

## Sugarcane Clones Suitable for Water logged Conditions of Andhra Pradesh

Ch. Mukunda Rao<sup>1</sup>, P.S. Rao<sup>1\*</sup>, M. Charumathi<sup>2</sup>, D. Adilakshmi<sup>2</sup> and T. Chitkala Devi<sup>3</sup>,  
M. Bharathalakshmi<sup>3</sup> and P.V.K. Jagannadha Rao<sup>4</sup>

<sup>1</sup>Department of Crop Physiology,

Acharya N.G Ranga Agricultural University, RARS, Anakapalle (Andhra Pradesh), India.

<sup>2</sup>Department of Plant Breeding,

Acharya N.G Ranga Agricultural University, RARS, Anakapalle (Andhra Pradesh), India.

<sup>3</sup>Department of Agronomy,

Acharya N.G Ranga Agricultural University, RARS, Anakapalle (Andhra Pradesh), India.

<sup>4</sup>Department of Post Harvest Technology

Acharya N.G Ranga Agricultural University, RARS, Anakapalle (Andhra Pradesh), India.

(Corresponding author: P.S. Rao\*)

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**ABSTRACT:** Sixteen pre-release sugarcane clones were tested against sugarcane varieties 87A 298 and 83V 15 as checks for their suitability to water logged/ Inundated conditions at Regional Agricultural Research Station, Anakapalle during 2020-21, 2021-22 and 2022-23. Sugarcane clones tolerant to water logging/ Inundation is need of the hour as sugarcane yields are drastically reducing due to situation of water logging. Field experiments were conducted with creation of water logging during grand growth stage of sugarcane for evaluation of sugarcane clones tolerance to water logging/Inundation conditions. Among fifteen prerelease sugarcane clones tested sugarcane clones 2015A 233 (88.78 t/ha), 2015A 57 (79.84 t/ha), 2015A 59 (79.44 t/ha), 2015A 93 (78.97 t/ha) and 2006A 102 (78.63 t/ha) recorded higher cane yield over other clones tested under water logging/ inundation. The standards 87A298 and 83V 15 recorded a cane yield of 73.30 t/ha and 76.06 t/ha which are lower than the superior clones. These clones also recorded significantly low SLA which indicates more photosynthetic assimilates per unit area and SPAD/SCMR values under water logging (Grand growth stage). These sugarcane clones also recorded significantly higher SPAD/SCMR values over standard 87A 298 (20.86). The ancillary data denoting water logging tolerance like sheath moisture per cent at water logging, root spread area, total bio mass production per stool underwater logging and physiological parameters like leaf proline content (169.98 to 182.29  $\mu$  moles/gr. fresh weight) is also high in these sugarcane clones denoting water logging stress tolerance. Based on three years findings, sugarcane clones 2015A 233, 2015A 15, 2015A 59, 2015A 93 and 2006A 192 were found to be suitable for water logging/inundation/ flooding conditions of cane cultivation based on cane yield, ancillary data and physiological traits in relation to water logging tolerance. The dead cane percent was ranged from 6.29% (87A 298) to 25.13% (2015A 230). The standards 87A 298 and 83V 15 recorded a dead canes percent of 6.29% and 18.35% respectively. The green leaves percent at water logging was high in sugarcane clones 2007A 81 (89.55) followed by 2015A 199 (88.50) and 2015A 187 (87.38) which are lesser than standard 87A 298 (90.29%).

**Keywords:** Water logging, Chlorophyll Stability Index, SPAD, leaf proline, Membrane injury index.

### INTRODUCTION

In India UP, Karnataka and Maharashtra are the three states accounted for more than 80% of Indian sugar production (Bhakshiram, 2021). AP stands 11<sup>th</sup> position in area and production and 10<sup>th</sup> position in productivity in the country (Anonymous, 2021a). Sugarcane is grown under soil moisture stress/drought conditions during summer season coupled with waterlogging conditions during south west and north east monsoon period in size able area under early planting (December–January) in North Coastal districts in addition to cane cultivation surrounded by Paddy cultivation. Nearly 20-25% of

cane cultivation of Andhra Pradesh will be grown under waterlogging conditions mainly due to cane cultivation under water logging coupled with high rainfall and Cyclones/ Thoofans. The crop experiences waterlogging at grand growth stage of sugarcane. In addition, the water resources are getting polluted day by day. The factors like over population, urbanization, industrialization etc. are contributing different percentage of pollutant to pollute the water bodies (Pareek *et al.*, 2015). Waterlogging stress also affects germination, cane length, cane diameter, single cane weight, cane elongation, biomass production, tiller production, NMC and cane yields under early planted cane (January planting) (Raja

Rajeswari *et al.*, 2009; Mukunda Rao *et al.*, 2021, 2022). The relative water content (RWC) of sugarcane leaves of susceptible varieties to drought/stress is lower than the tolerance once. 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 regrowth and longevity of sugarcane crop (Manimekalai *et al.*, 2021). In tolerant clones, high values of SPAD and other ancillary parameters with cane yield of sugarcane were recorded high under waterlogged conditions (Mukunda Rao *et al.*, 2017).

Besides, in Andhra Pradesh Sugarcane is being cultivating in low lying areas of east, west and Krishna districts where sugarcane is subjected to waterlogging / inundation conditions due to excess rain water / sugarcane surrounded by paddy cultivation and un predicted cyclones and thoofans where one month rainfall receives in one or two days under poor drainage situations. Flooding or waterlogging is a major abiotic stress of plants (Mano and Takadi 2012). Flooding is a common stage in agricultural land and impact on plant growth by lowering the gas diffusion in water (Dawood *et al.*, 2014). The research results showed that, the differences in resistance response of several sugarcane tested varieties leaves in parameter of number of leaves, number of yellow leaves, fresh weight of plant, plant height, stem diameter, root length, root breath, number of tillers, chlorophyll content, the rate of photosynthesis, stomatal density, short leaf size and leaf angle (Sholeh *et al.*, 2020). Reduction in cane yield, CCS yield and other ancillary data of sugarcane under flooding was reported by More *et al.* (2009 and 2010). Waterlogging or submergence or flooding is one of the environmental constraints that reduces both growth and survival of sugarcane, which cause 15-45% reduction in cane yield and sugar recovery. Extent of damage due to waterlogging depends on the genotypes, environmental conditions, stage of development and duration of stress (Gulzar *et al.*, 2019). It is estimated that, yield is reduced by 0.5t/ha for every day the water table is within 50 cm of the soil surface (Saltar *et al.*, 2018).

High tolerance to the flooding, cane improve plant's ability to survive in to environmental condition as opposed to the original (Chen *et al.*, 2013). Morphological character of sugarcane that cane resistant to aerenchyma in the roots, the plants tend to be little percentage of Recent research on sugarcane response in terms of growth and development, yield and quality to waterlogging stress and biological and molecular traits under water logged management, sugarcane variety also plays an important role along with other management practices to mitigate the yield loss to some extent (Rao *et al.*, 2022; Mukunda Rao *et al.*, 2023).

In A.P., sugarcane varieties 87A298 and 2003V46 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 water logging tolerance and higher cane yield and quality. Abiotic stresses which are common factors lowering yields of

AP. Under these circumstances this study was initiated with 16 pre release sugarcane clones under an objective to identify sugarcane clones tolerant to waterlogging/inundation/ flooding during crop season. Especially of formative stage of sugarcane for rainfed sugarcane which coincides with rainy season and grand growth and maturity stages of early planting which coincides with rainy and winter season are experiencing water logging stress during crop growth. According to N.V. Naidu *et al.* (2022) under present day situation of decreased cane cultivation and shrinkages sugar industries, development of climate resilient clones (tolerant to biotic and abiotic stresses) is also one of the important factors to sustain cane cultivation and sugar industry in Andhra Pradesh. Therefore, the present study was undertaken to identify newly evolved sugarcane clones with tolerant to abiotic stresses (water logging/ inundation / flooding).

## MATERIAL AND METHODS

Sixteen promising pre-release clones were studied with 87A 298 and 83V 15 as check varieties under early planted water-logged conditions at Regional Agricultural Research Station, Anakapalle during 2020-21, 2021-22 and 2022-23 for three years in low lying fields of 38A, 38B and 29C locally called as "Gothimadis". The design adopted was RBD with 2 replications. Each clone was planted in six rows of eight meters length with spacing of 80 cm between rows. Date of planting was in the month of January 2020, 2021 and 2022. Water logging treatment was imposed by irrigation water canal, flooding imposed from August 15<sup>th</sup> to one month prior to harvesting of sugarcane. Totally a period of 45-60 days with 2 to 2.5 feet depth, crop will be exposed to flooding. Trash mulching @ 3 t/ha was do neat 3<sup>rd</sup> day after planting. Soils are of light to medium textured 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/l and biologically controlled with using *Trichocards*. A fertilizer dose of 112 kg N +100 kg P<sub>2</sub>O<sub>5</sub> + 120 Kg K<sub>2</sub>O/ha was adopted. Nitrogen was applied into two equal splits at 45 and 90 DAP and P and K was applied as basal. 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). Statistical analysis was carried out by methods given by Panse and Sukhatme (1978).

## RESULTS AND DISCUSSION

The analyzed pooled data (2020, 2021 and 2022) on cane yield, yield components and other quality parameters with ancillary data are predicted in Table 2. The results obtained are presented on character wise. The weather parameters data was given for 2020-21, 2021-22 and 2022-23 in Table 1 (A, B &

C). Among three years of annual rainfall, 2020-21 year recorded highest rainfall of 1599.1 mm, which is higher than the years 2021-22 (1307.7 mm) and 2022-23 (1185.9 mm), against normal rainfall of 1122.1mm, 1146.5 mm and 1165.5 mm respectively.

**Table 1 A: Weather parameter during 2020-21 crop season at Anakapalle, A.P.**

Month	Total rainfall (mm)		No. of rainy days		Rainfall (+/-)	Temperature (°C)		RH (%)		Bright sunshine hrs.	Wind velocity (km.ph)	Evaporation (mm)
	Normal	Actual	N	A		Max	Min.	FN	AN			
March 2020	19.2	125.2	0.8	3	+106.0	33.8	22.2	90	50	7.0	3.3	5.4
April 2020	47.6	116.0	2.1	2	+68.4	35.6	24.7	90	52	7.8	4.3	6.1
May 2020	82.8	060.3	3.8	3	-22.5	35.4	25.8	86	61	6.8	3.8	5.4
June 2020	119.1	183.0	6.8	9	+63.9	34.2	26.0	85	65	3.6	3.6	4.3
July 2020	131.0	243.8	7.9	11	+112.8	33.3	25.4	90	68	4.3	3.3	4.1
August 2020	182.9	139.1	10.7	9	-43.8	32.4	25.3	91	69	2.5	4.3	3.5
September 2020	216.9	152.2	12.0	15	-64.7	33.6	25.2	90	68	5.2	3.1	3.6
October 2020	217.8	446.6	8.0	11	+228.8	32.1	24.0	92	69	3.3	2.6	2.6
November 2020	073.0	132.9	2.2	6	+59.9	30.7	20.0	86	58	5.6	2.8	3.2
December 2020	011.0	000.0	1.0	0	-	30.0	16.0	91	53	6.8	2.4	2.8
January 2021	002.1	000.0	0.1	0	-	31.1	18.0	93	47	4.9	2.4	3.2
February 2021	002.3	000.0	0.4	0	-	32.2	17.6	90	38	6.9	3.0	4.5
March 2021	016.4	000.0	0.7	0	-	35.5	21.6	92	41	6.9	3.2	5.2
Total / Mean	1122.1	1599.1	56.8	69	-	33.1	22.5	89.7	56.8	5.5	3.3	4.1

**Weather and crop condition (2020-21).** During 2020-21 sugarcane cropping period (March 2020- March 2021) a total of 1599.1 mm rainfall was received against normal rainfall of 1122.1 mm. An average of 54.25% deficit rain fall was received during August and September months. An excess of 228.8 mm rainfall was received in October *Nivarthoofan*. An average of 33.0°C and 22.4°C was recorded as monthly maximum

and minimum temperatures respectively. The diurnal temperatures variation during sugarcane maturity period recorded as 12.4°C. Monthly average of RH % at FN is 89.69% and AN is 56.84%. Monthly average bright sunshine hours recorded as 5.51. Monthly average wind velocity at 3.24 KMPH and evaporation is at 4.13 mm. During August – September months crops suffered due to moisture stress because of deficit rainfall.

**Table 1 B: Weather parameter during 2021-22 crop season at Anakapalle, A.P.**

Month	Total rainfall (mm)		No. of rainy days		Rainfall (+/-)	Temperature (°C)		RH (%)		bright sunshine hours	wind velocity (kmph)	Evaporation (mm)
	Normal	actual	Normal	Actual		Max	Min	FN	AN			
March-2021	16.4	0	0.7	0	-16.4	35.5	21.6	92	41	6.9	3.2	5.2
April-2021	42.8	37.6	2.0	3.0	-5.2	35.5	25.0	89	58	6.7	4.4	5.4
May-2021	74.4	121.5	4.1	10.0	47.1	35.7	26.0	86	57	5.4	3.8	5.2
June-2021	120.7	39.6	7.1	4.0	-81.1	35.3	27.1	81	57	4.5	4.8	4.9
July-2021	130.4	128.9	7.9	10.0	-1.5	33.0	25.8	90	69	3.8	3.6	3.8
August-2021	192.0	235.1	10.7	12.0	43.1	34.0	25.7	90	70	5.0	3.7	4.4
September-2021	243.2	469.3	12.8	15.0	226.1	32.1	25.0	94	76	3.1	2.1	3.1
October-2021	226.2	135.3	8.2	7.0	-90.9	32.8	24.7	94	67	5.0	2.6	3.1
November-2021	85.4	124.1	3.0	7.0	38.7	29.8	22.5	92	69	3.3	2.1	2.1
December-2021	10.5	15.0	1.0	1.0	4.5	29.3	18.4	85	55	5.1	3.1	3.6
January-2022	2.2	1.3	0.1	0	-0.9	30.1	16.2	87	55	5.9	3.1	1.6
February-2022	2.3	0	0.4	0	-2.3	32.1	16.8	87	53	6.9	3.4	3.3
March-2022	16.4	0	0	0	0	35.7	17.0	81	42	7.3	3.4	5.0
Total Mean	1146.5	1307.58	58	69	-	33.1	22.5	88.3	59.2	5.3	3.3	3.9

**Weather and crop condition (2021-22).** During 2021-22 sugarcane cropping period (March 2021- March 2022) a total of 1307.7 mm rainfall was received against normal rainfall of 1146.5 mm. An average of 90.9 % deficit rain fall was received during October month. An excess of 269.2 mm rainfall was received in August and September months. An average of 33.1°C and 22.4°C was recorded as monthly maximum and minimum

temperatures respectively. The diurnal temperatures variation during sugarcane maturity period recorded as 8.76 °c. Monthly average of RH % at FN is 88.30 % and AN is 59.2%. Monthly average bright sunshine hours recorded as 5.3 Monthly average wind velocity at 3.3 KMPH and evaporation is at 3.9mm. During June - July months crops suffered due to moisture stress because of deficit rainfall.

**Table 1C: Weather parameter during 2022-23 crop season at Anakapalle, A.P.**

Month	Total rainfall (mm)		No. of rainy days		Rainfall (+/-)	Temperature (°C)		RH (%)		Bright sunshine hours	Wind velocity (kmph)	Evaporation (mm)
	Normal	actual	Normal	Actual		Max	Min	FN	AN			
March-2022	16.4	0	1	0	-16.4	35.6	18.9	83	53	6.7	4.1	4.8
April-2022	42.3	0	2	0	-42.3	36.5	24.8	83	68	7.3	6.2	5.4
May-2022	88.1	178.2	4	6	90.1	35.7	24.7	83	70	6.3	5.4	4.7
June-2022	134.7	184.4	8	11	49.7	34.0	24.9	85	74	4.5	4.0	3.9
July-2022	120.2	66.4	8	6	-53.8	32.7	25.8	85	79	2.8	3.1	3.2
August-2022	189.5	158.6	10	9	-30.9	33.0	25.4	84	76	3.2	3.0	3.1
September-2022	243.7	257.2	13	18	13.5	32.3	25.1	88	77	3.7	1.8	2.1
October-2022	230.6	185.7	8	10	-44.9	31.4	23.7	89	82	4.7	2.1	3.0
November-2022	57.0	10	3	1	-47	31.8	21.2	89	81	5.1	2.9	2.4
December-2022	14.5	39.5	1	3	25	30.5	18.9	87	82	4.5	2.8	1.7
January-2023	0.2	0	0	0	-0.2	30.6	16.6	90	77	5.8	2.8	1.8
February-2023	1.8	0	0	0	-1.8	33.1	18.2	89	60	7.0	3.4	3.6
March-2023	26.5	105.9	1	3	79.4	34.4	19.0	90	57	6.5	3.7	3.7
Total Mean	1165.5	1185.9	59	67	-	33.2	22.09	86.3	72.0	5.2	3.48	3.34

**Weather and crop condition (2022-23).** During 2022-23 sugarcane cropping period (March 2022 - March 2023) a total of 1185.9 mm rainfall was received against normal rainfall of 1165.5 mm. An average of 42.35mm deficit rain fall was received during July and August months. An excess of 69.9 mm rainfall was received in May and June months. An average of 33.2°C and 22.1°C was recorded as monthly maximum and minimum temperatures respectively. The diurnal temperatures variation during sugarcane maturity period recorded as 11.08°C. Monthly average of RH % at FN is 86.30 % and AN is 72.0%. Monthly average bright sunshine hours recorded as 5.2 Monthly average wind velocity at 3.5 KMPH and evaporation is at 3.3mm. During July-August months crops suffered due to moisture stress because of deficit rainfall.

**Sugarcane cane yield and other ancillary data**

**Tiller population:** The data on tiller production at formative stage varied from 90.45 000/ha (2015A 157) to 127.24 000/ha (2015A 59). Tiller production at formative state was higher. It is clearly depicted that among 15 sugarcane clones tested, sugarcane clone 2015A 59 recorded higher tiller production of 127.24 000/ha, followed by 2015 A51(120.55 000/ha) and 2015A 199 (118.86 000/ha). The standards 87A 298 and 83V 15 recorded a tiller production of 112.61 000/ha and 101.63 000/ha respectively.

**Number of millable canes:** Among 16 sugarcane clones tested, sugarcane clones 2006A102 (101.70 000/ha), 2015A199 (100.09 000/ha) and 2015A 51 (94.07 000/ha) recorded significantly higher millable canes over other clones tested and these clones are on par with the standard clone 87A 298 (105.61 000/ha) and 83V 15 (93.09 000/ha).

**Cane yield:** Among 16 sugarcane clones tested, cane yield ranges between 88.78 t/ha (2015A 233) to 2015A 228 (66.15 t/ha). Higher cane yield was recorded in sugarcane clone 2015A 233 (88.78 t/ha) followed by 2015A 51 (79.80 t/ha), 2015A 93 (78.63 t/ha) and 2006A 102 (78.63 t/ha). The standard 87A 298 and 83V 15 recorded a cane yield of 73.30 t/ha and 76.06 t/ha respectively.

**Sucrose percent:** The quality in terms of sucrose percent was high in sugarcane clone 2015A 137 (18.62%) followed by sugarcane clones 2015A199 (17.52%) and 2015A 51 (17.42%). The standards 87A 298 and 83V 15 recorded a percent sucrose of 16.99% and 18.33% respectively.

**SPAD / SCMR values:** Higher SPAD/SCMR value at water logging was recorded in sugarcane clones 2006A 102 (33.92) followed by 2007A 81 (33.31) and 2015A 230 (31.92) at grand growth stage (300 DAP) of sugarcane clones. The standards 87A 298 (20.86) and 83V 15 (23.77) recorded significantly less SPAD/SCMR values with sugarcane clones 2006A102, 2007A 81 and 2015A 230.

**Chlorophyll stability index (CSI):** The Chlorophyll stability index of sugarcane clones under waterlogging was ranged between 75.54 (2006A 102) to 239.13 (2015A 59). Sugarcane clone 2015A 59 recorded significantly higher CSI value of 239.6% followed by 2015A 137 (231.14) and 2015A 51 (186.86). The standards 87A 298 and 83V 15 recorded a CSI value of 67.4 and 75.46 respectively which are significantly lesser than the above noted superior canes.

**Specific leaf area (SLA cm<sup>2</sup>/g):** The parameter indicating assimilation of photosynthesis in leaf is SLA (cm<sup>2</sup>/g). It is lower in sugarcane clones 2015A 199 (87.16 cm<sup>2</sup>/g) followed by 2006A 102 (95.37 cm<sup>2</sup>/g), 2015A 228 (96.11 cm<sup>2</sup>/g), 2015A 187 (98.17 cm<sup>2</sup>/g) and 2015A 183 (98.16 cm<sup>2</sup>/g) which indicates accumulation of more assimilates under given unit leaf area at waterlogging conditions. This parameter significantly influenced by the sugarcane clones tested with water logged conditions with a range of SLA 87.16 cm<sup>2</sup>/g (2015A 199) to 2015A 59 (122.91 cm<sup>2</sup>/g).

**Root spread area:** The parameter root spread area (cm<sup>2</sup>) /stool at waterlogging (grand growth stage) ranged between 247.17 cm<sup>2</sup> (2015A 183) to 611.17 cm<sup>2</sup> (2015A 59) which indicates spread of roots under waterlogging. The root spread area was significantly influenced by the sugarcane clones tested with higher value of 611.17 cm<sup>2</sup> with 2015A 59, followed by 2015A 187 (581.50 cm<sup>2</sup>) and 2015A 228 (532.83 cm<sup>2</sup>).

**Table 2: Performance of sugarcane clones under water logged conditions (Pooled data of 2020-21, 2021-22 and 2022-23).**

Sugarcane clone(s)	Tiller production (000/ha) (120 DAP)	NMC (000/ha)	Cane yield (t/ha)	Sucrose (%)	SPAD at water logging	CSI	SLA at water logging	Root spread area	Root volume (ml) at 150 DAP	Dead canes (%)	Leaf proline ( $\mu$ mole/g fresh weight) at 250 DAP (At water logging)	Total dry matter at 250 DAP (g) / stool (At water logging)	SOD at water logging ( $\text{OD min}^{-1} \text{g}^{-1}$ )	No. of green leaves	Sheath moisture percent	Adeventious rooting on cane	Fibre (%)
87A 298 (C)	112.61	105.61	73.30	16.99	20.86	67.46	93.11	487.50	42.3	6.29	147.57	1011.53	0.54	90.29	68.61	31.55	10.36
83V 15 (C)	101.63	93.03	76.06	18.31	23.77	75.45	150.87	441.00	30.1	18.35	142.49	1167.25	0.48	82.09	70.03	35.90	11.82
2015A 228	99.64	90.77	66.15	15.74	29.39	135.46	96.11	532.83	34.0	19.68	141.45	1180.59	1.08	86.44	67.87	49.67	9.40
2015A 199	118.86	100.09	75.48	17.52	31.35	91.61	87.16	415.00	35.6	19.25	164.91	1050.05	2.64	88.50	68.99	30.50	8.47
2015A 222	99.07	80.68	74.25	16.15	25.79	78.76	100.93	386.67	54.1	17.03	128.12	1453.41	0.54	82.38	72.65	26.48	11.43
2015A 152	90.45	76.74	70.08	15.19	29.10	41.65	107.76	422.17	30.3	10.75	116.18	1133.43	0.42	75.31	71.13	29.06	11.81
2007A 81	106.83	82.56	73.82	16.76	33.31	107.23	111.07	414.50	21.3	8.60	155.63	1127.53	1.38	89.55	75.17	52.93	10.39
2015A 183	99.64	92.18	76.05	15.95	22.89	107.04	98.16	347.17	32.5	21.57	146.32	985.72	0.12	67.50	69.46	30.50	11.04
2015A 187	103.99	80.36	75.57	17.40	24.82	177.95	98.17	581.50	20.0	15.99	184.35	888.56	0.60	87.38	71.81	34.75	10.52
2015A 137	112.84	85.55	78.51	19.09	27.29	231.14	108.01	466.00	33.8	12.39	167.28	1114.19	0.96	77.57	72.25	34.21	12.15
2015A 233	98.04	85.29	88.78	15.15	31.53	118.93	111.03	418.00	50.0	17.41	169.98	990.03	0.24	80.61	74.78	24.80	11.80
2015A 59	127.24	89.91	79.44	17.15	33.09	239.61	122.91	611.17	51.3	13.51	170.35	1094.40	0.18	78.00	71.24	48.88	8.68
2015A 51	120.55	94.07	79.80	17.42	28.66	186.86	105.00	371.50	26.3	15.76	165.07	1181.94	0.18	76.56	72.99	31.80	11.62
2015A 230	106.19	79.61	77.61	16.83	31.92	127.96	107.58	497.83	20.0	25.13	154.36	1031.47	0.24	77.70	73.03	30.95	8.54
2015A 93	118.12	79.99	78.92	17.15	30.79	176.75	116.74	480.67	43.8	15.19	180.24	1229.94	0.90	73.31	72.95	28.45	12.45
2006A 102	106.97	101.70	78.63	16.16	33.92	75.54	95.37	526.67	41.3	12.36	182.29	1072.00	0.48	77.19	69.33	32.28	10.56
SEm $\pm$	6.52	6.79	5.24	0.88	2.36	28.83	9.04	42.46	4.2	2.60	11.54	179.2	0.41	4.10	1.85	2.34	0.54
CD (0.05)	19.84	18.98	15.18	NS	6.01	87.70	26.24	122.51	12.8	7.97	35.12	480.6	1.23	11.86	NS	6.81	1.66

**Root volume (ml)/ stool:** The parameter root volume /stool (ml) at grand growth stage under water logging was higher with sugarcane clone 2015A 222 (54.1 ml) followed by 2015A 59 (51.3 ml) and 2015A 233 (50.0 ml). It ranges between 54.1 ml (2015A 222) to 20.0 ml (2015A 230). The standards 87A 298 and 83V 15 recorded a root volume of 42.3 ml and 30.1 ml respectively.

**Dead canes:** The percent dead canes which is a prominent trait denoting waterlogging of sugarcane clone is with sugarcane clone 2007A 81 (2.60%) and sugarcane clone 2015A 152 (10.75%). It ranges between 8.60% (2007A 81) to 2015A 230 (25.13%). The standards 87A 298 and 83V 15 recorded a dead cane percent of 6.29% and 18.35% respectively.

**Leaf proline ( $\mu$  moles/g fresh weight):** Leaf proline content, which is a waterlogging tolerance triggering amino acid content was higher under sugarcane clone 2015A 187 (184.35  $\mu$  moles /g fr.wt.) followed by 2006A 102 (182.29  $\mu$  moles /g fr.wt.), 2015A 93 (180.24  $\mu$  moles /g fr.wt.) and 2015A 59 (170.35  $\mu$  moles /g fr. wt.). The standards 87A 298 and 83V 15 significantly recorded lower leaf proline of 47.5  $\mu$  moles /g fr. Wt. and 142.49  $\mu$  moles /g fr.wt. respectively over other clones tested.

**Total dry matter / stool (g) (TDM):** The total dry matter /stool (g) which is an indicative for photosynthesis activity at grand growth stage under water logging was higher with sugarcane clone 2015A 222 (1453.41 g/stool) followed by 2015A 93 (1229.94 g/stool) and 2015A 51 (1181.94 g/stool). It ranges at 1453.41 g/stool (2015A 222) to 2015A 182 (888.56 g/stool). The standards 87A 298 and 83V 15 recorded a total dry matter/stool of 1011.53 g/stool and 1167.25 g/stool respectively which are significantly lower on above noted clones.

**SOD activity:** Super oxide dismutase enzyme activity, which is a prime most trait for denoting waterlogging tolerance is ranging between 0.12 OD  $\text{min}^{-1} \text{g}^{-1}$  (2015A 183) to 2.64 OD  $\text{min}^{-1} \text{g}^{-1}$  (2015A 199). Higher the SOD activity indicates higher stress tolerance in sugarcane clones. Higher SOD activity were recorded in sugarcane clone 2015A 199 (2.64 OD  $\text{min}^{-1} \text{g}^{-1}$ ), followed by 2007A 81 (1.38 OD  $\text{min}^{-1} \text{g}^{-1}$ ), 2015A 137 (0.96 OD  $\text{min}^{-1} \text{g}^{-1}$ ) and 2015A 93 (0.90 OD  $\text{min}^{-1} \text{g}^{-1}$ ). The standards 87A 298 and 83V 15 recorded a SOD activity of 0.54 and 0.48 OD  $\text{min}^{-1} \text{g}^{-1}$  respectively.

**Percent green leaves:** Green leaves of canopy at water logging are also an important trait of water logging tolerance. It was ranged at 75.31 (2015A 152) to 89.55% (2007A 81). The standards 87A 298 and 83V 15 recorded a percent green leaf of 90.29% and 82.04% respectively.

**Sheath moisture percent:** The trait sheath moisture percent during water logging condition ranges at 67.87% (2015A 228) to 2007A 81 (75.17%). Significantly higher sheath moisture percent was recorded in sugarcane clones 2007A 81 (75.17%), 2015A230 (73.05%), 2015A 93 (72.90%) and 2015A 222 (72.65%) which are superior with the standards 87A 298 (68.61%) and 83V 15 (70.03%).

**Adventitious rooting percent on cane at water logging:** It indicates one of the adaptations to stress (water

logging) conditions of sugarcane. It was ranged at 24.80% (2015A 233) to 49.67% (2015A 288). Significantly higher adventitious rooting percent was recorded under waterlogging with sugarcane clone 2007A 81 (52.93) followed by 2015A 288 (49.67) and 2015A 59 (48.88). The standards 87A 298 and 83V 15 recorded an adventitious rooting percent of 31.55 and 35.90 respectively which are significantly lesser than tested clones.

**Fibre percent:** The percent fibre in cane which denotes quality trait of sugarcane is significantly lower with sugarcane clone 2015A 199 (8.47%). It ranges at 8.47% (2015A 199) to 2015A 93 (12.45%). The standards 87A 298 and 83V 15 recorded a fibre percent of 10.36 and 11.82 respectively. Lower percent fibre indicates, more juice in cane.

Many sugarcane researchers identified similar traits of sugarcane with higher cane yield and quality under water logged/ inundation/ flooding conditions. Sugarcane physiological parameters like sheath moisture per cent, leaf proline content, chlorophyll in terms of SPAD/SCMR values, CSI, Membrane Injury Index, specific leaf area (SLA  $\text{cm}^2/\text{g}$ ) under water logged/ inundation conditions registered significant and positive correlation with cane yield. Similar type of findings on performance of sugarcane clones underwater logged/ inundation conditions of sugarcane was also studied and reported by Raja Rajeswari *et al.* (2009); Mukunda Rao *et al.* (2017, 2021 and 2022). Similar type of screening of sugarcane clones' study underwater logging/ inundation/ flooding with similar performance of physiological traits under water logged and inundated condition was also reported by More *et al.* (2010); Sholeh *et al.*, (2020). In addition, similar adaptive response of sugarcane to waterlogging stress and similar trends of waterlogging tolerant traits in sugarcane was also reported by Gomathi *et al.* (2015); Salter *et al.* (2018); Gulzar *et al.* (2019).

## CONCLUSIONS

Among 16 sugarcane clones studied in comparison with standards 87A298 and 83V15 under waterlogging stress conditions, sugarcane clones 2015A 233, 2015A 51, 2015A 59, 2015A 93 and 2006A 102 are found suitable for cane cultivation under waterlogging/ flooding/ Inundation situations of cane cultivation based on cane yield and quality parameters in relation to ancillary yield parameters and physiological waterlogging tolerance traits.

## FUTURE SCOPE

The sugarcane clones identified under waterlogging/inundation/ flooding conditions are to be tested in on farm testing in water logged / low lying areas of sugar factory operational areas and based on their performance and acceptance by sugarcane farmers, proceed further for release for general cultivation by State Varietal Release Committee (SVRC).

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