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High yielding elite Sugarcane clones suitable for adverse environmental situations

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Abstract
Sugarcane clones tolerant to rainfed and waterlogged conditions is the need of the hour as sugarcane yields are drastically reducing. The objective of the study is selection of high yielding climate resilient clones with high yield under rainfed and conditions and waterlogged conditions during 2019-20 to 2020-21. The experiment was carried out in Randomized Block Design with three replications. Gross plot size adopted was 8mt X 0.8mt X 8R = 51.20m^2 and Net plot size is 8mt X 0.8mt X 6R= 38.40 m^{2}The clones 2006A223,2009A107 and 2009A252 were found to be significantly superior over the standards,87A298 and 83V15 for NMC,cane yield, ccs yield, yield components.Significant morphophysiological traitslike number of nodes, adventitious roots,total dry matter production per stool,relativewater content were higher in 2006A223 followed by 2009A107and 2009A252 under rainfed conditions where as under water logged conditions the clones2003V46, 2006A223 and 2009A107 were found to be significantly superior over the standards,87A298 and 83V15 for NMC, cane yield, ccs yield, yield components besides quality traits. Significant morphophysiological traitslike number of nodes, adventitious roots, total dry matter production per stool, relative water content were higher in 2006A223 followed by 2003V46, 2009A252 and 2009A107 in Sugarcane.Identification of promising drought tolerant clones based on LAI and SCMR values, water use efficiency, SLA, root volume and leaf proline content highlights the potential of integrating physiological screening in collaboration with breeding selection strategies. In future, the new flood tolerant and promising rainfed and submergence tolerance sugarcane genotypes can can serve as valuable genetic resources for developing climate resilience through targeted breeding efforts.

Keywords: Sugarcane, high yielding clones, morpho, physiological studies, adverse environmental situations

Introduction

In India sugarcane is growing in Subtropical and tropical Zones Tropical zone comprises of southern States of Andhra Pradesh, Tamilnadu, Kerala, Karnataka and parts of Odisha.Cane productivity is low and stagnant in these states compared to neighboring states like Maharastra and Uttar Pradesh. Increase in cane area in marginal soils, rainfed conditions and moisture stress during formative phase, non-adoption of recommended package of practices in plant and ratoon crops are some of the major constraints of cane production the sugarcane cultivation area has decreased to 40,000 hectares after years of decline. Despite the fact that sugarcane yields higher returns than paddy, producers are transitioning from sugarcane cultivation to other crops. The high input costs and labour shortages in Andhra Pradesh resulted in the reduction of 29 sugar mills (10 cooperative and 19 private) to 5 (1cooperative and 4 factories) (www.indiatimes.com).Timely and cheap sugarcane harvesting is becoming a concern, especially in tropical regions. Increase in cane area in marginal soils, rain fed conditions and moisture stress during formative phase, non-adoption of recommended package of practicesinplantandratooncropsaresome of the major constraints of cane production. (Lakshmikantham,2002) [13]
Drought severely depresses cane yield to the tune of 20-40% whereas the sucrose formation and sucrose recovery up, to 5%. The severe drought causes the complete failure of crop and sucrose recovery. A number of technologies likesoaking setts in lime water and potash application etc., for managing droughtsituation but they are impractical and farmers are reluctant to use those technologies. The most efficient way of managing drought in waterdeficitareasistheuseofproper drought resistant/tolerant Varieties, there morpho-physiologicalstudiesbesides agronomicmanagement.
Hencethere is a dire need to develop drought resistance/ tolerance varieties which possess inherent capabilities under water deficit conditions of Rayalaseema, Telangana and coastal regions of Andhra Pradesh and Telangana states for improvement of cane, sugar yields andobtainbettersucrosepotential.
In sugarcane, four distinct growth stages have been characterized, namely: germination, tillering, grand growth and maturity. The tillering and grand growth stages, known asthe sugarcane formative phase, have been identified as the critical water demand period, mainly because this is the phase when 70-80% of cane yield is produced. In most of the areas, thecropexperiencemoisturestressduringthe formative phase of growth, affecting germination and tillering, thus leads to reduced stalk population and stalk growth finally resulting30-50%yieldloss. Varietiesresponses to water deficit stress during these growth stages could therefore be useful in identifying drought tolerant genotypes. Drought tolerance is an inbuilt character in tropical and subtropical canes. However, Co 6806, Co 7717, Co95021, Co97015, Co98014, Co1148and Bo 91 are highly tolerant to drought. Superior entries identified and released

for commercial cultivationareCo 86032, Co94008, Co99004, Co8371, Co86249, Co94012, Co85019, Co and97A85 etc,

Nearly 50-60% of area under sugarcanein Andhra Pradesh is occupied by Rayalaseema, Coastal districts. Hence, the average cane yield comes down from 85.00 t/ha to 70.00 t/ha due to cultivation of sugarcane in marginal and sub marginallandsinthedistrictswithvery few or no supplemental irrigation leads to drying of leaves, stunted growth of stem, entire crop loses its turgidity and drying willbe hastened in many susceptible varieties. Therefore, there is a need of evolving drought resistant/ tolerant varieties of high yielding, optimum sucrose per cent with desired morpho-physiological and agronomic characters with a view to manage drought and save crop from colossal loss.

High tillering variety with rapid initial growth, deep root system, thin stalk with narrow, erect leaves can tolerate, moisture stress. Drought tolerant varieties recover faster on availability of moisture (Sundara,2002). [24] Yield is the best measurement for measuring drought tolerance of genotypes under field conditions. Moisture stress affects tillering, leaf area, cane elongation, Stalk number, stalk height, cane yield and sucrose (Venkataramana,2003). [26]

Hemaprabha *et al* (2004) [5] observed that there is drastic reduction in sugarcane weight, cane length and cane yield of 55 sugarcane clones out of 97 clones studied. Six clones recorded better sucrose and high yield under drought situation. Vasantha *et al* (2005) [25] evaluated 15 sugarcane genotypes for their tolerance to drought and revealed that leaf area, leaf number, leaf area index, tiller population and number of millable canes was significantly less in drought treatment when compared to control, but the potential genotypes *viz.,* Co 95003, Co 95005 and Co 95006 recorded higher cane and sugar yields underdroughttreatment.

Gomathi and Vasantha (2006) [3] evaluated advanced breeders' material for drought tolerance and the genotypes Co 99004 and Co99012 recorded higher cane and sugar yields under drought conditions. The reduction in individual leaf area, leaf area index, tiller population, plant height, photosynthetic rate was significant due to drought treatment. Hemaprabha *et al* (2006) [6] revealed that utilization of potential parents' *viz.,* Co 740, Co 775, Co 6304, Co 6806 and Co 7201 could lead to evolving drought resistance varieties for improving sugarcane productivity in drought prone regions of India. Water relationship and photosynthetic responses to water deficit stress during this growth stage could therefore be useful in identifying drought genotypes (Silva *et al*, 2007). [23]

Alarmelu*et al* (2012) [1, 7, 8] stated that 10crosses are identified superior for cane yield and sucrose per cent along with high stalk number, stalklengthandwidthunder drought conditions. Hemaprabha*et al* (2012) [9, 11] evaluated 28 elite sugarcane hybrids under normal and drought conditions and revealed that brix per cent increased, sucrose per cent decreased and cane length was reduced by the shortening of internodes than number of internodes.

Gomathi *et al* (2012) [4] screened advanced varietal trail clones for drought tolerance and the clones Co 06022, Co 06010, Co 06013, Co 06015 and Co 06027 showed relatively higher photo chemical efficiency with better growth attributes*viz.* leafareaindex, leaf production, plant height, shoot population attributed to tolerance nature under drought. Hemaprabha*et al* (2013) evaluated drought tolerance potential of 28 elite sugarcane hybrids grown under normal and drought conditions. Proline accumulation and superoxide dismutase and peroxidase must doubledintolerantgenotypes*viz.* Co 740, ISH 100, Co85019, Co99008andNS83/247andtheycanbeutilizedincropimprove ment.

`Drought tolerance is polygenic and complex trait interplay with environment makes phenotypic evaluation difficult. The use of DNA markers can help breeders in improvingthespeedaswellasreliabilityof the process. RAPD markers are used toevaluate highly polymorphic alleles for estimation of genetic diversity in sugarcane (Khan*etal,*201Drought tolerance is polygenic and complex trait interplay with environment makes phenotypic evaluation difficult. Hence, there a need to screen for drought tolerance / resistance genotypes which possess inherent capabilities (Manimekalai *et al*., 2021). [14]

Due to cultivation of sugarcane in marginal and sub marginal lands in these districts with very few or no supplemental irrigation leads to drying of leaves, stunted growth of stem, entire crop loses its turgidity and drying will be hastened in many susceptible varieties. Therefore, there is a need of evolving drought resistant/ tolerant cultivars of high yielding, optimum sucrose per cent with desired morpho- physiological and agronomic characters with a view to manage drought and save crop from colossal loss in tropical zone of India (Mukunda Rao *et al.,* 2022.)

Mukunda Rao *et al*, (2023) [20] tested 15 prerelease sugarcane clones under drought condition revealed that the clones 2015A 51, 2015A 233, 2015A 183 and 2015A 93 were found to be performed well under drought conditions of Andhra Pradesh.

Water logging is also a common phenomenon for coastal region due to monsoonal cyclones during north east monsoon (October – December). Inundation is a major problem to sugarcane in reaping good yields. More over areas like munagapaka, Visakhapatnam district (Aava area) and sugar factory operational area M/s KCP lakshmipuram, Challapalle is a regular phenomenon of inundation of sugarcane dueto low lying and growing of sugarcane surrounded by paddy cultivation. Under this, identification of sugarcane clones tolerant to water logging / inundation and its loss estimation in a systematic manner is a long-time pending research gap for sugarcane research activity. Every year though research programmesarecarryingouton "Screening of sugarcane clones for water logging" it is not giving that much concurrent results due to irregularity in occurrence of inundation. Keeping in view this project was proposed to identify sugarcane clones tolerant to water logging / inundation and also to estimate lossof sugarcane (yield and quality) under inundationinascientificmanner.

High tolerance to the flooding can improve plants ability to survive in the environmental condition because it takes the availabilityofvarietiesthatareresistantto the condition of Agricultural land that often experienceflooding

(Chenetal,2013) [2] SholehAvivi *et al* (2019) studied eight clonesforresistanttowaterloggingstress. The research results showed that theresistanceresponseofvarietieswereseenin parameters of number of leaves, no, of tillers, chlorophyll content and Cane yield, of which PS8845 and VMC 7616 varieties showed resistance to water logging duly recording higherphysiologicalparameters, highertillering ability, highercaneyield whilePSJK922showed worstresponseofwat erloggingstress.

Further flood is a recurrent phenomenon in coastal areas of Andhra Pradesh, Assam, Orissa, West Bengal, Kerala, Karnataka and South Gujarat. The problem is accentuated due to poor drainage and topography of the land which impedes fast drainage from crop lands (Yamuna and Ashwini,2016) In general, the submergence exists up to 15 days which coincides the vegetative stage of the crop at 120DAP days after transplanting and recedes later. If the flood water stagnation remains for more than a month the varieties are unable to sustain and there by the yield levels are drastically reduced. Though deep water sugarcane is cultivated in small areas with low yield, attention should be given to develop high yielding deep water sugarcane to maintain stable sugarcane production(Santhosh and Maitra 2021).Apart from improving drainage and other preventive measures, farmers can adopt flood tolerant varieties that can withstand inundation for an extended period and reduce the risk from flood damage (Shalahuddin *et al*,2019).Continuous high rainfall in an short span leading to water logging causes inundation of sugarcane fields and lodging of the crop at tillering and grand growth stages causes huge losses to the farmer. The challenge is further aggravated by the fact that numerous better kinds ofwarrant adaptability to flooding (Maitra and Santosh 2024)

Materials and Methods

The objective of the study is selection of high yielding climate resilient clones with high yield under moisture stress conditions and waterlogged conditions in Andhra Pradesh,Eleven elite genotypes developed from breeding programme were tested under rainfed and waterlogged situation*viz*.,2003A255,2003V46,2004A55,2006A223,2007 A81,2009A107,2006A102,2008A234,2009A252,2005A128 ,2010A229 along with standards,87A298 and 83V15 during 2019-2020 to 2020-21.The experiment was carried out in Randomized Block Design with three replications. Gross plot size adopted was 8mt X 0.8mt X 8R = 51.20m^2 and Net plot size is 8mt X 0.8mt X 6R= 38.40 m^{2}40,000 three budded setts. per hectare seed rate was adopted and 80 cm between rows. Fertilizers applied 100 kg P_2O_5 + 120 kg K_2O /ha at the time of planting are applied as basal dressing. Nitrogen @ 112 kg N/ha in the form of urea will be applied in two split doses, 30% at ten days after transplanting and the remaining 70% at 60 days after transplanting. Data on NMC, Cane yield, yield components along with morpho-physiological parameters related to stress were recorded during the crop growth period. Juice sucrose was determined at harvest following the standard procedure Made & Chen (1977). Estimated CCS yield was determined based on CCS percent and cane yield. Statistical analysis was performed as per procedure of Panse and Sukhatme (1978) [21]

Physiological Attributes

The number of green leaves was counted manually on tagged canes at 120 DAP and expressed as mean per plot. Leaf area index was estimated using the linear measurement method standardized for sugarcane, by multiplying maximum leaf length, leaf breadth, a constant factor, and the number of green leaves. SPAD chlorophyll meter readings (SCMR) were taken on the third leaf from the apex on 20 randomly selected plants per genotype and mean values were used for analysis(Dhopte and Livera ,1989).Some of the important drought tolerant traits like Root spread (cm^2), number of nodes/ cane ,adventitious roots at nodal rooting, total dry matter / stool (g), RWC (%), CSI, Specific leaf area & percent of green leaves were recorded under drought andwater loggedconditions during crop growth period.

Results and Discussions

Effect of Rainfed conditions on quantitative and qualitative parameters as influenced by Sugarcane varieties.

Under drought conditions, qualitative and quantitative parameters were recorded during crop growth period. Among the clones 2006A 223 (92.15 thousands/ha) , cane yield (103.82 t/ha) and CCS yield (14.74 t/ha) followed by 2009A 107 (90.33 thousand /ha,98.34t/ha and 14.48 t/ha) and 2009A 252 (87.67 thousands /ha, 96.45 t/ha and 13.56 t/ha) recorded maximum number of NMC , cane yield and CCS yield at harvest and found to be significantly superior over standard 87A 298 (87.90 thousands/ha and 83.23 t/ha and 11.00t/ha) respectively. For percent juice quality traits 2003V46 recorded higher brix (21.92) and sucrose (19.76%) and 2009A 107 (21.88 % and 19.26%) when compared to standard 87A 298 (21.04%&19.50%).For yield component traits,the clone 2006A 223 recorded higher stalk length (165.33 cm) , stalk girth (3.50 cm) and single cane weight (1.20 Kg) followed by 2009A 107 (159.20 cm, 3.28 cm and 1.18 kg) and 2009A 252 (114.57 cm, 3.03 cm and 1.54 kg) at harvest (Table 1).Higher SPAD values and LAI are recorded in genotypes 2006A 223 (46.00 & 2.46), 2009A 252 (45.50 & 2.42) and 2003V 46 (45.95 & 2.40). SLA was lower in 2006A223(96.67) and 2004A 55 (96.38) and were on par with drought standards 87A 298 (96.36) and 83V 15 (94.99 cm^2/g) Significantly higher number of nodes recorded by 2006A223 (28.75) followed by 2009A107 (26.50) and 2009A252 (26.40). Adventitious roots were higher in 2003A255 (29.50) followed by 2003V46(22.86) and 2006A102(23.75). Total dry matter production per stool was higher in 2006A223(482.2) followed by 2005A128(355.60) and 2009A107(347.86). Relative water content is higher in 2006A223(79.69) followed by 2009A107 (76.00) and 2009A252(75.78). Drought Tolerance Efficiency was higher in genotypes of 2009A252 (89.66) followed by 2006A223(82.03) and 2009A107(80.82) (Table 2) and Fig 1

Table 1: Role of Quantitative and Qualitative Parameters of Elite Genotypes under Rain fed Conditions

S.No.	Genotype	Stalk population at 180DAP	NMC (000s/ ha)	Cane Yield (t/ha)	Brix %	Sucrose %	CCS %	Fibre %	Stalk Length (cm)	Stalk Girth (cm)	SingleCane Weight (Kg)	CCS Yield (t/ha)
1	2003A255	56.59	54.34	56.66	21.12	19.58	13.78	14.95	118.03	2.86	1.06	7.81
2	2003V46	68.40	69.02	62.08	21.92	19.76	13.75	14.20	100.90	2.45	1.06	8.54
3	2004A55	86.45	82.64	69.89	18.35	16.18	12.70	13.80	105.50	2.65	1.05	8.88
4	2006A223	86.68	92.15	103.82	19.76	18.06	14.21	14.62	165.33	3.50	1.20	14.74
5	2007A81	50.17	60.19	67.70	17.32	14.56	11.80	13.74	102.50	3.01	1.01	7.99
6	2009A107	86.00	90.33	98.34	21.88	19.26	14.83	14.48	159.20	3.28	1.18	14.48
7	2006 A102	67.53	63.30	52.74	16.58	14.46	10.92	13.77	112.25	2.65	1.00	5.76
8	2008A234	64.40	79.69	95.48	19.36	16.83	11.53	13.76	126.25	2.58	1.00	11.01
9	2009A252	85.76	87.67	96.45	20.82	18.30	13.99	13.83	114.57	3.03	1.54	13.56
10	2005A128	69.09	84.06	87.70	18.69	16.16	12.04	15.36	113.75	2.23	1.02	10.56
11	2010A229	65.62	75.45	84.61	18.78	16.81	12.68	14.36	122.00	2.46	1.01	10.73
12	87A 298 (C)	79.68	87.90	83.23	21.04	19.50	14.32	13.33	118.00	2.26	1.00	11.00
13	83V 15 (C)	65.97	87.02	66.56	20.81	18.65	14.24	14.20	102.00	2.28	1.00	9.48
	CD (0.05)	18.85	38.25	34.22	1.02	1.08	1.56	2.02	16.20	3.23	0.97	3.56
	C.V(%)	7.82	9.65	10.65	2.12	1.97	3.52	2.56	6.56	4.52	5.35	10.23

Table 2: Performance of Sugarcane Clones for Morphophysiological Traits Under Rainfed Conditions

S. N	Genotype	Tiller Population at 120DAP (000s/ha)	Leaf proline (µmoles / g.fr.wt.)	SPAD/SCMR at 120DAP	LAI at 120DAP	Root Spread (Cm^2) area	No. of Nodes	Adventitious Roots/nodal rooting per cent	SLA (cm^2/g) values (at 150 DAP/ stress)	Total dry matter / stool (g) at 180 DAP	RWC (%)	CSI (Chlorophyll Stability Index)	% dead canes	% Green leaves	Drought Tolerance Efficiency
1	2003A255	77.00	169.09	42.40	2.10	1345	21.65	29.50	208.99	248.06	67.39	1.106	25.88	90.87	47.18
2	2003V46	72.74	158.75	45.95	2.40	1790	18.13	22.86	98.47	323.51	67.99	0.697	30.78	88.50	49.52
3	2004A55	72.23	119.31	45.95	2.16	2019	20.00	19.50	96.38	282.27	70.32	0.613	26.94	91.75	82.03
4	2006A223	89.44	158.56	46.00	2.46	1570	28.75	18.86	96.67	482.20	79.69	0.981	23.55	90.75	82.03
5	2007A81	64.67	142.38	43.00	2.06	2226	20.48	19.75	140.64	340.62	71.94	0.842	26.90	86.50	76.49
6	2009A107	84.07	132.82	46.75	2.18	1320	26.50	21.64	114.64	347.86	76.00	0.876	22.74	83.37	80.82
7	2006A102	72.05	138.91	32.45	2.22	2052	23.75	23.75	119.44	355.63	70.34	0.646	26.11	90.65	70.02
8	2008A234	66.13	166.88	45.50	2.08	1456	22.75	18.07	202.19	345.35	69.52	1.341	27.51	66.75	88.66
9	2009A252	80.26	160.53	45.50	2.42	1623	26.40	18.30	109.63	337.09	75.78	1.310	24.99	87.50	89.66
10	2005A128	71.88	163.13	33.20	2.05	1718	24.25	18.01	101.19	355.60	70.77	0.714	26.36	83.50	94.03
11	2010A229	82.75	159.13	44.35	2.25	1720	28.00	19.55	116.79	312.52	69.32	0.559	25.70	79.12	97.32
12	87A298(C)	88.16	164.22	38.75	2.08	1392	23.00	22.52	96.36	305.64	68.16	0.128	27.28	76.00	96.36
13	83V 15 (C)	77.94	161.59	35.85	2.36	1356	27.75	20.55	94.99	265.35	67.96	0.765	29.48	72.87	94.99
	CD (0.05)	28.26	6.08	2199	1.08	92.32	6.90	NS	38.25	NS	NS	8.36	NS	79.12	-
	C.V(%)	9.87	3.09	5.56	6.54	15.98	10.25	--	14.03	-		13.26			-

Table 3: Role of Quantitative and Qualitative Parameters of Elite Genotypes under Waterlogged Conditions

S. No.	Genotype	Stalk population at 180DAP	NMC (000s/ha)	Cane Yield (t/ha)	Brix Percent	Sucrose Per cent	CCS Per cent	Fibre%	Stalk Length (cm)	Stalk Girth (cm)	Single Cane Weight (Kg)	CCS Yield (t/ha)
1	2003A255	222.76	107.21	98.23	20.52	19.50	14.76	11.08	285.00	2.43	1.00	14.50
2	2003V46	256.66	118.43	112.36	22.69	20.46	13.15	11.04	280.25	3.00	1.24	15.90
3	2004A55	193.12	93.85	85.65	20.04	19.00	13.27	10.30	284.75	2.33	1.01	11.37
4	2006A223	212.56	107.66	110.32	22.58	20.04	14.80	10.98	246.25	2.84	1.12	15.64
5	2007A81	198.30	95.03	78.32	20.58	18.00	13.44	10.60	240.25	2.05	1.22	10.53
6	2009A107	184.55	108.00	102.23	21.63	19.60	13.27	10.06	238.00	2.77	1.10	14.52
7	2006 A102	162.37	97.77	80.22	20.36	18.22	13.95	10.83	235.50	2.06	1.20	11.19
8	2008A234	184.10	98.95	78.22	20.68	18.66	13.61	10.78	282.75	2.45	1.02	10.65
9	2009A252	188.72	108.64	91.23	20.54	18.48	13.03	10.70	258.00	2.33	1.00	11.89
10	2005A128	175.49	104.48	94.90	21.45	19.06	14.08	10.35	239.00	2.25	1.08	13.36
11	2010A229	182.56	93.71	96.20	20.03	18.00	14.98	10.80	223.00	2.65	1.05	14.41
12	87A 298 (C)	188.02	99.61	73.40	22.03	19.72	14.00	10.63	255.00	2.87	1.02	10.28
13	83V 15 (C)	188.96	111.12	76.20	21.25	19.00	14.71	10.06	201.75	2.40	1.20	11.21
	CD (0.05)	46.23	45.23	32.21	1.95	1.01	1.12	2.30	32.00	4.23	3.33	-
	C.V(%)	10.98	10.28	8.65	2.21	1.98	1.20	1.96	7.62	5.68	3.58	-

Table 4: Performance of Sugarcane Clones for Morphophysiological Traits Under water logged Conditions

S no.	Genotype	Tiller Population at 120DAP	Leaf proline (µ moles /g.fr.wt.)	SPAD/ SCMR At 120 DAP	LAI at 120DAP	Root Spread (Cm2) Area	No. of Nodes	Adventitious roots / nodalrooting % cane	Total dry matter / stool (g) at 180 DAPS	RWC (%)	% ead canes	% Green leaves	SLA at Water logging (cm^2/g)
1	2003A255	104.10	170.7	48.87	2.02	579.0	24.50	37.50	1024.22	69.93	12.94	98.75	116.8
2	2003V46	111.56	178.6	46.40	2.26	274.5	35.25	48.86	1027.50	84.97	13.55	98.75	126.00
3	2004A55	88.30	148.1	44.00	2.25	385.0	31.75	37.75	1742.75	71.74	14.90	97.50	113.70
4	2006A223	84.55	174.4	49.27	2.32	366.0	33.75	36.64	1296.00	83.59	13.74	94.37	124.00
5	2007A81	92.37	157.0	48.20	2.36	363.0	23.50	35.59	1044.95	78.61	20.11	91.65	129.10
6	2009A107	114.10	168.30	42.93	2.02	460.5	34.00	48.60	1287.20	80.94	17.51	98.70	125.00
7	2006 A102	88.72	168.2	49.40	2.22	348.5	28.50	33.30	1097.80	68.08	14.99	97.50	102.60
8	2008A234	95.49	157.1	43.03	2.18	370.0	28.25	36.01	1011.50	78.76	16.36	94.50	131.35
9	2009A252	102.56	166.5	45.60	2.20	358.5	33.50	48.55	904.05	78.78	13.70	98.12	112.40
10	2005A128	88.02	177.7	45.30	2.00	549.0	25.75	40.52	1127.75	66.12	20.28	75.00	147.00
11	2010A229	98.96	154.0	43.97	2.06	432.5	27.00	40.55	1079.15	79.61	18.48	81.87	113.90
12	87A 298 (C)	97.67	161.7	40.73	2.00	434.0	31.00	38.64	1011.65	76.98	15.76	88.52	127.30
13	83V 15 (C)	96.91	165.6	48.20	2.10	361.0	32.50	38.92	1136.40	84.81	16.04	75.62	115.45
	C.D (0.05)	8.65	NS	3.85	2.23	89.35	11.90	NS	NS	NS	9.23	23.05	NS
	CV (%)	9.26	7.53	5.52	4.68	12.52	8.89	7.53	10.32	7.39	6.58	10.32	11.25

Effect of water logging conditions on quantitative and qualitative parameters as influenced by sugarcane varieties.

Among the clones, 2003V 46 (118.43), Cane yield (112.36) and CCS yield (15.90 t/ha) followed by 2006A 223 (107.66 thousands/ha, 110.32 (t/ha and 15.64 t/ha) and 2009A 107 (108.00 thousands/ha, 102.33 t/ha and 14.52 t/ha). For qualitative traits 2003V 46 recorded higher brix and sucrose percent (22.69 % and 20.46%) followed by 2006A 223 (22.58 / 20.04) and 2009A 107 (21.63% and 19.60%) at harvest. For yield components traits the clone 2003V 46 recorded significantly higher cane length, cane diameter and single cane weight (280.25 cm, 3.00 cm and 1.24 kg) followed by 2006A 223 (246.25, 2.84 cm and 1.12 kg) and 2009A 107 (238.00 cm, 2.77 cm & 1.1 kg) respectively at the time of harvest (Table 3). Morphological traits are most important in assessment of water logging conditions under adverse environmental conditions. Higher SPAD values and LAI were recorded in genotypes 2006A 223 (49.27 and 2.32) followed by 2003V 46 (46.40 & 2.26) & 2009A 252 (45.60 & 2.20). Number of nodes were higher in 2003V46 (35.25) followed by 2009A107(34.00) and 2009A252(33.50) when compared to standards,87A298(31.00) and 83V15(32.50). Adventitious Roots/nodal rooting per cent was higher in 2003V 46(48.86) followed by 2009A107 (48.60) and 2009A252(48.55) when compared to standards,87A298(38.64) and 83V15(38.92). Leaf proline content and relative water content were higher in 2003V46 (178.60s and 84.96) followed by 2006A223(174.40 &83.59) and 2009A107(168.30 & 80.94) and superior over standards,87A298(161.70 & 76.98) and 83V15(165.60&84.81).Number of green leaves were higher in 2003V46 (98.75) followed by 2009A107 (98.70) and 2009A252 (98.12) when compared to standards 87A298(88.52) and 83V15(75.62).Specific leaf area was increased in 2003V 46(126) followed by 2009A107(125) and 2006A223(124) under water logged conditions.Percentage of dead canes were lower in 2003V 46 (13.55%) followed by 2006A223(13.47%) and 2009A252(13.70%) when compared to other clones and standards,87A298(15.76%) and 83V15(16.04%) under waterlogged conditions (Table 4)

Fig 1: Study of Physiological Traits under Stress conditions

Conclusion

It is identified from the study that the clones 2006A 223, 2009A 107 and 2009A 252 performed well both under drought and water-logged conditions duly recorded quantitative traits like maximum number of numbers of millable canes, cane yield &CCS yield and qualitative traits of brix % and sucrose percent. Morphophysiological traits played major role under drought and water loggedconditions but subjected to specific for variety i.e., varieties vary under partial to severe drought conditions and partial sub mergence to complete submergence. Under adverse environmental conditions. It was proved from the present study indicated that the clones performed different for different characters under adverse environmental situations. Number of green leaves, SPAD values, LAI and chlorophyll stability index, % dead canes decreased under partial submergence and drought situation where as root spread, no. of nodes, adventitious roots at nodal in point, total dry matter per stool and RWC increases under drought and submerged conditions. The clones, 2003V 46, 2006A 223, 2009A 107 and 2009A 252 were identified as best varieties both under drought and waterlogged conditions. They can be used as valuable genetic resources. Development of climate resilient genotypes evolved through targeted breeding approach besides pre-breeding objectives. Identification of stress tolerant genotypes can be utilized for future varietal improvement in Sugarcane breeding programs. Identification of promising drought tolerant clones based on LAI and SCMR values, water use efficiency, SLA, root volume and leaf proline content highlights the potential of integrating physiological screening in collaboration with breeding selection strategies. In future, the new flood tolerant and promising rainfed and submergence tolerance sugarcane genotypes can can serve as valuable genetic resources for developing climate resilience through targeted breeding efforts.

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