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Evaluation of Promising Elite Sugarcane Genotypes in drought Situation of Tropical Region of India

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Abstract: Sugarcane clones tolerant to drought is the need of the hour as sugarcane yields were drastically reduced under drought situation. The present study was carried out at Regional Agricultural Research Station, Anakapalle (2020-21 to 2021-22) and at M/s Etikoppaka sugar factory site (2019-20 to 2020-21) where in the situation prevails. Field experiments were conducted at RARS, Anakapalle as well as M/s Etikoppaka sugar factory site in RCBD with three replications in a gross plot size of 8 mt x 0.8m x 8R = 51.20 m^2 and net plot size of 8m x 0.8m x 6R = 38.40 m^2. Recommended practices were followed for drought situation. Among 18 pre release clones tested along with a standard CoA 92081 (87A 298), three clones were found promising for cane yield, CCS yield, sucrose percent, yield components and physiological stress tolerance were 2016A 592, 2016A 672 and 2016A 580 whereas at M/s Etikoppaka sugar factory site, three varieties viz., 2000A 225, 2000A 213 and 2004A 107 were proved to be drought tolerant as they were significantly superior for cane yield, CCS yield, sucrose percent besides superior yield components like number of millable canes, cane length, cane diameter and single cane weight. In addition to the data, they were found superior for physiological parameters like SCMS values, leaf area index, water use efficiency, root volume and leaf proline content etc., these clones can be given to farmers of their sugar factory operational areas. Based on their performance and acceptance by sugarcane farmers, can be released for general cultivation in tropical zone of India. The promising elite genotypes evolved from the study viz., 2016A 592, 2016A 672 and 2016A 580 can further be tested in hybridization programs with targeted breeding approach besides pre breeding objectives. Identification of stress tolerant genotypes represent valuable genetic resources for future varietal improvement in sugarcane breeding programs.

Keywords: Sugarcane – Elite genotypes – drought situation – Tropical region of India.

INTRODUCTION

Drought is one of the most important environmental stress factors limiting sugarcane production worldwide. Sugarcane is one of the important cash crops of tropical region of India It is growing under limited irrigated, rainfed conditions of various parts of India. Cane productivity is low and stagnant in the tropical parts of India compared to neighboring states of North India. Increase in cultivable area in marginal lands, drought conditions and moisture stress during formative phase are some of the major constraints of Sugarcane production. Drought severely depresses Sugarcane yield to the tune of 18-35% whereas the sucrose formation and sucrose recovery up to 4-5%. A number of technologies like soaking setts in lime water and potash application etc., for managing drought situation but they are impractical and farmers are reluctant to use those technologies. The most efficient way of managing drought in water deficit areas is the use of proper drought resistant/ tolerant genotypes and their morpho-physiological studies besides agronomic management.

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However, farmers continue to grow sugarcane under such conditions as it is the only crop that gives minimum guaranteed income.

Hence there is a need to screen for drought resistance/ tolerance which possess inherent capabilities under water deficit conditions of tropical region of India for improvement of cane yield, sugar yield and obtain better sucrose potential apart from physiological parameters and yield components

Hemaprabha *et al* (2004) observed that there is drastic reduction in sugarcane weight, cane length and cane yield of 56 sugarcane clones out of 98 clones studied. Six clones recorded better sucrose and high yield under drought situation. Vasantha *et al* (2005) evaluated 15 sugarcane genotypes for their tolerance to drought and revealed that leaf area, leaf number, LAI, tiller population and number of stalks was significantly less in drought treatment when compared to control, but the potential genotypes *viz.,* Co 95002, Co 95006 and Co 95008 recorded higher cane and sugar yields under drought treatment.

Gomathi and Vasantha (2006) evaluated advanced breeders' material for drought tolerance and the genotypes Co 99004 and Co 99012 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) 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).

Alarmelu *et al* (2012) stated that 10 crosses are identified superior for cane yield and sucrose per cent along with high stalk number, stalk length and width under drought conditions. Hemaprabha *et al* (2012) 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) 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.,* leaf area index, 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 double in tolerant genotypes *viz.,* Co 740, ISH 100, Co 85019, Co 99008 and NS 83/ 247 and they can be utilized in crop improvement.

Drought 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).

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) 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.

MATERIALS AND METHODS

The present study was taken up with the objectives of Screening and evaluation of water use efficient cultivars for drought situation and Study of morpho-physiological parameters under drought conditions at RARS, Anakapalle where the situation prevails. Fourteen elite genotypes developed from breeding programme were tested against two drought situation from standards CoA 92081, and CoV 92102 were tested under drought condition from 2020-21 to 2021-22 viz., 2016A592, 2016A672, 2016A664, 2016A580, 2016A59, 2016A673, 2016A575, 2016A254, 2016A503, 2016A484, 2016A600, 2016A255 along with a standard CoA 92081.

In another experiment 18 released genotypes *viz.,* 2000A 225, 2004A 107, 2000A 213, 2001A63, 2000A 56, 98A 163, 2004A 55, 2000A 241, 2004A 104, 2000A 255, 2003V 46, 2006A 64, 2005A 128, 2006A 102, 2007A 81, 2000A 240, 2006A 223 along with a 87A298(C) were tested at M/s Etikoppaka sugar factory area (2019-20 to 2020-21) which is 35 km away from RARS, Anakapalle where in the drought situation prevails. 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)

RESULTS AND DISCUSSION

Hybridization programme was taken up with known source of drought genotypes available at National Hybridization Garden Sugarcane Breeding Institute, Coimbatore for development of water use efficient varieties through fluff supply programme was carried out during 2014-15 at RARS, Anakapalle. The clones evolved from different stages of nurseries, station yield trials, superior performance in Multilocation Yield Trials were selected for drought situation during 2020-21 & 2021-22.

Among the clones, 2016A 592 recorded number of millable canes, Cane yield, CCS yield (117.75 thousands/ha, 118.68 t/ha and 14.82 t/ha) followed by 2016A 672 (118.46 thousands/ha, 112.88 t/ha and 14.40 t/ha) and 2016A 664 (108.81 thousands/ha, 110.00 t/ha and 14.00 t/ha) and found to be significantly superior over best standard CoA 92081 (98.00 thousands/ha, 100.0 t/ha and 13.50 t/ha) respectively. For sucrose percent the clones viz., 2016A 672 (21.03), 2016A 580 (20.93) and 2016A 592 (20.91) when compared to best standard CoA 92081 (20.80) at harvest. SPAD / SCMR values at formative (120 days) at grand growth stage (240 days) were maximum in 2016A 503 (40.00 and 55.00) followed by 2016A 592 (40.00 & 48.80), 2016A 673 (39.35 & 46.32) when compared to best standard CoA 92081 (36.00 & 44.00). LAI was maximum in 2016A 592 (2.08 & 4.43) followed by 2016A 580 (2.06 & 4.50) and 2016A 672 (2.06 & 4.10) and found superior over CoA 92081 (2.02 & 4.00).

Water use efficiency was higher in 2016A 592 (42.11 kg/ha/mm) followed by 2016A 672 (40.80 kg/ha/mm) when compared to

best standard CoA 92081 (40.31 kg/ha/mm). SLA (Cm2/g) was lower in the genotypes viz., 2016A 592 (100.92), 2016A 672 (100.19) and 2016A 580 (103.88) and were found to be drought tolerant when compared to check CoA 92081 (98.00) when tested in the trial. Root volume was higher in 2016A 672 (59.32mL) followed by and 2016A 515 (56.08 mL) and 2016A 592 (54.12 mL) when compared to best standard CoA 92081 (51.00 mL). Leaf Proline content was higher in 2016A 503 (110.50 µ moles/g fresh wt) followed by 2016A 592 (110.33µmoles/g fresh wt) and 2016A 575 (107.46 µ moles/g fresh wt) when compared to standard 87A 298 (104.33 µ moles/g fresh wt) when tested in the study

In addition to major yield parameters, their yield components and physio morphological characters like cane length, cane diameter, single cane weight were also recorded at harvest. The genotypes 2016A 592 (140 cm, 3.02 cm and 1.10 kg) followed by 2016A 672 (131 cm, 3.00 cm and 1.10 kg) and 2016A 664 (126.33, 2.70 and 1.10 kg) recorded superior values when compared to best standard CoA 92081 (122.33cm, 2.65 cm and 1.08 kg). Table 1(a) and 1 (b) and Fig.1 &2

Fig. 1: Study of Physiological Traits under Stress conditions

Table 1(a): Performance of pre-release clones for drought situation at RARS, Anakapalle (2020-21 to 2021-22) in Andhra Pradesh

S. no	Genotype	Maturity group	NMC (thousands/ ha)	Cane Yield (t/ha)	Sucrose %	CCS Yield (t/ha)	SCMR Readings		LAI		WUE Kg/ha/ mm	SLA (Cm^2/g) at 150 DAP	Root volume (mL)	Leaf proline (µmoles/g fresh wt.)	Cane length (cm)	Cane diameter (cm)	Single cane weight (kg)
							120 DAP	240 DAP	120 DAP	240 DAP	120 DAP	120 DAP					
1.	2016A592	Early	117.75	118.68*	20.91	14.82	40.00	48.80	2.08	4.43	42.11	100.92	54.12	110.33	140.00	3.02	1.10
2	2016A672	Early	118.46	112.88*	21.03	14.40	39.33	46.32	2.06	4.10	40.80	100.19	59.32	105.25	131.00	3.00	1.10
3	2016A664	Early	108.81	110.00*	19.64	14.00	36.56	40.35	2.00	4.42	38.26	107.45	23.32	103.09	126.33	2.70	1.10
4	2016A580	Early	108.75	97.23	20.93	14.45	38.00	45.00	2.06	4.50	37.68	103.88	28.77	105.40	126.33	2.68	1.40
5	2016A595	Early	100.06	95.21	19.74	12.60	38.00	43.00	2.00	4.10	36.89	120.19	32.34	106.42	122.34	2.52	1.02
6	2016A673	Early	99.00	89.73	18.88	13.60	39.35	46.32	2.02	4.08	34.78	118.25	50.82	106.42	110.67	2.42	1.10
7	2016A575	Early	100.78	89.53	20.57	13.83	38.67	46.00	2.02	4.06	34.69	116.11	56.08	107.46	108.67	2.32	1.06
8	2016A554	Early	103.56	87.33	20.00	13.52	38.40	42.00	2.00	4.02	33.84	114.00	41.38	105.58	106.33	2.00	1.08
9	2016A503	Early	98.25	84.83	19.20	13.74	40.00	55.00	2.06	4.00	32.88	112.33	50.28	110.50	102.67	2.60	1.03
10	2016A484	Early	96.40	83.10	18.86	13.60	38.00	40.00	2.02	4.08	32.20	108.75	45.03	104.00	100.33	2.40	1.05
11	2016A600	Early	96.53	79.45	18.78	13.19	36.00	46.00	2.00	4.10	30.79	126.27	38.22	99.68	106.77	2.20	1.03
12	2016A255	Early	94.25	78.83	19.88	12.45	36.50	42.40	2.02	4.03	30.55	113.34	35.28	102.30	102.33	2.50	1.05
13	CoA 92081(C)	Early	98.00	100.00	20.80	13.50	36.00	44.00	2.02	4.00	40.31	98.00	34.00	104.33	122.33	2.65	1.08
14	CoV92102 (C)	Early	94.00	95.00	20.50	13.08	35.00	42.40	2.04	4.72	39.53	103.22	48.02	89.20	100.00	2.60	1.06
	CD(0.05)		8.76	10.38	1.16	1.56	-	-	-	-	-	-	-	-	8.13	1.23	0.62
	CV(%)		10.79	9.42	2.66	8.72	-	-	-	-	-	-	-	-	6.42	4.66	5.72

Table 1 (b): Promising clones identified for drought tolerance in the study

S. No.	*Character / Traits*	*Promising clones*
1	Number of millable canes, Cane and CCS yields	2016A 592
		2016A 672
		2016A 664
2	Juice sucrose percent	2016A 672
		2016A 580
		2016A 592
3	SCMR / SPAD readings	2016A 503
		2016A 592
		2016A 672
4	LAI at 120 and 240 DAP	2016A 592
		2016A 580
		2016A 672
5	WUE (kg/ha/mm)	2016A 592
		2016A 672
		2003V 46
6	SLA (cm^2/g)	2016A 592
		2016A 672
		2016A 580
7	Root volume (mL)	2016A 672
		2016A 575
		2016A 592
8	Leaf proline content (**(µmoles/g fresh wt.)**	2016A 503
		2016A 592
		2016A 575
9	Yield components	
	Cane length (cm)	2004A 107
	Cane diameter (cm)	2000A 225
	Single cane weight (kg)	2001A 63

Results of on farm research study at M/s Etikoppaka sugar factory site revealed that the clone 2000A 225 recorded NMC, Cane and CCS yields (95.32 thousands/ha and 95.62 t/ha and 11.40 t/ha) followed by 2004A 107 (94.08 thousands/ha, 94.00 t/ha and 11.00 t/ha) and 2000A 56 (92.67 thousands/ha, 85.63 t/ha and 10.98 t/ha) when compared to best standard 87A 298 (88.67 thousands/ha, 84.33 t/ha and 9.64 t/ha) respectively at harvest. For percent juice sucrose, the clone 98A 163 (19.60%) followed by 2003V 46 (19.55%) and 2006A 223 (19.50%) were found to be superior but on par with check 87A 298 (19.50) when tested in the experiment.

For SPAD / SCMR readings at 120 and 240 DAP the clones, 2000A 225 (40.00 & 48.00) followed by 2000A 213 (40.00 & 47.50) and 9A 163 (40.20 & 45.00) recorded maximum values when compared to standard 87A 298 (36.00 & 44.00) respectively. For LAI at 120 & 240 DAP, the clone 98A163 (2.46 & 4.86) followed by 2000A 213 (2.28 & 4.23) and 2000A 225 (2.28 & 4.18) were found superior when compared to the standard 87A 298 (2.02 & 4.00) respectively.

WUE values are higher in 2000A 225 (44.43 kg/ha/mm) followed by 2004A 107, 2000A 213 (44.86 kg/ha/mm) and 2003V 46 (44.43 kg/ha/mm) at 120 days after planting. SLA (Cm^2/g) was lower in varieties of 2000A

Table 2 (a) : Screening and Evaluation of sugarcane varieties for drought situation atM/SEtikoppaka Sugar Factory farm (2019-20 to 2020-21)

S. no	Genotype	Maturity group	NMC (thousands/ ha)	Cane Yield (t/ha)	Sucrose %	CCS Yield (t/ha)	SCMR Readings		LAI		WUE Kg/ha/ mm	SLA (Cm^2/g)	Root volume (mL)	Leaf proline (µmoles/g fresh wt.)	Cane length (cm)	Cane diameter (cm)	Single cane weight (kg)
							120 DAP	240 DAP	120 DAP	240 DAP	120 DAP	120 DAP					
1.	2000A 225	Midlate	95.32	95.62 *	19.50	11.40 *	40.00	48.00	2.28	4.18	44.43	100.32	38.93	162.22	122.62	2.40	1.05
2	2004A 107	Early	94.08	94.00*	18.76	11.00*	39.00	48.00	2.00	4.30	44.86	100.12	21.82	152.28	130.22	2.42	1.06
3	2000A 213	Early	85.33	96.11	19.00	10.08	40.00	47.60	2.28	4.23	32.10	98.32	21.30	110.63	118.33	2.20	1.04
4	2001A63	Early	81.56	75.67	19.48	10.04	38.00	45.00	2.25	4.00	33.68	112.33	25.33	160.30	120.67	2.30	1.05
5	2000A 56	Early	92.67	85.63	18.00	10.98	38.67	48.00	2.12	4.80	42.26	114.67	26.38	128.23	118.00	2.10	1.02
6	98A 163	Midlate	80.22	74.22	19.60	9.98	40.20	45.00	2.46	4.86	44.00	113.33	35.02	122.20	112.33	2.10	1.00
7	2004A 55	Early	88.33	72.33	19.22	9.60	38.00	40.00	2.12	4.08	32.28	114.22	38.22	124.85	114.33	2.25	1.03
8	2000A 241	Midlate	85.33	70.00	18.66	9.06	36.50	42.40	2.02	4.03	30.64	108.22	35.33	152.33	115.33	2.10	1.05
9	2004A 104	Midlate	85.33	70.00	18.48	8.83	38.40	42.00	2.08	4.02	41.23	103.86	35.03	152.22	111.33	2.00	1.02
10	2000A 255	Early	85.33	67.38	19.06	8.78	38.00	43.00	2.10	4.10	39.67	110.33	29.22	162.20	110.33	1.90	1.00
11	2003V 46	Early	75.33	66.48	19.55	8.70	36.56	40.35	2.20	4.42	44.43	112.67	27.56	157.22	108.38	1.85	1.05
12	2006A 64	Early	79.45	64.33	18.72	8.35	32.33	40.32	2.06	4.10	35.67	105.68	35.82	161.22	107.22	2.10	1.03
13	2005A 128	Early	76.33	60.00	19.00	7.80	34.00	39.50	2.00	4.22	34.42	106.33	28.82	159.22	105.32	2.12	1.00
14	2006A 102	Early	88.46	60.00	18.64	7.63	32.80	40.00	2.00	4.30	33.33	109.67	32.30	157.91	104.33	2.10	1.00
15	2007A 81	Early	74.63	59.67	19.40	8.06	40.00	43.00	2.20	4.20	32.09	118.67	34.42	155.20	110.66	2.08	0.90
16	2000A 240	Early	64.67	58.63	19.08	7.69	34.55	40.00	2.08	4.00	38.42	114.33	31.33	162.19	118.32	2.06	0.98
17	2006A 223	Early	81.63	58.00	19.50	7.61	35.00	42.40	2.34	4.72	42.20	101.10	22.22	155.29	115.33	2.12	0.95
18	87A298(C)	Early	88.67	84.33	19.40	9.64	36.00	44.00	2.02	4.00	40.16	96.33	23.68	160.00	113.00	2.30	1.00
	CD(0.05)		9.14	7.67	0.63	0.94	40.00	46.00	2.22	4.48	-	-	-	-	14.68	1.86	0.82
	C.V (%)		8.63	6 .68	2.05	6.26	39.00	48.00	2.00	4.30	-	-	-	-	5.62	4.32	4.84

Table 2 (b): Promising clones identified from the study at M/s Etikoppaka sugar factory site (2019-20 to 2020-21)

S. No.	*Character / Traits*	*Promising clones identified from study*
1	NMC, Cane and CCS yields	2000A 252
		2004A 107
		2000A 56
2	Juice sucrose percent	98A 163
		2003V 46
		2006A 223
3	SCMR / SPAD readings	2000A 225
		2000A 213
		98A 163
4	LAI at 120 and 240 DAP	98A 163
		2000A 213
		2000A 225
5	WUE (kg/ha/mm)	2000A 225
		2004A 107
		2000A 213
6	SLA (cm^2/g)	2000A 225
		2004A 107
		2000A 213
7	Root volume (ml)	2000A 225
		2004A 55
		2006A 64
8	Leaf proline content (µ/mm/g fresh.wt.)	2000A 225
		2000A 240
		2001A 63
9	Yield components	
	Cane length (cm)	2004A 107
	Cane diameter (cm)	2000A 225
	Single cane weight (kg)	2000A 213

2016A592 **2016A672**

Fig 2: Promising Clones Identified from the Study

225 (100.32), 2004A 107 (100.12) and 2000A 213 (98.32) and were found to be drought tolerant when compared to check 87A 298 (96.33) when tested in the trial.

Leaf proline content was high in 2000A 225 (162.22µmoles/g fresh wt.) followed by 2000A 240 (162.19µmoles/g fresh wt.) and 20016A 63 (160.30µmoles/g fresh wt.) and found to be superior over when compared to standard 87A 298 (160.00 µ mm/g wt.). Root volume was maximum in 2000A 225 (38.93 mL) followed by 2004A 55 (38.22 mL) and 2006A 64 (35.82 mL) and found to be superior over standard 87A 298 (23.68 mL). The yield contributing characters like cane length, cane diameter and single cane weight were maximum in 2004A 107 (130.22 cm, 2.42 cm and 1.06 kg) and found significantly superior followed by 2000A 225 (122.62 cm, 2.40 cm and 1.05 kg) and 2000A 213 (118.33 cm, 2.20 cm & 1.04 kg) respectively over best standard 87A 298 (113.00 cm, 2.30 cm and 1.00 kg) respectively. Table 2(a) and 2 (b).

CONCLUSION

It is identified from the study that the promising elite clones found superior for number of millable canes, cane yield and CCS yield, sucrose percent, SCMR values, water use efficiency, root volume and leaf proline content were 2016A 592, 2016A 672 and 2016A 580. It means that the clones were highly suitable for cane cultivation under stress conditions of drought tolerance in addition to yield components and physiological stress tolerance traits at RARS, Anakapalle whereas at M/s Etikoppaka sugar factory site, the clones 2000A 225, 2000A 213 and 2004A 107 were found superior for number of millable canes, cane and CCS yields, juice sucrose percent, SCMR, WUE, root volume, leaf proline content in addition to yield components. The clones can be given to farmers of their sugar factory operational areas. Based on their performance and acceptance by sugarcane farmers for general cultivation in tropical zone of India. The promising elite clones identified in the study viz., 2016A 592, 2016A 672 and 2016A 580 can serve as valuable genetic resources for developing climate resilient 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.

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