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Performance of cauliflower genotypes for yield and resistance against black rot (*Xanthomonas campestris* pv. *campestris*)

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ABSTRACT

Black rot disease of cole crops caused by *Xanthomonas campestris* pv. *campestris* occurs worldwide and causes substantial yield loss (10-50%) including curd quality and seed vigour. Resistant varieties are very much lacking in cauliflower due to non availability of resistant donors. Twenty one breeding lines/ varieties of cauliflower belonging to early and mid maturity groups were evaluated for marketable curd yield, curd quality and also screened artificially against 4 virulent strains of *X. campestris* pv. *campestris* (Xcc-C1, Xcc-C3, Xcc-C26 and Xcc-C28) for the disease resistance. The curd maturity ranged from 50-72 days after transplanting and marketable curd weight from 253-750 g. Among the early genotypes, PN-1 produced good quality white and compact curd (238.33 q/ha) and among mid maturity group DCH 822 produced 375.00 q/ha followed by DC-76 (311.67 q/ha). Significant disease incidence (59-100%) and severity (3.95-5.34) against 4 pathogen strains were recorded, however, PN-1 and VLCE-4 showed the minimum disease intensity (<60%) among the lines tested. Most of the lines showed partial resistance or moderate resistance, while IVMC-11 and PES showed susceptible reaction to black rot. The lines PN-1, VLCE-10, DC-76, DCH-822 showed high yield potential with better curd quality coupled with moderate resistance to black rot.

Key words: Cauliflower, *Brassica oleracea* var. *botrytis,* yield component, resistance, black rot, *Xanthomonas campestris* pv. *campestris*.

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is one of the important vegetable crops being cultivated through out the country round the year due to availability of varieties belonging to different maturity groups. Considerable yield losses (10-50%) occur due to black rot caused by *Xanthomonas campestris* pv. *campestris*, which is considered as the most serious disease of cauliflower and cabbage worldwide (William, 9; Singh and Shri Dhar, 6; Dhiman, 2). In the past, few resistant sources such as Pusa Snowball K-1 (Late group variety) under temperate conditions by Gill *et al.* (1) and Pusa Early Synthetic (PES) as moderate resistance by Sharma *et al.* (5) have been reported. However, there is a need to test newly developed breeding lines/ varieties against *X. campestris* pv. *campestris* isolates representative to different agro-climatic conditions to identify the new sources and resistant cultivars for wider adaptability with good quality curd, which are very much lacking in different maturity groups. Consequently, attempts were made to evaluate the varieties and breeding lines for their curd performance as well as level of resistance to black rot disease.

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MATERIALS AND METHODS

Twenty one breeding lines including varieties of cauliflower belonging to different maturity groups (early, mid and mid-late) were selected for the assessment of curd yield performance at Division of Vegetable Science, while disease screening experiment against four black rot isolates were conducted with challenge inoculation at Division of Plant Pathology during 2007-08 and 2008-09, separately. The seeds of all the 21 lines were sown in raised nursery beds in the third week of September and 25-day-old seedlings were transplanted in well prepared plots (4 m^2) each keeping planting distance of 50 cm × 50 cm apart in randomized block design with three replications. The recommended package of practices was followed to raise a good crop. Observations recorded on days to curd initiation, days to curd harvest, marketable curd weight and curd yield were subjected to standard statistical analysis.

The same seedlings of all the 21 lines were also transplanted in pots under glasshouse at Division of Plant Pathology for screening against four strains of *X. campestris* pv. *campestris* (Xcc-C1, Xcc-C3, Xcc-C26 and Xcc-C28) isolated from IARI farms in Delhi and other cauliflower growing areas in adjoining states. The purified strains of *X. campestris* pv. *campestris* were maintained at 4°C on YDC medium for different

studies in next year. Temperature conditions were not much variable during the experimental period as the maximum average temperature ranged from 24.4 to 30.3°C (day temperature), while the minimum varied between 5.5 and 12.2°C (night temperature). Twenty ml of a sterile saline solution (0.85% NaCl) was added to the Petri dishes containing 48-h-old cultures of all four strains of *X. campestris* pv. *campestris*. The cultures were scraped with a sterilized glass slide and the suspensions were homogenized by agitation on a vortex mixer. The population of test bacteria was measured by spectrophotometer and adjusted with sterile saline solution OD (600 nm) = 0.1, which was equivalent to 3.9×10^9 cfu/ml for *X. campestris* pv. *campestris.* Forty five-day-old plants of different cauliflower lines and varieties were inoculated with bacterial pathogen by clipping method. Cauliflower leaves were clipped at 10 places in each leaf and 3 leaves in each line/variety in each pot were inoculated with three replications. Observation on disease incidence and disease severity were recorded after 15 days of pathogen (Xcc) inoculation (Vicente *et al*., 8). The disease incidence was calculated by dividing total number of points showing disease symptoms with number of inoculated points on each leaf and expressed in percentage as PDI (percent disease incidence).

The severity of symptoms was assessed on a six-point scale of 0 - 9 based on the relative lesion size appeared only on injured points as: 0 = no symptoms, 1 = small necrosis or chlorosis surrounding the infection point, 3 = typical small V- shaped lesion with black veins, 5 = typical lesion half way to the middle vein, 7 = typical lesion progressing to the middle vein, and 9 = lesion reaching the middle vein. The pooled data of both years were analyzed statistically using factorial complete randomized design (FCRD). Cauliflower genotypes were categorized into four groups based on disease scores following the methods proposed by Vicente *et al*. (8).

RESULTS AND DISCUSSION

The analysis of variance revealed significant difference among the lines for all the traits, *viz*., days to curd initiation, days to curd harvesting, marketable curd weight and marketable curd yield. The days for curd initiation and curd harvesting ranged from 39-50 days and 50-72 days after transplanting, respectively (Table 1). PN-1 was significantly earliest (39 days) in curd initiation than the early maturing checks PES and Krisnna-1 (41 days), but there was no marked difference for curd maturity over the checks (50-51 days). However, the line DC-76 was mid-late in curd maturity (72 days). The range for marketable curd weight was 253-750 g and the best curd quality (white compact) producing line was DCH-822 (750 g), whereas DC-76 (623 g), Sel-6 (600 g) and DC 76-1 (580 g) belonging to mid-maturity group were at par statistically. Among the lines showing earliness in maturity and produced good quality curd were PN-1 (477 g) and VLCE-10 (467 g) against the best check Krishna-1 (377 g). For the economic trait marketable curd yield, the range varied from 126.67-375.00 q/ha. It is quite evident that the line DCH-822 having highest average marketable curd weight also gave the highest curd yield (375.00 q/ha) followed by DC-76 (311.67 q/ha) and Sel-6 (300 q/ha). The early maturing line PN-1 produced good quality white and compact curd (238.33 q/ha) against the best check PES (178.33 q/ha), which produces compact but creamish colour curd (Table 1).

Disease incidence and severity studies under field conditions against four virulent strains of *X. campestris* pv. *campestris*, *viz.* Xcc-C1, Xcc-C3, Xcc- C26 and Xcc-C28 indicated that strain Xcc-C1 isolated from cauliflower from the Experimental Farm of IARI, New Delhi was found most virulent followed by Xcc-C3 causing overall 77.05% disease incidence and 4.7 (0-9 scale) disease severity in cauliflower. The disease incidence ranged from 66.7-100, 73.3-100, 60.0-100 and 66.7-100% caused by Xcc-C1, Xcc- C3, Xcc- C26 and Xcc- C28 virulent strains, respectively. Minimum disease incidence (55.1%) was noted in line Sel-7 followed by PN-1 (59.84%) and VLCE-4 (59.98%) after 30 days of inoculation (Table 2). The significant variation in disease incidence was recorded among the lines/cultivars in artificially inoculated plants. There was no significant variation was found among the strains of *X. campestris* pv. *campestris* to cause disease incidence in cauliflower. Moreover, no significant interaction was recorded between lines/cultivars of cauliflower and strains of *X. campestris* pv. *campestris*.

The severity of black rot disease caused by *X. campestris* pv. *campestris* in 21 promising lines/ cultivars of cauliflower was recorded after 30 days of artificial inoculation under field conditions. Minimum disease severity was found in 3.87 (0-9 scale) in VLCE-3 followed by 3.95 in Sel-6 and 4.31 in VLCE-11. No significant variation among four strains of the pathogen was recorded and overall disease severity ranged from 4.62 to 4.70. The performance of cultivars/ lines of cauliflower showed significant variation and ranged from 3.77-6.06, 3.85-5.24, 3.82- 5.67, 3.61-6.13 caused by Xcc- C1, Xcc-C3, Xcc- C26, Xcc-C28, respectively (Table 3). In present studies, only black rot producing strains of *X. campestris* pv. *campestris* were considered to

Table 1. Performance of cauliflower lines and varieties.

Variety/line	Source	Days to curd initiation	Days to curd harvesting	Marketable curd wt. (g)	Estimated marketable yield (q/ha)	Curd quality
IVMC-11	IIVR	44	56	347	173.33	White compact
Sel-4	IARI	44	54	303	151.67	White compact
Sel-5	-do-	45	54	307	153.33	White compact
DC76	-do-	50	72	623	311.67	White compact
DC76-1	-do-	45	64	580	290.00	White compact
Sel-6	-do-	48	64	600	300.00	White compact
Sel-7	-do-	46	59	470	235.00	White compact
DC-78	-do-	46	59	457	228.33	Creamish compact
PN -1	PAU	39	50	477	238.33	White compact
Sel-2	IARI	45	59	430	215.00	White compact
Sel-3	-do-	41	54	410	205.00	White compact
Pusa Early Synthetic (C)	-do-	41	51	357	178.33	Creamish compact
VLCE-11	VPKAS	47	58	363	181.67	Creamish compact
VLCE-10	-do-	42	51	467	233.33	White loose
VLCE-9	-do-	44	54	303	151.67	White compact
VLCE-3	-do-	41	54	353	176.67	White compact
VLCE-4	-do-	45	59	347	173.33	White compact
VLCE-5	-do-	45	54	253	126.67	White loose
DC-333	IARI	41	59	343	171.67	White loose
DCH 822	-do-	48	61	750	375.00	White compact
Krishna-1 (C)		41	51	377	188.33	Creamish loose
CD at 5%		1.6	2.3	43.1	21.6	
CV%		2.3	2.5	6.2	6.2	

study pathogenic variability and all the lines/variety showed necrosis and sudden collapse of large area of mesophyll in advanced stage causing blackening of veins (Massomo *et al*., 3; Singh *et al.*, 7). It was also reported that *Brassica olaracea* sub-species (cole crops) showed susceptible to 24 strains of *X. campestris* pv. *campestris* isolated from different agro-climatic zones of India (Singh *et al*., 7).

Based on disease incidence and severity, none of the cultivars/ lines of cauliflower showed resistance against black rot disease under field conditions (Table 4). However, most of these lines were found partially resistant or moderately resistant except lines IVMC-11, Pusa Early Synthetic (C), DC-333, which showed susceptible reaction under artificial inoculation. It was also observed that none of the cultivar/line showed highly susceptible reaction against the four *X. campestris* pv. *campestris* strains. Earlier, Pandey *et al.* (4) have also reported moderate resistance in cauliflower. On the basis of above findings it is concluded that the lines PN-1, VLCE-10, DCH-822 (early maturity) and DC-76 (medium maturity) showed high yield potential with better curd quality coupled with moderate resistance to black rot disease, which may be utilized as variety/ donor for the development of disease resistant varieties.

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Table 2. Disease incidence of *Xanthomonas campestris* pv. *campestris* strains in cauliflower genotypes.

Variety/line	Incidence of black rot strain (%)				
	Xcc-C1	Xcc-C3	Xcc- C26	Xcc- C28	Mean
IVMC-11	100.0 (89.96)	100.0 (89.96)	83.3 (66.11)	96.7 (83.82)	82.47
Sel-4	86.7 (68.83)	83.3 (66.12)	93.3 (77.68)	90.0 (74.97)	71.89
Sel-5	90.0 (78.90)	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	87.19
DC76	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	96.7 (83.21)	88.43
DC76-1	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	89.96
Sel-6	76.7 (61.20)	76.7 (61.20)	73.3 (58.98)	76.7 (61.20)	60.64
Sel-7	66.7 (54.96)	73.3 (58.98)	60.0 (50.74)	70.0 (56.98)	55.41
DC-78	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	89.96
PN-1	73.3 (59.19)	76.7 (61.20)	63.3 (53.13)	76.7 (65.83)	59.84
Sel-2	86.7 (72.26)	80.0 (63.90)	76.7 (61.69)	76.7 (61.89)	64.94
Sel-3	93.3 (77.68)	90.0 (74.97)	100.0 (89.96)	96.7 (83.82)	81.61
Pusa Early Synthetic (C)	76.7 (61.20)	76.7 (61.20)	70.0 (56.77)	83.3 (70.75)	62.48
VLCE-11	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	96.7 (83.21)	88.43
VLCE-10	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	89.96
VLCE-9	100.0 (89.96)	90.0 (78.89)	100.0 (89.96)	100.0 (89.96)	87.20
VLCE-3	76.7 (61.20)	76.7 (61.20)	86.7 (68.83)	80.0 (63.90)	63.78
VLCE-4	80.0 (63.90)	80.0 (63.90)	70.0 (56.77)	66.7 (55.35)	59.98
VLCE-5	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	100.0 (89.96)	89.96
DC-333	90.0 (74.97)	96.7 (83.82)	100.0 (89.96)	100.0 (89.96)	84.67
DCH 822	86.7 (68.83)	86.7 (68.83)	93.3 (77.68)	76.7 (61.20)	69.13
Krishna-1 (C)	93.3 (81.11)	93.3 (77.68)	90.0 (78.89)	93.3 (81.11)	80.56
Mean	77.05	76.52	76.38	76.43	

CD at 5%: Variety/ line = 6.57; Bacterial strain = NS; Variety / line × bacterial strain = NS
*Parentheses show Arc Sine transformed value of data

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Table 3. Severity of black rot disease caused by *Xanthomonas campestris* pv. *campestris* in cauliflower genotypes under artificial inoculation.

Variety/line	Severity of black rot disease (0- 9 scale)				
	Xcc- C1	Xcc- C3	Xcc- C26	Xcc- C28	Mean
IVMC-11	6.07	4.67	4.54	6.11	5.34
Sel-4	4.70	4.44	4.71	4.79	4.66
Sel-5	4.25	4.73	4.80	5.33	4.78
DC76	4.53	4.47	4.60	4.79	4.60
DC76-1	4.73	4.53	4.67	4.60	4.63
Sel-6	4.05	4.32	3.82	3.61	3.95
Sel-7	4.52	4.73	5.67	4.45	4.84
DC-78	4.67	4.67	4.67	4.67	4.67
PN-1	4.61	4.64	4.92	4.26	4.61
Sel-3	5.00	5.09	4.78	4.62	4.87
Sel-3	4.73	5.00	4.73	5.20	4.91
Pusa Early Synthetic (C)	6.06	4.60	5.38	4.40	5.11
VLCE-11	4.13	4.73	4.27	4.12	4.31
VLCE-10	4.53	4.60	4.27	4.60	4.50
VLCE-9	4.20	4.38	5.07	5.00	4.66
VLCE-3	3.77	3.85	4.08	3.76	3.87
VLCE-4	4.42	5.24	5.00	4.67	4.83
VLCE-5	4.6	4.53	4.60	4.60	4.58
DC-333	4.32	5.07	4.93	6.13	5.11
DCH 822	4.61	4.61	4.65	4.56	4.61
Krishna-1 (C)	4.55	4.87	4.67	4.42	4.63
Mean	4.70	4.70	4.62	4.65	

CD at 5% = Variety/ line = 0.29; Bacterial strain = NS; Variety/ line × bacterial strain = 0.59

Table 4. Disease reaction of varieties/ lines of cauliflower against *X. campestris* pv. *campestris* strains under artificial inoculation.

Disease reaction	Varieties/ lines of cauliflower
Resistant	Nil
Partial resistant	Krishna-1 (C), DCH 822, VLCE-5, VLCE-4, VLCE-3, VLCE-9, VLCE-10, VLCE-11, Sel-3, Sel-3, DC-78, PN-1, Sel-7, Sel-6, DC76-1, DC76, Sel-5, Sel-4
Susceptible	IVMC-11, Pusa Early Synthetic (C), DC-333
Very susceptible	Nil

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