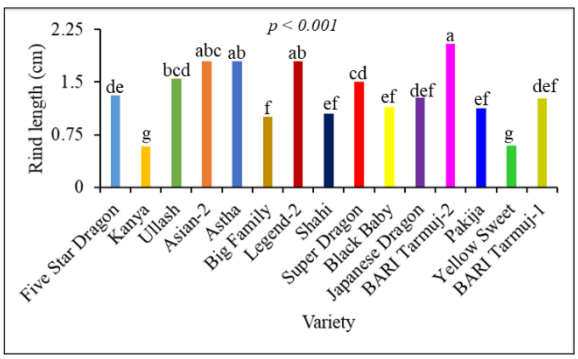

Figure 2. Rind length (cm) of fruits among fifteen watermelon varieties in off-season.

Table 4. Mean square values fort soluble solid (TSS) of watermelon varieties

Source of variation (SV)	Degrees of freedom (df)	Mean Square (MS)
Replication	2	0.3807
Variety	14	10.1265***
Error	28	0.1143
Total	44	-
CV (%)	-	3.69

CV: Coefficient of variation, ***: Significant at 0.1% level of probability

Table 5. Variation in total soluble solids (TSS) of fruits among fifteen watermelon varieties

Variety	Total Soluble Solid (TSS)
Five Star Dragon	8.02^{fgh}
Kanya	8.81^{ef}
Ullash	10.10^{d}
Asian-2	5.60^{i}
Astha	12.16^{a}
Big Family	7.61^{gh}
Legend-2	9.57^{de}
Shahi	7.07^{h}
Super Dragon	10.13^{cd}
Black Baby	8.06^{fgh}
Japanese Dragon	11.14^{bc}
BARI Tarmuj-2	11.32^{ab}
Pakija	8.03^{fgh}
Yellow Sweet	8.54f^{g}
BARI Tarmuj-1	11.16^{ab}
p value	0.00
CV (%)	3.69

Mean values within the column with similar letter (s) are not significantly ($p<0.05$) different; CV = Coefficient of variation; Data are means of three replications.

Organoleptic Assessment

The physical quality of fruit is commonly evaluated using organoleptic properties of color, features, taste, touch, and smell (Hasani et al., 2018). The sensation perceived by sensory organs (touch, sight, hearing, smell, and taste) while consuming fruit are referred to as organoleptic properties (Saliba-Colombani et al., 2001). The 5-point scale rating for the organoleptic evaluation of watermelon flesh after harvest was calculated for all panels and tabulated in Table 6. Juiciness was found peak in Kanya, Ullash and BARI Tarmuj-1 while Asian-2 exhibited the worst. Sweetness was the highest in Ashtha, Japanese Dragon and BARI Tarmuj-1 but sweetness of Asian-2 and Big Family was the lowest. Yau et al. (2010) showed that watermelon contains a higher amount of fructose is in excellent condition since the degree of sweetness of fructose is 1.5 to 2.0 times higher than sucrose. Watermelon is well recognized with its crispy texture and aroma. The results of the present study revealed that Kanya, Ullash, Legend-2 and Shahi had the firm texture while Asian-2 possessed the soft flesh. Varieties Ashtha, Japanese Dragon, Pakija, Yellow Sweet and BARI Tarmuj-1 offered the superior test but Asian-2, Big Family, Shahi and Super Dragon displayed the inferior.

Table 6. Organoleptic evaluation of watermelon fruits for quality traits

Variety	Juiciness	Sweetness	Firmness	Taste
Five Star Dragon	4	3	4	4
Kanya	5	4	5	4
Ullash	5	3	5	4
Asian-2	2	2	2	2
Astha	4	5	3	5
Big Family	3	2	4	2
Legend-2	4	4	5	4
Shahi	4	3	5	2
Super Dragon	3	4	3	2
Black Baby	4	3	3	4
Japanese Dragon	4	5	4	5
BARI Tarmuj-2	4	4	3	4

Variety	Juiciness	Sweetness	Firmness	Taste
Pakija	3	3	3	5
Yellow Sweet	4	3	4	5
BARI Tarmuj-1	5	5	4	5

1: very bad, 2: bad, 3: neither good nor bad, 4: good, and 5: excellent

CONCLUSION

Fruit number plant^{-1} was found the greatest in Ashta and Super Dragon followed by Ullash. Varieties Ashtha, Shahi and Japanese Dragon produced fruits with greater lengths. Fruit diameter was also higher in varieties Ashtha and Shahi. The superior individual fruit weight was observed in Ashtha trailed by Japanese Dragon and Shahi. Fruit yield plant^{-1} was recorded maximum in Ashtha followed by Ullash and Shahi. The highest total soluble solid was found in Ashtha followed by BARI Tarmuj-2 and BARI Tarmuj-1. Sweetness was the peak in Ashtha, Japanese Dragon and BARI Tarmuj-1. In addition, varieties Ashtha, Japanese Dragon, Pakija, Yellow Sweet and BARI Tarmuj-1 rendered the superior taste. Considering all the parameters, watermelon varieties Ashtha, Shahi and Japanese Dragon can be recommended for cultivation during the off season in the south-western coastal region of Bangladesh.

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