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## Morphological variations in *Alternaria* spp. isolated from different parts of Indian mustard entries

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**Abstract**

A comparative study of conidia and conidiophores of *Alternaria brassicae* and *A. brassicicola* on the basis of mean morphology and per cent frequency was done in fourteen entries of Indian mustard namely, NDYR32, NDRE8-16, NDRS2010, PRB2004-3, Ashirwad, NDRE8213, NDR8501, NDRE4, NDYR8, JD6, NDRE7, NDRE22, NDRE2011 and Varuna. Both the species *i.e.* *A. brassicae* and *A. brassicicola* were isolated from infected leaves, stems and pods. *A. brassicae* and *A. brassicicola* isolates obtained from leaves, stem and pods showed variability in colony diameter, size of conidiophores and conidia, septation in conidiophores and conidia. On mean basis, the maximum colony diameter of 35.00 mm in NDRE8-16 and 35.33 mm in NDRE4 were noted with *A. brassicae* and *A. brassicicola* isolates, respectively. The maximum length (160.45 mm) and width (21.48 mm) were noted in Ashirwad with conidia of *A. brassicae* as compared to *A. brassicicola* isolate. In conidia, higher number of transverse (15.00) and longitudinal septa (4.00) and maximum per cent frequency (73.33) were also recorded in Ashirwad with *A. brassicae* while in case of conidiophores, the maximum number of septa (7.00) found in Ashirwad and NDR8501.

**Keywords:** Colony diameter, septation, *A. brassicae*, *A. brassicicola*, per cent frequency

**Introduction**

Rapeseed-mustard is the most important *Rabi* oil seed crop and contributes a major share to the vegetable fat economy of the country. Rapeseed-mustard having first rank in area and production in India and next to the groundnut both in area and production. Area and production of rapeseed-mustard in India was 64.54 lakh ha and 72.82 lakh tones with average productivity of 1128 kg/ha (Anonymous, 2014) <sup>[1]</sup>. It accounts for nearly 20-22% of the total oilseeds produced in the country. In India, the major rapeseed-mustard growing states are Rajasthan, Uttar Pradesh, and Haryana. Uttar Pradesh is the second largest rapeseed-mustard growing state after Rajasthan and contributes 18 per cent to the national acreage and 18.70 per cent to the production. The oil of rapeseed-mustard serves as a very good cooking medium and dietary fat of the majority of population in Northern, North-Western, Central, Eastern and North-Eastern states. Besides oil, the leaves of young plants are used as green vegetables and whole plant as green fodder and sometimes used as bio fumigation. The seeds are highly nutritive containing 37.7-52.9% erucic acid, 8.5-19.0% linoleic acid and 8.6-17.1% oleic acid (Robbelen and Thies, 1980) <sup>[8]</sup>. Among the various causes of low productivity, diseases are most important ones. This crop suffers from a number of devastating diseases such as *Alternaria* blight, white rust, downy mildew, powdery mildew, bacterial rot and wilt (Kolte, 1985). Among diseases, *Alternaria* blight caused by *Alternaria brassicae* (Berk.) Sacc. is one of the most common and destructive disease of Indian mustard, which causes up to 47 per cent yield loss (Chattopadhyay, 2008) <sup>[2]</sup>. Information on cultural and pathogenic variability of *A. brassicae* population in India are meagre. A comparative knowledge of the nutritional patterns and factors influencing its growth are prerequisite to any study leading to the understanding of host-pathogen relationship and specificity. *Alternaria* blight severity on rapeseed mustard differs among seasons and regions as also between individual crops within a region. This may be due to existence of variability among isolates of *Alternaria* species. Some reports on the existence of cultural and pathogenic variability within the isolates of *Alternaria brassicae* have been reported by earlier workers (Sharma *et al.*, 2013, Pramila *et al.*, 2014) <sup>[9, 7]</sup>.

**Materials and Methods****Collection of diseased samples**

The infected leaves, stems and pods of Indian mustard were randomly collected from experimental fields of Student's Instructional Farm of Narendra Deva University of

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Agriculture and Technology Kumarganj (Faizabad). A total number of 420 isolates, 10 each from leaf, stem and pods of Indian mustard cultivars obtained for the study of morphology and per cent frequency of *A. brassicae* and *A. brassicicola* of each cultivar. Above mentioned study was completed against fourteen cultivars. Aerial parts of plants showing blight symptoms on leaves, stem and pods were collected from experimental fields randomly at 75, 90 and 105 days after sowing. The samples were kept in rough dry paper envelopes, especially meant for the purpose. Each envelope was marked clearly to show details of the variety, plant parts and date of collection. The collected samples were dried for 24 hours under shade in order to remove excess surface moisture in laboratory. After drying, the samples were repacked and maintained at 6 to 8 °C for subsequent study. Leaf, stem and pods showing typical symptoms were cut and arranged separately for isolating the fungi associated with the samples.

#### Sterilization of glasswares

Clean inoculation needles were dipped in spirit and heated red thrice. Glasswares, such as Petri dishes, culture tubes, funnels, beakers, flasks, watch glasses and glass rods, were cleaned in chromic acid (potassium dichromate 60 g, sulphuric acid concentrate 60 ml and distilled water 1000 ml) followed by washing in running water. Dry glasswares were sterilized at 160°C for 2 hours in hot air oven.

#### Preparation of basal medium

Medium consisting of following components was prepared and sterilized using the methods described by Waller *et al.* (2001).

Potato	200 g
Dextrose	20 g
Agar	20 g
Distilled water	1000 ml

#### Isolation and Purification of Pathogen

The samples maintained for the purpose were taken up separately for isolation. The isolated plant samples were washed using sterilized water and cut into small pieces by sterilized scalpel and forceps. Surface of washed pieces were sterilized with 0.1 per cent mercuric chloride (HgCl<sub>2</sub>) solution and washed thoroughly three times with sterilized water. These were demysturized by placing them between folds of sterilized blotting papers and transferred aseptically to Petri dishes containing potato dextrose agar (PDA) medium. On initiation of the mycelium growth around these pieces, the hyphal tips from the advancing mycelia were cut using cork borer and transferred into potato dextrose agar medium slants for further study. The pure culture of isolates were obtained through single spore isolation technique describe below.

A diluted spore suspension obtained from the culture tubes was poured on plain agar in Petri dishes to form a very thin layer on it and the spore were allowed to settle down on the agar surface. Sparsely settled spores were separated out from each other, selected under the microscope and encircled with the help of dummy cutter in Petri dishes. They are lifted along with agar blocks and transferred to Petri dishes containing sterilized potato dextrose agar medium. After proper growth of the fungus, regular subculturing was done by transferring them into potato dextrose agar slants at monthly intervals.

#### Selection of *A. brassicae* and *A. brassicicola* isolates

Isolates with conidiophores, conidia, and conidiophores-conidia attachment were selected for further studies.

#### Morphological variability

A total of 30 monoconidial isolates, each cultivar from leaf, stem and pods (10 from each part) were selected for the variability studies. Temporary slides were prepared, using lactophenol, from 10 days old cultures. Slides were examined with the help of a binocular compound microscope under the low and high magnification. Observations were recorded for colony growth, length, width, size and number of septa in the conidiophore and conidia of individual isolates.

#### Per cent frequency of isolation of individual species

A total of 420 isolates, 10 each from leaf, stem and pods of Indian mustard cultivars obtained for the study of per cent frequency of *A. brassicae* and *A. brassicicola* of each cultivar.

#### Results and discussion

##### Colony diameter

In general colony diameter of *A. brassicae* was found higher in comparison to *A. brassicicola* in case of each affected parts. Among the entries average maximum colony diameter (35.00 mm) of *A. brassicae* was noted in NDRE8-16 followed by NDR8501 (34.33 mm) and NDYR32 (34.00 mm). Minimum colony diameter of 25.66 mm was noted in NDRS2010 with *A. brassicae*. Maximum colony diameter of *A. brassicicola* was noted in NDRE4 (35.33 mm) followed by PRB2004-3 (34.00 mm). Minimum colony diameter 25.66 mm (NDR8501) was noted with *A. brassicicola* isolate (Table 3). Colony diameter of *A. brassicae* isolates obtained from leaves of different entries ranged between 26 mm to 41 mm, from stem between 23 mm to 40 mm and from pods between 22 mm to 38 mm, respectively. Colony diameter of *A. brassicae* and *A. brassicicola* isolates obtained from different part of NDRE8-16 were maximum followed by NDYR32 and PRB2004-3, respectively. Diameter of colonies of *A. brassicicola* obtained from leaves ranged between 22 mm to 39 mm, from stem (24 mm to 39 mm) and pods (22 mm to 40 mm), respectively (Table 1). Khan *et al.* (2007) [3] isolated *A. brassicae* with the samples collected from different places of Aligarh district and observed the variation in growth and colony size in case of *A. brassicae* and *A. brassicicola*. Singh *et al.* (2003) [10] also reported the variation in colony growth in case of *Alternaria tritricina* causing leaf blight in wheat.

##### Length and width of conidiophore

The conidiophores of *A. brassicae* were found lengthiest in comparison to *A. brassicicola* in case of each affected parts. In comparison the entries average maximum length of conidiophores of *A. brassicae* was noted in the isolates of Ashirwad (71.24µm) followed by PRB2004-3 (67.65µm). Shortest conidiophore of 58.00µm was found in NDRE8 in case of *A. brassicae*. Lengthiest conidiophore of *A. brassicicola* was noted in Ashirwad (41.60µm) followed by NDRE22 (41.40µm), NDRE8-16 (41.34µm) and NDRE7 (41.20µm). Shortest conidiophore of *A. brassicicola* was found in NDRE4 and JD6 (34.80µm), (Table 3). Conidiophores length of *A. brassicae* isolates obtained from leaves ranged between 58.38µm (NDRE2011) to 76.56µm (NDRE8213), from stem between 49.51µm (NDR8501) to 68.89µm (Ashirwad) and from pods between 57.68µm (NDYR8) to 68.41µm (PRB2004-3). Conidiophores length of *A. brassicicola* obtained from leaves ranged between 34.71µm (NDRE4) to 46.39µm (NDRE7) from stem between 32.50µm (NDRE4) to 40.69µm (Ashirwad) and from pods between 33.41µm (NDRE4) to 41.79µm (Ashirwad), (Table 1). The widest conidiophores were observed in *A. brassicae*

Isolate in comparison to *A. brassicicola* in case of each affected part of Indian mustard plant. In all the entries, average widest conidiophores of *A. brassicae* was noted in Ashirwad (7.71µm) followed by NDR8501 (6.65µm) and NDRE22 (6.90µm). Narrowest conidiophore of 5.06µm was noted in NDYR8 with *A. brassicae* isolate. Widest conidiophores of *A. brassicicola* was noted in Ashirwad (5.60µm) followed by NDRE22 and NDYR8 (5.10µm). Narrowest conidiophore of *A. brassicicola* was noted in JD6 (3.72µm). Conidiophores width of *A. brassicae* isolates obtained from leaves ranged between 5.71 to 8.10µm in NDRE2011 and Ashirwad, from stem between 4.01 to 7.11µm in JD6 and Ashirwad and from pods 4.00 to 7.91µm in NDYR8 and Ashirwad. Conidiophores width of *A. brassicicola* obtained from leaves also ranged between 4.12µm (JD6) to 5.91µm (NDYR8), from stem between 3.41µm (JD6) to 5.29µm (NDYR8) and from pods between 3.64µm (JD6) to 5.91µm (Ashirwad), (Table 1). Khan *et al.* (2007) [3] observed the variation in length and width of conidiophore in case of *A. brassicae* and *A. brassicicola*, the present studies support the views of earlier workers.

#### Number of septa

More septation was recorded in conidiophores of *A. brassicae* isolates in comparison to *A. brassicicola* obtained from different affected parts. On mean basis, among the entries mean maximum number of septa in *A. brassicae* was noted in the conidiophores of Ashirwad (7.00), NDR8501 (7.00) followed by PRB2004-3 (6.60) and Varuna (6.60). Minimum septation of 5.30 was noted in conidiophores of NDYR8 and JD6. While in case of septation of conidiophores of *A. brassicicola*, maximum number of septa was noted in Ashirwad (6.00) followed by JD6 (5.60) and NDYR8 (5.00). Minimum septation of 4.00 was recorded in NDRE8-16, NDR8501, NDRE4 and NDRE22 (Table 3). Number of septa in conidiophores of *A. brassicae* obtained from leaves ranged between 5 (JD6) to 8 (PRB2004-3, Ashirwad, NDRE7, and Varuna), from stem between 4 (NDRE7 and NDRE22) to 8 (NDR8501) and from pods between 4 (NDYR8) to 7 (NDRE8-16, Ashirwad, NDRE4 and NDRE22). While in case of *A. brassicicola* septation in conidiophores of leaves ranged between 4 (PRB2004-3, NDYR8 and Varuna) to 8 (JD6), in stem between 3 (NDRE8-16, NDRE7 and NDRE22) to 5 (Ashirwad and NDYR8) and in pods between 3 (NDR8501 and NDRE4) to 6 (Ashirwad and NDYR8), (Table 1). Khan *et al.* (2007) [3] also reported variation in septation (5-16). The variation in vertical and horizontal septation in case of *A. brassicae* and *A. brassicicola*.

#### Length and width of conidia

In general the conidial length of *Alternaria brassicae* was found more in comparison to *A. brassicicola* in case of each affected parts. Among the entries average lengthiest conidia of *A. brassicae* was noted in Ashirwad (160.45µm) followed by NDRE22 (160.20µm). Shortest conidia of 143.70µm was noted in NDRE8213. Lengthiest conidia of *A. brassicicola* was noted in NDR8501 (51.68µm) followed by NDYR32 (51.34µm) and Ashirwad (50.73µm). Shortest conidia of *A. brassicicola* was noted in NDRE2011 (45.88µm) (Table 3). Length of *A. brassicae* conidia obtained from leaves ranged between 151.11µm (NDYR8) to 189.67µm (Ashirwad), from stem between 125.64µm (JD6) to 143.91µm (NDYR8) and from pods between 143.69µm (NDRS2010) to 160.69µm (Ashirwad). Length of *A. brassicicola* conidia obtained from leaves ranged between 48.76µm (NDRE8213) to 57.62µm

(NDR8501), from stem between 43.20µm (NDRE2011) to 47.39µm (NDRE22) and from pods between 45.46µm (NDRS2010) to 52.76µm (NDR8501), (Table 1).

In general width of *Alternaria brassicae* was noted maximum in comparison to *A. brassicicola* in case of all affected plant parts. Among the entries average widest conidia of *A. brassicae* was noted in Ashirwad (21.48µm) followed by NDR8501 (20.10µm) and PRB2004-3 (20.07). Narrowest conidia was found in the NDYR8 (13.79) with *A. brassicae* isolate. Widest conidia of *A. brassicicola* was found in NDRE4 (15.10µm) followed by NDR8501 (13.28µm) and NDYR8 (13.23µm). Narrowest conidia of *A. brassicicola* was obtained from JD6 (11.30µm), (Table 3). Width of conidia of *A. brassicae* obtained from leaves ranged between 17.89µm (NDRS2010) to 25.67µm (Ashirwad), from stem between 11.46µm (NDRE4) to 18.67µm (NDR8501) and from pods between 13.61µm (NDRE4) to 20.44µm (NDR8501). Conidia width of *A. brassicicola* obtained from leaves ranged between 11.88µm (NDRE8213) to 17.48µm (NDRE4), from stem between 10.21µm (NDRE4) to 11.91µm (Ashirwad) and from pods between 11.00µm (JD6) to 17.69µm (NDRE4), (Table 1). Concurrent with present findings Khan *et al.* (2007) [3] isolated *A. brassicae* reported variation in conidial length (112.0 to 185.6 µm) and width (14.4 to 17.6µm). They observed the variation in length and width of conidia in case of *A. brassicae* and *A. brassicicola*. Kumar *et al.* (2003) [5] also reported distinct differences among the isolates *A. brassicae* in term of conidial length and width at Haryana in rapeseed and mustard. They reported that average conidial length varied appreciably from 118.62 to 194.52 µm and identified eight pathotypes. Mehta *et al.* (2003) [6] also worked on the morphological, pathological variations, variations in spore length, width and indicated the existence of variability in the pathogen in rapeseed-mustard isolates of *A. brassicae* collected from different agroclimatic zone of India.

#### Number of septa

Number of transverse septa in the conidia of *A. brassicae* was found maximum in comparison to *A. brassicicola* in case of each affected plant parts. On mean basis average highest number of septa in *A. brassicae* was noted in Ashirwad (14.00) followed by NDRE22 (13.00). The lowest number of septa was found in NDYR8 (9.30). Highest number of septa in *A. brassicicola* was noted in Ashirwad (8.00) followed by NDRE4 (7.00). Lowest number of septa (4.30) in *A. brassicicola* was found in NDYR32 (Table 3). The number of septa in *A. brassicae* obtained from leaves range between 10 (NDRS2010) to 15 (Ashirwad), from stem between 8 (NDYR8) to 13 (Ashirwad) and from pods between 10 (NDYR32, NDRS2010, NDRE8213, NDYR8 and NDRE2011) to 14 (Ashirwad). Likewise, the number of septa in *A. brassicicola* obtained from leaves ranged between 5 (NDY32, NDRS2010, NDRE8213, JD6 and NDRE2011) to 11 (NDR8501), from stem between 4 (NDYR32, NDRS2010, NDRE8213, NDRE7 and NDRE2011) to 8 (NDRE4) and from pods ranged between 4 (NDYE8, NDRE8213 and NDYR8) to 8 (Ashirwad), (Table 1).

Longitudinal septation in conidia of *A. brassicae* was also found maximum in comparison to *A. brassicicola* in all the affected plant parts. In all the entries the average maximum number of septa in *A. brassicae* was noted in Ashirwad (4.00) followed by NDRE22 (3.62). Minimum number of septa was found 2.55 in NDYR32. The maximum number of septa in *A. brassicicola* was noted (2.00) in Ashirwad and NDR8501.

Minimum number of septa was found in NDYR32 (0.67). Longitudinal septa of *A. brassicae* isolates obtained from leaves ranged between 3 to 5, from stem between 1 to 3 and from pods 3 to 4. The longitudinal septa of *A. brassicicola* obtained from leaves also ranged between 1 to 3, from stem 0 to 2 and from pods between 0 to 2 (Table 1). Khan *et al.* (2007) [3] isolated *A. brassicae* with the samples collected from different places of Aligarh district and reported the variation in septation (5-16). The variation in vertical and horizontal septation in case of *A. brassicae* and *A. brassicicola* in present studies support the views of earlier workers. The studies therefore, also indicate the existence of variability among the isolates of *A. brassicae* and *A. brassicicola*.

#### Per cent frequency of *A. brassicae* and *A. brassicicola* obtained from leaves, stems and pods

On mean basis per cent frequency of *A. brassicae* was found maximum in case of leaves isolates followed by pods and

stems. Among the entries average maximum per cent frequency of *A. brassicae* was noted in NDRE22 and Ashirwad (73.33%) followed by JD6 and NDRE7 (68.33%). Minimum per cent frequency of this pathogen was found in NDYR32 (38.33%). Maximum mean per cent frequency of *A. brassicicola* was found in NDYR32 (61.66%) followed by NDRE8-16 (60.00%) and minimum in Ashirwad and NDRE22 (26.67%), (Table 3). Per cent frequency of *A. brassicae* obtained from leaves isolates ranged between 45 (NDRE8-16) to 80 (NDRS2010, Ashirwad, JD6 and NDRE22), from stem between 25 (NDYR32) to 65 (Ashirwad and NDRE22) and from pods between 40 (NDYR32 and NDRE8-16) to 75 (Ashirwad and NDRE22). In case of *A. brassicicola* isolate, per cent frequency was 20 (NDRS2010, Ashirwad, JD6 and NDRE22) to 55 (NDRE8-16) from leaves isolates, 35 (Ashirwad and NDRE22) to 75 (NDYR32) from stem isolates and 25 (Ashirwad and NDRE22) to 60 (NDYR32 and NDRE8-16) from pod (Table 2).

**Table 1:** Morphological variability in *Alternaria* spp. isolates obtained from leaf, stem and pod from different entries of Indian mustard

Entries	Plant parts	Isolates	Colony Diameter (mm)	Conidiophores			Conidia			
				Length (µm)	Width (µm)	No. of Septa	Length (µm)	Width (µm)	No. of Septa	
									Transverse	Longitudinal
V <sub>1</sub> -NDYR32	Leaf	<i>A. brassicae</i>	32	60.91	6.11	6	159.88	18.67	11	3
		<i>A. brassicicola</i>	35	37.45	4.91	5	49.79	12.91	5	1
	Stem	<i>A. brassicae</i>	36	56.38	4.79	5	127.59	15.29	9	2
		<i>A. brassicicola</i>	32	33.36	4.11	4	44.35	10.60	4	1
	Pod	<i>A. brassicae</i>	34	58.31	5.91	6	146.90	18.36	10	3
		<i>A. brassicicola</i>	35	35.91	4.31	4	46.88	11.65	4	0
V <sub>2</sub> -NDRE8-16	Leaf	<i>A. brassicae</i>	34	71.31	5.99	7	155.79	21.87	14	5
		<i>A. brassicicola</i>	37	44.33	5.54	5	50.65	13.65	8	1
	Stem	<i>A. brassicae</i>	33	58.40	5.64	5	126.75	17.68	11	2
		<i>A. brassicicola</i>	39	38.72	4.51	3	47.39	11.41	6	1
	Pod	<i>A. brassicae</i>	38	66.91	5.91	7	149.69	19.69	13	4
		<i>A. brassicicola</i>	27	40.97	5.21	4	48.67	12.97	7	1
V <sub>3</sub> -NDRS2010	Leaf	<i>A. brassicae</i>	26	60.38	5.91	7	160.17	17.89	10	3
		<i>A. brassicicola</i>	33	36.41	4.99	5	48.91	11.94	5	1
	Stem	<i>A. brassicae</i>	26	55.37	4.10	5	126.76	15.31	9	2
		<i>A. brassicicola</i>	28	33.75	4.11	4	43.26	10.49	4	1
	Pod	<i>A. brassicae</i>	25	58.79	5.29	6	145.69	17.49	10	3
		<i>A. brassicicola</i>	40	34.31	4.40	5	45.46	11.73	5	1
V <sub>4</sub> -PRB2004-3	Leaf	<i>A. brassicae</i>	41	70.19	7.12	8	186.49	22.67	14	5
		<i>A. brassicicola</i>	39	39.91	5.21	4	54.43	13.69	7	2
	Stem	<i>A. brassicae</i>	23	64.36	4.39	6	130.91	17.63	9	2
		<i>A. brassicicola</i>	29	35.79	4.67	4	45.30	11.60	5	1
	Pod	<i>A. brassicae</i>	34	68.41	5.91	6	150.64	19.91	11	4
		<i>A. brassicicola</i>	34	38.27	4.97	5	47.97	11.97	6	2
V <sub>5</sub> -Ashirwad	Leaf	<i>A. brassicae</i>	34	73.92	8.10	8	189.67	25.67	15	5
		<i>A. brassicicola</i>	25	42.61	5.71	7	56.30	14.50	9	2
	Stem	<i>A. brassicae</i>	31	68.89	7.11	6	130.99	18.63	13	3
		<i>A. brassicicola</i>	36	40.69	5.19	5	46.50	11.91	7	2
	Pod	<i>A. brassicae</i>	30	70.91	7.91	7	160.69	20.14	14	4
		<i>A. brassicicola</i>	27	41.79	5.91	6	49.39	12.19	8	2
V <sub>6</sub> -NDRE8213	Leaf	<i>A. brassicae</i>	36	76.56	6.23	6	158.77	19.23	11	3
		<i>A. brassicicola</i>	23	36.76	4.44	5	48.76	11.88	5	1
	Stem	<i>A. brassicae</i>	29	56.77	4.12	5	125.98	15.29	9	2
		<i>A. brassicicola</i>	31	35.36	4.31	4	44.35	10.56	4	1
	Pod	<i>A. brassicae</i>	32	60.67	5.89	6	146.55	18.33	10	3
		<i>A. brassicicola</i>	36	36.76	4.45	5	46.26	11.75	4	1
V <sub>7</sub> -NDR8501	Leaf	<i>A. brassicae</i>	35	66.39	7.61	7	180.76	21.23	13	4
		<i>A. brassicicola</i>	25	37.37	4.35	5	57.62	16.60	11	3
	Stem	<i>A. brassicae</i>	40	62.79	6.63	8	135.65	18.67	9	2
		<i>A. brassicicola</i>	28	34.91	4.02	4	44.67	10.69	6	2
	Pod	<i>A. brassicae</i>	28	64.61	5.72	6	155.69	20.44	11	3
		<i>A. brassicicola</i>	24	36.41	4.22	3	52.76	16.49	5	1
V <sub>8</sub> -NDRE4	Leaf	<i>A. brassicae</i>	26	70.31	6.81	7	185.79	19.41	10	5
		<i>A. brassicicola</i>	33	34.71	4.72	5	53.89	17.48	6	1
	Stem	<i>A. brassicae</i>	33	49.51	5.11	5	136.86	11.46	12	1
		<i>A. brassicicola</i>	36	32.50	4.35	4	46.31	10.21	8	2
	Pod	<i>A. brassicae</i>	24	66.49	5.51	7	148.34	13.61	12	4
		<i>A. brassicicola</i>	37	33.41	4.52	3	47.34	17.69	7	1
V <sub>9</sub> -NDYR8	Leaf	<i>A. brassicae</i>	35	60.97	6.21	7	151.11	17.97	10	3

	Stem	<i>A. brassicicola</i>	22	40.38	5.91	4	56.76	15.49	7	1
		<i>A. brassicae</i>	23	55.37	4.99	5	143.91	11.91	8	2
		<i>A. brassicicola</i>	24	34.87	5.29	5	45.76	10.31	5	1
	Pod	<i>A. brassicae</i>	24	57.68	4.00	4	148.20	14.49	10	3
		<i>A. brassicicola</i>	37	38.34	5.46	6	46.69	13.89	4	1
V <sub>10</sub> -JD6	Leaf	<i>A. brassicae</i>	38	70.75	7.91	5	175.46	20.73	14	5
		<i>A. brassicicola</i>	35	36.19	4.12	8	48.49	12.67	5	1
	Stem	<i>A. brassicae</i>	33	55.79	4.01	5	125.64	11.69	11	3
		<i>A. brassicicola</i>	32	33.69	3.41	4	45.40	10.39	5	1
	Pod	<i>A. brassicae</i>	24	57.89	4.19	6	145.89	16.59	11	3
		<i>A. brassicicola</i>	39	34.79	3.64	5	46.79	11.00	6	1
V <sub>11</sub> -NDRE7	Leaf	<i>A. brassicae</i>	33	65.37	6.35	8	180.89	21.67	13	4
		<i>A. brassicicola</i>	35	46.39	5.63	6	52.67	12.19	6	2
	Stem	<i>A. brassicae</i>	32	57.91	4.72	4	135.65	16.69	9	2
		<i>A. brassicicola</i>	31	37.71	4.31	3	46.69	10.49	4	0
	Pod	<i>A. brassicae</i>	22	64.61	5.72	6	155.69	19.97	11	3
		<i>A. brassicicola</i>	29	39.51	4.91	5	47.67	11.46	5	1
V <sub>12</sub> -NDRE22	Leaf	<i>A. brassicae</i>	35	71.43	6.92	7	185.79	22.91	14	5
		<i>A. brassicicola</i>	33	44.71	5.72	5	53.31	13.61	8	1
	Stem	<i>A. brassicae</i>	33	65.21	6.21	4	137.16	17.21	12	2
		<i>A. brassicicola</i>	24	38.72	4.51	3	47.39	11.41	6	1
	Pod	<i>A. brassicae</i>	25	68.14	6.31	7	157.69	19.69	13	4
		<i>A. brassicicola</i>	25	40.97	5.21	4	49.67	12.97	7	1
V <sub>13</sub> -NDRE2011	Leaf	<i>A. brassicae</i>	26	58.38	5.71	7	160.17	18.49	10	3
		<i>A. brassicicola</i>	23	36.41	4.99	5	48.91	11.91	5	1
	Stem	<i>A. brassicae</i>	33	55.17	4.40	5	126.76	15.31	9	2
		<i>A. brassicicola</i>	25	34.87	4.00	4	43.20	10.49	4	1
	Pod	<i>A. brassicae</i>	22	57.79	5.29	6	145.69	17.89	10	3
		<i>A. brassicicola</i>	37	33.75	4.91	5	45.46	11.73	5	1
V <sub>14</sub> -Varuna	Leaf	<i>A. brassicae</i>	37	65.22	6.81	8	186.49	22.67	14	5
		<i>A. brassicicola</i>	38	39.41	5.01	4	55.43	13.69	7	2
	Stem	<i>A. brassicae</i>	36	60.40	4.89	6	130.91	17.63	9	2
		<i>A. brassicicola</i>	34	35.42	4.81	4	45.30	11.60	5	1
	Pod	<i>A. brassicae</i>	26	63.05	5.19	6	160.64	19.94	11	4
		<i>A. brassicicola</i>	21	37.85	4.93	5	47.97	11.90	6	2

Table 2: Per cent frequency of *Alternaria* spp. Isolates from leaves, stem and pods

Entries	Plant parts	Isolates	Frequency (%)	Entries	Plant parts	Isolates	Frequency (%)
V <sub>1</sub> -NDYR32	Leaf	<i>A. brassicae</i>	50	V <sub>8</sub> -NDRE4	Leaf	<i>A. brassicae</i>	70
		<i>A. brassicicola</i>	50			<i>A. brassicicola</i>	30
	Stem	<i>A. brassicae</i>	25		Stem	<i>A. brassicae</i>	50
		<i>A. brassicicola</i>	75			<i>A. brassicicola</i>	50
	Pod	<i>A. brassicae</i>	40		Pod	<i>A. brassicae</i>	55
		<i>A. brassicicola</i>	60			<i>A. brassicicola</i>	45
V <sub>2</sub> -NDRE8-16	Leaf	<i>A. brassicae</i>	45	V <sub>9</sub> -NDYR8	Leaf	<i>A. brassicae</i>	70
		<i>A. brassicicola</i>	55			<i>A. brassicicola</i>	30
	Stem	<i>A. brassicae</i>	35		Stem	<i>A. brassicae</i>	60
		<i>A. brassicicola</i>	65			<i>A. brassicicola</i>	40
	Pod	<i>A. brassicae</i>	40		Pod	<i>A. brassicae</i>	60
		<i>A. brassicicola</i>	60			<i>A. brassicicola</i>	40
V <sub>3</sub> -NDRS2010	Leaf	<i>A. brassicae</i>	80	V <sub>10</sub> -JD6	Leaf	<i>A. brassicae</i>	80
		<i>A. brassicicola</i>	20			<i>A. brassicicola</i>	20
	Stem	<i>A. brassicae</i>	55		Stem	<i>A. brassicae</i>	60
		<i>A. brassicicola</i>	45			<i>A. brassicicola</i>	40
	Pod	<i>A. brassicae</i>	60		Pod	<i>A. brassicae</i>	65
		<i>A. brassicicola</i>	40			<i>A. brassicicola</i>	35
V <sub>4</sub> -PRB2004-3	Leaf	<i>A. brassicae</i>	70	V <sub>11</sub> -NDRE7	Leaf	<i>A. brassicae</i>	75
		<i>A. brassicicola</i>	30			<i>A. brassicicola</i>	25
	Stem	<i>A. brassicae</i>	60		Stem	<i>A. brassicae</i>	60
		<i>A. brassicicola</i>	40			<i>A. brassicicola</i>	40
	Pod	<i>A. brassicae</i>	65		Pod	<i>A. brassicae</i>	70
		<i>A. brassicicola</i>	35			<i>A. brassicicola</i>	30
V <sub>5</sub> -Ashirwad	Leaf	<i>A. brassicae</i>	80	V <sub>12</sub> -NDRE22	Leaf	<i>A. brassicae</i>	80
		<i>A. brassicicola</i>	20			<i>A. brassicicola</i>	20
	Stem	<i>A. brassicae</i>	65		Stem	<i>A. brassicae</i>	65
		<i>A. brassicicola</i>	35			<i>A. brassicicola</i>	35
	Pod	<i>A. brassicae</i>	75		Pod	<i>A. brassicae</i>	75
		<i>A. brassicicola</i>	25			<i>A. brassicicola</i>	25
V <sub>6</sub> -NDRE8213	Leaf	<i>A. brassicae</i>	75	V <sub>13</sub> -NDRE2011	Leaf	<i>A. brassicae</i>	75
		<i>A. brassicicola</i>	25			<i>A. brassicicola</i>	25
	Stem	<i>A. brassicae</i>	55		Stem	<i>A. brassicae</i>	55
		<i>A. brassicicola</i>	45			<i>A. brassicicola</i>	45

V <sub>7</sub> -NDRE8501	Pod	<i>A.brassiccae</i>	60	V <sub>14</sub> -Varuna	Pod	<i>A.brassiccae</i>	65
		<i>A.brassiccola</i>	40			<i>A.brassiccola</i>	35
	Leaf	<i>A.brassiccae</i>	75		Leaf	<i>A.brassiccae</i>	65
		<i>A.brassiccola</i>	25			<i>A.brassiccola</i>	35
	Stem	<i>A.brassiccae</i>	55		Stem	<i>A.brassiccae</i>	60
		<i>A.brassiccola</i>	45			<i>A.brassiccola</i>	40
Pod	<i>A.brassiccae</i>	70	Pod	<i>A.brassiccae</i>	55		
	<i>A.brassiccola</i>	30		<i>A.brassiccola</i>	45		

**Table 3:** Mean of morphological variables in *Alternaria* spp. Isolates obtained from leaf, stem and pod of Indian mustard entries

Entries	Isolates	Colony Diameter (mm)	Conidiophores			Conidia				Frequency (%)
			Length (µm)	Width (µm)	No. of septa	Length (µm)	Width (µm)	No. of septa		
								Transverse	Longitudinal	
V <sub>1</sub> -NDYR32	<i>A. brassiccae</i>	34.00	58.53	5.60	5.60	144.79	17.44	10.00	2.56	38.33
	<i>A. brassiccola</i>	34.00	35.57	4.40	4.30	51.34	11.72	4.30	0.67	61.66
V <sub>2</sub> -NDRE8-16	<i>A. brassiccae</i>	35.00	65.54	5.84	6.30	160.00	19.70	12.60	3.60	40.00
	<i>A. brassiccola</i>	34.33	41.34	5.08	4.00	50.23	12.67	7.00	1.00	60.00
V <sub>3</sub> -NDRS2010	<i>A. brassiccae</i>	25.66	58.18	5.10	6.00	144.20	16.80	9.60	2.60	65.00
	<i>A. brassiccola</i>	33.66	35.01	4.63	4.60	45.87	11.30	4.60	1.00	35.00
V <sub>4</sub> -PRB2004-3	<i>A. brassiccae</i>	32.66	67.65	5.80	6.60	156.00	20.07	11.30	3.60	65.00
	<i>A. brassiccola</i>	34.00	37.99	4.95	4.20	49.20	12.42	6.00	1.60	35.00
V <sub>5</sub> -Ashirwad	<i>A. brassiccae</i>	31.66	71.24	7.70	7.00	160.45	21.48	14.00	4.00	73.33
	<i>A. brassiccola</i>	29.66	41.60	5.60	6.00	50.73	12.80	8.00	2.00	26.67
V <sub>6</sub> -NDRE8213	<i>A. brassiccae</i>	32.33	64.60	5.40	5.60	143.70	17.20	10.00	2.60	63.33
	<i>A. brassiccola</i>	30.00	36.29	4.40	4.60	46.40	11.30	4.30	1.00	36.67
V <sub>7</sub> -NDR8501	<i>A. brassiccae</i>	34.33	64.59	6.65	7.00	149.60	20.10	10.30	2.60	66.60
	<i>A. brassiccola</i>	25.66	43.60	4.46	4.00	51.68	13.28	7.30	2.00	35.33
V <sub>8</sub> -NDRE4	<i>A. brassiccae</i>	27.60	62.10	5.81	6.30	123.60	14.80	11.30	3.30	58.33
	<i>A. brassiccola</i>	35.33	44.40	4.91	4.00	49.18	15.10	7.00	1.30	41.67
V <sub>9</sub> -NDYR8	<i>A. brassiccae</i>	27.33	58.00	5.06	5.30	147.74	13.79	9.30	2.60	63.33
	<i>A. brassiccola</i>	27.34	37.80	5.10	5.00	49.70	13.23	5.30	1.00	36.67
V <sub>10</sub> -JD6	<i>A. brassiccae</i>	31.60	61.47	5.37	5.30	148.90	16.30	12.00	3.60	68.33
	<i>A. brassiccola</i>	35.30	34.80	3.72	5.60	46.80	11.30	5.30	1.00	31.67
V <sub>11</sub> -NDRE7	<i>A. brassiccae</i>	29.00	62.63	5.59	6.00	157.41	19.44	11.00	3.00	68.33
	<i>A. brassiccola</i>	31.00	41.20	4.68	4.66	49.01	11.30	5.00	1.00	31.67
V <sub>12</sub> -NDRE22	<i>A. brassiccae</i>	31.00	65.71	5.90	6.00	160.20	19.90	13.00	3.62	73.33
	<i>A. brassiccola</i>	27.00	41.40	5.14	4.00	50.10	12.60	7.00	1.00	26.67
V <sub>13</sub> -NDRE2011	<i>A. brassiccae</i>	27.30	58.18	5.10	6.00	144.20	16.80	9.60	2.60	65.00
	<i>A. brassiccola</i>	28.30	35.01	4.63	4.60	45.85	11.30	4.60	1.00	35.00
V <sub>14</sub> -Varuna	<i>A. brassiccae</i>	33.00	67.60	5.80	6.60	156.01	20.07	11.30	3.60	56.67
	<i>A. brassiccola</i>	31.00	37.99	4.95	4.30	49.20	12.42	6.00	1.60	40.33

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