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Management of black rot disease of rapeseed (*Brassica napus*)-Indian mustard (*Brassica juncea*) caused by *Xanthomonas campestris* pv. *campestris*

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Rapeseed (*Brassica napus* L.)-Indian mustard [*Brassica juncea* (L.) Czernj. & Coss.] is the second most important oilseed crop after groundnut (Meena *et al.* 2010). In spite of higher yield potential, the diseases are major constraints, of which black rot caused by *Xanthomonas campestris* pv. *campestris* (Pammel) Dowson is becoming a threat to rapeseed-mustard crops in Uttar Pradesh (Singh *et al.* 2016). Disease can be controlled by using cultural, chemical, biological and host resistance methods. Antibiotics are mostly used for controlling the bacterial diseases and among them, streptocycline has been reported most effective antibiotics to control the disease (Kavathiya *et al.* 2017, Thakre *et al.* 2017). However, use of genetic resistance is an alternative to chemical and efficient control method to manage the black rot disease.

An experiment was conducted to manage the black rot disease in rapeseed-Indian mustard during winter (*rabi*) season (2017–18 and 2018–19) at Genetics and Plant Breeding farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh. Genotypes/varieties of rapeseed-mustard were obtained from the Department of Genetics and Plant Breeding of the University (ANDUAT) and ICAR-DRMR, Bharatpur, Rajasthan. A total 340 genotypes/varieties, (289) *Brassica juncea*, (2) *B. rapa* var. brown sarson, (19) *B. rapa* var. toria, (13) *B. rapa* var. yellow sarson, (3) *Brassica carinata*, (8) *Eruca sativa* and (6) *B. napus* were taken to screen against black rot disease under field conditions by using 0–3 rating described by Vicente *et al.* (2001).

Xcc was isolated from infected leaves collected from experimental farm of the ANDUAT, University, Ayodhya, Uttar Pradesh on nutrient sucrose agar medium as method described by Singh *et al.* (2011). The culture of pathogenic bacteria was transferred on nutrient agar slant into culture tube and preserved at 4^0C for further studies. A concentration of 200 ppm of 7 antibiotics, viz. T_1, Streptocycline; T_2, Streptomycin; T_3, Tetracycline hydrochloride; T_4, Oxytetracycline hydrochloride; T_5, Ofloxacin; T_6, Chloramphenicol; T_7, Rifampicin and T_8, Bleaching powder @500 was used. The diameter of the inhibition zone was recorded and calculated per cent inhibition as described by Vincent (1927).

A field experiment on management of black rot disease on rapeseed-mustard var. NDR 8501 was conducted with the plot size of 4 m × 3 m, having 9 treatments with 3 replications in randomized block design (RBD) during winter (*rabi*) season. The disease rating was done as described by Vicente *et al.* (2001). The per cent disease index (PDI) was calculated as:

$$\text{PDI} = \frac{\text{Sum of all numerical ratings}}{\text{Total number of leaves observed}} \times \frac{100}{\text{Maximum rating}}$$

The data generated from evaluation of antibiotics/ antibacterial compounds against *Xcc* under *in vitro* conditions was statistical analyzed using complete randomized design. The data generated on disease incidence and disease severity for evaluation gemplasm and antibiotic under field conditions were statistically analyzed using randomized block design (RBD) (WASP 1.0).

Out of 340 rapeseed-mustard genotypes, 15 genotypes, viz. RTM 1624, RTM 1626, TM EPAU, DRMRAB-7-116, NPJ-177, LES-55, DRMRIJ 16-1, RH 1514, BASANTI, NDRS 1-2, TMR 14-1, TMR-14-4, TMR 14-5, TMR 14-3, T 27 showed resistant, 67 genotypes were partially resistant, 218 susceptible and 40 genotypes were found highly susceptible (Table 1).

All *Eruca sativa* genotypes were highly resistant due to their morphological characters like small sized leaves having wax coating on the surface, dwarf height and consequently the least canopy helps to escape the black rot disease. Similar findings were also reported by Gandhi and Prashar (1978). The race specific resistance was found in other varieties of *B. rapa, B. napus, B. juncea, B. nigra* and *B. oleracea* (Singh *et al.* 2016). Indian mustard genotype PM 25 was found partially resistant against the disease (Rathour *et al.* 2015).

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Table 1 Performance of rapeseed-Indian mustard genotypes against black rot disease caused by *Xcc* under field conditions during 2017–18 and 2018–19

Rating scale	No. of genotypes	Reaction		genotype
0	15	Resistant (0)	*Brassica juncea*	DRMRAB-7-116, NPJ-177, LES-55, DRMRIJ 16-1, RH 1514, BASANTI, NDRS 1-2
			Eruca sativa	TMR 14-1, TMR-14-4, TMR 14-5, TMR 14-3, T 27, RTM 1624, RTM 1626, TM EPAU
1	67	Partially Resistant (<33%)	*B. rapa* var. brown sarson	KOS-1, KBS-3
			B. rapa var. toria	PT-30
			B. rapa var. yellow sarson	JHUMKA, RAUDYS 14-05, NDYS 424
			B. napus	GSL-5, GSL-2
			B. juncea	RH 919, DRMRIJ 16-66, RGN 419, RRN 935, RTM 314, Pusa MH 8, RH 1372, NPJ 219, NPJ 220, DRMRSJ 9-1-1, NDRS 2009-1, NDRS 2017-4, RH 761, KM 126, KMR 15-4, PDZ 6, CS 1100-1-2-2-3, CS 2800-1-2-3-5-1, EC 399301, PHR 2, DRMRAB-7-131, DRMRAB-7-82, DRMRAB-7-53, ABS (3)-16, DRMRAB-76, RMWR-09-5, PRD-2013-3, PRD-2013-5, PDZ-3, RMM-09-04, RMM-09-1-1-2, PRD 2014-1, EC-399299, RB-72, RHH 1561, RH 1556, DRMRCI-59, PRE 2013-10, RB 86, RH 1202, PRE 2013-19, SVJH 94, RGN 394, RH 1599-7, RMWR-09-2-1, NPJ 208, KMR 16-4, DRMRCI-70, NRCDR 0-2, NDRS 7-2, GIRIRAJ, NDRS 2007-2, NDRE-7, PM 25, RH 749, RH 406, PM 26, ROHINI, RH 1326
2	218	Susceptible (33–66%)	*B. rapa* var. toria	ANURADHA, TS 38, TH 1402, TS 46, PT 2010-5, PT 2015-3, RAUDT 14-09, RAUDT 14-04, TKM 17-1, RMT 15-29
			B. rapa var. yellow sarson	PG 45, YSKM 17-1, PYS 2015-04, NRCYS-05-02, YSH 0401, PITAMBARI, YSKM 17-2
			B. carinata	KIRAN, DRMR-316, DLSC-1
			B. rapa var. gobhi sarson	SHEETAL, GSL-1, KGS 35
			B. juncea	CS 15000-1-1-1-1-2, SVJ 68, DRMR 1165-40, RH 1209, RLMCP 626, CS 508-1-P2, PAB 14-5, PRD-14-6, PRD 14-11, PRD 2014-16, PRD 14-18, RMM-09-06, PAB 14-14, PAB 14-17, PDZ 4, PDZ 7, DRMR 1-5, DRMR-2019, TM 277, NDRS 2011, KMR 17-1, KMR 17-2, JD-6, RH 1590, RH 1607, RH 1699-22, NPJ 212, JM-12-6, PR-2105-1, CS 2005-137, CS 2009-129, NDRS 2009-1-2, DRMRC 106, DRMRC 98, DRMR 2017-14, DRMRIJ 16-38, SKM 1328, PR 2015-5, SVJ 111, RB 94, RH 1650, RH 1656, PRE 2013-3, JMM 991, AKMS 9026, NPJ 209, NPJ 210, RGN 435, PBR 438, PBR 400, RH 1550, RH 1585, KMR 17-4, NPJ 211, NPJ 213, NPJ 214, DRMRCI 91, DRMR 2017-15, RH 1569, LES 56, PMH 8, NPJ 215, NPJ 216, PRL 2013-15, RH 1599-41, RMWR 09-2, RMT 10-13, PDZ 10#, DRMRO 4, 71J0001, 71J0002, DRMRCI 72, KMR 17-5, KMR 17-6, RGN 431, RH 1555, BAUM 09-13-1, TM 143, RB 76, TM 117, HUJM 16-8, AKMS 8138, KM 927, RHH 1665, RL 1359, PHR 3278, RRN 917, SVJH 100, Pusa MH 9, 71J0003, BIOYSR, DRMRIC 16-38, DRMRHJ 2503, RH 1378, RMWR 09-1, DRMR 2019, DRMR 5206, NPJ 217, NPJ 218, NDRE 8-14-1, NDR 2017-3, NDRE 2017-1, NDRE-4, NDR 2017-2, NDRE 1-11, RGN-337, NPJ 195, RH 0725, KMR 15-5, PBR 422, RGN 368, DRMR 1153-12, Albeli-1, Divya 88, RH 923, CS 700-2-1-4, DRMRAB-7-233, DRMRAB-7-146, DRMRAB-7-55, RH 1573, DRMRAB-7-13, DRMRAB-77, DRMRAB 7-150, PRD 2013-6, PRD 2013-2, PRD-2013-9, PRD 2014-22, DRMR-73, PAB-14-7, DRMR-7, PRD-2014-27, DRMR-2035, DRMRIJ 13-38, RMM 09-6-1, PAB 14-25, DRMR-72, PAB 14-22, DRMR 32, ABS (3)15, RH-1212, ABS(3) 44, ABS(3) 16,

Contd.

Table 1 (*Concluded*)

Rating scale	No. of genotypes	Reaction		genotype
				DRMR 2-11, NPJ-201, SVJ 72, NPJ-203, PRD-2013-6, DRMRHJ 913, PHR-126, LES 54, CS 2009-335, KMR 16-1, DRMRCI-58, RGN-400, DRMR 4005, TM-263-3, RH 1462, DRMRIJ 16-3, RMR 4685, TM 179, RRN 896, RHH 1539, CS 13000-3-1-1-4-2, SVJH-84, DRMR 4011, KMR 16-5, PHR 240, TM 172, TM 276, CS 2009-154, NIMH-23, DRMRIJ 16-2, CS 15000-1-1-1-4-2, RGN-403, KMR 16-3, KMR 16-6, PRD 2013-8, RB-69, NPJ-204, PR-2013-07, RGN 13, RGN 48, ASHIRWAD, VARUNA, VARDAN, MAYA, KANTI, NDRS 2008-1, NDRS 2017, PM 24, NRCHB 101, PM 27, PARWATI, , NDR 8501, KRANTI
3	40	Highly susceptible (>66%)	*B. rapa* var. toria	PT-303, T-9, RAUDT 10-33, TKM 17-2, TH 1603, PT 2015-11, RMT 15-2, BAUT 08-01
			B. rapa var. yellow sarson	PS-66, YSB 9, PYS 2015-03
			B. rapa var. gobhi sarson	AKMS 8141
			B. juncea	PRO 5222, PAB 16-2, PDZ 5, PDZ 2, BAUM-08-14, RLC 6, DRMRCI 85, DRMR 2017-5, LES 57, RLC 7#, PRL 2013-17, RH 1518, PDZ 1, RHH 1687, 71J0004, CS 15000-1-2-2-2-1, DRMRAB-72, PAB 14-11, PRD-2013-8, SKM 1104, PR 2013-02, PDZ-08, DRMRHJ 2513, DIVYA-99, CS 900-1-2-2-1-3, DRMRCI 65, VAIBHAV, NDYR-8

The efficacy of 7 antibiotics and antibacterial compounds was tested against *Xcc* under *in vitro* conditions. Maximum inhibition zone 3.8 cm diameter was formed against the *Xcc* with T_1, @200 ppm, 73.48% inhibition over control followed by T_5, (3.6 cm) (Fig 1). The result obtained in the present study was analogous with the work of Meena *et al.* (2007) under which they reported that Streptocycline was found most effective against *Xanthomonas* sp. (Jadhav *et al.* 2018).

Data (Table 2) indicates that all treatments significantly decreased the black rot disease severity on leaves as compared to untreated check except bleaching powder which was not found effective. Minimum disease incidence (13.29%) and maximum disease per cent over control (66.77%) was found in T_1, @200 ppm followed by T_5 and T_2. T_8 was not found effective against the disease (Table 2). This finding substantiates with Kavathiya *et al.* (2017) and Thakre *et al.* (2017). The maximum average yield was recorded in treatment T_1 followed by T_5, T_2 and T_6 (Table 2).

SUMMARY

Out of 340 genotypes/varieties screened against black rot disease in rapeseed-Indian mustard under field conditions, 15 genotypes found resistant, viz. RTM 1624, RTM 1626, TM EPAU, DRMRAB-7-116, NPJ-177, LES-55, DRMRIJ 16-1, RH 1514, BASANTI, NDRS 1-2, TMR 14-1, TMR-14-4, TMR 14-5, TMR 14-3, T 27, can be utilized as a donor for the development of black rot disease resistant varieties in crucifer crops. All genotypes of *Eruca sativa* were found resistant against black rot disease. Under *in vitro* conditions, streptocycline @200 ppm had maximum inhibition zone 3.8 cm diameter with 73.48% inhibition over control. *In vivo*, minimum disease severity 13.29% and 14.29%, lowest AUDPC 185.8% and 201.4% and highest yield 16.45 q/ha and 16.62 q/ha was recorded in the treatment T_1, Streptocycline @200 ppm on rapeseed-mustard var. NDR 8501 (Narendra Rai) in 2017–18 and 2018–19 respectively.

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Table 2 Evaluation of different antibiotics and antibacterial compounds against black rot disease caused by *Xcc* under lab and natural field condition

Treatment	Conc. (ppm)	Diameter of clear zone (cm)	Inhibition (%)	Disease incidence (%)		Reduction of disease incidence over control (%)		AUDPC		Yield (q/ha)		Yield increase over control (%)	
				2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19	2017–18	2018–19
T_1	200	3.8	73.68	13.29 (21.37)	14.25 (22.17)	66.77	67.00	185.8	201.4	16.45	16.62	50.22	55.47
T_2	200	3.3	69.69	16.45 (23.92)	17.97 (25.07)	58.87	58.39	232.1	253.7	15.97	15.79	45.84	47.70
T_3	200	2.6	61.53	19.75 (26.38)	22.19 (28.10)	50.62	42.67	274.3	310.1	14.85	15.01	35.61	40.41
T_4	200	3.0	66.66	19.26 (26.02)	21.08 (27.33)	51.85	51.19	271.7	295.5	14.43	14.53	31.78	32.69
T_5	200	3.6	72.00	15.81 (23.42)	16.63 (24.06)	60.47	61.49	219.2	234.8	16.36	16.65	49.40	55.75
T_6	200	3.5	71.42	16.96 (24.31)	18.95 (25.80)	57.60	56.12	239.2	267.1	15.85	16.03	44.74	46.39
T_7	200	3.2	68.75	18.56 (25.51)	20.04 (26.59)	53.60	53.60	257.8	282.2	15.20	15.11	38.81	41.34
T_8	500	1.0	0.00	36.30 (37.04)	38.42 (38.30)	9.25	11.04	401.7	391.9	11.04	11.25	0.82	5.23
Control	-	1.0	0.00	40.00 (39.23)	43.19 (41.08)	-	-	420.4	427.1	10.95	10.69	-	-
SEm±		0.05	0.72	0.37	0.26								
CD		(at 1%) 0.15	(at 1%) 2.10	(at 5%) 1 .11	(at 5%) 0.78								

Refer to methodology for treatment details.

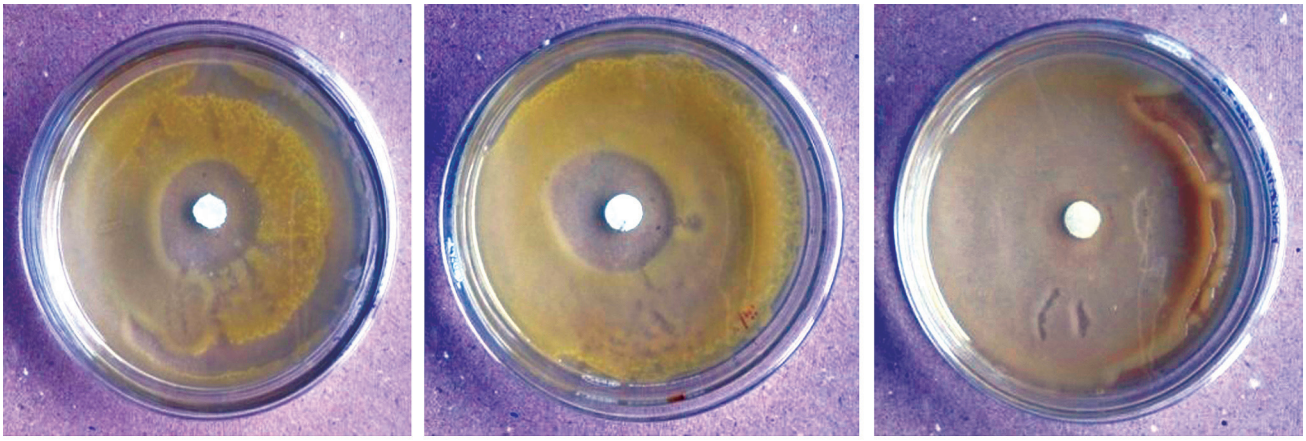

Fig 1 *In vitro* efficacy of different antibiotics on the growth of *Xcc.*

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