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SUITABILITY ASSESSMENT OF ORANGE FLESHED SWEETPOTATO VARIETIES AT NORTHERN REGION OF BANGLADESH

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ABSTRACT

The present experiment was conducted with four Bangladesh Agricultural Research Institute (BARI) released orange fleshed sweetpotato varieties and a local cultivar as check at Sadar Upazila of Gaibanda and Pirgachha Upazila of Rangpur district during 2019-20 cropping season for their suitability assessment. It was found that all yield and yield contributing characters varied significantly at both the locations. Due to higher adaptability in northern conditions, it was observed that the variety of BARI SP-12 produced the highest yield (39.63 ton/ha at Gaibandha and 30.02 t/ha at Rangpur) followed by BARI SP-8 (32.03 ton/ha at Gaibandha and 25.93 t/ha at Rangpur) while the lowest was recorded in BARI SP-15 (13.33 ton/ha at Gaibandha and 3.03 ton/ha at Rangpur). Considering locations, all the studied varieties performed better at Gaibandha than Rangpur district. The crop was evaluated at vegetative and harvesting stage at farmers' field by the farmers, researchers and extension staffs. At harvesting stage evaluation results revealed that, BARI SP-8 ranked first at Gaibandha and BARI SP-12 at Rangpur while BARI SP-4 ranked (2nd) at both locations. During harvesting stage evaluation, participants preferred BARI SP-12 as at both locations followed by BARI SP-8 at Gaibandha and BARI SP-4 at Rangpur. Through organoleptic test BARI SP-4 and BARI SP-12 found good to excellent by the farmers, researchers and extension staffs.

Keywords: Sweet potato, evaluation, organoleptic test.

1. INTRODUCTION

Sweetpotato (*Ipomoea batatus*), is an important staple crop in many parts of the world (Rahaman *et al.* 2015). It is a dicotyledonous plant that belongs to the Convolvulaceae family is also an important starch rich root crops in Bangladesh. The foliage has the potential for use as vegetable and animal feed (Otoo *et al.*, 2001). Worldwide, sweetpotato is the sixth most vital food crop after rice, wheat, potatoe, maize and cassava and for developing countries, it is in the fifth place. More than 105 million metric tons are produced globally each year; 95% of which are grown in developing countries (Anonymous, 2020). It is mainly cultivated by the marginal or subsistence farmers in a sporadic way in different river belts, char lands, deltas and seasonally inundated flood plains (Ahmed *et al.*, 1998). The average yield is very low as compare to many tropical to subtropical countries due to cultivation of local and poor quality indigenous sweetpotato varieties. (Vimala and Rajendra, 1998).

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Bangladesh ranks 88th out of 117 qualifying countries on the latest (2019) Global Hunger Index, much ahead of India, Pakistan and Afghanistan. Bangladesh reduced hunger significantly, but with a score of 25.8, the country still suffers from a level of hunger that is serious (bdnews.com, 2019).

Prevalence of malnutrition in Bangladesh is still alarming and it is even higher than countries like, Nepal, Cambodia, Ethiopia and Uganda. Bangladesh is placed in the bottom 25% of the Global Hunger Index (Anonymous, 2015). Under-nutrition in Bangladesh is among the highest in the world and remains a serious public health problem. Approximately 9 million Bangladeshi children between six months and five years of age (pre-school going age) suffer from under-nutrition, with 36 percent of children stunted, 33 percent of children underweight, and 14 percent wasted (NIPORT, 2016). Bangladeshi children also suffer from high rates of micronutrient deficiencies, particularly vitamin A, iron, iodine and zinc deficiency. Bangladesh should be commended for making significant progress in reducing vitamin A deficiency (VAD) among preschool children over the past 15 years; however, consumption of vitamin A rich foods is still low. Malnutrition among women is also extremely prevalent in Bangladesh. More than 50 percent of women suffering from chronic energy deficiency. A quarter of women population are underweight and around 15% have short stature, which increases the risk of difficult childbirth and low-birth weight infants. Half of all women suffer from anemia, mostly nutritional in origin (ICDDR'B, 2020). Clinical VAD is common among women of reproductive age and during pregnancy. Sub-clinical VAD and anemia are also highly prevalent among pregnant and lactating women.

Improving nutrition can have a significant impact on survival as well as physical and cognitive development and productivity (FAO,2010). Good nutrition, comprising adequate quality and quantity of food intake and reduction of illness is also a basic human right and is an essential input for economic development. Significant progress has been made in cereal production in Bangladesh over the past decades. However, the rapid population growth and resulting high and growing food requirements pose a difficult challenge given the limited availability of cultivable land in Bangladesh. Re-occurring disasters further complicate the stability of food production. Monga is a common phenomenon in the northwestern part of Bangladesh and food insecurity and nutritional problem are more severe in this area compare to other parts of Bangladesh (Karim and Tasnim, 2015). The farmers of northern regions of Bangladesh cultivated white fleshed local sweetpotato varieties despite of lower yield and very low nutritional benefits. There is a clear need to diversify food sources both in terms of land/environmental sustainability, development of the rural economy and increased consumption to achieve improvements in the nutritional status of the people of Bangladesh.

Orange fleshed sweetpotato is a biofortified food crops as it contained beta carotene with a good source of vitamin B, C, E and other minerals (Rahaman *et al.* 2016). It is a highly nutritious food crop which gives better and faster production under diverse agroecological conditions with less input and that has immense potential to combat malnutrition and poverty (CIP, 2008). To combat malnutrition, vitamin A deficiency and ensure food security, orange fleshed sweetpotato (OFSP) could be one of the best options for agricultural production.

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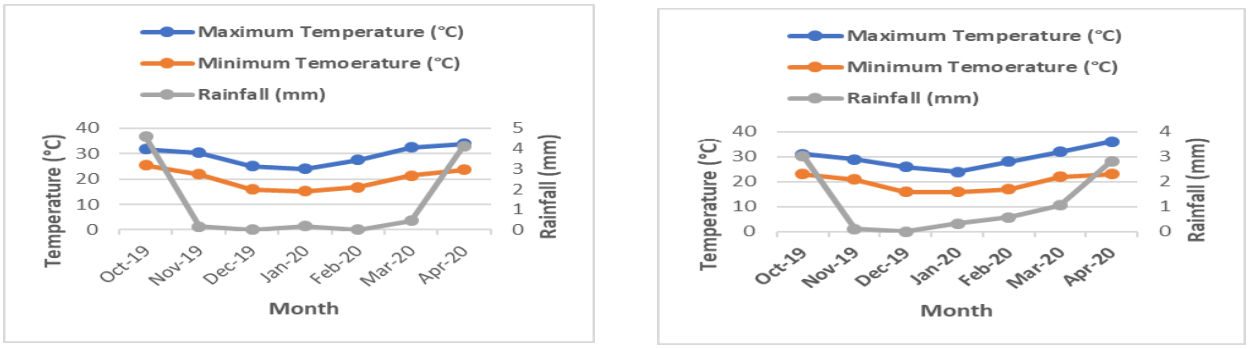
Since 1985, TCRC, BARI has released 16 high yielding sweetpotato varieties in Bangladesh. But dissemination rate of those varieties among the farmers in different agro-ecological zones is not in wide range due to limited promotional activities had been undertaken by different organizations. Considering this point of view, an adaptive trial of four BARI released OFSP varieties has been undertaken at two farmers' fields to identify some suitable varieties which will be accepted by the farmers of northern districts of Bangladesh.

2. MATERIALS AND METHODS

The present experiment was carried out at Sadar Upazila (sub-district) of Gaibandha and Pirgachha Upazila of Rangpur districts during 2019-20 cropping season. Four BARI released sweetpotato varieties viz. BARI SP- 4, BARI SP-8, BARI SP-12 and BARI SP-15 along with a local cultivar as check were included in this study. Vines were collected from TCRC, BARI and planted on 26 November 2019 at Sadar, Gaibandha and 15 December 2020 at Pirgachha, Rangpur, having plot size of 3.0m x 3.0m with 3 replications following Randomized Complete Block Design (RCBD). Fertilizers were applied in the experimental plots at the rate of 70-25-90-15-2-2 kg/ha of N-P-K-S-B-Zn as a source of Urea, TSP, MP, Gypsum, Boric Acid and Zinc Sulphate, respectively. Weeding, irrigation, earthing-up and other intercultural operations were done as and when necessary. The sweetpotato was harvested on 25 March 2020 and 14 April 2020 at Sadar, Gaibandha and Pirgachha, Rangpur, respectively. Physio-morphological characteristics of sweet potato roots of studied varieties are presented in Table 1.

Table 1. Root characteristics of BARI released four OFSP varieties

Variety	Shape and size	Skin color	Flesh color	B-carotene content (mg/100g fresh wt.)	Dry Matter (%)
BARI SP-4	Round elliptic	Orange brown	Orange	4.8	27.00
BARI SP-8	Round elliptic	Purple Red	Inter. yellow	1.1	35.30
BARI SP-12	Long elliptic	Brownish	Pink Orange	3.6	35.44
BARI SP-15	Round elliptic	Orange	Deep Orange	10.39	30.39



At Gaibandha **At Rangpur**

Fig. 1. Average maximum and minimum temperature with rainfall at Gaibandha and Rangpur during 2019-20 cropping season

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All the studied sweet potato varieties were evaluated in vegetative and harvesting stages following PVS method developed by Staff de Hann of CIP (Wangchuk *et al.*, 2015). After 90 days of planting, vegetative stage evaluation was done. Harvesting stage evaluation followed by organoleptic evaluation were done at 120 DAP. During evaluations, the following steps were performed:

Step 1: ***Evaluation at the time of vegetative stage***

a) Gathering and Ranking of Criteria

b) Ranking of the preferred varieties by plot

Step-2: ***Evaluation at the time of harvesting stage***

a) Gathering and Ranking of Criteria

b) Ranking of the preferred varieties by plot

Step-3: ***Organoleptic/Sensory evaluation***

Before evaluation of each stage (Vegetative and harvest), the method was explained properly. For the evaluation, a panel of fifteen participants (5 male farmers, 5 female farmers and 5 researchers & extension personnel's) were made. The participants of the group provided their opinions to select best varieties. Due to COVID-19 situation, all farmers, researchers and staffs were instructed to wear masks and use sanitizers in field and maintained social distancing.

For giving votes, two different types of seeds had been provided to the participants for segregating male or female participants. Six seeds were given each individual for voting. Among them, three seeds were used for first priority vote, two for second and one for third position for each criterion. Only three criteria/varieties they had to choose in all phases of evaluation. After computation of votes, it was termed as global score. According to global score order of importance was made, and first three characters/varieties were selected.

Step 1: Evaluation at the time of vegetative stage

At vegetative stage, first of all the participants mentioned some criteria which they wanted to be in the upcoming sweetpotato varieties. All the criteria were listed, and individual voting had been made for the specific characters. After voting, three criteria were selected on the basis of the highest score. After selection the criteria, participants visited the sweetpotato field and observed the vegetative growth stage of the varieties. After observation, all participants had given their votes to select three varieties.

Step-2: Evaluation at the time of harvesting stage

At the time of harvest, again fifteen participants were gathered and initially selected some harvesting stage criteria which they are expecting in the upcoming variety. Then they had given

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their votes to select the best three harvesting criteria from the initially selected criteria. After criteria selection, all the participants visited the harvested field of sweet potato and observed yield and tuberous root characters. After observation, they gave their opinions as a vote for best three varieties.

Step-3: Organoleptic/Sensory evaluation

After harvesting stage evaluation an organoleptic evaluation was performed. For this one kilogram of sweet potatoes from each variety was boiled, separated the varieties on different plates and clearly identified by registration number. The basic rules of evaluation were explained to the participants using simple words.

a. **Appearance:** The appearance refers to the visual aspect: how the boiled sweet potato varieties looks when presented on plates (Scale 5=Very good, 4=Good, 3=Fair, 2=Poor and 1=Very Poor)

b. **Flesh color:** After cross section of boiled sweet potato, how the flesh color looks of each variety (Scale 5=Very good, 4=Good, 3=Fair, 2=Poor and 1=Very Poor)

c. **Taste:** The taste is very personal criterion (Scale 5=Very good, 4=Good, 3=Fair, 2=Poor and 1=Very poor)

d. **Texture:** The texture refers to the dry matter that the sweetpotatoes possess (Scale 5=Mealy/Floury, 4=Less floury, 3=Fair/Intermediate, 2=Soggy and 1= More soggy/watery)

e. **Fiber:** The fiber refers to the presence of fiber in boiled sweetpotato flesh (Scale 5= No fiber presence, 4=Less fiber presence, 3=Fair/moderate fiber presence, 2=Poor/high presence of fiber and 1= Roots are fibrous)

Each panellist was given an evaluation form which was used to record the evaluation in reference to the appearance, flesh color, taste, texture and fiber of each variety. Each panellist evaluated clone by clone and washed his/her mouth with mineral water before moving on to the next sample.

3. RESULTS AND DISCUSSION

From the combined analysis of variance (ANOVA) table, it was observed that plant vigor at 90 DAP (Days After Planting), number of tuberous root per plant, tuberous root diameter, tuberous root yield per plant, tuberous root yield per plot and yield (ton/ha) varied significantly over the location (Table 2). Effects of variety showed significant variation for all the growth and yield contributing characters of the crops. Considering location and variety (LxV) interaction effects, most of the characters varied significantly except plant vigor at 90 DAP, percent foliage coverage at 60 DAP, tuberous root yield per plot, yield ton per hectare and dry matter percentage of root (Table 2).

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Table 2. Combined analysis of variance (ANOVA) of yield and yield contributing characters of sweetpotato over locations

Source of variation	df	Error Mean Square					
		Vine length (cm) at 60 DAP	Vine length (cm) at 90 DAP	Vine length (cm) at 120 DAP	Plant vigor at 60 DAP	Plant vigor at 90 DAP	Foliage Coverage (%) at 60 DAP
Location (L)	1	135.25 NS	14.70NS	369.60NS	1.63NS	4.03*	83.33NS
Error-1	4	84.48	88.69	141.44	0.37	0.26	173.33
Variety (V)	4	701.18**	1887.47**	5277.03**	6.58**	6.47**	1690.42**
L X V	4	322.73**	852.27**	1767.19**	1.22*	0.18NS	31.25NS
Residual	16	39.31	41.23	94.62	0.33	0.14	29.58

Table 2. cont'd.

Source of variation	df		Error Mean Square				
		Foliage Coverage (%) at 90 DAP	Foliage Coverage (%) at 120 DAP	No. Branches /plant at 90 DAP	No. Branches /plant at 120 DAP	No. of tuberous roots/plant	Tuberous root length (cm)
Location (L)	1	213.33NS	20.83NS	2.13NS	2.58NS	30.60**	12.81NS
Error-1	4	63.33	30.83	0.92	1.00	0.83	8.53
Variety (V)	4	3532.08**	1936.67**	8.27**	8.96**	1.60**	11.61*
L X V	4	419.58**	66.67*	5.45**	5.09**	1.81**	12.04*
Residual	16	38.33	17.29	0.65	0.83	0.32	2.91

Table 2. cont'd.

Source of variation	df	Error Mean Square				
		Tuberous root diameter (cm)	Tuberous roots yield/plant (gm)	Tuberous root yield (Kg/Plot)	Tuberous root yield (ton/ha)	Dry Matter (%)
Location(L)	1	30.20**	308053.33**	613.82**	758.02**	6.63NS
Error-1	4	1.18	6080.83	16.75	20.57	1.91
Variety (V)	4	34.66**	138995.00**	518.10**	640.18**	23.16**
L X V	4	12.27**	20870.00*	7.72NS	9.62NS	2.25NS
Residual	16	0.93	5997.50	5.99	7.42	2.35

Note: '*' and '**' indicate statistically significant at 5% and 1% level respectively.

Vine length at 60, 90 & 120 DAP varied significantly in both the locations. At Gaibandha, the highest vine length was found in BARI SP-8 (42.40cm at 60 DAP, 72.50cm at 90 DAP and 140.53cm at 120 DAP) followed by BARI SP-4 (32.70cm at 60DAP, 62.73cm at 90 DAP and 121.47cm at 120 DAP) and the lowest was observed in local variety (21.83 cm at 60 DAP, 31.67 cm at 90 DAP and 62.17 cm at 120 DAP). At Rangpur, the variety BARI SP-8 also exhibited highest vine length (53.07cm at 60 DAP, 75.96 cm at 90 DAP and 128.97cm at 120 DAP) followed by local variety (46.73cm at 60 DAP, 66.43cm at 90 DAP and 106.46 cm at 120 DAP) and the lowest was recorded in BARI SP-15 (12.17cm at 60 DAP, 18.63cm at 90 DAP and 32.90cm at 120 DAP)(Table 3). These may be happened due to adaptability of northern climatic condition.

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Table 3. Vine length of studied OFSP varieties at 60, 90 and 120 DAP at Gaibandha and Rangpur district of Bangladesh during 2019-2020 crop season

Variety	Vine Length at 60 DAP (cm)		Avg.	Vine Length at 90 DAP (cm)		Avg.	Vine Length at 120 DAP (cm)		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	32.70ab	29.97b	31.34	62.73a	38.47b	50.60	121.47b	98.03bc	109.75
BARI-SP-8	42.40a	53.07a	47.74	72.50a	75.96a	74.23	140.53a	128.97a	125.22
BARI-SP-12	23.33bc	25.97b	24.65	32.70b	33.47b	33.09	80.43c	84.00c	82.22
BARI-SP-15	26.40bc	12.17c	19.29	40.37b	18.63c	25.00	80.87c	32.90d	56.89
Local variety	21.83c	46.73a	34.28	31.67b	66.43a	49.05	62.17d	106.46b	84.32
Mean	29.33	33.58	31.46	47.99	44.79	46.39	93.28	90.07	91.68
CV (%)	19.93			13.58			10.39		

Note: Means with the same letter are not significantly different

Plant vigor was varied significantly at 60 and 90 DAP in both the locations. At 60 DAP, the highest plant vigor (4.67) was observed in BARI SP-8 at both locations while the lowest was found in BARI SP-15 (2.67 at Gaibandha and 1.00 at Rangpur). At 90 DAP, the local variety showed the highest vigorous growth (4.83) followed by BARI SP-8 (4.67) at Gaibandha and in Rangpur, BARI SP-8 and local variety exhibited high vigorous growth (4.00). On the other hand, the lowest vigorous growth was observed in BARI SP-15 in both the locations (2.33 at Gaibandha and 1.33 at Rangpur) (Table 4). These may be happened due to varietal characteristics.

Table 4. Plant vigor sweetpotato at 90 and 120 DAP at Gaibandha and Rangpur district of Bangladesh during 2019-2020 crop season

Variety	Plant Vigor at 60 DAP		Avg.	Plant Vigor at 90 DAP		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	3.67b	3.33b	3.50	4.00b	3.00c	3.50
BARI-SP-8	4.67a	4.67a	4.67	4.67a	4.00a	4.34
BARI-SP-12	3.67b	4.33a	4.00	3.67b	3.50b	3.59
BARI-SP-15	2.67c	1.00c	1.84	2.33c	1.33d	1.83
Local variety	4.00ab	3.00b	3.50	4.83a	4.00a	4.42
Mean	3.74	3.26	3.50	3.90	3.17	3.53
CV (%)	16.29			10.73		

Note: Means with the same letter are not significantly different

Numbers of stems per plant at 90 and 120 DAP varied significantly in all the locations. At 90 DAP, the highest number of stems per plant was recorded in BARI SP-08 at both the locations (8.17 at Gaibandha and 7.57 at Rangpur) while lowest was recorded in BARI SP-4 at Gaibandha (4.47) and BARI SP-15 at Rangpur (3.83). Similar trends were also observed at 120 DAP at both locations. At 120 DAP, BARI SP-8 produced highest number of stems per plant (8.70 at Gaibandha and 7.83 at Rangpur) followed by local variety at Gaibandha (7.07) and BARI SP-4 at Rangpur (6.33) and the lowest was recorded in BARI SP-4 at Gaibandha (4.93) and BARI SP-15 at Rangpur (4.13) (Table 5).

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Table 5. No. of Branches per plant at 90 DAP and 120 DAP of studied OFSP varieties at Gaibandha and Rangpur of Bangladesh during 2019-2020 crop season

Variety	No. of Stems per Plant at 90 DAP		Avg.	No. of Stems per Plant at 120 DAP		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	4.47c	6.03b	5.25	4.93c	6.33ab	5.63
BARI-SP-8	8.17a	7.57a	7.87	8.70a	7.83a	8.27
BARI-SP-12	4.73c	5.93b	5.33	4.97c	6.20b	5.59
BARI-SP-15	6.13b	3.83c	4.98	6.37bc	4.13c	5.25
Local variety	6.83ab	4.30c	5.57	7.07b	4.60c	5.84
Mean	6.07	5.53	5.80	6.41	5.82	6.11
CV (%)	13.86			14.90		

Note: Means with the same letter are not significantly different

Foliage coverage (%) at 90 and 120 DAP showed significant variation among the varieties at both the locations. The variety BARI SP-8 showed the highest foliage coverage at 90 & 120 DAP in both locations and it was almost 100%. At Gaibandha, the lowest foliage coverage was observed in BARI SP 15 (38.33% at 90 and 60.00% at120 DAP), while in Rangpur the lowest foliage coverage attained in the local variety (31.67%) at 90 DAP and in BARI SP-15 (53.33%) at 120 DAP (Table 6).

Considering tuberous roots per plant, there was no significant effect among the varieties at Gaibandha but have significant difference at Rangpur. At Gaibandha, local variety produced the highest number of tuberous root (5.00) followed by BARI SP-4 (4.73), while the lowest was in BARI SP-12 (4.20). At Rangpur, BARI SP- 8 produced the highest number of tuberous root (3.63) followed by BARI SP-12 (3.07) while BARI SP-15 produced the lowest (0.97). All the studied varieties produced higher number of tuberous roots per plant at Gaibandha compare to Rangpur (Table 6). These may be happed due to late planting at Rangpur.

Table 6. Foliage coverage (FC) (%) at 120 DAP and no. of tuberous root per plant of suited OFSP varieties at Gaibandha and Rangpur district of Bangladesh during 2019-2020 crop season

Variety	Foliage Coverage (%) at 90 DAP		Avg.	Foliage Coverage (%) at 120 DAP		Avg.	No. of Tuberous roots per plant		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	80.00b	95.00a	87.50	96.67a	98.33a	97.50	4.73a	3.00ab	3.87
BARI-SP-8	96.67a	100.00a	98.34	100.00a	100.00a	100.00	4.60a	3.63a	4.12
BARI-SP-12	68.33c	96.67a	82.50	93.33	100.00a	96.67	4.20a	3.07ab	3.64
BARI-SP-15	38.33d	68.33b	53.33	60.00b	53.33c	56.67	4.53a	0.97c	2.75
Local variety	81.67b	31.67c	56.67	93.33a	83.33b	88.33	5.00a	2.30b	3.65
Mean	73.00	78.33	75.67	88.67	87.00	87.83	4.61	2.59	3.60
CV (%)	8.18			4.73			15.65		

Note: Means with the same letter are not significantly different

Among the studied varieties, tuberous root length varied significantly at Rangpur but not significantly varied at Gaibandha. At Gaibandha, the root length ranged from 14.83 to 12.87 cm. At Rangpur, the highest root length (15.93 cm) was found in BARI SP-12 while the lowest (9.40

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cm) was recorded in BARI SP-15 (Table 7). There is no significant difference between BRAI SP-4, BARI SP-8(14.50) and local variety (13.37cm) at Rangpur. Considering both the locations, average root length varied from 14.85 cm (BARI SP-12) to 11.80 cm (BARI SP-4) (Table 7).

There were significant variations among the varieties on tuberous root breadth at both locations. At Gaibandha, the highest root breadth was recorded in BARI SP-12 (18.60 cm) followed by BARI SP-4 (17.87 cm) and local variety (16.30 cm) while the lowest was in BARI SP-15 (14.23cm). At Rangpur, the highest root breadth was observed in BARI SP-4 (18.17cm) followed by BARI SP-12 (16.73cm) and the lowest was found in local variety (9.63 cm). Considering both the locations, the average breadth of tuberous root were varied from 18.02 to 12.97 cm (Table 7).

Table 7. Tuberous root Length and Breadth of Sweetpotato at Gaibandha and Rangpur District of Bangladesh during 2019-2020 crop season

Variety	Tuberous Roots Length (cm)		Avg.	Tuberous Roots Breadth (cm)		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	12.87a	10.73bc	11.80	17.87ab	18.17a	18.02
BARI-SP-8	14.20a	14.50a	14.35	15.70cd	16.07b	15.89
BARI-SP-12	13.77a	15.93a	14.85	18.60a	16.73ab	17.67
BARI-SP-15	14.80a	9.40c	12.10	14.23d	12.07c	13.15
Local variety	14.83a	13.37ab	14.10	16.30bc	9.63d	12.97
Mean	14.09	12.79	13.44	16.54	14.53	15.54
CV (%)	12.69			6.21		

Note: Means with the same letter are not significantly different

There was significant effect on tuberous root yield per plant among the varieties at both the locations. At Gaibandha, BARI SP-12 attained the highest tuberous root yield per plant (693.33 gm/plant) followed by BARI SP-8 (626.67 gm/plant). At Rangpur, BARI SP-12 also gave the highest yield (550.00gm/plant) followed by BARI SP-8 (533.33 gm/plant) and BARI SP-4 (416.67gm/plant) which was significantly similar to BARI SP- 12 and BARI SP-8. In both locations, BARI SP-15 produced the lowest yield (408.33gm/plant at Gaibandha and 91.66 gm/plant at Rangpur) (Table 8). Considering both the locations, all the varieties given higher yield per plant at Gaibandha compare to Rangpur. The lower yield at Rangpur may be was the result of late planting and comparatively cool weather prevailed during crop growing stage.

Considering tuberous yield per plot, all the varieties showed significant variation at both locations. At both locations, BARI SP-12 produced the highest yield per plot (35.67 kg/plot at Gaibandha and 27.17 kg/plot at Rangpur) followed by BARI SP-8 (28.83 kg/plot at Gaibandha and 23.33 kg/plot at Rangpur) while the lowest was observed in BARI SP-15 (12.00 kg/plot at Gaibandha and 2.77 kg/plot at Rangpur) followed by local variety (21.50 kg/plot at Gaibandha and 10.33 kg/plot at Rangpur) (Table 8). These may be happened due to wide range of adaptability of BARI SP-12 which can tolerate more adverse condition like wormer and cooler temperature, on the other hand, BARI SP-15 had lower adaptability that is sensitive to cool temperature of northern Bangladesh conditions.

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Table 8. Tuberous roots yield per plant and yield per plot of studied OFSP varieties at Gaibandha and Rangpur district of Bangladesh during 2019-2020 crop season

Variety	Tuberous roots yield per plant (gm)		Avg.	Tuberous roots yield per plot (kg)		Avg.
	Gaibandha	Rangpur		Gaibandha	Rangpur	
BARI-SP-4	533.33bc	416.67a	475.00	27.33b	16.50c	21.92
BARI-SP-8	626.67ab	533.33a	580.00	28.83b	23.33b	26.08
BARI-SP-12	693.33a	550.00a	621.67	35.67a	27.17a	31.42
BARI-SP-15	408.33c	91.66b	250.00	12.00d	2.77e	7.38
Local variety	543.33b	200.00b	371.67	21.50c	10.33d	15.92
Mean	561.00	336.66	459.67	25.07	16.02	20.54
CV (%)	16.85			11.92		

Note: Means with the same letter are not significantly different

Yield of tuberous roots per hectare varied significantly among the studied varieties in Gaibandha and Rangpur. Due to higher adaptability in northern climate, BARI SP-12 attained the highest yield (39.63 ton/ha) followed by BARI SP-8 (32.03 ton/ha) and BARI SP-4 (30.37 ton/ha) in Gaibandha while the lowest was recorded in BARI SP-15 (13.33 ton/ha). Similar yield trend were also observed in Rangpur where BARI SP- 12 produced the highest yield (30.02 ton/ha) followed by BARI SP-8 (25.93 ton/ha) while, the lowest was recorded in BARI SP-15 (3.03 ton/ha) followed by local variety (11.47 ton/ha). Considering yield in both the locations, all the varieties attained higher yield at Gaibandha than Rangpur (Fig 2). The lower yield at Rangpur may be happened due to late planting.

Considering dry matters percentage of the tuberous roots, significant effect was found in all the varieties at both the locations. At Gaibandha, the highest dry matter was found in BARI SP-12 (31.40%) followed by local variety (29.87%), while the lowest was recorded in BARI SP-4 (25.13%)). At Rangpur, BARI SP-12 had the highest dry matter (30.30%) followed by BARI SP-8 (27.73%) where BARI SP-4 showed the lowest (25.73%) (Fig 2).

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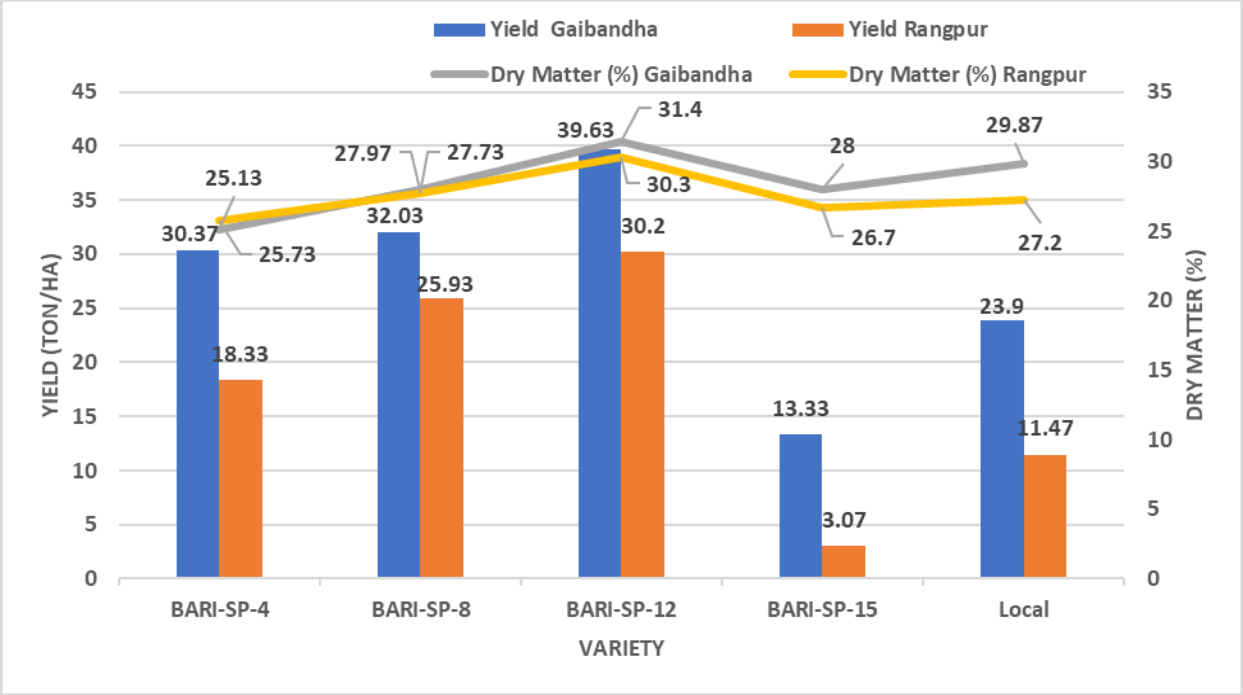

Fig.2. Tuberous root yield and dry matter (%) of studied OFSP varieties at Gaibandha and Rangpur district of Bangladesh during 2019-2020 crop season

Step-1. Evaluation at the time of vegetative stage

a) "Gathering and Ranking of Criteria" (vegetative stage)

Fifteen participants (5 male, 5 female and researchers and extension staff) were gathered in each location of Gaibandha and Rangpur to evaluate the vegetative stage of the crop. Before evaluation, participants were briefed about the trial objectives. Firstly, participants mentioned some of the criteria which they wanted in the upcoming sweetpotato varieties. All the criteria were listed, and individual voting had been taken for the specific characters. Through voting they have selected disease free variety as first, less insect infestation as second and bushy type plant as third in Gaibandha while in Rangpur, disease resistance scored as first, vigorous plant as second and good taste as leafy vegetables scored as third. (Table 9).

Table 9. Character selection at vegetative stage by the participants at Gaibandha and Rangpur.

Criteria	Men Score	Order of Importance	Women Score	Order of Importance	Total Score	Order of Importance
Gaibandha						
Plant should be soft or succulent type	5	V	1	V	6	V
Should be taste as leafy vegetable	8	IV	3	III	11	IV
Plant should be less insect infestation	15	I	9	II	24	II
Plant should be disease free	14	II	12	I	26	I
Plant should be bushy type	11	III	2	IV	13	III
Plant should be deep green	3	VII	2	IV	5	VI
Plant should be vigorous	4	VI	1	V	5	VI
Total	**60**		**30**		**90**	

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Rangpur						
Good taste as leafy vegetable	8	III	5	III	13	III
Plant should be vigorous	11	II	6	II	17	II
Leaf should be small in size	3	VIII	1	VII	4	VIII
Plant should be medium in size	6	V	2	II	8	VII
Plant should be disease resistance	16	I	5	III	21	I
Large leaf area index	7	IV	3	V	10	V
Plant should be large in size	5	VI	4	IV	9	VI
Vine should be more thick	4	VII	7	I	12	IV
Total	**60**		**30**		**90**	

b) "Ranking of the Preferred Clones by Plot" (vegetative stage)

After selecting the characters, these fifteen participants visited the research field and observed the varieties at vegetative stage. After observing, the participants had given their votes/opinions for specific varieties. According to the voting result (global score), BARI SP-8 ranked first followed by BARI SP-4 and BARI SP- 12 at Gaibandha. While in Rangpur, BARI SP-12 ranked first, BARI SP-4 ranked second and BARI SP-8 ranked third (Table 10).

Table 10. Voting results for selection of clones/variety at vegetative stage by the participants at Gaibandha and Rangpur region.

Variety	Score by men	Order of importance	Score by women	Order of importance	Global score	Order of ranking
Gaibandha						
BARI SP-4	13	III	9	II	22	II
BARI SP-8	19	I	11	I	30	I
BARI SP-12	16	II	6	III	21	III
BARI SP-15	2	V	0	V	2	V
Local Variety	10	IV	4	IV	14	IV
Total	**60**		**30**		**90**	
Rangpur						
BARI SP-4	18	II	8	II	26	II
BARI SP-8	16	III	8	II	24	III
BARI SP-12	21	I	10	I	31	I
BARI SP-15	1	V	1	IV	2	V
Local Variety	4	IV	3	III	7	IV
Total	**60**		**30**		**90**	

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Step-2. Evaluation at the time of harvest

a) "Gathering and Ranking of Criteria" (time of harvest)

At the time of harvesting, again fifteen participants (5 men, 5 women and 5 researcher and extension staff) were gathered and initially selected some yield & yield contributing characters which should have in the upcoming sweetpotato varieties. Then they had given their vote to select the best three criteria. According to voting results, they had selected insect resistant variety as first, good in taste as second and high yield & medium size root as third in Gaibandha. While in Rangpur, vitamin rich variety got highest votes followed by less insect infestation (2nd) and good in taste (3rd) (Table 11).

Table 11. Character selection at harvesting stage by the participants at Gaibandha and Rangpur region

Criteria	Score by Men	Order of Importance	Score by Women	Order of Importance	Total	Order of Importance
Gaibandha						
High yielding	13	II	1	V	14	III
Insect resistance variety	15	I	6	III	21	I
Nice to look at	3	VI	5	IV	8	V
Medium in size	7	V	7	II	14	III
Good in taste	9	IV	9	I	18	II
High storage capacity	10	III	1	V	11	IV
Disease free variety	3	VI	1	V	4	VI
Total	**60**		**30**		**90**	
Rangpur						
Skin don't crack after boil	1	VIII	0	VIII	1	VIII
Good in taste	7	IV	7	II	14	III
Vitamin rich	14	II	10	I	24	I
Red skin	4	VII	1	VII	5	VII
High yield variety	8	III	4	III	12	IV
High storage capacity	6	V	4	V	10	V
Less insect infestation	15	I	3	IV	18	II
Medium in size	5	VI	1	VI	6	VI
Total	**60**		**30**		**90**	

b) "Ranking of the best variety by farmers" (time of harvest)

After selecting the characters, these participants were observed the harvested tuberous roots in the field and were taken part in the selection process considering the traits of good yield, skin color, uniformity, good shape & size, marketable roots and disease resistance etc. According to global score of voting results, BARI SP-12 ranked first, BARI SP-8 second and BARI SP-4 ranked third at Gaibandha region. While in Rangpur region, BARI SP-12 ranked first, BARI SP-4 second and BARI SP-8 ranked third. (Table 12).

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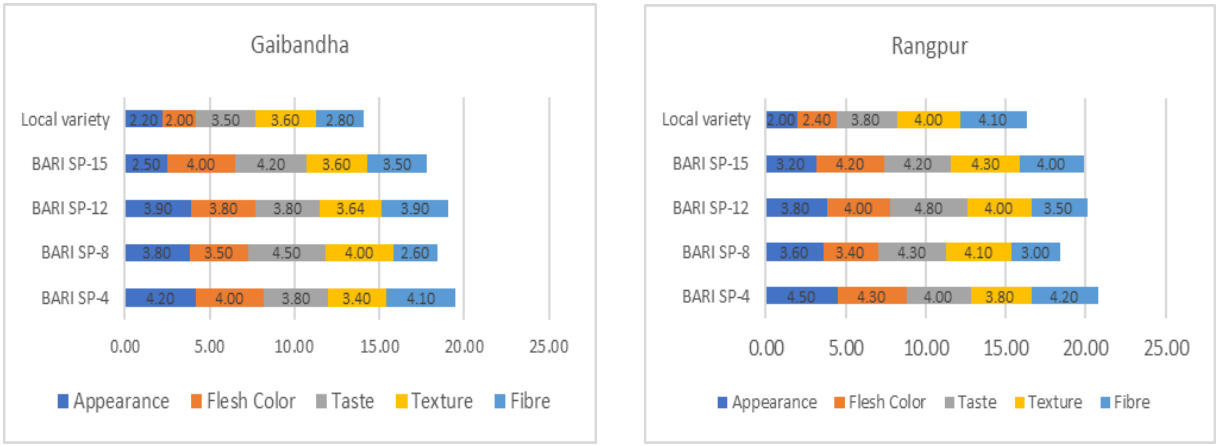
Table 12. Voting results for clones/varieties selection at harvesting stage by the participants at Gaibandha and Rangpur region.

Variety	Score by men	Order of importance	Score by Women	Order of importance	Global score	Order of ranking
Gaibandha						
BARI SP-4	16	II	7	III	23	III
BARI SP-8	15	III	9	II	24	II
BARI SP-12	22	I	11	I	33	I
BARI SP-15	0	V	1	V	1	V
Local Variety	7	IV	2	IV	9	IV
Total	**60**		**30**		**90**	
Rangpur						
BARI SP-4	19	II	8	III	27	II
BARI SP-8	17	III	9	II	26	III
BARI SP-12	21	I	11	I	32	I
BARI SP-15	0	V	0	V	0	V
Local Variety	3	IV	2	IV	5	IV
Total	**60**		**30**		**90**	

Step-3. Organoleptic Evaluation

After completing harvesting stage evaluation, participants were participated in the organoleptic evaluation program of the studied sweetpotato varieties at Gaibandha and Rangpur separately. At Gaibandha, considering mean appearance of the roots, flesh color, taste, presence of fiber and flesh texture of each variety, BAR SP-4 ranked first (following a scale of 1-5, where 1= very bad, 2=bad, 3=Fair, 4=Good, 5=Excellent) followed by BARI SP-12 on the other hand farmers' choice was the poorest to local variety. Similar trend also found in Rangpur (Fig.3).



** Overall Scale: 5-Very good; 4-Good; 3-Fair; 2-Bad and 1-Very bad

Fig 3. Organoleptic evaluation test performance of the varieties at Gaibandha and Rangpur region

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4. CONCLUSION

From the above studies, it was observed that BARI SP-12 performed well in northern district compare to other varieties. Considering vegetative and harvesting stage evaluation participants' (farmers and researchers) choice also went to BARI SP-12 at both locations. But in organoleptic evaluation, participants preferred BARI SP-4 as the best one followed by BARI SP-12. Considering overall performance of the studied varieties, it may be concluded that BARI-SP-12 and BARI SP-8 have higher adaptability under northern districts and BARI SP-15 is very sensitive to cooler weather which is not well adapted in these areas.

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