SCREENING OF PEARL MILLET GERMPLASM AGAINST RUST CAUSED BY *PUCCINIA SUBSTRIATA* VAR. *PENICILLARIAE*

ANNU*, KUSHAL RAJ, POOJA SANGWAN AND NARENDER SINGH

Department of Plant Pathology
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
*(e-mail : vermaannu06@gmail.com)

SUMMARY

Rust caused by *Puccinia substriata* var. *penicillariae* is one of the major diseases affecting both food grain and forage production in pearl millet. In order to find out economical and cost effective method to manage the disease, attempts were made to identify resistance sources against rust by screening of germplasm. The field screening involved the use of a highly susceptible line as infector row grown after every three test rows under natural epiphytotic conditions. Observations on rust severity were recorded at grain filling stage. In all, 228 entries of coordinated trials, none of the entries was free from rust severity, 10 entries showed 0.1-20 per cent rust severity, 48 entries showed 20.1-40 per cent rust severity, 80 entries showed 40.1-60 per cent rust severity, 67 entries showed 60.1-80 per cent rust severity and 23 entries showed more than 90 per cent rust severity. Amongst 276 entries of state trials, 39 entries were free from rust severity, 188 entries showed 0.1-20 per cent rust severity, 71 entries showed 20.1-40 per cent rust severity, 15 entries showed 40.1-60 per cent rust severity, two entries showed 60.1-80 per cent rust severity and none of the entries showed more than 80 per cent rust severity.

Key words : Ruse, disease, germplasm, pearl millet

Pearl millet [*Pennisetum glaucum* (L.) R. Br. Syn. *Pennisetum americanum* (L.) Leeke] is an important staple cereal in the arid and semi-arid region of the world, particularly in Asia and Africa. In India, this crop is mostly grown in the states of Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, parts of Delhi, Punjab and Uttar Pradesh and the total production of crop was 9.25 mt with an area of 7.89 m ha during 2013-14 (Anonymous, 2013-14). The yield of pearl millet has increased considerably with the introduction of hybrids, but these have become susceptible to fungal diseases. Amongst those, rust is one of major diseases in pearl millet growing areas of the world. *Puccinia substriata* var. *indica* Ramchar and Cumm (Syn : *Puccinia substriata* Ell. and Barth. var. *penicillariae* (Carvalho *et al.,* 2006), *Puccinia penniseti* Zimm), causes rust disease and has been observed throughout pearl millet growing areas in India. Rust in pearl millet not only reduces grain yield but also reduces the digestible dry matter yield. All growth stages of the plant are susceptible to rust attack and under favourable environment, plants can wither before flowering due to severe rust infection. Use of host plant resistance is the most feasible and economical mean for managing this disease as the crop is mainly cultivated by resource-poor farmers. Resistance to rust has been reported in some pearl millet germplasm accessions and breeding lines (Singh *et al.,* 1997). The present investigation, therefore, was undertaken to evaluate hybrid parental lines of pearl millet for resistance to rust in the era to come.

MATERIALS AND METHODS

In this planned experiment, a total of 504 pearl millet genotypes were collected under All India Coordinating Research Project (AICRP) and state trials of pearl millet. These lines were screened in field under natural epiphytotic conditions of disease development during **kharif** 2015 in the experimental area of Plant Pathology, CCSHAU, Hisar. The test rows were sown on 17 July 2015. All the recommended agronomic practices were adopted for raising the crop. Observations on rust severity at maturity were recorded at the grain filling stage using modified rust severity scale as per Plate 1 and the test entries were categorized in different grades on the basis of rust severity range.
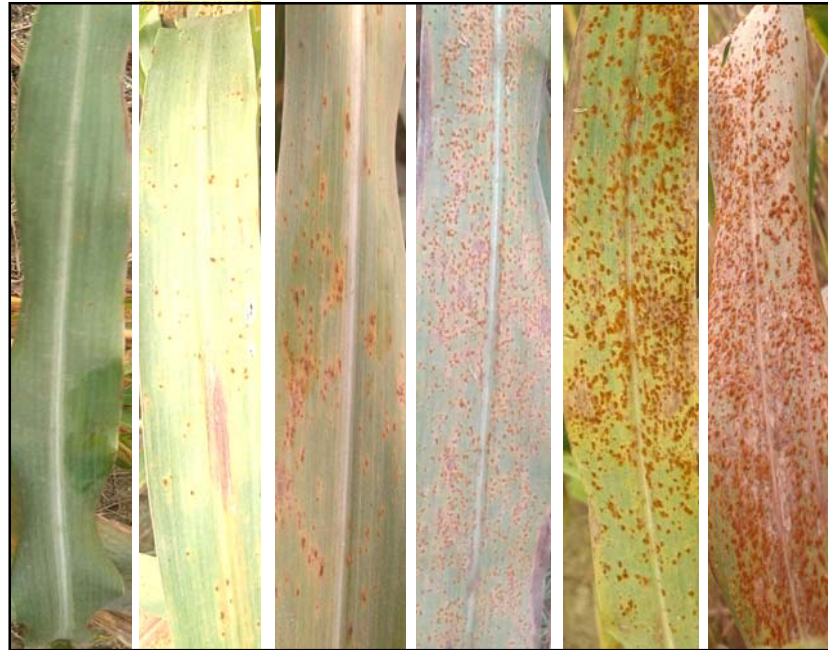
Grade	0	1	2	3	4	5
Rust severity (%)	0	0.1-20	20.1-40	40.1-60	60.1-80	80.1-100
Type	Immune	Resistant	Moderately resistant	Moderately susceptible	Susceptible	Highly susceptible

Plate 1. Modified rust severity scale.

Disease severity categorization

Grade	Rust severity range (%)	Type
0	0	Immune/highly resistant (HR)
1	0.1-20	Resistant (R)
2	20.1-40	Moderately resistant (MR)
3	40.1-60	Moderately susceptible (MS)
4	60.1-80	Susceptible (S)
5	80.1-100	Highly susceptible (HS)

RESULTS AND DISCUSSION

In general, rust severity in susceptible line was quite high both in coordinated and state trials. Among 228 entries of coordinated trials comprising initial varietal trial (IVT) (Table 1), advance varietal trial (AVT) (Table 2) and final yield trial (FYT) (Table 3), rust severity ranged from 0.1 to 100 per cent with maximum number of entries lied in the range of 60.1-80 per cent rust severity. None of the entries was free from rust, 10 entries viz., four entries (MH 2135, MH 2147, MH 2151

and MH 2165) from IVT, four entries (MH 1928, MH 2027, MH 2073 and B 2301) from AVT and two entries (Nandi 61 and JBV 2) from FYT showed 0.1-20 per cent (resistant) rust severity; 47 entries viz., 23 entries from IVT, 15 entries from AVT and nine entries from FYT showed 20.1-40 per cent (moderately resistant) rust severity; 80 entries viz., 45 entries from IVT, 24 entries from AVT and 11 entries from FYT showed 40.1-60 per cent (moderately susceptible) rust severity; 68 entries viz., 48 entries from IVT, 14 entries from AVT and six entries from FYT showed 60.1-80 per cent (susceptible) rust severity and 23 entries viz., 20 entries from IVT, two entries from AVT, whereas the entry RHB 177 from FYT showed more than 80 per cent (highly susceptible) rust severity.

In 276 entries of state trials comprising LST early (Table 4), LST late (Table 5), FYT early (Table 6), FYT late (Table 7), Inbreds (Table 8), Advance inbreds (Table 9), CMS pairs (Table 10), FYT population (Table 11), Multicut (Table 12), HHB 197 versions (Table 13) and HBL 11 versions (Table 14), rust severity ranged from 0 to 80 per cent (HHB 197 version) with maximum number of entries lying in the range of 0.1-20 per cent rust severity. The results revealed that 39 entries viz., 12

TABLE 1

Screening of pearl millet initial varietal trial (IVT) entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	MH 2135, MH 2147, MH 2151, MH 2165	4
2	20.1-40	Moderately resistant	MH 2095, MH 2105, MH 2109, MH 2166, MH 2167, MH 2180, MH 2089, MH 2107, MH 2139, MH 2140, MH 2146, MH 2160, MH 2162, MH 2164, MH 2169, MH 2175, MH 2176, MH 2177, MH 2186, MH 2183, MP 568, PAC 909, NBH 5061	23
3	40.1-60	Moderately susceptible	MH 2082, MH 2083, MH 2085, MH 2088, MH 2096, MH 2108, MH 2113, MH 2114, MH 2137, MH 2149, MH 2150, MH 2154, MH 2156, MH 2168, MH 2170, MH 2172, MH 2178, MH 2182, MH 2184, MH 2185, GBH 558, MH 2186, MP 562, MP 563, Kaveri Super Boss, MH 2084, MH 2092, MH 2106, MH 2117, MH 2132, MH 2133, MH 2136, MH 2153, MH 2158, MH 163, MH 2171, MP 564, MP 565, MP 566, MP 567, MP 572, 86M86, Raj 171, Pusa Composite 383, Dhanshakti	45
4	60.1-80	Susceptible	MH 2090, MH 2091, MH 2106, MH 2111, MH 2115, MH2122, MH2124, MH2126, MH2128, MH2131, MH2134, MH2138, MH2142, MH2143, MH2152, MH 2155, MH 2159, MH 2161, MH 2173, MH 2174, MH 2179, MP 570, RHB 177, HHB 67 Imp, GHB 905, NBNH 5767, MP-7792, ICMV 221, ICMV 155, MH 2081, MH 2094, MH 2097, MH 2098, MH 2101, MH 2104, MH 2112, MH 2118, MH2119, MH2120, MH2127, MH 2130, MH 2141, MH 2145, MP 569, MP 571, MP 573, Pratap (MH 1642), KBH 108	48
5	80.1-100	Highly susceptible	MH 2086, MH 2087, MH 2093, MH 2099, MH 2100, MH 2102, MH 2103, MH 2110, MH 2116, MH 2129, MH 2144, MH 2148, MH 2157, MP 561, ICMH 356, MPMH 17, RHB 173, JBV 2, MH 2112, MH 2125	20
Total number of entries				140

TABLE 2

Screening of pearl millet advance varietal trial (AVT) entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	MH 1928, MH 2027, MH 2073, B 2301	4
2	20.1-40	Moderately resistant	MH 1970, MH 2088, MH 2053, MH 2075, Pratap, PAC 909, MP-7792, MH 1939, MH 1962, MH 1974, MH 2010, MH 2024, MH 2047, MH 2072, GHB 744	15
3	40.1-60	Moderately susceptible	MH 1976, MH 1977, MH 1979, MH 1993, MH 2012, MH 2013, MH 2021, MH 2035, MH 2076, MH 2077, MP 552, KBH 108, 86M86, Nandi 61, GHB 732, 86M64, Dhanshakti, MH 2009, MH 2041, ICMH 356, GHB 558, Kaveri super boss, ICMV 221, ICMV 155	24
4	60.1-80	Susceptible	MH 1964, MH1996, MH1998, MH 2008, MH 2031, MH 2039, RHB 177, Raj 171, MH 1994, MH 1999, MH 2002, MH 2078, MPMH 17, RHB 121	14
5	80.1-100	Highly susceptible	HHB 67 Imp, RHB 173	2
Total no. of entries				59

inbred lines [HMS 57B, H 2302-1 (Tall), HMS 30 Begp, TPBLT-14/114, TPBLT-14/117, TPBLT-14/120, LPBLT-14/101, LPBLT-14/105, HMS 29B, HMS 39B, HMS 36B and HMS 04888], three advance inbreds lines (HPT-2-12-32, HPT-10-129 and H 78/711), 20 CMS pairs (HMS 14A/HMS 14B, HMS 16A/HMS 16B, HMS 18A/HMS 18B, HMS 20A/HMS 20B, HMS 32A/HMS 32B, HMS 33A/HMS 33B, HMS 34A/HMS 34B, HMS 36 A4/ HMS 36B4, HMS 37A4/HMS 37B4, HMS 38A/ HMS 38B, HMS 40A/HMS 40B, HMS 46A/HMS 46B, HMS 49A4/HMS 49B4, HMS 52A4/HMS 52B4, HMS 53A4/HMS 53B4, HMS 57A/HMS 57B, HMS 58A/ HMS 58B, HMS 61A/HMS 61B, HMS 62A/HMS 62B and HMS 64A/HMS 64B) and four FYT population

TABLE 3

Screening of pearl millet final yield trial (FYT) entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	Nandi 61, JBV 2	2
2	20.1-40	Moderately resistant	HHB 67 Imp, GHB 744, MP-7792, GHB 732, NBH 5061, ICMV 155, GHB 905, Pratap (mh 1642), Dhanshakti	9
3	40.1-60	Moderately susceptible	GHB 538, RHB121, Pusa Composite 3832, ICMV 221, HHB 226, MPMH 17, HHB 223, 86M86, Progaro 9444, Kaveri Super Boss, Raj 171	11
4	60.1-80	Susceptible	RHB 173, GHB 558, NBH 5767, MBC 2, HHB 197, KBH 108	6
5	80.1-100	Highly susceptible	RHB 177	1
Total no. of entries				29

TABLE 4

Screening of pearl millet LST early entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	1×551-, 324×431, 338×421, 21×31-K14, 28×32-K14, 21×38-K14, 22×50-K14 , 280×371, 298×431, 310×421, 334×371, 25×32-K14, 29×36 -K14, 26×40-K14, HHB 67 Imp, HHB 272	16
2	20.1-40	Moderately resistant	274×371, 304×371, 22×41-K14, 310×495, 22×38-K14, 22×44-K14 , 310×371	7
3	40.1-60	Moderately susceptible	236×541	1
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				24

TABLE 5

Screening of pearl millet LST late entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	HHB 223, 201×431, 336×553, 23×31-K14, 23×40-K14, 57×67-K14	6
2	20.1-40	Moderately resistant	236×523, 236×533, 236×545, 278×371, 304×491, HHB 197, 310×557	7
3	40.1-60	Moderately susceptible	236×525, 236×531	2
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				15

entries (RTC, TPBL, HRC and WHC 901-445 E were free from rust. In LST early, LST late, FYT early, FYT late, Multicut, FYT early HHB 197 version and HBL 11 version trial none of the entries was free from rust. Out of remaining entries, 188 entries showed 0.1-20 per cent (resistant) rust severity, 71 entries showed 20.1-40 per cent (moderately resistant) rust severity, 15 entries showed 40.1-60 per cent (moderately susceptible) rust severity, whereas only two versions HHB 197-718 × 715 and HHB 197-718 × 712 showed 60.1-80 per cent (susceptible) rust severity and none of the entries showed more than 80 per cent rust severity.

Similar to our studies, Sharma *et al.* (2009) evaluated 214 advanced breeding lines against pearl

TABLE 6

Screening of pearl millet FYT early entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	HMS 41A/HPT-1-12-84, HMS 60A/HPT-10-129, ICMA 04888/PT-1-10-1047, ICMA 94222/HPT-1-12-84, ICMA 08111/RAJ 3, ICMA 94555/PT-1-10-1021, HMS 47 A/HPT-2-12-32, HHB 272(check)	8
2	20.1-40	Moderately resistant	HMS 47A/HPT-2-12-32, HMS 60 A/HPT-10-129, ICMA 88004/H 14/004, HHB 226/check, HHB 234/ (check), HMS 48A/PT-1-10-1131, ICMA04999/TCH 26-1, ICMA 99111/TCH 26-1, ICMA 94555/HPT-2-12-32	9
3	40.1-60	Moderately susceptible	HMS 53 A/SGP-10-107, ICMA 843-22/H 14/005, HHB 67 (Imp) (check), ICMA 04999/H 1305	4
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				21

TABLE 7

Screening of pearl millet FYT late entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	ICMA 98222/H 13/0001, ICMA 94555/H12/009, ICMA 02333/RAJ 3, ICMA 04888/RAJ 3, ICMA 04999/MP 293-4, ICMA 97444/HPT-10-129, ICMA 02333/H 14/001, ICMA 02333/H 14/002	8
2	20.1-40	Moderately resistant	ICMA 94555/AC 04/13, HMS 47 A/HFIT-3-11-125, ICMA 97111/PT-1-10-1047, ICMA 97111/H 10/0144, HMS 50 A/H 78/711, ICMA 02333/H 14/003, ICMA 04888A/H 13/0001, HHB 223(Check), ICMA 94555/HFePPT-2/12-152, ICMA 94555/TPC 1, ICMA 94555/HFePPT-2/12-130, HHB 19(/Check), HHB 146(Check)	13
3	40.1-60	Moderately susceptible	HMS 51A/TCP-10-110, ICMA 94555/HPT-2-12-32, ICMA 04999/MP 293-4	3
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				24

millet rust, including 126 designated B-lines, 23 designated R-lines and 65 potential R-lines at ICRISAT and found that one elite B-line (ICMB 96222) and three elite R-lines (ICMR 06999, ICMP 451-P8 and ICMP 451-P6) were resistant both in field and greenhouse. Some of the resistant lines used in breeding were 700481-21-8 (ICML 17), IP 537 B (ICML 18), IP 11776 (ICML 19), IP 2084 (ICML 20), P 24 (ICML 21) and IP 2696 (ICML 11). Whereas Lakshmana *et al.* (2010) observed that among the parents, 81B a susceptible check showed susceptibility to rust and the parents viz., P-2933-1, IP-6240-3 and 70048-1-5-3 showed resistant reaction. In corroboration to our studies Munirathnam *et al.* (2015) screened 17 genotypes of foxtail millet against rust for two years at RARS, Nandyal (A. P.), India. Ten genotypes viz., SiA 3221, TNSI 266, SiA 3156, SiA 3164, SiA 3222, SiA 3145, SiA 326, VMFC 329, SiA 3146 and SiA 3223 exhibited resistant reaction to rust disease during 2013-14, while six genotypes exhibited moderately resistant reaction. During 2014-15, only one genotype DHFtMV 2-5 was recorded as resistant and 10 genotypes viz., SiA 3221, SiA 3162, TNSI 266, SiA 3164, SiA 3190, SiA 3222, SiA 326, SiA 3223, VMFC 329 and DHFtMV 553 exhibited moderately resistant reaction.

Baiswar *et al.* (2015) conducted screening trial for identification of resistant varieties/lines against soybean rust caused by *Phakopsora pachyrhizi* under natural epiphytotic conditions. Twenty-three varieties/lines were included in the trial along with a susceptible check JS 335 and revealed that only two lines NRC 80 and MAUS 417 were moderately susceptible. Lines TS

TABLE 8
Screening of pearl millet inbreds against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	HMS 57B, H 2302-1 (Tall), HMS 30 Begp, TPBLT-14/114, TPBLT-14/117, TPBLT-14/120, LPBLT-14/101, LPBLT-14/105, HMS 29B, HMS 39B, HMS 36B, HMS 04888	12
1	0.1-20	Resistant	HMS 60B, HFePPT-2/12-102, HMS 20B, HFePPT-2/12-130, HMS 28B4, ISK 51, TPBLT-14/104, TPBLT-14/113, TPBLT-14/115, TPBLT-14/210, LPBLT-14/119, SGBLT-14/111, EMBLT-14/106, HMS 13B, HFePPT-2/12-239, HMS 61B, HFePPT-2/12-141, 78/711, HTP 93/109-2, HMS 39B, TPBLT-14/105, HMS 33B	22
2	20.1-40	Moderately resistant	HFePPT-2/12-146, HMS 18B, HMS 6B, TPBLT-14/123, LPBLT-14/113, SGBLT-14/110, SGBLT-14/118, EMBLT-14/107, HBL 561, HFePPT-2/12-123, SGBLT-14/104	11
3	40.1-60	Moderately susceptible	None	0
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				45

TABLE 9
Screening of pearl millet advance inbreds against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	HPT-2-12-32, HPT-10-129, H 78/711	3
1	0.1-20	Resistant	HPT-10-144, H77/833-2-202, PT-1-10-1047, 35, 40, 41, H12/009, IH 8, ISK 51, 99 HS139, HFePPT-2/12-141, HFePPT-2/12-152, HFePPT-2/12-155, HTP 93/109-1, TPC 1, HPT-2-12-6, HPT-10-129, PT-2-10-173, TCH 26-1, SGP-10-107, HFIT-3-11-125, 33, 36, 37, 38, 39, 42, 43, 44, 45, 46, 47, 48, 49, 50, HFePPT-2/12-123, PT-1-10-1002, RAJ 3, AC 04/13	39
2	20.1-40	Moderately resistant	31, 32, HFePPT-2/12-130, MP 293-4, TCP-10-110	5
3	40.1-60	Moderately susceptible	None	0
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				47

5, Himso 1676 and MAUS 282 were highly susceptible and all other lines were susceptible. No line or variety was in the moderately resistant or resistant category as all the lines exhibited tan type lesions. Parameshwar *et al*. (2012) screened 84 genotypes of soybean under natural condition for identifying resistant source for rust and revealed that two genotypes EC-241778 and EC-241780 were found to be resistant to rust. Remaining 82 genotypes recorded highly susceptible reaction to the rust.

Krisnawati *et al*. (2016) evaluated ten elite black soybean lines to rust disease. Resistance reaction to rust disease fluctuated over time. Two elite lines of Cikuray × W9837-171 and Cikuray × W9837-184 showed a consistent resistance to *Phakopsora pachyrhizi*. W9837 × Cikuray-66 and check cultivar of Detam-1 consistently showed a moderately resistant. As per the experiment of our studies, the highly resistant germplasm identified in this study can be utilized in breeding programme to develop rust resistant hybrids for pearl millet growing areas after testing against different pathotypes. Therefore, these genotypes may be used as donors for specific disease resistance in future breeding programmes.

TABLE 10

Screening of pearl millet CMS pairs against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	HMS 14A/HMS 14B, HMS 16A/HMS 16B, HMS 18A/HMS 18B, HMS 20A/HMS 20B, HMS 32A/HMS 32B, HMS 33A/HMS 33B, HMS 34A/HMS 34B, HMS 36 A4/ HMS36B4, HMS37A4/HMS 37B4, HMS 38A/HMS 38B, HMS 40A/HMS 40B, HMS 46A/HMS 46B, HMS 49A4/HMS 49B4, HMS 52A4/HMS 52B4, HMS 53A4/ HMS 53B4, HMS 57A/HMS 57B, HMS 58A/HMS 58B, HMS 61A/ HMS 61B, HMS 62A/HMS 62B, HMS 64A/HMS 64B	20
1	0.1-20	Resistant	HMS 6A/HMS 6B, HMS 7A-1/HMS 7B-1, HMS 13A/HMS 13B, HMS 22A/HMS 22B, HMS 26A/HMS 26B, HMS 39A/HMS 39B, HMS 41A/HMS 41B, HMS 42A/HMS 42B, HMS 43A/HMS 43B, HMS 45A/HMS 45B, HMS 47A/HMS 47B, HMS 54A5/HMS 54B5, HMS 59A/HMS 59B, HMS 63A/HMS 63B, HMS 7A/HMS 7B, HMS 21A/HMS 21B, HMS 29A5/HMS 29B5, HMS 30 Aegp/HMS 30 Begp, HMS 48A/HMS 48B, HMS 51A4/HMS 51B4, HMS 56A4/HMS 56B4, HMS 60A/HMS 60B	22
2	20.1-40	Moderately resistant	HMS 23A/HMS 23B, HMS 44A/HMS 44B, HMS 50A/HMS 50B, HMS 55A1/HMS 55B1	4
3	40.1-60	Moderately susceptible	HMS 28A4/HMS 28B4	1
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of pairs				47

TABLE 11

Screening of pearl millet FYT population entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	RTC, TPBL, HRC, WHC 901-445 (E)	4
1	0.1-20	Resistant	LPRC, DMRC, ASRC-1, HIC, HC 10, ATC, 98109 SL, WHC 901-445 X HMS36 B, HC 20	9
2	20.1-40	Moderately resistant	BRBC, TPC-II, WHC 901-445 (M), TPC-1	3
3	40.1-60	Moderately susceptible	HPC	1
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				17

REFERENCES

Anonymous. 2013-14 : Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi. *www.agricoop.nic.in.*

Baiswar, P., A. N. Tiameren, D. N. Upadhyay, and S. Chandra. 2015 : Screening of varieties against soybean rust caused by *Phakopsora pachyrhizi* in mid-hills of Meghalaya. *Indian J. Hill Farm.,* **25** : 17-20.

Carvalho, A., D. J. Soares, M. G. F. Carmo, A. C. T. Costa, and C. Pimentel. 2006 : Description of the life- cycle of the pearl millet rust fungus–*Puccinia substriata* var. *penicillariae* with a proposal of reducing var. *indica* to a synonym. *Mycopathol.,* **161** : 331-336.

Krisnawati, A., A. S. Gatut-Wahyu, and M. M. Adie. 2016 : Screening of elite black soybean lines for resistance

TABLE 12
Screening of pearl millet multicut entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	HCF-86 (BBNH 0601-8), BBNH 0601-11, HFP (High forage progenies), BAWAL BAJRI, HCF-82 (BBNH 0601--2), HCF -83 (BBNH 0601-5), BBNH 0601-6, SWEAT TYPE	8
2	20.1-40	Moderately resistant	BBNH 0601-7, HC 20, HCF-81 (BBNH 0601-17), HCF 87 (BBNH 0601× HC 20)	4
3	40.1-60	Moderately susceptible	None	0
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				12

TABLE 13
Screening of pearl millet HHB 197 version entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	None	0
2	20.1-40	Moderately resistant	HHB 197 - 718×716, HHB 197 (C), HHB 67 (IMP) (C)	3
3	40.1-60	Moderately susceptible	HHB 197- 718×711, HHB 197- 718×713, HHB 197 - 718×717, HHB 223 (C)	4
4	60.1-80	Susceptible	HHB 197- 718×715 , HHB 197- 718×712	2
5	80.1-100	Highly susceptible	None	0
Total no. of entries				9

TABLE 14
Screening of pearl millet HBL 11 version entries against rust caused by *Puccinia substriata* var. *penicillariae*

Grade	Rust severity range (%)	Type	Entry name	Total number of entries
0	0	Immune	None	0
1	0.1-20	Resistant	711 - P1, 711 P1 × 712 P1, 713, 716 P-1, 717-P2, 711, 712 P1, 716 P2, 717-P1	10
2	20.1-40	Moderately resistant	712, 717, HBL -11 (check), 716, 717-P3	5
3	40.1-60	Moderately susceptible	None	0
4	60.1-80	Susceptible	None	0
5	80.1-100	Highly susceptible	None	0
Total no. of entries				15

to rust disease, *Phakopsora pachyrhizi.* *Biodiversitas.,* **17** : 134-139.

Lakshmana, D., B. D. Biradar, and S. Lingaraju. 2010 : Studies on inheritance of resistance to rust in pearl millet, *Karnataka J. Agric. Sci.,* **23** : 485-486.

Munirathnam, P., K. Venkataramanamma, and A. Anusha. 2015 : Evaluation of foxtail millet genotypes for blast and rust diseases under field conditions. *Curr. Biotica.,* **9** : 263-268.

Parameshwar, G., G. T. Basavaraja and S. Bhat. 2012 : Screening of genotypes against rust and yellow mosaic diseases in soybean [*Glycine max* (L.) Merrill]. *Environ. & Ecol.,* **30** : 306-309.

Sharma, R., R. P. Thakur, K. N. Rai, S. K. Gupta, A. S. Rao, and S. Kumar. 2009 : Identification of rust resistance in hybrid parents and advanced breeding lines of pearl millet–An open access. *J. ejournal.icrisat.org.,* **7** : 1-4.

Singh, S. D., J. P. Wilson, S. S. Navi, B. S. Talukdar, D. E. Hess, and K. N. Reddy. 1997 : Screening techniques and sources of resistance to downy mildew and rust in pearl millet. *Information Bulletin No. 48.* Patancheru, Andhra Pradesh, India : International Crops Research Institute for the Semi-Arid Tropics. pp. 104.