

Original Research Article

Screening of exotic collections of Arabica coffee genotypes for Coffee berry borer and Coffee leaf rust disease incidence

Abstract

In India, commercial cultivation of coffee relies upon two important species like *Coffea arabica* (Arabica coffee) and *Coffea canephora* (Robusta coffee). In the consumer market, arabica coffee is preferred for its fine beverage quality, aromatic characteristics and low caffeine content compared to robusta coffee. Since, in India coffee is grown under natural agroecosystem offers arabica coffee to fetch premium price in the international market. In spite of the commercial importance and the appropriate environmental conditions, the drastic reduction of arabica coffee area in India is might be due to the lack of adaptable cultivars for each ecological zone of the region, susceptibility to major pests and diseases like, coffee berry borer and leaf rust, respectively and increased cost of production coupled with low productivity (470 kg clean coffee/ha) compared to that of robusta coffee. Therefore, the study was aimed at screening of exotic collections of Arabica coffee genotypes maintained at Central Coffee Research Institute (CCRI), Balehonnur, Karnataka, India against Coffee Berry Borer (CBB) and Coffee Leaf Rust (CLR). Results revealed that, the CLR disease severity infection was ranged from 1.34 to 32.67 per cent and the genotypes S.1495, S.1561, S.2504, S.2509, S.2510, S.2529, S.2602 and S.2724 exhibited moderately resistant to leaf rust disease infection based on mean per cent disease severity level (1-5%). Hence, these genotypes will be valuable as new sources of resistance to these pathogens in the future and can be utilized in coffee breeding programmes in India.

Similarly, all the genotypes utilized in the study were established low to least infestation of coffee berry borer (1.03 to 5.03 %).

Keywords: Arabica coffee, Coffee berry borer, Coffee leaf rust, Infestation and Resistance

Introduction

Coffee is an important beverage crop of India and is the second most important export commodity next to the petroleum products. In India, 70 per cent of the total coffee produces is meant for export only (Anon, 2014). There are two important species of *Coffea* which are being commercially cultivated in India and across the world are Arabica coffee (*Coffea arabica* L.) and Robusta coffee (*Coffea canephora*). Among these two species, Arabica coffee fetches highest price in the international market when compared with Robusta coffee as Arabica coffee produces finest cup quality coffee than Robusta coffee. However, Arabica coffee is highly susceptible to major pests like coffee white stem borer and coffee berry borer and diseases such as coffee leaf rust and black rot of coffee, respectively compared to Robusta coffee which is highly tolerant (Gichuru *et al.*, 2008, Kathurima *et al.*, 2009 and Gimase *et al.*, 2014). Coffee genotypes respond differently to biotic factors mainly coffee leaf rust (CLR) and coffee berry borer (CBB).

Coffee Berry Borer (CBB) (*Hypothenemus hampei*) is an important major and monophagous pests of coffee in which both the species of coffee were susceptible. This pests known to cause 30-40 per cent yield loss in coffee (Annon, 2014). In addition, berry borer attacks coffee in field and even at the time of storage. Although there are many studies on chemical, biological and cultural control, coffee breeding for this pest has not been studied due to lack of resistance sources in the *Coffea* genus and related species (Vijayalakshmi *et al.*, 2014).

Similarly, CLR is a fungal disease caused by *Hemileia vastatrix* and is one of the major diseases of coffee. It causes premature leaf fall, yield loss and even death of the tree in severe cases. Defoliation caused by leaf rust before floral induction or during fruit development results in reduced flowering and poor coffee bean formation (Godoy *et al.*, 1997). On a two-year average, rust can cause yield losses of 35 to 50%, depending on the susceptibility of the cultivar, humidity, crop load and nutritional status of the plant (Zambolim *et al.*, 1997). The use of resistant cultivars is the most economical and environmentally friendly way to control this disease, because the chemical control, although effective when used adequately, is costly for growers. Many coffee cultivars are resistant to most rust races (Sera *et al.*, 2007b and Sera *et al.*, 2010a). However, the resistance to leaf rust has been broken by the frequent appearance of new races of the fungus, making it difficult to breed cultivars with complete and durable resistance (Varzea *et al.*, 2002). The susceptibility and poor adaptability nature of arabica coffee to major pests and diseases and adverse environmental conditions is mainly attributed to low genetic diversity when compared with that of robusta coffee due to its narrow genetic base. This necessitated the systematic breeding efforts for selection of genotypes with respect to leaf rust resistance, high yielding potential, wide adaptability and superior quality. Therefore identification and selection of tolerant or resistant sources of Arabica coffee genotypes for pests and diseases is at most important. Hence, the present study was aimed at screening of exotic collections of Arabica coffee genotypes maintained at Central Coffee Research Institute (CCRI), Balehonnur, Karnataka, India against CBB and CLR.

Materials and Methods

Forty one *Coffea arabica* genotypes were screened for their response to CBB and CLR incidence under field conditions at CCRI research farm. CBB and CLR incidence was assessed

in field conditions in 2020-21 and 2021-22 when CBB and CLR incidence pressure was at peak (September and November, respectively).

CCRI is situated in Southern hill zone of Karnataka state at 13° 22" North latitude and 75° 28" East longitudes and at an altitude of 885 m above the mean sea level. During the study, about forty one Arabica coffee genotypes (Table 1) comprising of exotic collections such as World collections (14), Costa Rica collections (15), Ethiopian collections (10) and check varieties of CCRI (2) maintained at CCRI germplasm of uniform age groups (16 years old) were selected for assessment against coffee leaf rust and coffee berry borer. The experiment was conducted in randomized complete block design (RCBD) with two replications. Four randomly selected plants from each replication were tagged for recording observations on coffee leaf rust and coffee berry borer and cup quality parameters. Further, the regular calendar of operations like weeding, fertilizer application, harvesting and processing were carried out during the course of investigation.

The weather data was recorded during the year 2020 and 2021 at the meteorological observatory of CCRI. The average rainfall of area was 2645 mm and distributed over a period of five to six months (June-October). During 2020-21 and 2021-22, the average monthly maximum (27.01 and 26.97°C) and minimum (18.58 and 18.45°C) mean temperatures, the average mean monthly maximum (94.92 and 93.67%) and minimum (64.75 and 69.58%) relative humidity was recorded. The total rain fall received during 2020 and 2021 was 2755 and 2433 mm, respectively. The minimum and maximum bright sunshine hours per day varied from 1.0 to 8.1 hrs in 2020-21 and 3.0 to 7.0 hrs in 2021-22, respectively and the same is presented in Table 2.

Observations on incidences of following CBB and CLR was recorded.

- a. Coffee berry borer infestation (%):** The infestation of coffee berry borer (CBB), *Hypothenemus hampei* was recorded in all the genotypes. Random sampling method was followed to enumerate the CBB infestation within the berries. The sampling was carried out before the crop harvest. The berries with CBB damage were counted and converted to per cent infestation by using the following formula. The incidence level of CBB was measured using the scale >1% (1-9%) (Low) and >10% (High) by Irulandi *et al.* (2007).

$$\text{CBB infestation (\%)} = \frac{\text{Total number of berries infested}}{\text{Total number of berries examined}} \times 100$$

- b. Leaf rust disease severity (%):** The coffee leaf rust (CLR), *Hemileia vastatrix* was recorded at the end of post monsoon season (October and November). The leaves with CLR infection were observed and converted to per cent severity. The leaf rust disease severity was calculated by grading the leaf rust infected area based on the following disease 0-5 grade scale given by (Muthappa, 1974 and Kushalappa, 1989).

Rust disease severity scale can be obtained by using the formula developed by Muthappa (1974) and Kushalappa (1989)

$$\text{RDS (\%)} = \frac{\text{Sum of numerical disease rating recorded}}{\text{Total number of leaves examined} \times \text{Maximum disease rating}} \times 100$$

Chart 1 : Grade wise Distribution

Grade	Per cent infected leaf area	Reaction type	Reaction type
G ₀	0	Healthy	Immune
G ₁	1-5	Mild	Moderately resistant
G ₂	6-10	Medium	Tolerant
G ₃	11-20	Severe	Moderately susceptible
G ₄	21-50	Very severe	Susceptible
G ₅	>50	Destructive	Highly susceptible

Results and Discussion

To identify the sources of resistance, forty one genotypes were screened and categorized based on reaction type against coffee leaf rust disease infection and coffee berry borer infestation (Table 3) under natural epiphytic conditions during 2020-21, 2021-22 and pooled average over years. The data on incidence and their grouping as per the reaction type of each Arabica coffee genotypes for leaf rust disease infection and coffee berry borer infestation during 2020-21, 2021-22 and pooled average over years are presented in Table 4 and 5. Genotypes showing moderately resistant and susceptibility against coffee leaf rust are depicted in Plate 1 and 2.

Table 1: Details of the Arabica coffee genotypes used for present study

Sl. No.	Name of the genotypes	Source
1.	S.1477	World collections
2.	S.1482	

3.	S.1484		
4.	S.1493		
5.	S.1495		
6.	S.1496		
7.	S.1497		
8.	S.1500		
9.	S.1502		
10.	S.1561		
11.	S.1565		
12.	S.1572		
13.	S.1573		
14.	S.1655		
15.	S.2501		Costa Rica collections
16.	S.2502		
17.	S.2503		
18.	S.2504		
19.	S.2505		
20.	S.2506		
21.	S.2507		
22.	S.2508		
23.	S.2509		
24.	S.2510		
25.	S.2511		
26.	S.2529		
27.	S.2532		
28.	S.2724		
29.	S.2725		
30.	S.2601	Ethiopian collections	
31.	S.2602		
32.	S.2606		
33.	S.2608		
34.	S.2613		
35.	S.2616		
36.	S.2659		
37.	S.2660		
38.	S.2671		
39.	S.2672		
40.	Cauvery - Check	CCRI, selections	
41.	Chandragiri - Check		

Table 2: Meteorological data recorded during experimental period (2020-21 and 2021-22) at Central Coffee Research Institute, Balehonnur

Months	Temperature (°C)				RH (%)				Rainfall (mm)		Sunshine (hrs)	
	2020-21		2021-22		2020-21		2021-22		2020-21	2021-22	2020-21	2021-22
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.				
January	28.5	17.5	25.3	16.5	96	51	75	98	-	135.6	7.5	6.0
February	30.0	17.0	26.0	16.3	87	35	95	82	-	72.4	8.1	4.5
March	30.8	18.8	29.7	16.7	90	53	95	46	23.2	5.6	6.5	6.5
April	31.0	20.0	29.8	19.5	95	44	92	63	72.2	87.6	6	6.5
May	28.3	21.0	27.8	19.5	98	70	92	55	218.6	230.8	4.5	6.0
June	26.5	19.5	26.3	20.0	97	80	96	49	269.6	353.4	4.0	4.5
July	24.8	19.5	26.3	19.5	96	79	96	66	439.9	782.2	1.5	3.0
August	23.0	19.0	25.4	17.4	96	78	97	78	1057.4	297.4	1.0	3.5
September	24.3	19.5	26.0	19.0	96	79	97	82	465.6	186.4	1.0	3.5
October	24.8	18.5	27.0	21.8	97	72	95	80	163.2	284.6	3.5	4.5
November	25.8	16.3	26.0	19.2	95	63	97	78	44.0	195.6	4.0	4.0
December	26.3	16.3	28.0	16.0	96	73	97	58	1.4	9.8	5.0	7.0

Max – Maximum, Min – Minimum, RH – Relative humidity

During 2020-21 and 2021-22 (Table 3), the mean per cent rust disease severity infection ranged from 1.33 to 33.00 per cent and 1.34 to 32.34 per cent, respectively. The genotype S.2724 was manifested minimum rust disease severity infection followed by S.2504, while the rust disease severity infection was maximum in case of check variety Cauvery during both the years of study. The same trend of leaf rust disease severity infection also followed in pooled average over years. Results revealed that, the mean per cent rust disease severity infection ranged from 1.34 to 32.67 per cent. The genotype S.2724 was manifested minimum rust disease severity infection of 1.34 per cent followed by S.2504 (2.73%), while the rust disease severity infection was maximum in case of check variety Cauvery (32.67%) on pooled average over years. Based on mean per cent disease severity infection level (1-5%), genotypes S.1495, S.1561, S.2504, S.2509, S.2510, S.2529, S.2602 and S.2724 exhibited moderately resistant to leaf rust disease infection (Table 4). While the genotypes S.1497, S.2501, S.1655, S.2507, S.2506, S.2506, S.2505, S.2503, S.2508, S.2613 and Chandragiri manifested tolerant (6-10%) to leaf rust disease infection. However, the genotypes S.1493, S.1484, S.1482, S.1477, S.1496, S.1502, S.1565, S.1573, S.2502, S.2511, S.2532, S.2725, S.2608, S.2606, S.2672, S.2671 and S.2660 established moderately susceptible (11-20%) to leaf rust disease infection. Very few of the genotypes viz., S.1500, S.1572, S.2601, S.2659, S.2616 and Cauvery had shown susceptibility (21-50%) to leaf rust disease infection during 2020-21, 2021-22 and pooled over the years. This study has shown that it is possible to transfer desirable genes for resistance to the most important coffee pathogens to new genotypes. These genotypes will be valuable as new sources of resistance to these pathogens in the future and can be utilized in coffee breeding programmes in India but there was no information about the resistance genes they contain. There was also no information about the

rest of the genotypes and probably they have not been characterized. This confirmed the report by Gichimu (2012) and Shigueoka *et al.* (2014).

Data on mean per cent infestation of coffee berry borer infestation was recorded during 2020-21, 2021-22 and pooled over the years (Table 3) and it ranged from 1.08 to 4.98 per cent (2020-21) and 0.98 to 5.08 per cent (2021-22) and 1.03 to 5.03 per cent (pooled over the years). The mean per cent infestation of coffee berry borer was found to be low (1-9%) in all the genotypes studied (S.1477, S.1482, S.1484, S.1493, S.1495, S.1496, S.1497, S.1500, S.1502, S.1561, S.1565, S.1572, S.1573, S.1655, S.2501, S.2502, S.2503, S.2504, S.2505, S.2506, S.2507, S.2508, S.2509, S.2510, S.2511, S.2529, S.2532, S.2724, S.2725, S.2601, S.2602, S.2606, S.2608, S.2613, S.2616, S.2659, S.2660, S.2671, S.2672, Cauvery, Chandragiri) (Table 5). The genotype S.2671 had the least per cent infestation of coffee berry borer that (1.08% in 2020-21, 0.98% in 2021-22 and 1.03% in pooled over years). While, the higher mean per cent infestation of coffee berry borer was observed in genotype S.1561 (4.98, 5.08 and 5.03%, respectively) during 2020-21, 2021-22 and pooled over years. From the present study, it can be inferred that all the genotypes utilized in the study established low to least infestation of coffee berry borer (tolerant), this might be due to the occurrence of natural rain (act as a natural barrier for suppressing the infestation of coffee berry borer) during the month of September (peak infestation) in both the years (2020-21 and 2021-22) brought down the infestation level of coffee berry borer on all the genotypes studied. However, this study was focused only on mean per cent infestation of coffee berry borer and no economic loss assessment have been made. Similar results were obtained by Irulandi *et al.* (2007), Samuel *et al.* (2013) and Garbaba and Garedeu (2019).

Conclusion

Forty one Arabica coffee genotypes were evaluated for their response to coffee leaf rust infection and coffee berry borer infestation under field conditions. Significant variation for moderately resistant to tolerance of CLR infection was observed among the genotypes such as S.1495, S.1561, S.2504, S.2509, S.2510, S.2529, S.2602 and S.2724, S.1497, S.2501, S.1655, S.2507, S.2506, S.2506, S.2505, S.2503, S.2508, S.2613. These genotypes will be valuable as new sources of resistance to these pathogens in the future and can be utilized in coffee breeding programmes in India. Similarly, all the genotypes utilized in the study were established low to least infestation of coffee berry borer. The low genetic diversity among the Arabica coffee genotypes evaluated was expected. This was due to the process of autogamy and narrow genetic base, resulting from the process of homozygosis and the successive selection cycles. This was also confirmed by the fact that the Arabica genetic materials were probably derived from a few seeds that survived the efforts of expanding the Yemen borders for the cultivation of coffee plants, reaching the present cultivation sites.

Table 3: Screening of forty one Arabica coffee genotypes for coffee leaf rust infection and coffee berry borer infestation during 2020-21, 2021-22 and pooled average over years

Genotypes	RDS (%)			CBB (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
S.1477	12.53	12.44	12.49	1.64	1.27	1.46
S.1482	16.40	16.68	16.54	2.40	2.30	2.35
S.1484	12.42	12.38	12.40	4.16	4.28	4.22
S.1493	14.55	14.63	14.59	4.26	4.54	4.40
S.1495	4.43	4.28	4.36	2.00	1.92	1.96
S.1496	19.65	19.31	19.48	2.50	3.00	2.75
S.1497	8.01	8.17	8.09	3.14	3.19	3.17
S.1500	28.68	29.10	28.89	3.38	3.82	3.60
S.1502	10.30	10.20	10.25	1.24	1.18	1.21
S.1561	4.51	4.55	4.53	4.34	4.55	4.45
S.1565	12.91	12.76	12.84	3.33	3.64	3.49
S.1572	20.49	20.12	20.31	3.17	3.26	3.22
S.1573	18.75	18.64	18.70	2.29	2.58	2.44
S.1655	7.13	7.06	7.10	1.62	1.19	1.41
S.2501	7.14	7.20	7.17	3.77	4.01	3.89
S.2502	13.31	13.69	13.50	3.73	4.13	3.93
S.2503	5.38	5.32	5.35	3.85	4.27	4.06
S.2504	2.69	2.76	2.73	2.84	3.08	2.96
S.2505	6.86	8.17	7.52	4.19	4.33	4.26
S.2506	6.59	6.36	6.48	2.30	2.49	2.40
S.2507	8.37	8.21	8.29	3.20	3.27	3.24
S.2508	5.81	5.95	5.88	3.78	4.26	4.02
S.2509	3.64	3.66	3.65	3.22	3.49	3.36
S.2510	4.88	4.75	4.82	3.85	4.38	4.12
S.2511	16.84	16.36	16.60	3.16	3.64	3.40
S.2529	4.44	4.39	4.42	2.12	2.31	2.22
S.2532	10.01	10.12	10.07	3.85	3.73	3.79
S.2724	1.33	1.34	1.34	3.24	3.38	3.31
S.2725	14.40	14.20	14.30	3.32	3.73	3.53
S.2601	27.51	28.01	27.76	1.92	1.80	1.86
S.2602	4.91	4.97	4.94	2.96	3.48	3.22
S.2606	14.95	14.83	14.89	3.88	4.03	3.96
S.2608	18.91	18.64	18.78	2.07	2.18	2.13
S.2613	9.16	9.03	9.10	2.07	2.07	2.07
S.2616	20.01	19.87	19.94	1.10	1.19	1.15
S.2659	29.70	29.53	29.62	4.98	5.08	5.03
S.2660	15.15	15.05	15.10	4.11	4.07	4.09

S.2671	18.36	17.86	18.11	1.08	0.98	1.03
S.2672	17.78	17.92	17.85	1.90	1.84	1.87
Cauvery - Check	33.00	32.34	32.67	3.77	4.09	3.93
Chandragiri - Check	8.45	8.52	8.49	3.10	3.01	3.06
Mean	12.69	12.36	12.48	2.99	3.07	3.00
S.Em±	0.25	0.30	0.27	0.29	0.07	0.15
C.D. @ 5%	0.72	0.86	0.81	0.84	0.20	0.45

RDS – Rust disease severity, **CBB** – Coffee berry borer

Table 4: Grouping of forty one Arabica coffee genotypes based on rust disease scoring on pooled average over years

Rust disease grades	Rust disease severity scale	Reaction type	Genotypes
G ₀	0	Immune	-
G ₁	1-5	Moderately resistant	S.1495, S.1561, S.2504, S.2509, S.2510, S.2529, S.2602, S.2724
G ₂	6-10	Tolerant	S.1497, S.2501, S.1655, S.2507, S.2506, S.2505, S.2503, S.2508, S.2613, Chandragiri
G ₃	11-20	Moderately susceptible	S.1477, S.1482, S.1484, S.1493, S.1496, S.1502, S.1565, S.1573, S.2502, S.2511, S.2532, S.2725, S.2608, S.2606, S.2672, S.2671 S.2660
G ₄	21-50	Susceptible	S.1500, S.1572, S.2601, S.2616, S.2659, Cauvery
G ₅	>51	Highly susceptible	-

Table 5: Grouping of forty one Arabica coffee genotypes based on coffee berry borer incidence scale on pooled average over years

Coffee berry borer incidence scale	Reaction type	Genotypes
>1-9	Tolerant	S.1477, S.1482, S.1484, S.1493, S.1495, S.1496, S.1497, S.1500, S.1502, S.1561, S.1565, S.1572, S.1573, S.1655, S.2501, S.2502, S.2503, S.2504, S.2505, S.2506, S.2507, S.2508, S.2509, S.2510, S.2511, S.2529, S.2532, S.2724, S.2725, S.2601, S.2602, S.2606, S.2608, S.2613, S.2616, S.2659, S.2660, S.2671, S.2672, Cauvery, Chandragiri
>10	Susceptible	-

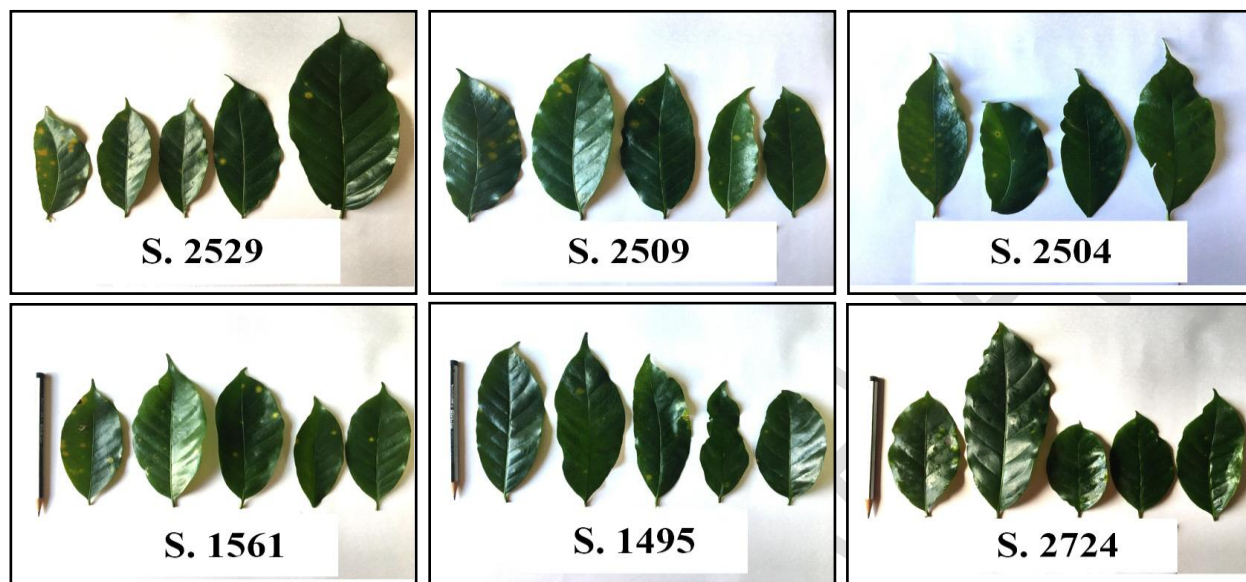


Plate 1: Genotypes established moderately resistant to coffee leaf rust disease

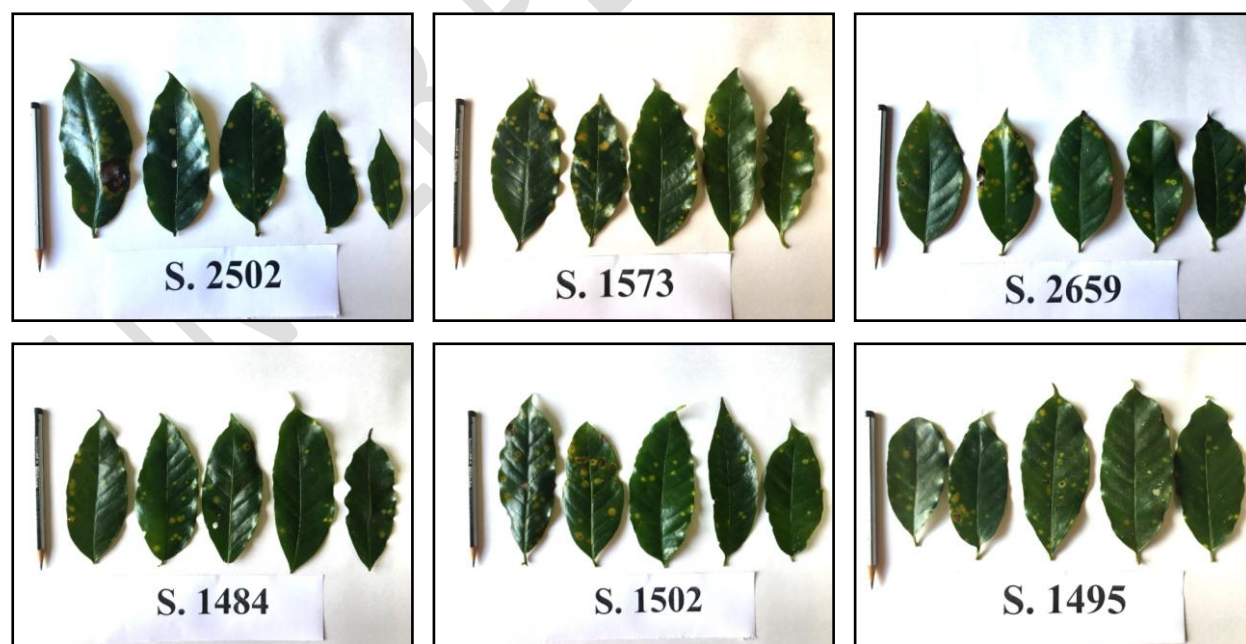


Plate 2: Genotypes showing susceptibility to coffee leaf rust disease**Reference**

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