Project ID 746

Competitive Research Grant

Sub-Project Completion Report

on

Screening of sugarcane genotypes based on adaptive mechanisms under drought and salinity stress due to climatic change

Project Duration

April 2017 to September 2018

Physiology and Sugar Chemistry Division
Bangladesh Sugarcrop Research Institute
Ishurdi-6620, Pabna.

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

September 2018

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Screening of sugarcane genotypes based on adaptive mechanisms under drought and salinity stress due to climatic change

Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

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Acronyms

BSRI Bangladesh Sugarcrop Research Institute

SU Spad Unit

* Tolerance rating scale (1-5) is based on greenness of plants and other data collected where

1 = highly tolerant, 2 = tolerant, 3 = moderately tolerant, 4 = intolerant and

5 = highly tolerant.

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Executive Summary

The performance of eleven sugarcane genotypes (I 127-09, I 130-09 , I 85-10 , I 101-10 & I 103-10 under ZYT-III & I 7-11 , I 111-11, I 198-11, I 230-11, I 118-10 & I 131-10 under ZYT II) and one standard variety (Isd 39) were selected for drought and salinity stress were evaluated under induced drought and salinity stress during 2017-2018 cropping season at Physiology and Sugar Chemistry Division yard of Bangladesh Sugarcrop Research Institute, Ishurdi, Pabna, and in some farmers field under natural drought and salinity stress situated on drought and saline prone areas of Bangladesh to select drought and salinity tolerant genotypes of sugarcane. Under drought and salinity stress greenness of plants, tillers, millable canes and yield were strongly correlated, indicating usefulness of these parameters in identifying drought and salinity tolerant genotypes. Under natural saline prone areas BSRI bred chewing varieties viz. BSRI AKH 41, BSRI AKH 42 and a local variety were also evaluated in Terokhada, Khulna location. The genotypes I 127-09 (green leaf 59.26%, Chl. 45.8 at 90d, pol % 14.75) & I 101-10 (green leaf 56.04%, Chl. 43.4 at 90d, pol % 14.79) under ZYT III and genotypes I 7-11 (green leaf 59.19%, Chl. 47.55 at 90d, pol % 14.66) & I 118-10 (green leaf 48.85%, Chl. 46.8 at 90d, pol % 15.17) under ZYT II showed better performance under induced drought stress . Genotypes I 127-09, I 85-10 & I 103-10 under ZYT III were recorded as highly tolerant against natural drought stress condition, and produced 106.39, 101.57 and 127.85 t ha^{-1} yield at Jealmari (Rajshahi) location while those genotypes showed lower performance under farmer's field drought stress condition at Patuadangi (Thakurgaon) with cane yield 34.54, 49.11, and 56.32 t ha^{-1} respectively due to poor soil condition at Thakurgaon location. Genotypes I 7-11 and I 198-11 under ZYT-II performed better at Godagari, Rajshahi location having cane yield 145.11 and 121.37 t ha^{-1} respectively. Those genotypes showed comparatively better performance in Thakurgaon location having cane yield 59.16 and 63.88 t ha^{-1}.

On the contrary, The genotypes I 127-09 (green leaf 23.79 %, Chl. 28.77 at 90d, pol % 15.87), & I 101-10 (green leaf 24.99%, Chl. 28.80 at harvest, pol % 13.46) under ZYT III and genotypes I 118-10 (green leaf 24.83%, Chl. 29.53 at harvest pol % 15.08) under ZYT II showed better performance under induced salinity stress at 12dS/m salinity level. Genotypes I 127-09, I 130-09 & I 103-10 under ZYT III were recorded as highly tolerant against natural salinity stress condition, and produced 86.65, 89.38 and 87.90 t ha^{-1} at Satkhira location. Genotypes I 7-11, I 198-11, I 230-11 I 131-10 under ZYT-II also performed better having cane yield 84.14, 94.58, 105.87 and 90.50 t ha^{-1} respectively. Among the chewing varieties BSRI Akh 41 performed better than the others in respect of yield.

Results indicated strong possibilities of present technique to screen sugarcane genotypes for superior tolerance to drought and salinity stress. On the other hand, total expenditure for the project is 33, 15009/- (Thirty three lakh fifteen thousand and nine taka only)

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project:
   Screening of sugarcane genotypes based on adaptive mechanisms under drought and salinity stress due to climatic change

2. Implementing organization:
   Physiology and Sugar Chemistry Division, Bangladesh Sugarcrop Research Institute, Ishurdi-6620, Pabna.

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):
   Principal Investigator (Full address with phone and e-mail): Dr. Mst. Kohinoor Begum, Principal Scientific Officer (cc), Physiology and Sugar Chemistry Division, Bangladesh Sugarcrop Research Institute, Ishurdi-6620, Pabna. Phone no: +8801731919174. Email: kohinoorbegum.bsri@gmail.com

4. Sub-project budget (Tk): 3455190.00
   4.1 Total: 3455190.00
   4.2 Revised (if any): 3455190.00
5. Duration of the sub-project: From April 2017 to September 2018
   5.1 Start date (based on LoA signed):
   5.2 End date: 30 September 2018
6. Justification of undertaking the sub-project:
   Abiotic and biotic stress conditions such as drought, heat, salinity, cold, water-logging, flood, pest infestation etc. can have a devastating impact on plant growth and yield under field conditions. Nevertheless, the effects of these stresses on plants are typically being studied under controlled growth conditions in the laboratory. Crop plants experience more than one abiotic and/or biotic stress under natural field conditions. The field environment is very different from controlled conditions used in laboratory studies, and often involves the simultaneous exposure of plants to more than one abiotic stress condition, such as a combination of drought and heat, drought and cold, salinity and heat, salinity and flood/water-logging, salinity and drought, and also drought-salinity-flood/water-logging etc. Recent studies have revealed that the response of plants to combinations of two or more stress conditions is unique and cannot be directly extrapolated from the response of plants to each of the different stresses applied individually (Nobuhiro Suzuki *et al.*,2014). In addition, current climate prediction models indicate a gradual increase in ambient temperature, and an enhancement in the frequency and amplitude of heat stress in the near future (Ahuja *et al*., 2010; Mittler & Blumwald, 2010; Mittler*et al*., 2012; Li *et al*., 2013). Moreover, high temperatures will be accompanied by other weather disasters, such as extended droughts, flood and salinity intrusions, that could drastically impact crop production worldwide (IPCC, 2008). In Bangladesh, over 30% of the net cultivable area lies in the

coastal zone of Bay of Bengal, of which approximately 53% is affected by varying degrees of salinity. The salt affected area in the coastal zone of the country was about 0.83 million ha in 1966-76, which expanded to 3.1 million ha over the last two decades (Kader, 2006). In addition, more area in that zone is expected to become saline affected in future due to increase in sea water level as a consequence of the greenhouse effect. The other concern is that the area under irrigation is increasing worldwide day-by-day allowing more area to be affected by salinity stress. As estimated by FAO, about 20-30 million ha of irrigated lands worldwide were seriously damaged in 2002 due to the build-up of salts and every year 0.25-0.50 million ha of irrigated lands worldwide are lost from production due to salts build-up (Martinez-Beltran and Manzur, 2005). On the other hand, some areas of Bangladesh have been identified as drought prone due to climate change. The major drought prone areas are located mainly in the north-eastern part of Bangladesh. Water scarcity is severe in greater Rajshahi and Natore district, where huge yield loss has been observing for most of the crops.

An urgent need to generate crops with enhanced tolerance to stress combinations therefore exists. So, it is important to investigate the effect of combined stresses (drought and salinity) and genetic potential of existing sugarcane varieties to sustain the production.

7. Sub-project goal:

   Increased productivity and production of sugarcane in drought and saline areas.

8. Sub-project objective (s):

   Selecting sugarcane varieties with superior tolerance to abiotic stress condition.

9. Implementing location (s):

   BSRI, Rajshahi, Thakurgaon, Khulna and Satkhira.

10. Methodology in brief:

    The BSRI bred genotypes were included in the study to conducted in the following phases:

    i) Testing under induced drought and salinity stress condition

    ii) Testing under natural drought salinity stress condition at farmer's field.

    i) Testing under induced drought and salinity stress condition

    Drought stress: In this case Single-budded setts of different test genotypes were planted in to 60×10 cm PVC pipes each containing 6 kg soil. Four months after planting the PVC pipes containing plants subjected to artificially made drought stress by using PEG (Polyethylene Glycol 6000). Normal intercultural operations including fertilization, weeding etc. were done. Sugarcane genotypes under ZYT III and other selected genotypes were used for this purpose.

    Salinity stress: In this case, single-budded setts of different test genotypes were grown in poly bags and were transplanted in drums after 2 months of germination. Soils of drums were treated with different levels of salt concentration (8 dS/m, 10

dS/m, 12 dS/m). Sugarcane genotypes under ZYT III and other selected genotypes were used for this purpose.

iii) Testing under natural drought and salinity stress condition at farmer's field.

Same experiment were conducted in the farmer's field under natural saline and drought prone areas using double-bedded setts and the plot size were 6m×6m. The experiments were conducted at drought and saline prone locations such as Jealmari (Rajshahi) and Patuadangi farm, RSRS (Thakurgaon) for drought stress and Khulna and satkhira for salinity stress. Eleven promising genotypes were tested at all the locations. The experiments were laid out in RCB design with three replications. The experiment was set up on 1st November at Jealmari (Rajshahi) and 3rd November at RSRS (Thakurgaon) locations 11 December at Khulna , 1 january at Shatkhira location . Two budded setts were planted at trenches following end to end method of planting. NPKS fertilizers were applied @ 325 kg urea, 250 kg TSP, 190 kg MP, 180 kg Gypsum and 9 kg $ZnSo_4$ per hectare. Urea was application in 3 splits and MP was applied in two splits. All necessary cultural practices were done as and when required. Data were recorded on tolerance rating at 15 d interval during drought period, tiller count, millable canes and yield. Tolerance rating scale were recorded on greenness of leaves and other factors recorded. Soil P^H, Organic carbon(%), N(%), P(ppm), K(meq) and S(ppm) were 7.2, 0.66, 0.06, 11.0, 0.20 and 17.0 at Jealmari (Rajshahi) location and 5.3, 1.15, 0.08, 20.0, 0.12 and 18.0 at Patuadangi farm, RSRS (Thakurgaon) location respectively.. Due to low P^H nutrients availability was lower at Patuadangi farm, RSRS (Thakurgaon) location. So, the soil was recorded as poor at Patuadangi farm, RSRS (Thakurgaon) location than Jealmari (Rajshahi) location.

11. Results and discussion:

Table 1. Performance of BSRI bred genotypes under induced drought stress conditions. (Pot)

Varieties / cl Ones ZYT - III	Drought (days)						Air dry weight of Root/ plant (g)	Volume of Root	Tolerance rating scale (1-5)*
	30		60		90				
	Dry leaf (%)	Green leaf (%)	Dry leaf (%)	Green leaf (%)	Dry leaf (%)	Green leaf (%			
I 127-09	16.83	83.17	29.83 b	37.18	40.75 b	59.26 a	48.0 bc	135 c	1
I 130-09	15.44	84.56	38.67 ab	61.34	52.55 ab	47.46 ab	100 b	237.5 b	1
I 85-10	21.92	78.09	56.46 a	43.54	67.22 a	32.78 b	153.5 a	395.0 a	2
I 101-10	17.32	82.68	37.98 ab	62.02	65.63 a	34.38 b	35.0 c	40 d	2
I 103-10	34.15	65.85	55.13 a	44.88	53.97 ab	46.04 ab	20.0 c	160 c	1
ISD 39	15.76	84.25	38.53 ab	61.47	48.98 ab	51.02 ab	33.5 c	165 c	1

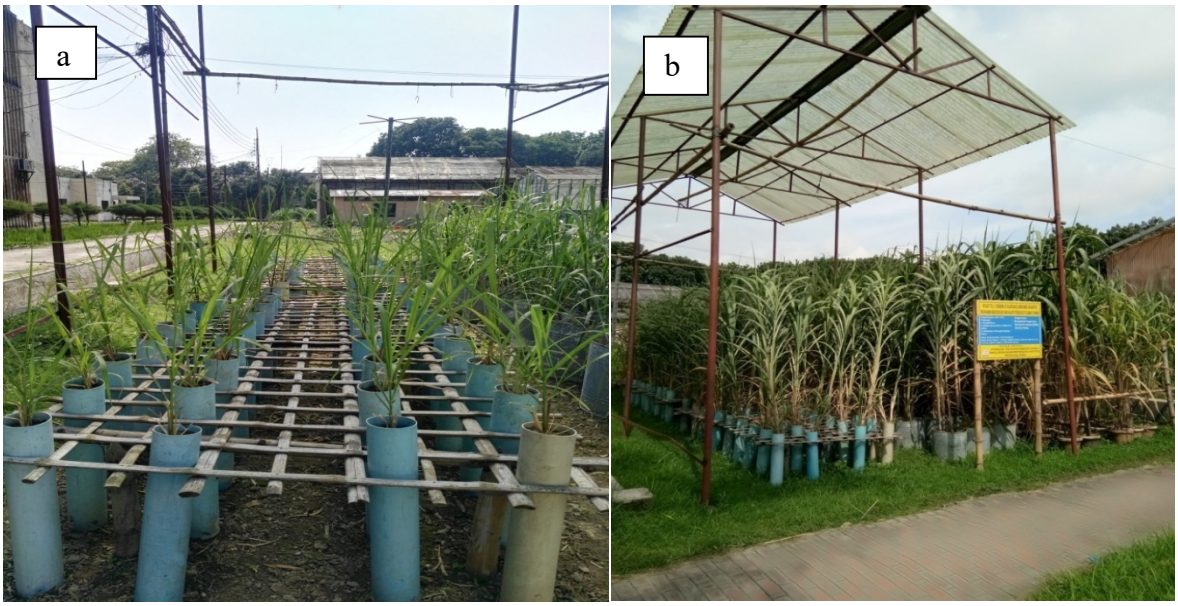

Fig. 1. Early (a) and harvesting (b) stage of the experiment conducted under induced drought stress.

Table 2. Performance of BSRI bred genotypes under induced drought stress conditions. (Pot)

Varieties / genotypes ZYT - II	Drought (days)						Air dry weight of Root/ plant (g)	Volume of Root	Tolerance rating scale (1-5)*
	30		60		90				
	Dry leaf (%)	Green leaf (%)	Dry leaf (%)	Green leaf (%)	Dry leaf (%)	Green leaf (%			
I 7-11	23.09 ab	76.91 bcd	43.94 b	56.06 a	60.82 ab	59.19 a	23.5 abc	75.0 ab	1
I 111-11	23.1 ab	76.91 bcd	57.22 ab	42.79 ab	76.27 ab	23.74 ab	38.5 abc	112.5 ab	2
I 198-11	20.18 abc	75.83 cd	65.2 a	34.80 b	83.75 a	16.25 b	0 c	0 b	2
I 230-11	26.52 a	73.48 d	57.62 ab	42.39 ab	67.06 ab	32.94 ab	11.0 bc	26.0 b	2
I 118-10	11.54 d	88.46 a	38.18 b	61.82 a	51.15 ab	48.85 ab	52.0 ab	162.5 a	1
I 131-10	15.02 cd	84.98 ab	49.17 ab	50.84 ab	58.85 ab	41.16 ab	62.0 a	185.0 a	1
Isd 39	15.76 bcd	84.25 abc	38.53 b	61.47 a	48.98 b	51.02 ab	33.5 abc	165.0 a	1

Table 3. Performance of BSRI bred genotypes under induced drought stress conditions. (PVC pipe)

Varieties/ genotypes	Chlorophyll (spad)		Brix%	Purity	Pol% cane	RS	Grading (1-5)*
ZYT III	30 days	90 days					
I 127-09	45.85	45.8 a	21.0	88.89	14.75	0.84	1
I 130-09	57.6	35.7 ab	19.6	86.36	13.37	1.30	2
I 85-10	89.2	45.8 a	19.2	86.14	13.07	1.24	2
I 101-10	56.35	43.4 a	21.0	89.17	14.79	0.50	1
I 103-10	54.55	28.95 b	19.6	73.55	12.74	2.60	2
ISD 39	42.65	40.55 ab	21.6	89.06	15.20	0.29	1

Table 4. Performance of BSRI bred genotypes under induced drought stress conditions. (PVC pipe)

Varieties/ genotypes	Chlorophyll (spad)		Brix%	Purity	Pol% cane	RS	Grading (1-5)*
ZYT II	30 days	90 days					
I 7-11	70 .8 a	37.55 b	20.6	90.10	14.66	1.30	1
I 111-11	47.65 b	37.7 b	19.8	88.78	13.89	1.37	2
I 198-11	56.1 ab	0 c	19.4	88.78	13.39	1.37	2
I 230-11	73.7 a	39.7 ab	19.5	88.78	13.59	1.37	2
I 118-10	59.05 ab	46.8 a	21.4	89.71	15.17	0.62	1
I 131-10	43.65 b	35.9 b	22.4	88.30	15.63	0.41	1

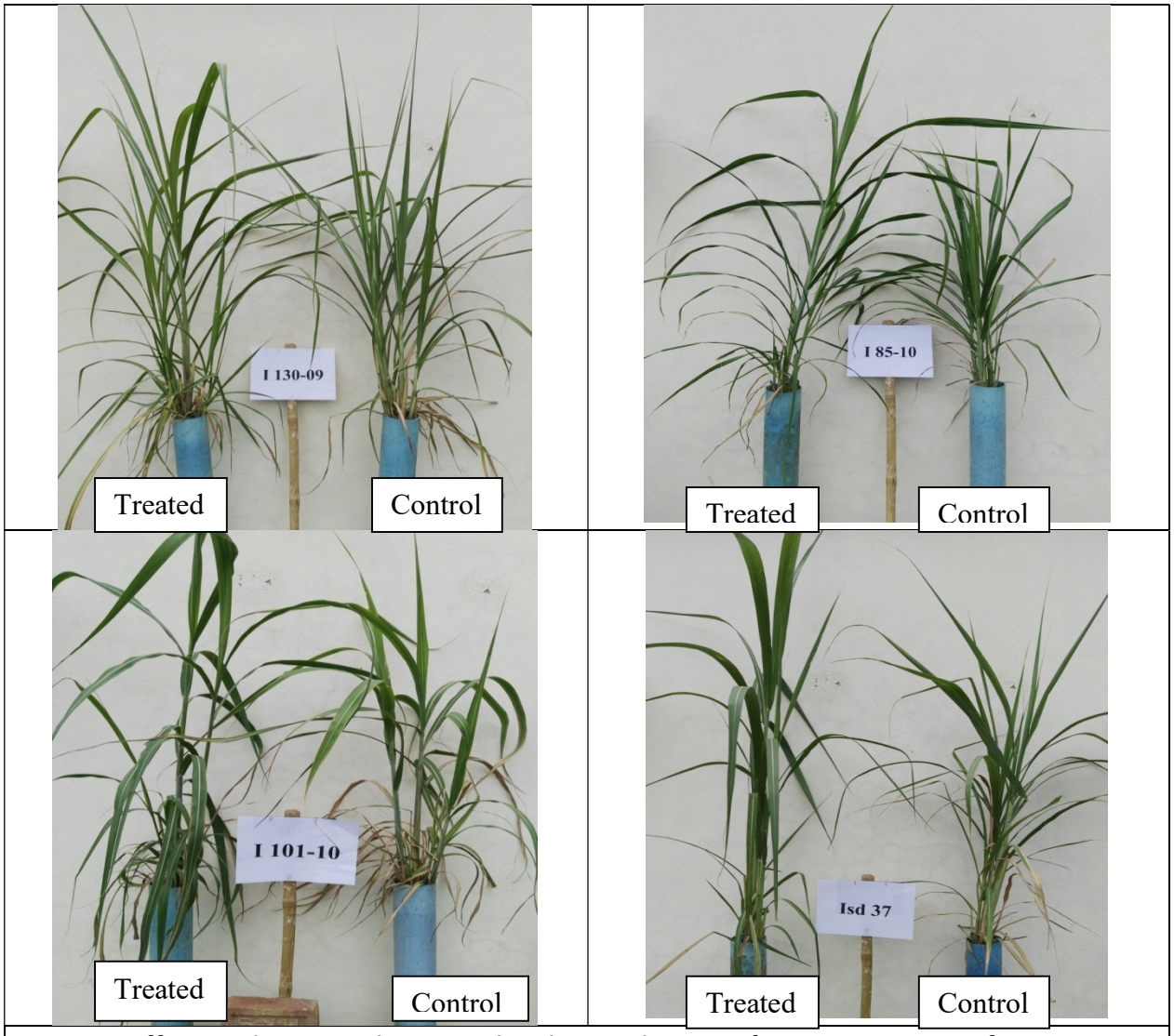

Fig. 2. Difference between the treated and control stage of some genotypes of sugarcane collected from the expt. conducted under induced drought stress

Fig. 3 (a, b). Late tillering stage of the experiment conducted under natural drought stress in some drought prone areas of Bangladesh. (Fig. a. Godagari, Rajshahi & Fig. b. Thakurgaon)

Table 5. Screening Sugarcane against Drought Stress under Farmers' Field Condition at Different Location

Varieties /genotypes ZYT-III	Rajshahi			Thakurgaon		
	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*
I 127-09	89.4 c	106.39 bc	1	37.11 h-j	34.54 f	3
I 130-09	80.46 c	96.56 c	2	44.89 f-i	40.54 d-f	3
I 85-10	111.62 b	101.57 c	1	52.78 b-f	49.11 b-e	3
I 101-10	110.6 b	87.38 c	2	65.22 a	60.46 ab	2
I 103-10	148.66 a	127.85 a	1	56.78 a-e	56.32 a-c	2
Isd 39	133.08 a	123.76 ab	1	56.11 a-f	48.99 b-e	3

Table 6. Screening Sugarcane against drought stress under farmers' field condition at different location

Varieties /genotypes ZYT-II	Rajshahi	Thakurgaon				
	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*
I 7-11	152.75 a	145.11 a	1	60.65 a-d	59.16 a-c	2
I 111-11	77.39 d	69.65 d	2	52.44 b-f	55.50 a-c	2
I 198-11	143.78 ab	121.37 b	1	61.22 a-c	63.88 a	2
I 230-11	121.33 bc	106.77 bc	2	48.55 e-h	45.95 c-f	3
I 118-10	116.73 c	87.54 cd	2	29.44 j	33.55 f	3
I 131-10	87.10 d	89.38 cd	2	36.44 ij	38.71 ef	3
Isd 39	133.08 abc	123.76 ab	1	56.11 a-f	48.99 b-e	3

Morpho physiological characters like green leaf percentage, root wt. were collected from eleven sugarcane genotypes from the expt. conducted under induced drought stress condition at BSRI (yard) (Table 1 &2). Juice quality were also determined from the expt. conducted under induced drought stress expt. (Table 3 & 4). Under ZYT III I 127-09 (59.26) produced highest green leaf percentage at 90 d followed by I 130-09 (47.46) & I 103-10 (46.04) like the standard var. Id 39 (51.02). Genotypes I 85-10 produced highest root (153.5g) followed by I 130-09 (100g). After combination of these data I 127-09, I 130-09 & I 103-10 got 1 according to tolerance rating scale like the standard var. Isd 39. Under ZYT II genotype I 7-11, I 131-10 and I 118-10 got 1 according to tolerance rating scale on the basis of green leaf content at 90d and root wt.

On the basis of chlorophyll content and juice quality I 127-09 (45.8 spad unit, pol% 14.75) and I 101-10 (43.4 spad unit, pol% 14.79) got 1 under ZYT III. Under ZYT II, I 7-11 (Chl. 37.55 SU,

pol% 14.66) & I 118-10 (Chl. 46.8 SU, pol% 15.17) got 1 on the basis of chlorophyll content and sucrose content. The results obtained on yield contributing characters such as tillers production, millable canes and yield of eleven promising sugarcane genotypes at drought prone Jealmari (Rajshahi) and RSRS (Thakurgaon) locations have been presented in Tables 5 and 6. It is seen from the Table 5 & 6 that the genotypes I 127-09, I 85-10, I 103-10, I 7-11 and I 198-11 showed highly tolerant reaction having tolerance rating 1 against drought stress under farmer's field condition at Jealmari (Rajshahi), and produced 106.39, 101.57, 127.85, 145.11 and 121.37 t ha $^{-1}$ cane yield respectively. Genotypes I 130-09, I 101-10, I 111-11, I 230-11, I 118-10 and I 131-10 showed tolerant reaction having tolerance rating 2 against field drought stress, and produced 96.56, 87.38, 69.65, 106.77, 87.54 and 89.38 t ha $^{-1}$ cane yield respectively in the same location**.**

Tables 5 & 6 also shows that the genotypes I 101-10, I 103-10, I 7-11, I 111-11and I 198-11 showed tolerant reaction at field drought stress test at Patuadangi farm, RSRS, Thakurgoan location having tolerance rating scale 2 and obtained cane yield of 60.46, 56.32, 59.16, 55.50 and 63.88 t ha^{-1} respectively**.** It is seen from the tables 5 & 6 that there is no consistency in cane yield between highly tolerant and tolerant genotypes, and in several cases tolerant genotypes produced higher cane yield compared to highly tolerant genotypes. This indicates that stress tolerance is not the only factor for cane yield, and stress level was not too long to cause severe damage. It is also seen that clone I 101-10 & I 111-11 performed equally good under both poor and fertile soils conditions, while the other genotypes did much better under fertile soils of Jealmari (Rajshahi) compared to poor soils of Patuadangi farm of RSRS (Thakurgoan). From the above facts it is seen that the genotypes which give highly tolerant reaction according to tolerance rating scale give better yield than other genotypes. Those genotypes which showed more freshness and greenness in stress period produced more photosynthate, and gave higher yield. According to Malik *et al.,* (1992) photosynthesis may be reduced 90% when leaves are wilted. Varieties show different behaviour of growth and plant survival during moisture stress. Drought tolerant genotypes maintain near optimum growth for longer period of time show lesser yield reduction under moisture stress condition. This varietal adaptability is due to morphological and anatomical modification of plant parts and tissue and some physiological traits associated with plant survival (Malik *et al.,* 1992). Tolerance rating 2, genotypes I 130-09 and I 101-10 produced cane yield 96.56 and 87.38 t ha^{-1}at Jealmari (Rajshahi) and 40.54 & 60.46 t ha^{-1} at RSRS (Thakurgaon) locations. Joshi *et. al.,* (1994) reported that the performance of sugarcane varieties is mostly dependant on climatological factors during different growth phases along with soil conditions and agronomical management. Thus the varieties/genotypes performing better at one location may not be equally good at another location which is in agreement with our findings. Anon (2003) obtained average yield 94.9, 94.2 and 92.8 t ha^{-1} for the clone I 142-98, I 137-97 and I 202-97 respectively in different location. The variations might be due to some other factors like climate, soil condition, weather, fertilizer and drought stress condition etc. Cane planted in poor soil face severe stress than organic matter rich soils (Malik *et al.,* 1992).The results of this study will help the breeders to improve drought resistant varieties, and might be recommended for release for cultivation in drought and saline prone areas.

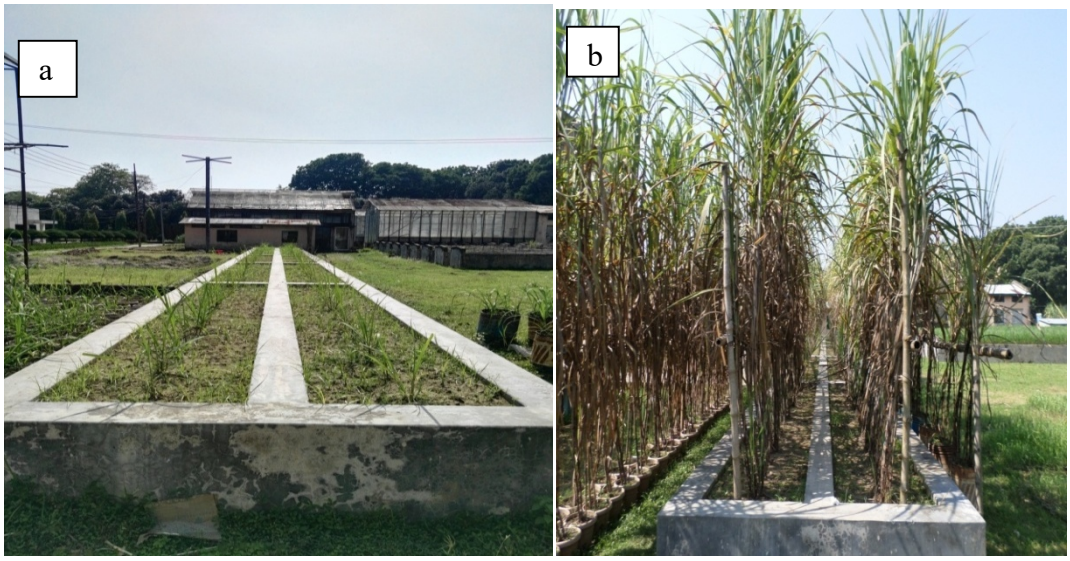

Fig 3. Early (a) and harvesting (b) stage of the experiment conducted under induced salinity stress.

Table 7. Screening sugarcane against salinity stress. location : BSRI, yard

	30 days			At harvest		
	8 dS/m					
ZYT III	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 127-09	**10.05 ab**	**89.95**	**42.67 ab**	**75.70**	**24.30**	**33.33 a**
I 130-09	**4.10 b**	**95.89**	**38.07 b**	**79.61**	**20.39**	**31.20 ab**
I 85-10	**12.07 ab**	**60.93**	**49.57 a**	**79.82**	**20.18**	**28.60 ab**
I 101-10	**8.40 ab**	**91.60**	**43.67 ab**	**75.66**	**24.34**	**23.63 b**
I 103-10	**16.12 a**	**83.88**	**40.43 ab**	**79.56**	**20.44**	**26.10 ab**
Isd 39	**8.92 ab**	**91.08**	**43.80 ab**	**80.79**	**19.21**	**25.17 ab**

Table 8. Screening Sugarcane against Salinity Stress. Location : BSRI, Yard

	30 days			At harvest		
	10 dS/m					
ZYT III	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 127-09	**15.82**	**84.18**	**38.43**	**74.63**	**25.37**	**32.63 ab**
I 130-09	**8.04**	**91.96**	**36.77**	**77.09**	**22.91**	**30.27 abc**
I 85-10	**17.24**	**82.76**	**40.10**	**79.19**	**25.81**	**38.77 a**
I 101-10	**18.37**	**81.63**	**37.07**	**77.25**	**22.75**	**29.63 abc**
I 103-10	**18.02**	**81.98**	**38.17**	**75.32**	**24.47**	**20.77 c**
Isd 39	**16.04**	**83.96**	**36.60**	**77.69**	**22.31**	**26.67 bc**

Table 9. Screening Sugarcane against Salinity Stress. Location : BSRI, Yard

	30 days			At harvest		
ZYT III	12 dS/m					
	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 127-09	**9.10 b**	**90.90 a**	**44.30**	**76.21 b**	**23.79 ab**	**28.77 a**
I 130-09	**18.92 ab**	**81.08 ab**	**38.47**	**75.82 b**	**24.18 a**	**26.73 a**
I 85-10	**19.84 ab**	**80.16 ab**	**45.30**	**79.91 ab**	**19.96 ab**	**26.83 a**
I 101-10	**15.64 ab**	**84.36 ab**	**40.50**	**75.00 b**	**24.99 a**	**28.80 a**
I 103-10	**25.74 a**	**74.26 b**	**37.23**	**83.75 a**	**16.25 b**	**17.67 b**
Isd 39	**11.44 b**	**8856 a**	**36.23**	**76.27 b**	**20.40 ab**	**21.30 ab**

Table 10. Screening Sugarcane against Salinity Stress. Location : BSRI, Yard

	30 days			At harvest		
	8 dS/m					
ZYT II	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 7-11	**13.75 abc**	**86.25 abc**	**41.63 bc**	**92.28**	**7.72 b**	**20.63 c**
I 111-11	**9.80 bc**	**90.20 ab**	**38.83 c**	**89.66**	**10.34 b**	**24.13 bc**
I 198-11	**14.51 abc**	**85.49 abc**	**46.30 abc**	**78.59**	**21.41 b**	**30.40 ab**
I 230-11	**18.55 a**	**81.45 c**	**50.83 ab**	**86.42**	**13.58 b**	**19.63 c**
I 118-10	**15.19 abc**	**85.08 abc**	**53.07 a**	**77.18**	**51.24 a**	**33.87 a**
I 131-10	**17.84 ab**	**82.16 bc**	**39.96 bc**	**78.89**	**21.11 b**	**23.33 c**
Isd 39	**8.92 c**	**91.08 a**	**43.80 abc**	**80.79**	**19.21 b**	**25.10 bc**

Table 11. Screening Sugarcane against Salinity Stress. Location : BSRI, Yard

	30 days			At harvest		
	10 dS/m					
ZYT II	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 7-11	**20.34**	**79.66**	**39.40 ab**	**90.65 a**	**92.35 c**	**29.07 ab**

	30 days			At harvest		
	10 dS/m					
I 111-11	**13.15**	**87.19**	**36.70 ab**	**90.46 a**	**9.54 c**	**32.87 ab**
I 198-11	**22.87**	**78.13**	**39.10 ab**	**67.91 c**	**32.09 a**	**21.20 b**
I 230-11	**15.90**	**84.10**	**46.57 a**	**82.31 ab**	**17.69 bc**	**33.50 ab**
I 118-10	**16.67**	**83.33**	**46.87 a**	**75.15 ab**	**14.62 bc**	**38.93 a**
I 131-10	**22.08**	**77.92**	**32.73 b**	**75.38 bc**	**24.62 ab**	**21.63 b**
Isd 39	**16.04**	**83.96**	**36.60 ab**	**77.69 bc**	**22.31 ab**	**26.67 ab**

Table 12. Screening Sugarcane against Salinity Stress. Location : BSRI, Yard

	30 days			At harvest		
	12 dS/m					
ZYT II	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)	Dry leaf (%)	Green leaf (%)	Chlorophyll (spad unit)
I 7-11	**24.14**	**75.89**	**41.47**	**95.18 a**	**5.48 b**	**21.07 ab**
I 111-11	**17.36**	**82.64**	**37.07**	**82.88 ab**	**17.12 ab**	**22.03 ab**
I 198-11	**21.95**	**78.04**	**38.37**	**86.39 ab**	**13.61 ab**	**26.10 ab**
I 230-11	**11.34**	**88.66**	**45.63**	**85.45 ab**	**14.55 ab**	**18.37 b**
I 118-10	**18.90**	**81.10**	**44.20**	**75.17 b**	**24.83 a**	**29.53 a**
I 131-10	**20.68**	**79.32**	**34.93**	**75.18 ab**	**24.82 a**	**23.43 ab**
Isd 39	**11.44**	**88.56**	**36.23**	**79.60 ab**	**20.40 a**	**21.3 ab**

Table 13. Screening Sugarcane against Salinity Stress. Location : yard

Varieties /Genotypes	**Brix**				**Pol% cane**			
ZYT III	**Control**	**8 dS/m**	**10dS/m**	**12 dS/m**	**Control**	**8 dS/m**	**10dS/m**	**12 dS/m**
I 127-09	**20.5**	**20.8**	**20.75**	**22.30**	**14.10**	**14.64**	**14.71**	**15.87**
I 130-09	**17.6**	**20.5**	**19.6**	**21.10**	**12.38**	**14.30**	**13.74**	**14.24**
I 85-10	**18.4**	**19.8**	**18.5**	**18.50**	**12.99**	**13.84**	**12.71**	**12.64**
I 101-10	**18.8**	**19.65**	**19.05**	**19.35**	**13.14**	**13.90**	**13.32**	**13.46**
I 103-10	**16.8**	**19.55**	**18.5**	**19.50**	**11.3**	**13.63**	**12.86**	**12.70**
Isd 39	**19.30**	**21.50**	**22.2**	**21.30**	**13.24**	**15.34**	**15.78**	**15.52**

Table 14. Screening Sugarcane against Salinity Stress. Location : BSRI, yard

Varieties /Genotypes	Purity (%)				RS			
ZYT III	Control	8 dS/m	10dS/m	12 dS/m	Control	8 dS/m	10dS/m	12 dS/m
I 127-09	87.06	89.11	89.72	90.10	0.93	0.62	0.67	0.61
I 130-09	89.06	88.38	88.71	83.42	0.79	0.42	0.51	0.63
I 85-10	89.35	88.44	86.93	81.51	1.44	0.67	0.72	0.93
I 101-10	88.47	87.99	88.46	88.03	0.44	0.37	0.22	0.63
I 103-10	85.13	88.17	87.97	82.44	1.53	1.07	0.73	0.86
Isd 39	86.82	90.30	89.96	92.44	0.58	0.12	0.17	0.18

Table 15. Screening sugarcane against salinity stress. Location : BSRI, yard

Varieties /Genotypes	Brix				Pol% cane			
ZYT II	Control	8 dS/m	10dS/m	12 dS/m	Control	8 dS/m	10dS/m	12 dS/m
I 7-11	20.00	20.30	21.50	22.20	14.07	14.27	15.37	15.88
I 111-11	22.00	22.50	20.20	22.40	15.80	15.67	14.01	15.97
I 198-11	18.50	20.20	20.80	20.30	12.99	14.13	14.79	14.51
I 230-11	19.00	20.30	20.00	21.60	13.28	14.17	14.61	14.95
I 118-10	21.40	20.15	21.50	21.20	15.17	14.05	14.74	15.08
I 131-10	20.90	20.50	20.30	19.25	14.86	14.30	14.20	13.36
Isd 39	19.30	21.50	22.20	21.30	13.24	15.34	15.78	15.52

Table 16. Screening sugarcane against salinity stress. Location : yard

Varieties /Genotypes	Purity				RS			
ZYT II	Control	8 dS/m	10dS/m	12 dS/m	Control	8 dS/m	10dS/m	12 dS/m
I 7-11	89.03	88.96	90.49	90.55	2.60	0.35	0.46	0.24
I 111-11	90.90	88.15	87.74	90.23	0.68	0.26	0.34	0.13
I 198-11	88.87	88.53	53.99	89.13	1.04	0.10	0.13	0.21
I 230-11	88.48	88.33	89.70	91.05	0.43	0.41	0.44	0.33
I 118-10	89.73	88.26	89.19	90.05	0.43	0.55	0.24	0.40
I 131-10	90.01	88.28	88.47	87.80	0.47	0.20	0.27	0.46
Isd 39	86.82	90.30	89.96	92.44	0.58	0.12	0.17	0.18

Fig. 4. Late tillering phase of the expt. Conducted under natural salinity stress at Satkhira (a) & Khulna (b) location.

Table 17. Screening sugarcane against salinity stress. Location : Shatkhira

Varieties /Genotypes ZYT III	Tiller ($x10^3$ ha^{-1})	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*
I 127-09	107.62 c	88.41 d	86.65 b	1
I 130-09	116.03 c	95.08 cd	89.38 b	1
I 85-10	113.78 c	91.59 cd	75.10 c	2
I 101-10	131.27 b	100.63 c	73.46 c	2
I 103-10	140.48 ab	111.27 b	87.90 b	1
Isd 39	151.27 a	121.90 a	110.93 a	1

Table 18. Screening sugarcane against salinity stress. Location : Satkhira

Varieties /Genotypes	Tiller ($x10^3$ ha^{-1})	Millable cane ($x10^3$ ha^{-1})	Yield (t ha^{-1})	Grading (1-5)*
ZYT II				
I 7-11	123.81 c	93.49 cd	84.14 c	1
I 111-11	109.05 d	84.44 d	75.16 d	2
I 198-11	140.00 b	111.27 b	94.58 b	1
I 230-11	151.90 a	126.03 a	105.87 a	1
I 118-10	113.18 d	89.84 cd	71.87 d	2
I 131-10	121.59 c	97.30 c	90.50 bc	1
Isd 39	151.27 a	121.90 a	110.93 a	1

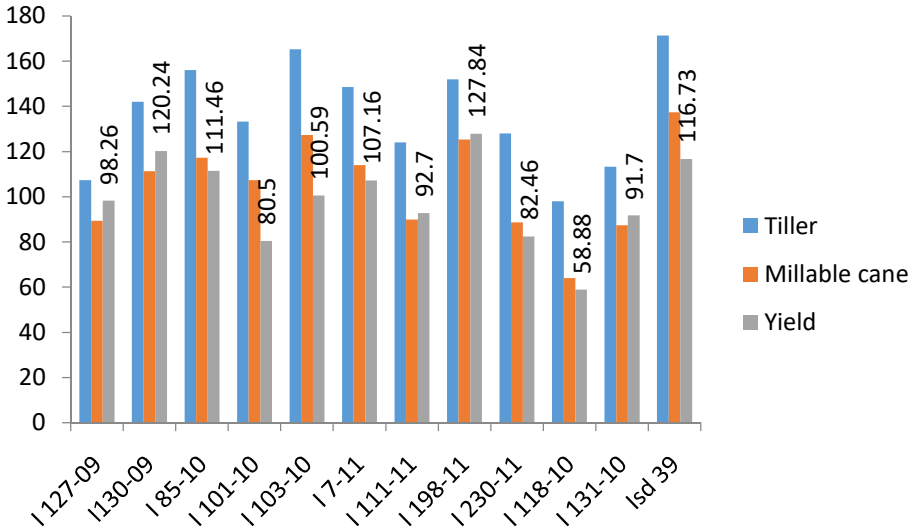

Figure 5. Screenig sugarcane against salinity stress. Location. Khulna

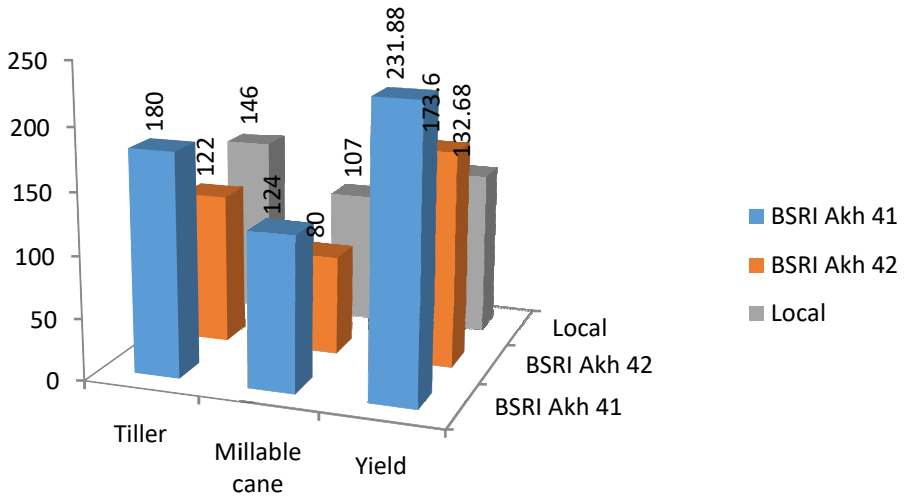

Figure 6. Screenig sugarcane against salinity stress. Location. Khulna

Average salinity level of the experimental plots are stated bellow:

Months	Salinity level EC (dS /m)	Growing phase of the sugarcane plant
November, 2017	1.10	Germination stage
December, 2017	1.03	
January, 2018	2.43	Growth stage
February, 2018	4.21	

Months	Salinity level EC (dS /m)	Growing phase of the sugarcane plant
March, 2018	6.4	Tillering stage
April, 2018	15.2	
May, 2018	5.4	
June, 2018	2.1	Crop formative stage
July, 2018	2.9	
August, 2018	3.4	
September, 2018	3.7	
October, 2018	2.2	
November, 2018	1.3	Harvesting stage

Proline content of some salinity tolerant genotypes

Name of the varieties	Proline (mg/g) in normal condition	Proline (mg/g) in stress condition
I 127-09	0.211	0.541
I 130-09	0.215	0.399
I 85-10	0.197	0.280
I 7-11	0.481	0.522
I 103-10	0.201	0.361
Isd 39	0.342	1.519

A trial was conducted at Terokhada (Khulna) and Satkhira with BSRI bred sugarcane genotypes under ZYT II & ZYT III and the standard variety Isd 39 during 20017-2018 cropping season. A trial was also conducted with BSRI bred chewing varieties and a local varieties at Terokhada Khulna location. The highest cane yield (127.84 t ha^{-1}) was obtained in I 198-11 followed by I 130-09 (120.24 t ha^{-1}), I 85-10 (111.46 t ha^{-1}) and Isd 39 (116.73 t ha^{-1}) having tolerance rating 1 in Khulna location. In Satkhira location I 127-09, I 130-09, I 103-10, I 7-11, I 198-11, I 230-11, I 131-10 and the variety Isd 39 performed better in respect of cane yield which is above 84 t ha^{-1} having tolerance rating 1. The genotypes I 127-09 (green leaf 23.79 %, Chl. 28.77 at 90d, pol % 15.87), I 130-09 (green leaf 24.18 %, Chl. 26.73 at 90d, pol % 14.24)& I 101-10 (green leaf 24.99%, Chl. 28.80 at harvest, pol % 13.46) under ZYT III and genotypes I 118-10 (green leaf 24.83%, Chl. 29.53 at harvest pol % 15.08) under ZYT II showed better performance under induced salinity stress at 12dS/m salinity level. Among the chewing varieties highest yield was obtained from BSRI akh 41 (231.88 t ha^{-1}) followed by BSRI Akh 42 (173.6 t ha^{-1}) and local (132.68 t ha^{-1}). It may be concluded that the genotypes I 127-09, I 130-09 & I 103-09 under ZYT III and I 7-11, I 198-11, 230-11 and I 131-10 under ZYT II were recorded as highly tolerant against salinity stress condition

12. Research highlight/findings (Bullet point – max 10 nos.)

- Among 5 genotypes of sugarcane under ZYT-III, **I 127-09, I 101-10, I 85-10 and I 103-10** performed better than others in drought stress.
- Among 6 genotypes of sugarcane under ZYT-II, **I 198-11 and I 7-11** performed better than others in drought stress.
- Among 5 genotypes of sugarcane under ZYT-III, **I 127-09, I 130-09, I 101-10 & I 103-09** performed better than others in salinity stress.
- Among 6 genotypes of sugarcane under ZYT-II, **I 7-11, I 198-11, 230-11 and I 131-10** performed better than others in salinity stress.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target				Achievement				Remarks
Facilities description	**Unit**	**Qty**	**Unit price**	**Total price**	**Unit**	**Qty**	**Unit price**	**Total price**	
a) Lab/Field Equipments									
EC meter	number	1	160000	160000	number	1	160000	160000	
Desktop Computer	number	1	60000	60000	number	1	60000	60000	
Laptop	number	1	60000	60000	number	1	60000	60000	
Laser Printer	number	1	20000	20000	number	1	20000	20000	
Scanner	number	1	10000	10000	number	1	10000	10000	
Digital camera	number	1	25000	25000	number	1	25000	25000	
Vortex mixture	number	1	35000	35000	number	1	35000	35000	
Micro pipette	number	1	35000	35000	number	1	35000	35000	
Ocular meter	number	2	10000	20000	number	2	10000	20000	
b) Office equipments									
Executive Table	number	1	20000	20000	number	1	20000	20000	
Executive chair	number	1	10000	10000	number	1	10000	10000	
File cabinet	number	1	20000	20000	number	1	20000	20000	
Steel Almira	number	1	24000	24000	number	1	24000	24000	
Visitors chair	number	4	4000	16000	number	4	4000	16000	
Computer Table	number	1	5000	5000	number	1	5000	5000	
Computer chair	number	1	3500	3500	number	1	3500	3500	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	237440	234475	234475	0	100	
B. Field research/lab expenses and supplies	1914250	1894004	1894004	0	100	
C. Operating expenses	410000	330953	330953	0	100	
D. Vehicle hire and fuel, oil & maintenance	200000	200585	200585	0	100	
E. Training/workshop/seminar etc.	-	-	-	-	-	
F. Publications and printing	100000	100000	100000	0	100	
G. Miscellaneous	70000	31600	31600	0	100	
H. Capital expenses	523500	523392	523392	0	100	

D. Achievement of Sub-project by objectives:

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
Selecting sugarcane varieties with superior tolerance to abiotic stress condition.	In order to achieve the above objectives twelve experiments were set up under induced drought and salinity stress at BSRI (Yard) location and under natural drought and salinity prone areas of Bangladesh in farmers field.	Among thirteen genotypes six were selected as drought tolerant and eight were selected as saline tolerant which should be further evaluated.	Farmers of the stress prone areas will be benefited through cultivate these genotypes

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	3 (Three)	**completed**	
Journal publication	2 (Two)	**Under processing**	**Bangladesh Journal of Sugarcane**
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)
Six genotypes were selected as drought tolerant and eight were selected as saline tolerant genotypes.

ii. Generation of new knowledge that help in developing more technology in future
Screening technique has developed to screen stress tolerant genotypes.

iii. Technology transferred that help increased agricultural productivity and farmers' income

iv. Policy Support

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

ii) Field Monitoring (time& No. of visit, Team visit and output): 16 February, 2017, Team visited the drought prone areas of Rajshahi location. They observed the situation of the experiments and talk with the farmers and collect their reaction. All the farmers of that location react positively with the genotypes supplied by BSRI and the methodology which were followed during the experiment set up.

Fig. Members of monitoring team were visited the experiments at Godagari, Rajshahi a drought prone area of Bangladesh in the month of 16 February.

I. Lesson Learned/Challenges (if any)

Due to higher demand of food and vegetables sugarcane growing lands are transferred to stress prone areas like flood, waterlog, drought and saline.

J. Challenges (if any)

In order to increase the area under sugarcane cultivation, price of cane should be increased. Price will be increase if the entire sugar mill should be modified with modern technology and go under multipurpose uses besides sugar like alchohol, vinegar, acetic acid etc. and also generate electricity.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal