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Cultural and morphological variability of *Fusarium oxysporum* f.sp. *ricini* isolates from castor growing areas of Gujarat

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Abstract
Cultural and morphological variability in five isolates of *Fusarium oxysporum* f.sp. *ricini* collected from different castor growing areas of Gujarat was studied. Varied cultural characteristics, mycelial colour, substratum pigmentation, growth pattern, dry mycelial weight, sporulation and size of micro and macro conidia of all isolates was observed which were further influenced by all five culture media *viz*., Rose bengal medium, Potato dextrose medium, Richard's medium, Asthana and Hawker's medium and Glucose asparagine medium. There was a significant variation among all five isolates of *F. oxysporum* f.sp. *ricini* in respect of cultural characteristics, mycelial colour, substratum pigmentation, mycelial growth, dry mycelial weight, sporulation, size of microconidia and macroconidia. Each isolate exhibited cultural and morphological variations under influence of different culture media. The findings of present study will be useful for developing *Fusarium* wilt resistant castor hybrids/varieties.

Keywords: Cultural variability, Culture media, *Fusarium oxysporum* f.sp. *ricini*, Morphological variability, Sporulation, Wilt of castor

INTRODUCTION

Castor (*Ricinus communis* L.) is one of the most important non-edible oilseed crop of arid and semi -arid regions which belongs to genus *Ricinus* of *Euphorbiaceae* family. India is the largest castor producer in the world. The crop is affected by several biotic and abiotic stresses among which wilt disease caused by *F. oxysporum* f.sp. *ricini* is most important. Depending upon the crop growth stage, the seed yield loss may be extended from 39 to 77 % (Raoof and NageshwarRao, 1999). The disease incidence up to 80% was recorded by Moshkin (1986) in Russia. Yield loss was observed in all cultivated castor hybrids in Gujarat (Dange *et al*., 1997) and as high as 85 % wilt incidence was recorded under North Gujarat condition (Dange, 2003). The reduction from 10 to 40 % in yield, 8-14 % in seed weight and 1-2 % in oil content was reported by Lakshminarayana and Raoof (2006). During the survey on disease scenario in Gujarat, 1.0 to 35.0% wilt incidence was recorded on different castor hybrids (Anonymous, 2018). Cultivation of resistant varieties is cheapest and best way to manage soil-borne diseases. Hence, efforts were made to develop *Fusarium* wilt resistant varieties/hybrids as a result several *Fusarium* wilt resistant castor hybrids and varieties has been developed and released for cultivation. However, genetic resistance has a problem that it's limited durability of effectiveness due to genetic adaptation by the pathogen (Niks *et al*., 1993). Castor hybrid GCH-4, a renowned wilt resistant castor hybrid eventually turned out to become wilt susceptible (Patel *et al*.,1991). Similarly, Anjani *et al.* (2004) reported that the wilt resistant variety DCS-9 exhibited upto 60 % wilt incidence which is indicating gradual breakdown of resistance. This may be due to the continuously evolving new *Fusarium* pathotypes which necessitate the identification of newer potential sources

for wilt resistance. Hence, it is essential to study the variability in the wilt pathogen. Keeping this facts in mind, the present study was carried out to test cultural and morphological variability in different isolates of *Fusarium oxysporum* f.sp. *ricini*.

MATERIALS AND METHODS

The study was conducted at Castor and Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar (Gujarat) during 2015-16. To study the variability among five isolates of *F. oxysporum* f.sp. *ricini*, different five media were tried in solid and liquid form. Growth and sporulation of five *F. oxysporum* f.sp. *ricini* isolates collected from different castor growing areas of Gujarat (Table 1) were studied on five media *viz.*, Rose Bengal (RB) medium, Potato dextrose (PD) medium, Richard's medium, Asthana and Hawker's (AH) medium and Glucose asparagine (GA) medium.

The media were prepared separately according to their composition using distilled water (Sinclair and Dhingra, 1995). For study on solid media, agar @ 2.0 per cent was added in each of the medium. Both liquid and solid media were sterilised through autoclaving. The pH of all the media was adjusted to 6.0 by using 0.1 N hydrochloric acid (HCl) or 0.1 N sodium hydroxide (NaOH) solutions. Each solid media (20 ml) were poured separately in Petri dishes under aseptic conditions. Similarly, 20 ml of each liquid media were poured separately in 100 ml conical flasks and then flasks containing medium were sterilised by autoclaving. All flasks or Petri dishes containing sterilized medium were inoculated with 5 mm disc cut from periphery of the actively growing colony of *F. oxysporum* f. sp. *ricini* isolates. These flasks and Petri dishes were labelled and incubated at 27 ± 2ºC temperature. On solid media, data on colony diameter (mm), colony characters and pigmentation were also recorded. In liquid media study, after 15 days of incubation mycelial mat was harvested and data on dry mycelial mat, sporulation, size of micro-conidia and macro-conidia were recorded.

RESULTS AND DISCUSSION

The colony characteristics *viz.,* mycelia colour, growth pattern and pigmentation of different isolates of *F. oxysporum* f. sp. *ricini* exhibited on the five media were recorded and are presented in Table 2.

Varied colony characteristics of each isolate exhibited varied colony characteristics on different media. Based on mycelia colour, the isolate *For 2* produced white colour and *For 1* produced pale white colour in all the five media. The isolate *For 4* produced pale white colour on Potato dextrose agar (PDA), Glucose asparagine agar (GAA) and Richard's agar (RA), but produced white colour on Asthana and Hawker's agar (AHA) and Rose Bengal agar (RBA) media. The isolates *For 3* produced pale white colour on AHA, GAA and RA, but produced white colour on PDA and RBA. The isolates *For 5* produced cottony white colour on PDA, RA, GAA and RBA, but produced pale white colour on AHA. Similarly, variation in substrate pigmentation by all five isolate was observed and the isolates *For 1*, *For 2* and *For 3* exhibited pale white pigmentation, while *For 4* exhibited violate and *For 5* exhibited white pigmentation on PDA. All the isolates exhibited pale white and pinkish pigmentation on AHA and RBA, respectively. The isolates *For 1, For 2, For 3* and *For 4* exhibited pale white pigmentation, but *For 5* exhibited light violet pigmentation on GAA. The isolates *For 1, For 3* and *For 4* exhibited pale white pigmentation, but *For 2* exhibited white and *For 5* exhibited pale yellowish white pigmentation on RA medium. Based on growth pattern on PDA, the isolates *For 1, For 2* and *For 3* exhibited flat growth with regular margin, while *For 4* exhibited partial flat growth with partial regular margin and *For 5* exhibited fluffy cottony growth with regular margin. On AHA medium, the isolates *For 1* and *For 4* exhibited flat growth with regular margin, while isolate *For 3* exhibited flat growth with thread like spreading at periphery and partial regular margin, *For 2* exhibited slight fluffy with irregular margin and *For 5* exhibited fluffy growth with regular margin. On RBA medium, all the isolates observed fluffy growth with regular margin (*For 4* and *For 5*), partial regular margin (*For 2* and *For 3*) and irregular margin (*For 1*). The isolates *For 2* and *For 3* exhibited flat growth with regular margin, while *For 4* exhibited flat growth with partial regular margin and *For 1* exhibited flat growth with irregular margin, but *For 5* exhibited fluffy cottony growth with partial regular margin on GAA medium. The isolate *For 1* and *For 3* exhibited flat growth with thread like spreading at periphery with irregular margin, while *For 2* and *For 4* exhibited flat growth with partial regular margin and *For 5* exhibited fluffy aerial cottony growth with irregular margin on RA medium. Significant variation in colony growth was noticed among five isolates of *F. oxysporum* f. sp. *ricini* as well as on different media (Table 3).

Among the media, significantly higher mean growth (70.60 mm) was observed on PDA followed by RA (66.76 mm), AHA (60.50 mm) and GAA (57.33 mm). However, Minimum mean growth (19.00 mm) was observed on RBA. Maxi-

Table 1. List of isolates of *F. oxysporum* f.sp. *ricini* collected from different castor growing areas of Gujarat.

Isolates	Locations		
	Village	Taluka	District
For 1	Bhakhar	Dantiwada	Banaskantha
For 2	Bhachau	Bhachau	Kachchh
For 3	Hadiol	Himmatnagar	Sabarkantha
For 4	Vinchhol	Mahemdabad	Kheda
For 5	Nana Anejiya	Nakhatrana	Kachchh

Table 2. Cultural characteristics of five isolates of *F. oxysporum* f.sp. *ricini* on different media after eight days of incubation at 27 ± 2 °C.

Media	Isolates	Cultural characteristics	Mycelial colour	Substratum pigmentation
Potato dextrose Agar (PDA)	*For-1*	Flat growth with regular margin	Pale white	Pale white
	For-2	Flat aerial growth with regular margin	White	Pale white
	For-3	Flat growth with regular margin	White	Pale white
	For-4	Partial flat growth with partial regular margin	Pale white	Violet
	For-5	Fluffy cottony growth with partial regular margin	Cottony white	White
Asthana and Hawker's agar (AHA)	*For-1*	Flat growth with partial regular margin	Pale white	Pale white
	For-2	Slight fluffy growth with irregular margin	White	Pale white
	For-3	Flat growth with thread like spreading at periphery and partial regular margin	Pale white	Pale white
	For-4	Flat growth with regular margin	White	Pale white
	For-5	Fluffy growth with regular margin	Pale white	Pale white
Rose Bengal agar (RBA)	*For-1*	Fluffy growth with irregular margin	Pale white	Pink
	For-2	Fluffy growth with partial regular margin	White	Pink
	For-3	Fluffy growth with partial regular margin	White	Pink
	For-4	Fluffy growth with regular margin	White	Pink
	For-5	Fluffy cottony growth with regular margin	Cottony white	Pink
Glucose asparagine agar (GAA)	*For-1*	Flat growth with irregular margin	Pale white	Pale white
	For-2	Flat growth with regular margin	White	Pale white
	For-3	Flat growth with thread like spreading at periphery and regular margin	Pale white	Pale white
	For-4	Flat growth with partial regular margin	Pale white	Pale white
	For-5	Fluffy cottony growth with regular margin	Cottony white	Violet
Richard's agar (RA)	*For-1*	Flat growth with thread like spreading at periphery and irregular margin	Pale white	Pale white
	For-2	Flat growth with partial regular margin	White	White
	For-3	Flat growth with thread like spreading at periphery and irregular margin	Pale white	Pale white
	For-4	Flat growth with partial regular margin	Pale white	Pale white
	For-5	Fluffy aerial growth with irregular margin	Cottony white	Pale yellowish white

Table 3. Growth of five isolates of *F. oxysporum* f. sp. *ricini* on different media after eight days of incubation at 27 ± 2°C.

Isolates	Colony diameter (mm)*					Mean
	Potato dextrose agar	Asthana and Hawker's agar	Rose Bengal agar	Glucose asparagine agar	Richard's agar	
For-1	72.50	70.83	15.50	65.33	71.83	59.20
For-2	58.16	40.66	17.16	40.66	49.66	41.26
For-3	78.16	66.83	20.00	64.66	75.83	61.10
For-4	82.33	65.83	22.66	61.00	68.33	60.03
For-5	61.83	58.33	19.66	55.00	68.16	52.60
Mean	70.60	60.50	19.00	57.33	66.76	-
C. D. at 5 %		Isolates (A)	: 1.39			
		Media (B)	: 1.39			
		A × B	: 3.11			

*Mean of three replications.

mum mean growth was observed with *For 3* (61.10 mm) and *For 4* (60.03 mm) which were statistically similar and fallowed by *For 1* (59.20 mm), *For 5* (52.60 mm) and *For 2* (41.26 mm). Interaction of different isolates and media was significant in the respect of growth rate and isolates *For 4* exhibited maximum growth (82.33 mm) on PDA which was followed by isolate *For 3* on PDA (78.16 mm) and RA (75.83 mm). All the isolates poorly grew in RBA. There was a considerable variation among all the five isolates of *F. oxysporum* f. sp. *ricini*. The cultural variability among different isolates of castor wilt pathogen, *F. oxysporum* f. sp. *ricini* collected from different castor growing areas of the country were also observed by Piplani *et al.*(1985), Desai *et al.* (2003), Prasad *et al*. (2008) and Mulekar *et al*. (2017).

In the liquid media study, growth of dry mycelium, sporulation and morphological observation of all the five isolates grown in different media. There was also variation in dry mycelial weight among different media as well as isolates (Table 4).

Among different five media, significantly maximum mean dry mycelial weight (290.73 mg) was record-

Table 4. Dry mycelial weight of five isolates of *F. oxysporum* f. sp. *ricini* grown in different liquid media after fifteen days of incubation at 27 ± 2°C.

Isolates	Dry mycelial weight (mg)					Mean
	Potato dextrose agar	Asthana and Hawker's agar	Rose Bengal agar	Glucose asparagine agar	Richard's agar	
For-1	128.00	46.66	39.33	59.66	323.00	119.33
For-2	119.33	39.66	41.00	25.66	301.66	105.46
For-3	129.33	39.66	50.66	44.00	255.00	103.73
For-4	116.33	33.33	38.66	34.66	254.66	95.53
For-5	149.66	38.33	38.66	44.33	319.33	118.06
Mean	128.53	39.53	41.66	41.66	290.73	-
C. D. at 5 %		Isolates (A)	: 6.99			
		Media (B)	: 6.99			
		A × B	: 15.64			

*Mean of three replications.

Table 5. Sporulation of five isolates of *F. oxysporum* f. sp. *ricini* grown in different liquid media after 15 days of incubation at 27 ± 2°C.

Isolates	Sporulation (millions/ml)					Mean
	Potato dextrose agar	Asthana and Hawker's agar	Rose Bengal agar	Glucose asparagine agar	Richard's agar	
For-1	23.03	9.90	3.16	12.50	15.43	12.80
For-2	6.70	3.70	2.23	0.83	3.36	3.36
For-3	17.83	2.33	0.96	12.43	7.60	8.23
For-4	33.53	5.73	2.36	22.16	15.96	15.95
For-5	12.63	5.20	1.23	4.33	6.50	5.98
Mean		18.74	5.37	1.99	10.45	9.77
C. D. at 5 %		Isolates (A)	: 1.17			
		Media (B)	: 1.17			
		A × B	: 2.61			

*Mean of three replications.

ed in Richard's medium followed by PD medium (128.53 mg). Maximum mean dry mycelial weight was exhibited by *For 1* (119.33 mg) and *For 5* (118.06 mg) which were statistically equal. This was followed by isolates *For* 2 and *For 3* which produced mean dry mycelial weight by 105.46 and 103.73 mg, respectively. Statistically significant interaction of different isolates and media in the respect of dry mycelial weight was observed. Maximum dry mycelia weight was recorded on Richard's medium for all five isolates followed by PD medium. Significantly higher mean sporulation (18.74 million/ml) was in PD medium (Table 5) followed by GA medium (10.45 million/ml) and Richard's medium (9.77 million/ml).

Maximum mean sporulation (15.95 million/ml) was recorded with *For 4* followed by *For 1* (12.80 million/ml) and *For 3* (8.23 million/ml). Interaction of different isolates and media was significant in the respect of sporulation. The isolates *For 4* preferred PD, GA and Richard's media for sporulation (33.53 million/ml, 22.16 million/ml and 15.43 million/ml, respectively) and *For 1* preferred AH (19.90 million/ml) and RB medium (3.16 million/ml, respectively) over other media. The present findings are in agreement with work of Mishra and Dhar (2007) they studied four liquid media for mycelial growth and sporulation of *F. udum* isolates and observed wide variation among the isolates in respect of mycelia growth and sporulation according to different media. Kumar and Upadhyay (2014) collected fifteen isolates of *F. udum* from Bihar, Jharkhand, Orrisa and West Bengal states and observed variability and dry mycelium weight was ranged from 98.3 to 201.0 milligram, while number of spores ranged from 0.8 to 3.6 million per millilitre with Potato dextrose broth. The result obtained by above research workers supported the finding of present research work.

Morphological study revealed the variation in size of microconidia and macroconidia among five isolates of castor wilt pathogen grown in different liquid media. The microconidia were 0-1 septate, whereas the macroconidia were 2-15 septate (Table 6).

In PD medium, the average length of microconidia varied from 8.96 µm (4.80-16.00 µm) of isolates *For 3* to 11.12 µm (6.40-14.40 µm) of isolates *For 1*, while the breadth of microconidia from 3.29 µm (2.24-4.80 µm) of isolates *For 5* to 4.72 µm (3.20-9.60 µm) of isolates *For 4*. The average length of macroconidia varied from 18.56 µm (11.20-32.00 µm) of isolates *For 4* to 25.04 µm (16.00-35.20 µm) of isolates *For 1*, while the breadth of macroconidia from 3.28 µm (3.20-4.80 µm) of isolates *For 5* to 3.92 µm (3.20-6.40 µm) of isolates *For 3.* In AH medium, the length of microconidia varied from 6.16 µm (4.80-10.24 µm) of isolates *For 3* to 10.19 µm (6.40-13.12 µm) of isolates *For 1*, while

Table 6. Size of microconidia and macroconidia of five isolates of *F. oxysporum* f. sp. *ricini* grown in different liquid media after 15 days of incubation at 27 ± 2°C.

Media	Isolates	Microconidia					Macroconidia				
		Length (µm)		Breadth (µm)		Septation	Length (µm)		Breadth (µm)		Septation
		Range	Average	Range	Average		Range	Average	Range	Average	
Potato dextrose (PD) medium	*For-1*	6.40-14.40	11.12	2.88-5.76	3.69	0-1	16.00-35.20	25.04	3.20-6.40	3.60	3-7
	For-2	4.80-12.80	9.68	3.20-4.80	3.42	0-1	12.80-25.60	20.96	3.20-4.80	3.52	3-5
	For-3	4.80-16.00	8.96	3.20-6.40	3.84	0-1	12.80-44.80	22.40	3.20-6.40	3.92	3-5
	For-4	6.40-16.00	9.92	3.20-9.60	4.72	0-1	11.20-32.00	18.56	2.56-4.80	3.39	3-6
	For-5	4.80-16.00	9.04	2.24-4.80	3.29	0-1	16.00-35.20	24.08	3.20-4.80	3.28	3-7
Asthana and Hawker's (AH) medium	*For-1*	6.40-13.12	10.19	3.20-8.00	5.49	0-1	19.20-70.40	39.44	3.20-5.44	4.06	4-15
	For-2	3.20-10.89	6.24	2.88-5.44	3.39	0-1	8.00-16.00	11.90	3.20-5.44	4.16	3-4
	For-3	4.80-10.24	6.16	2.88-4.80	3.20	0-1	8.00-25.60	11.01	3.20-5.44	3.76	3-6
	For-4	6.40-13.12	9.30	3.20-5.76	4.20	0-1	12.8-48.32	26.92	3.20-5.76	4.02	3-9
	For-5	3.20-12.80	7.52	2.24-6.40	3.66	0-1	22.40-46.40	31.65	3.20-6.40	4.16	4-7
Rose Bengal (RB) medium	*For-1*	4.80-12.80	8.50	2.24-5.44	3.82	0-1	11.20-32.32	18.96	3.52-6.72	4.11	3-5
	For-2	5.44-12.80	8.11	2.88-5.12	3.92	0-1	13.12-24.00	17.21	3.20-5.76	3.90	3-5
	For-3	6.40-9.92	8.22	3.20-5.44	4.14	0-1	12.80-20.48	15.84	3.20-4.16	3.65	3-4
	For-4	6.40-11.20	7.33	2.56-4.80	3.52	0-1	12.80-25.92	17.63	2.88-4.80	3.66	3-4
	For-5	6.72-11.20	9.57	2.88-6.40	4.18	0-1	12.80-22.72	17.60	2.56-4.48	3.25	3-4
Glucose asparagine (GA) medium	*For-1*	6.08-9.92	8.25	2.88-4.80	3.87	0-1	13.12-32.00	21.86	3.52-4.80	4.13	3-5
	For-2	7.68-9.60	8.61	2.56-4.16	3.46	0-1	13.44-32.32	18.37	3.52-4.48	3.94	3-5
	For-3	6.40-10.24	8.57	3.20-4.80	3.94	0-1	19.20-38.72	25.47	3.50-4.48	4.13	3-7
	For-4	4.80-12.80	8.83	3.20-5.44	4.32	0-1	12.80-26.56	20.74	3.20-640	4.42	3-9
	For-5	3.52-12.80	7.71	1.92-4.48	3.55	0-1	9.92-46.40	29.18	3.52-6.08	4.22	3-11
Richard's medium	*For-1*	4.80-14.08	9.85	3.20-5.44	4.38	0-1	7.68-25.28	13.50	3.20-5.44	4.19	3-5
	For-2	5.76-10.88	7.52	3.20-5.12	4.26	0-1	8.64-13.44	10.94	3.52-4.48	3.84	2-4
	For-3	5.44-14.40	8.96	3.20-4.80	4.12	0-1	11.20-20.16	14.02	3.52-5.12	4.00	2-4
	For-4	6.72-19.52	12.25	3.84-6.40	4.77	0-1	9.92-21.44	14.27	3.52-5.44	4.48	3-6
	For-5	6.40-19.20	11.48	3.52-5.12	4.38	0-1	9.92-25.97	16.10	3.20-4.48	3.81	3-7

the breadth of microconidia from 3.20 µm (2.88-4.80 µm) of isolates *For 3* to 5.49 µm (3.20-8.00 µm) of isolates *For 1*. The average length of macroconidia varied from 11.01 µm (8.00-25.60 µm) of isolates *For 3* to 39.44 µm (19.20-70.40 µm) of isolates *For 1*, while the breadth of macroconidia from 3.76 µm (3.20-5.44 µm) of isolates *For 3* to 4.16 µm (3.20-6.40 µm) of isolates *For 5*. The isolates *For 1* produced 4-15 septate straight as well as sickle shaped macroconidia on Asthana and Hawker's medium. In RB medium, the length of microconidia varied from 7.33 µm (6.40-11.20 µm) of isolates *For 4* to 9.57 µm (6.72-11.20 µm) of isolates *For 5*, while the breadth of microconidia from 3.52 µm (2.56-4.80 µm) of isolates *For 4* to 4.18 µm (2.88-6.40 µm) of isolates *For 5*. The length of macroconidia varied from 15.84 µm (12.80-20.48 µm) of isolates *For 3* to 18.96 µm (11.20-32.32 µm) of isolates *For 1*, while the breadth of macroconidia from 3.25 µm (2.56-4.48 µm) of isolates *For 5* to 4.11 µm (3.52-6.72 µm) of isolates *For 1*. In GA medium, the length of microconidia varied from 7.71 µm (3.52-12.80 µm) of isolates *For 5* to 8.83 µm (4.80-12.80 µm) of iso-

lates *For 4*, while the breadth of microconidia from 3.46 µm (2.56-4.16 µm) of isolates *For 2* to 4.32 µm (3.20-5.44 µm) of isolates *For 4*. The length of macroconidia varied from 18.37 µm (13.44-32.32 µm) of isolates *For 2* to 29.18 µm (9.92-46.40 µm) of isolates *For 5*, while the breadth of macroconidia from 3.94 µm (3.52-4.48 µm) of isolates *For 2* to 4.42 µm (3.20-6.40 µm) of isolates *For 4*. In Richard's medium, the length of microconidia varied from 7.52 µm (5.76-10.80 µm) of isolates *For 2* to 12.25 µm (6.72-19.52 µm) of isolates *For 4*, while the breadth of microconidia from 4.12 µm (3.20-4.80 µm) of isolate s *For 3* to 4.77 µm (3.84-6.40 µm) of isolates *For 4*. The length of macroconidia varied from 10.94 µm (8.64-13.44 µm) of isolates *For 2* to 16.10 µm (9.92-25.92 µm) of isolates *For 5*, while the breadth of macroconidia from 3.81 µm (3.20-4.48 µm) of isolates *For 5* to 4.48 µm (3.52-5.44 µm) of isolates *For 4.* The present findings are in agreement with work done on different formae species of *Fusarium* wilt by several workers. Previously, Piplani *et al.* (1985), Desai *et al.* (2003), Chauhan (2007) and Prasad *et al.* (2008) reported morphological variability among different isolates of *F. oxysporum* f. sp. *ricini.* Presence of genetic variation in different isolates of *F. oxysporum* f.sp. *ricini* isolated from different castor growing regions has been reported by Prasad *et al*. (2008). Diverse cultural, morphological and pathogenic characteristics were recorded in different *F. oxysporum* f.sp. *ricini* isolates and it was also observed that highly virulent isolates produces abundant spores as compared to moderately virulent isolates (Nanda and Parasad, 1974; Desai *et al*., 2003). Mulekar *et al*. (2017) recorded morphological variability in 24 isolates of *Fusarium oxysporum* f.sp. *ricini* representing various castor growing regions of India in Andhra Pradesh, Gujarat, Rajasthan Tamil Nadu, Telangana states. Similarly in the present study, significant variation in growth and sporulation of five isolates of *Fusarium oxysporum* f.sp. *ricini* representing various castor growing areas of Gujarat was observed. The results indicate existence of variability in the respect of morphological character among five isolates of *F. oxysporum* f.sp. *ricini* causing wilt disease in castor. Each isolate exhibited cultural and morphological variation influence by different media and this may be due to varied compositions of growth media which provides different kinds of nutrition.

Conclusion

This was concluded that there was a significant variation among all five isolates of *F. oxysporum* f.sp. *ricini* collected from different castor growing areas of Gujarat. The findings will be useful for developing *Fusarium* wilt resistant castor hybrids/ varieties.

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