CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

CS58: new high yielding, salt and alkaline tolerant cultivar of Indian mustard

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Abstract: *CS58 is a newly developed, salt-tolerant, high-yielding Indian mustard variety from ICAR- CSSRI, Karnal, India, to harness the yield potential of salt-affected soils of India. It produced 24-25% higher seed yield than the national check varieties CS54 and Kranti and was well received and adopted by farmers in salt-affected areas of the country during on-farm demonstrations.*

Keywords: *Brassica juncea, salt and alkaline tolerance, high seed and oil yield.*

INTRODUCTION

Salinity and sodicity stresses affect an area of 932.2 million hectares in the world (Szabolcs 1989); an area of nearly 6.73 million hectares is affected by these stresses in India (NRSA 1996, Singh et al. 2014). Indian mustard (*Brassica juncea* L. Czern and Coss) is an important oil-seed crop in the world and is grown in more than 50 countries across the globe. This crop is often subject to saline stress, as it is grown extensively in arid and semi-arid regions of the world. Soil and water salinity stresses contribute to greater yield losses (both seed and oil yield), and this low economic yield is related to susceptibility of the crop (Singh and Sharma 2016). There is a considerable need to improve crop plants for salinity tolerance. Moreover, Indian mustard has received increasing attention due to its potential to phytoremediate metal-polluted saline soils (Novo et al. 2013, Novo et al. 2014). Hence, it is necessary to develop salt-tolerant genotypes in Indian mustard.

Selection of elite germplasm in intermediate climatic growing conditions allows selection of a suitable germplasm across the diverse range of climatic conditions evaluated (da Silva et al. 2019). One approach is characterization of the available germplasm in salt affected environment, which provide an initial germplasm base for breeding salt-tolerant crops.

High-yielding, salt-tolerant Indian mustard varieties play an important role in harnessing the yield potential of salt-affected soils (Singh and Sharma 2016). ICAR-Central Soil Salinity Research Institute (ICAR-CSSRI) has developed three salt-tolerant varieties of Indian mustard, *viz*., CS52, CS54, and CS56, through traditional plant breeding, which have had a favorable impact on salt-affected areas of India. However, integration of farmer-participatory variety selection in traditional plant breeding strengthens and expedites the adoption of varieties by farmers, who are the end users of varietal technology. In this quest, a new

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variety CS58 not only performed better in the All India Salinity Alkalinity Tolerant Variety Trials (AISATVT) in different salinity and alkalinity stress locations, including the states of Haryana, Punjab, and Uttar Pradesh, but was also well received and adopted by farmers in salt-affected areas of the country.

Using these approaches, salt-tolerant varieties and pre-breeding materials of Indian mustard were screened and evaluated under varied saline and alkaline environments in India from 2012-13 to 2015-16 by the multi-disciplinary team of scientists of ICAR-CSSRI.

PEDIGREE AND BREEDING METHOD

The Indian mustard variety CS58 was developed by crossing two genotypes, CS52 and CS609-B10. The CS52 is a highly salt-tolerant variety, and CS609-B10 is a high-yielding (seed and oil) genotype. The 50 F_1 crosses were space planted and harvested in bulk. The F_2 to F_6 generations were planted at the commercial seed rate and spacing and harvested in bulk. The population size in each of these generations was 30 thousand plants. About 30 thousand plants were space planted in the F_7 generation, and from these plants, only 5000 plants with higher primary and secondary branches, high main shoot length, and higher number of siliques on the main shoot under salinity (12.0 d Sm^{-1}) and alkalinity (pH 9.4) conditions were selected, and their seeds were harvested separately. Individual plant progenies were grown in multi-row plots. Weak and inferior progenies were rejected, and only 300 individual homozygous plant progenies with desirable traits were selected and harvested in bulk. A preliminary yield trial was conducted at the ICAR-CSSRI experimental farms for two years, along with the national check varieties CS54 and Kranti, for agronomic traits; and Rohini, YSB9, PHR2, EC399301, EC399299, EC399000, DLSC-1, and Varuna were used as checks for resistance/tolerance to disease and mustard aphid infestation. Replicated yield trials were conducted for three years at 5 locations per year under saline and alkaline conditions in salt-affected soils of the states of Haryana, Punjab, Rajasthan, and Uttar Pradesh

Table 1. Seed and oil yield (kg ha^{-1}) of cultivars under saline (ECe 12 d Sm^{-1}) and alkaline (pH 9.4) conditions in an all India coordinated research project on rapeseed-mustard (AICRPRM)

Traits	Year of testing	CS58	CS54 (NC)*	Kranti (NC)*
Seed yield (kg ha^{-1})	2012-13	2168	1923	1841
	2013-14	2053	1649	1770
	2014-15	2049	1550	1502
	2015-16	1734	1288	1337
	Mean	2001[a]	1603[b]	1613[b]
	CD (P<0.05)		132.60	
	CV (%)		4.32	
Per cent increase (+) or decrease (-) compared to checks	2012-13		12.74	17.76
	2013-14		24.50	15.99
	2014-15		32.19	36.42
	2015-16		34.63	29.69
	Mean		24.87	24.09
Oil yield (kg ha^{-1})	2012-13	#	#	#
	2013-14	789	639	683
	2014-15	807	602	584
	2015-16	685	523	498
	Mean	760[a]	588[b]	588[b]
	CD (P<0.05)		72.80	
	CV (%)		4.85	
Per cent increase (+) or decrease (-) compared to checks	2012-13		#	#
	2013-14		23.47	15.52
	2014-15		34.05	38.18
	2015-16		30.98	37.55
	Mean		29.31	29.24

*NC = National Check; # in the year 2012-13, data on oil yield were not reported, CD = critical difference, CV = coefficient of variation. Means with the same letter in the row did not have a statistically significant difference at P < 0.05 by Duncan's Multiple Range Test.

using the standard national check varieties CS54, RH749, RH406, NRCHB101, DRMRIJ31, and Kranti under an all India coordinated research project on rapeseed-mustard (AICRPRM). CS58 was more than 10% superior to the standard checks in terms of seed and oil yield and disease and pest tolerance under saline and alkaline conditions. Thus, it was released as a new variety.

TRAIT PERFORMANCE

On the basis of four-year (2012-13 to 2015-16) trials conducted for saline and alkaline conditions in AICRPRM, CS58 provided a mean seed yield of 2001 kg ha^{-1} under saline and alkaline conditions, which was 24% and 25% higher than the yields of two national check varieties, i.e., CS54 (1603 kg ha^{-1}) and Kranti (1613 kg ha^{-1}), respectively. It also provided 29% higher oil yield (760 kg ha^{-1}) than CS54 and Kranti (588 kg ha^{-1}) (Table 1). This variety matures, on average, in 135 days, and takes 60 days to flower. It attains a height of approximately 180 cm, main shoot length of 85 cm, and 1000 seed weight of 5g (Table 2).

Table 2. Ancillary data of cultivars under saline (ECe 12 d Sm^{-1}) and alkaline (pH 9.4) conditions in AICRPRM

Traits	Year of testing	CS58	CS54 (NC)*	Kranti (NC)*
Plant height (cm)	2012-13	170	164	176
	2013-14	170	172	175
	2014-15	188	167	167
	2015-16	193	187	186
	Mean	180[a]	173[b]	176[b]
	CD (P<0.05)		3.46	
	CV (%)		3.92	
Primary branches (number)	2012-13	5	5	5
	2013-14	6	6	5
	2014-15	5	5	6
	2015-16	7	5	6
	Mean	6[a]	5[b]	6[a]
	CD (P<0.05)		0.34	
	CV (%)		12.49	
Secondary branches (number)	2012-13	10	9	12
	2013-14	8	9	8
	2014-15	9	7	7
	2015-16	9	8	9
	Mean	9[a]	8[b]	9[a]
	CD (P < 0.05)		0.55	
	CV (%)		12.49	
Main shoot length (cm)	2012-13	87	90	98
	2013-14	88	87	94
	2014-15	92	87	81
	2015-16	73	76	75
	Mean	85[b]	85[b]	87[a]
	CD (P < 0.05)		2.00	
	CV (%)		5.80	
1000-seed weight (g)	2012-13	5	5	4
	2013-14	6	4	5
	2014-15	5	5	4
	2015-16	5	5	4
	Mean	5[a]	5[a]	4[b]
	CD (P < 0.05)		0.29	
	CV (%)		12.16	

*NC = National Check, CD = critical difference, CV = coefficient of variation. Means with the same letter in the row do not have a statistically significant difference at P < 0.05 by Duncan's Multiple Range Test.

CS58 also showed higher resistance to *Alternaria* blight under natural conditions than the check Rohini and the salt-tolerant variety CS54. The severity of *Alternaria* blight in pods was similar to the checks. Furthermore, it also showed much lower incidence of white rust, powdery mildew, downy mildew, and *Sclerotinia* rot compared to the check Rohini.

Table 3. Score for reaction to major diseases (100 days after sowing under natural conditions) of cultivars under saline (ECe 12 d Sm^{-1}) and alkaline (pH 9.4) conditions in AICRPRM

Particular aspect	Year of testing	CS58	Check variety							
			Rohini	YSB 9	PHR 2	EC-399301	EC-399299	EC-399000	DLSC-1	CS 54
	2012-13	28.2	35.2	46.6	***	***	***	***	***	***
	2013-14	28.4	29.0	***	23.7	20.5	22.6	14.9	11.2	27.9
	2014-15	41.8	42.6	***	29.4	35.3	29.2	19.2	30.0	***
% AB severity	2015-16	38.5	39.3	***	***	42.1	39.4	37.5	22.8	23.9
	Mean	34.2^{b}	36.5^{b}	46.6^{a}	26.6^{c}	32.6^{b}	30.4^{bc}	23.9^{c}	21.3^{c}	25.9^{c}
	CD (P<0.05)					7.35				
	CV (%)					10.40				
	2012-13	24.6	33.0	***	***	***	***	***	***	***
	2013-14	16.9	17.8	***	17.7	14.9	11.5	0.0	2.3	***
	2014-15	36.1	43.4	***	33.3	19.6	9.8	0.0	0.0	***
% WR severity	2015-16	28.2	32.0	***	***	17.7	18.4	8.5	1.1	***
	Mean	26.5^{a}	31.6^{a}	***	25.5^{a}	17.4^{b}	13.2^{b}	2.8^{c}	1.1^{c}	***
	CD (P<0.05)					10.92				
	CV (%)					5.25				
	2012-13	22.1	17.9	7.2	***	***	***	***	***	***
	2013-14	25.0	21.9	***	5.2	2.8	1.0	0.0	0.0	***
	2014-15	***	***	***	***	***	***	***	***	***
% Stag head severity	2015-16	6.9	14.7	***	***	4.7	3.9	4.2	0.0	***
	Mean	18.0^{a}	18.2^{a}	7.2^{b}	5.2^{b}	3.8^{b}	2.5^{b}	2.1^{b}	0.0^{c}	***
	CD (P<0.05)					7.37				
	CV (%)					3.71				
	2012-13	70.2	86.0	26.6	***	***	***	***	***	***
	2013-14	36.7	34.5	***	36.8	41.5	29.9	0.0	26.0	***
	2014-15	55.2	67.7	***	59.3	65.0	68.4	0.0	0.0	***
% PM severity	2015-16	40.5	28.0	***	***	34.4	39.0	29.9	3.3	
	Mean	50.7^{a}	54.1^{a}	26.6^{ab}	48.1^{a}	47.0^{a}	45.8^{a}	10.0^{b}	9.8^{b}	***
	CD (P<0.05)					32.56				
	CV (%)					15.55				
	2012-13	47.0	58.4	43.3	***	***	***	***	***	***
	2013-14	47.5	53.6	***	37.6	29.8	16.6	0.0	0.0	***
	2014-15	23.8	42.9	***	31.0	22.5	33.5	0.0	0.0	***
% DM severity	2015-16	27.8	25.0	***	***	22.2	22.2	25.0	0.0	***
	Mean	36.5^{a}	45.0^{a}	43.3^{a}	34.3^{a}	24.8^{ab}	24.1^{ab}	8.3^{b}	0.0^{b}	***
	CD (P< 0.05)					22.92				
	CV (%)					10.95				
	2012-13	19.4	30.0	36.9	***	***	***	***	***	***
	2013-14	22.9	2.5	***	5.4	4.8	6.9	7.1	11.0	8.8
	2014-15	12.5	57.7	***	7.5	20.0	7.5	0.0	0.0	***
% SR severity	2015-16	5.3	16.1	***	***	11.7	8.4	17.5	5.0	***
	Mean	15.0^{c}	26.6^{b}	36.9^{a}	6.5^{d}	12.2^{c}	7.6^{d}	8.2^{d}	5.3^{d}	8.8^{d}
	CD (P<0.05)					5.97				
	CV (%)					8.44				

AB = Alternaria blight, WR = White rust, PM = Powdery mildew, DM = Downy mildew, SR = Sclerotinia rot, CD = critical difference, CV = coefficient of variation. *** Not a check variety for the specific disease in the specific trial (initial or advance varietal trial) of this year. Means with the same letter in the row do not have a statistically significant difference at P < 0.05 by Duncan's Multiple Range Test.

Table 4. Score for reaction to mustard aphid of cultivars under saline (ECe 12 d Sm^{-1}) and alkaline (pH 9.4) conditions in AICRPRM

Particular aspect	Year of testing	CS58	Check variety			
			CS 54	Kranti	Rohini	Varuna
Average aphid infestation index (AAII)	2012-13	1.3	1.4	1.3	1.5	1.5
	2013-14	1.1	1.3	1.5	1.2	1.2
	2014-15	1.5	1.9	1.8	2	1.7
	2015-16	1.9	**	**	2.3	2.6
	Mean	1.5^{b}	1.5^{b}	1.5^{b}	1.8^{a}	1.8^{a}
	CD (P < 0.05)			0.30		
	CV (%)			5.63		

** Not a check variety for mustard aphid in this year. CD = critical difference, CV = coefficient of variation. Means with the same letter in the row do not have a statistically significant difference at P < 0.05 by Duncan's Multiple Range Test.

Similar performance was recorded under artificial conditions (Table 3). Against mustard aphid, data from 24 trails showed a lower average aphid infestation index (AAII) compared to the checks CS54, Kranti, Rohini, and Varuna (Table 4).

CS58 responded favorably to additional application of fertilizer (NPK). Further recommended dose of fertilizer (80:40:40; N:P:K, kg ha^{-1}, respectively) was found suitable for this genotype.

Considering its higher seed and oil yields and disease resistance under saline (6.0-12.0 d Sm^{-1}) and alkaline (pH 9.0-9.4) conditions, CS58 was released for salt-affected soils of the country.

SEED PRODUCTION

Genotype CS58 was released and notified by the central sub-committee on "crop standards, notification, and release of varieties" (see the notification in the official gazette for this variety: number S.O. 1007 (E), dated 30 March 2017), under the Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India. ICAR-CSSRI is the developer and maintainer of this cultivar and produces its genetic seeds.

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