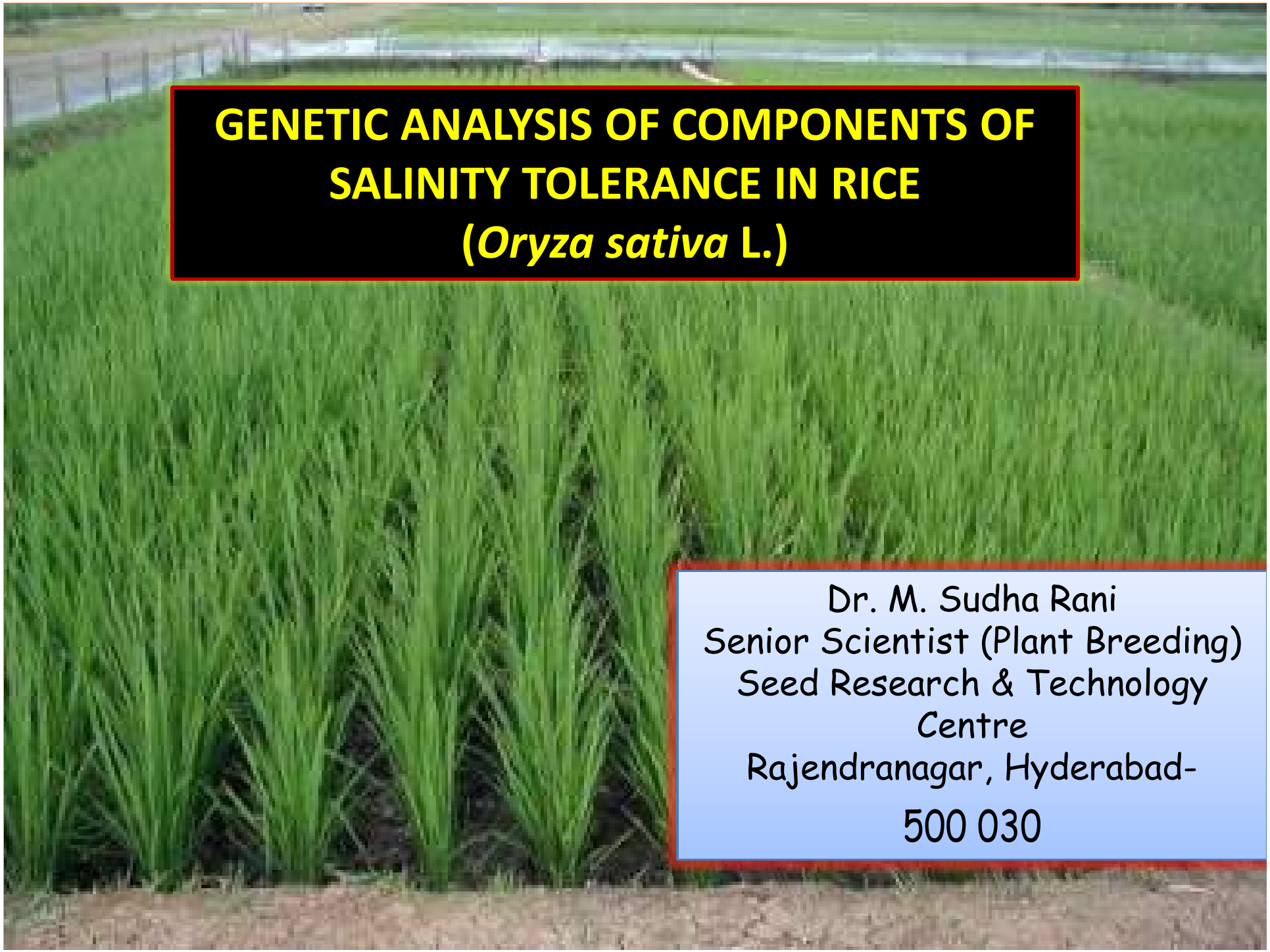

welcome



GENETIC ANALYSIS OF COMPONENTS OF SALINITY TOLERANCE IN RICE (*Oryza sativa* L.)

Dr. M. Sudha Rani
Senior Scientist (Plant Breeding)
Seed Research & Technology Centre
Rajendranagar, Hyderabad-500 030

AREA AND PRODUCTION LEVELS OF RICE

	INDIA	ANDHRA PRADESH
Area (m. ha)	42.56	4.75
Production (m. t)	95.33	14.42
Productivity (kg/ha)	2240	3035

DES Annual report,2012

EXTENT OF SALT-AFFECTED SOILS

FAO Database

397 x 10^6 ha (3.1%) – Saline soils

434 x10^6 ha (3.4%) - Sodic soils

Word: 800 m.ha (Zhu *et al.* 2001)

India: 8.5 m. ha

2.19 m. ha coastal saline

Andhra Pradesh: 2.74 lakh ha

What are the salt-affected soils ?

Salt-affected type	Electrical conductivity EC_e (dSm^{-1})#	Exchangeable Sodium Percentage ESP (%)	Sodium Absorption Ratio SAR	pHs
Saline	> 4	< 15	< 13	< 8.8
Sodic	< 4	> 15	> 13	8.5-10.5
Saline - sodic	> 4	> 15	Variable	> 8.5

at 25°C

$$ESP = \frac{\text{Exchangable Sodium} \times 100}{\text{Cation Exchange Capacity}}$$

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Salt affected field

How to Manage the Salt-affected Areas ?

Do we need ST cultivars ?

1. Environment modifying approach : Change the environment for the normal growth of plants

2. Crop based approach : Select or develop crop variety which can withstand the salt stress

Rice has enormous variability

3. Hybrid Approach

It is the combination of environment modifying and plant based approach.

Advantages:

- More viable
- Highly productive
- Low resource cost

Salt tolerant rice variety, CSR13, with 25% Gypsum

Local variety without gypsum

Physiology: traits associated with salinity tolerance

Regulation of uptake

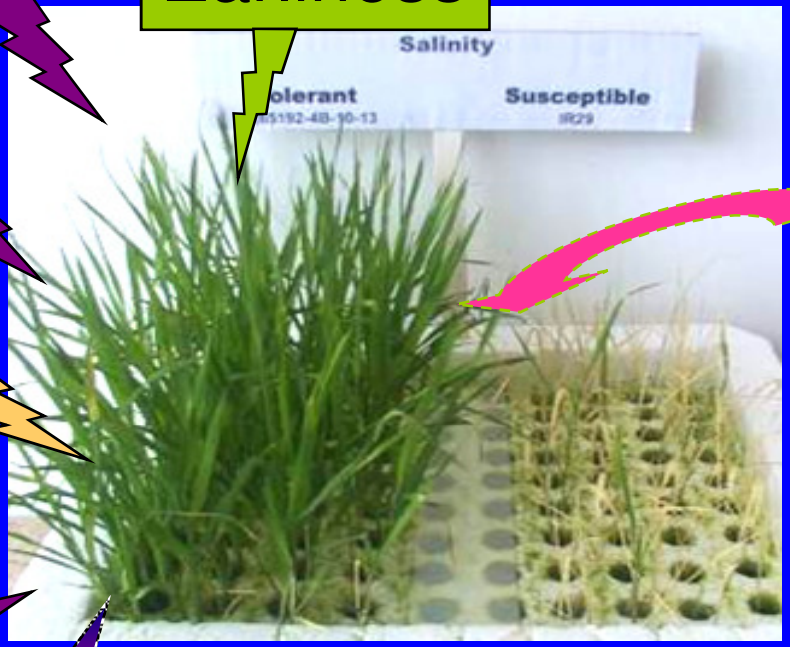
Earliness

Compartmentation In old tissue

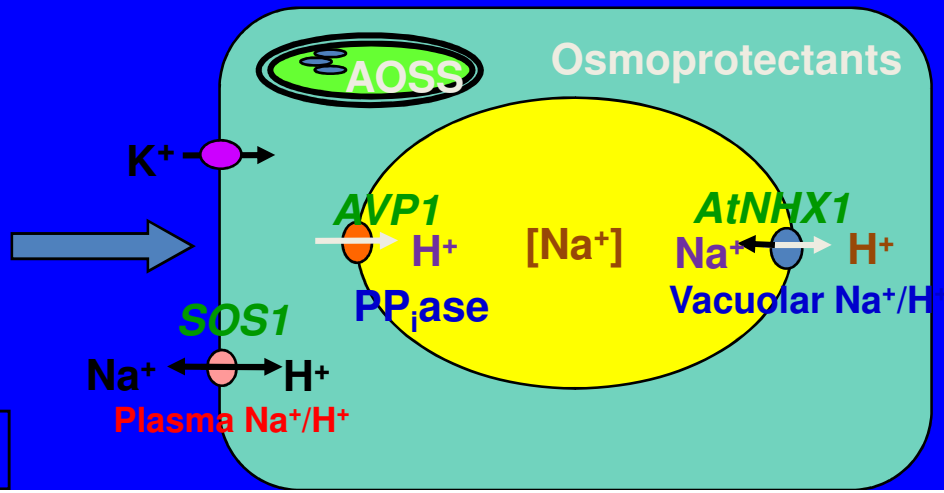
Upregualtion of osmoprotectants

Protective metabolites
Polyamines, dehydrins, glyoxalates

Vigorous growth



Compartmentation within tissue (tissue tolerance)

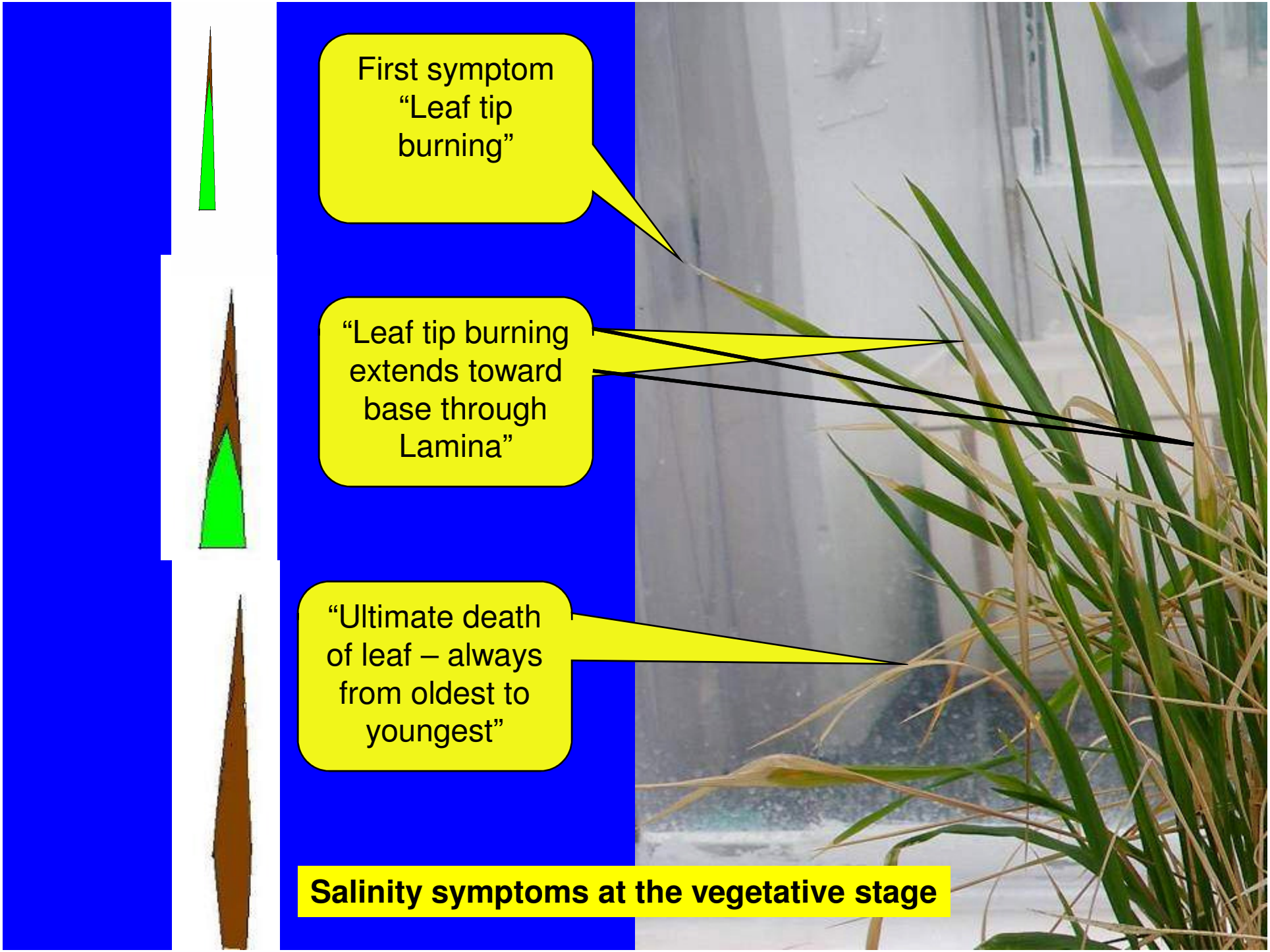


Source : Ismail, A. M. 2007

Manifestation of Salt Stress

Morphological Symptoms

- White leaf tip followed by tip burning (salinity)
- Leaf browning & death (sodicity)
- Stunted plant growth
- Low tillering
- Spikelet sterility
- Low harvest index
- Less florets per panicle
- Less 1000 grain weight
- Low grain yield
- Change in flowering duration
- Leaf rolling
- White leaf blotches
- Poor root growth
- Patchy growth in field


First symptom "Leaf tip burning"
"Leaf tip burning extends toward base through Lamina"
"Ultimate death of leaf – always from oldest to youngest"
Salinity symptoms at the vegetative stage

Effect of salinity at Reproductive stage – Spikelet Sterility

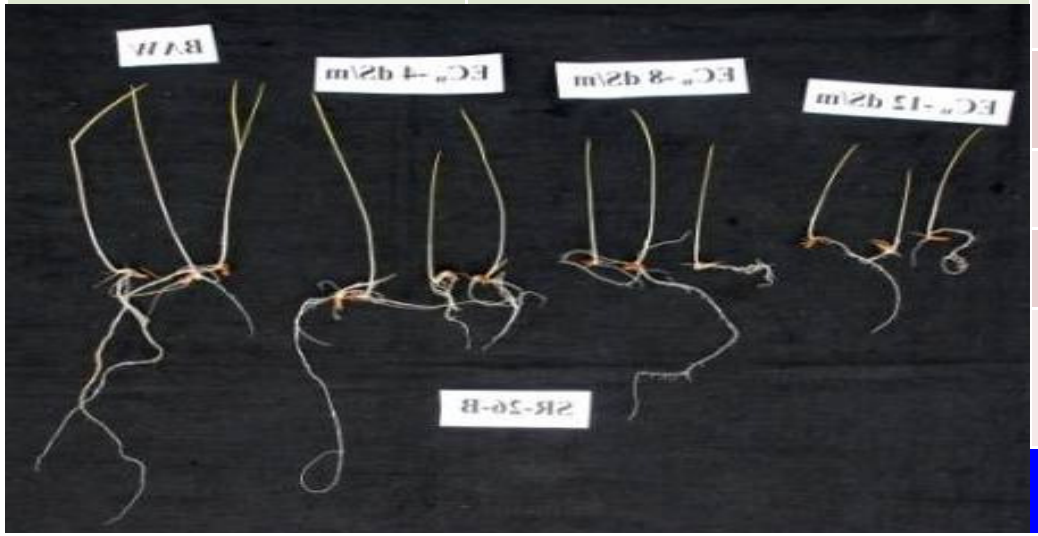
Effect of salinity at reproductive stage – papery sterile spikelets

Objectives

- To evaluate the response of rice cultivars to salinity stress at seedling stage
- To understand the extent of relationship among grain yield, physiological and yield contributing parameters
- To estimate the extent of heterosis and inbreeding depression
- To study the nature of gene action and combining ability
- To identify the best combiners and best hybrids to select superior recombinants

Screening of rice cultivars against salinity tolerance

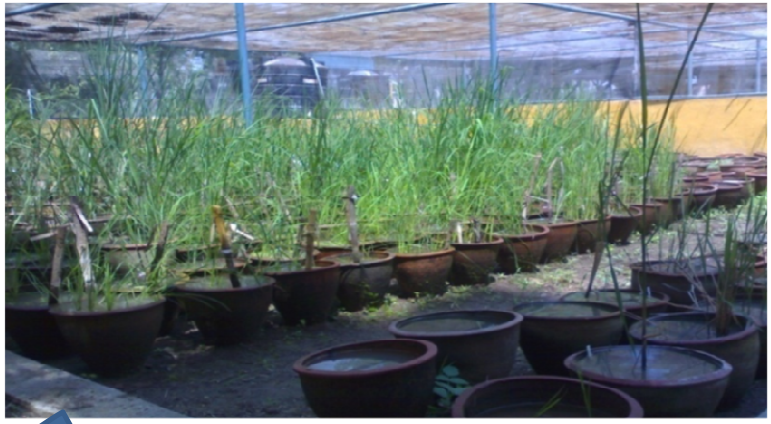
Location	DRR, Hyderabad (Lab)
Genotypes	24
Replications	Three
Design	Factorial CRD
Treatments	Control, 4,8 and 12 dS/m



Data recorded
Germination (%)
Root length (cm)
Shoot length (cm)
Seedling length (cm)
Root dry weight (g)
Shoot dry weight (g)
Seed vigour index(SVI)
Sodium concentration in root (mg g^{-1})
Potassium concentration in root (mg g^{-1})
Sodium concentration in shoot (mg g^{-1})
Potassium concentration in shoot (mg g^{-1})
Sodium and potassium ratio in root
Sodium and potassium ratio in shoot
Standard Evaluation Score (SES) for visual salt injury

Salient features of the parents used for crossing

- **RPBio-226 :** 125 days duration, resistant to BLB with fine grain quality
- **MTU -7029 :** 155 days duration, moderately resistant to BLB and SB, GLH and low nitrogen responsive cultivar with dark green foliage.
- **CSR-27 :** 140 days duration, moderately resistant to BLB, LF, semi dwarf plant type and tolerant to salinity and alkalinity.
- **CSR-30 :** 130 days duration, tall plant type with aromatic slender grain and suitable for export.
- **CST 7-1:** 140 days duration, semi dwarf, medium slender grain type and tolerant to salinity.
- **CSRC(S) 5-2-2-5:** 135 days duration, resistant to LB, RTV, moderately resistant to SB, LF and tolerant to salinity.
- **SR 26 B :** 140 days duration, tall plant type, resistant to salinity with medium bold grain type.
- **CSRC(S)7-1-4:** 135-140 days duration, tolerant to salinity with medium bold grain.



STUDY OF COMBINING ABILITY AND HETEROSIS

***Khar*if, 2010**	**Generated 28F1 hybrids**
***Rabi*, 2010-11**	**1. Selfed 28F1 hybrids**
	2. Once again fresh crosses affected
***Kharif*, 2011**	**Evaluation of F1 and F2 and parents**

Evaluation of Breeding Material

Location	ARS, Machilipatnam (Two soil conditions)
Season	Kharif, 2011
Treatments	28 F_1 progenies with eight parents
Replications	Three
Design	RBD
Spacing	20 X 15 cm

Data recorded
Plant height (cm) (PH)
Days to 50 per cent flowering (DFF)
Number of tillers per plant (TT)
Number of productive tillers per plant (PT)
Panicle length (cm) (PL)
Panicle weight (g)
Number of filled grains per panicle (GPP)
Spikelet fertility (%):
Test weight (g) (TW)
Grain yield per plant (g) (GY)
Harvest Index (%):
SPAD chlorophyll meter readings
Na^+/K^+ ratio
Root / shoot ratio
Standard Evaluation Score (SES) for visual salt injury
Yield reduction (%):

Screening of hybrids (in pots) along with parents

Rabi, 2010-11

Location	DRR, Hyderabad
Genotypes	28 F_1 hybrids and eight parents
Replications	Three
Design	Factorial CRD
Treatments	Control, 6 and 12 dS/m

Data recorded
Grain yield per plant (g)
Na^+/K^+ ratio
Standard Evaluation Score (SES) for visual salt injury

Salinity tolerance reaction of rice genotypes

Genotypes	SES	Na^+ in shoot	K^+ in shoot	Na^+/K^+ in shoot	Reaction to salinity
RPBio-226	5.88	5.443	4.480	1.214	Susceptible
Swarna	5.94	6.127	4.740	1.075	Susceptible
CSR-27	3.78	1.107	3.660	0.300	Tolerant
CSR-30	3.23	2.137	4.127	0.517	Moderately tolerant
CST-7-1	3.20	3.007	5.427	0.550	Moderately tolerant
CSRC(S)7-1-4	2.58	0.913	2.543	0.353	Tolerant
SR26-B	1.91	2.163	4.313	0.500	Tolerant
CSRC(S)5-2-2-5	2.30	2.030	3.957	0.510	Tolerant

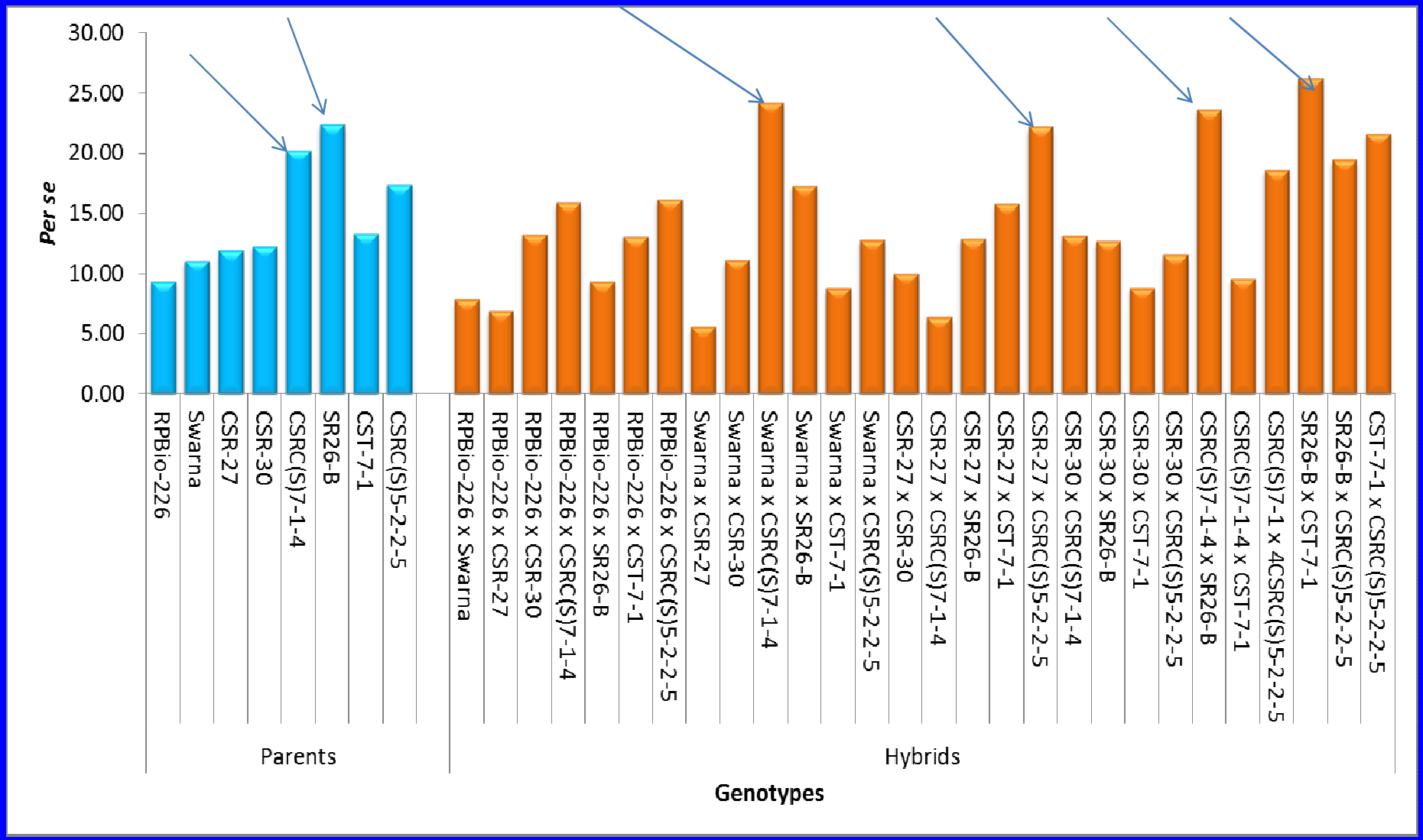
Comparision of salt injury score at seedling and adult stages

Genotypes	Seedling stage		Adult stage			
	SES	Tolerance	SES (Field)	Tolerance	SES (pots)	Tolerance
RPBio-226	**5.88**	**S**	**7.06**	**S**	**7.05**	**S**
Swarna	**5.94**	**S**	**6.17**	**S**	**7.09**	**S**
CSR-27	**3.78**	**MT**	**4.46**	**MT**	**4.23**	**MT**
CSR-30	**3.23**	**MT**	**5.18**	**S**	**5.00**	**MT**
CSRC(S)7-1-4	**3.20**	**MT**	**3.39**	**MT**	**3.40**	**MT**
SR26B	**2.58**	**T**	**3.40**	**MT**	**2.82**	**T**
CST-7-1	**1.91**	**T**	**4.32**	**MT**	**4.73**	**MT**
CSRC(S)5-2-2-5	**2.30**	**T**	**3.65**	**MT**	**3.55**	**MT**

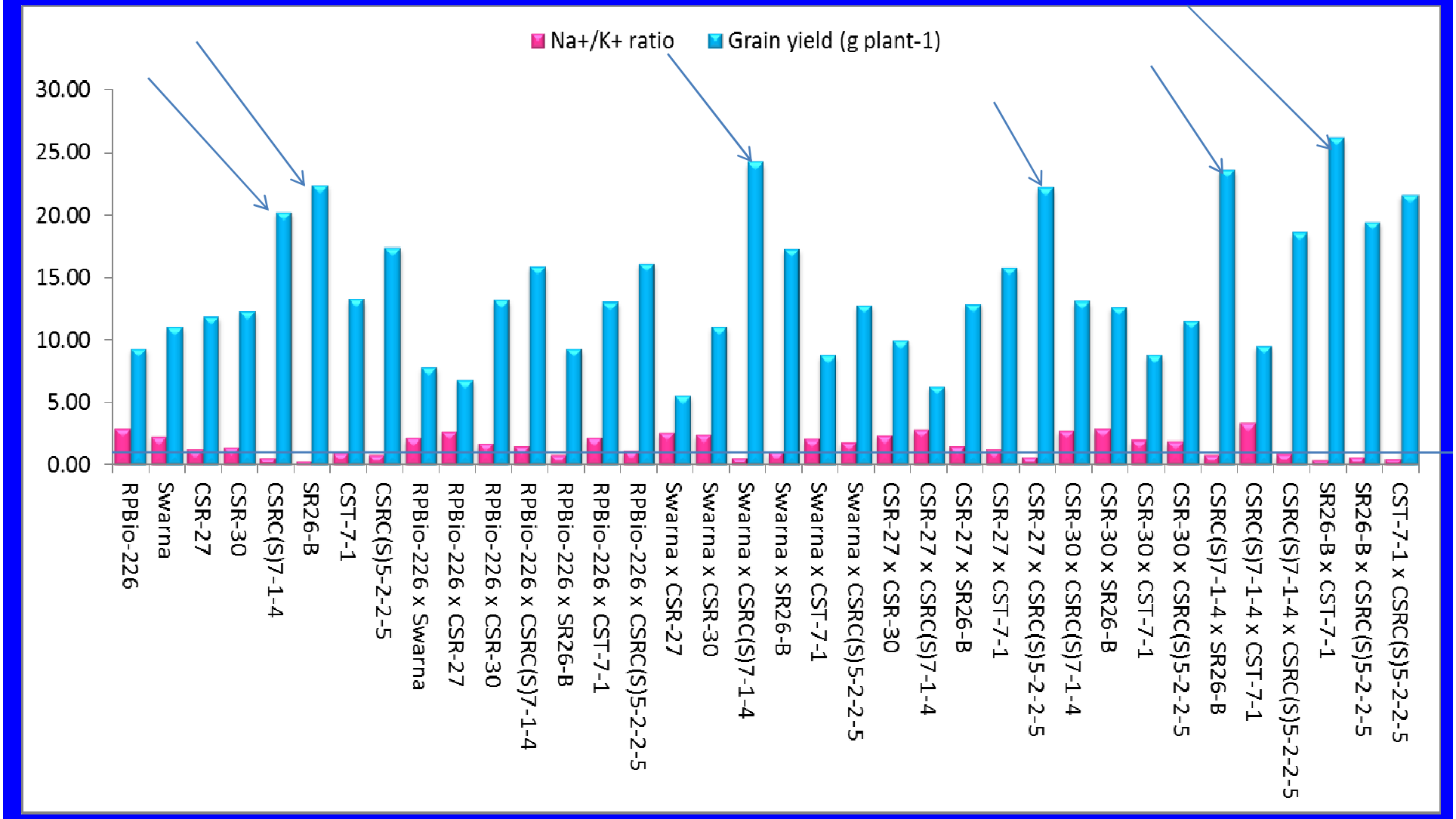
Superior parents and hybrids based on *per se*

Genotype/Hybrids	Characters
SR26B	NPT, NFG, PW, TW, GY, HI,SCMR, SES and Na/K ratio (9)
CSRC(S)7-1-4	PL, PW, NFG, TW, GY, HI, RSR and SES (8)
SR26B x CST7-1	TT, NFG, PL, TW, SF and GY
Swarna x CSRC(S)7-1-4	NPT, PL, GY, RSR, HI and SCMR

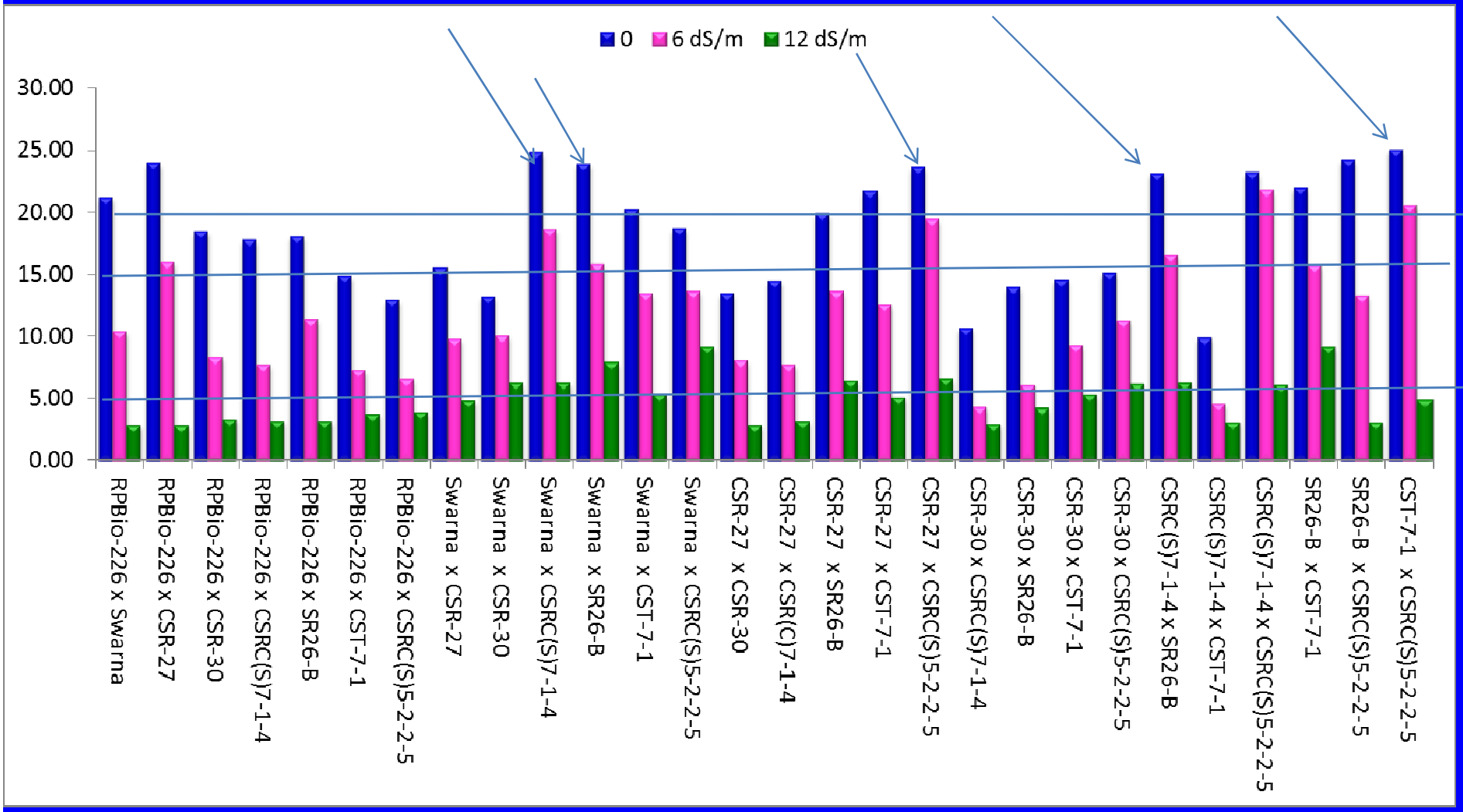
Mean performance of parents and hybrids for grain yield/plant under saline soils



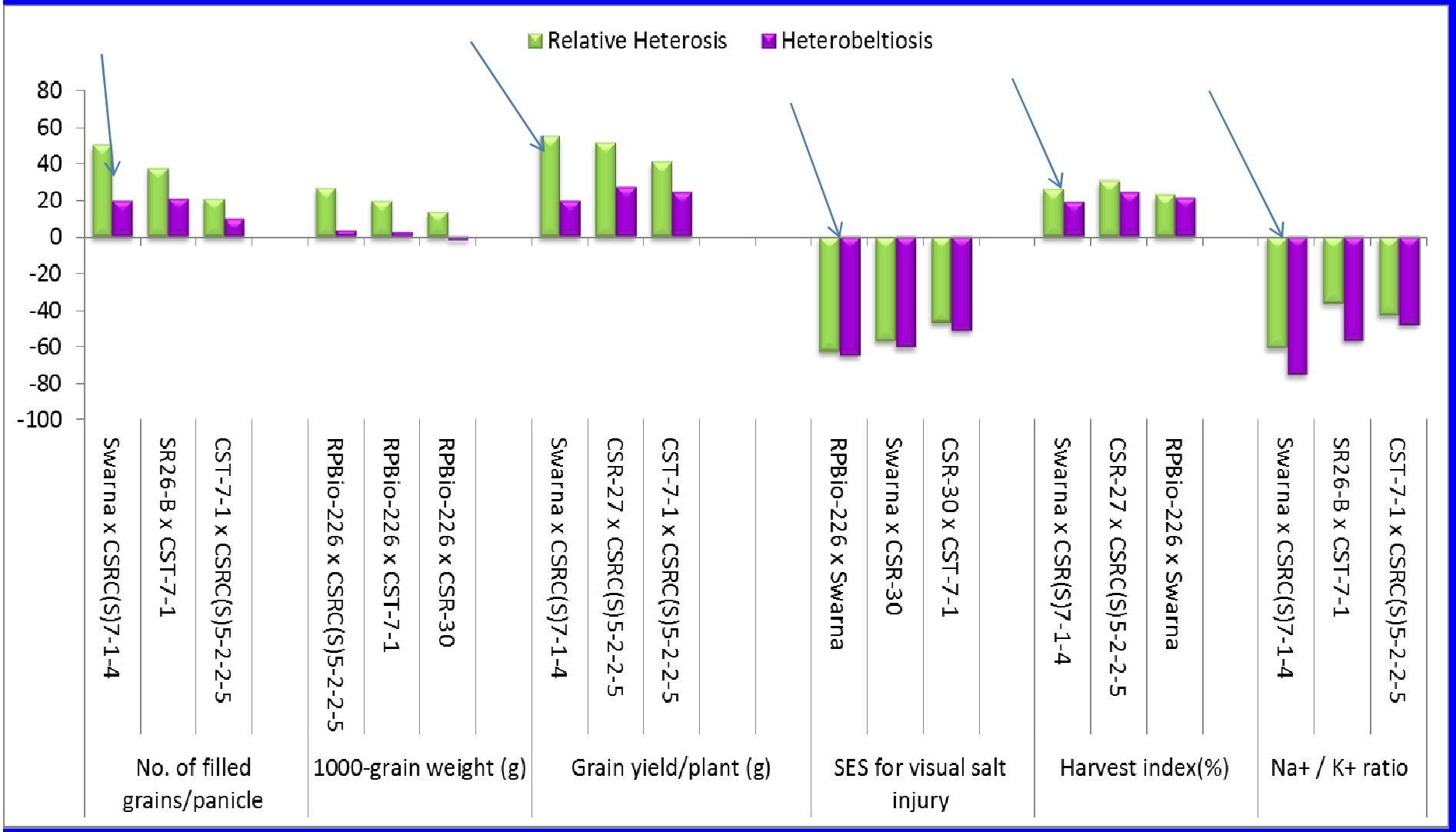
Relationship between Na^+/K^+ ratio and grain yield plant^{-1} among eight parents and 28 F_1 hybrids under saline soil conditions



Per se performance of 28 F_1 hybrids for grain yield plant^{-1} at various levels of salinity



The heterotic hybrids for various traits under saline soil conditions



Promising heterotic hybrids under saline soils

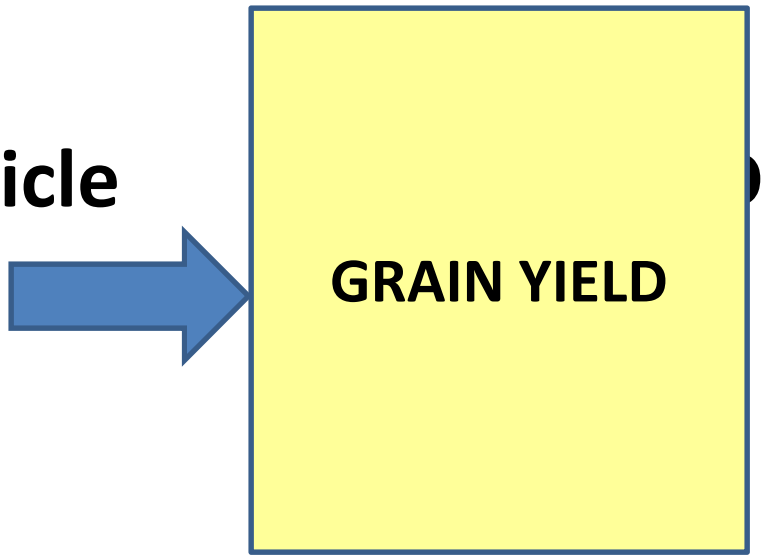
Character	Hybrid
Plant height (cm)	CSR-30 x CSRC(S)7-1-4
Days to 50% flowering	**Swarna x CSRC(S)7-1-4**
Number of tillers plant^{-1}	RPBio-226 x CSR-30
Number of productive tillers plant^{-1}	RPBio-226 x CSR-30
Panicle length (cm)	RPBio-226 x CSR-30
Panicle weight (g)	RPBio-226 x CSR-30
No. of filled grains panicle^{-1}	**Swarna x CSRC(S)7-1-4**
1000-grain weight (g)	RPBio-226 x CSRC(S)5-2-2-5
Grain yield plant^{-1} (g)	**Swarna x CSRC(S)7-1-4**

Promising heterotic hybrids under saline soils

Character	Hybrid
SES for visual salt injury	RPBio-226 x Swarna
Root/shoot ratio	RPBio-226 x Swarna
Harvest index(%)	Swarna x CSR(S)7-1-4
Na^+/K^+ ratio	Swarna x CSRC(S)7-1-4
SPAD valve	RPBio-226 x CSR-30
Yield reduction(%)	Swarna x CSRC(S)7-1-4

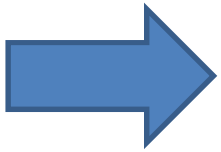
Association of characters with grain yield

No.of tillers/plant
Panicle weight (g)
No. of filled grains/panicle
Spikelet fertility (%)
1000 grain weight (g)
Harvest index (%)
SCMR
SES for visual salt injury
Na^+/K^+ ratio



Direct effects on grain yield

No.of tillers/plant
No. of filled grains /panicle
Spikelet fertility (%)



GRAIN YIELD

SES for visual salt injury
Na^+/K^+ ratio

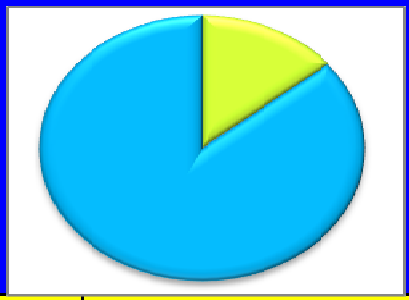
Best combiners under saline soil condition

Parents	Characters
CSRC(S)5-2-2-5	**TT, PT, PL, PW, NFG, SF, TW, GY, SES, RSR, Na^+/K^+ ratio, SCMR and YR (13)**
SR26-B	**TT, PT, PL, PW, NFG, SF, TW, GY, SES, HI, Na^+/K^+ ratio and YR.(12)**
CSRC(S)7-1-4	**TT,PT, PW, NFG, TW, GY, RSR, Na^+/K^+ ratio, SCMR and YR. (10)**

Top ranking desirable crosses for specific combining ability with their *per se* performance, Heterosis (H_1) and Heterobeltiosis (H_2) under saline conditions

1.Plant height (cm)

Predominant gene action : Non additive



Cross combination	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
CSR-30×CSRC(S)7-1-4	H × L	-21.85	72.50	-29.63	-30.09
CSR-30×SR26-B	H × L	-14.20	81.43	-21.47	-21.47
CSR-27×CSRC(S)7-1-4	L × L	-13.88	83.90	-18.57	-19.09

Top ranking desirable crosses for specific combining ability with their *per se* performance, Heterosis (H_1) and Heterobeltiosis (H_2) under saline conditions

2. Days to 50% flowering

Predominant gene action : Non additive

Cross combination	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×CSRC(S)7-1-4	L × L	-8.74	108.33	-9.14	10.49
CST-7-1×CSRC(S)5-2-2-5	H × L	-7.44	105.33	-12.74	-2.78
CSR-27×CSR-30	H × H	-6.91	99.33	0.00	0.00

3.Number of tillers per plant

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×CSRC(S)5-2-2-5	L × H	3.23	12.67	23.68	5.28
SR26-B×CST-7-1	H × L	2.20	12.00	-34.93	-64.91
RPBio-226×CSRC(S)7-1-4	L × H	2.06	12.33	18.90	10.79

4.Number of productive tillers per plant

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×CSRC(S)5-2-2-5	L × H	2.62	9.67	13.56	0.00
RPBio-226×CSRC(S)7-1-4	L × H	2.05	8.33	13.08	-16.09
SR26-B×CST-7-1	H × L	2.05	9.33	-3.64	-3.64

5.Panicle length (cm)

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
SR26-B × CST-7-1	**H × L**	**4.30**	**24.87**	**6.95**	**6.95**
RPBio-226 × CSR-30	**L × L**	**3.83**	**19.70**	**15.00**	**-15.27**
CSRC(S)7-1-4 × CSRC(S)5-2-2-5	**L × H**	**1.79**	**23.57**	**-0.86**	**1.36**

6.Panicle weight (g)

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
RPBio-226 × CSR-30	**L × L**	**1.24**	**3.01**	**31.87**	**-22.31**
Swarna × **CSRC(S)7-1-4**	**L × H**	**0.93**	**3.43**	**-4.99**	**-11.37**
RPBio-226 × **CSRC(S)7-1-4**	**L × H**	**0.89**	**3.73**	**3.23**	**-3.70**

No.of filled grains/panicle

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
SR26-B×CST-7-1	H × L	57.03	176.00	21.10	21.10
Swarna×**CSRC(S)7-1-4**	L × H	53.43	163.00	19.80	12.39
RPBio-226×CSR-30	L × L	28.36	102.70	18.92	-29.36

Spikelet fertility (%)

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
CSR-30×**SR26-B**	L × L	13.15	57.37	-28.02	-28.02
Swarna×**CSRC(S)7-1-4**	L × L	11.21	78.00	-1.60	-2.13
RPBio-226×**CSRC(S)7-1-4**	L × L	8.57	80.43	1.47	0.92

1000 grain weight (g)

Predominant gene action : Non additive

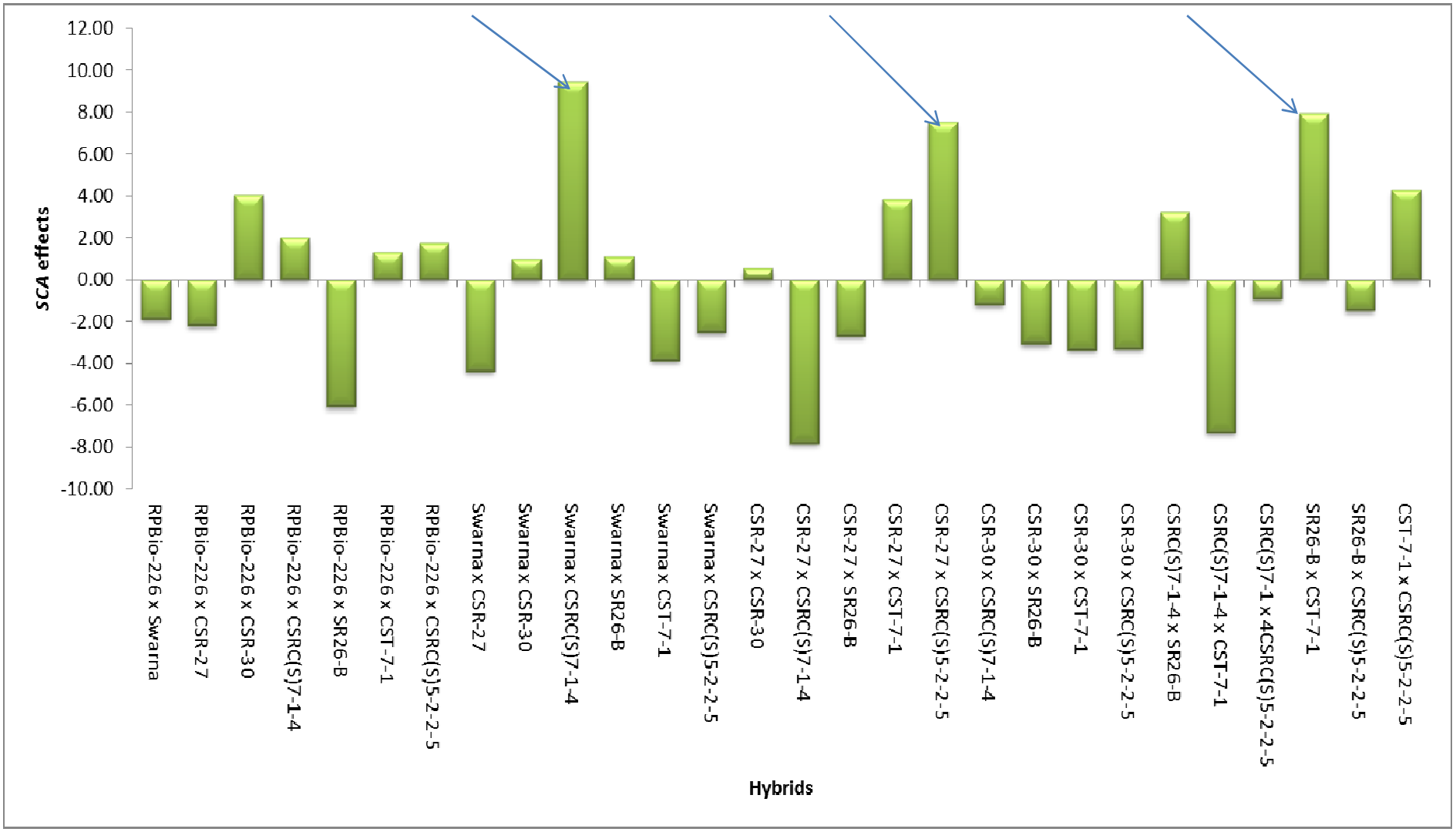
Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
RPBio-226×CSRC(S)5-2-2-5	**L × H**	**4.29**	**23.60**	**3.49**	**-0.04**
SR26-B×CST-7-1	**L × H**	**2.76**	**23.73**	**0.49**	**0.49**
Swarna×**CSRC(S)7-1-4**	**L × H**	**3.73**	**23.72**	**4.48**	**0.45**

Grain yield (g/plant)

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×**CSRC(S)7-1-4**	**L × H**	**9.47**	**24.22**	**19.08**	**8.24**
SR26-B×CST-7-1	**H × L**	**7.92**	**26.19**	**17.01**	**17.01**
CSR-27×CSRC(S)5-2-2-5	**L × H**	**7.51**	**22.17**	**27.58**	**-0.92**

SCA effects of 28 hybrids for grain yield plant^{-1} under saline soil conditions



SES for visual salt injury

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×CSR-30	H × L	-1.85	2.45	-60.24	-27.91
RPBio 226×Swarna	L × H	-1.81	2.48	-64.92	-27.23
CSR-30×CST-7-1	L × H	-1.71	2.53	-51.19	-25.66

Root / shoot ratio

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
SR26-B×CST-7-1	L × L	0.08	0.55	4.40	4.40
RPBio-226×CSRC(S)5-2-2-5	L × H	0.08	0.57	11.76	7.55
CSR-27×CSRC(S)5-2-2-5	L × H	0.08	0.56	6.29	6.29

Harvest index (%)

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
Swarna×CSRC(S)7-1-4	L × L	7.32	47.83	19.09	11.85
Swarna×CSR-30	L × L	7.07	43.57	22.61	1.87
CSR-27×CSRC (S)5-2-2-5	L × L	5.91	47.27	24.71	10.52

Na^+/K^+ ratio

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
RPBio-226×CSR-30	L × L	-0.66	1.51	-40.64	383.18
CSR-27×CSRC(S)5-2-2-5	L × H	-0.62	0.63	-48.77	75.70
RPBio-226×SR26-B	L × H	-0.60	0.78	-73.25	117.76

SPAD chlorophyll meter reading

Predominant gene action : Non additive

Crosses	*gca* effects	*sca* effects	*per se*	Heterosis	Heterobeltiosis
1) Swarna×**CSRC(S)7-1-4**	H × L	6.81	44.00	28.28	3.86
2) RPBio-226×CSR-30	L × L	6.41	37.70	31.36	-11.01
3) CST-7-1×CSRC(S)5-2-2-5	L × L	5.29	41.20	30.66	-2.75

Best specific combinations under saline soil condition

Hybrids	Characters
Swarna x CSRC(S)7-1-4	DFF, PL, PW, NFG, SF, TW, GY, SES, RSR, HI, Na^+/K^+ ratio, SCMR and YR. (13)
SR26-B x CST-7-1	PT, PL, PW, NFG, SF, TW, GY, SES, RSR and Na^+/K^+ ratio.(10)
RPBio-226 x CSR-30	DFF, TT, PT, PL, PW, NFG, TW, Na^+/K^+ ratio, SCMR and YR.(10)
RPBio-226 x CSRC(S)7-1-4	DFF, TT, PT, PW, SF, TW, SES, Na^+/K^+ ratio, SCMR and YR. (10)

Conclusions

Predominant gene action - Non additive

Selection criteria

No.of tillers/plant

No. of filled grains /panicle

Spikelet fertility (%)

SES for visual salt injury

Na^+/K^+ ratio

Promising parents - SR26B and CSRC(S)7-1-4

Promising cross combinations - Swarna/ CSRC(S)7-1-4
RP Bio-226/CSR-30

Breeding methodology - Heterosis breeding
Population improvement
methods , DSM and
Biparental mating systems


Thank You
ZWANI.COM