

7. Stability or changes in reaction to pathogens and grain yields and diversity analysis with DNA fingerprints of varieties

A. Reaction of varieties to Pathogens

Pyricularia oryzae

The data on repeat evaluation tests for the reaction of varieties to *P. oryzae* was compared with that of the original claim on resistance, moderate resistance or susceptibility of a variety as per the all-India coordinated multi-location tests (METs) at release for commercial cultivation. Leaving aside the two susceptible checks, the reaction of 118 varieties blast disease was categorized in METs and declared as 47 resistant (scores <5), 32 moderately resistant (scores ≤ 5 to <7) and 39 susceptible (scores ≥ 7) (Fig. 3). The current tests revealed (Table 4) changes in the numbers of varieties so classified; only 34 resistant, 60 moderately resistant and 24 were susceptible to blast infection in these repeat tests.

This changed reaction was analyzed further; only five varieties *viz.*, ASD18, Dhanrasi, DRRH2, Gurjari and Sabita had changed reaction to blast from resistance to susceptibility while seven other had changed from moderate resistance to susceptibility. Besides, 71 varieties had shown some changes from resistance to moderately resistance (27), moderate resistance to resistance (11) or to susceptibility (7), resistance to susceptibility (5), and susceptibility to moderate resistance (19) or to resistance (8 varieties) (Fig. 4).

The original disease scores claimed at release of varieties based on AICRIP's METs were compared for the varieties that showed a changed reaction from resistance to susceptibility to blast disease (Table 15). This change was due to the altered disease scores from 3.0 to 6.5 in three varieties and to 7 in two others. Change between old (claimed at release of a variety) and current reaction of rice variety to pathogens in repeat replicated tests in terms of disease scores in seven varieties from moderate resistance (MR) to susceptibility (S) are presented in Table 16. While six varieties had shown a changed reaction score from 6 to 7, only one *viz.*, Ratna changed from score 6 to 8.

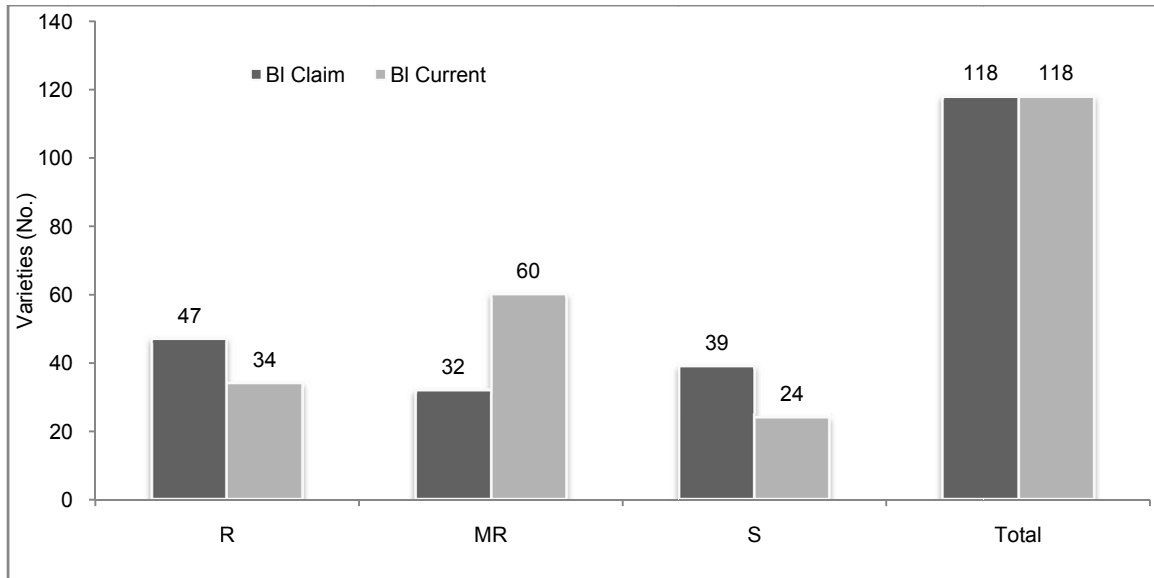


Figure 3. Frequency distribution of reaction of varieties to leaf blast (BI) claimed at release based on all-India coordinated multi-location tests (METs) and in the current repeat tests.

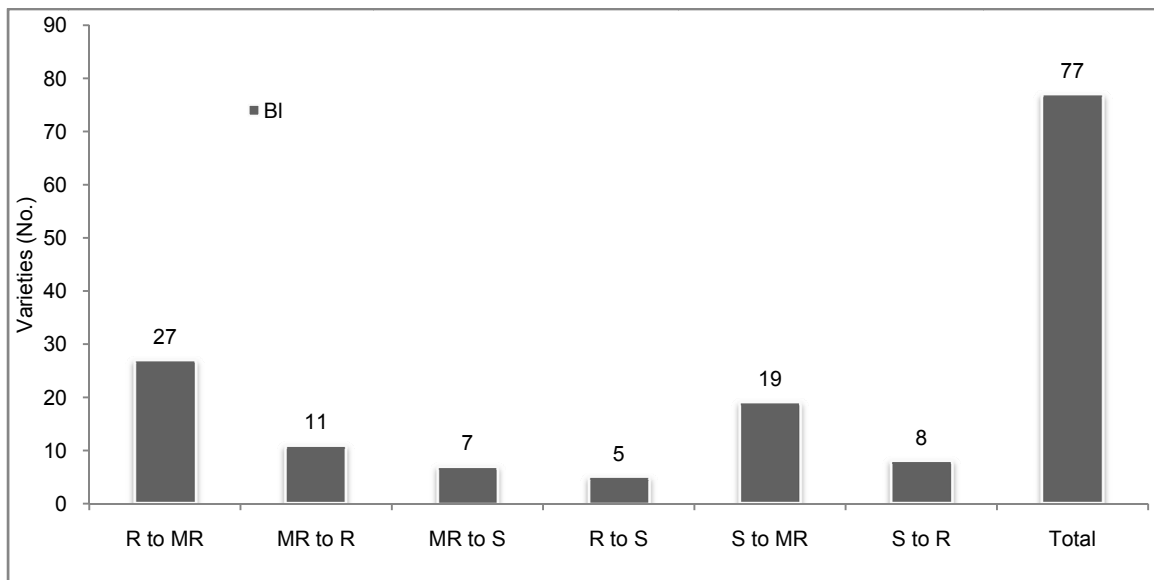


Figure 4. Frequency distribution of changed reaction of varieties to leaf blast in current repeat tests. R to MR = resistance to moderate resistance; MR to R = moderately resistant to resistance; MR to S = moderately resistant to susceptible; S to MR = susceptible to moderate resistance; S to R = susceptible to resistance.

Rhizoctonia solani

The data on repeat evaluation tests for the reaction of varieties to *R. solani* was compared with that of the original claim on resistance, moderate resistance or susceptibility of a variety as per the all-India coordinated multi-location tests (METs) at release for commercial cultivation. Leaving aside the two susceptible checks, the reaction of 118 varieties sheath blight disease was categorized in METs and declared as none resistant (scores <5), 22 moderately resistant (scores ≤ 5 to <7) and 96 susceptible (scores ≥ 7) (Fig. 5). The current tests revealed (Table 6) changes in the numbers of varieties so classified indicated that only 19 moderately resistant and 99 were susceptible to sheath blight infection.

This changed reaction (Table 6) was analyzed further which showed changed reaction limited to 25 varieties; 14 varieties had changed reactions to sheath blight from moderate resistance to susceptibility while 11 other varieties had changed from susceptibility to moderate resistance (Fig. 6).

Similar to the original disease scores claimed at release of varieties based on AICRIP's METs, no variety was resistant to sheath blight disease (Table 15). Change between old (claimed at release of a variety) and current reaction of rice variety to pathogens in repeat replicated tests in terms of disease scores from moderate resistance (MR) to susceptibility (S) are presented in Table 16. Nine varieties had shown a change from disease scores 6 to 7, while five others were with scores <7.8

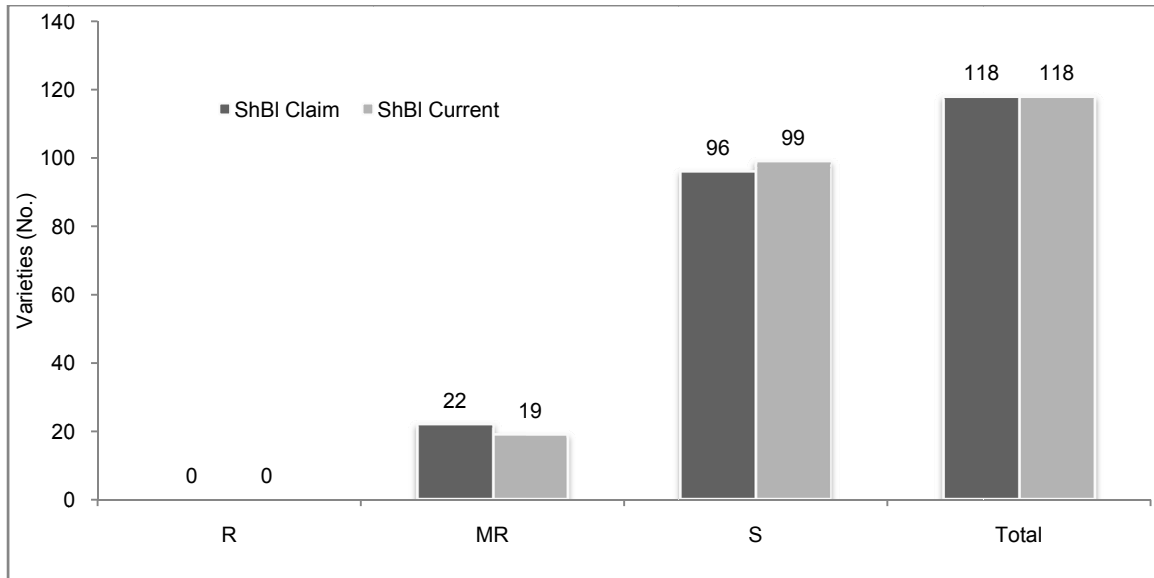


Figure 5. Frequency distribution of reaction of varieties to sheath blight (ShBI) claimed at release based on all-India coordinated multi-location tests (METs) and in the current repeat tests.

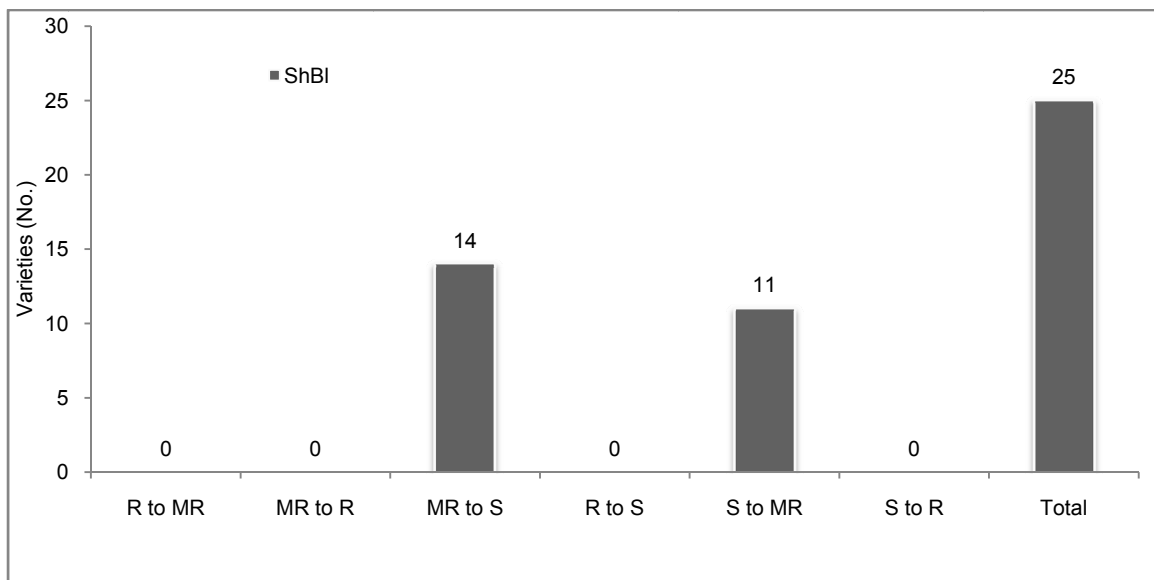


Figure 6. Frequency distribution of changed reaction of varieties to sheath blight in current tests. R to MR = resistance to moderate resistance; MR to R = moderately resistant to resistance; MR to S = moderately resistant to susceptible; S to MR = susceptible to moderate resistance; S to R = susceptible to resistance.

Xanthomonas oryzae pv. *oryzae*

The data on repeat evaluation tests for the reaction of varieties to *X. oryzae* pv. *oryzae* compared with that of the original claim on resistance, moderate resistance or susceptibility of a variety as per the all-India coordinated multi-location tests (METs) at release for commercial cultivation. Leaving aside the two susceptible checks, the reaction of 118 varieties to bacterial leaf blight disease was categorized in METs and declared as 9 resistant (scores <5), 26 moderately resistant (scores ≤ 5 to <7) and 83 susceptible (scores ≥ 7) (Fig. 7). The current tests revealed changes in the numbers of varieties so classified; this indicated that none was resistant, 21 moderately resistant and 97 were susceptible to bacterial leaf blight infection.

This changed reaction (Table 8) was analyzed further; only 6 varieties *viz.*, ADT36, GR101, IR36, PR111, PR116 and Sabita had changed reaction to bacterial leaf blight from resistance to susceptibility. Besides, 35 varieties had shown some changes from resistance to moderately resistance (3) or susceptibility (6), moderate resistance to susceptibility (17), and susceptibility to moderate resistance (9 varieties) (Fig. 8).

The original disease scores claimed at release of varieties based on AICRIP's METs were compared for the varieties that showed a changed reaction from resistance to susceptibility to bacterial leaf blight disease (Table 15). This change was due to the altered disease scores from 3.0 to 6.7 in three varieties, to 7.0 in two varieties, and to 7.8 in one other variety. Change between old (claimed at release of a variety) and current reaction of rice variety to pathogens in repeat replicated tests in terms of disease scores

from moderate resistance (MR) to susceptibility (S) are presented in Table 16. Six varieties had shown a changed reaction from scores 6 to 7, nine varieties from scores 6 to 8, Narendradhan118 from score 6 to 8.3 and ASD20 from 6 to 8.7.

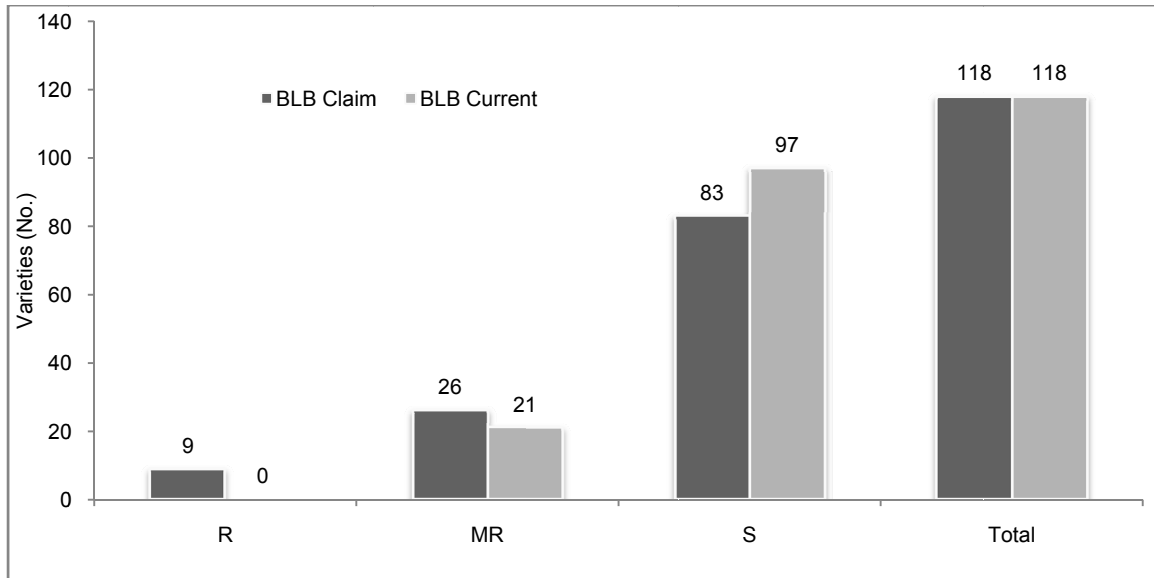


Figure 7. Frequency distribution of reaction of varieties to bacterial leaf blight (BLB) claimed at release based on all-India coordinated multi-location tests (METs) and in the current repeat tests.

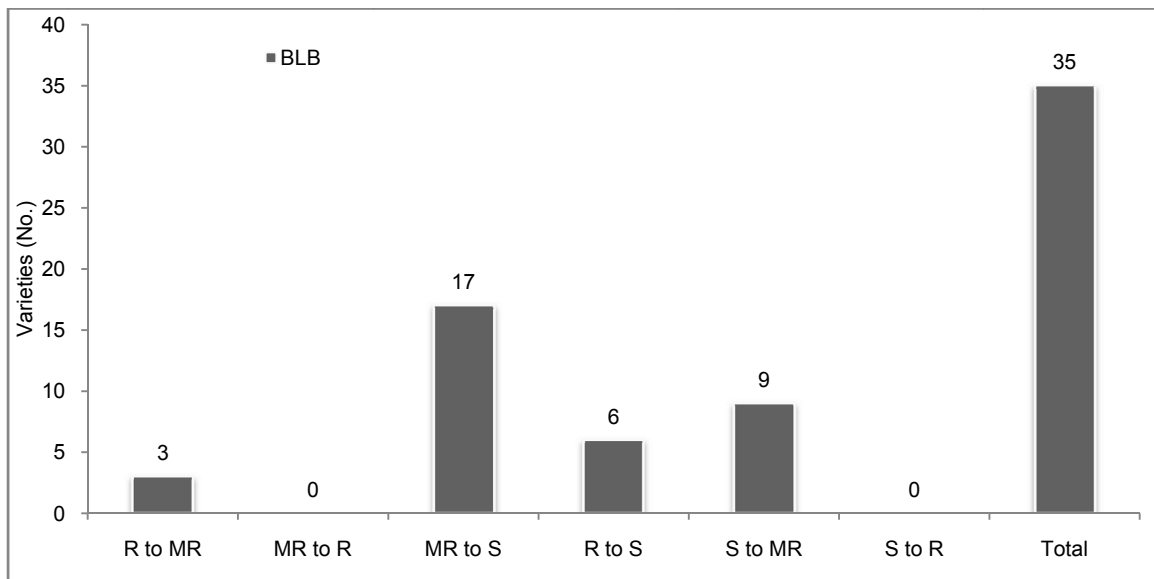


Figure 8. Frequency distribution of changed reaction of varieties to bacterial leaf blight in current tests. R to MR = resistance to moderate resistance; MR to R = moderately resistant to resistance; MR to S = moderately resistant to susceptible; S to MR = susceptible to moderate resistance; S to R = susceptible to resistance.

Rice tungro virus

The data on repeat evaluation tests for the reaction of varieties to rice tungro virus was compared with that of the original claim on resistance, moderate resistance or susceptibility of a variety as per the all-India coordinated multi-location tests (METs) at release for commercial cultivation. Leaving aside the two susceptible checks, the reaction of 118 varieties tungro virus disease was categorized in METs and declared as 5 resistant (scores <5), 17 moderately resistant (scores ≤ 5 to <7) and 96 susceptible (scores ≥ 7) (Fig. 9). The current tests revealed changes in the numbers of varieties so classified; this indicated that only 7 varieties resistant, 61 moderately resistant and 50 were susceptible to rice tungro virus infection.

This changed reaction (Table 10) was analyzed further; only 2 varieties *viz.*, Dinesh and DRRH2 had changed reaction to rice tungro virus from resistance to susceptibility while one other had changed from moderate resistance to resistance. In all, 58 varieties had shown some changes from resistance to moderately resistance (1), moderate resistance to resistance (1), moderate resistance to susceptibility (3), resistance to susceptibility (2) and susceptibility to moderate resistance (47) or to resistance (4 varieties).

The original disease scores claimed at release of varieties based on AICRIP's METs were compared for the varieties that showed a changed reaction from resistance to susceptibility to tungro virus disease (Table 15). This change was due to the altered disease from scores 3 to 7 in Dinesh, and to 8 in DRRH2. Change between old (claimed

at release of a variety) and current reaction of rice variety to pathogens in repeat replicated tests in terms of disease scores from moderate resistance (MR) to susceptibility (S) are presented in Table 16. Tulasi changed score from 6 to 7, while Dhanarasi and Narendradhan118 changed reaction from 6 to 8.2 and 8.3, respectively.

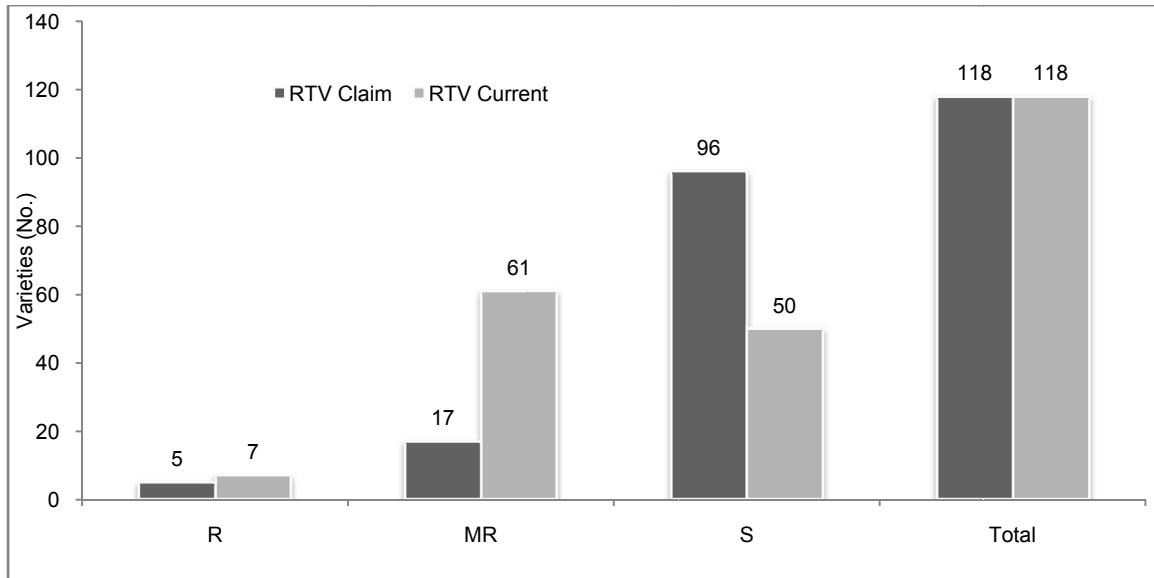


Figure 9. Frequency distribution of reaction of varieties to rice tungro virus (RTV) claimed at release based on all-India coordinated multi-location tests (METs) and in the current repeat tests.

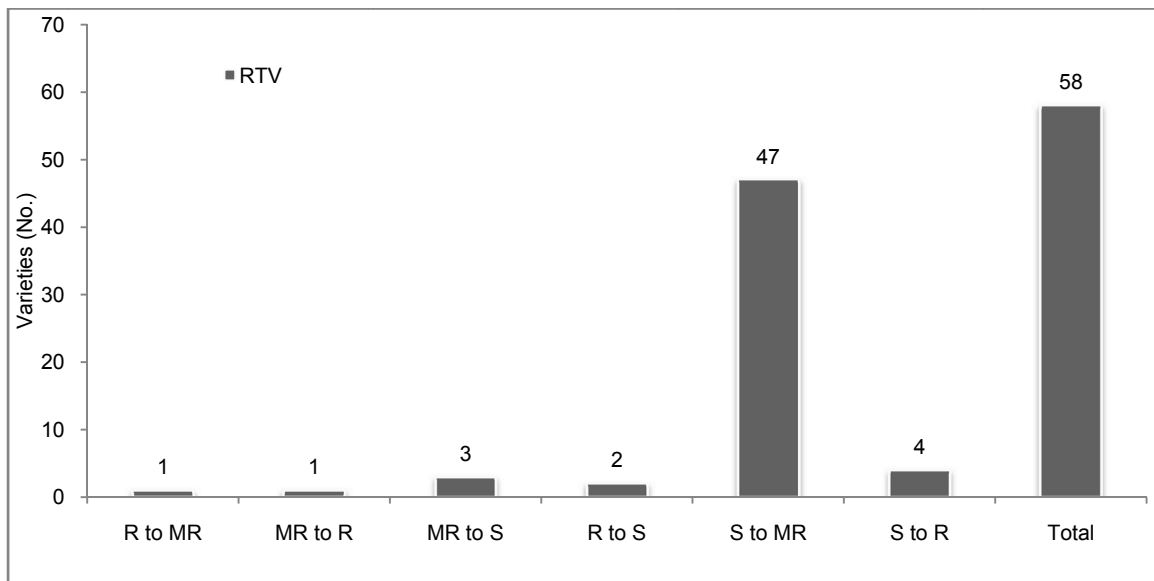


Figure 10. Frequency distribution of changed reaction of varieties to rice tungro virus in current tests. R to MR = resistance to moderate resistance; MR to R = moderately resistant to resistance; MR to S = moderately resistant to susceptible; S to MR = susceptible to moderate resistance; S to R = susceptible to resistance.

Table 15. Changes between old (claimed at release of a variety) and current reactions of rice varieties to pathogens in repeat replicated tests in terms of disease scores from resistance (R) to susceptibility (S).

Leaf blast			Sheath blight			Bacterial leaf blight			Rice tungro virus		
Variety	Old	Current	Variety	Old	Current	Variety	Old	Current	Variety	Old	Current
ASD18	3.0	6.5	Nil			ADT36	3.0	6.7	DINESH	3.0	7.0
DHANARASI	3.0	6.5				GR101	3.0	7.8	DRRH2	3.0	8.3
DRRH2	3.0	6.5				IR36	3.0	6.7			
GURJARI	3.0	7.0				PR111	3.0	7.0			
SABITA	3.0	7.0				PR116	3.0	7.0			
						SABITA	3.0	6.7			

Table 16. Changes between old (claimed at release of a variety) and current reactions of rice varieties to pathogens in repeat replicated tests in terms of disease scores from moderate resistance (MR) to susceptibility (S).

Leaf blast			Sheath blight			Bacterial leaf blight			Rice tungro virus		
Variety	Old	Current	Variety	Old	Current	Variety	Old	Current	Variety	Old	Current
AMULYA	6.0	7.0	AISWARYA	6.0	6.5	AMULYA	6.0	6.9	DHANARASI	6.0	8.2
COTTON DORA SANNALU	6.0	6.5	AMULYA	6.0	6.7	ASD20	6.0	8.7	NARENDRA 118	6.0	8.3
GR11	6.0	7.2	CO48	6.0	7.2	BHARANI	6.0	8.0	TULASI	6.0	7.0
GR3	6.0	6.8	COTTON DORA SANNALU	6.0	6.5	COTTON DORA SANNALU	6.0	8.0			
KHITISH	6.0	7.2	DINESH	6.0	7.8	DHANARASI	6.0	6.8			
RATNA	6.0	8.3	KANCHANA	6.0	7.2	GOVIND	6.0	7.0			
VIJETHA	6.0	6.5	KARJAT4	6.0	7.5	KARJAT3	6.0	7.3			
			KHARVELI	6.0	7.3	KHARVELI	6.0	6.7			
			PR113	6.0	7.2	KHITISH	6.0	7.6			
			PR114	6.0	7.7	MANA SAROVAR	6.0	7.7			
			PR115	6.0	7.2	NARENDRA DHAN 118	6.0	8.3			
			SWARNA	6.0	7.3	NARENDRA DHAN 97	6.0	7.5			
			TRIGUNA	6.0	6.7	PR114	6.0	6.7			
			VIKRAMARYA	6.0	7.7	SARJOO52	6.0	7.0			
						TKM9	6.0	7.2			
						TRIGUNA	6.0	7.7			
						TULASI	6.0	7.7			

B. Grain yields in varieties

The mean grain yields from each of the 100 varieties released for commercial cultivation over years tested for the three kharif and two rabi seasons were tabulated separately. Then a set of overall grain yields (mean yields t/ha) for each ecosystem for the two seasons (kharif first set and rabi second set of means) were calculated using this data.

A third set of mean grain yields was also derived based on regression models of Muralidharan et al (1996) for predicting kharif mean yields of rice varieties (see page 61) in irrigated (early and medium maturity), rainfed lowlands (photoperiod sensitive or insensitive and late maturity), semideep–deep water (photoperiod sensitive and late maturity) and rainfed upland (early maturity) ecosystems (Table 17).

While the overall model derived mean yield was 3.24 t/ha, the mean grain yields obtained seasons from varieties released was 3.50 t/ha in kharif and 4.0 t/ha in rabi seasons. Therefore, the mean yield (kg/ha) derived using models that were developed using AICRIP METs data of kharif seasons were adjusted by adding field estimated difference between khari and rabi to field estimation in rabi (fourth set of means).

The Pearson product-moment correlation coefficient is a measure of the linear correlation (dependence) between two variables *viz.*, mean yield obtained in field estimation of 100 varieties in three kharif seasons (first set) and model derived yield (third set), as well as between models derived mean yields adjusted for rabi yields (fourth set), and mean grain yields in field estimation of 100 varieties in rabi (second set).

Positive correlation coefficients (Table 17) were estimated for mean grain yields of varieties released for different ecosystems in kharif ($r = 0.578$ non-significant) and rabi ($r = 0.779$ highly significant at $P = 0.01$) seasons.

Table 17. Comparison of paired mean grain yields in field estimation of 100 varieties in kharif and rabi seasons with model[†] derived yields for difference rice ecosystems.

1	2	3	4	5	6
Ecosystem	Mean yield (kg/ha) field estimation of 100 varieties in kharif (First set)	Mean yield (kg/ha) field estimation of 100 varieties in rabi (Second set)	Difference between field estimation in kharif (col 3) and rabi (col 2)	Mean yield (kg/ha) derived using models for kharif [†] (Third set)	Mean yield (kg/ha) model adjusted and derived for rabi (by adding difference in col 4 to col 5) [†] (Fourth set)
HRIR	2.98	3.96	0.98	3.22	4.20
IRE	3.60	4.11	0.51	3.79	4.30
IRM	3.74	4.55	0.81	3.79	4.60
IRME	3.91	4.47	0.56	3.79	4.35
RSL	3.51	4.21	0.70	3.99	4.69
RUP	3.80	3.97	0.17	3.22	3.39
SCR	3.60	3.58	-0.02	3.79	3.77
SDW	3.12	4.11	0.99	2.19	3.18
DW	3.27	3.34	0.07	1.37	1.44
Mean	3.50	4.03		3.24	3.77
Variance	0.100	0.150		0.797	1.032
<i>F-value</i>				0.126 NS	0.145NS
<i>t-value</i>				-2.923 NS	-2.923**
Pearson Correlation				0.578 NS	0.779**

HRIR/HRUR = hill rice irrigated/upland; IRE = irrigated early maturity; IRME = irrigated mid-early maturity; IRM = irrigated medium maturity; RUP = rainfed upland; RSL = rainfed shallow lowland; SCR = scented rice; SDW = semideep water (30-50 cm water depth); DW = deep water (>50-100 cm water depth); [†] (Muralidharan et al 1996).

A comparison of mean grain yields in field estimation of 100 varieties in kharif seasons was made with model derived yields for different rice ecosystems (Fig. 11). The difference between the mean grain yields actually harvested in kharif seasons and Muralidharan et al (1996) models derived yield showed small decreases (0.05 to 0.48 t/ha) in yields in varieties released for hills (HRIR), irrigated (IRE, IRM, IRME), rainfed lowland (RSL) and scented rice (SCR) ecosystems. Altogether the total number of varieties tested in these six ecosystems was 87. However, there were increases (0.58, 0.93 and 1.9 t/ha) in a total of only 13 of the released varieties tested (9 for rainfed upland (RUP), and 2 each for semideep water (SDW) and deep water (DW) ecosystems). It is pertinent to point out that the yield tests in the present studies were made only in irrigated ecosystem at DRR Rajendranagar farm which apparently provided more favourable conditions for crop growth and productivity. Even granting for the deviation to high yields in 13 commercially released varieties than what was predicted with models, overall, a 87% of varieties tested produced stable grain yield that were near or negligibly different from the model predicted yields of the varieties (Fig. 11).

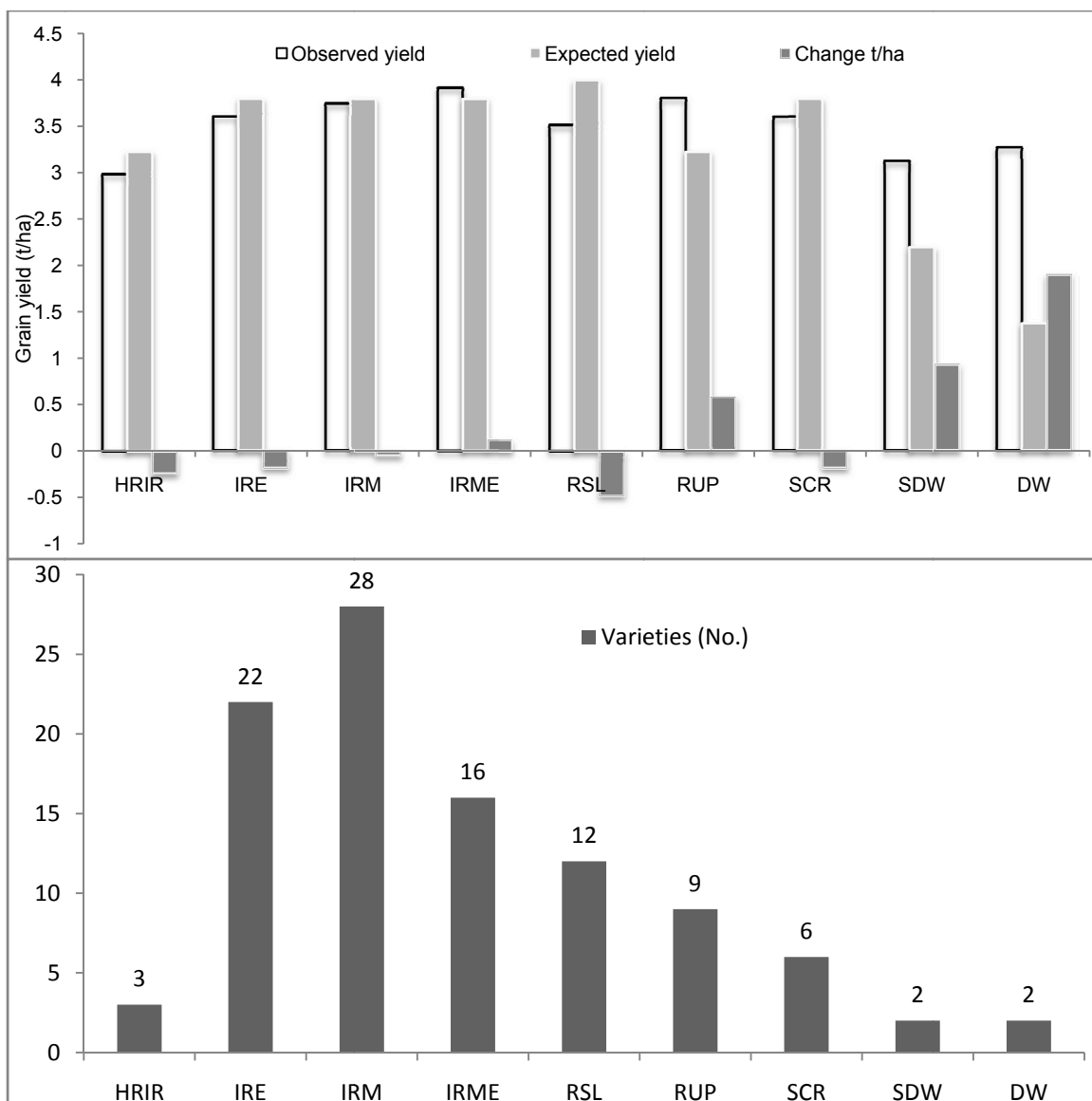


Figure 11. Comparison of mean grain yields in field estimation of 100 varieties in kharif seasons with model derived yields for difference rice ecosystems†

HRIR/HRUR = hill rice irrigated/upland; IRE = irrigated early maturity; IRME = irrigated mid-early maturity; IRM = irrigated medium maturity; RUP = rainfed upland; RSL = rainfed shallow lowland; SCR = scented rice; SDW = semideep water (30-50 cm water depth); DW = deep water (>50-100 cm water depth); † (Muralidharan et al 1996).