Biological Forum – An International Journal **13(4): 292-296(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Sugarcane Clones Suitable for Moisture Stress/Drought Conditions under Early Planting (December/January)

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(Received 09 August 2021, Accepted 18 October, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Fifteen pre release sugarcane clones were tested against sugarcane variety Co 6907 for their suitability to early planted conditions (December/January planting) under moisture stress/drought at Regional Agricultural Research Station, Anakapalle during 2018-19 and 2019-20. Sugarcane clones tolerance to moisture stress is need of the hour as sugarcane yields are drastically reducing due to moisture stress/drought. A field experiments were conducted with stress and non stress treatments for evaluation of sugarcane clones tolerance to soil moisture stress/drought. Among fifteen pre release clones tested sugarcane clones 2009A 107 (80.2 t/ha), 2006A 223 (79.50 t/ha), 2009A 252 (76.42 t/ha), 2011A 313 (72.64 t/ha) and 2011A 252 (71.48 t/ha) recorded higher cane yield over other clones tested. The standards 87A 298 and 83V 15 recorded a cane yield of 71.08 t/ha and 58.13 t/ha which are lower than the superior clones. These clones also recorded significantly low SLA which indicates more photosynthetic assimilates per unit area. SPAD/SCMR values at 120 DAP under stress conditions (Summer). These sugarcane clones also recorded significantly higher SPAD/SCMR values with standard 87A 298. The ancillary data denoting stress tolerance like sheath moisture per cent, root spread area, total bio mass production per stool under stress and physiological parameters like leaf proline content is also high in these sugarcane clones. Based on two years findings, sugarcane clones 2009A 107, 2006A 223, 2009A 252, 2011A 313 and 2011A 252 were found to be suitable for drought/soil moisture stress condition of cane cultivation based on cane yield, ancillary data and physiological traits in relation to moisture stress tolerance. The drought tolerance efficiency per cent was high in 2009A 107 (95.37%) followed by 2009A 252 (86.39%) and 2011A 252 (84.92%) over other clones tested. The standards 87A 298 and 83V 15 recorded a drought tolerance efficiency per cent of 85.38 and 84.53 respectively.

Keywords: Moisture stress/drought/limited irrigations, SPAD/SCMR, leaf proline, cane yield, per cent juice sucrose, root spread area, Number of millable canes and Fibre per cent.

INTRODUCTION

On industrial scale over 103 countries are producing white sugar using sugarcane and sugar beet as raw material. (FAO STAT, 2018). In India UP, Karnataka and Maharashtra are the three states accounted for more than 80% of Indian sugar production (Bhakshiram 2021). AP stands 11th position in area and production and 10th position in productivity in the country (Anonymous 2021a). Sugarcane is grown under soil moisture stress/drought conditions in sizeable area under early planting (December – January) in North Coastal districts in addition to rainfed cane cultivation. Nearly 40-50% of cane cultivation of North Coastal zone is under moisture stress conditions/rainfed cane cultivation. The crop experiences moisture stress at all crop growth stages. Moisture stress affects germination, cane length, cane diameter, single cane weight, cane elongation, biomass production, NMC and cane yields under early planted rainfed conditions (Raja Rajeswari *et al*. 2003 and 2009). The relative water content (RWC) of sugarcane leaves of susceptible varieties to drought is lower than the tolerance once (Rayes *et al*. 2021). An abiotic or biotic stress in growing phase in the period of rapid growth, cane drastically reduces the yield as well as affects the potential for re growth and longevity of sugarcane crop (Manimekalai *et al*., 2021). The cane yields obtained are ranged from 40 - 45 t/ha under moisture stress conditions of Andhra Pradesh. SPAD/SCMR values, SOD values and carbon isotope discrimination values indices of moisture stress tolerance in field conditions (Mukunda Rao *et al.*, 2021a). High values of SPAD and other ancillary parameters with cane yield of sugarcane were recorded high under moisture stress conditions (Sujatha and Jhansi, 2016; Mukunda Rao *et al*. 2017). Under drought management sugarcane variety also plays an important role along with other management practices to mitigate the yield loss to some extent (Mukunda Rao *et al.*, 2021b).

In A.P., sugarcane varieties 87 A 298 and 2003 V 46 are the leading varieties occupying considerable area of

sugarcane which were released nearly 15 years back. Now due to degeneration of existing good varieties there is a dire need of ample number of new sugarcane varieties especially with drought tolerance and higher cane yield and quality. Abiotic stresses which are common factors lowering yields of AP. Under this circumstances this study was initiated with 15 pre releasing sugarcane clones under an objective to identify sugarcane clones tolerance to moisture stress/drought during crop season.

MATERIAL AND METHODS

Fifteen promising pre release clones were studied with 87A 298 as check variety under early planted moisture stress conditions at Regional Agricultural Research Station, Anakapalle during 2018-19 and 2019-20. The design adopted was RBD with 2 replications. Each clone was planted in six rows of eight meters length with spacing of 80 cms between rows. Date of planting was in the month of January 2018 and 2019. Moisture stress I_0 treatment was imposed by withholding irrigation from March, 15th except two life irrigations at 10 DAP and 40 DAP till harvesting of sugarcane, where as check I_1 (Normal) treatment was imposed by need based monthly one irrigation from planting to harvesting of cane. Trash mulching @ 3 t/ha was done at 3rd day after planting. Soils are of light to medium texture with low to medium N and medium P and K nutrient status. Crop was raised by following all good management practices. Management of early shoot borer and white fly was carried out by spraying Monochrotophos @ 1.6ml/lt and biologically controlled with using *Trichocards*. A fertilizer dose of 112 kg N + 100 kg P_2O_5 + 120 Kg K_2O/ha was adopted. Nitrogen was applied into two equal splits at 45 and 90 DAP, (and ×) P and K was applied as basal. Detrashing and spreading of dried leaves was carried out in between two rows to conserve soil moisture after cessation of rains. Data was recorded on cane yield, per cent juice sucrose, ancillary data (Meade and Chen, 1971) and NMC at harvest, SCMR values at 120 DAP and leaf proline at 120 DAP were recorded by adopting standard procedures (Dhopte and Manuel Livera, 1989), duly following soil moisture data at formative stage during summer months. Statistical analysis was carried out by methods given by Panse and Sukhatme (1978).

RESULT AND DISCUSSION

The analyzed data of 2018-19 and 2019-20 on cane yield, yield components and other quality parameters with ancillary day are given in Table 1. The results obtained are presented on character wise. The rainfall data during crop growth period of 2018-19 and 2019-20 is given in Fig. 1 and 2.

Table 1: Performance of sugarcane clones under limited irrigated conditions (Early planting).

Sugarcane variety	Tiller population (000'/ha) (at 120 DAP)			SPAD / SCMR values (at 120 DAP/ stress)			SLA at 120 DAP (cm^2)			Percent leaf sheath moisture at 120 DAP			Leaf proline (µ moles) at 120 DAP		
	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean	I_0	I_1	Mean
2011A 175	**70.62**	**75.58**	**72.60**	**36.0**	**47.3**	**41.65**	**134.82**	**131.94**	**133.38**	**69.30**	**68.07**	**68.69**	**126.94**	**81.0**	**103.97**
2011A 252	**59.40**	**75.68**	**67.54**	**35.9**	**37.3**	**36.60**	**112.67**	**151.07**	**131.87**	**70.76**	**71.34**	**71.05**	**148.03**	**95.72**	**121.87**
2011A 260	64.57	72.27	68.42	39.9	42.1	41.00	140.17	176.35	158.26	68.95	70.58	69.77	121.69	77.63	99.66
2011A 262	70.51	78.43	74.47	47.4	51.1	49.25	76.44	158.47	117.46	72.76	76.33	74.55	95.63	71.25	83.44
2006A 102	117.04	119.57	118.31	44.2	39.4	41.80	107.45	127.35	117.40	53.45	73.08	63.07	90.85	68.81	79.83
2006A 223	**74.14**	**89.98**	**82.06**	**40.2**	**37.7**	**38.95**	**124.33**	**208.49**	**166.41**	**72.73**	**73.09**	**72.91**	**79.13**	**64.78**	**71.96**
2009A 107	**57.92**	**65.56**	**61.77**	**40.2**	**45.7**	**42.95**	**98.75**	**147.48**	**123.12**	**68.61**	**72.19**	**70.40**	**129.38**	**73.13**	**101.26**
2010A 229	71.06	79.55	75.31	45.8	31.3	38.55	120.19	139.63	138.41	70.98	74.63	72.81	129.85	80.44	105.15
87A298 (C)	**79.64**	**86.35**	**82.99**	**26.2**	**31.1**	**28.65**	**108.15**	**148.09**	**128.11**	**67.09**	**70.03**	**68.56**	**148.97**	**88.13**	**118.55**
2009A 252	**61.05**	**78.76**	**69.91**	**42.3**	**45.1**	**43.70**	**88.61**	**145.11**	**116.86**	**69.32**	**76.03**	**72.68**	**107.72**	**71.16**	**89.44**
2011A 222	85.91	100.87	93.39	43.1	40.7	41.90	130.15	153.55	142.10	67.58	71.82	69.70	59.07	52.69	55.88
2011A 319	**75.46**	**75.06**	**73.26**	**37.8**	**40.8**	**39.30**	**136.05**	**165.23**	**150.65**	**71.94**	**73.96**	**74.94**	**115.22**	**67.88**	**91.55**
2011A 313	**91.41**	**93.94**	**92.68**	**33.5**	**40.6**	**37.05**	**136.57**	**178.17**	**157.37**	**70.72**	**72.31**	**71.52**	**92.44**	**61.88**	**77.16**
2011A 294	90.20	107.03	98.62	34.0	34.5	34.25	113.34	120.88	117.08	72.50	74.72	73.64	67.13	53.07	60.10
83V 15 (C)	**88.22**	**90.64**	**89.43**	**41.93**	**47.2**	**44.59**	**148.02**	**150.46**	**149.24**	**71.55**	**72.10**	**71.83**	**125.94**	**80.07**	**102.76**
Mean	77.14	85.68		39.23	40.79		118.3	153.48		69.22	72.69		109.17	72.49	
	SEm±	**CD (0.05)**		**SEm±**	**CD (0.05)**		**SEm±**	**CD (0.05)**		**SEm±**	**CD (0.05)**		**SEm±**	**CD (0.05)**	
I	1.27	3.68		0.47	1.30		2.68	8.39		0.30	0.92		2.45	7.08	
V	3.49	10.09		1.29	3.73		4.16	12.34		0.42	1.18		6.70	19.39	
I × V	NS	-		1.52	5.28		NS	-		NS	-		10.48	27.43	

Sugarcane variety	Number of millable canes at harvest (000 ha)			Cane yield (t/ha)			Drought tolerance efficiency (%	Sucrose (%)			Fibre (%)			Root structure study (Under stress)	
														Root spread area/stool (Cm^2) at 120 DAP	Total biomass / stool (g) (at 120 DAP)
	I_0	I_1	Mean	I_0	I_1	Mean		I_0	I_1	Mean	I_0	I_1	Mean		
2011A 175	**59.83**	**62.25**	**61.04**	**59.85**	**78.41**	**69.13**	**76.32**	**16.48**	**19.71**	**18.09**	**13.24**	**10.76**	**12.00**	**943.33**	**732.8**
2011A 252	**54.45**	**53.92**	**54.19**	**65.65**	**77.30**	**71.48**	**84.92**	**16.61**	**16.55**	**16.58**	**15.76**	**9.07**	**12.42**	**744.00**	**887.30**
2011A 260	50.79	57.74	54.26	50.34	75.20	62.77	66.94	16.67	18.66	17.66	14.88	13.36	14.12	1466.67	574.50
2011A 262	46.63	55.14	50.89	56.20	78.10	67.15	71.95	14.84	13.52	14.18	16.70	11.64	14.17	805.83	589.90
2006A 102	52.53	56.35	54.44	46.52	58.90	52.71	78.98	12.86	15.50	14.18	14.69	14.78	14.73	985.33	1034.50
2006A 223	**54.62**	**62.43**	**58.53**	**66.00**	**93.0**	**79.50**	**70.96**	**19.74**	**17.68**	**18.71**	**16.27**	**12.68**	**14.48**	**1104.00**	**702.40**
2009A 107	**51.84**	**55.56**	**53.70**	**78.32**	**82.12**	**80.22**	**95.37**	**16.79**	**17.34**	**17.06**	**12.59**	**12.75**	**12.67**	**1493.33**	**1208.50**
2010A 229	51.67	56.06	54.12	56.40	66.60	61.50	84.68	12.59	14.15	13.37	15.95	14.20	15.08	1709.33	1536.70
87A298(C)	**51.14**	**65.89**	**58.52**	**56.44**	**66.10**	**61.22**	**85.38**	**17.73**	**17.78**	**17.75**	**18.04**	**13.21**	**15.63**	**1085.67**	**943.10**
2009A 252	**54.79**	**63.82**	**59.31**	**70.84**	**82.00**	**76.42**	**86.39**	**16.67**	**19.33**	**18.00**	**16.43**	**10.14**	**13.29**	**1080.67**	**838.50**
2011A 222	43.85	52.88	48.36	42.05	58.00	50.02	72.50	18.51	15.50	17.00	17.31	13.74	15.53	1541.67	758.50
2011A 319	**54.62**	**60.52**	**57.57**	**52.16**	**90.00**	**71.08**	**57.96**	**18.50**	**11.94**	**15.22**	**14.55**	**13.28**	**13.92**	**2151.33**	**1131.50**
2011A 313	**47.85**	**53.40**	**55.63**	**49.28**	**96.00**	**72.64**	**51.33**	**17.60**	**18.55**	**18.07**	**18.13**	**15.46**	**16.80**	**1522.33**	**768.10**
2011A 294	44.37	58.78	51.58	51.84	63.40	57.62	81.76	17.91	19.45	18.68	16.72	15.27	15.99	1041.33	739.20
83V 15 (C)	**54.79**	**63.82**	**59.31**	**53.26**	**63.00**	**58.13**	**84.53**	**17.51**	**19.89**	**18.70**	**13.55**	**13.39**	**13.47**	**1436.00**	**805.20**
Mean	51.58	58.62		56.37	75.21		74.95	16.73	17.04		15.65	12.91			
	SEm±	**CD (0.05)**		**SEm±**	**CD (0.05)**		-	**SEm±**	**CD (0.05)**		**SEm±**	**CD (0.05)**		**SEm±** **CD (0.05)**	**SEm±** **CD (0.05)**
I	1.42	2.13		0.79	2.28		-	0.01	0.03		0.18	0.52		58.6 179.0	126.0 378.0
V	4.63	5.48		2.16	6.26		-	0.03	0.09		0.49	1.44			
I × V	NS	-		3.26	8.86		-	NS	-		0.70	2.04			

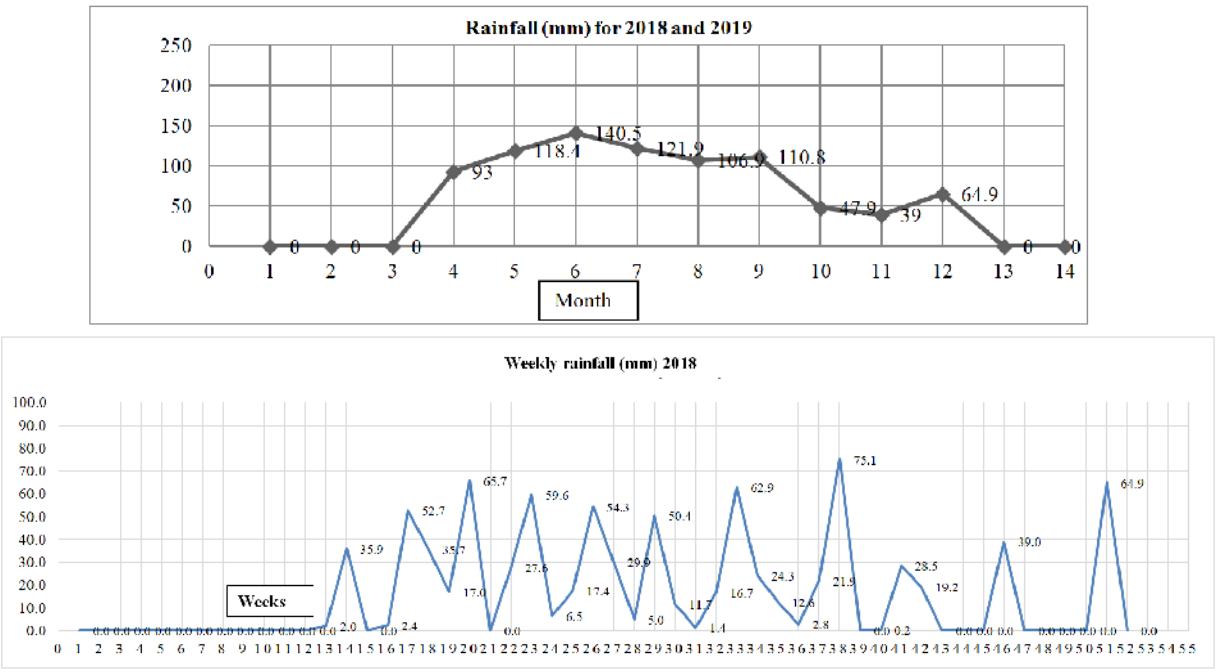

Fig. 1. Graphical representation of rainfall pattern during 2018-19 at RARS, Anakapalle.

Per cent (×) Soil Moisture per cent

Month	March	April	May	November	December	January
I_0	10.11	10.51	11.91	13.15	12.54	11.71
I_1	10.77	12.09	13.79	13.20	14.14	13.26

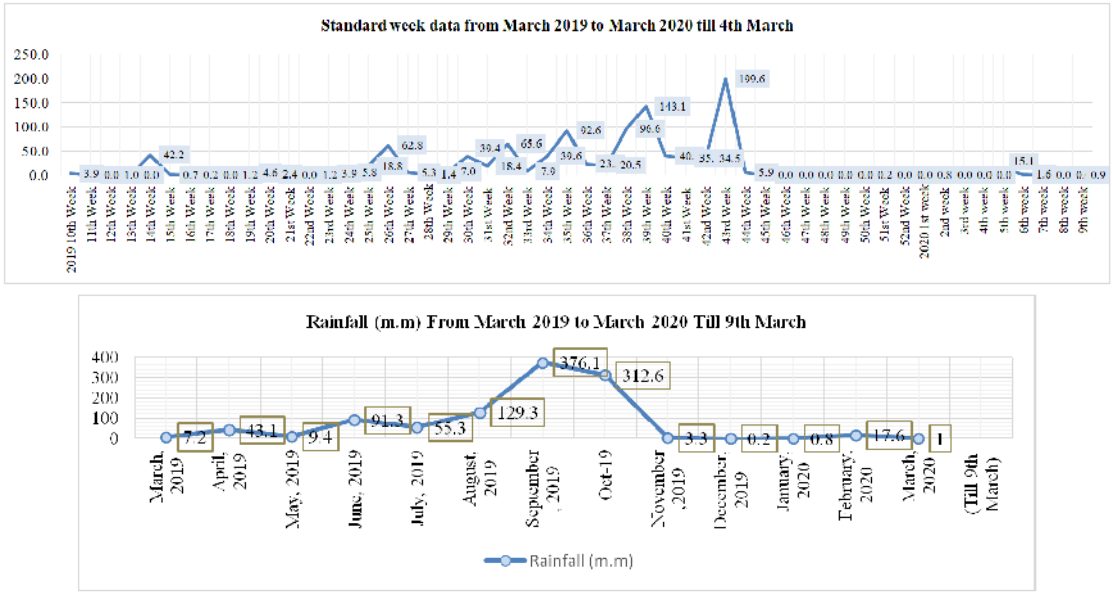

Fig. 2. Graphical representation of rainfall pattern during 2019-20 at RARS, Anakapalle.

Per cent (×) Soil Moisture percent (2019-20).

Month	April	May	June	July	August	December	January
I0	10.09	11.54	7.05	9.90	9.30	6.02	5.20
I1	10.49	12.20	11.02	11.90	9.90	11.50	9.90

The weather parameters during 2018-19 crop season of sugarcane revealed that a total of 899.44 mm rainfall received against normal rainfall of 1225 mm which accounts to -26.58% rainfall. The average monthly maximum °C accounts to 33.91 and minimum °C accounts to 21.08. The average monthly wind velocity is at 3.62 kmph with monthly average evaporation of 4.59 mm. The monthly average bright sun shine hours are at 5.49 hours.

The weather parameters during 2019-20 crop season of sugarcane revealed that a total of 1047.2 mm rainfall received against normal rainfall of 1126.7 mm which accounts to -7.1 % rainfall. The average monthly maximum °C accounts to 33.1 and minimum °C accounts to 27.79. The average monthly wind velocity is at 3.2 kmph with monthly average evaporation of 4.3 mm. The monthly average bright sun shine hours are at 4.8 hours.

Tiller population: The data on tiller production at formative stage under stress varied from 67.54 000/ha (2011A 252) to 118.31 000/ha (2006A 102). Among 15 sugarcane clones tested 2006A 102 (118.31 000 ha) recorded significantly higher tiller production over standard 87A 298 (82.99 000/ha). Tiller production at formative stage was significantly high in normally irrigated I_1 condition (81.68 000 ha) over stress condition I_0 (77.14 000ha).

Number of Millable canes: Number of millable canes were high in I_1 treatment (58.62 000ha) over stress I_0 treatment (51.58 000 ha). Among the clones tested 2009A 252 recorded a higher millable canes of 59.31 000 ha followed by 2006A 223 (58.53 000ha), 2011A 319 (57.57 000 ha) and 2011A 313 (55.67 000 ha) over other clones tested. The standards 87A 298 recorded a millable cane of 58.52 000 ha which is on par with the said superior clones.

Percent juice sucrose: The cane quality in terms of percent juice sucrose was ranged from 13.27% (2010A 229) to 18.71% (2006A 223). Sugarcane clone 2006A 223(18.71%) recorded higher per cent juice sucrose over other clones tested and on par with the check 87A 298 (17.73 %).

Specific leaf area (cm^2/g): The parameter indicating assimilation of photosynthates in leaf is SLA (cm^2/g). It is ranged from 117.08 cm^2/g (2011A 294) to 166.41 cm^2g (2006A 223). The SLA of sugarcane clones 2011A 294 (117.08 cm^2/g), 2006A 102 (117.40 cm^2/g), 2011A 262 (117.46cm^2/g), 2009A 107 (123.12 cm^2/g) recorded low SLA over other clones tested and standard 87A 298 (128.11 cm^2/g) which indicated more photosynthetic assimilates per unit area under stress conditions. More over the SLA was compared to low in stress condition I_0 (118.3 cm^2/g) over normal condition I_1 (153.48 cm^2/g).

Root spread area: Among 15 sugarcane clones tested the root spread area at 120 DAP (stress conditions) ranged from 805.83cm^2 (2011A 262) to 2151.33 cm^2 (2011A 319). Sugarcane clones 2011A 319 (2151.33 cm^2), 2011A 313 (1522.33 cm^2) and 2010A 229 (1709.33 cm^2) recorded higher root spread area over other clones tested. The standard 87A 298 recorded a root spread area of 1085.67 cm^2.

Total bio mass production per stool (g/stool): The dry matter production at 120 DAP (under stress) in sugarcane clones tested is ranged from 574.50 g/stool (2011A 260) to 1536.70 g/stool (2010 A 229). The dry matter production at 120 DAP at formative stage (under stress) was high in 2010A 229 (1536.7 g/stool) followed by 2009A 107 (1208.50 g/stool), 2011A 319 (1131.50 g/stool). The standard 87A 298 recorded a biomass production of 943.10 g/stool.

Sheath moisture per cent: Percent moisture in sheath which is an important trait for moisture stress studies was ranged from 68.56 per cent (87A 298) to 74.94 per cent (2011A 319). The percent leaf sheath moisture percent under stress was 69.22 percent which is lower over I_1 treatment (72.69%). Higher leaf sheath moisture under stress conditions during formative phase (Summer) was recorded in 2011A 319 (74.94%).

Leaf proline (µ moles/g fresh weight): Leaf proline content which is an important physiological drought tolerance denoting trait ranged from 55.58 µ moles/g fresh weight (2011A 222) to 128.87 µ moles/g fresh weight (2011 A 252). High leaf proline content recorded in 2011A 252 (121.87 µ moles/g fresh weight) followed by 2010A 229 (105.15 moles/g fresh weight), 2011A 3 175 (103.97 µ moles/g fresh weight). The standard 87A 298 recorded a leaf proline content of 118.55 µ moles/g fresh weight.

SPAD/SCMR values: The values of SPAD/SCMR of sugarcane clones tested at formative stage are ranged from 28.65 (87A 298) to 43.70 (2009 252). The SPAD/SCMR values of sugarcane clones under stress was low (39.23) than normally irrigated (40.79). Higher SPAD/SCMR values were recorded in sugarcane clones 83V 15 (44.59), 2009A 252 (43.70), 2011A 175 (41.65) and 2006A 102 (41.80) which are superior over 87A 298 (28.65).

Fibre per cent: The fibre percent of sugarcane clones ranged from 12.00% (2011A 175) to 16.80 (2011A 313). Highest fibre percent was recorded in 2011A 313 (16.80%) followed by 2011A 294 (15.99%) and 2011A 222 (15.53 %). The fibre percent of standard 87A 298 is at 15.63%.

Cane yield: Among 15 sugarcane clones tested cane yield was high in 2009A 107 (80.22 t/ha) and 2006A 223 (79.50 t/ha) which are significantly superior with check 87A 298 (61.22 t/ha) followed by sugarcane clones 2011A 313 (72.64 t/ha), 2011A 252 (71.48 t/ha) and 2011A 319 (781.08 t/ha). Cane yield was high in normal irrigated (I_1) clones (75.21 t/ha) over stress induced clones (56.37 t/ha).

Drought tolerance efficiency percentage: A physiological trait which significantly denotes drought tolerance efficiency based on cane yield under stress and normal conditions is high in 2009A 107 (95.37%) followed by 2009A 252 (86.39%) and 2011 252 (84.92%) over other clones tested. The standard check 87A 298 recorded a drought tolerance percentage of 85.38.

Many sugarcane researchers identified similar traits of sugarcane with higher cane yield and quality under soil moisture stress conditions. Sugarcane physiological parameters like sheath moisture per cent, leaf proline content, chlorophyll in terms of SPAD/SCMR values, specific leaf area (SLA cm^2/g) under stress conditions registered significant and positive correlation with cane yield. Similar type of findings on performance of sugarcane clones under stress situation and moisture stress conditions of sugarcane was also studied and reported by Raja Rajeswari *et al*., (2009); Sujatha and Jhansi, 2016; Mukunda Rao *et al*., (2017 and 2021). Similar type of screening of sugarcane clones study

under moisture stress with similar performance of physiological traits under moisture stress and normal condition was also reported (Anonymous 2021).

CONCLUSION

Among 15 sugarcane clones studied in comparison with 87A 298 under early planted stress conditions, sugarcane clones 2009A 107, 2006A 223, 2009A 252, 2011A 313 and 2011A 252 are found suitable for cane cultivation under stress situations of limited irrigated conditions based on cane yield and quality parameters in relation to ancillary yield parameters and physiological stress tolerance traits.

Acknowledgement. The authors are sincerely thankful to the Acharya N.G. Ranga Agricultural University, Guntur for extending facilities, support and encouragement in the execution of the project and according permission for publication and presentation of the research paper.

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How to cite this article: Mukunda Rao Ch; Rao, P.S.; Charumathi, M.; Bharathalakshmi, M. and Jamuna, P. (2021). Sugarcane Clones Suitable for Moisture stress/Drought Conditions under Early Planting (December/January). *Biological Forum – An International Journal*, *13*(4): 292-296.