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INFLUENCE OF PLANT GROWTH STAGE ON SCLEROTINIA STEM ROT SEVERITY IN DIVERSE BRASSICA GENOTYPES

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ABSTRACT

Sclerotinia stem rot, caused by *Sclerotiniasclerotiorum* (Lib.) de Bary, poses a significant threat to rapeseed-mustard production globally. This study investigated the influence of plant growth stage on disease severity across twelve diverse *Brassica* genotypes representing three species (*B. juncea*, *B. rapa*, and *B. carinata*) during two consecutive Rabi seasons 2022-23 and 2023-24under artificial inoculation at Dholi research farm. Plants were inoculated at 55, 65, and 75 days after sowing (DAS) using mycelial disc technique and observation were recorded after 10 days of inoculation.*B. rapa* varieties (yellow sarson, toria) exhibited maximum disease severity 81.2-92.3% when inoculated at 55 DAS, while *B. juncea* genotypes showed peak susceptibility when inoculated at 65 DAS with severity ranging from 73.3-88.6%. In contrast, *B. carinata* (NPC-16) demonstrated consistently low disease severity 44.28-48.3% across all inoculation timings. Plants inoculated at 75 DAS developed higher disease severity and earlier stem breakage compared to those inoculated at 55 and 65 DAS, indicating that the late vegetative to early reproductive stage (75 DAS) represents the most critical period for infection. These findings suggest that different *Brassica* species exhibit distinct susceptibility patterns across phenological stages, with implications for optimizing fungicide application timing and developing growth stage-specific disease management strategies for Sclerotinia stem rot in rapeseed-mustard production systems.

***Key words*: *Brassica* species, *Sclerotiniasclerotiorum*, plant growth stage, disease severity, phenological susceptibility, stem breaking, artificial inoculation, rapeseed-mustard**

Introduction

Rapeseed-mustard (*Brassica* spp.) is one of the most important oilseed crops globally and ranks second in India, contributing approximately 32% of total oilseed production (Meena *et al*., 2010). The cultivated species include *B. juncea*, *B. rapa* (varieties toria, yellow sarson, and brown sarson), *B. napus*, *B. carinata*, and *Eruca sativa* (Rakesh *et al*., 2016). Despite their economic importance, production faces substantial challenges from Sclerotinia stem rot, one of the most devastating diseases affecting oilseed brassicas worldwide. *Sclerotiniasclerotiorum* (Lib.) de Bary, the causal agent of stem rot, is a ubiquitous necrotrophic fungal pathogen capable of infecting over 400-500 plant species (Bolton *et al*., 2006; Sharma *et*

al., 2015). This soil-borne pathogen produces persistent sclerotia that serve as primary inoculum through carpogenic germination and subsequent ascospore release (Abawi and Grogan, 1979). Economic losses are substantial, with reported yield reductions of 72% in Uttar Pradesh and 50.9% in Rajasthan (Shukla, 2005), while internationally, losses range from 50-70% in European countries (Twengström *et al*., 1998) and AU$59 million in Western Australia alone (Khangura *et al*., 2014).

Plant growth stage has emerged as a significant factor influencing disease susceptibility. Ghasolia and Shivpuri (2009) reported higher disease incidence when plants were inoculated at 20 and 40 days after sowing compared to older plants. However, Rakesh *et al*., (2016) demonstrated that different *Brassica* species exhibit distinct susceptibility patterns across growth stages: *B. rapa* varieties showed maximum disease severity at 50 days, *B. juncea*, *B. nigra*, and *B. alba* at 60 days, and *B. napus* and *B. carinata* at 70 days after sowing. These contrasting observations suggest that the relationship between plant growth stage and disease susceptibility is not uniform and may be influenced by species-specific characteristics. Additionally, substantial genotypic variation exists in response to *S. sclerotiorum* infection, which may be attributed to differences in anatomical features, biochemical defenses, or escape mechanisms (Uloth *et al*., 2015). Despite the recognized importance of both plant growth stage and genotypic variation, comprehensive field-based investigations examining their interaction across multiple *Brassica* species remain scarce. Most existing studies have focused on individual species under controlled environments, which may not fully represent natural disease development. The present study was therefore undertaken to systematically investigate the influence of plant growth stage on Sclerotinia stem rot severity across diverse *Brassica* genotypes under artificial field inoculation. The specific objectives were to:

(i) determine the growth stages at which different *Brassica* species are most susceptible to infection,

(ii) evaluate disease response of multiple genotypes at different phenological stages, and

(iii) assess the relationship between inoculation timing, disease severity, and stem breakage across genotypes.

Materials and Methods

Experimental Location

Field experiments were conducted over two consecutive Rabi seasons 2022-23 and 2023-24 at the Dholi research farm to determine the growth stage at which rapeseed-mustard plants are most susceptible to *Sclerotiniasclerotiorum*.

Experimental field and design

A set of diverse genotypes: DRMRSJ-25, DRMRSJ-361, DRMRIS-20-1, DRMRIS-20-4, DRMRIS-20-5, DRMRDR-2238, DRMRDR-2239, Rohini, NRCHB-101, BioYSR (all *Brassica juncea*), NRCYS-05-02 (*B. rapa* var. yellow sarson) and NPC-16 (*B. carinata*) was evaluated. The genotypes were sown on 28th October in paired rows measuring 3 m length, following a Randomized Block Design with three replications. Five plants from each genotype in every replication were artificially inoculated to assess their susceptibility at different growth stages. Inoculation was performed at 55, 65 and 75 days after sowing (DAS) using a method based on Zhao *et al*. (2004), with slight modifications. A 5-mm mycelial disc from a seven-day-old culture was placed on the main stem after causing a small injury at the third internode with a strip of parafilm tape and tightly wrapped around to facilitate pathogen entry. High humidity favorable for disease development was maintained through frequent irrigation.

Observations:

Plants were monitored for symptom development, and stem breakage (days after inoculation) was recorded frominoculated plants.

Disease severity was assessed using a modified 0-4 scale of Lesovoi *et al*., (1987):

Scale	Symptoms
0	No visible infection
1	Lesion girdling up to one-quarter of the stem
2	Half of the stem girdled
3	Three-quarters of the stem girdled
4	More than three-quarters girdling

Percent disease severity was calculated (Wheeler, 1969) as

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{total no. of main stems observed} \times \text{maximum disease rating}} \times 100$$

Results

Twelve diverse Brassica genotypes representing three species, namely *Brassica juncea*, *B. rapa* and *B. carinata*, were evaluated through artificial inoculation at three crop growth stages, i.e., 55, 65 and 75 days after sowing (DAS). Disease severity and days to stem breaking after inoculation were recorded for each

Table 1: Effect of plant growth stage (DAP) on disease severity (%) and days to stem breaking after inoculation of *Sclerotinia sclerotiorum* in different *Brassica* species during rabi 2022-23.

Species	Entry	Disease severity (%) 2022-23			Days to stem breaking after after inoculation 2022-23		
		55 DAP	65 DAP	75 DAP	55 DAP	65 DAP	75 DAP
Brassica juncea	DRMRSJ-25	68.3 (55.73)	60.32 (50.95)	58.36 (49.81)	11.25	10.25	9.56
Brassica juncea	DRMRSJ 361	74.6 (59.73)	68.31 (55.74)	61.06 (51.38)	12.85	11.45	10.35
Brassica juncea	DRMRIS 20-1	71.3 (57.61)	65.58 (54.07)	60.2 (50.88)	16.65	14.65	12.35
Brassica juncea	DRMRIS 20-4	70.4 (57.03)	62.54 (52.26)	60.58 (51.10)	21.15	19.65	17.45
Brassica juncea	DRMRIS 20-5	69.5 (56.47)	59.62 (50.54)	58.65 (49.98)	33.25	31.15	28.65
Brassica juncea	DRMRDR 2238	66.4 (54.57)	56.25 (48.59)	54.2 (47.40)	35.7	33.54	31.25
Brassica juncea	DRMRDR 2239	67.8 (55.42)	60.35 (50.97)	58.65 (49.98)	29.56	27.56	25.65
Brassica juncea	Rohini (SC)	84.4 (66.31)	74.32 (59.55)	70.54 (57.12)	32.2	30.24	28.45
Brassica juncea	NRCHB 101 (SC)	85.4 (67.53)	73.3 (58.88)	70.25 (56.94)	33.45	31.15	30.25
Brassica juncea	BioYSR (RC-WR)	92.3 (73.88)	84.25 (66.61)	78.14 (62.12)	36.6	33.65	31.25
Brassica rapa	NRCYS-05-02 (TS-C)	86.2 (68.19)	81.2 (64.30)	77.45 (61.64)	36.52	33.25	30.48
Brassica carinata	NPC 16 (C)	48.3 (44.02)	47.4 (46.20)	46.3 (42.87)	30.25	28.65	26.78
SE(m) ±		2.31	1.81	1.65			
CD (*p*=0.05)		6.90	4.00	3.84			
CV (%)		13.42	11.48	10.89			
( ) value in the parenthesis in square root transformed value							

genotype.

Disease severity during *Rabi* 2022-23

Significant variation in disease severity was observed among the Brassica genotypes and across crop growth stages (Table 1). At 55 DAS, disease severity ranged from 48.3% in NPC 16 (*B. carinata*) to 92.3% in BioYSR (*B. juncea*). The susceptible check BioYSR recorded the highest disease severity (92.3%), followed by NRCHB 101 (85.4%), Rohini (84.4%) and NRCYS-05-02 (86.2%). The lowest disease severity was recorded in NPC 16 (48.3%), indicating relatively lower susceptibility at this stage. At 65 DAS, disease severity increased across most entries and ranged from 47.4% (NPC 16) to 84.25% (BioYSR). The highest severity was again observed in BioYSR (84.25%), followed by NRCYS-05-02 (81.2%), Rohini (74.32%) and NRCHB 101 (73.3%). The genotype NPC 16 maintained the lowest disease severity (47.4%). At 75 DAS, disease severity further increased and varied from 46.3% in NPC 16 to 78.14% in BioYSR. The susceptible entries BioYSR (78.14%), NRCYS-05-02 (77.45%), Rohini (70.54%) and NRCHB 101 (70.25%) recorded the highest disease levels, whereas NPC 16 remained the least affected (46.3%).Statistical analysis revealed that differences among genotypes and growth stages were significant, with CD (P = 0.05) values of 6.90, 4.00 and 3.84 at 55, 65 and 75 DAS, respectively. The coefficient of variation ranged from 10.89% to 13.42%, indicating acceptable experimental precision.

Disease severity during *Rabi* 2023-24

A similar trend in disease development was observed during the 2023-24 season (Table 2). At 55 DAS, disease severity ranged from 46.5% in NPC 16 to 91.4% in BioYSR. The highest disease severity was recorded in BioYSR (91.4%), followed by NRCHB 101 (88.6%), NRCYS-05-02 (84.9%) and Rohini (82.7%). NPC 16 again showed the lowest disease severity (46.5%). At 65 DAS, disease severity ranged from 45.62% (NPC 16) to 90.65% (BioYSR). BioYSR (90.65%), NRCHB 101 (84.40%), NRCYS-05-02 (82.35%) and Rohini (81.10%) exhibited the highest disease severity. The lowest value was recorded in NPC 16 (45.62%). At 75 DAS, disease severity further increased and ranged from 44.28% in NPC 16 to 89.35% in BioYSR. The highest disease severity was observed in BioYSR (89.35%), followed by NRCHB 101 (82.41%), NRCYS-05-02 (80.48%) and Rohini (80.15%). NPC 16 consistently exhibited the lowest disease severity (44.28%). The CD (P = 0.05) values for disease severity were 7.55, 7.46 and 7.29 at 55, 65 and 75 DAS, respectively, with CV values ranging from 12.25% to 14.39%.

Days to stem breaking after inoculation on different DAS during *Rabi* 2022-23 and 2023-24

The number of days required for stem breaking after inoculation varied significantly among genotypes and growth stages during both seasons. During 2022-23, the earliest stem breakage was recorded in DRMRSJ-25 (9.56 days) at 75 DAS, while the longest duration was observed

Table 2: Effect of plant growth stage (DAP) on disease severity (%) and days to stem breaking after inoculation of *Sclerotinia sclerotiorum* in different *Brassica* species during rabi 2023–24.

Species	Entry	Disease severity (%) 2023-24			Days to stem breaking after after inoculation 2023-24		
		55 DAP	65 DAP	75 DAP	50 DAP	60 DAP	70 DAP
Brassica juncea	DRMRSJ-25	66.3 (54.51)	61.15 (51.44)	60.25 (50.91)	10.36	9.58	9.58
Brassica juncea	DRMRSJ 361	73.4 (58.95)	70.45 (57.07)	69.98 (56.78)	11.56	10.23	10.23
Brassica juncea	DRMRIS 20-1	69.4 (56.41)	66.04 (54.35)	64.02 (53.14)	19.65	17.65	17.65
Brassica juncea	DRMRIS 20-4	71.8 (57.92)	69.82 (56.67)	68.45 (55.83)	21.25	18.25	18.25
Brassica juncea	DRMRIS 20-5	66.7 (54.75)	62.25 (52.09)	60.25 (50.91)	32.25	30.45	30.45
Brassica juncea	DRMRDR 2238	63.5 (52.83)	61.15 (51.44)	60.45 (51.03)	34.5	31.96	31.96
Brassica juncea	DRMRDR 2239	68.9 (56.10)	64.54 (53.45)	63.25 (52.68)	28.56	26.65	26.65
Brassica juncea	Rohini (SC)	82.7 (65.42)	81.10 (64.23)	80.15 (63.54)	31.25	29.78	29.78
Brassica juncea	NRCHB 101 (SC)	88.6 (70.26)	84.40 (66.73)	82.41 (65.20)	30.59	28.65	28.65
Brassica juncea	BioYSR (RC-WR)	91.4 (72.94)	90.65 (72.19)	89.35 (70.95)	35.57	33.45	33.45
Brassica rapa	NRCYS-05-02 (TS-C)	84.9 (67.13)	82.35 (65.15)	80.48 (63.78)	38.85	37.45	37.45
Brassica carinata	NPC 16 (C)	46.5 (42.99)	45.62 (42.48)	44.28 (41.72)	30.45	29.45	29.45
SE(m) ±		2.42	2.93	2.34			
CD (*p*=0.05)		7.55	7.46	7.29			
CV (%)		12.25	13.45	14.39			
( ) value in the parenthesis in square root transformed value							

in BioYSR (36.60 days) at 55 DAS. In general, stem breakage occurred earlier when inoculation was performed at 75 DAS compared to 55 and 65 DAS. NPC 16 exhibited delayed stem breakage across all stages, recording 30.25, 28.65 and 26.78 days at 55, 65 and 75 DAS, respectively.

During 2023-24, a similar pattern was observed. The minimum days to stem breaking were recorded in DRMRSJ-25 (9.58 days) at 65 and 75 DAS, whereas NRCYS-05-02 recorded the maximum duration of 38.85 days at 55 DAS. NPC 16 again showed delayed stem breakage with 30.45, 29.45 and 29.45 days at 55, 65 and 75 DAS, respectively. Across both seasons, inoculation at 75 DAS resulted in earlier stem breakage compared to 55 and 65 DAS, indicating increased vulnerability of plants at later growth stages.

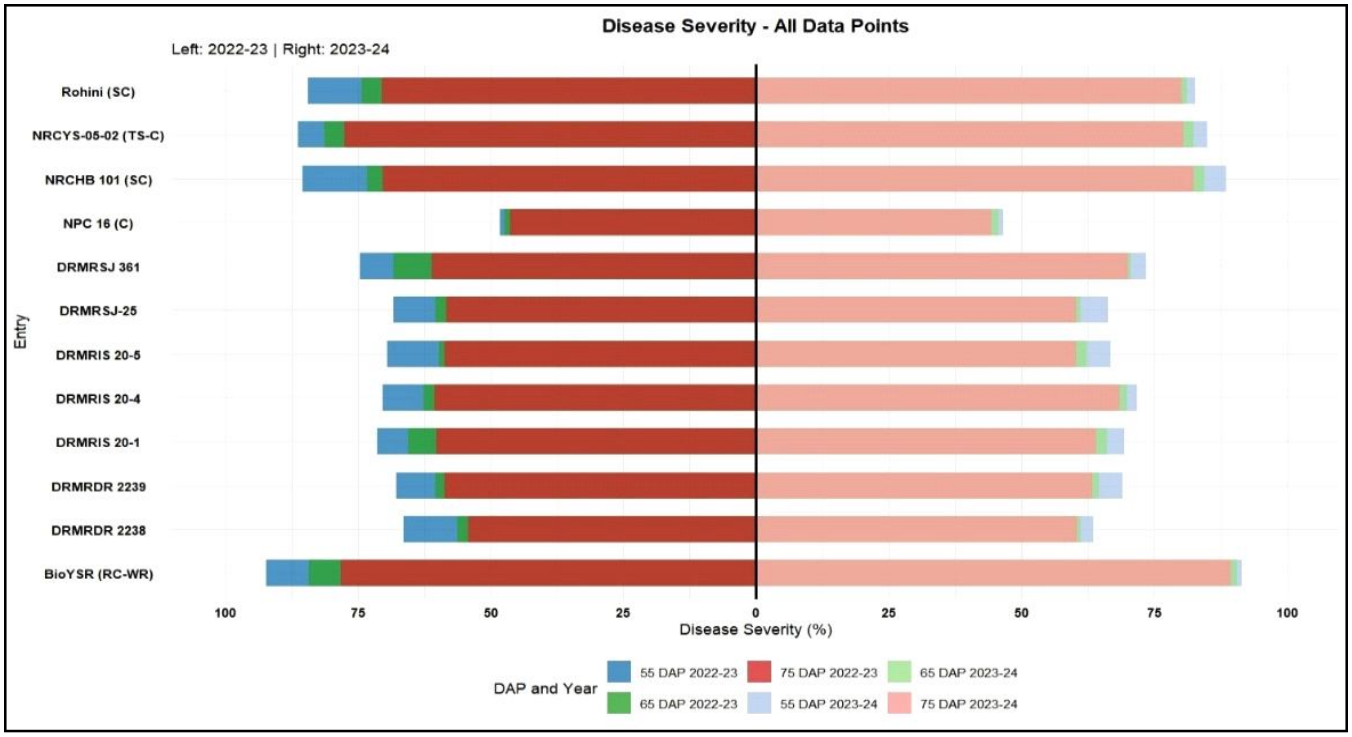

Fig. 1: Comparative Disease Severity (%) Across Brassica Entries at Different Growth Stages in 2022-23 and 2023-24.

Comparative disease response across growth stages

A comparative analysis of disease severity across genotypes and growth stages during both seasons is presented in Fig. 1. The results clearly indicated a progressive increase in disease severity from 55 DAS to 75 DAS in most genotypes. The susceptible checks BioYSR, NRCHB 101, Rohini and NRCYS-05-02 consistently exhibited high disease severity across all growth stages, whereas NPC 16 (*B. carinata*) showed the lowest disease severity in both years. Overall, the results demonstrated that plants inoculated at 75 DAS developed comparatively higher disease severity and earlier stem breakage than those inoculated at 55 and 65 DAS, indicating that the late vegetative to early reproductive stage was most favourable for *Sclerotiniasclerotiorum* infection under field conditions.

Discussion

The present findings clearly established that plant growth stage plays a decisive role in SSR infection success and subsequent disease development, as disease severity increased when infection coincided with physiologically and micro climaticallyfavorable phases of rapeseed-mustard growth. This stage-dependent escalation is epidemiologically logical because *Sclerotiniasclerotiorum* infection is strongly influenced by the host canopy environment, particularly periods of high humidity and prolonged leaf/stem wetness that develop as canopy density increases (Abawi & Grogan, 1979; Rothmann & McLaren, 2018). In oilseed Brassica crops, disease expression is frequently most conspicuous when inoculum availability overlaps with flowering to early pod development, since senescing tissues (especially petals) serve as nutrient sources facilitating infection establishment and lesion initiation (O'Sullivan *et al*., 2021).

Hence, increased disease expression during later crop stages aligns well with global SSR epidemiology, where flowering-stage infections are regarded as a primary epidemic trigger followed by rapid lesion expansion under cool, moist canopy conditions (Abawi& Grogan, 1979; Rothmann & McLaren, 2018). Importantly, differential disease expression across stages supports that SSR severity is not simply time-dependent, but reflects host-stage susceptibility coupled with evolving tissue vulnerability and microclimatic suitability. Similar stage-linked SSR behaviour has been documented in Brassica, where disease severity peaks vary among species depending on crop physiology and stem vulnerability at specific developmental phases (Rakesh *et al*., 2016). Epidemiological studies further confirm that SSR progression is closely associated with cooler temperatures and high relative humidity, which commonly coincide with dense canopy periods and promote infection efficiency (Sushree *et al*., 2017; Rothmann& McLaren, 2018). Such environmental-stage coupling has also been highlighted in oilseed Brassica systems where canopy closure supports apothecial development and ascospore infection through shading and moisture retention (Gorman, 2020; Abawi& Grogan, 1979). Therefore, identification of the favourable infection window under field conditions is epidemiologically important for stage-targeted forecasting and timely intervention scheduling, strengthening the basis for effective SSR management strategies in rapeseed-mustard (Rothmann& McLaren, 2018; O'Sullivan *et al*., 2021).

Conclusion

Plant growth stage susceptibility studies conducted for two consecutive seasons of Rabi 2022-23 and 2023-24 revealed progressive increase in disease severity from 55 DAS to 75 DAS across Brassica genotypes on 55 DAS inoculated plants during 2022-23, disease severity ranged from 48.3% (NPC 16) to 92.3% (BioYSR), while 75 DAS inoculated plants ranged from 46.3% (NPC 16) to 78.14% (BioYSR). During 2023-24, severity ranged from 46.5% (NPC 16) to 91.4% (BioYSR) at 55 DAS, and 44.28% (NPC 16) to 89.35% (BioYSR) at 75 DAS. In both seasons, inoculation at 75 DAS resulted in greater vulnerability and earlier stem breakage. Minimum days to stem breaking were recorded in DRMRSJ-25 (9.56-9.58 days) at later stages, whereas maximum duration occurred in BioYSR (36.60 days) at 55 DAS.

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