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Phenotypic screening of rice genotypes for identifying resistance sources against rice tungro virus disease

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Abstract
Host plant resistance has long been considered the most practical, environmentally sound, selective and effective means to combat a major destructive rice tungro virus disease. The disease is caused by the co-infection of a DNA virus (RTBV) & an RNA virus (RTSV) causing severe yield losses in rice crop. Therefore a large number of advanced breeding lines and germplasm which claimed to perform high level of resistance to tungro under the All India Coordinated Rice Pathology Program were collected from IIRR and rechecked for their consistency against rice tungro virus disease in the Plant Pathology glass house conditions (28 ± 2^0c, > 95% RH), Indian Institute of Rice Research. To facilitate selection, artificial inoculation techniques using vector aided transmission has been used in the greenhouse. Thus, the repeat evaluation tests revealed that among the 221 lines from National Screening Nurseries (2010-2015), 56 were resistant (scored 3) and 143 moderately resistant (scored 5) and 22 were susceptible (scored 7). Of the 86 lines, from Germplasm Screening Nurseries the current test exhibited 42 as resistant, 24 lines changed from resistant to moderate while 20 changed their reaction from resistant to susceptible by scoring 7 on the SES scale. The strategy of genetic evaluation programs through increased screening process aims to recombine different types and sources of resistance steadily through traditional breeding strategies.

Keywords: rice tungro virus disease, rice tungro bacilliform virus, rice tungro spherical virus, repeat evaluation tests

Introduction
The genus of the *Gramineae* family *Oryza* is considered to be the world's most important food crop besides serving as an untapped reservoir of genetic diversity. It is composed of two domesticated (*O.sativa* and *O.glaberrima*) and 22 wild species (Vaughan, 1994) [18] and represents between 15 and 25 million years of evolutionary diversification. *Oryza sativa* is grown globally while *Oryza glaberrima* has been cultivated in some restricted parts of West Africa. The rice plant has been the preferred model crop due to its small genome size, extensive genetic resources, ease of transformation and conserved synteny as compared with other cereal crops.

However, sustainable rice production is threatened by a variety of biotic stresses (insects, fungi, bacteria, viruses and weeds) and abiotic stresses (drought, flooding and extreme temperatures) (Dai and Beachy, 2009) [4]. Among the various biotic constraints, occurs a destructive and sporadic tungro virus disease (RTD) affecting the rice crop in South and Southeast Asia, estimated to cause a worldwide annual loss in rice production of approximately US $ 1.5 billion (Herdt, 1988) [5]. The two viral particles *viz.,* Rice tungro bacilliform virus (RTBV, genus Tungro virus, family Caulimoviridae) a pararetrovirus with a double stranded DNA genome and Rice tungro spherical virus (RTSV, genus Waikavirus, family Secoviridae), a plant picorna virus with a single – stranded (+)-sense RNA genome interact to allow disease development and full symptom expression of tungro disease. The monophagous nature of green leafhopper *N.virescens* (Distant) besides its close biological relationship with rice, makes it by far the most important vector species (Hibino and Cabunagan, 1986) [7] of tungro virus. The vector transmits both these DNA / RNA viruses in a semipersistant manner. However, RTBV depends on the helper produced by RTSV for its own transmission by the green leafhopper (Hibino, 1983) [6], and is mainly responsible for the severe tungro symptoms. The typical symptoms of rice infected with RTBV and RTSV are stunting (John, 1970) [9], yellow or yellow to orange discoloration of infected leaves, reduced tillering, sterile panicles and often irregular-shaped dark brown specks are visible on the leaves (Bunawan *et al.,* 2014) [3].

The application of appropriate techniques is needed for disease management in order to suppress disease to a tolerable level. This could be achieved by breeding for resistance to viruses, and its vectors green leaf hoppers through various national and germplasm screening nurseries / rice genotypes to accelerate genetic improvement of rice for resistance against tungro. The All India Coordinated Rice Pathology Program has an effective linkage and testing mechanism to assess large number of advanced breeding lines and germplasm over a wide range of ecologies, climatic and disease epidemic conditions at various locations coming under the state agricultural universities, national institutes, and departments of agriculture, agrochemical industry and others to identify specific and broad spectrum of resistance to major rice diseases. This helps in developing need based management methods to control major diseases of rice (Ravindrababu *et al.,* 2016) [14]. Keeping this in view, the present study has been aimed to select and recheck the lines that claimed to perform high level of resistance to tungro during the years 2010 – 2015. These entries included various nurseries from advanced breeding material (AVTs) in national screening nursery

1(NSN1), initial varietal trial entries (IVTs) in NSN2, entries bred for hill regions in NSNH and experimental hybrids in NHSN, donor screening nurseries (DSN) and germplasm screening nurseries (GSN). This could help in providing, a straight forward, durable, an effective and an environmentally sound approach in breeding for resistance to viruses and its vectors green leaf hoppers (GLH), as compared to control by insecticides.

Materials and Methods

For tungro incidence to occur, virus inoculums, presence of green leafhopper vectors and a susceptible crop are essential factors (Krishnaveni *et al.,* 2009) [10]. Green leaf hoppers vectors are attracted to young transplanted crop at the time when color changes from yellow to green. In the present investigation, 221 lines from National Screening Nurseries (2010-2015), 86 lines from Germplasm Screening Nurseries collected from IIRR were selected for testing their reaction against rice tungro virus disease by keeping cultivar Vikramarya as resistant check and T(N)1 as susceptible check and other rice genotypes recording distinct tungro symptoms, in the Plant Pathology glass house conditions (28 ± 2^0c, > 95% RH), Indian Institute of Rice Research (IIRR), Hyderabad. The screening of selected genotypes for their differential responses against rice tungro disease in the present investigation involves the following steps:

Artificial rearing of GLH

The main requirements for mass rearing of the rice green leafhopper, *Nephotettix virescens* are a green house, rearing cages, oviposition cages and plastic or metallic trays for the propagation of T(N)1 plants. The T(N)1 plants should be prepared for feeding the insects and for oviposition, before starting the mass rearing of green leaf hoppers. The T(N)1 seeds are sown in pots and grown until the one- leaf stage, followed by transplanting the seedlings in pots @ rate of 5 seedlings per pot at weekly intervals. Mass rearing of the insects can be initiated when the first batch of plants are 45 days old. Adult GLH are collected from rice fields with the help of a sweep net and about 500-1000 adult GLH are confined in a cage with 45 days old T(N)1 plants for 2-3 days oviposition (28 ± 2^0 c, > 95 % RH). The plants used for oviposition should be transferred to another cage and replaced with a fresh batch for oviposition. Clean the plants to be used for oviposition, remove the old leaves and leaf sheaths and wash the plants before introducing them into the cage to remove ants and predators. Maintain plants (45 days old T(N)1 plants) used for oviposition until the nymphs emerge into adults. Newly emerged adults are transferred to the oviposition cage and a new batch of adult insects are made available for every 2-3 days. Dead insects are replaced by additional adult insects for egg laying. Hence, a constant supply of insects can be maintained by continuing the process. The number of egg cages used may be adjusted according to the number of GLH required.

Maintainance of virus – infected rice plants

Mass screening for tungro resistance requires a constant supply of rice plants infected with both RTBV and RTSV. The inoculum source should be same when evaluating breeding, because use of multiple sources may result in different phenotypes. Tungro diseased plants from the field are identified, uprooted and transplanted in pots in the absence of tungro sources in the green house. The plants showing symptoms of severe yellowing and stunting can be assumed to be infected with both viruses and can be used as a source to propagate tungro diseased plants (Azzam *et al.,* 2000) [1]. The transmission of tungro viruses from diseased plants to healthy T(N)1 plants or other susceptible rice varieties is accomplished by viruliferous insects. A 4 days acquisition access is given to adult GLH on 45 days old virus source plants. Immediately after the acquisition feeding, these viruliferous adult insects were used for inoculation. Inside the insect cages T(N)1 plants are inoculated for about 4hrs with the viruliferous GLH @ rate of 3 insects / seedling. The inoculated T(N)1 plants are confined in the screen cages and observed for symptom expression for 2-3 weeks. These doubly infected plants are selected and kept as a virus source. The process is repeated and thus rice tungro disease is maintained.

Inoculation of rice genotypes with RTD by using insect vector GLH

Rice tungro disease was maintained on susceptible rice cv. T(N)1 utilized for screening of the rice genotypes against their reaction to the disease under controlled conditions. Seeds of one hundred and twenty (120) rice genotypes were soaked overnight in Petri dishes. After 3-4 days of germination, 20 seedlings/row were transplanted in seed boxes (69x26x9cm) comprising of 11 genotypes for each seed box along with rice cv. T(N)1 as susceptible and rice cvs.

Vikramarya and Nidhi as resistant checks. After 9 to 10 days of transplantation in seed boxes, rice seedlings were ready for inoculation with RTD infection. The seed box containing rice seedlings were placed inside the water tray with size of 97x65.5x30 cm which was again covered with top screen cage. Viruliferous green leafhopper population were released into the insect cage size (53x53x90 cm) at the rate of 6-7 insects per seedling with an inoculation access period of 2-3 h. The trays were filled with water until it covered the seedlings. Once the water level reached the seedlings the insects moved to the upper screen cage *i.e.*, cover screen cage of size 100x69.5x46 cm and it was removed.

The process was repeated for remaining rice genotypes. Viruliferous insects were again allowed to reacquire the virus overnight by placing RTD infected plants in the cage for inoculation in the succeeding days (up to 4 days).

Evaluation of rice genotypes against rice tungro virus infection (RTD)

456 rice genotypes/screening nurseries, inoculated with RTV infection (35 days old plants), were scored according to Standard Evaluation System for rice (SES scale of 1 to 9) proposed by IRRI (1996).

1 - No symptoms of x

3 - 1-10 % plant height reduction, with no distinct leaf discoloration

5 - 11-30 % plant height reduction, with no distinct leaf discoloration

7 - 31-50 % plant height reduction, with yellow to orange leaf discoloration

9 - More than 50 % plant height reduction, with yellow to orange leaf discoloration

The following formula was used to calculate average disease severity score in different rice genotypes against RTV infection.

$$\text{Average Disease Severity Score (DSS)} = \frac{1A1 + 3A3 + 5A5 + 7A7 + 9A9}{N}$$

Where A1, A3, A5, A7, A9 represents the number of plants rated based on 1, 3, 5, 7 and 9 scale reaction.
N = Total number of plants inoculated with RTV
The average disease severity score of each rice genotype comprising of 10 plants were taken and the per cent infection were used to categorize the rice genotypes against RTV infection. Rice genotypes with average disease severity score of 1-3 were subjected for further evaluation using forced tube inoculation method with 3-5 viruliferous insect vectors were fed with a single rice seedling in a test tube for 24 h. The inoculated rice seedlings were transplanted and kept in the glasshouse for visual expression of symptoms.

Table 1: Categorization of rice genotypes against RTD based on per cent infection (IRRI, 1996)

S. No.	RTV infection (%)	Categorization of rice genotypes
1.	0-30%	Resistant
2.	31-60%	Moderately resistant
3.	61-100%	Susceptible

Results and Discussion

The application of appropriate techniques to realize and comprehend the molecular and biochemical response of various genotypes of rice (susceptible and resistant) to virus infection (singly or mixed) had become necessary in order to understand the rice–RTD interactions, besides disease management. Therefore, breeding for resistance to viruses, and its vectors green leaf hoppers through various national and germplasm screening nurseries / rice genotypes to accelerate genetic improvement of rice for resistance against tungro had been employed. 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 multilocation tests (METs) at release for commercial cultivation. Leaving aside the susceptible - T(N) 1 and resistant - Vikramarya checks, the reaction of 221 lines which included NSN1, NSN2, NHSN and DSN to tungro virus disease were categorised in METs and declared all the screened lines as resistant (score 3). This changed reaction was further analyzed and it was observed that among 221 National screening lines, 56 were resistant (scored 3) and 143 moderately resistant (scored 5) and 22 were susceptible (scored 7). The current tests revealed changes in the numbers of screening nurseries so classified; this indicated that only 22 varieties were susceptible to rice tungro virus infection. The original disease score claimed at release of these lines based on AICRIP's METs were compared for the lines that showed a changed reaction from resistance to moderate and resistance to susceptible to tungro virus disease. Therefore, these 221 National screening lines had shown some changes from resistant to moderately resistant (143), resistant to susceptibility (22) and 56 remained resistant only. Change between old (claimed at release of a line) and their current reaction to pathogen in repeat replicated tests in terms of disease scores from resistance to moderate and resistance to susceptible to tungro virus disease are placed in (fig.1) (Table 1.a, 1.b, 1.c, 1.d). Similarly a change of reaction to tungro had been observed in Germplasm screening nursery (GSN), whereby the previous score claimed for all the 86 GSN lines was resistant (score 3). Later evaluation of the GSN revealed the change between old (claimed) and their current reaction to pathogen in repeat replicated tests in terms of disease scores. Therefore, of the 86 lines, the current test exhibited 42 as resistant with same score 3; 24 lines changed from resistant to moderate and scored disease score 5; while 20 changed their reaction from resistant to susceptible by scoring 7 on the SES scale. (Fig. 2) (Table 2.a, 2.b, 2.c, 2.d). The results of the present study are in agreement with the findings of Roseswar Rao (2014) [16] whose 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 to tungro virus disease were categorized in METs and declared as 5 resistant (scores ≤ 5 to < 7) and 96 susceptible (scores ≥ 7). The current tests revealed changes in the numbers of varieties so classified; this indicated that only 7 varieties were resistant, 61 were moderately resistant and 50 were susceptible to rice tungro virus infection. Our results are in line with previous reported evidence (Taghouti *et al.,* 2017) [17] indicating that the yellow color index in Moroccan Durum wheat grain *Triticum durum turgidum* var. L. *durum* presented first a decreasing trend compared to old varieties with a relative genetic gain RGG= -0.07% per year over time (1947- 2003). However, a change of yellow color index evolution occurred since 2003 where the RGG has increased and has reached 1.46% per year (2003-2017). Gluten strength also showed an increase over time with RGG passing from 0.22% per year to 1.93% per year during the first decade of the 2000s. Plants have developed a set of mechanisms to face the challenge of foreign pathogens through a long history of co-evolution (Muralidharan, 2005) [11]. The continuous changes in host plants, pathogens, production technology and environment are reasons for periodical re-evaluation of variety performances and adaptation. So, the aim of AICRIP program is to improve yielding ability, increase efficiency in the use of external inputs and incorporate resistance to biotic and abiotic stresses (Muralidharan and Siddiq, 1997) [12]. The multi-locational or multi-environmental (METs) testing of breeding stock developed at different research centers is organized by AICRIP. Analyses of old varieties help understand the yield potential and stability of varieties. Nsarellah *et al.* (2011) [13] re-assessed the adaptation of the main registered durum wheat (*Triticum turgidum* var.L. *durum*) varieties in Morocco. The varieties from the medium breeding era were widely adapted but were devoid of high yield potential in the more favourable environments. Internationally coordinated public wheat breeding efforts have focused in recent decades on increasing resistance to disease and abiotic stress (Reynolds and Borlaug, 2006; Braun *et al.*, 2010) [15, 2].
Increasingly it is felt important to rigorously re-test all the old varieties to assess their stability in the level of resistance and in grain production capacity.

Conclusion

Cultivation of resistant varieties is one of the best means and is the simplest and the most inexpensive method to combat against RTD. The importance of re-evaluation of

varieties under commercial cultivation was realized in all crops, more importantly in food grain crops as reports are continuously made on the level of yield losses from different cropped fields, districts, states or countries. Genetic uniformity invites disaster because it makes a crop vulnerable to attack from a pest or disease that strikes one plant and quickly spreads throughout the crop. Hence the objective had been aimed to re-evaluate the reaction (Susceptible, Moderate, Resistant) of originally claimed screening nurseries for their current performances to tungro infection.

Thus, it has become important for plant breeders for centuries to customize cultivars/screening nurseries for specific environments in order to better understand their role in breeding applications.

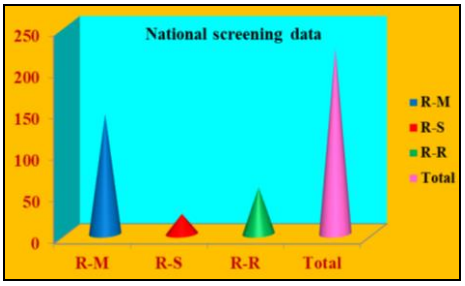

Fig 1: Frequency distribution of changed reaction of National screening lines (NSN 1, NSN 2, NHSN and DSN to Rice tungro disease claimed at release based on all –India coordinated multilocation tests (METs) and in the current repeat tests. R-M= Resistance to Moderate resistance; R-S = Resistance to Susceptible; R-R = Resistance to Resistance.

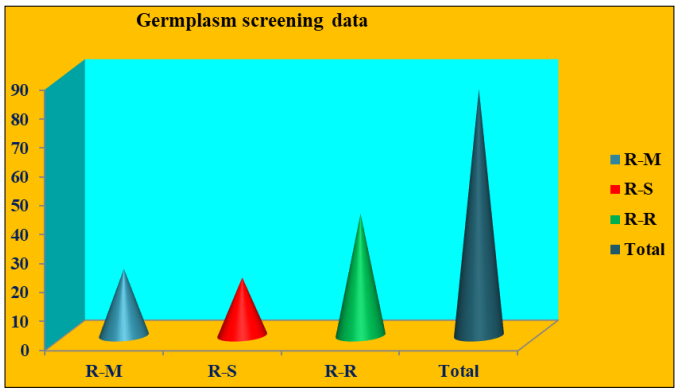

Fig 2: Frequency distribution of changed reaction of Germplasm screening nursery (GSN) to Rice tungro disease claimed at release based on all –India coordinated multilocation tests (METs) and in the current repeat tests.

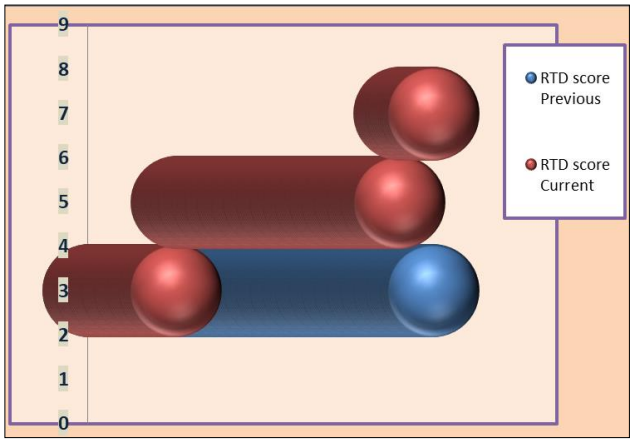

Fig 3: Overall graphical representation for changed reactions to RTD of National Screening Nurseries (2010-2015) in terms of Previous and Current Scores.

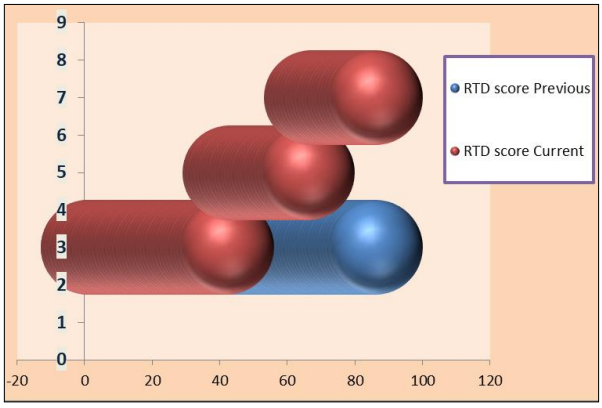

Fig 4: Overall graphical representation for changed reactions to RTD of Germplasm Screening Nurseries (2010-2015) in terms of Previous and Current Scores.

Tables

1.a, 1.b and 1.c represent the "Changes between old (claimed at release of a line) and current reaction of National screening lines to pathogen in repeat replicated tests in terms of disease scores from: (1.a) resistance to resistance; (1.b) resistance to moderate and (1.c) resistance to susceptible to tungro virus disease".

Table 1a

S. No.	Year	Nursery	IET No.	RTD score	
				Previous	Current
1	2010	NSN 1	21683	3	3
2	2010	NSN 1	20827	3	3
3	2010	NSN 1	21281	3	3
4	2010	NSN 1	21419	3	3
5	2010	NSN 1	21477	3	3
6	2010	NSN-1	21281	3	3
7	2010	NSN-1	20114	3	3
8	2010	NSN-2	21873	3	3
9	2010	NSN-2	21354	3	3
10	2010	NSN-2	21709	3	3
11	2010	DSN	RP Patho-2	3	3
12	2010	DSN	RP Patho-3	3	3
13	2010	DSN	CR 2429-5	3	3
14	2010	DSN	CB 07-115	3	3
15	2010	DSN	TNRH 233	3	3
16	2010	NSN 1	HR 12	3	3
17	2010	NSN 2	21996	3	3
18	2010	NSN 2	22001	3	3
19	2010	NSN 2	21726	3	3
20	2010	NSN 2	21735	3	3
21	2011	NSN 1	Badshabhog	3	3
22	2011	NSN 2	21895	3	3
23	2011	NSN 2	22451	3	3
24	2011	NSN-1	21346	3	3
25	2011	NSN-1	21411	3	3
26	2011	NSN-1	21573	3	3
27	2011	NSN-1	21686	3	3
28	2012	NSN 1	22859	3	3
29	2012	NSN 2	22674	3	3
30	2012	NSN 1	21839	3	3
31	2012	NSN 1	21855	3	3
32	2012	NSN 1	22155	3	3
33	2013	NSN 1	23110	3	3
34	2014	NSN 1	23647	3	3
35	2014	NSN 1	23695	3	3
36	2014	NSN 1	24116	3	3
37	2014	NSN 1	23596	3	3
38	2014	NSN 1	23193	3	3
39	2014	NSN-1	23804	3	3
40	2014	DSN	21751	3	3
41	2014	DSN	22164	3	3
42	2014	DSN	RP Patho-8	3	3
43	2014	NSN 2	24558	3	3
44	2014	DSN	-	3	3
45	2014	DSN	-	3	3
46	2014	DSN	-	3	3
47	2014	DSN	-	3	3
48	2014	DSN	-	3	3
49	2014	DSN	-	3	3
50	2014	DSN	-	3	3
51	2015	NSN 1	DHMASQ 1642B	3	3
52	2015	NSN 2	24489	3	3
53	2015	NSN 2	25224	3	3
54	2015	NSN 2	25184	3	3
55	2015	NHSN	24959	3	3
56	2015	DSN	RP-Patho-10	3	3

Table 1b

S. No.	Year	Nursery	IET No.	RTD score	
				Previous	Current
1	2010	NSN 1	21289	3	5
2	2010	NSN 1	20744	3	5
3	2010	NSN 1	21558	3	5
4	2010	NSN 1	21576	3	5
5	2010	NSN 1	21433	3	5
6	2010	NSN 1	21208	3	5
7	2010	NSN 1	21278	3	5
8	2010	NSN-1	21476	3	5
9	2010	NSN-1	21477	3	5
10	2010	NSN-2	21708	3	5
11	2010	NSN 1	KRH 2	3	5
12	2010	NSN 1	IR 50	3	5
13	2010	NSN 2	21865	3	5
14	2010	NSN 2	21870	3	5
15	2010	NSN 2	21873	3	5
16	2010	NSN 2	21879	3	5
17	2010	NSN 2	21354	3	5
18	2010	NSN 2	21342	3	5
19	2010	NSN 2	20706	3	5
20	2010	NSN 2	21703	3	5
21	2010	NSN 2	21704	3	5
22	2010	NSN 2	21708	3	5
23	2010	NSN 2	21709	3	5
24	2010	NSN 2	21711	3	5
25	2010	NSN 2	21718	3	5
26	2010	NSN 2	21719	3	5
27	2010	NSN 2	21978	3	5
28	2010	NSN 2	21984	3	5
29	2010	NSN 2	22002	3	5
30	2010	NSN 2	22003	3	5
31	2010	NSN 2	21954	3	5
32	2010	NSN 2	21965	3	5
33	2010	NSN 2	21235	3	5
34	2010	NSN 2	21737	3	5
35	2010	NSN 2	21916	3	5
36	2010	NSN 2	21909	3	5
37	2010	NSN 2	21222	3	5
38	2010	NSN 2	21231	3	5
39	2010	NSN 2	21851	3	5
40	2010	NSN 2	22213	3	5
41	2010	NSN 2	22214	3	5
42	2010	NSN 2	22141	3	5
43	2010	NHSN	IR 64	3	5
44	2010	DSN	Ragolu-(RGL-7001)	3	5
45	2011	NSN 1	21793	3	5
46	2011	NSN 2	22658	3	5
47	2011	NSN 2	22682	3	5
48	2011	NHSN	PR113/Lalat/Sasyasree/MTU 1010	3	5
49	2011	NSN-1	21423	3	5
50	2011	NSN-1	21523	3	5
51	2011	NSN-2	21883	3	5
52	2011	NSN-2	21895	3	5
53	2011	NSN-2	22311	3	5
54	2011	NSN-2	22619	3	5
55	2012	NSN 2	23144	3	5
56	2012	NSN 2	23145	3	5
57	2012	NSN 2	23160	3	5
58	2012	NSN 2	23163	3	5
59	2012	NSN 2	23164	3	5
60	2012	NSN 2	23187	3	5
61	2012	DSN	GSR 113	3	5
62	2012	NSN 2	22494	3	5
63	2013	NSN 1	Jalmagna	3	5
64	2013	NSN 1	23480	3	5

65	2013	NSN-1	23110	3	5
66	2013	NSN-1	23275	3	5
67	2013	NHSN	24116	3	5
68	2013	NHSN	24118	3	5
69	2013	NHSN	24145	3	5
70	2013	NHSN	24148	3	5
71	2013	NHSN	24150	3	5
72	2013	DSN	RP-Patho-12	3	5
73	2013	DSN	VL 31630	3	5
74	2013	NSN 2	23939	3	5
75	2013	NSN 2	23772	3	5
76	2013	NSN 2	22624	3	5
77	2013	NSN 2	24002	3	5
78	2013	NSN 2	23960	3	5
79	2013	NSN 2	23965	3	5
80	2014	NSN 1	23832	3	5
81	2014	NSN 1	24003	3	5
82	2014	NSN 1	23467	3	5
83	2014	NSN 1	23455	3	5
84	2014	NSN 1	23984	3	5
85	2014	NSN 1	23947	3	5
86	2014	NSN 1	24166	3	5
87	2014	NSN 2	24240	3	5
88	2014	NSN 2	24241	3	5
89	2014	NSN 2	24274	3	5
90	2014	NSN 2	24449	3	5
91	2014	NSN-2	24449	3	5
92	2014	DSN	22603	3	5
93	2014	NSN 2	23897	3	5
94	2014	NSN 2	24492	3	5
95	2014	NSN 2	24500	3	5
96	2014	NSN 2	24506	3	5
97	2014	NSN 2	24306	3	5
98	2014	NSN 2	24311	3	5
99	2014	NSN 2	24340	3	5
100	2014	NSN 2	24586	3	5
101	2014	NSN 2	24590	3	5
102	2014	NSN 2	24424	3	5
103	2014	NSN 2	24426	3	5
104	2014	NSN 2	24551	3	5
105	2014	NSN 2	24557	3	5
106	2014	NSN 2	24682	3	5
107	2014	NSN 2	24529	3	5
108	2014	NSN 2	24363	3	5
109	2014	NSN 2	24384	3	5
110	2014	NSN 2	24406	3	5
111	2014	NSN 2	24661	3	5
112	2014	NSN 2	24663	3	5
113	2014	NSN 2	23814	3	5
114	2014	NSN 2	24782	3	5
115	2014	NSN 2	24746	3	5
116	2014	NSN 2	24721	3	5
117	2014	NSN 2	24738	3	5
118	2014	NHSN	24794	3	5
119	2014	NHSN	24806	3	5
120	2014	NHSN	NDR-359	3	5
121	2014	NHSN	24865	3	5
122	2014	NHSN	24877	3	5
123	2014	NHSN	24888	3	5
124	2014	DSN	-	3	5
125	2014	DSN	-	3	5
126	2014	DSN	-	3	5
127	2014	DSN	-	3	5
128	2014	DSN	-	3	5
129	2014	DSN	-	3	5
130	2014	DSN	-	3	5
131	2015	NSN 1	24028	3	5
132	2015	NSN 1	24424	3	5

133	2015	NSN 1	24630	3	5
134	2015	NSN 1	24359	3	5
135	2015	NSN 1	24825	3	5
136	2015	NSN 1	24310	3	5
137	2015	NSN 1	24708	3	5
138	2015	NSN 1	Tetep	3	5
139	2015	NSN 1	Tetep	3	5
140	2015	NSN 2	Sabita	3	5
141	2015	NSN-1	23272	3	5
142	2015	NSN-1	24570	3	5
143	2015	NHSN	24888	3	5

Table 1c

S. No.	Year	Nursery	IET No.	RTD score	
				Previous	Current
1	2010	NSN 1	21009	3	7
2	2010	NSN 1	21528	3	7
3	2010	NSN 1	21469	3	7
4	2010	NSN 1	21204	3	7
5	2010	NSN 1	CH 45	3	7
6	2010	NSN 2	21878	3	7
7	2010	NSN 2	21986	3	7
8	2010	NSN 2	21972	3	7
9	2010	NSN 2	21226	3	7
10	2013	NSN 1	Dinesh	3	7
11	2014	NSN 1	24100	3	7
12	2014	NSN 1	23831	3	7
13	2014	NSN 2	24249	3	7
14	2014	NSN 2	24269	3	7
15	2014	NSN 2	24448	3	7
16	2014	DSN	RPDN-198	3	7
17	2014	NSN 2	23785	3	7
18	2014	NSN 2	24636	3	7
19	2014	NSN 2	24718	3	7
20	2014	DSN	-	3	7
21	2015	NSN 1	CST 7-1	3	7
22	2015	NSN 1	24640	3	7

Table 1d: Categorization of changed reaction of national screening lines of rice against tungro disease under field conditions during the Kharif 2010-2015.

S. No.	Category	IET No's- NSN 1, NSN 2, NHSN, DSN
1.	Resistant to Resistant (3-3 Score)	21683, 20827, 21281, 21419, 21477, 21281, 20114, 21873, 21354, 21709, RP Patho-2, RP Patho-3, CR 2429-5, CB 07-115, TNRH 233, HR 12, 21996, 22001, 21726, 21735, Badshabhog, 21895, 22451, 21346, 21411, 21573, 21686, 22859, 22674, 21839, 21855, 22155, 23110, 23647, 23695, 24116, 23596, 23193, 23804, 21751, 22164, RP Patho-8, 24558, DHMASQ 1642B, 24489, 25224, 25184, 24959, RP-Patho-10.
2.	Resistant to Moderately resistant (3-5 score)	21558, 21576, 21433, 21208, 21278, 21476, 21477, 21708, KRH 2, IR 50, 21865, 21870, 21873, 21879, 21354, 21342, 20706, 21703, 21704, 21708, 21709, 21711, 21718, 21719, 21978, 21984, 22002, 22003, 21954, 21965, 21235, 21737, 21916, 21909, 21222, 21231, 21851, 22213, 22214, 22141, IR 64, Ragolu-(RGL-7001), 21793, 22658, 22682, PR113/Lalat/Sasyasree/MTU 1010, 21423, 21523, 21883, 21895, 22311, 22619, 23144, 23145, 23160, 23163, 23164, 23187, 22494, Jalmagna, 23480, 23110, 23275, 24116, 24118, 24145, 24148, 24150, RP-Patho-12, VL 31630, 577098, 23939, 23772, 22624, 24002, 23960, 23965, 23832, 24003, 23467, 23455, 23984, 23947, 24166, 24240, 24241, 24274, 24449, 24449, 22603, 23897, 24492, 24500, 24506, 24306, 24311, 24340, 24586, 24590, 24424, 24426, 24551, 24557, 24682, 24529, 24363, 24406, 24661, 24663, 23814, 24782, 24746, 24721, 24738, 24794, 24806, NDR-359, 24865, 24877, 24888, 24028, 24028, 24424, 24630, 24359, 24825, 24310, 24708, Tetep, Sabita, 23272, 24570, 24888.
3.	Resistant to Susceptible (3-7 score)	21009, 21528, 21469, 21204, CH 45, 21878, 21986, 21972, 21226, Dinesh, 24100, 23831, 24249, 24269, 24448, RPDN-198, 23785, 24636, 24718, CST 7-1, 24640.

Table

2a, 2b, 2c, represent the "Changes between old (claimed at release of a line) and current reaction of Germpalsm screening lines to pathogen in repeat replicated tests in terms of disease scores from: (2.a) resistance to resistance; (2.b) resistance to moderate and (2.c) resistance to susceptible to tungro virus disease" Table 2.a

Table 2a

S. No.	Year	Nursery	ACC. No.	RTD score	
				Previous	Current
1	2010	GSN	232	3	3
2	2010	GSN	239	3	3
3	2010	GSN	257	3	3
4	2010	GSN	1447	3	3
5	2010	GSN	2137	3	3
6	2010	GSN	2269	3	3
7	2010	GSN	2296	3	3
8	2010	GSN	2415A	3	3
9	2010	GSN	2420	3	3
10	2010	GSN	2569B	3	3
11	2010	GSN	2633	3	3
12	2010	GSN	2643	3	3
13	2010	GSN	2711	3	3
14	2010	GSN	2834	3	3
15	2010	GSN	2841	3	3
16	2010	GSN	2856	3	3
17	2010	GSN	3764	3	3
18	2011	GSN	545467	3	3
19	2011	GSN	545470	3	3
20	2011	GSN	450164	3	3
21	2011	GSN	545488	3	3
22	2011	GSN	460015	3	3
23	2011	GSN	463239	3	3
24	2011	GSN	576993	3	3
25	2011	GSN	463274	3	3
26	2011	GSN	462362	3	3
27	2011	GSN	462394	3	3
28	2011	GSN	463328	3	3
29	2011	GSN	462500	3	3
30	2011	GSN	577079	3	3
31	2011	GSN	463609	3	3
32	2011	GSN	465001	3	3
33	2011	GSN	464997	3	3
34	2012	GSN	346207	3	3
35	2014	GSN	85720	3	3
36	2014	GSN	85754	3	3
37	2014	GSN	86035	3	3
38	2014	GSN	208050	3	3
39	2014	GSN	248014	3	3
40	2014	GSN	276834	3	3
41	2014	GSN	462040	3	3
42	2014	GSN	462121	3	3

Table 2b

S. No.	Year	Nursery	ACC. No.	RTD score	
				Previous	Current
1	2010	GSN	244	3	5
2	2010	GSN	245	3	5
3	2010	GSN	246	3	5
4	2010	GSN	256	3	5
5	2010	GSN	2247	3	5
6	2010	GSN	2293	3	5
7	2010	GSN	2415B	3	5
8	2010	GSN	2519	3	5
9	2010	GSN	2795	3	5
10	2010	GSN	2187	3	5
11	2010	GSN	2914	3	5
12	2010	GSN	4326	3	5
13	2010	GSN	4740	3	5
14	2010	GSN	5103	3	5
15	2011	GSN	463070	3	5
16	2011	GSN	463272	3	5
17	2011	GSN	462459	3	5
18	2011	GSN	463581	3	5

19	2013	GSN	577098	3	5
20	2014	GSN	86091	3	5
21	2014	GSN	86114	3	5
22	2015	GSN	75960	3	5
23	2015	GSN	76033	3	5
24	2015	GSN	216596	3	5

Table 2c

S. No.	Year	Nursery	ACC. No.	RTD score	
				Previous	Current
1	2010	GSN	2142	3	7
2	2010	GSN	2179	3	7
3	2010	GSN	2234	3	7
4	2010	GSN	2291	3	7
5	2010	GSN	2581	3	7
6	2010	GSN	2595	3	7
7	2010	GSN	2632	3	7
8	2010	GSN	2836	3	7
9	2010	GSN	2867	3	7
10	2010	GSN	4288	3	7
11	2010	GSN	4611	3	7
12	2010	GSN	4648	3	7
13	2011	GSN	463044	3	7
14	2011	GSN	466352	3	7
15	2011	GSN	463267	3	7
16	2011	GSN	463334	3	7
17	2011	GSN	577093	3	7
18	2011	GSN	464971	3	7
19	2015	GSN	461079	3	7
20	2015	GSN	216856	3	7

Table 2d: Categorization of changed reaction of germplasm screening lines of rice against tungro disease under field conditions during Kharif 2015

S. No.	Category	Accession No's of GSN
1.	Resistant to Resistant (3-3 Score)	232, 239, 257, 1447, 2137, 2269, 2296, 2415A, 2420, 2569B, 2633, 2643, 2711, 2834, 2841, 2856, 3764, 545467, 545470, 450164, 545488, 460015, 463239, 576993, 463274, 462362, 462394, 463328, 462500, 577079, 463609, 465001, 464997, 346207, 85720, 85754, 86035, 208050, 248014, 276834, 462040, 462121.
2.	Resistant to Moderately Resistant (3-5 score)	244,245, 256, 2247, 2293, 2415B, 2519, 2795, 2187, 2914, 4326, 5103, 4740, 86114, 463070, 463272, 462459, 463581, 86091, 75960, 76033, 216596,
3.	Resistant to Susceptible (3-7 score)	2142, 2179, 2234, 2291, 2581, 2595, 2632, 2836, 2867, 4288, 4611, 4648, 463044, 466352, 463267, 463334, 577093, 464971, 461079, 216856

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