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Effect of drought stress on yield and yield components of sugarcane

M. K. Begum and M. S. Islam
Bangladesh Sugarcane Research Institute, Ishurdi-6620, Pabna, Bangladesh.

Abstract: The performance of fourteen sugarcane genotypes under drought stress was evaluated during 2008-2009 cropping season at Patuadangi farm of Regional Sugarcane Research Station (RSRS) Thakurgoan and at farmers' field, Jealmari (Rajshahi). Under drought stress tillers, millable canes, stalk height, stalk diameter affected yield indicating usefulness of these parameters in identifying drought tolerant genotypes. The clones I 124-00, I 95-01, I 145-02, I 78-03, I 111-03, I 99-01, , Isd 32 & Isd 36 produced better cane yield in control condition in Rajshahi location but only the genotypes I 95-01, Isd 35 & Isd 36 produced better cane yield both under control and stress condition. In Thakurgaon location also the genotypes I 95-01, Isd 32 & Isd 36 showed better performance in yield and yield contributing characters under both the control and stress condition. Under stress, the tolerant genotypes showed higher productivity, stalk number, height and diameter than the susceptible one. Linear association was found between productivity and its yield components.
Key words: Tiller, Millable cane, Stalk height, Stalk diameter, Yield

Introduction

Drought is a major limitation to sustainable crop production worldwide because it affects simultaneously a varied number of morphological and physiological traits in plants. Relation between the traits and drought tolerance are suitable indicators for selection of drought tolerant genotypes in breeding programs to reduce the impact of water deficit on crop yield. For sugarcane, researches have concentrated on agronomic and physiological traits, which could lead to adaptation to these conditions or be correlated to drought tolerance and could be used for development of new varieties (Domaingue, 1995). One of the main problems associated with the development of drought tolerant varieties is the difficulty to identify single traits that can be used for selection (Quizenberry, 1982). Apart from that, the information on drought response among cultivars is generally gained after they have been released for commercial production (Inman-Bamber and Smith, 2005), and only a few genotypes are compared (Domaingue, 1995). Number of millable stalks is reduced under restricted water availability (Ramesh and Mahadevaswamy, 2000). Stalk diameter is influenced by water regime; however, it can also be affected by genotype (Da Silva and Da Costa, 2004). Cane elongation and stalk height are negatively and strongly affected by drought conditions (Inman-Bamber and Smith, 2005). According to Domaingue (1995) and Soares *et al.* (2004), stalk height is the most severely reduced parameter under drought conditions. Moisture stress at tillering, and grand growth phase during March to June is one of the important constraint which limit millable canes production, cane height and unit stalk weight, and these yield contributing characters have affect on yield. Apart from low management with unavailable modern cultivars drought stress due to high evaporative demand during crops canopy development and reproductive phase is conceived as the most dominant factor for low yield. Due to rapidly declining aquifer and rising cost of irrigation, development of modern drought resistant variety could be the most alternative solution of achieving higher yield of this crop. Thus, selection procedures should aim at identifying genotypes which are able to keep on elongating even in water stress conditions, with a view to increase cane height under these conditions. The performance of sugarcane varieties is mostly dependent on climatological factors during different growth phases along with soil conditions and agronomical management. Thus, varieties performing best at one location may not have been same performance at another location. It is, therefore, highly essential to test some promising sugarcane varieties under a given set of agronomic condition (Joshi, *et. al.,* 1994). Direct screening in the field conditions is, therefore, very difficult, and in many cases, doubtful. The objective of this study was to investigate the relationships of stalk number, stalk height and stalk diameter with cane yield for sugarcane growing in a field under natural water stress during its grand growth period in order to provide information to help breeders in adopting traits for selecting drought tolerant varieties.

Materials and Methods

The experiments were conducted at drought prone locations such as Jealmari (Rajshahi) and Patuadangi farm, RSRS (Thakurgaon). Fourteen genotypes were tested at both Jealmari (Rajshahi) and at Patuadangi farm, RSRS (Thakurgaon) 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. 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 without irrigation were done as and when required. Required irrigation were given only in control plots and in the stressed plots there were given only one irrigation after plantation only for settling establishment. Data were recorded on tiller count, millable canes, stalk height, stalk diameter and yield. 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.

Results and Discussion

The results obtained on yield contributing characters such as tillers production, millable canes, stalk height, stalk diameter and yield of fourteen promising sugarcane genotypes at drought prone Jealmari (Rajshahi) and RSRS

(Thakurgaon) locations have been presented in Table 1 and 2. Tiller, millable cane, stalk height, stalk diameter as well as productivity, were affected by genotypes and drought stress. All the parameters showed significant difference under control and stress condition in both the locations. Tiller and millable cane production for the wet treatment was higher than dry treatments in all genotypes in both the locations. The number of stalks can be considered within the expected values for number of millable canes, i.e., between 10 to 14 tillers per meter (Castro and Christoffoleti, 2005). The formation of tillers in sugarcane is important because of the contribution they make to yield by acting as a storage sink (Ramesh and Mahadevaswamy, 2000). During its growth, sugarcane passes through four distinct physiological stages, named, germination, tillering, grand growth, and maturity. Tillering together with early grand growth are known as the formative phase, and this has been identified as a critical water-demand period. Stress during this phase affects the final yield. Thus, the tillering ability and subsequent growth efficiency largely determine the yield of a given cultivar (Joshi *et al.*, 1996). Higher tiller production, irrespective of environmental conditions or cultivar, leads to higher number of stalks at harvest, despite differences in tiller mortality.

Table 1. Effect of water stress on yield and yield contributing characters in sugarcane (Location : Rajshahi)

Varieties/Clones	Treatment	Tiller (10^3 ha^{-1})	Millable cane (10^3 ha^{-1})	Stalk height (m)	Stalk diameter (cm)	Yield (t ha^{-1})
I 124-00	Control	124.0ghi	84.0fg	2.81cd	2.397abc	80.19cd
	Drought	104.0mn	68.4no	2.61ghi	2.137g	64.2i
I 95-01	Control	125.0fgh	85.0efg	2.93a	2.483a	82.0a
	Drought	123.6hi	80.2j	2.81cd	2.280def	80.67abcd
I 112-01	Control	127.3e	87.3cd	2.73de	2.383abc	80.67abcd
	Drought	117.1j	81.8hij	2.53ij	2.137g	62.3j
I 145-02	Control	127.1ef	86.3cde	2.813cd	2.370bcd	80.0de
	Drought	122.5i	83.9gh	2.61ghi	2.147g	68.3h
I 191-02	Control	155.3a	90.6b	2.77cde	2.390abc	78.67ef
	Drought	151.2b	93.7a	2.53ij	2.203fg	61.5j
I 7-03	Control	116.3j	83.5ghi	2.71ef	2.353cde	76.64g
	Drought	96.0p	71.2klm	2.51j	2.143g	51.27l
I 78-03	Control	124.1ghi	84.43efg	2.81cd	2.423abc	81.17abcd
	Drought	103.0no	69.9lmno	2.57hij	2.227fg	61.5j
I 111-03	Control	134.5c	87.3cd	2.913ab	2.410abc	81.58ab
	Drought	106.1m	68.2o	2.63fgh	2.217fg	62.5j
I 137-03	Control	131.3d	81.5ij	2.84bc	2.423abc	78.0f
	Drought	114.1k	69.2mno	2.61ghi	2.207fg	68.3h
I 231-03	Control	125.1fgh	73.2k	2.58hij	2.397abc	65.5i
	Drought	104.3mn	69.2mno	2.51j	2.233fg	51.4l
I 99-01	Control	126.1efg	88.3c	2.83bc	2.463ab	81.5abc
	Drought	101.3o	70.5lmn	2.53ij	2.267ef	58.5k
Isd 32	Control	123.1hi	85.2defg	2.96a	2.447abc	81.0abcd
	Drought	116.4j	83.5ghi	2.82c	2.230fg	80.9abcd
Isd 36	Control	130.3d	86.1def	2.91ab	2.463ab	80.6bcd
	Drought	126.1efg	84.5efg	2.82c	2.267ef	78.4f
Isd 38	Control	108.3l	71.5kl	2.69efg	2.383abc	62.0j
	Drought	97.1p	54.3p	2.51j	2.183fg	48.3m
LSD (0.05%)		2.173	2.179	0.08895	0.1027	1.349

Cane elongation and stalk height are negatively and strongly affected under drought conditions (Inman-Bamber and Smith, 2005). In this study all the fourteen genotypes showed higher stalk height in wet condition than in stress condition. This result shows the strong effect of the lack of water on this trait and it is in accordance with Domaingue (1995) and Soares *et al.* (2004). Ramesh and Mahadevaswamy (2000) obtained 177 cm from four genotypes, with moderate drought treatment applied between 60 – 150 days after planting. And Da Silva and Da Costa (2004) obtained the average of 263 cm for stalk height when water deficit treatment was applied during the third to sixth months of age on eight genotypes, while the average was of 300 cm on the irrigated side.

Stalk diameter response to water regime has been found to depend on the genotype (Da Silva and Da Costa, 2004). In the present study, the stalk diameter is higher in wet treatments than in dry treatments. Therefore, the combination of all these agronomic traits could affect final yield, as observed by. Ramesh & Mahadevaswamy (2000) found the low value of 1.96 cm for four varieties under moderate drought from 60 to 150 days after planting. In this study we found that the productivity was affected by the irrigation. The wet treatment resulted in higher productivity than the dry treatment in fourteen genotypes in both the locations The value obtained by Da Silva and Da Costa (2004) was 1.29 kg, and Ramesh and Mahadevaswamy (2000) obtained 0.66 kg, and Robertson *et al.* (1999) 0.41 kg, however, all these authors worked with one or few genotypes. Biometric agronomic traits are important components for formation of final production in sugarcane. The decisive production attributes for the formation of the agricultural potential are the combination of stalk height, stalk number and stalk diameter, whether the stalk density is considered equal to 1.0. In this study all the genotypes produced higher yield in wet condition and the yield was drastically reduced in stress condition but the genotypes I 95-01 (82.0 tha^{-1} in wet condition and 80.67

tha^{-1} in stress condition), Isd 32 (81.0 tha^{-1} in wet condition and 80.9 tha^{-1} in stress condition) and Isd 3680.6 tha^{-1} in wet condition and 78.4 tha^{-1} in stress condition) showed less reduction in productivity under stress condition than in wet condition both in Rajshahi and Thakurgaon location.

Table 2 . Effect of water stress on yield and yield contributing characters in sugarcane (Location:Thakurgaon:)

Varieties/Clones	Treatment	Tiller (10^3 ha^{-1})	Millable cane (10^3 ha^{-1})	Stalk height (m)	Stalk diameter (cm)	Yield (t ha^{-1})
I 124-00	Control	115.1m	87.1c	2.71bcd	2.21bcdef	73.20b
	Drought	105.0q	70.0mn	2.47hij	2.350a	50.3q
I 95-01	Control	123.1hi	79.3fg	2.81ab	2.25abc	73.1b
	Drought	114.0m	75.9h	2.713bc	2.13cdefgh	70.5de
I 112-01	Control	121.3j	78.3g	2.77ab	2.187bcdefgh	70.4de
	Drought	118.9k	72.8jk	2.53fghi	2.083fgh	65.1ij
I 145-02	Control	125.1fg	81.3de	2.82a	2.20bcdefg	71.95bcd
	Drought	111.4n	72.2kl	2.56efgh	2.06h	62.9kl
I 191-02	Control	121.8ij	82.3d	2.81ab	2.21bcdef	77.90a
	Drought	109.7o	74.4hij	2.53fghi	2.07gh	63.8jk
I 7-03	Control	106.0pq	74.1ij	2.53fghi	2.20bcdefg	58.80o
	Drought	96.1r	67.3p	2.41j	2.09efgh	51.3q
I 78-03	Control	134.6c	101.2a	2.55efgh	2.20bcdefgh	66.36hi
	Drought	124.1gh	86.3c	2.49ghij	2.06h	61.6lm
I 111-03	Control	105.3q	71.1lm	2.51fghij	2.27ab	60.89mn
	Drought	90.5t	62.3q	2.47hij	2.13cdefgh	53.1p
I 137-03	Control	131.8d	75.0hi	2.61def	2.24abcd	69.25ef
	Drought	122.7hij	69.3no	2.48ghij	2.11defgh	59.4no
I 231-03	Control	156.3a	80.1ef	2.58efg	2.18bcdefgh	64.16jk
	Drought	126.1ef	72.3kl	2.43ij	2.13cdefgh	51.1q
I 99-01	Control	137.1b	89.3b	2.73abc	2.19bcdefgh	72.9bc
	Drought	117.0l	71.1lm	2.61def	2.08fgh	59.3no
Isd 32	Control	124.2gh	81.3de	2.78ab	2.21bcdef	70.46de
	Drought	93.2s	68.3op	2.73abc	2.10efgh	67.0gh
Isd 36	Control	127.1e	82.5d	2.77ab	2.25abc	71.33cd
	Drought	107.1p	75.3hi	2.71bcd	2.22abcde	68.3fg
Isd 38	Control	107.3p	78.2g	2.65cde	2.17bcdefgh	59.0o
	Drought	95.3r	67.3p	2.53fghi	2.08fgh	51.1q
LSD (0.05%)		1.541	1.657	0.1027	0.1359	1.650

Table 3. Monthly Average temperature and Rainfall of Rajshahi and Thakurgaon location during 2008-2009 cropping season

Name of Months	Rajshahi location			Thakurgaon location		
	Average temperature (^{0}C)		Rainfall (mm)	Average temperature (^{0}C)		Rainfall (mm)
	Maximum	Minimum		Maximum	Minimum	
November, 2008	29.6	16.5	0	28.0	15.6	0
December, 2008	25.0	15.0	0	24.58	14.39	0
January, 2009	24.5	12.3	1	20.59	11.15	0
February, 2009	29.5	12.6	7	26.48	12.59	0
March, 2009	33.4	18.0	28	31.53	14.06	.13
April, 2009	37.4	23.9	0	23.46	13.3	1.4
May, 2009	34.9	24.4	13.1	33.63	23.08	8.58
June, 2009	36.7	26.6	15.8	24.42	25.47	17.2
July, 2009	33.5	26.6	83	24.32	26.94	11.03
August, 2009	32.9	26.4	95	31.63	26.83	28.35
September,2009	33.6	25.9	82	33.41	26.77	1.9
October, 2009	31.9	22.1	45	28.62	21.89	8.7
November, 2009	29.7	17.8	0	28.32	16.47	0
December, 2009	25.4	11.6	0	23.89	11.39	0

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/clones performing better at one location may not be equally good at another location which is in agreement with our findings. 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. The climatic factors like temperature and rainfall which has direct effects on drought of these two locations is presented in table 3. Cane planted in poor soil face severe stress than organic matter rich soils.

Productivity was plotted against stalk number in Fig. 1a-1b at Thakurgaon location & figure 4a-4b at Rajshahi location.2. A linear relationship between stalk productivity at final harvest and stalk number (tha-^{1}) explains 11% of the variation for the control (Fig. 1a) and 23% for the drought treatment (Fig. 1b) at Thakurgaon location and 83% of the variation for the control (Fig. 4a) and 35% for the drought treatment (Fig. 4b) at Rajshahi location. The tolerant genotypes I 95-01, Isd 32 & Isd 36 presented productivity of 73.1 t ha-[1] , 70.4 t ha-[1] & 71.1 t ha-[1] and stalk number of 79.3 (10^3ha^{-1}), 81.3 (10^3ha^{-1}) & 82.5 (10^3ha^{-1}) under control conditions (Fig. 1a), while a productivity of 70.5 t ha^{-1}, 67.0 t ha-[1] & 68.3 t ha-[1] and stalk number of 75.9 (10^3ha^{-1}), 68.3 9 (10^3ha^{-1}) & 75.3 (10^3ha^{-1}) under drought condition at Thakurgaon location respectively, suggesting that these two traits are positively associated (Fig. 1a-1b).

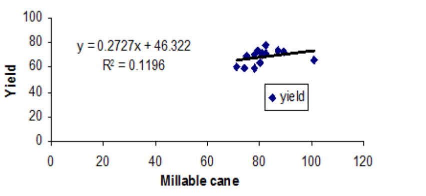

Figure 1a. Relationship between millable cane and yield in control condition at Thakurgaon location

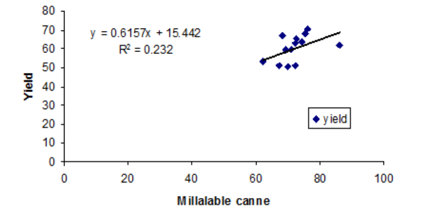

Figure 1b. Relationship between millablecane and yield in drought condition at Thakurgaon location

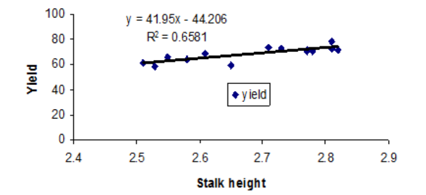

Figure 2a. Relationship between stalk height and yield in control condition at Thakurgaon location

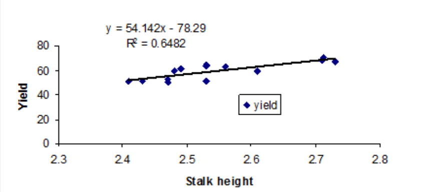

Figure 2b. Relationship between stalk height and yield in drought condition at Thakurgaon location

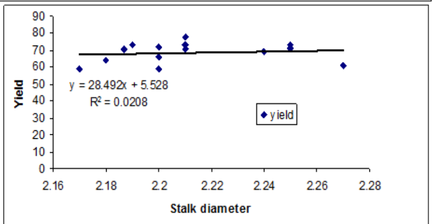

Figure 3a. Relationship between stalk diameter and yield in control condition at Thakurgaon location

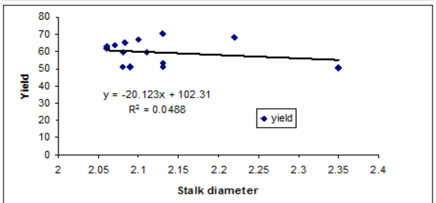

Figure 3b.Relationship between stalk diameter and yield in drought condition at Thakurgaon location

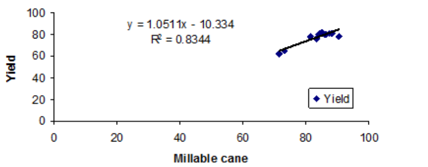

Figure 4a. Relationship between millable cane and yield under control condtion at Rajshahi loction

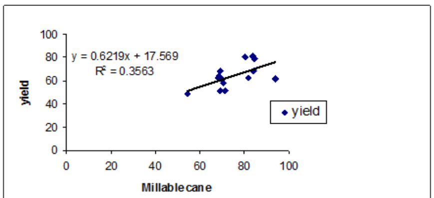

Figure 4b. Relationship between Millable cane and yield in drought conditionat Rajshahi location

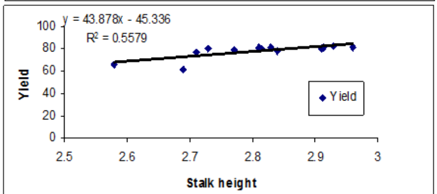

Figure 5a. Relationship between stalk height and yield under control condition at Rajshahi location

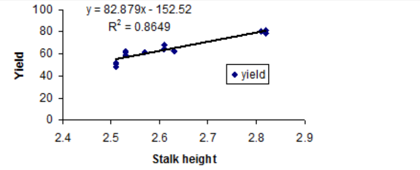

Figure 5b. Relationship between stalk height and yield in drought condition at Rajshahi location

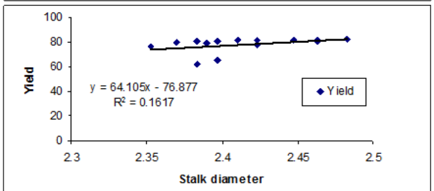

Figure 6a. Relationship between stalk diameter and yield under control condition at Rajshahi location.

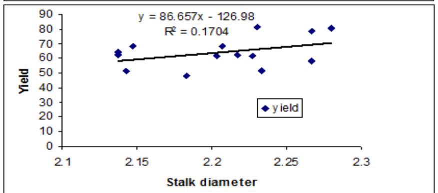

Figure 6b. Relationship between stalk diameter and yield in drought condition at Rajshahi location

Productivity of 82.0 t ha-[1] , 81.0 t ha-[1] & 80.6 t ha-[1] and stalk number of 85.0 (10^3ha^{-1}) , 85.2 (10^3ha^{-1}) & 86.1 (10^3ha^{-1}) under control conditions (Figure 4a), while a productivity of 80.67 t ha^{-1} , 80.9 t ha-[1] & 78.4 t ha-[1] and stalk number of 80.2 (10^3ha^{-1}), 83.5 (10^3ha^{-1}) & 84.5 (10^3ha^{-1}) under drought stress (Fig. 4b) at Rajshahi location which is not so high but total productivity was based collectively on all attributes, and it was not considered in function of only one attribute. The data points also illustrate that gains on productivity can be obtained by selecting high stalk number genotypes, considering that genotypes with higher stalk number can be associated with higher productivity under water stress. On the contrary the susceptible genotype Isd 38 produced 59.0 t ha^{-1} ,51.1 t ha^{-1} yield under control and drought condition was plotted against 78.2 (10^3ha^{-1}) and 67.3 (10^3ha^{-1}) stalk number at Thakurgaon location and 62.0 t ha^{-1}, 48.3 t ha^{-1} yield under control and drought condition was plotted against 71.5 (10^3ha^{-1}) and 54.3 (10^3ha^{-1}) stalk number at Rajshahi location. These findings is in agreement with Silva *et al.*, (2007), who showed that a tolerant genotype would be one that has an above average value in both favourable (irrigated) as well as unfavourable (rainfed) conditions and a susceptible one shows below average values in both superior and inferior environments, besides they can be considered good indicators of the stalk number response to water stress.

A linear relationship was identified between productivity and stalk height (Figs. 2a-2b and 5a-5b). The linear regression explained 65% of the variation for the control treatment and 64% for the drought treatment at Thakurgaon location and 56% of the variation for the control treatment and 86% for the drought treatment at Rajshahi location. The productivity of the drought tolerant genotypes I 95-01, Isd 32 and Isd 36 (82.0 t ha^{-1}, 81.0 t ha^{-1} & 80.6 t ha^{-1}) was plotted against 2.93 m, 2.96 m & 2.91 m of stalk height in control condition at Rajshahi location (Figure 5a), while the productivity of these genotypes are 80.67 t ha^{-1} ,80.9 t ha^{-1} & 78.4 t ha^{-1} had a relationship with 2.81 m, 2.82 m & 2.82 m of stalk height under drought condition (Fig. 5b). On the other hand, the productivity of the drought tolerant genotypes I 95-01, Isd

32 and Isd 36 (73.1.0 t ha^{-1},70.46 t ha^{-1}, 71.33 t ha^{-1}) was plotted against 2.81 m, 2.78 m & 2.91 m of stalk height in control condition at Thakurgaon location (Fig. 2a), while the productivity of these genotypes are 70.5 t ha^{-1}, 67.0 t ha^{-1} & 68.3 t ha^{-1} had a relationship with 2.71 m, 2.73 m & 2.82 m of stalk height under drought condition (Fig. 2b) . On the contrary, the susceptible genotype Isd 38 produced 59.0 t ha^{-1} ,51.1 t ha^{-1} yield under control and drought condition was plotted against 2.65 m and 2.53 m stalk height at Thakurgaon location and 62.0 t ha^{-1}, 48.3 t ha^{-1} yield under control and drought condition was plotted against 2.69 m and 2.51m stalk height at Rajshahi location. This is consistent with the findings of Da Silva and Da Costa (2004) and Ramesh and Mahadevaswamy (2000) who reported that under drought conditions the highest height values always were associated with the most productive genotypes, and the lowest productive genotypes showed the lowest stalk height values.

Variation was observed between productivity and stalk diameter in response to treatments. The linear regression explained .20% of the variation for the control treatment and .48 % for the drought treatment at Thakurgaon location and 16% of the variation for the control treatment and 17% for the drought treatment at Rajshahi location (Figure 3a-3b & Figure 6a-6b). The productivity of the drought tolerant genotypes I 95-01, Isd 32 and Isd 36 (82.0 t ha^{-1}, 81.0 t ha^{-1} 80.6 t ha^{-1}) was plotted against 2.483 cm, 2.447 cm & 2.463 cm of stalk diameter in control condition at Rajshahi location, while the productivity of these genotypes are 80.67 t ha^{-1} 80.9 t ha^{-1} & 78.4 t ha^{-1} had a relationship with 2.280 cm, 2.230 cm & 2.267 cm of stalk diameter under drought condition. On the other hand, the productivity of the drought tolerant genotypes I 95-01, Isd 32 and Isd 36 (73.1.0 t ha^{-1},70.46 t ha^{-1}, 71.33 t ha^{-1}) was plotted against 2.25 cm, 2.21 cm & 2.25 cm of stalk diameter in control condition at Thakurgaon location, while the productivity of these genotypes are 70.5 t ha^{-1}, 67.0 t ha^{-1} & 68.3 t ha^{-1} had a relationship with 2.13 cm, 2.10 cm & 2.22 cm of stalk diameter under drought condition . On the contrary, the susceptible genotype Isd 38 produced 59.0 t ha^{-1}, 51.1 t ha^{-1} yield under control and drought condition was plotted against 2.17 cm and 2.08 cm stalk diameter at Thakurgaon location and 62.0 t ha^{-1}, 48.3 t ha^{-1} yield under control and drought condition was plotted against 2.383 cm and 2.183 cm stalk diameter at Rajshahi location. It is expected that all the above attributes are affected by drought stress, mainly in susceptible cultivars, and, consequently, the productivity will also be affected. Da Silva and Da Costa (2004) obtained 90.61 t ha–1, and Ramesh and Mahadevaswamy (2000), 88.0t ha–1, involving eight and four genotypes, respectively, under water stress. On the other hand, it was well above the 33.3 and 22.4 t ha–1 values obtained by Robertson *et al.* (1999) with two different genotypes.

Selection in breeding programs based on secondary traits associated with tolerance to water stress is known to be useful. Stalk number, stalk height, and stalk diameter are traits affected by environmental changes. However, they are also heritable. It is clear that an ideal secondary trait for selection purpose should be inexpensive and rapid to measure, in addition to being heritable (Altinkut *et al.*, 2001). However, Da Silva and Da Costa (2004) reported that these parameters are very important in yield determination under water deficit conditions, but the response can vary for different genotypes.

All these observations demonstrate that certain sugarcane traits can provide useful tools for breeding programs for the selection of better genotypes under drought conditions. It is possible to select sugarcane genotypes under water deficit conditions with higher productivity associated with higher stalk number, stalk height and stalk diameter. Therefore, these traits could be considered as useful tools during crop breeding procedure in order to make this process more rapid and cheaper.

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