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RESEARCH ARTICLE

A novel hydroponic approach for efficient screening and rapid phenotyping for identification of Fusarium wilt resistance in brinjal (*Solanum melongena* l.) and wild *Solanum* species

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Abstract

Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *melongenae* (Fomg), has emerged as a serious disease limiting brinjal productivity**.** Soil-borne nature of the pathogen, limited reproducibility and environmental variability complicate the use of the laborious traditional screening methods for resistance to Fusarium wilt in breeding programs. To facilitate reliable screening and rapid phenotyping, we resorted to a novel hydroponic approach. In this study, 90 brinjal genotypes, including diverse cultivated and wild accessions, were grown in Hoagland solution and inoculated with Fomg, isolated from a Fusarium wilt-endemic field at the host institute. Disease indices (DI), area under disease progress curve (AUDPC) and area under disease progress stairs (AUDPS) were used to identify resistant genotypes and study disease progression. Host phenotypic trait assessments and histopathological studies were also used to characterize resistant sources. Five genotypes, namely BR-40-7, Pink, Bouldar, *S. sisymbriifolium*, and *S. torvum* were found immune to Fusarium wilt, while fifteen genotypes each were found highly resistant and resistant to the disease. Genotypes immune to the disease were asymptomatic. Highly resistant genotypes were late-wilters, while the resistant genotypes were slow-wilters. Highly susceptible genotypes exhibited early, rapid and severe wilting. Resistant genotypes exhibited superior root and shoot development compared to susceptible genotypes. The broad applicability of the hydroponic screening method to diverse plant species and root pathogens underscores its potential to address critical challenges in agriculture. This study is the first to use Fusarium-specific screening of germplasm in hydroponic brinjal and wild *Solanum* cultures.

Keywords: Brinjal germplasm, Root pathogen, Disease progression, Histopathology, Trait assessments.

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Introduction

Brinjal (*Solanum melongena* L.) is a vital solanaceous vegetable grown widely in the tropics and subtropics. India, being its original home, houses an incredible diversity of brinjal and produces 12.77 million tonnes from an area of 6.76 lakh hectares (NHB, 2022-23), making it the second largest producer in the world (FAO, 2022). However, stable production of brinjal is threatened by several biotic stresses, among which Fusarium wilt caused by *Fusarium oxysporum* f. sp. *melongenae* (Fomg) is one of the most serious diseases causing a potential yield loss of 75 to 81% (Rao et al., 2019). Host natural resistance offers a sustainable solution against current management strategies like crop rotation, biocontrol agents, and chemical controls, which fail to be promising in the long run (Chitwood-Brown et al., 2021; Manikandan et al., 2024). The ability of the soil-borne pathogen to survive for extended periods in the absence of a host significantly hinders cultivar phenotyping and effective management

of the disease (Jambagi & Dixelius, 2023). Resistant lines identified under field conditions are often susceptible under challenged inoculation, necessitating screening in artificial inoculated conditions, usually done in pot cultures. Traditional methods for evaluating host resistance to Fusarium wilts, such as field trials and artificial inoculations in pots, are time-consuming, labor-intensive and susceptible to environmental variability. This makes it difficult to efficiently screen large populations for resistance traits (Jorben et al., 2023). Consequently, there is a critical need for more precise and controlled rapid phenotyping techniques. Hydroponic systems offer a promising alternative by providing a controlled environment where nutrient levels, pH, temperature, and oxygen can be meticulously managed. This controlled setting facilitates rapid inoculum spread, enabling the early and accurate assessment of host resistance. Consequently, large numbers of genotypes can be efficiently screened in a short period (Jambagi & Dixelius, 2023; Jorben et al., 2023). The simplified phenotypic and histopathological analyses further enhance the utility of this method. Therefore, this study aimed to utilize hydroponic techniques to evaluate brinjal and wild *Solanum* germplasm for resistance to Fusarium wilt using native inoculum.

Materials and Methods

Plant materials

A diverse germplasm collection of 90 genotypes, consisting 73 cultivated brinjal genotypes including indigenous and exotic cultivars, breeding lines, released varieties, and landraces and 17 accessions of 8 wild *Solanum* species (*Solanum incanum, S. unduatum, S. macrocarpon, S. insanum, S. integrifolium, S. aethiopicum, S. sisymbriifolium* and *S. torvum*) sourced from ICAR-National Bureau of Plant Genetic Resources and ICAR-Indian Agricultural Research Institute, were evaluated for wilt resistance. Nursery raising of seedlings was carried out in portrays containing a potting mix of sterilized cocopeat, vermiculite and perlite in a 3:1:1 ratio. Seedlings were regularly irrigated and drenched with 19:19:19 (0.5%) every two weeks.

Pathogen multiplication and inoculum preparation

The isolate of Fomg was obtained from infected brinjal stems collected from a Fusarium wilt-endemic field at the Vegetable Research Farm, ICAR-IARI, New Delhi. The isolate was cultured on Potato Dextrose Agar (PDA) plates and incubated at 27 ± 2°C for 10 days. Four discs from pure PDA plates each were cultured in 100 mL of potato dextrose broth (PDB) flasks and incubated at 27 ± 2°C. After 14 days, the mycelia were harvested, lyophilized, and ground into a fine powder for DNA extraction. ITS and β-tubulin regions were amplified from the genomic DNA by PCR using the primer combinations ITS1/ITS4 (Datta et al., 2011) and Bt1a/Bt1b (Jiménez-Gasco et al., 2002)the causal agent of fusarium wilt of chickpea, consists of two pathotypes (yellowing and wilting. The PCR product was sequenced using Sanger sequencing and analyzed by BLAST to confirm the species' identity with the GenBank database. Thereby, the identity of the pathogen was confirmed through morphological, cultural, molecular, and pathogenicity tests. To prepare the inoculum, the pathogen was cultured and multiplied in PDB flasks, as mentioned earlier. 14-day-old cultures were harvested and macerated in sterile distilled water. The conidial suspension was adjusted to a concentration of 6 x 10^4 spores mL^{-1} using a hemocytometer.

Hydroponic set-up and inoculation

The hydroponic phenotyping experiment was carried out at ICAR-NBPGR, New Delhi, in a temperature-controlled growth facility maintained at 27 ± 2°C, with a 16 hours photoperiod and 45% relative humidity. Healthy 4-week-old seedlings (three replicates per genotype) at 4 to 5 leaf stage were transplanted into sterile, aerated hydroponic systems containing sterile distilled water (20 L) supplemented with full-strength Hoagland's nutrient solution (200 mL) (Hoagland and Arnon, 1950). Control plants were grown in a nutrient solution without inoculum. For inoculation, 200 mL of the prepared suspension was added to each of the three replicates of hydroponic trays. Plants were monitored for disease symptoms for 30 days post-inoculation (DAI). The nutrient solution and conidial suspension were replenished every 10 days.

Disease assessment and progression

A six-point disease severity scale (modified from Pouralibaba et al., 2015) was used to assess individual leaf symptoms: 0 = no symptoms; 1 = initial chlorosis; 2 = progressive yellowing; 3 = complete yellowing; 4 = wilted, curled, dried, or defoliated; 5 = completely dead plant *i.e.,* all leaves with a score of 4). A plant-level disease index (DI) was calculated using individual leaf scores to compare resistance among genotypes by the formula: DI = . Where n1-n4 = number of leaves with symptom types 1 to 4, respectively; t = total number of leaves, including asymptomatic and fallen leaves and 0.25, 0.5, 0.75 and 1 = indices corresponding to symptom categories 1 to 4. Based on DI values obtained, genotypes were categorized for their specific disease reaction: 0% - immune; 0.1 to 10% - highly resistant; 10.1 to 25% - resistant; 25.1 to 50% - moderately susceptible; 50.1 to 75% - susceptible; 75.1 to 100% - highly susceptible. Asymptomatic plants were assigned a 0% DI, while dead plants received 100% DI. Fusarium wilt progression was recorded at 10-, 15-, 18-, 21-, 24-, 27- and 30 DAI. The area under the disease progress curve (AUDPC) and area under the disease progress stairs (AUDPS) were calculated (Jorben et al., 2023)

Microscopic and histopathological observations

At 30 DAI, variation in the degree of infection in resistant and susceptible genotypes was examined. Seedling roots were

cleaned, sectioned, and mounted on slides for microscopic analysis. Three replicate seedlings per genotype were examined at 10X magnification. Longitudinal sections of stems from resistant and susceptible genotypes were also observed under a stereo binocular microscope.

Host phenotypic traits assessment

To evaluate the impact of Fomg on host phenotypes, three replicates of selected resistant and susceptible genotypes were sampled to measure growth parameters. These parameters included root and shoot lengths, fresh and dry weights, dry matter percentage, root area, and root volume. Roots were rinsed with distilled water, blotted dry, and then dried at 58 ± 2°C for 6 days to determine dry weight. Root length, area, and volume were quantified using WinRHIZO image analysis. The collected data were analyzed to calculate means and assess the relative reduction in growth parameters between resistant and susceptible genotypes.

Statistical analysis

The experiment was carried out using a Completely Randomized Design (CRD) in three replications. The statistical analysis of DI, AUDPC, AUDPS and various parameters was done using a statistical package for social science, version 16.0 (SPSS 16.0) (Ivan, 2021).

Results and Discussion

Disease screening and identification of resistant genotypes

The results pertaining to disease screening and grouping of genotypes based on disease reaction have been given in Table 1 and Table 2 respectively. At 7 DAI, symptoms began to appear as a tiny initiation of chlorosis (score-1) in the older leaves of G-9, G-204, BB-44, Dinhala Local, Keonjhar Local, Tripura Panjo and Guhela Local. These genotypes were the earliest to show a susceptible disease reaction, recording a DI of 3.33 (G-9, G-204, BB-44, Guhela Local) and 1.67 (Dinhala Local, Keonjhar Local, Tripura Panjo). 10 DAI marked the beginning of the symptoms in many genotypes characterized by tiny initiation of chlorosis in older leaves (score 1) and/or progressive chlorosis in older leaves (score 2). However, many cultivated and wild genotypes appeared asymptomatic. Disease progression was evident at 15-, 18-, 21-, 24- and 27- DAI which displayed a specific pattern – initiation of yellowing in older leaf (score 1), progressive yellowing (score 2), complete yellowing (score 3), wilting/ curling/drying/ defoliation (score 4) and complete drying/ death of plants (score 5) (Fig. 1). Plant-level DI at 30 DAI were used to compare resistance/susceptibility among genotypes (Fig. 2).

Five genotypes (BR-40-7, Pink, Bouldar, *S. sisymbriifolium*, *S. torvum*) found immune to Fusarium wilt recorded a consistent DI of 0% due to the absence of disease symptoms.

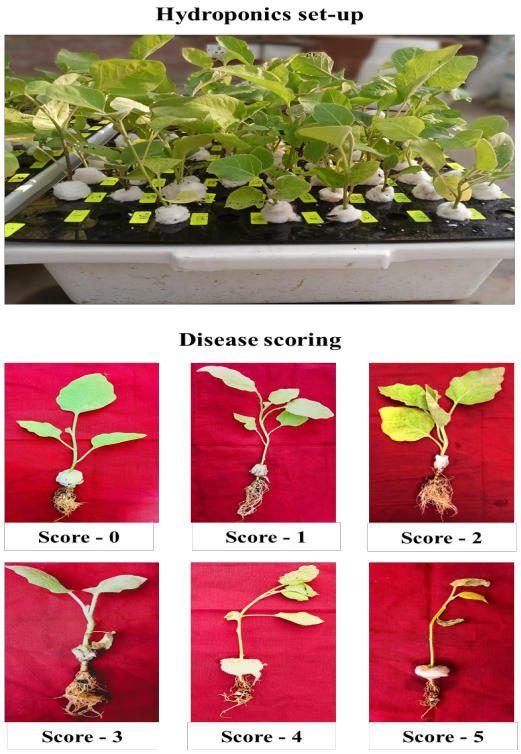

Fig. 1: Hydroponics set-up and disease scoring

15 notable genotypes (Swarna Mani, 190-10-12, H-183, Pant Rituraj, CH-151, Special Muktakeshi, Sidhasar Local, Brinjal Hazari Bhatpura, Brinjal Muktakeshi, Bhangor Baigan, EC-384970, *S. macrocarpon* white fruit, *S. macrocarpon* Netherland Acc, PSB-1 x S. *incanum*, *S. macrocarpon* green fruit Ac-2) classed as highly resistant recorded a low DI in the range 0.1-10% which were statistically at par among one another. 11 cultivated genotypes (G-92, G-131-L, 91-2, Pusa Safed Baigan-1, Pusa Bindu, Pusa Ouishiki, Pusa Ankur, DBR-160-2-3-13, Debjhuri Hazari, Brinjal Very Proms purple, EC-304072) and four wild accessions (*S. incanum* EC-873410, *S. insanum*, *S. aethiopicum* Ac-1, *S. torvum*) with DI ranging between 10.1% and 25% were categorized as resistant to the disease with some significant differences. The results indicated that the disease in highly resistant genotypes appeared late, was very minimal or progressed at a negligible rate, reaching a maximum of 10% disease severity at 30 DAI, while in resistant genotypes, the disease was mild and progressed slowly even though there were variations in the day of appearance of symptoms. These genotypes may possess inherent resistance mechanisms that delay or prevent the establishment of the disease. This resistance could be due to genetic factors that either inhibit the pathogen's ability to infect the plant or enhance the plant's immune responses. This could involve mechanisms such as the production of antimicrobial compounds, cell wall modifications, or the activation of defense pathways (Das et al., 2023; Zhu et al., 2023).

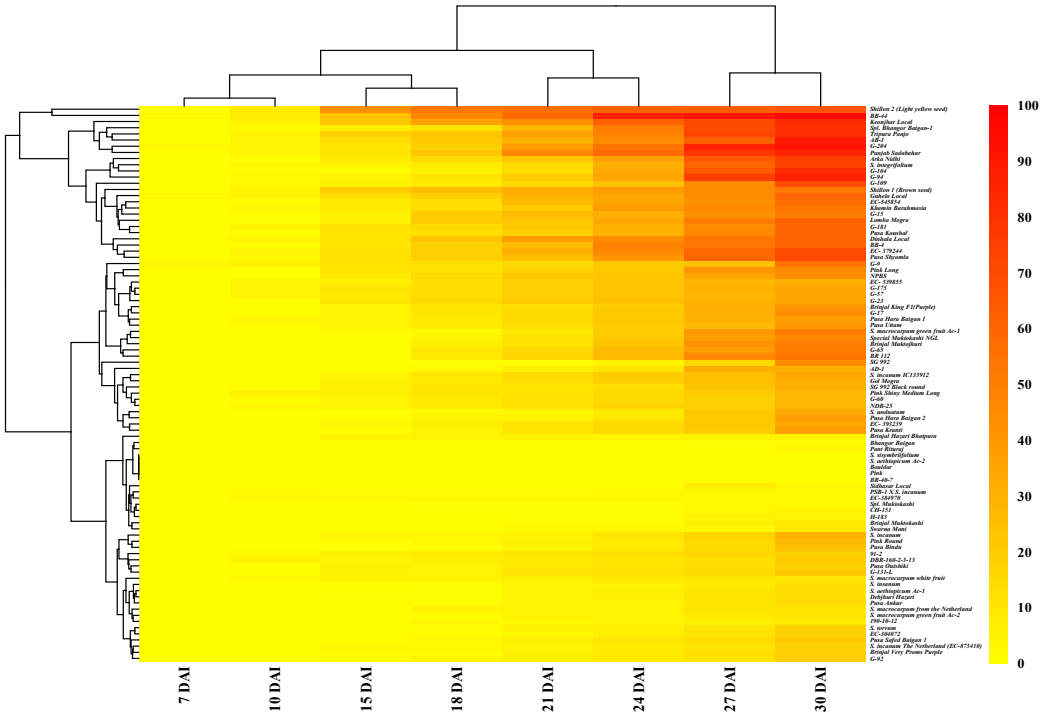

Fig. 2: Heat map indicating Fusarium wilt severity scores for brinjal genotypes from highly susceptible (red) to highly resistant (yellow) lines

A maximum number (28) of genotypes were classified under the moderately susceptible group with DI 25.1 to 50%. About 18 genotypes were found to be susceptible, with 50.1 to 75% DI. High DI (75.1–100%) values were recorded from highly susceptible genotypes, which were the worst affected by the disease and showed typical wilting symptoms with pronounced vascular discoloration followed by death of the plants. BB-44 recorded the highest DI of 96.67%. Thus, highly susceptible/susceptible genotypes showed early disease infection along with rapid progression, reaching a complete wilting stage at an early stage (Pouralibaba et al., 2015). AUDPC and AUDPS were calculated for DI values of all host genotypes. Minimum AUDPC (0.00) and AUDPS (0.00) values were recorded from genotypes immune to the disease. Maximum AUDPC (1133.33) and AUDPS (1297.62) were recorded from BB-44, followed by Shillong-2 (1011.67, 1121.19) and Keonjhar Local (1011.67, 1121.19) which were statistically significant.

Microscopic and histopathological observations

At 30 DAI, root and stem tissues were examined for variations in the degree of infection in resistant (Swarna Mani) and susceptible (Punjab Sadabahar) genotypes. Both susceptible and resistant genotypes showed the presence of fungal mycelium on the root surface. The resistant variety displayed less pronounced and restricted discoloration of the xylem vessel than the susceptible variety. The susceptible variety showed noticeable progressive discoloration and disruption of xylem vessels extending upwards. Adjacent root cells also showed complete disintegration. Punjab Sadabahar revealed distinguished browning in the vascular region of the stem, while browning was not prominent in Swarna Mani (Fig. 3). Histopathological studies also confirmed early and rapid disintegration of stem and root vascular regions in susceptible genotypes, in contrast to delayed infection in resistant genotypes (Jorben et al., 2023).

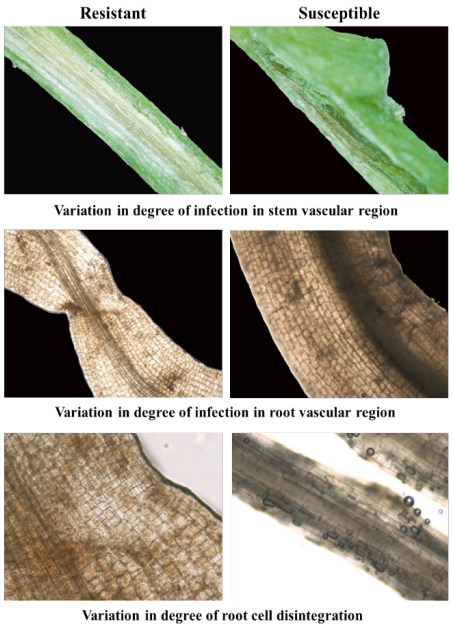

Fig. 3: Histopathological observations in resistant and susceptible genotypes

Table 1: Fusarium wilt indices on hydroponic screening at specific time intervals for identification of resistant genotypes

S. No.	Genotype	MEAN DI VALUES										
		7 DAI	10 DAI	15 DAI	18 DAI	21 DAI	24 DAI	27 DAI	30 DAI	AUDPC	AUDPS	Disease reaction
1	G-92	0.00	0.00	1.67	5.00	6.67	8.33	11.67	20.00^{zABC}	131.67^{wxyzA}	164.52^{zABCDE}	R
2	G-131-L	0.00	0.00	5.00	5.00	10.00	11.67	15.00	21.67^{yzA}	177.50^{uvwx}	213.10^{wxyz}	R
3	91-2	0.00	3.33	6.67	8.33	10.00	13.33	16.67	18.33^{ABCD}	212.50^{stuv}	242.62^{vwxy}	R
4	Pusa Kranti	0.00	0.00	0.00	5.00	10.00	15.00	20.00	38.33^{qrs}	207.50^{stuv}	270.48^{uvwx}	MS
5	Pusa Shyamala	0.00	3.33	11.67	18.33	25.00	41.67	60.00	71.67^{gh}	602.50^{fgh}	720.24^{fghi}	S
6	Pusa Kaushal	0.00	1.67	10.00	13.33	18.33	30.00	46.67	60.00^{ijk}	461.67^{ijk}	560.24^{mn}	S
7	Swarna Mani	0.00	0.00	0.00	0.00	3.33	3.33	3.33	8.33^{FGHI}	42.5^{DEFGHI}	56.19^{HIJKL}	HR
8	NDB-25	0.00	3.33	5.00	8.33	11.67	16.67	18.33	$28.33^{t vwx}$	240.83^{qrst}	287.38^{tuv}	MS
9	BR-40-7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00^{J}	0.00^{I}	0.00^{L}	I
10	BR-112	0.00	0.00	1.67	8.33	16.67	26.67	46.67	53.33^{lm}	381.67^{lm}	469.29^{o}	S
11	Pusa Safed Baigan-1	0.00	0.00	0.00	3.33	6.67	10.00	13.33	21.67^{yzA}	132.50^{wxyzA}	168.10^{zABCD}	R
12	Pusa Bindu	0.00	0.00	0.00	0.00	5.00	8.33	15.00	25.00^{xyz}	122.50^{xyzAB}	163.57^{zABCDE}	R
13	190-10-12	0.00	0.00	0.00	3.33	3.33	5.00	6.67	8.33^{FGHI}	$67.50^{BCDEFGH}$	81.19^{GHIJK}	HR
14	Punjab Sadabahar	0.00	5.00	10.00	23.33	46.67	58.33	78.33	85.00^{cde}	807.50^{d}	947.14^{cd}	HS
15	Pusa Uttam	0.00	1.67	5.00	8.33	13.33	20.00	26.67	41.67^{pq}	294.17^{opq}	362.62^{qrs}	MS
16	NPBS	0.00	0.00	8.33	15.00	21.67	23.33	35.00	45.00^{op}	385.83^{lm}	459.76^{op}	MS
17	Pusa Ouishiki	0.00	0.00	6.67	5.00	8.33	10.00	13.33	18.33^{ABCD}	164.17^{vwx}	194.29^{yzAB}	R
18	Pusa Hara Baigan-1	0.00	3.33	5.00	8.33	15.00	21.67	30.00	38.33^{qr}	315.83^{nop}	378.81^{qr}	MS
19	Pusa Hara Baigan-2	0.00	0.00	0.00	5.00	5.00	10.00	21.67	38.33^{qr}	182.50^{uvwx}	245.48^{vwxy}	MS
20	Pusa Ankur	0.00	1.67	1.67	1.67	5.00	5.00	10.00	15.00^{BCDE}	100.83^{yzABCD}	$125.48^{BCDEFGH}$	R
21	Pink Shiny Medium Long	0.00	5.00	6.67	10.00	10.00	15.00	20.00	$28.33^{t vwx}$	254.17^{qrs}	300.71^{stuv}	MS
22	Pink Round	0.00	0.00	0.00	3.33	6.67	8.33	15.00	26.67^{wxy}	140.00^{wxyz}	183.81^{yzABC}	MS
23	Pink	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00^{J}	0.00^{I}	0.00^{L}	I
24	Pink Long	0.00	0.00	10.00	11.67	16.67	21.67	41.67	45.00^{op}	382.50^{lm}	456.43^{op}	MS
25	G-9	3.33	5.00	10.00	11.67	15.00	21.67	25.00	55.00^{klm}	367.5^{mn}	463.33^{op}	S
26	G-15	0.00	1.67	6.67	20.00	26.67	31.67	43.33	51.67^{lmn}	475.83^{ijk}	560.71^{mn}	S
27	G-17	0.00	0.00	5.00	10.00	15.00	21.67	31.67	45.00^{op}	322.50^{nop}	396.43^{pqr}	MS

S. No.	Genotype	MEAN DI VALUES										
		7 DAI	10 DAI	15 DAI	18 DAI	21 DAI	24 DAI	27 DAI	30 DAI	AUDPC	AUDPS	Disease reaction
28	G-23	0.00	1.67	10.00	15.00	20.00	25.00	30.00	35.00^{rstu}	369.17^{mn}	426.67^{opq}	MS
29	G-57	0.00	5.00	8.33	13.33	18.33	23.33	28.33	35.00^{rst}	355.83^{mn}	413.33^{opq}	MS
30	G-60	0.00	1.67	5.00	8.33	11.67	15.00	18.33	28.33$^{t\ vwx}$	229.17^{rstu}	275.71^{tuvw}	MS
31	G-65	0.00	0.00	0.00	10.00	15.00	26.67	38.33	50.00^{mno}	345.00^{mno}	427.14^{opq}	MS
32	G-94	0.00	3.33	5.00	10.00	20.00	35.00	75.00	86.67^{cd}	583.33^{gh}	725.71^{fghi}	HS
33	G-104	0.00	1.67	1.67	6.67	13.33	33.33	65.00	83.33^{de}	493.33^{j}	630.24^{jkl}	HS
34	G-109	0.00	3.33	6.67	8.33	15.00	25.00	45.00	70.00^{gh}	425.00^{kl}	540.00^{n}	S
35	G-175	0.00	5.00	10.00	13.33	18.33	23.33	30.00	35.00^{rst}	367.50^{mn}	425.00^{opq}	MS
36	G-181	0.00	5.00	11.67	15.00	21.67	30.00	45.00	60.00^{jk}	491.67^{j}	590.24^{lmn}	S
37	G-204	3.33	5.00	10.00	18.33	38.33	55.00	86.67	93.33^{ab}	800.00^{d}	958.81^{cd}	HS
38	SG-992	0.00	0.00	0.00	0.00	0.00	5.00	15.00	45.00^{op}	127.50^{wxyzAB}	201.43^{xyzA}	MS
39	SG-992 Black round	0.00	0.00	6.67	10.00	10.00	13.33	23.33	31.67$^{r\ tuvw}$	244.17^{qrs}	296.19^{tuv}	MS
40	H-183	0.00	0.00	0.00	0.00	1.67	1.67	5.00	5.00^{GHIJ}	32.5^{EFGHI}	40.71^{JKL}	HR
41	Pant Rituraj	0.00	0.00	0.00	0.00	0.00	0.00	1.67	3.33^{GHIJ}	10.00^{HI}	15.48^{KL}	HR
42	DBR-160-2-3-13	0.00	5.00	5.00	6.67	8.33	10.00	13.33	20.00^{zAB}	185.00^{tuvw}	217.86^{wxyz}	R
43	Arka Nidhi	0.00	1.67	8.33	15.00	23.33	36.67	65.00	75.00^{fg}	572.5^{h}	695.71^{ghi}	S
44	AB-1	0.00	5.00	13.33	21.67	30.00	45.00	63.33	90.00^{bc}	688.33^{e}	836.19^{e}	HS
45	AD-1	0.00	1.67	1.67	3.33	6.67	10.00	31.67	31.67$^{r\ tuvw}$	215.83^{stuv}	267.86^{uvwx}	MS
46	BB-4	0.00	1.67	10.00	18.33	26.67	48.33	53.33	61.67^{ij}	579.17^{h}	680.48^{hij}	S
47	CH-151	0.00	0.00	0.00	1.67	1.67	1.67	3.33	5.00^{GHIJ}	32.50^{EFGHI}	40.71^{JKL}	HR
48	BB-44	3.33	8.33	25.00	46.67	58.33	86.67	91.67	96.67^{a}	1133.33^{a}	1297.62^{a}	HS
49	Special Muktakeshi	0.00	0.00	0.00	1.67	1.67	1.67	3.33	3.33^{GHIJ}	30.00^{FGHI}	35.48^{JKL}	HR
50	Dinhala Local	1.67	5.00	10.00	23.33	38.33	45.00	53.33	61.67^{ij}	635.00^{efg}	739.05^{fgh}	S
51	Sidhasar Local	0.00	0.00	0.00	1.67	1.67	1.67	3.33	3.33^{GHIJ}	30.00^{FGHI}	35.48^{JKL}	HR
52	Keonjhar Local	1.67	5.00	21.67	36.67	43.33	61.67	70.00	83.33^{de}	869.17^{c}	1008.81^{c}	HS
53	Special Bhangor Baigan-1	0.00	1.67	6.67	11.67	28.33	51.67	71.67	80.00^{ef}	643.33^{ef}	774.76^{f}	HS
54	Khamin Barahmasia	0.00	3.33	8.33	13.33	21.67	38.33	45.00	53.33^{lm}	481.67^{j}	569.29^{lmn}	S
55	Tripura Panjo	1.67	5.00	18.33	23.33	36.67	48.33	73.33	81.67^{de}	763.33^{d}	900.24^{d}	HS

S. No.	Genotype	MEAN DI VALUES										
		7 DAI	10 DAI	15 DAI	18 DAI	21 DAI	24 DAI	27 DAI	30 DAI	AUDPC	AUDPS	Disease reaction
56	Debjhuri Hazari	0.00	0.00	1.67	1.67	5.00	6.67	10.00	13.33$^{B\ DEF}$	96.67^{zABCD}	118.57^{CDEFGHI}	R
57	Lomba Mogra	0.00	1.67	6.67	20.00	23.33	35.00	51.67	61.67^{ij}	515.83^{ij}	617.14^{jklm}	S
58	Brinjal Muktojhuri	0.00	1.67	1.67	6.67	11.67	23.33	43.33	50.00^{mno}	343.33^{mno}	425.48^{opq}	MS
59	Bouldar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00^{J}	0.00^{I}	0.00^{L}	I
60	Brinjal Hazari Bhatpura	0.00	0.00	5.00	5.00	5.00	5.00	5.00	5.00^{GHIJ}	87.50^{zABCDEF}	95.71^{EFGHIJ}	HR
61	Gol Mogra	0.00	1.67	6.67	8.33	13.33	18.33	25.00	31.67$^{r\ tuvw}$	275.83^{pqr}	327.86^{rstu}	MS
62	Brinjal Muktakeshi	0.00	0.00	0.00	0.00	1.67	1.67	6.67	8.33^{FGH}	42.50^{DEFGHI}	56.19^{HIJKL}	HR
63	Brinjal Very Proms Purple	0.00	0.00	1.67	1.67	6.67	8.33	13.33	18.33^{ABCD}	124.17^{xyzAB}	154.29^{zABCDEF}	R
64	Guhela Local	3.33	5.00	13.33	18.33	30.00	35.00	45.00	61.67^{ij}	555.83^{hi}	662.62^{ijk}	S
65	Brinjal King F1	0.00	1.67	5.00	10.00	13.33	20.00	31.67	41.67^{pq}	314.17^{nop}	382.62^{qr}	MS
66	Bhangor Baigan	0.00	0.00	0.00	0.00	1.67	1.67	1.67	1.67$^{H\ J}$	17.50^{GHI}	20.24^{KL}	HR
67	EC-384970	0.00	3.33	3.33	3.33	3.33	3.33	3.33	3.33^{GHIJ}	71.67^{ABCDEFG}	77.14^{GHIJK}	HR
68	EC-304072	0.00	0.00	0.00	1.67	3.33	6.67	10.00	18.33^{ABCD}	92.50^{zABCDE}	122.62^{CDEFGHI}	R
69	EC-545854	0.00	0.00	8.33	13.33	26.67	35.00	43.33	56.67^{jkl}	473.33^{jk}	566.43^{lmn}	S
70	Special Muktakeshi NGL	0.00	0.00	0.00	5.00	10.00	21.67	38.33	46.67^{nop}	295.00^{opq}	371.67^{qr}	MS
71	EC-393239	0.00	1.67	3.33	6.67	10.00	15.00	21.67	35.00^{rstu}	232.50^{rstu}	290.00^{tuv}	MS
72	EC-539855	0.00	5.00	6.67	13.33	18.33	23.33	28.33	31.67$^{r\ tuvw}$	344.17^{mno}	396.19^{pqr}	MS
73	EC-379244	0.00	5.00	11.67	18.33	31.67	46.67	58.33	70.00^{gh}	636.67^{efg}	751.67^{fg}	S
74	*S. incanum*	0.00	0.00	3.33	3.33	5.00	10.00	16.67	30.00^{tuvwx}	163.33^{vwx}	212.62^{wxyz}	MS
75	*S. unduatum*	0.00	0.00	0.00	3.33	3.33	8.33	21.67	33.33^{rstuv}	160.00^{vwxy}	214.76^{wxyz}	MS
76	*S. macrocarpum* (green fruit) Ac-1	0.00	0.00	1.67	3.33	8.33	20.00	40.00	50.00^{mno}	296.67^{opq}	378.81^{qr}	MS
77	*S. incanum* (EC-873410)	0.00	0.00	3.33	3.33	5.00	8.33	11.67	18.33^{ABCD}	125.83^{wxyzAB}	155.95^{zABCDEF}	R
78	*S. macrocarpum* white fruit	0.00	3.33	5.00	5.00	6.67	8.33	10.00	10.00^{EFG}	138.33^{wxyz}	154.76^{zABCDEF}	HR
79	*S. macrocarpum* Netherland Acc	0.00	0.00	0.00	5.00	5.00	5.00	10.00	10.00^{EFG}	90.00^{zABCDEF}	106.43^{DEFGHIJ}	HR
80	*S. incanum* (IC-135912)	0.00	0.00	5.00	10.00	15.00	20.00	25.00	35.00^{rst}	282.50^{pqr}	340.00^{rst}	MS
81	*S. insanum*	0.00	0.00	0.00	1.67	5.00	5.00	8.33	13.33$^{B\ DEF}$	80.00^{zABCDEF}	101.90^{DEFGHIJ}	R
82	*S. aethiopicum* Ac-1	0.00	1.67	1.67	1.67	5.00	6.67	10.00	13.33$^{B\ DEF}$	103.33^{yzABC}	125.24^{BCDEFGH}	R
83	PSB-1 X *S. incanum*	0.00	1.67	1.67	1.67	1.67	3.33	3.33	3.33^{GHIJ}	48.33^{CDEFGHI}	53.81^{IJKL}	HR

S. No.	Genotype	MEAN DI VALUES							AUDPC	AUDPS	Disease reaction
		7 DAI	10 DAI	15 DAI	18 DAI	21 DAI	24 DAI	27 DAI	30 DAI		
84	*S. macrocarpum* (green fruit) Ac-2	0.00	0.00	0.00	1.67	5.00	5.00	8.33	10.00^{EFG}	$75.00^{ABCDEFG}$	91.43^{FGHIJ}	HR
85	*S. integrifolium*	0.00	3.33	5.00	8.33	15.00	31.67	60.00	73.33^{g}	488.33^{j}	608.81^{klm}	S
86	*S. aethiopicum* Ac-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00^{J}	0.00^{l}	0.00^{L}	I
87	Shillong-1	0.00	5.00	20.00	26.67	33.33	38.33	45.00	53.33^{lm}	610.00^{fgh}	697.62^{ghi}	S
88	Shillong-2	0.00	8.33	43.33	53.33	56.67	61.67	63.33	66.67^{hi}	1011.67^{b}	1121.19^{b}	S
89	*S. sisymbriifolium*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00^{J}	0.00^{l}	0.00^{L}	I
90	*S. torvum*	0.00	0.00	0.00	1.67	5.00	6.67	11.67	18.33^{ABCD}	102.5^{yzABCD}	$132.62^{ABCDEFG}$	R
	CD (P < 0.05)								**5.57**	**49.71**	58.77	
	SEm±								**1.99**	**17.8**	**21.04**	
	CV %								9.39	10.26	10.07	

Numbers in the same column followed by the same alphabet are not significantly different for the DMRT test at α=5%.
DI: Disease index; DAI: Days after inoculation; AUDPC: Area under disease progress curve; AUDPS: Area under disease progress stairs; HR: Highly resistant; R: Resistant; MR: Moderately resistant; MS: Moderately susceptible; S: Susceptible; HS: Highly susceptible; CD: Coefficient of dispersion; SEm: Standard error of the mean; CV: Coefficient of variation.

Assessment of changes in host phenotypic traits

The significant changes in host phenotypic traits are summarized in Table 3. 28 genotypes were selected based on their resistance/susceptible reaction to *Fusarium oxysporum* f. sp. *melongenae* and were assessed for changes in the following phenotypic traits: shoot length, root length, root area, root volume, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, shoot dry matter percentage and root dry matter percentage. Plants infected with Fusarium wilt experienced significant reductions in shoot length. Susceptible genotypes suffered the most, with reductions ranging from 16.49 to 50.91%. Immune/resistant genotypes showed less severe reductions (0.94–11.79%). Maximum reductions were observed from Pusa Hara Baigan-1 (50.91%), BB-44 (49.10%) and G-104 (41.09%) and minimum reductions were shown by Pant Rituraj (0.94%), *S. aethiopicum* Ac-2 (4.24%) and CH-151 (4.40%) while demonstrating greater resilience. Interestingly, Pink and Sidhasar Local grew slightly taller (8.44, 3.64%), respectively, despite infection. Fusarium wilt negatively impacted plant root growth. Susceptible genotypes experienced significant reductions (29.12–63.78%), while resistant and immune genotypes showed milder effects (1.32–5.35%) or no effects at all, while they recorded better root lengths even under inoculated conditions. Pusa Kaushal recorded the highest reduction in root length (63.78%) and the least reduction was seen in CH-151 (1.32%). Surprisingly, root lengths of some resistant genotypes (*S. insanum*, *S. torvum*, *S. macrocarpon* Ac-2 and Swarna Mani) were affected and considerable high reductions were recorded (27.86, 32.49, 38.75 and 60.89%) from them, respectively.

Fusarium wilt reduced plant root area, with susceptible genotypes suffering the most (31.01–73.70%). Resistant and immune genotypes showed less severe impacts (1.02–16.52%) or no effects at all. However, some resistant genotypes (Special Muktakeshi, *S. macrocarpon* Ac-2 and Swarna Mani) were unexpectedly affected, with significant reductions in root length (23.00, 41.89, and 48.92%, respectively). The highest reduction was recorded from Guhela Local (73.70%) and the least from Pant Rituraj. Significant reductions in root volumes were observed under inoculated conditions. Susceptible genotypes experienced the most severe reductions, ranging from 14.63 to 80.49% in root volume, with an exception being Shillong-2 (4.55%). In contrast, immune and resistant genotypes exhibited milder reductions (4.17–11.54%) or no effect on root volume at all. A few resistant genotypes, including Swarna Mani, Pink, Special Muktakeshi, Sidhasar Local and EC-384970, successfully recorded an increase in root volume even under wilt stress conditions. Pusa Hara Baigan-1 (80.49%) recorded the highest reduction, while H-183 recorded the least (0.00%) or no reduction at all. Significant reductions in shoot fresh weights were observed on infection with Fom. Both

Table 2: Grouping of brinjal genotypes based on different disease reaction under hydroponic conditions

S. No.	*Disease reaction*	*No. of genotypes*	*Genotypes*
1.	Immune	5	BR-40-7, Pink, Bouldar, *S. aethiopicum* Ac-2, *S. sisymbriifolium*
2.	Highly resistant	15	Swarna Mani, 190-10-12, H-183, Pant Rituraj, CH-151, Special Muktakeshi, Sidhasar Local, Brinjal Hazari Bhatpura, Brinjal Muktakeshi, Bhangor Baigan, EC-384970, *S. macrocarpon* white fruit, *S. macrocarpon* Netherland Acc., PSB-1x *S. incanum*, *S. macrocarpon* (green fruit) Ac-2
3.	Resistant	15	G-92, G-131-L, 91-2, Pusa Safed Baigan-1, Pusa Bindu, Pusa Ouishiki, Pusa Ankur, DBR-160-2-3-13, Debjhuri Hazari, Brinjal Very Proms Purple, EC-304072, *S. incanum* EC-873410, *S. insanum*, *S. aethiopicum* Ac-1, *S. torvum*
4.	Moderately Susceptible	28	Pusa Kranti, NDB-25, Pusa Uttam, NPBS, Pusa Hara Baigan-1, Pusa Hara Baigan-2, Pink Shiny Medium Long, Pink Round, Pink Long, G-17, G-23, G-57, G-60, G-65, G-175, SG-992, SG-992 Black round, AD-1, Brinjal Muktojhuri, Gol Mogra, Brinjal King F1, Special Muktakeshi NGL, EC-393239, EC-539855, *S. incanum*, *S. unduatum*, *S. macrocarpon* (green fruit) Ac-1, *S. incanum* (IC135912)
5.	Susceptible	18	Pusa Shyamala, Pusa Kaushal, BR-112, G-9, G-15, G-109, G-181, Arka Nidhi, BB-4, Dinhala Local, Khamin Barahmasia, Lomba Mogra, Guhela Local, EC-545854, EC-379244, *S. integrifolium*, Shillong-1, Shillong-2
6.	Highly Susceptible	9	Punjab Sadabahar, G-94, G-104, G-204, AB-1, BB-44, Keonjhar Local, Special Bhangor Baigan, Tripura Panjo

susceptible and resistant genotypes suffered reductions ranging from 2.43 to 81.65%. The highest reduction (81.65%) was seen in Pusa Hara Baigan-1. Immune and resistant genotypes exhibited huge variations in reductions (2.43–55.76%), while some of them (Pink, Special Muktakeshi, *S. insanum*, *S. aethiopicum*) managed to record an increase in shoot fresh weights even under infection. Surprisingly, Guhela Local, being susceptible, recorded a 5.67% increase in fresh weight and, thereby, did not follow the expected pattern of reduction as in other susceptible genotypes.

Fusarium wilt negatively affected root fresh weights. Both resistant and susceptible genotypes were almost equally affected and encountered losses (5.17–55.41%). However, a few resistant and immune genotypes showed less severe impacts (*S. torvum* 5.17%, CH-151 6.34%, H-183 10.98%), no impact (Pink, Pant Rituraj), or showed increased root fresh weights on the infection (Special Muktakeshi, Sidhasar Local, EC-384970, *S. macrocarpon* white fruit, *S. sisymbriifolium*). The highest reduction was recorded from Pusa Hara Baigan-1 (55.41%). Interestingly, *S. integrifolium*, although susceptible, recorded a 13.33% increase in fresh weight, thereby being an exception to the usual reduction pattern in susceptible genotypes. Many resistant and susceptible genotypes were affected and showed reductions in shoot dry weights (15.38–77.88%). The most severe reduction was recorded from Pusa Hara Baigan-1 (77.88%). Although some immune and resistant genotypes showed lesser reductions (*S. sisymbriifolium* 5.00%, Sidhasar Local 6.82%, H-183 7.14%, EC-379244 8.62%), a few of them succeeded in recording an increase in shoot dry weights (Pink, Pant Rituraj, Special Muktakeshi, *S. insanum*, *S. aethiopicum* Ac-2). A few susceptible genotypes (Arka Nidhi, G-204, Guhela Local and Pusa Shyamala) showed an increase in shoot dry weights with an exceptionally high 6 times increase in shoot dry weight recorded from infected plants of Arka Nidhi over their controls.

Resistant and susceptible genotypes witnessed both reductions and increases in root dry weights. The highest reduction of 45.16% was recorded from BR-112, a susceptible genotype, followed by 40.91% from Swarna Mani, a highly resistant genotype. Least reduction of 7.50% was recorded from *S. macrocarpon* Ac-2, a highly resistant genotype followed by 9.09% from Pink, a genotype found immune to Fusarium wilt. Arka Nidhi, Shillong-2 and *S. torvum* recorded 0% impact. Among those genotypes showing an increase in root dry weights, *S. macrocarpon* white fruit and *S. sisymbriifolium* recorded a 100% increase, whereas the least increase by 16.67% was recorded from Pant Rituraj. Susceptible genotypes showed an increase in shoot dry matter percentage with huge variation in the range (6.82–133.05%). An exceptional increase in shoot dry matter percentage was recorded from infected plants of Arka Nidhi (11 times), G-204 (8 times) and BB-44 (1.3 times) over their controls. Resistant genotypes more or less maintained consistent shoot dry matter percentage in both control and inoculated conditions, with a few genotypes (H-183, *S. insanum*, *S. macrocarpon* Ac-2, *S. torvum*) showing a substantial increase (47.29, 40.83, 52.80, 84.82%).

Many susceptible and resistant genotypes recorded an increase in root dry matter percentage, whereas most resistant genotypes maintained more or less the same root dry matter percentage in both control and inoculated conditions. However, *S. insanum* (resistant) recorded a 1.9 times increase in root dry matter percentage. Among susceptible genotypes, the maximum increase was recorded from Pusa Kaushal (2.3 times), followed by G-104

Table 3: (Contd.) Shoot and root analysis of 28 resistant and susceptible genotypes grown in hydroponics

S. No.	Genotypes	SFW (g)		RFW (g)		SDW (g)		RDW (g)		SDM %		RDM %	
		C	I	C	I	C	I	C	I	C	I	C	I
1	Pusa Shyamala - **S**	2.47	1.61^{ef}	1.44	0.75^{defgh}	0.30	0.31^{cd}	0.24	0.33^{bcd}	12.15	19.5^{bcd}	16.67	44.44^{fgh}
2	Pusa Kaushal - **S**	3.64	1.81^{ef}	1.62	0.8^{defg}	0.18	0.14^{d}	0.24	0.39^{bcd}	4.95	7.55^{l}	14.81	48.54^{efg}
3	Swarna Mani - **HR**	3.67	2.39^{cdef}	0.64	0.36^{hijk}	0.40	0.26^{cd}	0.44	0.26^{cde}	10.90	10.72^{k}	68.75	72.22^{b}
4	BR-112 - **S**	3.54	1.00^{f}	1.02	0.8^{defg}	0.46	0.24^{cd}	0.62	0.34^{bcd}	12.99	24.08^{a}	60.78	42.5^{ghi}
5	Pusa Hara Baigan-1 - **MS**	6.92	1.27^{f}	0.74	0.33^{jk}	1.04	0.23^{cd}	0.36	0.22^{cdef}	15.03	17.89^{cde}	48.65	67.68^{b}
6	Pink - **I**	1.72	2.61^{cdef}	0.36	0.36^{hijk}	0.18	0.52^{cd}	0.22	0.2^{cdef}	10.47	19.82^{bc}	61.11	55.56^{cd}
7	G-104 - **HS**	6.34	1.59^{ef}	0.94	0.46^{fghijk}	0.30	0.09^{d}	0.14	0.19^{def}	4.73	5.86^{l}	14.89	40.58^{hij}
8	G-204 - **HS**	6.89	1.54^{f}	1.04	0.66^{defghij}	0.16	0.33^{cd}	0.40	0.48^{b}	2.32	21.65^{b}	38.46	73.23^{b}
9	H-183 - **HR**	3.99	2.54^{cdef}	0.82	0.73^{defghi}	0.42	0.39^{cd}	0.40	0.41^{bc}	10.53	15.51^{fgh}	48.78	56.42^{cd}
10	Pant Rituraj - **HR**	4.53	4.42^{cd}	1.01	1.02^{cd}	0.60	0.63^{bc}	0.30	0.35^{bcd}	13.25	14.19^{hi}	29.70	34.64^{jkl}
11	Arka Nidhi - **S**	3.72	2.11^{def}	1.02	0.46^{fghijk}	0.06	0.43^{cd}	0.25	0.25^{cde}	1.61	20.38^{b}	24.51	54.68^{cde}
12	CH-151 - **HR**	7.02	4.64^{bc}	1.42	1.33^{bc}	0.80	0.5^{cd}	0.44	0.39^{bcd}	11.40	10.78^{k}	30.99	29.07^{lm}
13	BB-44 - **HS**	4.78	2.21^{cdef}	1.70	1.38^{b}	0.34	0.37^{cd}	0.28	0.38^{bcd}	7.11	16.57^{efg}	16.47	27.6^{m}
14	Special Muktakeshi - **HR**	8.19	8.67^{a}	1.75	2.23^{a}	1.26	1.46^{a}	0.54	0.71^{a}	15.38	16.88^{efg}	30.86	31.64^{klm}
15	Sidhasar Local - **HR**	2.94	2.74^{cdef}	0.74	0.86^{de}	0.44	0.41^{cd}	0.18	0.32^{bcd}	14.97	15.1^{fghi}	24.32	37.07^{ijk}
16	Guhela Local - **S**	1.94	2.05^{def}	0.86	0.6^{efghij}	0.26	0.37^{cd}	0.12	0.18^{def}	13.40	17.86^{cde}	13.95	30^{lm}
17	EC-384970 - **HR**	3.71	3.18^{cdef}	0.63	0.74^{defgh}	0.58	0.53^{cd}	0.18	0.3^{bcd}	15.63	16.56^{efg}	28.57	40.72^{hij}
18	EC-379244 - **S**	8.00	4.04^{cde}	0.81	0.73^{defghi}	0.84	0.45^{cd}	0.30	0.39^{bcd}	10.50	11.22^{jk}	37.04	52.73^{cde}
19	*S. incanum* - **MS**	3.60	1.66^{ef}	0.48	0.3^{jk}	0.26	0.22^{cd}	0.32	0.21^{cdef}	7.22	13.28^{hij}	66.67	68.13^{b}
20	*S. unduatum* -**MS**	6.78	2.13^{def}	0.68	0.41^{ghijk}	0.58	0.28^{cd}	0.36	0.23^{cdef}	8.55	13.17^{ij}	52.94	54.84^{cde}
21	*S. macrocarpon* white fruit -**HR**	4.46	3.45^{cdef}	0.62	0.83^{def}	0.58	0.47^{cd}	0.14	0.28^{bcde}	13.00	13.53^{hi}	22.58	33.47^{klm}
22	*S. insanum* - **R**	5.48	6.62^{ab}	1.50	1.01^{cd}	0.58	0.99^{b}	0.18	0.35^{bcd}	10.58	14.9^{ghi}	12.00	34.87^{jkl}
23	*S. macrocarpon* (green fruit) Ac-2 - **HR**	1.99	0.95^{f}	0.96	0.64^{defghij}	0.22	0.16^{cd}	0.40	0.37^{bcd}	11.06	16.9^{efg}	41.67	58.64^{c}
24	*S. integrifolium* – **S**	3.80	1.27^{f}	0.30	0.34^{ijk}	0.50	0.22^{cd}	0.36	0.3^{bcd}	13.16	17.37^{def}	120.00	87.38^{a}
25	*S. aethiopicum Ac-2* **- I**	0.98	1.44^{f}	0.53	0.42^{ghijk}	0.21	0.3^{cd}	0.09	0.08^{ef}	21.43	20.65^{b}	16.98	19.84^{n}
26	Shillong-2 **- S**	3.31	2.78^{cdef}	0.76	0.6^{efghij}	0.76	0.43^{cd}	0.30	0.3^{bcd}	22.96	15.33^{fghi}	39.47	50^{def}
27	*S. sisymbriifolium* **- I**	1.05	0.95^{f}	0.08	0.12^{k}	0.20	0.19^{cd}	0.01	0.02^{f}	19.05	20.35^{b}	12.50	17.14^{n}
28	*S. torvum* **– R**	3.21	1.42^{f}	0.58	0.55^{efghij}	0.37	0.3^{cd}	0.30	0.3^{bcd}	11.53	21.31^{b}	51.72	53.61^{cde}
	C.D.$_{0.05}$		2.062		0.33		0.391		0.177		1.987		5.97
	SE(m) ±		0.726		0.116		0.138		0.062		0.7		2.102
	C.V. %		18.193		18.45		19.585		15.34		7.558		7.738

Numbers in the same column followed by the same alphabet are not significantly different for the DMRT test at α=5%

SL: Shoot length (cm); RL: Root length (cm); RA: Root area (cm^2); RV: Root volume (cm^3); SFW: Shoot fresh weight (g); RFW: Root fresh weight (g); SDW: Shoot dry weight (g); RDW: Root dry weight (g); SDM: Shoot dry matter (%); RDM: Root dry matter (%) C: Control; I: Inoculated; HR: Highly resistant; R: Resistant; MR: Moderately resistant; MS: Moderately susceptible; S: Susceptible; HS: Highly susceptible; CD: Coefficient of dispersion; SEm: Standard error of the mean; CV: Coefficient of variation.

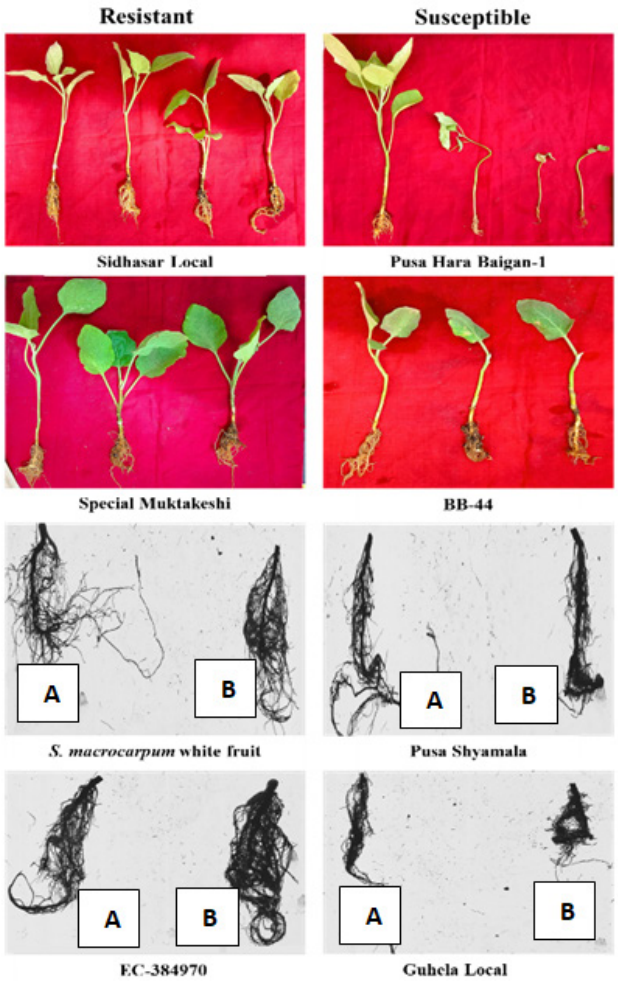

Fig. 4: Changes in shoot and root morphologies 30 DAI in resistant and susceptible genotypes over their controls in hydroponics conditions; A: Control; B: Inoculated

(1.72 times) and Pusa Shyamala (1.66 times). Our findings deviate from Jorben et al. (2023), as we did not identify a significant correlation between host morphology and disease resistance. This divergence may be explained by the genetic diversity of the host plants, highlighting the complex interplay between host genetics and pathogen infection. Fusarium wilt negatively impacted both resistant and susceptible genotypes, as evidenced by reduced root and shoot lengths, area, and volume, while the latter suffered more severe reductions (Fig. 4). Although Fomg infection significantly reduced shoot and root fresh weights in most genotypes, some resistant and immune genotypes exhibited increases or minimal reductions (Jorben et al., 2023). This suggests that these genotypes possess robust defense mechanisms that can mitigate the negative impact of the pathogen, maintaining or even increasing biomass (Zhu et al., 2023). Shoot and root dry weight responses to infection were variable, with both increases and decreases observed. The increase in shoot dry matter percentage in susceptible genotypes suggests a potential stress response, attempting to maximize photosynthetic capacity and carbon assimilation (Das et al., 2023). Both resistant and susceptible genotypes exhibited increases in root dry matter percentage, though the magnitude varied. These varied responses in root dry matter percentage indicate genotype-specific adaptations to the stress imposed by the pathogen (Das et al., 2023).

Brinjal germplasm in India houses a diverse array of disease-resistant sources. The study identified five genotypes immune to Fusarium wilt and fifteen highly resistant genotypes spreading across released varieties, local germplasm, exotic lines and related wild species, which hold the potential to serve as invaluable breeding materials for resistance traits. Hydroponic systems offered advantages over traditional field or greenhouse-based screening methods in terms of rapid inoculum spread, early disease detection, accurate disease quantification, and controlled environment necessitating specific skills. By providing identical conditions, the hydroponics system reduced variability and improved the reliability of phenotyping data while accelerating the identification of resistant genotypes. Hence, this screening method has the potential to significantly impact both applied breeding programs and fundamental research on plant-pathogen interactions. Its versatility allows for its application to a wide range of plant species and soil-borne pathogens, including other Fusarium species and root-infecting pathogens.

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सारांश

फ्यूजेरियम विल्ट (फ्यूजेरियम ऑक्सीस्पोरम) बैंगन की एक गंभीर बीमारी है। इस अध्ययन में, 90 बैंगन जीनोटाइप, जिसमें विविध खेती और जंगली एक्सेस शामिल हैं, को होगलैंड घोल में उगाया गया और मेजबान संस्थान में फ्यूजेरियम विल्ट-स्थानिक क्षेत्र से अलग किए गए फ़ोमेग के साथ टीका लगाया गया। रोग सूचकांक (DI), रोग प्रगति वक्र के अंतर्गत क्षेत्र (AUDPC) और रोग प्रगति सीढ़ियों के अंतर्गत क्षेत्र (AUDPS) का उपयोग प्रतिरोधी जीनोटाइप की पहचान करने और रोग प्रगति का अध्ययन करने के लिए किया गया था। प्रतिरोधी स्रोतों की विशेषता निर्धारित करने के लिए मेजबान फेनोटाइपिक विशेषता आकलन और हिस्टोपैथोलॉजिकल अध्ययनों का भी उपयोग किया गया था। 5 जीनोटाइप्स अर्थात् BR-40-7, पिंक, बोल्डर, एस. सिसिम्ब्रीफोलियम, एस. टोरवम को फ्यूजेरियम विल्ट के प्रति प्रतिरक्षित पाया गया, जबकि पंद्रह जीनोटाइप्स प्रत्येक को रोग के प्रति अत्यधिक प्रतिरोधी और प्रतिरोधक पाया गया। प्रतिरोधी जीनोटाइप्स ने अतिसंवेदनशील जीनोटाइप्स की तुलना में बेहतर जड़ और टहनी विकास का प्रदर्शन किया। विविध पौधों की प्रजातियों और जड़ रोगजनकों के लिए हाइड्रोपोनिक स्क्रीनिंग विधि की व्यापक प्रयोज्यता कृषि में महत्वपूर्ण चुनौतियों का समाधान करने की क्षमता को रेखांकित करती है।